17 HAZARD AND RISK

Chapter 17 describes the existing hazard and risk assessment process in the area of the Queensland Curtis LNG (QCLNG) Project Gas Field Component. It outlines the potential impacts of construction and operation of the Gas Field in so far as it creates a hazard or risk to the community and/or to the environment. Measures to mitigate those impacts are presented. A preliminary hazard and risk impact assessment of Gas Field infrastructure has been prepared and is provided in *Appendix 3.9.*

As part of front-end engineering and design (FEED), QGC is considering options for infrastructure type, configuration and location for coal seam gas (CSG) extraction, transport and processing equipment. The aim of this process is to reduce any unnecessary hazards and risks from construction, operation and subsequent decommissioning of the Gas Field. The hazard and risk assessment described in this chapter is based on the Environmental Impact Statement Reference Case described in *Volume 2, Chapter 2.*

The Project environmental objective for the assessment of hazard and risk is to protect the ecological health, public amenity and safety of those on site or in proximity to the site from hazardous events.

17.1 LEGISLATION, STANDARDS AND CODES OF PRACTICE

17.1.1 Legislation, Standards and Codes of Practice

A full list of Queensland and Commonwealth Acts and regulations, codes of practice and standards that may apply to the Project are provided in *Volume 5, Chapter 18, Annex F*. QGC will comply with all applicable legal and statutory requirements, codes and standards during the design, construction and operation of the LNG Facility. To ensure that the legislation, codes and standards are applied correctly and in the appropriate parts of its business, QGC will undertake reviews and gap analyses of its internal systems and procedures and revise these accordingly.

The legislation, standards and codes of practice as they apply to health and safety, and to the transport, storage and handling of hazardous materials are identified in *Table 3.17.1.*

Table 3.17.1 Legislative requirements – Hazardous Materials

Queensland Legislation	Requirement	Compliance
Workplace Health and Safety Act 1995 (Qld) and *Regulation 1997*	To prevent a person's death, injury or illness being caused by a workplace, by a relevant workplace area, by work activities, or by plant or substances for use at a workplace. Preventing or minimising a person's exposure to the risk of death, injury or illness. Establishing a framework for minimisation and prevention.	Safety in design and Safety Management System for construction and operational phases.
Dangerous Goods Safety Management Act 2001 (Qld) and *Regulation 2001* and National Standard for the Control of Major Hazard Facilities (MHF) (NOHSC:1014 [2002]) (if relevant).	The objective of the *Dangerous Goods Safety Management Act 2001* is to protect people, property and the environment from harm caused by hazardous materials and dangerous goods, including those from a major hazard facility. To achieve this, the Act creates broad safety obligations for all people involved with the storage, handling and manufacture of hazardous materials.	Management of dangerous goods in accordance with the requirements of the relevant Australian Standards for the storage and handling of dangerous goods. Safety Management System will be designed.
Explosives Act 1999(Qld) and *Regulation 2003*	To ensure the safe utilisation, storage, handling and disposal of explosives during all stages of the Project so as not to endanger persons, property or the environment.	Health, Safety, Security and Environment (HSSE) plan during construction.
Building Act 1975 (Qld) and *Building Fire and Safety Regulation 1991*	The safe design and operation of all buildings so as not to endanger persons, property or the environment.	Design and maintenance compliance with Building Code of Australia Safety Management System.
Fire and Rescue Service Act 1990 (Qld) and *Fire and Rescue Service Regulation 2001*	Establish effective relationships and implementation with the Queensland Fire and Rescue Service (QFRS) and to provide for the prevention of and response to fires and certain other incidents endangering persons, property or the environment and for related purposes.	Involvement of QFRS in emergency planning.
Electricity Safety Act 2002 (Qld) and *Electrical Safety Regulation 2002*	Eliminating the human cost to individuals, families and the community of death, injury and destruction that can be caused by electricity.	Safety in design and Safety Management System for construction and operational phases.

17.1.2 *Internal Company Standards*

See *Volume 5, Chapter 18.*

17.2 CRITERIA FOR HAZARD ASSESSMENT

Where feasible, hazards have been assessed using quantitative risk criteria relating to the likelihood and consequences of identified hazards. Where quantitative analysis was not possible, hazards have been assessed using qualitative criteria.

17.2.1 Qualitative Hazard Assessment

Qualitative hazard assessment is based on professional judgment about the consequence and likelihood of risks associated with a hazard.

Table 3.17.2 describes the criteria for assessing the likelihood of a hazard. The assessment assumes internal controls have been implemented to reduce the likelihood of a hazard.

Table 3.17.2 Likelihood of a Hazard

Rare	Unlikely	Possible	Likely	Almost Certain
Highly unlikely to occur	Unlikely to occur	It is possible that this could occur	Above average chance of occurring	Almost certain to occur
<1% chance of occurrence	1% to 10% chance of occurrence	10% to 50% chance of occurrence	50% to 90% chance of occurrence	>90% chance of occurrence

Table 3.17.3 describes the criteria for assessing the consequence, on people and the environment, of a hazard occurring.

The combination of consequence and likelihood provides a risk rating for each hazard. The risk ratings are:

- negligible – manage by routine procedures
- low – management responsibility must be specified and action taken
- medium – senior management attention required; immediate action to address issue
- high – detailed assessment and management planning required at senior level.

Table 3.17.3 Consequence of a Hazard

	Negligible	Minor	Moderate	Major	Critical
Safety and Health[1]	First aid	Minor injury Restricted work day Medical treatment	Major injury Long-term Injury Occupational illness	Single fatality	Multiple Fatalities
Environment	Magnitude of change comparable to natural variation. Not significant to the decision to be made on the Project.	Detectable but not significant. Impact warrants being brought to the attention of the decision-maker. Impact can be controlled by adoption of normal good practice. Monitoring is required to ensure mitigation is working properly and that the impact is not worse than predicted.	Significant. Impact warrants being brought to the attention of the decision-maker and deserves careful attention in decision making. Amenable to mitigation but likely to require conditions to ensure mitigation is undertaken. Monitoring required to ensure mitigation works properly and that the impact is not worse than predicted.	Significant. Impact mitigation measures must be found to reduce impacts. Impact warrants being given considerable weight in decision making. Residual impacts must be compensated for if possible. Monitoring required to ensure mitigation works properly and that the impact is not worse than predicted.	Intolerable, not amenable to mitigation. Alternatives must be found.

1 Based on the QGC Risk Management Plan, Issue 2, February 2009

Table 3.17.4 provides a risk matrix, used for qualitative risk assessment, based on the above consequence and likelihood criteria.

Table 3.17.4 Risk Matrix

		Consequence				
		Negligible	**Minor**	**Moderate**	**Major**	**Critical**
Likelihood	**Almost certain**	Medium	Medium	High	High	High
	Likely	Low	Medium	Medium	High	High
	Possible	Low	Low	Medium	Medium	High
	Unlikely	Negligible	Low	Low	Medium	Medium
	Rare	Negligible	Negligible	Low	Low	Medium

17.2.2 Quantitative Hazard Assessment

The methodology adopted by the following references has been used for quantitative hazard assessment:

- Department of Urban Affairs and Planning (DUAP) (1992). *Guidelines for Hazard Analysis.* Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 (and *Hazard Analysis Consultation Draft*, July 2008)
- Department of Urban Affairs and Planning (DUAP) (1997). *Risk Criteria for Land Use Safety Planning*. Hazardous Industry Planning Advisory Paper (HIPAP) No. 4
- Standards Australia Association (SAA) HB 105. *Guideline to Pipeline Risk Assessment in Accordance with Australian Standard (AS) 2885.1*.

The Queensland Government has adopted HIPAP No. 4 definitions of acceptable and unacceptable risk limits (as per *Table 3.17.5)* for new industrial installations located near residential developments.

Table 3.17.5 HIPAP Suggested Individual Fatality Risk Criteria

Land Use	**Suggested Criteria (risk in a million per year)**
Hospitals, schools, child-care facilities, old-age housing	0.5 (expressed as 0.5 x 10^{-6}/yr)
Residential, hotels, motels, tourist resorts	1 (expressed as 1 x 10^{-6}/yr)
Commercial developments, including retail centres, offices and entertainment centres	5 (expressed as 5 x 10^{-6}/yr)
Sporting complexes and active open space	10 (expressed as 10 x 10^{-6}/yr)
Industrial	50 (expressed as 50 x 10^{-6}/yr)

Source: http://www.emergency.qld.gov.au/chem/publications/pdf/Interim_Risk_Objectives_for_MHFs.pdf Hazardous Industry Planning Advisory Paper 4: Risk Criteria for Land-Use Safety Planning, NSW Department of Planning (often referred to as HIPAP 4). This document is not currently available. A draft, HIPAP 10, has been released for comment and covers the same material as HIPAP 4, plus new material.

For an industrial facility in an industrial area, Queensland Government guidelines for risk criteria state that the risk of fatality at a neighbouring industrial facility should not exceed 50 x 10^{-6} per year. Risk levels lower than 1 x 10^{-6} per year are defined as acceptable for adjacent residential areas, whereas those greater than 1 x 10^{-6} per year are defined as unacceptable for residential areas. The risk-level probabilities are explained in *Table 3.17.6*.

Table 3.17.6 Risk level probabilities

Numerical Value Notation	Shorthand	Chance per Year of Fatality
1 x 10^{-3}/year	10^{-3}	One chance in 1,000 of being killed per year
1 x 10^{-4}/year	10^{-4}	One chance in 10,000 of being killed per year
1 x 10^{-5}/year	10^{-5}	One chance in 100,000 of being killed per year
1 x 10^{-6}/year	**10^{-6}**	**One chance in 1,000,000 of being killed per year**
1 x 10^{-7}/year	10^{-7}	One chance in 10,000,000 of being killed per year
1 x 10^{-8}/year	10^{-8}	One chance in 100,000,000 of being killed per year

In addition to the legislated risk criteria levels, QGC has a set of internal risk acceptability guidelines. For the general public, in areas surrounding new facilities, these guidelines apply:

- Risk levels lower than 1 x 10^{-7} per year are defined as broadly acceptable.
- Risk levels greater than 1 x 10^{-5} per year are intolerable.
- Risk levels between these values should be reduced to as low as reasonably practicable (ALARP).

17.2.2.1 Risk Acceptability Criteria for Workers

HIPAP 10 (previously HIPAP 4) provides no guidance on acceptable levels for risk to workers at a particular facility that arise from operations or other activities from that facility. QGC's internal criteria provide these guidelines for individual worker risk acceptability:

- Risk levels greater than 1 x 10^{-3} per year are intolerable and fundamental risk reduction measures are required.
- Risk levels lower than 1 x 10^{-6} per year are broadly acceptable.
- Risk levels between these values are tolerable if it can be demonstrated that the risks are as low as reasonably practicable (ALARP).

For new facilities, QGC will strive to keep the maximum worker risk below 1 x 10^{-4} per year.

17.2.2.2 Impact Consequences

The consequences of fires and explosions are expressed in terms of the physiological effects of fires (radiant impact) and explosions (overpressure levels). These are defined in *Table 3.17.7* and *Table 3.17.8* respectively.

Table 3.17.7 HIPAP-defined Radiant Impact Levels

Radiant Flux Level	Defined Impact per HIPAP 10
1.2 kW/m^2	Received from the sun at noon in summer
2.1 kW/m^2	Minimum to cause pain after one minute
4.7 kW/m^2	Will cause pain in 15 to 20 seconds and injury after 30 seconds (at least second-degree burns will result)
12.6 kW/m^2	Significant chance of fatality after extended exposure. High chance of injury. After long exposure, causes the temperature of wood to rise to a point where it can be readily ignited by a naked flame. Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
23.0 kW/m^2	Likely fatality after extended exposure and chance of fatality after instantaneous exposure. Spontaneous ignition of wood after long exposure. Unprotected steel will reach thermal stress temperatures that can cause failures. Pressure vessel needs to be relieved or failure will occur.
35 kW/m^2	Cellulosic material will pilot-ignite within one minute's exposure. Significant chance of fatality for people exposed instantaneously.

Table 3.17.8 HIPAP Defined Overpressure Impact Levels

Overpressure Level	Defined Impact per HIPAP10
3.5 kPa (0.5 psi)	90 per cent glass breakage. No fatality and very low probability of injury.
7 kPa (1 psi)	Damage to internal partitions and joinery but repair possible. 10 per cent probability of injury. No fatality.
14 kPa (2 psi)	House uninhabitable and badly cracked.
21 kPa (3 psi)	Reinforced structures distort. Storage tanks fail. 20 per cent chance of fatality to a person in a building.
35 kPa (5 psi)	House uninhabitable. Wagons and plant items overturned. Threshold of eardrum damage. 50 per cent chance of fatality for a person in a building and 15 per cent chance of fatality for a person in the open.
70 kPa (10 psi)	Threshold of lung damage. 100 per cent chance of fatality for a person in a building or in the open. Complete demolition of houses.

The methodology for hazard assessment is further detailed in *Appendix 3.9.*

17.2.3 Risk Criteria for Methane Release

The principal constituent of CSG is methane, comprising approximately 97.5 mol per cent of CSG. The consequences of unplanned CSG releases were predicted using the model for Areal Locations of Hazardous Atmospheres (ALOHA).

Although, methane is not toxic, it is a flammable gas, which means that it can ignite in air on contact with a source of ignition. The lower flammability limit is

4.4 per cent and the upper flammability limit is 15 per cent of the total parts of the atmosphere. If a spark is created while the air and fuel are in the flammable range, an explosion or fire will result. The risk criteria used in the ALOHA model for potential flammable gas-release scenarios (methane) are summarised in *Table 3.17.9* and *Table 3.17.10.*

The levels of concern for explosion overpressure and heat radiation were modified to ensure consistency with DUAP 1997 effect levels (the default ALOHA values are shown in brackets). The consequence analysis of heat effects was also modelled at 35 kW/m^2 and 5 kW/m^2 to provide a comparison with criteria specified in the Terms of Reference (ToR).

Methane is classified as an asphyxiant in the guidelines on National Exposure Standards (NES) for atmospheric contaminants in the occupational environment (Australian Safety and Compensation Council 2009[2]). Asphyxiants are gases that, when present in an atmosphere in high concentrations, lead to a reduction of oxygen. However, as methane is not toxic, there are no Australian guidelines on toxic concentrations of methane in air from an occupational health and safety perspective. In this case, therefore, the default ALOHA values have been used as the risk criteria. The threshold level of most concern (Temporary Emergency Exposure Limits –TEEL-3) of 25,000 parts per million (ppm) (or 2.5 per cent) equals about 57 per cent of the lower flammability limit (4.4 per cent).

Table 3.17.9 Risk Criteria for Methane Release (Not Burning)

Hazard – methane not burning	Threat zone		
	Level of concern		
	Classification	**Units**	**Level**
Toxic area from vapour cloud	TEEL-3	ppm	25,000 (2.5%)
	TEEL-2	ppm	5,000
	TEEL-1	ppm	3,000
Flammable area of vapour cloud	60% LEL	ppm	26,400
	10% LEL	ppm	4,400
Blast area of vapour cloud explosion	Destruction of buildings	kPa/psi	10 or 70 kPa (8 psi)
	Serious injury likely	kPa/psi	3 or 21 kPa (3.5 psi)
	Shatters glass	kPa/psi	0.5 or 3.5 kPa (1 psi)

TEEL = Temporary Emergency Exposure Limits (TEELs) defined by the US Department of Energy.

TEEL-3 = Maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

TEEL-2 = Maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their ability to take protective action.

TEEL-1 = Maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient health effects or perceiving a clearly defined objectionable odour.

LEL – Lower explosive limit = lower flammability limit. The minimum concentration of fuel in the air needed for a fire or explosion.

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2 Australian Safety and Compensation Council (ASSC) 2009. Hazardous Substances Information System. http://hsis.ascc.gov.au/Default.aspx. Accessed March 2009.

Table 3.17.10 Risk Criteria for Methane Release (Burning)

Hazard – methane burning	**Threat zone**		
	Level of concern		
	Classification	Units	Level
Thermal radiation	Potentially lethal within 60 seconds	kW/m^2	12.6 (10)
	Second-degree burns	kW/m^2	4.7 (5)
	Pain within 60 seconds	kW/m^2	2.1 (2)
Downwind toxic effects of fire by-products	No thresholds Not modelled by ALOHA		

17.2.3.1 *Separation Distances*

The New South Wales Department of Infrastructure, Planning and Natural Resources (DIPNR) has prepared *Locational Guidelines: Development in the Vicinity of Operating Coal Seam Methane Wells*. The objective of this document was to assist NSW consenting authorities assessing proposals for development near existing and future operating CSG wells.

The guidelines describe the use of separation distances as buffers between an existing or future operating coal seam gas well (and associated equipment) and residential and sensitive uses. The recommended separation distances are provided in *Table 3.17.11.*

The separation distances reflect the level of technical and operational controls applied to CSG wells. Separation distances to gas pipelines are also provided by council planning schemes. Schedule 2 of the Murilla Shire (which includes the townships of Miles and Dalby) Planning Scheme recommends a minimum separation distance of 200 m to petroleum and gas pipelines.

Table 3.17.11 Separation Distances between Gas Wellhead and Residential and Sensitive Uses (DIPNR 2004)

Well Configuration	**Separation Distance (m)**	
	Residential use[1]	**Sensitive use[2]**
Early intermediate Operation Wells (typically up to two years)		
Manual	10	20
Automatically controlled (with separator/optional pump)	10	20
Automatically controlled (no pump/separator)	5	10
Established Wells (typically after two years)		
Manual	10	15
Automatically controlled (with separator/optional pump)	10	15
Automatically controlled (no pump/separator)	5	8

Note 1: Residential and places of regular occupancy (i.e. where people are regularly present).

Note 2: Schools, hospitals, old-age accommodation and other uses where vulnerable people are concentrated.

17.3 *HAZARD IDENTIFICATION, CONSEQUENCES AND CONTROLS*

Based on the anticipated construction sequencing, methodologies and activities known at preliminary design, QGC undertook a preliminary hazard identification assessment for construction, operation and decommissioning of the Gas Field infrastructure. The following hazards were identified:

- unplanned gas release with possibility of fire or explosion through introduction of an ignition source
- live and high-energy sources
- inappropriate/unauthorised infrastructure use or access
- infrastructure or equipment failure, other than gas-processing equipment
- natural disaster
- pollutant release to air, soils or water
- release of Associated Water
- traffic accidents involving multiple or single vehicles.

Hazards relating to the release of CSG and potential fires and explosions have been assessed through a quantitative risk analysis (QRA) described in *Sections 17.4* to *17.6.*

Other hazardous events, possible causes, consequences and proposed controls to address the identified hazards are provided in *Table 3.17.12* to *Table 3.17.18.*

Site-specific hazard identification assessment or study (HAZIDs) will be conducted in the detailed design of the infrastructure causing the hazard. Job hazard analyses will identify and address the site and activity-specific hazards before construction and operations begin.

For further information on decommissioning hazards, see *Volume 5, Chapter 18.*

17.3.1 *Residual Risk Analysis*

A residual risk analysis has been conducted for the hazards identified above. Residual risk is that which remains after the proposed controls have been implemented. The introduction of controls reduces the likelihood or consequence of an event, thereby reducing the risk.

For each of the causes of hazardous events identified above, the consequence, likelihood and resulting residual risk rating are shown in *Table 3.17.19* to *Table 3.17.25*.

Table 3.17.12 Hazard Identification – Live and High-Energy Sources

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Contact with live energy sources: - electric - pneumatic - hydraulic	Accidental contact with third-party power supply. Energising electrical equipment for the first time resulting in electrical short or explosion. Faulty equipment. Failure to isolate energy sources. Failure of hydraulic system on wellhead pumps.	Minor to major injury. Fatality.	Hardwire safety switches at source. Quarterly inspection and tag. Isolation and tag out procedures. Earthing rods for all portable generators and welders. Site awareness and training. Bunded areas.
Unexploded ordinance	Accidental contact during construction.	Minor to major injury. Fatality.	Extremely unlikely. Ask relevant authorities about any past military activity.
Unplanned detonation of explosives	Incorrect handling, storage or use of explosives.	Minor to major injury. Fatality.	No explosives will be used.

Table 3.17.13 Hazard Identification – Unauthorised Access or Use

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Inappropriate/ unauthorised infrastructure use or access	Lack of site security leads to unauthorised access to ponds, pipelines (buried or exposed), wells, compressors, access roads and other infrastructure.	Minor to major injury. Fatality from drowning, heat stress, dehydration, electrocution, crushing, falling, etc. Property damage. Environmental damage from release of contaminants Stock/fauna injury or death.	Comprehensive Site Safety and Security Plan. Site access control. Induction for employees and visitors.
	Lack of fencing/signage leads to falls and/or entrapment of people and stock in open trenches.		Appropriate fencing, barriers, signs. Notify landholders of works.
	Landholders ignore safety/security access restrictions.		Consult landholders to emphasise safety issues.
	Stock/fauna contact with infrastructure.		Adequate barriers/fencing.

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
	New access roads/right of ways (ROWs) encourage non-landholders to access previously unreachable areas.		New roads will have locked gates and warning signs.

Table 3.17.14 Hazard Identification – Infrastructure or Equipment Failure

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Infrastructure or equipment failure, other than gas-processing equipment	Pond failure, including overtopping, embankment failure, spillway failure.	Minor to major injury. Fatality. Property damage. Environmental damage from release of contaminants or spread of fire. Stock/fauna injury or death.	Engineer pond to high safety standard and for 1:100-year rainfall event.
	Separators or water transfer or treatment facility failure.		High safety design standards, regular maintenance and bunds in sensitive areas Emergency shutdown (ESD) procedures. Adequate pond storage to handle delays.
	Failure of materials storage including pipes, borrow material and soil stockpiles due to poor storage practices.		Safety procedures for pipe storage and handling. Safety procedures for stockpiles storage and handling.
	Fire at fuel storage. Fire at wellhead pump (diesel).		Fire-fighting equipment available. ESD procedures. Bunded area.
	Fire at oily water storage.		Bunded area. Vent with flame arrester.
	Seismic event from nearby blasting.		Consult local mines/industry about blasting activity.
	Drill rig or construction vehicle failure, or similar.		Drill rig/construction vehicle testing. Safety standards/procedures in place with drill rig and construction contractors.
	Failure of gas cylinder during handling and		Designated storage areas.

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
	storage due to faulty components or handling errors.		Inspect hoses regularly. Secure cylinders at all times. Transport within allowable limits.
	Failure of pressure testing or leak testing leading to release of stored energy.		Exclusion zones. Limit size of system being tested to minimise stored energy whenever possible. Staged pressure increases. Calculations to quantify amount of stored energy in system being tested.

Table 3.17.15 Hazard Identification – Natural Disasters

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Natural Disaster	Seismic event	Minor to major injury. Fatality. Property damage. Environmental damage from release of contaminants or spread of fire. Stock/fauna injury or death.	Design standards for all potentially affected infrastructure based on probability of seismic activity in Gas Field.
	High wind condition		Early notification of site personnel. Tie down loose items and general clean-up. Lower crane booms and anchor equipment if possible. Shut down site and non-essential road traffic. Use heavy equipment to provide windbreak for vulnerable structures.
	Bushfire caused internally by cutting, welding and grinding (hot work)		Contact the local fire authority before beginning hot work to ascertain whether a fire ban applies. If so, the fire officer shall obtain a written permit authorising the work for that day. Work will be performed in accordance with the permit. A well-maintained, self-contained, mobile fire-fighting unit with a minimum of 500 L of water, pump, hoses and other fire-fighting equipment such as rakes, shovels and hessian bags will be stationed within 100 m of work site. Flammable material within 4 m of the work area will be dampened and suitably protected.

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
			A protective screen will be put in place to arrest sparks. A minimum of four people will be present in the vicinity of the hot work. All mobile plant and vehicles will have a fully charged fire extinguisher ready for use at all times. At the completion of all hot work, the area will be checked thoroughly to ensure no fire has started or may start. All machinery powered by an internal combustion engine and working within designated live gas areas will be fitted with an effective exhaust system and spark arrester.
	Bushfire caused externally		Early notification of potential bushfire size, direction and severity. Emergency evacuation and shutdown procedures. Cease gas flow in affected areas. Liaise with fire service regarding fire-fighting procedures.
	Flooding		Locate infrastructure, where possible, above 1:100-year flood zones or design infrastructure to reduce impact of flooding. Emergency evacuation and shutdown procedures of potentially affected infrastructure.

Table 3.17.16 Hazard Identification – Pollutant Release

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Pollutant release to air, soil or water	Chemical storage failure, including reverse osmosis water treatment chemicals, coolant, batteries, paint, cleaning agents, fuel, oil, agricultural chemicals etc.	Toxic effects causing minor to major injury or health risk or fatality. Introduction of disease or pest vectors, such as mosquitoes, midges, rats, etc. Environmental damage from release of contaminants or spread of fire. Stock/fauna injury or death. Contamination of soil, water or air resulting in long-term health implications for humans, stock and environment.	All tanks and drums to be in bunded area and meet Australian Standards. Regular inspection of bunded areas. All chemicals and fuels will be stored either in lined bunds or on self-bunded pallets. On-site Material Safety Data Sheet (MSDS) register available to all employees. All hazardous materials clearly labelled.
	TEG[2] spill during dehydration with possible fire. TEG[2] spill during regeneration with steam release.		Bunding. Spill containment measures. Isolate and stop as per ESD procedures. Blowdown plant to flare. Infrared fire detection.
	Accidental chemical, fuel, oil spill due to operator error, equipment failure.		All refuelling performed away from watercourses to avoid surface water contamination. Fuelling area to have spill kits and containment. Response plan for spills. Spill management materials provided at all fuel or chemical storage locations. Training for people using hazardous materials, including incident response. Personal protective equipment (PPE) required for handling chemicals
	Fire at chemical or fuel/oil storage.		Diesel fuel used in majority of vehicles.[3] Eliminate petrol-powered equipment and vehicles as far as possible. Special storage for petrol. No smoking at fuel storage areas. Meet Australian Standards for separation distances and vessel type, and provide sufficient clearance from other flammable materials (including vegetation). Fire extinguishers at fuelling points. Safety showers and eye washers where material properties require them.

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
	Hazardous goods release or spill during transport to site or on site.		All hazardous materials clearly labelled. Training for people using hazardous materials, including incident response. Safe transport of hazardous materials. PPE required for handling chemicals. On-site MSDS register available to all employees. Up-to-date list of all hazardous materials plus their storage sites. Vehicles equipped with spill mitigation measures where practical. Bunding of drainage lines and emergency clean-up and remediation procedures.
	Drilling mud/fluids.		Bunding around drill site and use of non-oil based fluids Adequate safety design of mud/fluid containers.
	Release of oily water from compressors.		Bunding around oily water tanks.
	Release of acidic waters from acid sulfate soils.		Acid sulfate soils have not been identified in the Gas Field.
	Exposure, through drilling, trenching and construction on contaminated land, to possible contaminants including pathogens from livestock carcass disposal, buried chemicals, heavy metals from animal dips, hydrocarbons/ asbestos on road verges		Consult landholders before construction to determine whether tips or dips are likely to be found. Review Department of Environment and Resource Management (DERM) Contaminated Lands Register and Environmental Management Register for properties with potential contaminated sites. Areas of known or potential contamination will be avoided where possible. If areas cannot be avoided or trenchless techniques are inappropriate, site-specific management practices will be developed. Contaminated material would only be removed from the work area with DERM approval. Training and site management procedures will be implemented.
	Raw sewage or effluent release. Release of sludge after treatment of sewage.		Appropriately designed and constructed sewage treatment system. Secure storage of sludge containers in bunded area.
	Spray drift from irrigation with treated sewage water.		Irrigation only when wind speeds are below pre-determined level.

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
			Quality of irrigation water meets relevant criteria.
	Pollutant enters surface water (potable water supplies) through accidental release.		Waste Management Plan. See *Volume 3, Chapter 16.*
	Pollutant enters groundwater.		Waste Management Plan. See *Volume 3, Chapter 16.*
	Eutrophication of pond water.		Pond water quality testing. Pond designed for 1:100-year flood event. Water treatment as appropriate.
	Putrescible waste disposal.		Waste Management Plan. See *Volume 3, Chapter 16.*
	Dust generation – health impacts and visual impairment on roads/ROWs		Water roads/construction areas. Review of construction techniques. See *Volume 3, Chapter 4 and 12.*
	Air emissions of NOx, hydrocarbons, CO, ozone, particulates.		See *Volume 3, Chapter 12.*
	Unpleasant odour emissions.		See *Volume 3, Chapter 12.*
	Noise emissions.		See *Volume 3, Chapter 13.*
	Pest vectors.		Strategies to minimise the potential impacts from mosquitoes will be based on Guidelines to Minimise Mosquito and Biting Midge Problems in New Development Areas (Queensland Health, 2002). Prevent the creation of areas where water stagnates and breeding can occur, including washdown areas, sedimentation traps, containers and rubbish areas. Regular inspections will be performed to ensure adequate drainage and management controls are in place. Earthworks will be undertaken to prevent the accumulation of water and areas containing water will be regularly inspected for the presence of mosquito larvae. Pools of stagnant water will be drained and/or the areas filled as soon as practicable. Containers capable of accumulating water will be removed from site or stored

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
			in an inverted position. If larvae are detected in large numbers, Queensland Health will be contacted for assistance in selecting and implementing suitable control methods.

Note 2: TEG is a liquid higher glycol of very low vapour pressure with uses that are primarily industrial. It has a very low order of acute toxicity by inhalation (vapour and aerosol) routes of exposure. It does not produce primary skin irritation or cause skin sensitisation. Acute eye contact with the liquid causes mild local transient irritation but does not induce corneal injury. TEG is not classified as a dangerous good according to the Australian Code for the Transport of Dangerous Goods by Road and Rail. It has a flash point of 168°C and therefore is classified as a combustible liquid. Combustible liquids are liquids that burn, but are more difficult to ignite than flammable liquids. They have a flashpoint greater than 60.5°C and are not classified as dangerous goods (whereas liquids with a lower flashpoint are dangerous goods Class 3 – flammable liquids). C1 combustible liquids have flash points of <150°C while C2 combustible liquids have flash points >150°C. TEG therefore is classified as a C2 combustible liquid. Each TEG unit will hold approximately 5000 L. In addition, approximately 10 drums (or 2,000 L) will be stored at the warehouse. TEG should be stored in accordance with AS 1940:2004, *The Storage and Handling of Flammable and Combustible Liquids*.

Note 3: Diesel fuel is a C1 combustible liquid. It is more difficult to ignite than flammable liquids such as petrol, so it is not classified as a dangerous good. Diesel exhausts (e.g. fine particulates and combustion gases) may cause health effects in confined areas with poor ventilation. Diesel will be stored at the central processing plants in either 5,000 L or 10,000 L tanks. Back-up diesel generators will be stored at the field compression station but storage quantities will be limited. Diesel should be stored in accordance with AS 1940:2004, *The Storage and Handling of Flammable and Combustible Liquids*.

Table 3.17.17 Hazard Identification – Release of Associated Water

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Release of Associated Water	Pond failure, including flooding/ overtopping, embankment failure, spillway failure.	Minor to major health risk. Fatality. Environmental damage. Contamination of soils and water with long-term health implications for humans, stock and environment.	Engineer pond to high safety standard and for 1:100-year rainfall event.
	Failure of untreated water pipelines or water treatment facility.		High safety design standards. ESD procedures. Leak detection system to feed data to control room. Adequate pond storage to handle delays.
	Failure of saline brine treatment and storage units.		High safety design standards. ESD procedures. Leak detection system to feed data to control room. Emergency storage areas (ponds, tanks) for saline brine.
	Accidental/deliberate release caused by unauthorised third-party actions, including at ponds, well sites (separator), plugged/abandoned wells. Terrorism/deliberate sabotage.		Site security and safety plan.
	Hydrotesting and pigging.		Disposal of hydrotest/pigging water to controlled areas.
	Seepage of saline water through water storage ponds (including through liner failure) into surface water and groundwater.		Low permeability clay lining in large ponds. Low permeability geofabric, subject to quality assurance, on small ponds. Surface and groundwater-testing and monitoring with appropriate actions where required, such as pond decommissioning.
	Decommissioning of ponds with saline residue.		Rehabilitation activities associated with the disposal of saline residues and evaporation ponds will involve a physical and chemical investigation of soils and groundwater to determine area extent of saline contamination; undisturbed landform characteristics; and landholder requirements (e.g. preferred vegetation type).

Table 3.17.18 Hazard Identification – Traffic Accident

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Traffic accident involving multiple or single vehicles	Driver failure due to speed, drowsiness, judgment error, night travel etc.	Minor to major injury. Fatality. Vehicle damage. Environmental spill. Increase in road kill/ injury of stock and native fauna.	Driver training. Fatigue management. Ongoing training and awareness. Limit night-time driving. Monitor speed and driver behaviour and take action if unsafe.
	Existing roads inadequate – width, surface, parked vehicles.		Road maintenance and inspection. Alerts to Project drivers about road hazards, implement speed zones to Project drivers. Remove public vehicles from site. Restrict speeds on private roads, Gas Field roads.
	Vehicle in poor condition. Vehicle not manufactured to safe standards.		Vehicle inspection program. Fit heavy vehicles with reversing beepers. Suitable roll cage or provisions in heavy vehicles and equipment.
	Dust causes visual impairment.		Dust control on roads, principally road watering. Driver training.
	Dangerous intersection created or existing intersection becomes more dangerous due to increased traffic volumes.		Adequate signage. Consider road standards in consultation with relevant road authorities. Traffic management plan.
	Project causes changed traffic conditions, such as road closures for deliveries.		Adequate notice to road users through mobile signage and attended traffic control where necessary. Consult road authorities.
	Increased probability of contact with high-risk road users, such as school children, pedestrians and cyclists.		Reduced use of roads at times or locations when high-risk road users are on road. Consult road authorities.
	Loss of load during delivery.		Impose load safety standards on contractors.
	Failure of bridge/floodway crossings due to traffic volume or vehicle size.		Assess bridge/floodway before use by heavy vehicles. Use alternative routes or upgrade bridge/floodway.

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
	Deterioration of existing roads caused by Project. Poor road design or maintenance activities.		Road improvements/maintenance. Use other transport methods such as rail.
	Level (rail) crossing incident.		Warn drivers of all rail crossings. In consultation with rail authorities, consider upgrading rail crossings to include boom gates where necessary.
	Roadworks coinciding with increased traffic volumes.		Consult State and local roads departments.
	Increase in heavy load/oversized vehicles on roads.		Limit heavy vehicle access on roads unable to take them safely. Traffic escorts.
	Transport of large machinery (drill rigs etc) results in contact with infrastructure such as power lines.		Traffic escorts. Form traffic management plans in consultation with relevant authorities.

Note 1: Medical preventions, treatment or facilities includes:

- provision of paramedic services
- pre-employment medical screening
- provision of emergency response team and equipment
- provision of ambulance and emergency response vehicles
- emergency communication procedures and process
- protective clothing issues to workers
- potable water supply
- amenities for rest
- other PPE (sunscreen, insect repellent etc.)
- drug and alcohol testing
- health promotion.

Table 3.17.19 Hazard Risk Rating – Live and High Energy

Hazard	Likelihood	Consequence	Rating
Contact with live energy sources	Rare	Major	Low
Accidental contact with Unexploded Ordnance (UXO) during construction	Rare	Critical	Medium
Incorrect handling, storage or use of explosives	Rare	Critical	Medium

Table 3.17.20 Hazard Risk Rating – Unauthorised Access or Use

Hazard	Likelihood	Consequence	Rating
Lack of site security leads to unauthorised access to ponds, pipelines (buried or exposed), wells, compressors, access roads and other infrastructure	Likely	Moderate	Medium
Lack of fencing/signage leads to falls and/or entrapment in open trenches	Possible	Minor	Low
Landholders ignore safety/security access restrictions	Unlikely	Moderate	Low
Stock/fauna contact with infrastructure	Unlikely	Insignificant	Negligible
New access roads/ROWs encourage non-landholders to access previously unreachable areas	Unlikely	Minor	Low

Table 3.17.21 Hazard Risk Rating – Infrastructure or Equipment Failure

Hazard	Likelihood	Consequence	Rating
Pond failure, including overtopping, embankment failure, spillway failure	Rare	Critical	Medium
Separators or water transfer or treatment facility failure	Possible	Moderate	Medium
Failure of materials storage including pipes, borrow material and soil stockpiles due to poor storage practices	Possible	Moderate	Medium
Fire at fuel storage Fire at wellhead pump (diesel)	Unlikely	Moderate	Low
Fire at oily water storage	Rare	Moderate	Low
Seismic event from nearby blasting	Rare	Moderate	Low
Drill rig or construction vehicle failure, or similar	Unlikely	Major	Medium
Failure of gas cylinder during handling and storage due to faulty components or handling errors	Unlikely	Moderate	Low
Failure of pressure testing or leak testing leading to release of stored energy	Unlikely	Moderate	Low

Table 3.17.22 Hazard Risk Rating – Natural Disasters

Hazard	Likelihood	Consequence	Rating
Seismic event	Rare	Critical	Medium
Bushfire caused internally by cutting, welding and grinding (hot work)	Unlikely	Major	Medium
Bushfire – caused externally	Possible	Major	Medium
High wind condition	Unlikely	Major	Medium
Flood event	Possible	Moderate	Medium

Table 3.17.23 Hazard Risk Rating – Pollutant Release

Hazard	Likelihood	Consequence	Rating
Chemical storage failure – including reverse osmosis water treatment chemicals, coolant, batteries, paint, cleaning agents, fuel, oil, agricultural chemicals, etc	Unlikely	Minor	Low
TEG spill during dehydration with possible fire TEG spill during regeneration with steam release	Unlikely	Moderate	Low
Accidental chemical, fuel, oil spill due to operator error, equipment failure	Possible	Minor	Low
Fire at chemical or fuel/oil storage	Unlikely	Moderate	Low
Hazardous goods release or spill during transport to site or on site	Unlikely	Minor	Low
Drilling mud/fluids	Unlikely	Minor	Low
Release of oily water from compressors	Unlikely	Minor	Low
Release of acidic waters from acid sulfate soils	Rare	Moderate	Low
Exposure, through drilling, trenching and construction of contaminated land, to possible contaminants, including pathogens from livestock carcass disposal, buried chemicals, heavy metals from animal dips, hydrocarbons/ asbestos on road verges	Unlikely	Minor	Low
Raw sewage or effluent release Release of sludge after treatment of sewage	Unlikely	Moderate	Low
Spray drift from irrigation with treated sewage water	Possible	Minor	Low
Pollutant enters surface water (potable water supplies) through accidental release	Unlikely	Moderate	Low
Pollutant enters groundwater	Unlikely	Minor	Low
Eutrophication of pond water	Unlikely	Minor	Low
Putrescible waste disposal	Unlikely	Minor	Low
Dust generation – health impacts and visual impairment on roads/ROWs	Possible	Major	Medium
Air emission of nitrous oxide, hydrocarbons, carbon monoxide, ozone, particulates	Almost Certain	Negligible	Medium
Unpleasant odour emissions	Possible	Negligible	Low
Noise emissions	Almost Certain	Minor	Medium
Pest vectors	Unlikely	Minor	Low

Table 3.17.24 Hazard Risk Rating – Release of Associated Water

Hazard	Likelihood	Consequence	Rating
Pond failure, including flooding/overtopping, embankment failure, spillway failure	Rare	Critical	Medium
Failure of untreated water pipelines or water treatment facility	Unlikely	Moderate	Low
Failure of saline brine treatment and storage units	Unlikely	Moderate	Low
Accidental/deliberate release caused by unauthorised third-party actions, including at ponds, well sites (separator), plugged/abandoned wells Terrorism/deliberate sabotage	Unlikely	Major	Medium
Hydrotesting and pigging	Unlikely	Minor	Low
Seepage of saline water through unlined water storage ponds into surface water and groundwater	Likely	Minor	Medium
Decommissioning of ponds with saline residue	Possible	Moderate	Medium

Table 3.17.25 Hazard Risk Rating – Traffic Accident

Hazard	Likelihood	Consequence	Rating
Driver failure due to speed, drowsiness, judgment error, night travel etc.	Possible	Critical	High
Existing roads inadequate – width, surface, parked vehicles	Possible	Critical	High
Vehicle in poor condition Vehicle not manufactured to safe standards	Unlikely	Critical	Medium
Dust causes visual impairment	Possible	Critical	High
Dangerous intersection created or existing intersection becomes more dangerous due to increased traffic volumes	Unlikely	Critical	Medium
Project causes changed traffic conditions, such as road closures for deliveries	Unlikely	Major	Medium
Increased probability of contact with high-risk road users, such as school children, pedestrians and cyclists	Unlikely	Critical	Medium
Loss of load during delivery	Unlikely	Major	Medium
Failure of bridge/floodway crossings due to traffic volume or vehicle size	Rare	Major	Low
Deterioration of existing roads caused by Project. Poor road design or maintenance activities	Possible	Major	Medium
Level (rail) crossing incident	Rare	Critical	Medium
Road works coinciding with increased traffic volumes	Possible	Moderate	Medium
Increase in heavy load/oversize vehicles on roads	Unlikely	Major	Medium
Transport of large machinery (drill rigs, etc) results in contact with infrastructure such as power lines	Rare	Major	Medium

17.3.2 Mitigation of Risks

Hazards with high residual risk ratings are listed in

Table 3.17.26*,* with further potential risk abatement procedures or reasons for acceptance of the risk.

Table 3.17.26 High Residual Risks

High Residual Risk Hazard	Abatement
Driver failure due to speed, drowsiness, judgment error, night travel etc.	Identify travel routes and volumes for various activities. Identify routes, drivers and times of driving that present the greatest risk. Compulsory driver training and repeated safety message for all high risks.
Existing roads inadequate – width, surface, parked vehicles	In consultation with relevant authorities, upgrade existing high-risk roads.
Dust causes visual impairment	Increase number of water trucks to keep dust levels low, especially where there are multiple unsealed roads and multiple projects in the same area. Avoid driving in conditions where dust causes visual impairment.

17.4 HAZARD IDENTIFICATION – GAS RELEASE

Table 3.17.27 describes the possible causes and consequences of unplanned CSG release and proposed controls to address the resulting hazards.

The risk presented by a hazard is a combination of the consequence and likelihood of the hazard.

Table 3.17.27 Hazard Identification – Unplanned Gas Release

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
Unplanned gas release with possibility of vapour cloud, fire or explosion through introduction of an ignition source	Well incident during drilling, commissioning, operation or decommissioning at wellhead, separator or well pump. Initiating events include failure of pump seals, pumping rods and valves through corrosion and overpressurisation.	Toxic effects from gas, vapour flash cloud, overpressure (blast force) from vapour, thermal radiation and toxic effects from fires, leading to: • minor to major injury • fatality • property damage • environmental damage • stock/fauna injury or death	Well safety procedures. Exclusion zones with control of potential ignition sources. Wellhead collar has a pressure rating of at least twice the maximum shut-in pressure. Non-return valve installed to prevent backflow from the gathering line in the event of a major leak. Choke valve to limit maximum flow from the well. Pressure piping upstream of the choke designed to withstand very high pressure. Separator has a design pressure rating at least equal to the maximum operating pressure of the gathering system. Pressure safety valve (PSV) with vertical vent line sufficient to relieve full flow from the well.
	Incident at well that has been decommissioned (plugged and abandoned) and is accessed by a third party		Secure well after decommissioning, including warning signs
	Compressor failure for variety of reasons (e.g. heat stress, component malfunction, valve failure, corrosion, damage to flanges and gaskets, failure of temperature and pressure control). Possible high temperature (>100^{o}C) and high pressure gas release (>10,000 kPa)		Isolate the central processing plant (CPP)/field compression station (FCS) and stop all compressors and TEG unit. Emergency safety systems in design, such as ESD at gate. No ignitions sources near compressors. Evacuation alarm. Automatic isolated valves on suction and discharge. Automatic blowdown to atmosphere. Appropriately designed flares. Venting at wellhead.
	Gas flare failure for variety of reasons (e.g. heat stress, component malfunction) with flame out		ESD and safety design standards. In-built safety systems in design including seals, dual pilots, automatic re-ignition.
	Pipeline sited parallel to power lines, creating electrical interference		500 m corridor width between pipeline and powerlines
	Pipeline failure due to stress corrosion, alternating current (AC) corrosion, scour damage, faulty		Design, test, monitor and maintain in accordance with AS 2885.1. Quality control in pipe fabrication.

Hazardous Event	Possible Causes	Possible Consequences	Proposed Controls[1]
	construction, weld failure, pressure surges, valve failure, pump failure, ground movement, erosion, subsidence during construction or maintenance activities		Quality control in pipe-laying operations. Physical measures in accordance with AS 2885.1: • cross-country sections – minimum depth – 750 mm. • beneath roads – 1,200 mm unless rock. • fire break – 1,200 mm. Physical protection of the pipe in any exposed location. Installation of protective devices such as emergency isolation valves and non-return valves. Leak detection by automatic sensors.
	Landholder/third-party external interference damages pipeline		Pipeline routes signposted. Warning signs in line of sight at each change of direction and crossing, in accordance with AS 2885.1. Information on pipeline routes publicly available and lodged with relevant authorities. Rural (R1/R2) location classification requires one physical and two procedural measures. Adequate depth of cover important.
	Ignition source in hazardous zone		ESD valve to isolate the well. Exclusion zone and control of potential ignition sources. Fire detection system for automatically controlled wells. All electrical equipment appropriate to the hazardous area classification. Protect wells from impact. Permit to work procedures including Job Safety Analysis. Safety management system, including education.
	Natural disaster, including seismic event, bushfire, high winds. Seismic event from nearby blasting.		Reduction in operations with adequate warning. Design basis for permanent infrastructure. Rapid response plan after disaster event. Removal of all potential ignition sources.
	Sabotage or theft of infrastructure. Terrorism.		Comprehensive site safety and security plan

17.4.1 Likelihood Analysis

The likelihood of hazardous events identified was assessed by reviewing data on equipment failure, ignition probabilities or human error.

The frequency (or likelihood) determination for pipeline threats specified by Australian Standard SAA HB105 is provided in *Table 3.17.28* and *Table* 3.17.29.

Table 3.17.28 Frequency Determination for Pipeline Threats

Frequency of occurrence	Description	Nearest numerical frequency for guidance (per 1,000 km per year)
Frequent	Expected to occur at least once per year	1 or greater
Occasional	Expected to occur several times in the life of the Pipeline	0.1
Unlikely	Not likely to occur in the life of the Pipeline, but is possible	0.01
Remote	Very unlikely to occur in the life of the Pipeline	0.001
Improbable	Examples of this event have occurred historically, but it is not anticipated for the Pipeline at this location	10^{-5}
Hypothetical	Theoretically possible but has not occurred at this date	10^{-6} or lower

Source: SAA HB105[3]

Table 3.17.29 General Failure Rate Data for Gas Pipelines

Cause	Failure Rate (per km/year)	Failure Rate (per 1,000 km/yr)
External force	3×10^{-4}	0.3
Corrosion	1×10^{-4}	0.1
Material defect	1×10^{-4}	0.1
Other	5×10^{-5}	0.05
Total	5.5×10^{-4}	0.55

Source: R2A (2002)[4]

Ignition probability data for gas releases at varying release rates is presented in *Table 3.17.30*.

3 SAA HB105. *Guideline to pipeline risk assessment in accordance with AS 2885.1*

4 R2A (2002). *Issue Paper, Guide to Quantitative Risk Assessment (QRA)*. Prepared for Office of Gas Safety, Standards Australia ME-038-01 Committee, Pipelines – Gas and Liquid Petroleum. Risk & Reliability Associates Pty Ltd

Table 3.17.30 Probability of Ignition Following CSG Release

Release Rate (kg/min)	Ignition Probability (Gas or Mixture)	
	Probability	Likelihood (1 x 10^{-6})
<60	0.01	10,000
60 – 3,000	0.07	70,000
>3,000	0.3	300,000

The following information was reported in Kimber's 2005 Australian Pipeline Research Program keynote address, *Keeping the Australian Pipeline Standards up to Date:*[5]

- The most common cause of pipeline damage is external interference.
- External interference accounts for 76 per cent of all incidents.
- The second most common cause of pipeline damage is corrosion.
- There have been no deaths or injuries (~1985 to 2005).
- Six ruptures and 20 leaks were reported to the incident database.
- Pipe deformation (scratches, gouges and dents) accounts for two-thirds of incidents.
- The average incident rate for loss of containment is 0.015 per 1,000 km per year.
- The overall accident rate is 0.13 per 1,000 km per year.
- The average incident rate for loss of containment in Australia is an order of magnitude lower than the loss of containment rates in Europe and the USA.
- The incident rate for external interference varies with location class, ranging from 0.05 per 1,000 km per year in remote rural areas to 0.48 per 1,000 km per year in rural residential and suburban areas.

For this hazard assessment, the likelihood analysis has two components relating to a jet fire:

- the likelihood of loss of containment
- the likelihood of ignition.

The incident rates described by the Australian Pipeline Research Program (2005) were lower than those reported by other sources (see *Table 3.17.29* and *Table 3.17.30*) but generally consistent with the frequency classifications of AS 2885 and the SAA HB105. In addition, they are Australia-specific and more recent than other failure-rate data. Both the conservative estimate of 0.55 per 1,000 km per year and the Australian value of 0.13 per 1,000 km per

5 Kimber, MJ. Australian Pipeline Research Program Keynote Address Keeping the Australian Pipeline Standards Up to Date. PRCI-EPRG-APIA 15th Joint Technical Meeting On Pipeline Research Orlando, Florida, USA 16-18 May 2005

year have been used in this report. The higher failure rate presents a worst-case scenario while the Australian rate is most representative of the rates in rural Australia.

There is no information on failure or release rates from gas wells or compressors. QGC believes there is a low likelihood of significant releases during operation, although minor wellhead leaks have been caused during installation. The only other release event noted was caused by an increase in pressure in the gas/water separator above the set pressure, which resulted in gas being bypassed to the flare line.

As for the Pipeline scenarios, more detailed assessment would consider the number of flanges, valves and instrument fittings to enable use of failure data on a per-part basis. More detailed analysis would also consider the risks associated with the failure of more than one component (e.g. compressor) at any one time, although this scenario is considered unlikely, given ESD procedures.

Therefore, generic data for failure rates has been used in this assessment. A summary of incident rates, ignition probabilities and estimates for the likelihood of a fire is provided in *Table 3.17.31* and *Table 3.17.32*.

17.4.2 Consequence Analysis

The consequences of all types of gas releases were analysed using the ALOHA model. This model provides quantitative estimates of threat zones, such as distance to a pre-defined level of concern for toxic effects (airborne concentrations, ppm or mg/L), vapour cloud flash (based on flammable limits of the gas percentage) and thermal radiation (kW/m^2).

The consequences of a CSG release (considered to be 100 per cent methane for the purposes of this hazard assessment) are described in *Figure 3.17.1*.

Table 3.17.31 Summary of Likelihood Data for CSG Release and Ignition – Wells and Compressors

Release Source	Hole size	No. of parts	Pressure	Likelihood of release	Likelihood of release	Calculated release rate[A]	Ignition Probability	Likelihood of fire[1]
	Mm		(kPa)	($x\ 10^{-6}$ per part per year)	$x\ 10^{-6}$ per year	(kg/mins)		($x10^{-6}$ per year)
Gas well (full bore)	110	1 well	300	20[4]	20	54	0.01	0.200
					20		0.25	5.000
	10	1 well	300	20[4]	20	1.6	0.01	0.200
Screw compressor/FCS	25	8 x 4[2]	1,500	170[5]	5,440	21	0.01	54
					5,440		0.032	174
Reciprocating compressor/CPP	25	10 x 4[3]	10,200	170[5]	6,800	21	0.01	68

A Derived from consequence modelling described in *Section 17.4.2*

1 Likelihood of fire = likelihood of release x likelihood of ignition

2 No. of compressors per FCS, assumes four valves

3 No. of compressors per CPP, assumes four valves

4 Failure probability for a casing pump

5 Assuming four valves per compressor on inlet and discharge lines – 25 mm hole size

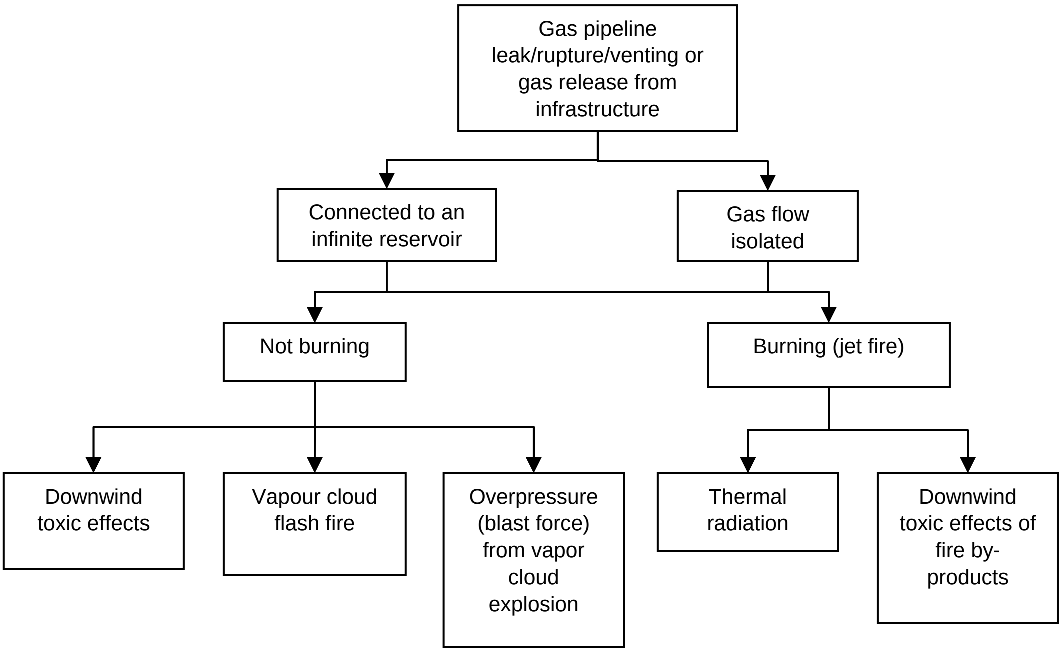
Table 3.17.32 Summary of Likelihood Data for CSG Release and Ignition – Pipeline Scenarios

Release Source	Hole size	1,000 km	Pressure	Likelihood of release	Likelihood of release	Calculated release rate[A]	Ignition Probability	Likelihood of fire[1]	Likelihood of fire[1]
	Mm		(kPa)	(per total km per year)	(per 1,000 km per year)	(kg/mins)		(per 1,000 km per year)	(per million km per year)
Loss of containment rate (POG/APIA 2005)									
High density polyethylene (HDPE) flow lines (full bore)	143	3	300	0.015	0.045	43	0.01	0.000	0.45
Steel trunklines	25	0.15	1500	0.015	0.00225	67	0.07	0.000	0.16
Incident rate (POG/APIA 2005)									
HDPE flow lines (full bore)	143	3	300	0.13	0.39	43	0.01	0.004	3.90
Steel trunklines	25	0.15	1500	0.13	0.0195	67	0.07	0.001	1.37
General failure rate (R2A 2002)									
HDPE flow lines (full bore)	143	3	300	0.55	1.65	43	0.01	0.017	17
Steel trunklines	25	0.15	1500	0.55	0.0825	67	0.07	0.006	5.78

A Derived from consequence modelling described in *Section 17.4.2*

1 Likelihood of fire = likelihood of release x ignition probability

Figure 3.17.1 Hazard Assessment



The consequences modelled for a gas release that is not burning are:

- downwind toxic area of vapour cloud – the predicted area where the ground-level toxic vapour concentration may be hazardous
- flammable area of vapour cloud – the predicted area where the ground-level vapour (fuel) concentration in air is within the flammable range and can be ignited (the area where a flash fire could occur at some time after the release)
- blast area of vapour cloud explosion – the predicted area where the blast force from the explosion is hazardous.

The consequences for a gas release that is burning (i.e. when a flammable gas catches fire as it is released) are:

- thermal radiation (modelled by ALOHA)
- smoke and toxic by-products from a jet fire (not modelled by ALOHA but expected to be minimal from a coal seam gas fire).

17.4.3 Gas Field Infrastructure Modelling Assumptions

The Gas Field infrastructure is described in *Volume 2, Chapters 7* and *11*. In addition, the following modelling parameters relevant to hazard modelling, based on engineering design, are shown in *Table 3.17.33* to *Table 3.17.35*.

Table 3.17.33 Gas Well Parameters

Description	Function	Pipeline type	Maximum Allowable Operating Pressure (MAOP)	Shut-in Pressure	Pressure	Diameter	Pipeline length	Individual lengths	Gas supply control	Maximum length from reservoir or isolation valve
			MPa	kPa	kPa	mm	m	m	type	m
Wellhead	Gas supply node	na	0.7	3,790 (new well)[1]	350 to 700 Modelled data – 206 to 324[2]	110	na	na	Infinite (connected to reservoir)[3]	na
		na	na	1,038 kPa[A] (after two years)[1]	Na	110	na	na	Infinite (connected to reservoir)[3]	na

na = not applicable

1 DIPNR (NSW) 2004[6]

2 Field pressure = 200 to 300 kPa

3 If free-flowing well (as opposed to well and pump)

Table 3.17.34 Compressor Parameters

Description	Function	Pipeline type	MAOP	Pipeline inlet pressure	Diameter	Wall thickness	Internal diameter	Gas supply control	Max length from reservoir or isolation valve
			MPa	kPa	mm	mm	cm	type	m
Compressor discharge pipeline	Transport compressed gas	Steel	Gas – 1.25 MPa	1,500 (screw compressor). 10,200 (reciprocating compressor).	109	9	10	Finite – isolation valve before compressor	Not available

6 Department of Infrastructure, Planning and Natural Resources (2004). *Locational Guidelines – Development in the Vicinity of Operating Coal Seam Methane Wells*. May 2004.

Table 3.17.35 Pipeline Parameters

Pipeline description	Function	Pipeline type	MAOP	Pipeline inlet pressure	Diameter	Wall thickness	Internal diameter	Pipeline length	Individual lengths	Gas supply control	Max length from reservoir or isolation valve
			MPa	kPa	mm	mm	cm	m	m	type	m
Flow lines	HDPE flow lines from wellhead to FCS	HDPE	Gas – 1.25 MPa	300[1a]	152	9	14.3	2,000	20	Finite – non-return valve after gas/water separator	2,000
Trunklines	FCS to CPP	Class 150 steel	1.86 MPa (1,856 kPa)	1,500[1b]	406	9	39.7	5,000	na	Finite – isolation valve	5,000

na = not applicable

1a Field pressure = 200 to 300kPa

1b Trunkline pressure = ~1,500 kPa

17.5 IMPACTS – GAS RELEASE

Various types of gas releases from the following equipment or infrastructure were modelled:

- Gas wellhead – full bore rupture
- Gas wellhead – 10 mm valve leak
- Screw and reciprocating compressors – 25 mm hole
- HDPE gathering lines – full bore rupture
- Trunklines – 25 mm hole

Table 3.17.36 to *Table 3.17.41* detailing the consequence models are listed at the end of *Section 17.4.2*.

17.5.1 Meteorological Conditions

Unplanned gas releases were modelled under a range of meteorological conditions based on average data collated from the Bureau of Meteorology for Dalby, Miles, Biloela and Gladstone. Data from Miles is most representative of the meteorological conditions in the Gas Field (i.e. gas wells, gathering lines, trunklines and compressors).

While data from Miles is representative of most field activities (Gas Field baseline conditions), a range of meteorological conditions has been modelled to ensure the impacts of lower and higher wind speeds on the potential consequences of CSG releases were evaluated.

The four meteorological scenarios included in the consequence modelling were:

- Gas Field baseline morning conditions
- Gas Field baseline afternoon conditions
- low wind speed (0.85 m/s)
- high wind speed (5.9 m/s).

Further details about modelled meteorological conditions are provided in *Appendix 3.9, Section 6.*

17.5.2 Wellheads

The current maximum volume of gas that may be released from a well is 141.6 ML/day. The total gas release from a full bore rupture was calculated to be 107 ML/day, although the maximum duration for such an event is one hour. The consequence results presented in *Table 3.17.36* therefore present an extreme scenario. A gas release from a valve or gasket leak (i.e. 10 mm leak), as presented in *Table 3.17.37*, is more likely.

Results show that for a full bore rupture of a wellhead:

- the concentration of methane in air at which nearly all individuals could be exposed without developing life-threatening health effects (TEEL-3) is 33 m from the wellhead
- the potential for ignition, at 60 per cent of the lower flammability limit, occurs within 44 m of a wellhead
- there is no possibility of experiencing blast pressures greater than 21 kPa
- there is no potential for fatality and very low probability of injury from a blast (not burning) of 3.5 kPa at a distance of 38 m from the wellhead
- the potential for significant chance of fatality from extended exposure or high chance of injury from thermal radiation from burning gas is less than 10 m from the wellhead
- the potential for injury after 30 seconds (4.7 kW/m^2) from thermal radiation from burning gas is less than 16 m from the wellhead.

Results show that, for a 10 mm valve leak at a wellhead:

- the concentration of methane in air at which nearly all individuals could be exposed without developing life-threatening health effects (TEEL-3) is less than 10 m from the wellhead
- the potential for ignition, at 60 per cent of the lower flammability limit, occurs within 10 m of a wellhead
- there is no possibility of blast pressures greater than 3.5 kPa
- the potential for injury after 30 seconds (4.7 kW/m^2) from thermal radiation from burning gas is less than 10 m from the wellhead.

17.5.3 Screw and Reciprocating Compressors

Releases from the compressors were modelled as pipeline sources. The pipeline length was modified to simulate a release of approximately 30 m^3, the volume expected to be released during a screw compressor start or blowdown. This gas volume was considered to be a credible release scenario assuming standard control measures, such as unit isolation valves, blowdown valves and vents, and PSVs and vents.

The impacts of a gas release of 30 m^3 from the discharge pipeline were similar from both a screw compressor and reciprocating compressor. The primary difference was the duration of the release because of differences in temperature and pressure.

The results of these scenarios are presented in *Table 3.17.38* and *Table 3.17.39*. The model scenario evaluated is based on a 25 mm hole size, which is equivalent to a hole caused by fitting failure but conservative for a leak from a valve or flange (more likely to be 10 mm).

The consequences of leaks from pipe work at the compressor stations would be similar to those modelled for the trunklines from the FCS to the CPP and the Collection Header and Export Pipelines (see *Volume 4, Chapter 16*).

Results show that, for a 25-mm hole in a screw compressor:

- the concentration of methane in air at which nearly all individuals could be exposed without developing life-threatening health effects (TEEL-3) is less than 20 m from the compressor
- the potential for ignition, at 60 per cent of the lower flammability limit, occurs within 28 m of a compressor
- there is no possibility of experiencing blast pressures greater than 21 kPa
- there is no potential for fatality and very low probability of injury from a blast (not burning) of 3.5 kPa at a distance of 35 m from the compressor
- the potential for injury after 30 seconds (4.7 kW/m^2) from thermal radiation from burning gas is less than 10 m from the compressor.

Results show that, for a 25 mm hole in a reciprocating compressor:

- the concentration of methane in air at which nearly all individuals could be exposed without developing life-threatening health effects (TEEL-3) is less than 21 m from the compressor
- the potential for ignition, at 60 per cent of the lower flammability limit, occurs within 28 m of a compressor
- there is no possibility of blast pressures greater than 21 kPa
- there is no potential for fatality and very low probability of injury from a blast (not burning) of 3.5 kPa at a distance of 36 m from the compressor

the potential for injury after 30 seconds (4.7 kW/m^2) from thermal radiation from burning gas is less than 10 m from the compressor.

17.5.4 *HDPE Gathering Lines*

The worst-case scenario for an HDPE gathering line is a full bore rupture. The pipeline lengths modelled represent the worst-case scenarios resulting from the maximum length from isolation valves. The results of consequence modelling for a full bore rupture are presented in *Table 3.17.40*.

Results show that, for a full bore rupture of a gathering line:

- the concentration of methane in air at which nearly all individuals could be exposed without developing life-threatening health effects (TEEL-3) is less than 24 m from the gathering line
- the potential for ignition, at 60 per cent of the lower flammability limit, occurs within 33 m of a gathering line
- there is no possibility of blast pressures greater than 3.5 kPa

- the potential for injury after 30 seconds (4.7 kW/m^2) from thermal radiation from burning gas is less than 16 m from the gathering line.

17.5.5 *Trunklines*

The results of consequence modelling for a 25 mm hole in a trunkline are presented in *Table 3.17.41*.

Results show that, for a 25 mm hole in a trunkline:

- The concentration of methane in air at which nearly all individuals could be exposed without developing life-threatening health effects (TEEL-3) is less than 36 m from the trunkline.
- The potential for ignition, at 60 per cent of the lower flammability limit, occurs within 50 m of a trunkline.
- There is no possibility of blast pressures greater than 21 kPa.
- There is no potential for fatality and very low probability of injury from a blast (not burning) of 3.5 kPa at a distance of 35 m from the trunkline.
- The potential for injury after 30 seconds (4.7 kW/m2) from thermal radiation from burning gas is less than 10 m from the trunkline.

Table 3.17.36 Results of Consequence Modelling – Gas Wellhead, Full Bore Rupture

Met data	Release duration (mins)	Release rate (kg/mins)[1]	Total amount released (kg)	Threat zone (m) not burning – toxic			Threat zone (m) not burning – flammable		Threat zone (m) not burning – blast			Threat zone (m) burning			
				TEEL-3 (25,000 ppm)	TEEL-2 (5,000 ppm)	TEEL-1 (3,000 ppm)	60% LEL	10% LEL	70 kPa	21 kPa	3.5 kPa	Max flame (m)	35 kW/m^2	12.6 kW/m^2	4.7 kW/m^2
Baseline morning	60[2]	54.2	3,195	25	56	73	34	85	Not exceeded	Not exceeded	22	9	<10	10	14
Baseline afternoon	60[2]	53.6	3,161	25	56	72	34	84	Not exceeded	Not exceeded	27	9	<10	10	14
Low wind speed	60[2]	54	3,183	33	73	94	44	109	Not exceeded	Not exceeded	38	9	<10	10	12
High wind speed	60[2]	53.4	3,153	25	56	74	34	86	Not exceeded	Not exceeded	24	9	<10	10	16

Note 1: Bore size = 110 mm, depth = 400 m, infinite source

Note 2: Limited to 60 minutes duration by model

Table 3.17.37 Results of Consequence Modelling – Gas Wellhead, 10 mm Valve Leak

Met data	Release duration (mins)[1]	Release rate (kg/mins)	Total amount released (kg)	Threat zone (m) not burning – toxic			Threat zone (m) not burning – flammable		Threat zone (m) not burning – blast			Threat zone (m) burning			
				TEEL-3 (25,000 ppm)	TEEL-2 (5,000 ppm)	TEEL-1 (3,000 ppm)	60% LEL	10% LEL	70 kPa	21 kPa	3.5 kPa	Max flame (m)	35 kW/m^2	12.6 kW/m^2	4.7 kW/m^2
Baseline morning	29	1.56	5.66	<10	<10	13	<10	14	Not exceeded	Not exceeded	Not exceeded	1	<10	<10	<10
Baseline afternoon	28	1.54	5.55	<10	<10	12	<10	14	Not exceeded	Not exceeded	Not exceeded	1	<10	<10	<10
Low wind speed	29	1.55	5.6	<10	13	16	<10	19	Not exceeded	Not exceeded	Not exceeded	1	<10	<10	<10
High wind speed	28	1.52	5.47	<10	<10	12	<10	14	Not exceeded	Not exceeded	Not exceeded	1	<10	<10	<10

Note 1: Bore size = 110 mm, depth = 400 m, pipeline closed at end

Table 3.17.38 Results of Consequence Modelling – Screw Compressor, 25 mm Hole

Met data	Release duration (mins)	Release rate (kg/mins)	Total amount released (kg)	Threat zone (m) not burning – toxic			Threat zone (m) not burning – flammable		Threat zone (m) not burning – blast			Threat zone (m) burning			
				TEEL-3 (25,000 ppm)	TEEL-2 (5,000 ppm)	TEEL-1 (3,000 ppm)	60% LEL	10% LEL	70 kPa	21 kPa	3.5kPa	Max flame (m)	35 kW/m^2	12.6 kW/m^2	4.7 kW/m^2
Baseline morning	4	21	22.1	16	35	45	22	53	not exceeded	not exceeded	23	2	<10	<10	<10
Baseline afternoon	4	21	22.1	16	35	45	21	52	not exceeded	not exceeded	23	2	<10	<10	<10
Low wind speed	4	21	22.1	20	45	59	28	68	not exceeded	not exceeded	35	2	<10	<10	<10
High wind speed	4	21	22.1	16	35	45	22	53	not exceeded	not exceeded	21	2	<10	<10	<10

Table 3.17.39 Results of Consequence Modelling – Reciprocating Compressor, 25 mm Hole

Met data	Release duration (mins)	Release rate (kg/mins)	Total amount released (kg)	Threat zone (m) not burning - toxic			Threat zone (m) not burning – flammable		Threat zone (m) not burning – blast			Threat zone (m) burning			
				TEEL-3 (25,000 ppm)	TEEL-2 (500,036 ppm)	TEEL-1 (3,000 ppm)	60% LEL	10% LEL	70 kPa	21 kPa	3.5 kPa	Max flame (m)	35 kW/m^2	12.6 kW/m^2	4.7 kW/m^2
Baseline morning	1	22.14	22	16	36	47	22	54	not exceeded	not exceeded	24	2	<10	<10	<10
Baseline afternoon	1	22.14	22	16	36	46	22	54	not exceeded	not exceeded	23	2	<10	<10	<10
Low wind speed	1	22.14	22	21	47	60	28	70	not exceeded	not exceeded	36	2	<10	<10	<10
High wind speed	1	22.14	22	16	36	47	22	55	not exceeded	not exceeded	21	2	<10	<10	<10

Table 3.17.40 Results of Consequence Modelling – HDPE Gathering Lines, Full Bore Rupture

Met data	Release duration (mins)	Release rate (kg/mins)	Total amount released (kg)	Threat zone (m) not burning – toxic			Threat zone (m) not burning – flammable		Threat zone (m) not burning – blast			Threat zone (m) burning			
				TEEL-3 (25,000 ppm)	TEEL-2 (5,000 ppm)	TEEL-1 (3,000 ppm)	60% LEL	10% LEL	70 kPa	21 kPa	3.5 kPa	Max flame (m)	35 kW/m^2	12.6 kW/m^2	4.7 kW/m^2
Baseline morning	8	30.5	42.8	19	42	55	26	63	not exceeded	not exceeded	not exceeded	11	<10	10	15
Baseline afternoon	8	30	41.9	19	42	54	25	63	not exceeded	not exceeded	not exceeded	11	<10	10	15
Low wind speed	8	30.5	42.8	24	55	70	33	81	not exceeded	not exceeded	not exceeded	11	<10	10	11
High wind speed	8	29.5	41.2	19	42	54	25	63	not exceeded	not exceeded	not exceeded	11	<10	11	16

Table 3.17.41 Results of Consequence Modelling – Trunklines, 25 mm Hole

Met data	Release duration (mins)	Release rate (kg/ mins)	Total amount released (kg)	Threat zone (m) not burning – toxic			Threat zone (m) not burning – flammable		Threat zone (m) not burning – blast			Threat zone (m) burning			
				TEEL-3 (25,000 ppm)	TEEL-2 (5,000 ppm)	TEEL-1 (3,000 ppm)	60% LEL	10% LEL	70 kPa	21 kPa	3.5 kPa	Max flame (m)	35 kW/m^2	12.6 kW/m^2	4.7 kW/m^2
Baseline morning	60[1]	67	2,996	28	63	81	38	94	not exceeded	not exceeded	25	2	<10	<10	<10
Baseline afternoon	60[1]	66.2	2,953	28	62	80	38	93	not exceeded	not exceeded	24	2	<10	<10	<10
Low wind speed	60[1]	66.7	2,982	36	81	105	50	121	not exceeded	not exceeded	35	2	<10	<10	<10
High wind speed	60[1]	66.1	2,948	28	63	82	38	96	not exceeded	not exceeded	23	2	<10	<10	<10

Note 1: Limited to 60 minutes duration by model

17.5.6 Consequences for Human Health

A classification system for the consequence modelling described above is provided in *Table 3.17.42.* Each potential consequence of a gas release has different levels of impact, as reflected in *Table 3.17.7* to *Table 3.17.10*. The level of impact from a gas release is assigned a ranking from negligible to critical.

The risk criterion adopted as the level at which fatality from heat radiation occurs for instantaneous exposure is 35 kW/m^2. Therefore, the classification of fatality is negligible where the effect level is not exceeded or major where the effect level is exceeded.

Table 3.17.7 indicates there is a significant chance of fatality for extended exposure (> 60seconds) at the lower level of 12.6 kW/m^2 and a high chance of injury. Extended exposure means the victim is unable to move away from the heat radiation, which might, for example, occur if someone was injured separately before the fire. The likelihood of this scenario is very low and therefore exposure to a heat radiation level of 12.6 kW/m^2 is treated as a moderate injury risk.

The consequence to human health for each of the modelled scenarios is presented in *Table 3.17.43.* There are no scenarios that present a potential fatality risk to the public.

The consequences of all modelled scenarios to the public are negligible for fatalities and negligible to moderate for injuries. There are no scenarios with critical or major consequences.

The scenarios causing moderate injury risk (12.6 kW/m^2) from heat radiation are:

- gas wellhead, full bore rupture, up to 10 m
- HDPE pipeline, full bore rupture, up to 11 m.

The flammable vapour cloud scenarios with moderate injury risk were not evaluated quantitatively because the likelihood of ignition and heat radiation generated are unknown for vapour clouds. However, the identified threat zones for these scenarios provide guidelines for separation distances from potential ignition sources.

There are no scenarios resulting from the toxic effects of methane or blast overpressure that result in moderate, major or critical consequences.

Table 3.17.42 Qualitative Descriptions of Consequences

Level	Descriptor	Example Detailed Description	Heat Radiation (kW/m^2)	Blast Overpressure (kPa)	Toxic Effects (ppm)	Potential flammability (ppm)
1	Negligible	Health – no medical treatment required	1.2	< 3.5	5,000	<4,400
2	Minor	Health – reversible disability requiring hospitalisation	4.7	3.5	25,000	4,400
3	Moderate	Health – moderate irreversible disability or impairment (<30%) to one or more persons	12.6	14	>25,000	26,400 (at > 50m)
4	Major	Health – single fatality and/or severe irreversible disability (>30%) to one or more persons	35	21, 35	na[1]	na[2]
5	Critical	Health – multiple fatalities or significant irreversible effects to >50 persons	>35	70	na[1]	na[2]

Note 1: No criteria available above TEEL-3 of 25,000 ppm.

Note 2: Consequence modelling indicates the threat zone from a possible ignition. No criteria above 60 per cent of lower flammability limit assessed.

Table 3.17.43 Consequences for Human Health

Scenario	Incident	Incident Outcome	Incident Outcome Case	Risk to Human Health	
				Fatality	Injury
Wellhead release	Full bore release – continuous supply	No ignition – not burning	Toxic effects	Negligible	Minor – for distances up to 94 m
			Flammable vapour cloud	Negligible	Minor – isolated pockets up to 109 m
			Explosion	Negligible	Minor – for distances up to 38 m
		Ignition – burning	Jet flame	Negligible	Minor – for distances up to 16 m
					Moderate – for distances up to 10 m
	10 mm flange or valve leak	No ignition – not burning	Toxic effects	Negligible	Minor – for distances up to 16 m
			Flammable vapour cloud	Negligible	Negligible – isolated pockets up to 19 m
			Explosion	Negligible	Negligible - blast force <3.5kPa
		Ignition – burning	Jet flame	Negligible	Negligible
Compressor release	25 mm fitting failure	No ignition – not burning	Toxic effects	Negligible	Minor – for distances up to 60m
			Flammable vapour cloud	Negligible	Minor – isolated pockets up to 70 m
			Explosion	Negligible	Minor – for distances up to 36 m
		Ignition – burning	Jet flame	Negligible	Negligible
HDPE gathering line release	Full bore release – isolated	No ignition – not burning	Toxic effects	Negligible	Minor – for distances up to 70 m
			Flammable vapour cloud	Negligible	Minor – isolated pockets up to 81 m
			Explosion	Negligible	Negligible – blast force <3.5 kPa
		Ignition – burning	Jet flame	Negligible	Moderate – for distances up to 11 m
					Minor – for distances up to 16 m
Trunklines	25 mm puncture hole	No ignition – not burning	Toxic effects	Negligible	Minor – for distances up to 105 m
			Flammable vapour cloud	Negligible	Moderate – for distances up to 50 m
					Minor – for distances up to 121 m
			Explosion	Negligible	Minor – for distances up to 3 m
		Ignition – burning	Jet flame	Negligible	Negligible

17.5.7 Individual Fatality Risks

All fatality risks from the above scenarios are considered negligible. No further modelling was performed.

17.5.8 Individual Injury Risks

17.5.8.1 HDPE Gathering Line – Full Bore Rupture

The consequence of full bore rupture of HDPE gathering line, with ignition, is moderate injury at distances less than 11 m. The likelihood of this event is described in *Table 3.17.32*. The most conservative estimate of the likelihood of fire is 17 x 10^{-6} p.a. assuming a consequence rating of 100 per cent, or one, for injury at less than 11 m, the injury risk is 17x10^{-6} p.a. (1 x 17x10^{-6} p.a.). This is within the range of injury risk criteria of 10 x 10^{-6} p.a. and 50 x 10^{-6} p.a. specified in the ToR.

At distances between 11 m and 16 m, the consequence of injury is minor, and the consequence rating for a chance of injury is between a value approaching zero and one. At a distance between 11 m and 16 m, the risk of injury is between values approaching zero (0 x 17x10^{-6} p.a.) and 17 x 10^{-6} p.a. (1 x 17 x 10^{-6} p.a.). This range includes the injury risk criterion of 10 x 10^{-6} p.a. Thus, at distances greater then 16 m, the most conservative injury risk criterion is not exceeded.

17.5.8.2 Wellhead – Full Bore Rupture

The consequence of full bore rupture of a wellhead, with ignition, is moderate injury at distances less than 10 m. The likelihood of this event is described in *Table 3.17.31*. The most conservative estimate of the likelihood of fire is 5 x 10^{-6} p.a. assuming a consequence rating of 100 per cent, or one, for injury at less than 10m, the injury risk is 5x10^{-6} p.a. (i.e. 1 x 5x10^{-6} p.a.). This is less than the injury risk criteria of 10 x 10^{-6} p.a. and 50 x 10^{-6} p.a. specified in the ToR. Thus, at distances greater than 10 m, the most conservative injury risk criterion is not exceeded.

17.5.9 Societal Risk Contours

Assessment of societal risks provides a mechanism whereby the number of people exposed can be taken into account as well as the magnitude of the individual risk to each of these people. This analysis requires population presence data. Due to the uncertainty of the exact location of Gas Field infrastructure, this was not available. The Gas Field infrastructure will be located in a predominantly rural area, thereby decreasing the fatality risk to society.

Review of the proposed Gas Field layout and surrounding residences indicates the societal risks are likely to be highest west and southwest of Chinchilla, southeast of Wandoan and around Condamine. These areas comprise land zoned as rural-residential and could contain higher population densities than elsewhere in the Gas Fields.

17.5.10 Cumulative Impacts

Cumulative impacts can occur due to onsite interactions between Project infrastructure or other industrial facilities and the Project infrastructure.

17.5.10.1 Onsite Cumulative Impacts

The possibility of onsite interactions will be reduced by infrastructure design, layout and separation distances. Layout and design will include reference to Australian Standards including:

- AS 1940. *The Storage and Handling of Flammable and Combustible Liquids*
- AS 2885.1. *Pipelines – Gas and Liquid Petroleum. Part 1: Design and Construction*
- AS 2430. *Classification of Hazardous Atmospheres.*

The siting of installations, such as compressor stations, must account for the potential of an accident at the compressor causing damage to buildings and propagating to a neighbouring operation, hence initiating further hazardous incidents.

17.5.10.2 Offsite Cumulative Impacts

The risk of offsite accident propagation is low because most of the surrounding land uses are rural. However, the location of other major infrastructure such as open-cut coal mines, power stations and storage facilities (e.g. anhydrous ammonia storage providing fertilizers) in the area will be considered when siting installations.

The bushfire risk around the infrastructure (wellheads, compressor stations and pipelines) is low-to-medium because the majority of the surrounding countryside has been cleared for pastures or cropping. Potential pasture and crop fires will be controlled by the local rural fire service.

17.6 MITIGATION MEASURES – GAS RELEASE

The greatest risk posed is moderate injury from thermal radiation from a full bore rupture of a wellhead or gathering line at distances of less than 11 m. These risks are manageable with conventional safety and mitigation measures for gas wells, compressor stations and pipelines.

The flammable vapour-cloud model results provide minimum separation distances between infrastructure and adjoining land uses where the presence or use of ignition sources is outside the control of the proposed development. The model results indicate separation distances for wellheads, compressors, HDPE flowlines and trunklines as listed below:

- CSG well – 109 m
- compressor – 70 m
- HDPE gathering line – 81 m
- trunkline – 121 m.

These separation distances are conservative because the risk of moderate injury from gas release, assuming an ignition source is present, is less than 11 m from the source of the gas release.

Council planning schemes recommend minimum separation distances to petroleum and gas pipelines of 200 m. The NSW DIPNR (2004) recommends separation distances between a CSG wellhead and residential and sensitive land-use areas of approximately 10 to 20m respectively.

Further mitigation measures for the unplanned release of gas are described in *Table 3.17.27*.

Emergency Management Plans are described in the section that follows.

17.7 EMERGENCY MANAGEMENT PLANS

The Emergency Management Plans for the Project fall within the structure of BG Group's existing Crisis Management Standard. The Standard establishes:

- emergency management teams
- systems and procedures at the BG Group coordinating asset (i.e. the QCLNG Project) and specific-site levels
- links between these levels.

An incident and emergency response hierarchy will be used on the Project to link the management of incidents for the Project with overall BG Group incident management plans.

BG Group's Standard for Crisis Management requires that a Local Incident Management Plan (LIMP) be prepared for each asset. Such plans will be prepared for each asset component of the Project. The plan includes information on:

- the organisation for incident management of the asset
- the process for identifying incidents
- the procedure for notifying incidents

- the procedure for escalation, if necessary
- the procedure for activation of the incident management organisation
- tools for the management of an incident
- roles and responsibilities of incident management teams.

17.7.1 Emergency Response Plans

In the event of an incident, the primary response will usually occur at site level. In many instances the incident will be adequately addressed at this level by prevailing Emergency Response Plans (ERPs) that will be prepared in advance of construction, commissioning and operational phases over the life of the Project. However, to prevent an incident from escalating, a Local Incident Management Team (LIMT) may be activated to bring greater resources to bear. This may be in terms of command and control and/or support with resources, expertise or logistics. In major incidents, further escalation to a Group-level Crisis Management Team can occur.

ERPs are prepared at the site level and include descriptions of:

- expectations of individuals at the site responding to an emergency
- roles and responsibilities for emergency response leaders
- resources available (human and material) for response to an emergency
- the process for identification, notification and escalation of incidents
- the linkages to the higher asset and group-level incident management systems.

In accordance with the BG Group Standard, the Crisis Management Team/LIMT arrangement will be tested at least annually to determine the effectiveness of the links between the BG Group and the Project.

Reviews of Incident and Emergency Management procedures will be conducted after desktop exercises, simulated incidents and actual incidents, to determine:

- the effectiveness and appropriateness of plans
- the extent to which personnel are capable of implementing plans
- any gaps in planning and implementation and any proposed steps for improvement.

17.7.2 Emergency Management Procedures

While it is not possible to foresee all contingencies, it is necessary to have an ERP at all sites where risk exists. These ERPs include:

- building evacuation
- infrastructure shutdown
- oil spill

- fire.

17.7.2.1 *Consultation in Development of ERPs*

ERPs will be developed in consultation with regional emergency service providers including:

- Queensland Police
- Department of Community Safety (formerly the Department of Emergency Services) and Queensland Fire and Rescue Service.

17.7.2.2 *ERP Contents*

Emergency response plans will include information on:

- organisation and responsibilities
- site evacuation procedures
- notification and communications
- mobilisation and response
- training
- facilities and equipment
- layout plans and evacuation plans
- release management
- public affairs and media
- investigation and follow-up.

Emergency response capabilities will be developed based on detailed risk assessment outcomes and will include the following scenarios:

- traffic accidents
- facility/infrastructure failures and fires
- high energy sources
- unplanned Associated Water release
- security breaches and terrorism
- site evacuation
- hydrocarbon, chemical and other contaminant release
- gas/vapour leaks and potential ignition
- natural disasters (bushfires, storms, floods, earthquakes).

17.7.2.3 *Site Security and Access*

Strategies for site security and access for the construction and operational phases of the Project will be developed during the detailed design phase. For the construction phase, contractors will be required to establish security and access procedures and policies that will apply to all personnel visiting the site. A number of policies will be communicated to the contractors including:

- behaviour-code criteria on site and in construction camps
- no smoking within completed buildings, well construction areas, enclosed spaces, or enclosed areas including vehicles
- exposure to UV light
- dress code
- no domestic animals on site
- no alcohol or drugs
- the right of the contractors to exclude any person from any organisation found to be in breach of procedures or policies.

Following practical completion of the Gas Field facilities, the security and access procedure will be under the control of the operations division and its designated contractors. Each active construction site may have security fencing installed to restrict access to unauthorised personnel. Landholders will be consulted about additional security arrangements that may be required.

Where appropriate, the construction site will be isolated by fencing to prevent inadvertent public access.

Appropriate signs and warnings will be posted to notify the public of the construction site, typically with a contact name and phone number to call for more information.

Public safety officers, police or other law enforcement organisations provide security/public safety functions on public property, roads or other public jurisdictions.

Appropriate security risk assessments and mitigation plans, including for third-party sabotage or terrorism, will be developed to address security risks as they are identified in risk studies. Security plans will be aligned with emergency response and evacuation planning, law enforcement agencies and prevailing Queensland laws and regulations.

17.7.2.4 Dangerous Goods Storage

Neither TEG nor diesel are classified as dangerous goods as they have a flashpoint greater than 60.5^{o}C.

Water treatment chemicals will be required should the preferred option for water management be desalination using reverse osmosis with pre-treatment of Associated Water.

The proposed water treatment chemicals have been identified as dangerous goods under *Dangerous Goods Safety Management Regulation* (DGSMR) 2001. All water treatment chemicals have been identified as Class 8 (corrosive) dangerous goods. The degree of risk a dangerous good presents is represented by the Packing Group (PG). PG I is high risk, PG II is moderate risk and PG III is low risk. Water treatment chemicals are either PG II or PG III.

The classification of a dangerous goods location depends on the volume of dangerous goods stored at the location. The aggregate quantity of each PG for Class 8 corrosives was compared to the prescribed quantities for Dangerous Goods Location (DGL) and Large Dangerous Goods Location (LDGL) specified in the DGSMR.

A location is defined as a Major Hazard Facility (MHF) if it holds certain dangerous goods as defined in the DGSMR. The proposed water treatment chemicals are not included in the DGSMR schedules for a MHF. Water treatment locations are therefore not classified as MHFs.

To calculate the aggregate quantity of water treatment chemicals on hand, it has been assumed that the following volumes of water will be treated at each location:

- 20 ML/day in the NWDA
- 30 ML/day in the CDA
- 55 ML/day in the SEDA.

Table 3.17.44 shows, for each location, the dangerous goods class, PG and volume of water treatment chemicals for each location. This aggregate volume for each class and PG has been compared to the prescribed maximum quantity for ranking the location as either a DGL or LDGL.

Table 3.17.44 Classification and Approximate Volumes of Water Treatment Chemicals

Water Treatment Chemical	Dangerous Goods Class	Packing Group	NWDA	CDA	SEDA
			Volume (L)		
Ferric chloride	8	III	3,227	4,841	8,876
Sodium hypochlorite	8	III	4,076	6,114	11,208
Aqueous ammonia	8	III	607	910	1,668
Total			**7,910**	**11,865**	**21,752**
Prescribed quantity for DGL			1,000	1,000	1,000
Prescribed quantity for LDGL			10,000	10,000	10,000
Classification			**DGL**	**LDGL**	**LDGL**
Sulfuric Acid	8	III	37,714	56,571	103,714
Scale Inhibitor	8	III	772	1,158	2,124
Sodium Hydroxide	8	III	369	553	1,014
Total			**38,855**	**58,282**	**106,852**
Prescribed quantity for DGL			250	250	250
Prescribed quantity for LDGL			2,500	2,500	2,500
Classification			**LDGL**	**LDGL**	**LDGL**

All locations will be classified as LDGLs. Further information on dangerous goods classification is shown in *Appendix 3.10*.

Most water treatment chemicals will cause health effects following inhalation, skin contact or eye exposure. The toxicities of the water treatment chemicals vary, but most MSDS identify the products as harmful to aquatic organisms, with the potential to cause long-term effects. The potential for water, soil and groundwater contamination primarily depends on the water solubility, mobility in soil and biodegradation rates of individual compounds.

The primary hazards associated with water treatment chemicals are unloading, storage and handling of chemicals.

A residual risk analysis (risk following mitigation measures) has been conducted for water treatment chemicals. The results are shown in *Table 3.17.45.*

Table 3.17.45 Water Treatment Chemicals Risk Analysis

Hazardous Event	Consequence	Likelihood	Residual Risk
Loss of material during transfer – inhalation, dermal and eyes	Minor	Possible	Low
Loss of material during transfer – environmental effects	Moderate	Possible	Medium
Overfilling of tank – human health effects	Minor	Possible	Low
Overfilling of tank - environmental effects	Moderate	Possible	Medium
Filling incorrect tank and/or mixing of incompatible substances – human health	Moderate	Possible	Medium
Tank rupture or failure – human health effects	Moderate	Possible	Medium
Tank rupture or failure – environmental effects	Moderate	Possible	Medium
Process failure (equipment malfunction) – environmental effects	Moderate	Possible	Medium

The following mitigation measures are proposed:

- training of personnel in accordance with AS 3780 – *The Storage and Handling of Corrosive Substances*
- transfer of liquids in accordance with AS 3780 and the Australian Dangerous Goods (ADG) Code
- Hazardous chemical signage in accordance with the ADG Code
- segregation of bulk corrosive substances from incompatible goods and goods with which they may react dangerously, in accordance with AS 3780
- preparation of individual MSDSs
- implementation of clean-up procedures for spills
- suitable compound drainage in accordance with AS 3780

- prevention of spilled chemicals from entering the stormwater system
- spills contained within bunds
- bulk container filling in accordance with AS 3780
- design of bulk containers to resist to all likely sources of corrosion (particularly any product spills)
- provision of compounds (bunded areas) for all above-ground bulk containers of corrosive substances in accordance with AS 3780
- storage in bunded areas designed and constructed so it is safe and suitable for conditions of use in accordance with AS 1940
- identification of the location as a Hazardous Area
- ensuring there are no ignition sources in the vicinity of the bunded area
- maintenance of spill kits including pumps and hoses for transferring spilt liquids
- preparation of an emergency plan.

17.7.2.5 Fire Prevention and Detection

Facility/Infrastructure Fires

The management of fire risks will include collaboration with local fire authorities in reducing the fire hazard risk in areas adjacent to static sites and in areas along the gathering line routes which may pose a significant fire risk. The maintenance of fuel-reduced zones around the sites will be a key aspect in reducing the impact of bush and grass fires. Such zones will also provide access points for firefighting equipment should a fire occur.

Fire Management Systems

The fire protection system for the Project will include the installation of fire hydrants and portable extinguishers in the temporary construction camps. Permanent buildings will be equipped with firefighting equipment as specified in the *Building Fire Safety Regulations* 1991 and will be maintained as per AS 1851-2005, *Maintenance of Fire Protection Systems and Equipment*. A detailed risk assessment will be undertaken during the detailed design phase and will identify the needs for fire preventative measures. The design of the Gas Field infrastructure will incorporate fire mitigation measures identified in the risk assessment process.

Typical fire management systems on a construction site include the following:

- training and education of workforce regarding specific fire hazards and risks, drills and practice
- supply and use of fire extinguishers:
    - hand-held for general use
    - trolley-mounted for larger fire risk areas and fuel storage
- water truck with pump to meet limited fire-fighting needs

- no smoking policy
- hot-work permit policy
- temporary building specification, materials and spacing which meets Queensland Fire Code/Building Code requirements for temporary structures
- flammable materials storage and use
- volunteer fire response team:
  - training of the response team
  - drill and practice for first responders
- coordination with local fire service with jurisdiction

Accommodation Fire Safety Measures

Typical fire management systems for temporary camp accommodations include:

- no smoking and cooking permitted in accommodation units
- building specification, materials and spacing meet Queensland Fire Code/Building Code requirements for temporary living accommodation
- installation and maintenance of a smoke detection and fire alarm system for living quarters, commons areas and cafeteria/mess assembly areas
- 24-hour security/front-desk attendance for emergency dispatch
- supply and use of fire extinguishers:
  - hand-held for general use
  - trolley-mounted for larger fire risk areas and fuel storage
  - carbon dioxide systems for cooking areas of kitchen
- water truck with pump to meet limited fire-fighting needs
- training and education of workforce regarding specific fire hazards and risks, drills and practice
- volunteer fire response team:
  - training of the response team
  - drill and practice for first responders
- coordination with local fire service with jurisdiction.

Bushfire Mitigation

The overall risk of starting a bushfire is low, especially once the site is cleared of timber and vegetation. The larger impact would be of an external bushfire impinging on the construction and camp site.

Construction sites typically have strict policies to prevent open burning. Cleared vegetation will be mulched or spread over lease areas rather than burned. Education campaigns regarding prevention of bushfires are added to the employee orientation program and to toolbox talks during high fire-risk seasons.

Construction personnel are typically not trained to respond to bushfires, forest fires or wildfires. The overall strategy will be to minimise impact or risk to personnel by either sheltering in place or evacuation, and minimise impact to physical or mechanical equipment or structures, and to cooperate with civil authorities managing the fire fight.

The highest risk of starting a bushfire would be during clearing activities. Chainsaws can be equipped with spark arrestors to help prevent ignition. Vehicles will only be used off road or off right of way where necessary.

Once the site is cleared, the area will be maintained clear of bush. Bushfire will be included in the overall site risk evaluation and emergency response planning.

17.7.3 Emergency Planning and Response Procedures

A risk assessment will be conducted to identify the highest risks posed to workers and the public during construction.

Emergency response plans will be developed to address:

- medical emergency response (heart-attack, stroke or similar)
- major accident (construction related) with injury response
- confined space rescue
- high-angle rescue
- excavation rescue
- structural rescue
- medical treatment and response as result of major accident
- fire
- environmental response to major spill or chemical release
- weather or seismic event
- tropical cyclone
- transient thunderstorm/lightning
- earthquake
- flooding
- civil disobedience
- labour strike
- external protests

A typical Emergency Response Plan contains information relating to:

- ownership
- scope and extent
- facility/infrastructure description overview
- incident management team
- organisation
- roles and responsibilities
- incident command
- logistics coordination
- specialised teams

17.8 CONCLUSION

A quantitative risk assessment was undertaken for the unplanned release of gas from Queensland Curtis LNG (QCLNG) Project Gas Field Component infrastructure. All other hazards were identified and assessed using a qualitative risk assessment process.

For each hazard assessed qualitatively, controls have been proposed to minimise the likelihood and consequence of the hazard. Hazards with the greatest residual risk were related to transport incidents. Further control measures were proposed to minimise these risks.

A number of scenarios were considered for the unplanned release of gas, relating to the type of equipment and the size of the hole from which gas is released. For each scenario there are potentially five consequences: toxic effects, vapour-cloud flash fire, blast overpressure, thermal radiation from gas ignition, and downwind toxic effects of a fire.

All fatality risks from the above scenarios are considered negligible. Moderate injury risk criteria are highly unlikely to be exceeded at distances greater than 16 m.

Establishment and maintenance of adequate safety zones for each infrastructure type will ensure that the risk to human health is as low as reasonably practical.

It is probable that both fatality and injury risk will be less than the model predicts. Infrastructure will be constructed to Australian Standards, which data shows results in a lower likelihood of gas release than the likelihood used in the model.

Comprehensive Emergency Management Plans will be developed to further mitigate potential hazards and manage any hazards, should they occur.

The overall QCLNG Project risk in relation to the environment is minor to negligible due to the mitigation strategies and the hazard and risk identification program to be implemented throughout the Project's life. A summary of the impacts outlined in this chapter is provided in *Table 3.17.46*.

Table 3.17.46 Summary of Impacts for Hazards and Risks

Impact assessment criteria	**Assessment outcome**
Impact assessment	Negative
Impact type	Direct
Impact duration	Short term
Impact extent	Local
Impact likelihood	Likely

Overall assessment of impact significance: negligible.