Preliminary hazard and risk 24

Enter ▶ Go back to contents ▶

Contents

Tables

Figures

24 Preliminary hazard and risk

24.1 Introduction

This section describes the potential hazards and risks that may be associated with the GFD Project.

Land use surrounding the GFD Project area is predominantly agricultural but also includes mine sites, various reserves, parks and state forests, as well as some towns (including Roma, Surat, Wallumbilla, Miles, Taroom, Wandoan, Injune and Rolleston). The surrounding land uses have been taken into consideration in the hazard and risk assessment.

Full details of the hazard and risk assessment are provided in Appendix X: Hazard and risk.

This section has been prepared in accordance with section 7.1 of the *Terms of reference for an environmental impact statement*, dated March 2013. The index to locate where each ToR requirement is met within the EIS is included in Appendix B: Terms of reference cross-reference.

24.2 Regulatory context

This EIS has been prepared in accordance with the State and Commonwealth regulatory context as provided in Appendix C: Regulatory framework. The legislation, policies and guidelines that apply specifically to hazard and risk are outlined within Table 24-1.

Table 24-1 Regulatory context – hazard and risk

Legislation, policy or guideline	Relevance to the GFD Project
Environmental Protection Act 1994 (Qld) (EP Act) The EP Act is the principal legislation for the protection and management of environmental values within Queensland. The Act aims to protect the natural environment and associated ecological systems and processes, while allowing for sustainable development.	The EP Act defines the environment to include people and is therefore relevant to hazard and risk. The EP Act considers the storage and handling of dangerous chemicals and the potential risks to human health and the environment.
Petroleum and Gas (Production and Safety) Act 2004 (Qld) (P&G Act) and *Petroleum and Gas (Production and Safety) Regulation 2004* (Qld) (P&G Regulation) The P&G Act regulates petroleum activities with the aim of developing a safe, efficient and viable petroleum and fuel gas industry in Queensland. Petroleum tenure is granted under the Act. The regulation provides safety requirements associated with the production, transportation and use of petroleum and fuel gas.	The P&G Regulation, which is an instrument of the P&G Act, sets the requirements for safe operations of petroleum installations. Under the P&G Regulation, operators of a petroleum facility are obligated to prepare and submit a suitable safety management plan that is appropriate to the level of risk at that facility.
Work Health and Safety Act 2011(Qld) (WHS Act) The Act prescribes the health and safety requirements affecting most workplaces, work activities and the use of plant and substances in Queensland.	The WHS Act aims to provide a balanced framework to secure the health and safety of workers and workplaces and protect persons from harm to the highest level that is reasonably practicable. The WHS Act applies to most construction activities and establishes a framework for preventing or minimising workers' exposure to risks. This is done by imposing safety obligations on certain persons and establishing benchmarks for industry.
Electrical Safety Act 2002 (Qld) This Act is directed at eliminating the human cost to individuals, families and the community of death, injury and destruction that can be caused by electricity.	The Act may be relevant to the GFD Project where electrical work is performed, except for excluded provisions, such as petroleum plants operated under the P&G Act.

Legislation, policy or guideline	Relevance to the GFD Project
Multi-level Risk Assessment Guideline (New South Wales Department of Planning, 2011a) and *Hazardous Industry Planning Advisory Papers No. 6 Hazard Analysis* (HIPAP No.6) (New South Wales Department of Planning, 2011b). These are the most commonly applied guidelines for land use safety planning in Queensland in the absence of State-specific guidelines.	The risk assessment methodology for the preliminary hazard analysis (PHA) was based on these guidelines. A PHA is usually required for an EIS for a potentially hazardous industrial development.
Australian/New Zealand Standards (AS/NZS).	*AS/NZS ISO 31000:2009 Risk Management* *Managing Environment-related risk (HB203:2012).*
National Fire Protection Association (NFPA) standards and reference documents.	NFPA 30: Flammable and Combustible Liquids Code NFPA 58: Storage and Handling of Liquefied Petroleum Gases NFPA 59: Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants NFPA 70: National Electrical Code NFPA 77: Static Electricity NFPA780: Lightning Protection Code NFPA 307: Construction and Fire Protection at Marine Terminals, Piers and Wharves NFPA 497A: Classification of Class I Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas NFPA 497B: Classification of Class II Hazardous (Classified) Locations for Electrical *Installations in Chemical Process Areas.*
American Petroleum Institute (API) standards and reference documents.	API RP 620: Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks API RP 2003: Protection Against Ignitions Arising Out of Static, Lightning and Stray currents API Std.2510: Design and Construction of Liquefied Petroleum Gas (LPG) Installations. API RP 500: Classification of Locations for Electrical Installations at Petroleum Facilities API RP 520: Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries API RP 521: Guide for Pressure- Relieving and Depressurising Systems API Pub. 2510A: Fire Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities.

This EIS seeks to obtain primary approvals for the project including the Queensland Government Coordinator-Generals Report and Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* (Cth) approval.

Application for or amendments to existing environmental authorities will occur subsequent to this EIS process. Other subsequent approvals required after the EIS process has been completed, corresponding triggers and legislative frameworks applicable to the GFD Project are identified in Section 2: Project approvals.

Approval of this EIS will trigger a number of subsequent approvals required for the GFD Project to proceed. Approvals will be required on tenure and off-tenure. Section 2: Project approvals summarises the key approvals necessary for the planning, construction, operations and decommissioning of the GFD Project. The triggers for each approval, the relevant administering authority and application details are provided. Consultation on the subsequent approvals will be ongoing with the administering authorities.

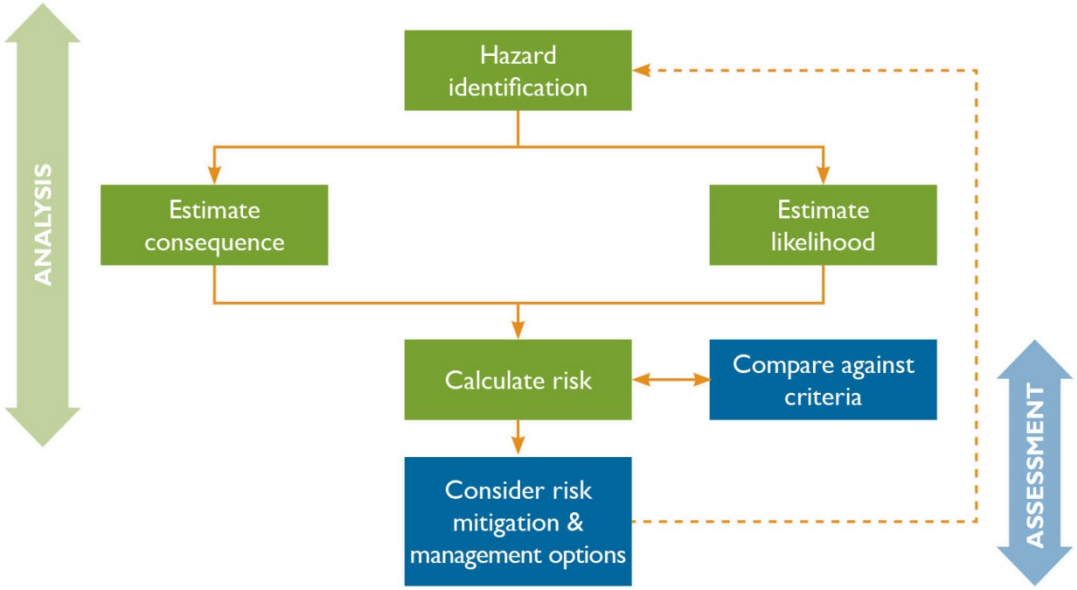
24.3 Assessment methodology

This assessment describes the potential hazards and risks associated with the GFD Project. The potential hazards and risk were assessed using the risk assessment methodology, which considers the likelihood and consequence of a potential impact to assess its level of risk. The full description of the risk assessment methodology is described in section 5.6.3 of Section 5: Assessment framework and in Appendix X: Hazard and risk.

In addition, the consequence criteria has been expanded to consider the hazardous impacts to people, based on the NSW Department of Planning guidelines, *Multi-level Risk Assessment Guideline* (2011a) and *HIPAP No. 6 Hazard Analysis* (2011b).

A semi-quantitative assessment was used for the PHA undertaken for this EIS, consistent with a level 2 risk assessment as described in the *Multi-level Risk Assessment Guideline*. The basic methodology for PHA is shown in Figure 24-1 (reproduced from HIPAP No. 6). Further details of the PHA methodology are also given in section 5 of Appendix X: Hazard and risk.

Figure 24-1 Preliminary hazard assessment methodology



Source: modified after NSW Department of Planning, 2011b

24.3.1 Hazard identification

As the first stage in the assessment, a hazard identification task was undertaken for the GFD Project. The hazard identification aimed to identify potential hazards generated by the GFD Project and external natural hazards with the potential to impact the GFD Project infrastructure, which is described in full in section 3.4 of Appendix X: Hazard and risk. Identified potential hazards are further discussed in section 24.5.

24.3.2 Consequence analysis

Consequence analysis was undertaken for hazardous events identified in the hazard identification task. The consequences of the identified hazardous events are further described in section 24.5.

24.3.3 Likelihood estimation

The likelihood of an event is estimated based on the number of occurrences of that event over a specified time period, generally taken as one year. The likelihood of the hazardous scenarios with offsite impact occurring was estimated using event tree analysis, taking into account the following:

- Leak frequencies from equipment and pipelines
- Ignition probability
- Release orientation.

24.3.4 Risk assessment

Risk assessment involves combining the offsite scenario consequences and their associated likelihoods and comparing them against agreed criteria. The risks of the hazardous events considered in this study were assessed as follows:

- Risks associated with wells, gas compression facilities and gas gathering and gas transmission pipelines were assessed on a qualitative basis.
- Risks associated with the gas gathering and gas transmission pipelines were further assessed on a quantitative basis and are presented as risk transects, which show the risk as a function of distance from the gas gathering or gas transmission pipelines.

Risks are presented as residual risk based on the adoption of existing processes and controls in the approved management and regulatory framework for the GLNG Project. This recognises that this assessment will be supplemented in the future by further planning, risk assessment, engineering design and risk mitigation controls and measures to ensure that risks from the GFD Project are reduced to levels that are as low as reasonably practicable (ALARP).

24.3.4.1 Qualitative risk categories

As described above, the qualitative assessment of risk is conducted based on an assessment of the likelihood and consequences of an event. The likelihood and consequence categories used are shown in Table 24-2 and Table 24-3 respectively.

Table 24-2 Likelihood categories

Likelihood category	Description
Almost certain Common	The event will occur, or is of a continuous nature, or the likelihood is unknown. There is likely to be an event at least once a year. It often occurs in similar environments. The event is expected to occur in most circumstances.
Likely Has occurred in recent history	There is likely to be an event on average every one to five years. Likely to have been a similar incident occurring in similar environments. The event will probably occur in most circumstances.
Possible Could happen, has occurred in the past, but not common	The event could occur. There is likely to be an event on average every 5 to 20 years.
Unlikely Not likely or uncommon	The event could occur but is not expected. A rare occurrence (once per 100 years).
Remote Rare or practically impossible	The event may occur only in exceptional circumstances. Very rare occurrence (once per 1,000 years). It is unlikely that it has occurred elsewhere; and, if it has occurred, it is regarded as extremely unique.

Table 24-3 Consequence categories

Consequence category	Description	Impacts to people
Critical Severe, widespread long-term effect	Destruction of sensitive environmental features. Severe impact on ecosystem. Impacts are irreversible and/or widespread. Regulatory and high level government intervention/action. Community outrage expected. Prosecution likely. Financial loss in excess of $100 million.	Multiple fatalities.
Major Wider spread, moderate to long-term effect	Long-term impact of regional significance on sensitive environmental features (e.g. wetlands). Likely to result in regulatory intervention/action. Environmental harm either temporary or permanent, requiring immediate attention. Community outrage possible. Prosecution possible. Financial loss from $50 million to $100 million.	Single fatality.
Moderate Localised, short-term to moderate effect	Short-term impact on sensitive environmental features. Triggers regulatory investigation. Significant changes that may be rehabilitated with difficulty. Repeated public concern. Financial loss from $5 million to $50 million.	Permanent disabling injury/injuries.
Minor Localised short-term effect	Impact on fauna, flora and/or habitat but no negative effects on ecosystem. Easily rehabilitated. Requires immediate regulator notification. Financial loss from $500,000 to $5 million.	Injury/injuries requiring medical treatment (lost time injury/injuries).
Negligible Minimal impact or no lasting effect	Negligible impact on fauna/flora, habitat, aquatic ecosystem or water resources. Impacts are local, temporary and reversible. Incident reporting according to routine protocols. Financial losses up to $500,000.	First aid treatment, or illness/injury not requirement treatment (no lost time injuries).

Consistent with the Santos GLNG Environment, Health and Safety Management Standard (EHSMS)09: *Managing Environment, Health and Safety Risks*, the resulting risk levels (Table 24-4) can be categorised as follows:

- A very low or low risk level is considered to be 'tolerable' and existing controls will be maintained. This does not prevent additional controls being applied to further reduce the risk.
- A medium risk level 'may be tolerable subject to ALARP' i.e. the risk may be accepted as tolerable if it can be shown that adopting further risk control measures will incur costs that are grossly disproportionate to the benefits gained or that the only risk control measures available are impractical, i.e. the risk is ALARP.
- A high or very high risk level is 'intolerable' and associated activity/operation/plant will not commence or, if activity/operation/plant has commenced, will be immediately stopped, provided that this can be done without creating a greater risk, and shall not recommence until the risk level has been reduced to a tolerable level.

Table 24-4 Resulting risk levels

Consequence	Likelihood				
	Almost certain	Likely	Possible	Unlikely	Remote
Critical	Very high	Very high	High	High	Medium
Major	Very high	High	High	Medium	Medium
Moderate	High	Medium	Medium	Medium	Low
Minor	Medium	Medium	Low	Low	Very low
Negligible	Medium	Low	Low	Very low	Very low

24.3.4.2 Quantitative risk criteria

The likelihood and consequence of gas pipeline releases were assessed and quantitative estimates of risk were developed for a range of categories, based on the models described in section 5 of Appendix X: Hazard and risk. The risks associated with the gas gathering and transmissions lines were assessed based on the quantitative risk criteria provided in *Risk Criteria for Land Use Safety Planning* (NSW Department of Planning, 2011c), as shown in Table 24-5.

Table 24-5 Risk criteria for land use planning

Safety risk	Land use	Criteria (per year)
Individual fatality risk	Hospitals, child-care facilities and old age housing (sensitive land uses)	5×10^{-7}
	Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use)	1×10^{-6}
	Commercial developments, including offices, retail centres and entertainment centres (commercial land use)	5×10^{-6}
	Sporting complexes and active open space areas	1×10^{-5}
	Target for site boundary	5×10^{-5}
Injury risk – heat radiation not exceeding 4.7 kilowatts per square metre (kW/m^2)	Residential and sensitive use	5×10^{-5}
Injury risk – explosion overpressure not exceeding	Residential and sensitive use	5×10^{-5}
	Injury risk – toxic exposure	

Safety risk	Land use	Criteria (per year)
7 kilopascals (kPa)	Residential and sensitive use areas. Seriously injurious to sensitive members of the community following a relatively short period of exposure	1×10^{-5}
	Residential and sensitive use areas. Irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community	5×10^{-5}
Risk of property damage and accident propagation – 23 kW/m^2 heat flux	Neighbouring potentially hazardous installations or at land zoned to accommodate such installations	5×10^{-5}
Risk of property damage and accident propagation – 14 kPa explosion overpressure	Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings	5×10^{-5}

Source: NSW Department of Planning, 2011c

24.4 Environmental values

Land use surrounding the GFD Project area is predominantly agricultural but also includes mines, various reserves, parks and State forests. In addition, there are a number of towns (Injune, Roma, Wallumbilla, Yuleba, Taroom and Wandoan) that contain a mixture of residential, commercial, health and educational uses.

This assessment is concerned with maintaining and protecting the health, safety and wellbeing of people, property and the wider environment in and surrounding the GFD Project area.

24.5 Potential hazards

A number of potential hazards both external natural and project related exist within the project areas. These are discussed in the sections below.

24.5.1 External natural hazards

As part of the hazard identification, the potential for external natural hazards to affect the GFD Project facilities was reviewed and is summarised in Table 24-6.

Table 24-6 External natural hazards

Natural hazard	Assessment
Earthquake	According to the Global Seismic Hazard Assessment Program (GSHAP), the GFD Project area is classified as a low to moderate earthquake hazard. In the event of an earthquake, the worst case scenario is considered to be a release of natural gas from the affected GFD Project facilities. Additionally, emergency response by local authorities may be limited given the likely widespread effects of an earthquake.
Landslide/ subsidence	Landslide or subsidence may result in structural failure of GFD Project facilities. In the event of a landslide/subsidence, the worst case scenario is considered to be a release of natural gas from the affected GFD Project facilities.
Bushfire	The GFD Project area is surrounded by predominantly agricultural land, as well as various reserves, parks and State forests. Bushfires are therefore considered a credible threat to the GFD Project facilities. In the event of a bushfire, the worst case scenario is considered to be a release of natural gas from the affected GFD Project facilities. Additionally, emergency response by local authorities may be limited given the potentially widespread effects of a bushfire. The risk associated with bushfires to the GFD Project is detailed in section 7.4.3.3 and section 7.5 of Section 7: Climate.

Flooding	Several rivers run through or in the vicinity of the GFD Project area. Flooding of the GFD Project facilities may occur in the event of a rise in the water level of these rivers. In the event of flooding, the worst case scenario is considered to be a release of natural gas from the affected GFD Project facilities. Additionally, emergency response by local authorities may be limited given the potentially widespread effects of a significant flood event.
Cyclone	The majority of cyclones are limited to coastal areas though some have affected areas further inland. High winds associated with cyclones may result in structural failure of GFD Project facilities. In the event of a cyclone, the worst case scenario is considered to be a release of natural gas from the affected GFD Project. Additionally, emergency response by local authorities may be limited given the potentially widespread effects of a cyclone.
Storm surge	Storm surges accompany a tropical cyclone as it comes ashore. According to the Bureau of Meteorology, the area of seawater flooding associated with storm surges 'may extend along the coast for over 100 kilometres (km), with water pushing several kilometres inland if the land is low lying'. Given that the GFD Project area is located approximately 300 km from the coast, storm surge is not considered a credible threat to the GFD Project facilities.
Lightning	Equipment complying with relevant Australian Standards will be installed to manage the risks associated with lightning.
Extreme temperatures	Equipment will be designed to manage the risks associated with extreme temperatures.
Climate change	Climate change is likely to result in more extreme impacts of the natural hazards considered above, e.g. larger and/or more frequent flood events, bushfires, etc.
Wildlife	Personnel contact with dangerous animals (e.g. snakes, dingos and kangaroos) or disease vectors (e.g. mosquitoes and midges) may result in injury.

24.5.2 GFD Project hazards

The hazard identification identified a number of hazardous scenarios where there may be potential for offsite impacts. These hazardous scenarios are listed according to their presence across the life of the GFD Project in Table 24-7.

Table 24-7 Summary of hazard scenarios with potential offsite impacts

GFD Project component	Hazardous scenario	Phase[1]		
		C	O	D
Well	Release of natural gas from well head or equipment/piping at well lease	✓	✓	✓
Gas gathering line	Release of natural gas from gas gathering line (aboveground high density polyethylene (HDPE))	✓	✓	✓
	Release of natural gas from gas gathering line (underground HDPE)	✓	✓	✓
	Damage to adjacent gas pipeline during construction of gathering line	✓	×	×
Nodal gas compression facility	Release of natural gas from well head or equipment/piping at nodal gas compression facility	✓	✓	✓
	Escalation of fire to diesel storage	✓	✓	✓
Gas transmission pipeline	Release of natural gas from medium pressure transmission line (underground steel)	✓	✓	✓
	Release of natural gas from high pressure transmission line (underground steel)	✓	✓	✓
	Damage to adjacent gas transmission pipeline during construction of transmission pipeline	✓	×	×
Hub gas compression facility	Release of natural gas from equipment/piping at hub gas compression facility	✓	✓	✓
	Escalation of fire to diesel storage	✓	✓	✓

GFD Project component	Hazardous scenario	Phase[1]		
		C	O	D
Water management facilities	Catastrophic failure of water storage	✓	✓	✓

[1]C: Construction and commissioning; O: Operations; D: Decommissioning and rehabilitation.

The potential consequences of the hazardous scenarios listed in Table 24-7 are:

- Jet fire — occurs if a natural gas leak from a pressurised inventory is ignited immediately. Fatalities are assumed to occur within the dimension of the jet fire, reducing with decreasing heat radiation levels away from the flame.
- Fireball — occurs in the event of immediate ignition following a pipeline rupture
- Flash fire — in the event that the natural gas release is not ignited immediately, a vapour cloud will form. If ignition occurs, the vapour cloud burns rapidly without a blast wave and will flash back to burn as a jet fire from the release point. With a flash fire, there is a high chance of fatality to anyone within the ignited vapour cloud (assumed 100% for the analysis), but there is a low chance of significant impact outside the vapour cloud radius
- Vapour cloud explosion — occurs if ignition of the vapour cloud is within a congested or confined plant area. The wells do not have significant congestion and most equipment at compression facilities will be at grade and well-spaced, i.e. there will be no large areas of congestion or confinement. A vapour cloud explosion is therefore not considered further in this EIS
- Bund fire — occurs in the event of escalation of a fire to diesel stored at the compression facilities or associated facilities (e.g. accommodation facilities)
- Catastrophic flooding — occurs in the event of catastrophic failure of a water storage structure.

GFD Project activities will also involve use of materials, detailed in Appendix A of Appendix X: Hazard and risk, which can pose a series of additional hazards associated with releases to the environment. These materials include:

- Natural gas extracted for market and used for power generation
- Triethylene glycol (TEG) used in dehydrator packages at gas compression facilities
- Diesel used for vehicles and power generation
- Chemicals used for treatment of coal seam water (e.g. acids, alkalis, hypochlorite, biocides, salts)
- Chemicals used for drilling and well stimulation (e.g. common acids and alkalis, sands/proppants).

24.5.3 Risks to people

24.5.3.1 Construction and commissioning

Construction and commissioning activities are unlikely to result in significant offsite impacts to people from the GFD Project hazards identified in Table 24-7 and will be adequately controlled by implementation of the Santos GLNG Environment, Health and Safety Management System, as well as construction management plans and procedures.

Hazardous scenarios identified for the construction and commissioning phase involve damage to an adjacent gas pipeline during construction of the gas gathering or transmission pipelines. The risks to people from these scenarios were assessed by qualitative risk assessment as medium (Appendix X: Hazard and risk) i.e. the risks may be accepted as tolerable if they can be shown to be reduced to ALARP.

Other scenarios during the construction and commissioning phase are considered to be similar to those for the operations phase, which are described in the section below.

24.5.3.2 Operations

Wells and gas compression facilities

The primary risks to people from wells and gas compression facilities are associated with the potential for fires resulting from the release of gas from a well head or equipment/piping at a well lease or a gas compression facility.

The risks of the identified hazardous scenarios were assessed by the qualitative risk assessment (Appendix X: Hazard and risk) as medium, i.e. the risks may be accepted as tolerable if they can be shown to be ALARP.

Water management facilities

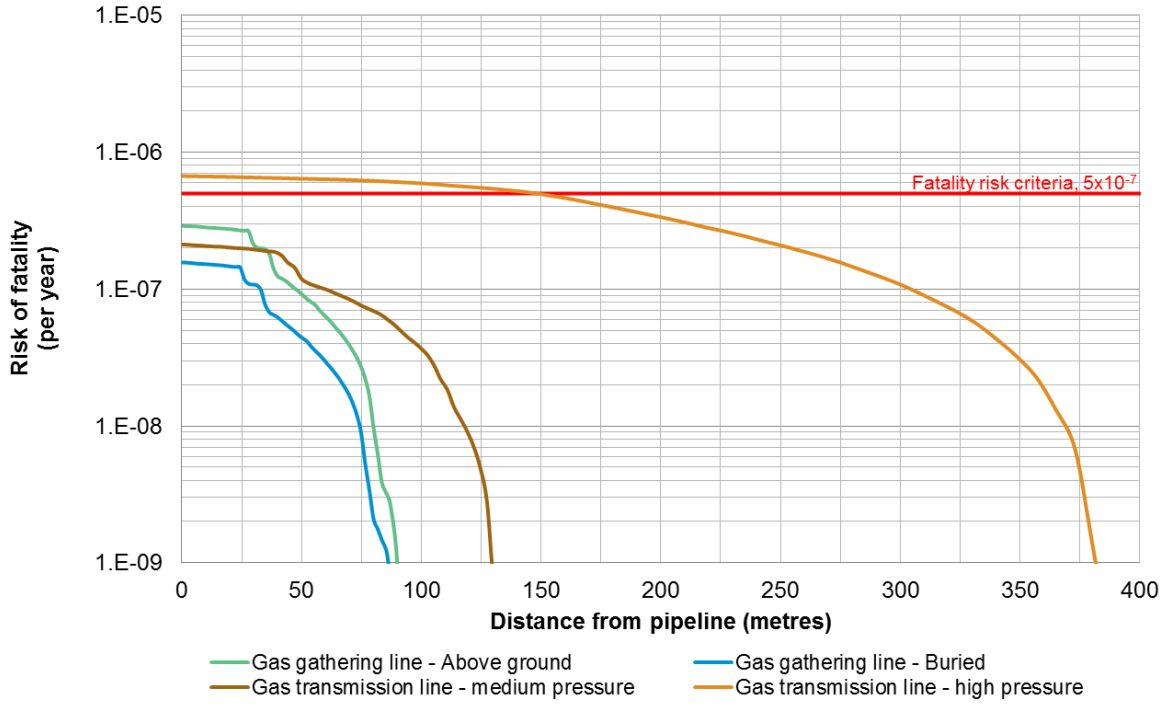
The likelihood of catastrophic failure of a water storage structure is considered to be remote, given the regulation of dams required by the Queensland Government Department of Natural Resources and Mines, *Queensland Dam Safety Management Guidelines* (2002). The risk to people due to this scenario is therefore assessed to be medium; i.e. the risk may be accepted as tolerable if it can be shown to be ALARP.

Gas gathering and gas transmission pipelines

The primary risk to people from gas gathering and gas transmission pipelines is associated with the potential for fires resulting from the release of gas from gas gathering pipelines and gas transmission pipelines. The risks of the identified hazardous scenarios were assessed by the qualitative risk assessment (Appendix X: Hazard and risk) as medium (based primarily on the potential consequence).

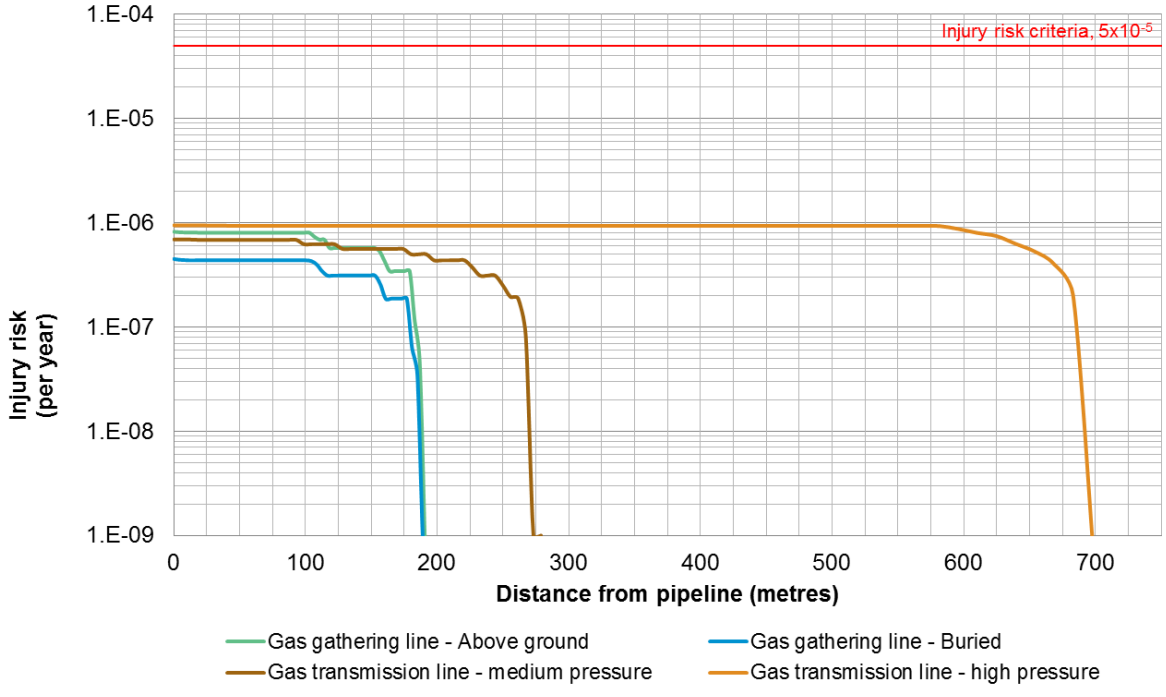
The risks to people from fires from the gas gathering and gas transmission pipelines were further assessed in the quantitative assessment. The results of this assessment are shown as fatality and injury risk transects in Figure 24-2, which shows the risk of fatality or injury as a function of the distance from the pipelines. The high pressure gas transmission pipeline satisfies the individual fatality risk criteria, with the exception of the criterion relating to sensitive land uses (5×10^{-7} per year) (Table 24-5). For the gas gathering lines and medium pressure gas transmission pipelines, the estimated risks of fatality are well below the criterion for sensitive land uses.

Figure 24-2 Fatality risk transects for gas gathering and transmission pipelines (operations)



Injury risk transects for fires from the gas gathering and gas transmission pipelines are shown in Figure 24-3. The highest estimated injury risk is approximately 1 x 10^{-6} per year for the high pressure gas transmission pipeline. This is below the injury risk criteria of 5 x 10^{-5} per year given in Table 24-5 for heat radiation from fires.

Figure 24-3 Injury risk transects for gas gathering and transmission pipelines (operations)



24.5.3.3 Decommissioning

As for construction, decommissioning will be relatively short-term. Decommissioning activities are unlikely to result in significant offsite impacts to people and should be adequately controlled by implementation of the Environment, Health and Safety Management System, as well as decommissioning plans and procedures.

Prior to decommissioning, gas compression plants, gas pipelines and water treatment plants, process equipment and pipework will be purged of flammable gas and other hazardous materials such as acids and alkalis. The consequences of failing to properly prepare equipment for decommissioning and demolition are similar to those during operations when equipment is prepared for maintenance. The risks to people from wells, compression facilities and gas gathering and transmission lines during decommissioning are therefore considered to be similar to those for the operations phase.

As water storage structures have potential long-term use, they may be left following decommissioning of other infrastructure with the agreement of the land holder, or incompletely demolished leaving potential restrictions to flow of floodwaters. The potential impacts associated with these facilities are primarily due to remaining structures affecting flood flows, which would occur if these structures were located in areas such as natural drainage paths for floodwater or in flood plains. The risk associated with this can be adequately mitigated by appropriate siting of the water storage structures during design and construction and consultation with the land holder.

24.5.4 Risks to property

24.5.4.1 Construction and commissioning

Hazardous scenarios identified for the construction and commissioning phase involve damage to an adjacent gas pipeline during construction of the gas gathering or transmission pipelines. The risks to property from these scenarios were assessed by the qualitative risk assessment (Appendix X: Hazard and risk) as low i.e. the risks are considered to be 'tolerable' and existing controls will be maintained.

Other scenarios during the construction and commissioning phase are considered to be similar to those for the operations phase, the risks of which are assessed below.

24.5.4.2 Operations

Wells and compression facilities

The primary risks to property associated with wells and compression facilities are associated with the potential for fires resulting from the following hazards:

- Damage to adjacent pipelines during the construction of gas gathering lines and transmission pipelines
- Release of natural gas from a well head or equipment/piping at a well lease, nodal gas compression facility or hub gas compression facility.

As the wells and compression facilities are generally located in isolated areas with no immediate surrounding buildings or occupied areas, there is minimal potential for offsite escalation, impact on forests or water resources, or damage to infrastructure (e.g. roads and rail level crossings) or third party property.

The risks to property from these scenarios were assessed by the qualitative risk assessment (Appendix X: Hazard and risk) as low i.e. the risks are considered to be 'tolerable' and existing controls will be maintained.

Gas gathering and gas transmission lines

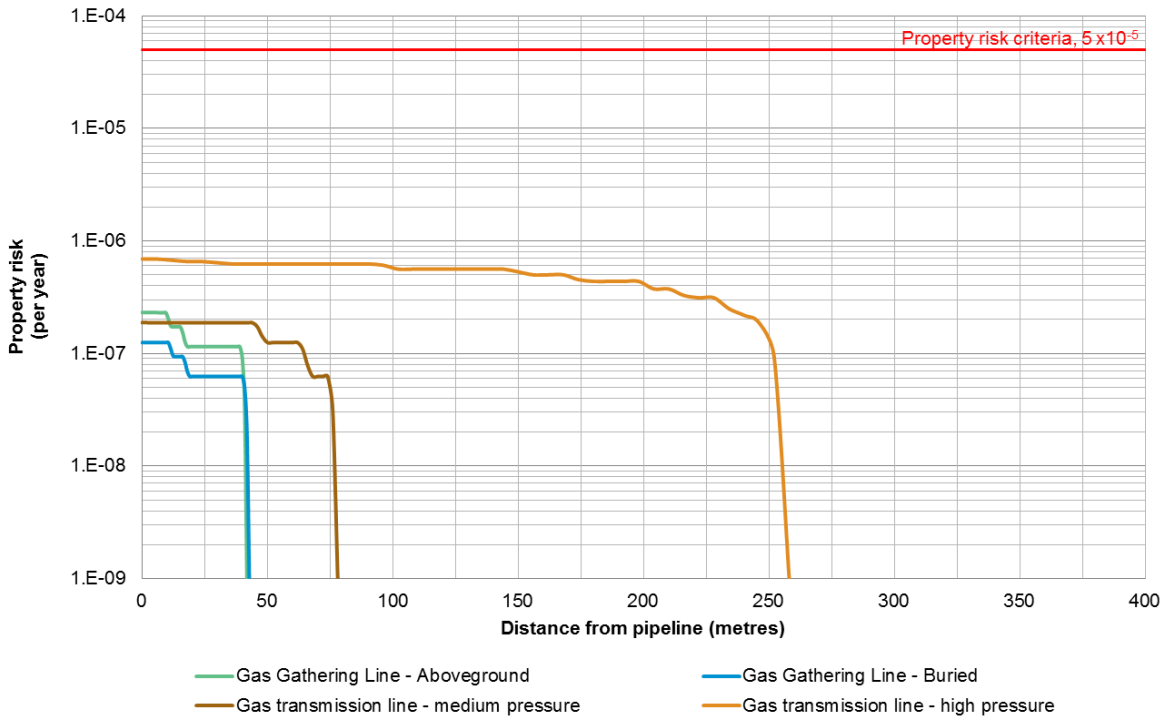
The risk to property from gas gathering and gas transmission pipelines is associated with the potential for fires resulting from the release of natural gas from gas gathering pipelines and gas transmission pipelines. The risks of the identified hazardous scenarios were assessed by the qualitative risk assessment (Appendix X: Hazard and risk) as low.

The quantitative assessment of risks from pipelines was conducted and property risk transects for the gas gathering and gas transmission pipelines are shown in Figure 24-4. The highest estimated property risk is approximately 7 x 10^{-7} per year immediately next to a high pressure gas transmission line. This and the property risks associated with the other gas gathering and gas transmission pipelines are well below the criterion for risk of property damage and accident propagation of 5 x 10^{-5} per year (Table 24-5).

Water management facilities

The likelihood of catastrophic failure of a water storage structure is considered to be remote. However, in the event of catastrophic failure of a water storage dam, the impact to forests or water resources, infrastructure (roads or railways) or third party property may be significant, the consequences could be major. The risk to property due to this scenario is therefore assessed to be medium; i.e. the risk may be accepted as tolerable if it can be shown to be ALARP.

Figure 24-4 Property risk transacts for gas gathering and transmission pipelines (operations)



24.5.4.3 Decommissioning

The risks to property from wells, compression facilities and gas gathering and transmission lines during decommissioning are considered to be similar to those for the operations phase.

The risk associated with water storage structures is considered to be adequately mitigated by appropriate siting of the water storage structure during design and construction and consultation with the land holder.

24.5.5 Cumulative impact assessment

The vicinity around the GFD Project area includes a variety of major developments currently being assessed or approved and being implemented. Further details on these projects are provided in Appendix X: Hazard and risk. These developments have the potential to act cumulatively with GFD Project impacts to people and property. Among these projects, it has been identified that the Queensland Curtis LNG Project (QCLNG) pipeline travels through part of the Scotia gas field. It is expected to be constructed and operational prior to the development of the Scotia gas field. Given the generally low risk associated with gas pipelines as discussed in sections 24.5.3 and 24.5.4, it is considered that the cumulative risks of the QCLNG pipeline and GFD Project will be unlikely to exceed the injury and property risk criteria given in Table 24-5.

The other developments in the region are generally located one kilometre or more from the GFD Project. At this distance, no cumulative risk impacts to people and property are expected. Natural and induced emergency situations; and counter disaster and rescue procedures also have the potential to impact on resources such as forests, water reserves, roads, rail level crossings, residential, work and recreational areas. One potential cumulative impact may arise if two projects both had emergency situations at the same time. In this event, the limited emergency services available in the region may be stretched. However, Santos GLNG will have significant emergency response capabilities and have an ability to respond to their emergency situations. Therefore, the significance of the overall cumulative impact on risk levels for the GFD Project is considered to be low.

24.6 Mitigation measures

Santos GLNG's management framework, described in Section 6: Management framework, includes EHSMS09. The hazard and risk measures for the GFD Project are described below and are consistent with the hierarchy of controls detailed in the EHSMS09:

- Elimination (e.g. by eliminating inventories of dangerous goods)
- Substitution (e.g. by using a less hazardous material in place of a more hazardous material)
- Engineering (e.g. compliance with internal and external standards)
- Isolation (e.g. erection of physical barriers)
- Administrative (e.g. emergency procedures)
- Protective (e.g. use of personal protective equipment).

The measures applied have been based on the existing measures contained within the approved environmental management framework that Santos GLNG has already developed and implemented for the GLNG Project. Applying the same measures from the GLNG Project to the GFD Project will ensure a consistent approach by construction and operations personnel and a common understanding for both regulators and the community of the measures to be applied.

To facilitate the consistent management of hazards and risks for the GLNG Project and the GFD Project, Santos GLNG has implemented a number of management plans and procedures which are summarised in Table 24-8.

Table 24-8 Management framework relevant to hazard and risk

Management Plan	Description and mitigation measures
GFD Project environmental protocol for constraints planning and field development (the Constraints protocol)	The Constraints protocol applies to all gas field related activities. The scope of the Constraints protocol is to: • Enable Santos GLNG to comply with all relevant State and Federal statutory approvals and legislation • Support Santos GLNG's environmental policies and the General Environmental Duty (GED) as outlined in the EP Act • Promote the avoidance, minimisation, mitigation and management of direct and indirect adverse environmental impacts associated with land disturbances • Minimise cumulative impacts on environmental values. The Constraints protocol provides a framework to guide placement of infrastructure and adopts the following management principles: • Avoidance — avoiding direct and indirect impacts • Minimisation — minimise potential impacts • Mitigation — implement mitigation and management measures • Remediation and rehabilitation — actively remediate and rehabilitate impacted areas • Offset — offset residual adverse impacts in accordance with regulatory requirements. The Constraints protocol enables the systematic identification and assessment of environmental values and the application of development constraints to effectively avoid and / or manage environmental impacts.
Hydraulic fracturing risk assessment: compendium of assessed fluid systems (Hydraulic fracturing risk assessment)	The Hydraulic fracturing risk assessment report synthesises the hydraulic fracturing risk assessments completed on various hydraulic fracturing fluids and provides a framework for including new fluid systems within the risk assessment document. The body of the report provides generalised information, including the geology and hydrogeology of the area, risk assessment methodologies (qualitative and quantitative) and a high level understanding of current results. The appendices include risk assessments of individual hydraulic fracturing fluid systems.
Queensland incident management plan (QIMP)	The QIMP describes the use of the Santos GLNG incident management framework, including the procedures and systems that apply to the Santos GLNG operations and activities. It is an operational document and not included in this EIS. In accordance with EHSMS13 Emergency Preparedness an emergency response plan is to be developed for each asset or activity.
Emergency response plan (ERP)	The ERP forms part of Santos GLNG's overall emergency response. It is supplementary to the Queensland Incident Management Plan and provides the necessary information to deal with emergencies at the asset level. This is an operational document and is not included in this EIS. Santos GLNG will engage with Queensland Ambulance Service and Queensland Fire and Emergency Services across the life of the GFD Project concerning joint responsibilities for emergency response.
Contingency plan for emergency environmental incidents (Contingency plan)	The Contingency plan details the management practices in place within Santos GLNG to minimise environmental harm during an emergency environmental incident. The plan identifies potential incidents, and provides response actions, including escalation, communication, reporting and monitoring.

Management Plan	Description and mitigation measures
Social impact management plan (SIMP)	The SIMP established for the GLNG Project will be implemented across the GFD Project. The plan outlines the roles, responsibilities and rights of Santos GLNG, the government, impacted communities and other stakeholders in relation to the GFD Project. In particular, it outlines the framework for community engagement, management strategies to avoid, mitigate or minimise potential impacts and to maximise opportunities and benefits arising throughout the life of the GFD Project, as well as a monitoring and reporting process. The GLNG Project SIMP will be supplemented by issue action plans relating to the GFD Project that focus on the following key areas as agreed with the Coordinated Project Delivery Division of the Coordinator-General's office: • Water and environment • Community safety • Social infrastructure • Community wellbeing and liveability • Local industry participation and training • Aboriginal engagement and participation. The SIMP is an operational document that is updated to reflect the ongoing needs of Santos GLNG and the communities it operates in. It is available on the web at: http://www.santosglng.com/resource-library/community/social-impact-management-plan-community-handbook.aspx
Chemical and fuel management plan (CFMP)	The CFMP details the appropriate storage and handling practices of chemicals and fuels. The objectives of the plan are to: • Facilitate compliance with relevant legislation, regulations and approvals • Provide a framework for Santos GLNG to store and handle bulk chemicals and fuels in a way that minimises risk to the environment and human health • Assess the potential risk of a chemical or fuel prior to its use • Identify and implement appropriate mitigation measures.
Decommissioning and abandonment management plan (DAMP)	The DAMP describes the management framework in place for when petroleum activities cease. The objectives of the plan are to: • Undertake decommissioning of assets in a manner that complies with regulatory requirements and minimises the risk of environmental harm • Undertake decommissioning activities in a manner that meets stakeholder expectations • Leave a landform that is stable and compatible with intended post-closure land use • Provide for the beneficial reuse of Santos GLNG infrastructure constructed to third parties (e.g. landholders or local authorities) where an appropriate agreement has been signed by both parties and regulatory authorities are satisfied.

Public liability

During phases of the GFD Project up to and including decommissioning and rehabilitation, no public liability will attach to the State for:

- Private infrastructure built as part of the GFD Project
- Visitors on public land who may be affected by action of the GFD Project unless:
  - — Explicitly agreed otherwise with the State
  - — Damage and injury occurs as a result of negligence by an agent of the State.

Wells and gas compression facilities will be secured areas and land access procedures will be in place.

Following successful decommissioning and rehabilitation of the GFD Project components, Santos GLNG will no longer have responsibility for infrastructure that remains, or for persons entering upon former GFD Project areas.

24.7 Conclusion

The hazard and risk assessment identified the various infrastructure components that may result in scenarios with potential offsite risks to people or property. The risk assessment shows that the residual risks associated with the various hazardous scenarios are considered medium for risks of fatality or injury to people and are considered to range from low to medium for risks of damage to property. Relevant quantitative risk criteria relating for the gas gathering and gas transmission pipelines were met for the hazardous scenarios assessed except for high pressure transmission pipelines in proximity to sensitive land uses (hospitals, child-care facilities and old age housing). Sensitive land uses will be avoided in the placement and construction of high pressure transmission pipelines. Overall, no major hazards were identified as likely.

Medium risks levels are acceptable provided they can be demonstrated to be ALARP. Risks will be managed to ALARP level throughout the GFD Project's lifecycle using existing controls as documented in EHSMS09 and the mitigation measures outlined in section 24.6.

The residual risks are summarised in Table 24-9.

Table 24-9 Residual risk – hazard and risk

GFD Project component	Hazardous scenario	Risk receptor	Consequence	Likelihood	Residual risk
Well	Release of natural gas from well head or equipment/piping at well lease	People	Critical	Remote	Medium
		Property	Moderate	Remote	Low
Gas gathering line	Release of natural gas from gas gathering line (aboveground)	People	Critical	Remote	Medium[1]
		Property	Moderate	Remote	Low[1]
	Release of natural gas from gas gathering line (underground)	People	Critical	Remote	Medium[1]
		Property	Moderate	Remote	Low[1]
	Damage to adjacent gas pipeline during construction of gathering line	People	Critical	Remote	Medium
		Property	Moderate	Remote	Low
Nodal gas compression facility	Release of natural gas from well head or equipment/piping at nodal gas compression facility	People	Critical	Remote	Medium
		Property	Moderate	Remote	Low
Gas transmission pipeline	Release of natural gas from medium pressure transmission line	People	Critical	Remote	Medium[1]
		Property	Moderate	Remote	Low[1]
	Release of natural gas from high pressure transmission line	People	Critical	Remote	Medium[2]
		Property	Moderate	Remote	Low[1]
	Damage to adjacent gas transmission pipeline during construction of transmission pipeline	People	Critical	Remote	Medium
		Property	Moderate	Remote	Low
Hub gas compression facility	Release of natural gas from equipment/piping at hub gas compression facility	People	Critical	Remote	Medium
		Property	Moderate	Remote	Low
Water management facilities	Catastrophic failure of water storage	People	Critical	Remote	Medium
		Property	Moderate	Remote	Low

[1] Satisfies relevant quantitative risk criteria

[2] Satisfies relevant quantitative risk criteria with the exception of the criterion relating to sensitive land uses