Section 10 Hazard and Risk

10.1 Introduction

This section of the EIS identifies hazards and risks associated with the construction, operation and decommissioning phases of the CSG fields, gas transmission pipeline and LNG facility, and provides measures to mitigate any of the identified potential impacts.

The hazard and risk study has been completed by integrating RISQUE, (which identifies risks to environment, community and economics) and a preliminary hazard analysis (PHA), (which identifies risks to people and property). The combination of the two provides an overall project risk to the community and the environment.

The RISQUE assessment was undertaken in the initial stages of EIS project planning and provided strategic guidance for the individual technical studies that were being undertaken. It covered the environmental and health and safety aspects of the project and their potential impacts on people, property and the environment. The PHA formed a component of the overall RISQUE assessment, and focused on the potential hazards and risks of the project to human health and safety.

10.2 Regulatory Framework

Section 1.9 of the EIS provides an overview of the general regulatory framework as it applies to the entire project, however, legislation relevant to hazards and risks associated with the project includes:

- *Airports Act 1996 (Cth);*
- *Maritime Transport and Offshore Facilities Securities Act 2003 (Cth);*
- *Transport Infrastructure Act 1994 (Qld);*
- *Transport Planning and Coordination Act (Qld) 1994;*
- *Petroleum Act 1923 (Qld);*
- *Petroleum and Gas (Production and Safety) Act 2004 (Qld);*
- *Dangerous Goods Safety Management Act 2001 (Qld);*
- *Explosives Act 1999 (Qld);*
- *Workplace Health and Safety Act 1995 (Qld);*
- *Petroleum (Submerged Lands) Act 1982 (Qld);*
- *Electrical Safety Act 2002 (Qld); and*
- *Coal Mining Safety and Health Act 1999 and Regulation 2001 (Qld).*

Airports Act 1996 (Cth)

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

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

Maritime Transport and Offshore Facilities Securities Act 2003 (Cth)

The *Maritime Transport and Offshore Facilities Securities Act 2003* establishes a security framework that enables maritime industry participants to develop individual security plans that are relevant to their particular circumstances and specific risks. Relevantly, the act applies to Australian ports, port facilities, and port service providers that serve security regulated ships, and Australia's offshore facilities. The act requires development, implementation and management of a Maritime Security Plan. As Santos is a Port Facility Operator within a Security Regulated Port, under the *Maritime Transport and Offshore Facilities Securities Act, 2003* it is required to submit a Maritime Security Plan for review and approval.

The Maritime Security Plan is, amongst other things, to contain a security assessment and the security measures or activities to be implemented at each level of security (1, 2 and 3). The Maritime Security Plan must be accompanied with a map in a size and scale that clearly shows the boundaries of the relevant site, and location of any port security zones established, or to be established or changed, within the area covered by the plan.

An assessment has been made of the security requirements under this legislation. Given the sensitive nature of this information, this assessment has been included in Appendix FF (Confidential Information) for assessment by the relevant government agencies. This includes the information required to be addressed by the Terms of Reference (ToR) paragraph 3.11.1 and 3.11.3: the identification of hazards arising from the potential for deliberate breaching of LNG Carriers (LNGC) hulls and the resulting breach size and spill rate, and the design and operation of proposed safety/contingency systems to address terrorist attacks.

Transport Infrastructure Act 1994 (Qld)

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

It is likely the project will require approvals under the TI Act pertaining to road closures, the construction and operation of a potential bridge and road across Port Curtis, and the transportation of oversized loads of plant, equipment and materials. These approvals will be obtained on an as-needs basis during the course of the project future design and construction phases when the necessary design and construction information required for the permit applications is available.

Transport Planning and Coordination Act 1994

The objectives of this Act are to improve the economic, trade and regional development performance of Queensland, and the quality of life of Queenslanders, by achieving overall transport effectiveness and efficiency through strategic planning and management of transport resources. Road or intersection upgrades as detailed in section 4 of this EIS, or any future activities associated with the development of the project that may impact a public passenger service, active transport system or works on a local government road may require approval under this Act.

Petroleum and Gas (Production and Safety) Act and Regulation 2004 (Qld)

The *Petroleum and Gas (Production and Safety) Act 2004* (Qld) (P&G (PSA) Act) regulates petroleum and natural gas in Queensland. It aims to facilitate and regulate the carrying out of responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel gas industry. It aims to achieve this in a way that minimises land use conflicts and encourages responsible land use management (among other measures).

Petroleum activities include:

- The exploration, distillation, production, processing, refining, storage and transport of petroleum;
- The distillation, production, processing, refining, storage and transport of fuel gas; and
- Other activities authorised under the act for petroleum authorities.

The safety obligations contained in the P&G (PSA) Act apply to an operating plant as defined in the P&G (PSA) Act. However, if a facility has been classified as a major hazard facility under the *Dangerous Goods Safety*

Management Act 2001 (DGSM Act), it is an operating plant under the P&G (PSA) Act only to the extent to which the *Dangerous Goods Safety Management Act 2001* does not apply to the facility.

Some of the CSG field petroleum authorities are governed by the *Petroleum Act 1923* (Qld) (Petroleum Act). This Act is provides a regulatory regime similar to that of the P&G (PSA) Act.

Dangerous Goods Safety Management Act 2001 (Qld)

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

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

The DGSM Act and regulation are concerned with protecting against harm or injury to people or damage to property or the environment arising from an explosion, fire, harmful reaction or the evolution of flammable, corrosive or toxic vapours involving dangerous goods; or the escape, spillage or leakage of any dangerous goods. They also define the criteria by which a facility would be classified as a Large Dangerous Goods Location or a major hazards facility. Additional risk minimisation requirements are defined for such facilities in order for them to obtain the necessary licenses to operate.

Relevantly, certain parts of the act and regulations do not apply to:

- Land that under the P&G (PSA) Act is used to obtain, produce or transport petroleum; and
- Pipes under the P&G (PSA) Act (other than pipes within the boundaries of a major hazard facility or dangerous goods location).

Major hazard facilities are administered by the Department of Emergency Services. The GLNG Project will be required to obtain the necessary licenses to operate under the DGSM Act.

Explosives Act 199 (Qld)

The *Explosives Act 1999* provides for the regulation of explosives, including using, manufacturing and storing and transporting explosives in order to ensure the safety of the community from all activities associated with explosives.

Workplace Health and Safety Act 1995 (Qld)

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

Petroleum (Submerged Lands) Act 1982 (Qld)

The *Petroleum (Submerged Lands) Act 1982* (PSLA) regulates petroleum and natural gas in Queensland across certain submerged lands adjacent to the coasts of Queensland.

The PSLA also imposes safety duties on certain persons to secure the occupational health, safety and welfare of persons at or near facilities across certain submerged lands adjacent to the coasts of Queensland. Where the PSLA applies, it does so to the exclusion of certain prescribed State safety legislation.

The PSLA is relevant to the construction and operation of the submerged section of the gas transmission pipeline.

Electrical Safety Act 2002 (Qld)

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

The act may be relevant to the project to the extent that electrical work, as defined, is performed. However, certain excluded provisions will not apply to the project.

Coal Mining Safety and Health Act 1999 (Qld)

The *Coal Mining Safety & Health Act 1999 (CMSHA Act)* regulates the operation of coal mines, to protect the safety and health of persons at coal mines and persons who may be affected at coal mining operations. These objects are achieved by, among other things, imposing safety and health obligations on certain persons and providing for safety and health management systems.

The CMSHA Act may be relevant to the project to the extent that operating plant is in the area of a coal mining lease or in an area adjacent to a coal mining lease.

10.2.1 Standards

There are specific standards, both Australian and international, which will provide input into the detailed design of the project. From the perspective of the hazard and risk study however, the following overarching standards are relevant.

National Standard for the Control of Major Hazard Facilities [NOHSC:1014 (2002)]

The objective of this national standard is to prevent major accidents and near misses, and to minimise the effects of any major accidents and near misses by requiring operators to:

- Identify and assess all hazards and implement control measures to reduce the likelihood and effects of a major accident;
- Provide information to the relevant public authority, and the community, including other closely located facilities, regarding the nature of hazards at a major hazard facility and emergency procedures in the event of a major accident;
- Report and investigate major accidents and near misses, and take appropriate corrective action; and
- Record and discuss the lessons learnt and the analysis of major accidents and near misses with employees and employee representatives.

The requirements of this standard have essentially been enacted as law under the DGSM Act.

AS 2885.1 – Australian Standard for pipelines; gas and liquid petroleum, Part 1: design and construction

Key requirements of the pipeline standard AS 2885, which limit the risk of off-site impacts are as follows:

- The development of a ‘Fracture control plan’. This ensures the safe shut-down of the pipeline in the event of a pipeline rupture;
- The standard of resistance to penetration of the pipeline. This affects the likelihood of rupture;
- Prevention of rupture in ‘High Density’ class locations; and
- Maximum tolerable energy release rates. This limits the radiated heat flux generated from a fire.

AS 3961-2005 – Australian Standard for the storage and handling of liquefied natural gas

This standard specifies requirements for the design, construction and operation of installations for the storage and handling of liquefied natural gas (LNG). The standard will be a key design input, particularly with reference to the installation of tanks and transfer equipment for supplying the marine export terminal.

NFPA 59A - National Fire Protection Association Standard for Production, Storage and Handling of Liquefied Natural Gas

The National Fire Protection Association standard NFPA 59 requires that a safe radiated heat flux and concentration of flammable mixture is not exceeded at the boundary of the LNG facility. It also specifies the distance of separation of storage vessels so that the integrity of containment is maintained in the event of a fire. This standard will be a key input into the detailed design of the project.

EN 1473 - The European Norm Standard for Installations and Equipment for Liquefied Natural Gas - Design of onshore installations

The European standard requires that a safe radiated heat flux is not exceeded at the boundary of the LNG facility. This standard also provides criteria for evaluating the cumulative risk for the entire LNG facility and requires that this does not exceed a given level of risk. This standard will be a key input into the detailed design of the project.

Other Specific Standards

Other principal reference documents relevant to the GLNG Project are listed below:

- AS/NZS 4360 Risk Management;
- National Fire Protection Association (NFPA);
  - 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
  - NFPA 780: Lightning Protection Code
- American Petroleum Institute (API);
  - 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 current
  - API Std.2510: Design and Construction of Liquefied Petroleum Gas (LPG) Installations.

Further references used for general guidance:

- National Fire Protection Association (NFPA);
  - 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);
  - 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.

10.2.2 Codes of Practice

There are State and Federal codes of practice which have application to the project. The main code of practice relevant to the project is the National Code of Practice for the Control of Major Hazard Facilities.

National Code of Practice for the Control of Major Hazard Facilities [NOHSC:2016(1996)]

This National Code of Practice for the Control of Major Hazard Facilities [NOHSC:2016(1996)] provides a practical guide on how to meet the requirements of the National Standard for the Control of Major Hazard Facilities [NOHSC:1014(1996)].

10.2.3 Guidelines

Safe Storage and Handling of Dangerous Goods: Guideline for Industry

The guidelines, produced in reference to the Queensland DGSM Act and regulations, provide practical guidance on meeting the requirements of the act and regulation for manufacturers, importers and suppliers of stated dangerous goods and combustible liquids, and occupiers storing and handling those goods.

10.3 Risk Assessment

10.3.1 RISQUE Assessment

The risk management approach adopted for the GLNG Project is based on the RISQUE (Bowden et al., 2001) method which is a widely accepted approach to risk management, often involving the use of a multi-disciplinary “expert panel” for assessing the probabilities and consequences associated with potential risk events.

This approach was selected because it is able to assess (on a relatively even basis) risks associated with social, environmental, engineering and economic issues and events. Highly complex systems involving feedback mechanisms and multi-faceted inter-relationships have been incorporated into the risk assessment through the use of a team of subject matter specialists.

The goal of the RISQUE assessment was to use subject matter specialists in a workshop setting to identify the key risks of the various stages of the project, which in turn informed the EIS study teams of project risks. A detailed report is provided in Appendix FF.

10.3.1.1 Methodology

A risk assessment of the entire GLNG Project has been undertaken to understand the risks to the wider environment and to key stakeholders. The aims of the risk assessment were to:

- Evaluate and communicate the effects and risk posed by the proposed GLNG Project (i.e. residual risk after risk treatment measures);
- Provide information to assist the GLNG Project design team to reduce the risk posed by the project to a level that is as low as reasonably practicable; and
- Link the risk assessment outputs to on-going risk management via the Environment Management Plans (EMPs).

10.3.1.2 Definition of Risk

Risk is a condition resulting from the prospect of an event occurring and the magnitude of its consequences. Therefore, risk is an intrinsic combination of:

- The likelihood of an event and its associated consequences occurring (this incorporates consideration of the frequency of the event and the probability of the consequences occurring each time the event occurs); and
- The magnitude of potential consequences of the event.

In quantitative terms, "risk" is defined by a risk "quotient", which is:

Risk Quotient = Likelihood x Consequence

The risk quotient is therefore a numerical value that describes the level of risk posed by an event.

Both likelihood and consequence can be measured in several ways using different techniques, depending on the aims of the risk assessment and the nature of the risk issue. The selected methodologies for assessing likelihoods and consequences for the risk assessment are described in Appendix FF.

10.3.1.3 Overall approach

In general terms, the RISQUE method is a cyclical process based on the Australia and New Zealand Standard for Risk Management (AS 4360) framework, as described in Figure 10.3.1 below.

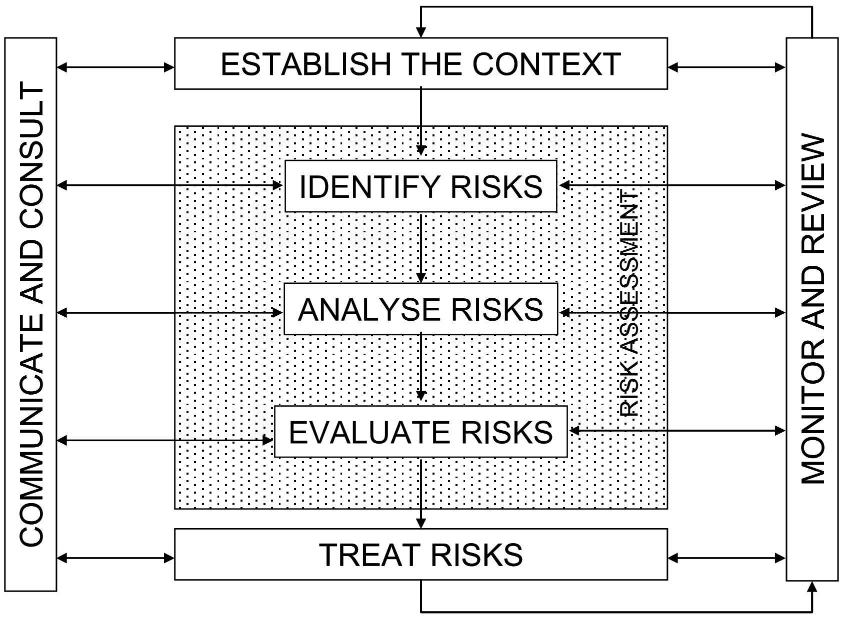

Figure 10.3.1 Overview of AS 4360 Risk Management Process

Figure 10.3.1 shows that the AS 4360 risk management process is iterative and that the main elements of the process include:

- Communicate and consult with stakeholders at each stage of the process;
- Establish the context for the project which is described in Section 3 of this EIS. This step provides background to the analysis and structure of the risk assessment;

- Identify risks including when, where, why and how risk events could occur. Information was obtained from Santos personnel and from subject matter specialists. The process was essentially workshop-based with support from other discussions, meetings, and reviews that took place outside of workshops;
- Analyse risks and identify existing controls, evaluate likelihoods and consequences to determine levels of risk;
- Evaluate risks and compare estimated levels of risk with evaluation criteria, consider benefits versus adverse outcomes. The role of the risk analyst in the risk evaluation process was to generate appropriate outputs from the risk analysis that would be useful for stakeholders (including Santos, community and regulators) to evaluate the risk posed by the project and to form their views;
- Treat risks including development and implementation of specific strategies for increasing benefits and reducing potential costs; and
- Monitor and review the effectiveness of all steps of the risk management process.

10.3.1.4 Dealing with Uncertainty

As risk is a concept used to describe events that may or may not occur, and for which the scale of potential impacts cannot be accurately predicted, there is always inherent uncertainty associated with the estimation of risk.

Considering the two-dimensional nature of risk (likelihood x consequence), there are two key types of uncertainty in any estimation of risk:

- Uncertainty in the estimated likelihood of an event occurring; and
- Uncertainty in the magnitude of the event consequences.

The underlying cause of the uncertainty itself may be a result of a combination of issues such as lack of historical information for similar situations, uncertainty in scientific knowledge, natural variability, or uncertainty due to assumptions inherent in technical models or calculations used for forecasts and predictions. In assessing and measuring uncertainty, one must take into account each of the assumptions made and the extent of its validity.

10.3.1.5 Incorporation of Cumulative Effects

Three broad categories of cumulative effects have been identified. These are:

- The combination of multiple effects on assets (public health and safety, economics, social, environmental and property/infrastructure) within a project area (i.e. the combined effect of the increase of biting insects and the introduction of feral animals and other exotic fauna due to construction activities);
- The combined effects on a single asset (public health and safety, economics, social, environmental and property/infrastructure) due to activities in different project areas (i.e. effects on terrestrial fauna in one project area combined with effects on the same species in another project area); and
- The combined effects of the project activities with those of other projects or existing activities in the region (i.e. the combined effect on accommodation availability due to increased workforce for the GLNG Project along with increased workforce for other approved projects).

10.3.1.6 Risk Identification Process

The risk identification process was an iterative one, for which the key inputs were progressively refined based on evolving levels of information and knowledge. The key steps in this iterative process are outlined as follows:

- Initial list of risks identified;
- Development of event trees;
- Population of the event trees with likelihood and consequence data, based on specialist knowledge; and

- Ongoing review and updating of the likelihood and consequence data based on new information and project developments.

10.3.1.7 Event Tree Development

A series of three facilitated group workshops were held between April and July 2008 for the purpose of risk identification, assigning likelihoods and consequences to the identified risk events and the development of mitigation measures.

The preliminary list of risks was developed into event trees by establishing cause and effect relationships. Separate event trees were developed for the construction, operation and decommissioning periods. An event tree is a diagram that clearly shows the linkages between initiating events and their subsequent impacts and consequences for each risk event.

The event trees are linear by nature. That is, in order to derive the two components of risk (likelihood and consequence) they indicate a linear cause and effect process that links the likelihoods of an event and its subsequent impacts occurring with the magnitude of the consequences, to provide an estimate of risk for each event. For example, in the first line of Table 10.3.1 the initiating event is an accident and the likelihood of this event occurring during the construction period is 0.1. The impact associated with the event is a Lost Time Incident (LTI) that has a probability of 0.01. The consequences of this impact are personnel rehabilitation and/or compensation. The total frequency is the combination of the likelihood during the construction period and the probability of the impact occurring.

Table 10.3.1 Example Event Tree

CONSTRUCTION												
						Potential Consequence						
Initiating Event	Likelihood during construction period	Impact	Prob-ability	Consequence	Total Freq	Prop / Infra	Enviro	Social	Econ	Public H&S	Combined Conseq Level	Risk
Accident - LTI	0.1	LTI	0.01	Personnel rehab/Compensation	0.001					1	1	0.001
Accident - Fatality/serious injury	0.0001	Fatality/serious injury	1E-05	Personnel rehab/Compensation	1E-09			1		10	11	1E-08
Land Disturbance	0.005	Crop loss/Environmental Damage	1	Compensation/Rehabilitation	0.005		1		1		2	0.01
Inter-aquifer transfer	0.001	Reduce groundwater quality, quantity	0.0001	Compensation, Re-assess Groundwater impact study	1E-07		10		10		20	2E-06
Cultural Heritage disturbance	0.0001	Destruction of Heritage	1	Compensation	1E-04			1			1	1E-04
Water disposal - quality	1	stock impacts, veg & soil	0.01	Compensation/Rehab	0.01		10		10		20	0.2
Water disposal - quantity	1	Environmental receptors/No guarantee of supply	0.01	Compensation/Rehab	0.01		0.1		0.1		0.2	0.002
Weed spreading	0.01	Noxious weeds	0.1	Compensation/Infestation control	0.001		1		1		2	0.002
Vermin	0.001	Environmental damage	0.0001	Management/monitoring	1E-07		0.1				0.1	1E-08

The second workshop dealt with populating the event tree with the likelihoods and consequences for each event. In the third workshop these inputs were validated by the entire team of subject matter specialists. The reality check focussed on the risk issues that were considered to be high risk and those that were thought to be of low risk. The panel thought it was important to validate these extreme risks as they have the greatest impact on the risk assessment and generally representative of the entire set of risk issues.

The third workshop dealt with mitigation measures to reduce the high level risks to an acceptable level. Workshop participant selection was based on their expertise and knowledge in areas of relevance to the project, and comprised a broad range of subject matter experts and technical specialists that have been undertaking specialist technical studies for the GLNG Project as well as a team of risk advisors, facilitators and workshop documenters. An outline of the workshops and a list of workshop attendees and their areas of expertise are provided in Appendix FF.

10.3.1.8 Estimating Likelihoods and Consequences

Estimating Likelihoods

For common events (i.e. those with a likelihood above a one in ten (10 %) chance of occurrence over the life of the project), the event likelihood was usually estimated to the nearest few percent based on the subject matter experts' experience or knowledge of similar types of events, and documented information in the industry and literature.

For untested activities and events with likelihoods below a 1 % chance over the life of the project, an individual expert's experience becomes increasingly less direct as the likelihoods become lower. In these cases, project likelihoods are estimated more conceptually and expressed in order of magnitude terms (for example a one in 100 or a one in 1,000 chance).

To assist in ensuring consistency of approach to making this type of conceptual level estimate for events with lower likelihoods, a likelihood guide was supplied to assist participants in estimating likelihoods. The likelihood guide used in the workshop is included in Appendix FF.

Estimating Consequences

The consequences table used in this risk assessment was adopted from previous projects in Australia and altered to apply to the issues associated with the GLNG Project.

The consequences table was developed to achieve a practical level of consistency when estimating consequence levels across different disciplines. The consequences table incorporates qualitative descriptions for different consequence types and levels, and normalises them into a consistent set of quantitative measures. The consequences table is provided in Appendix FF.

Each category has been assigned a qualitative consequence level (Negligible, Minor, Moderate, Major, and Extreme) in the top row shown in Table 10.3.2. A generic qualitative description for each level is shown in the middle row and a quantitative value is indicated along the bottom row. The quantitative values show that each subsequent consequence level represents an order of magnitude (factor of ten) increase in the scale of the consequence, which was a critical factor in ensuring that the levels could be applied consistently across all disciplines. The generic qualitative descriptions describe not only the level of impact but also provide a description of how widely the impact could be felt (i.e. number of individuals or communities affected), as this is also a key factor in being able to estimate the magnitude of the consequence.

Table 10.3.2 Consequence levels in the Consequence Table

Negligible	Minor	Moderate	Major	Extreme
Minimal, if any impact for some communities. Potentially some impact for a small number (<10) of individuals.	Low level impact for some communities, or high impact for a small number (<10) of individuals.	High level of impact for some communities, or moderate impact for communities area-wide.	High level of impact for communities area-wide.	High level of impact State-wide.
0.1	1	10	100	1,000

10.3.1.9 Risk Analysis

Risk analysis involved quantifying and modelling the probabilities and consequences for each substantive risk event for the overall project and for each of the project components. Risk profiles were generated for operations, construction and decommissioning for each of the project components and the overall project. Risk profiles are developed from the risk analysis, a profile is created for each identified risk for each component of the project.

The profile is presented in a tabular format to visualise the risk profile against the risk target and other identified project risks.

Tables have been provided in Appendix FF that list the top 15 risk issues (highest risk quotients) for the overall risk profile and the risk profiles for the three asset types: CSG fields, gas transmission pipeline and LNG facility. These tables show the total risk quotient for each of the risk events and the individual risk quotients for construction, operations and decommissioning that contribute to the total risk quotient. These individual risk quotients indicate the project time period when the risk event is estimated to occur. The table also shows the risk contributed by each of the consequence categories.

In order to understand the levels of risk that may be considered acceptable in the context of this major project, a risk target was established. Any event that posed a level of risk greater than 10 has been categorized as high risk. Therefore, a risk target of 10 was adopted for the project, which is equivalent to a 10 % chance of a major consequence occurring or, alternatively a 1 % chance of an extreme event occurring. For the GLNG Project, no extreme consequences of potential risk events were identified in this risk assessment.

The risk target set for the GLNG Project is the same as that applied to the risk assessment for the Port Phillip Bay Channel Deepening Supplementary EES, which is a major project in Victoria. The entire risk assessment and its targets were accepted by the Victorian Civil and Administration Tribunal (VCAT) review panel.

10.3.1.10 Risk Evaluation

The risk profile developed shows that for the GLNG Project the five highest risk events involve management of associated water within the CSG fields and increased road traffic related to the CSG fields and gas transmission pipeline components of the project. Currently these top five risk events are either marginally greater than, or relatively close to, the target risk level. The eight next highest risk events pose between one and two orders of magnitude less risk than the target, and all of the remaining risk events (within the top 50) pose risk levels that are at least two orders of magnitude less than the target.

A detailed breakdown of the ranked risks in relation to the project stage (construction, operation and decommissioning) and the asset (public health and safety, economics, social, environmental and property/infrastructure) is provided in Appendix FF.

10.3.1.11 Mitigation Measures

Risk management is an on-going process, aimed to reduce risk levels to as low as reasonably practicable, by implementation of targeted strategies. The risk profiles that were first derived from the risk assessment process were used during the project planning stage to identify which events, at the time, contributed most to the overall risk. Potential treatment actions were focused on these higher priority risk events. Strategic actions were developed for specific risk issues in order to reduce the level of risk posed to as low as reasonably practicable. This risk assessment has assumed that all of the identified mitigation measures have been implemented (or will be implemented prior to project commencement).

A detailed list of the strategic actions that were developed to mitigate the issues that initially posed relatively high risk is contained in the RISQUE report in Appendix FF.

10.3.1.12 Conclusions

The following conclusions have been derived from this risk assessment:

- Reference to a wide range of experts and the inclusion of 186 potential risk events have made it unlikely that the risk assessment has not considered a major risk issue.
- The risk profiles show residual levels of risk that will remain even after implementation of generally best practice engineering and environmental management, and implementation of project-specific risk reduction activities.
- Generally the project risk is low, with only five risk events presenting levels of risk slightly over or close to the selected risk target for any event. Around 175 risk events show risk levels that are less than or equal to two orders of magnitude less than the selected risk target.
- For the entire project, the five highest risk events involve management of associated water within the gas field, and increased road traffic related to the CSG field and gas transmission pipeline components of the project.
- The top five risk events are either marginally greater than or relatively close to the target risk level.
- Around eight risk events lie within two orders of magnitude of the selected risk target.
- Associated water management risk is relevant only during operation. Traffic risk is equivalent during construction and operation.
- For the majority of the top 50 risk events a large proportion of the overall risk is posed during the construction period.
- Environmental and social concerns contribute to the risk posed by the three relatively high risk associated water management issues. Public safety concerns are the main contributors to the two relatively high risk road traffic issues.
- Social and environmental concerns contribute to much of the risk for the top 50 risk events.
- Risk to the economy, infrastructure and public safety is relatively low.

10.3.2 Preliminary Hazard Assessment

In accordance with Section 3.11 of the ToR, a preliminary hazard assessment (PHA) has been conducted in order to identify the nature and scale of hazards which might occur during the construction and operation of the project. This has included (amongst other things):

- Hazards involving construction accidents; pipeline, processing unit or storage vessel rupture or loss of containment, and explosions and fires associated with such incidents;
- Release of liquid gaseous or particulate pollutants or any other hazardous material used, produced or stored on the site; and
- Spills of materials during ship loading.

A risk assessment associated with marine operational activities, while LNG vessels are at berth, during loading and during vessel movements within the port limits has also been undertaken (refer section 10.3.3) to identify risks and mitigation measures required to ensure that operational activities associated with LNG vessels do not impact on other operational activities within the port.

A PHA is a broad hazard-screening tool that identifies the hazards associated with the operation of a facility. The results of the PHA are used to determine the need for additional, more detailed hazard analysis, serve as a precursor documenting that further analysis is deemed necessary and serves as a baseline hazard analysis.

The PHA for the proposed GLNG Project including the CSG fields development, gas transmission pipeline and the LNG facility was undertaken. This section presents a summary of the analysis and findings of the PHA. The detailed assessment report is presented in Appendix FF.

The aims of the PHA were to provide a preliminary hazard assessment of off-site risk impacts which affect people and property.

The assessment included the following steps:

- An identification of the hazards associated with the project to offsite people and property;
- A consequence analysis of the hazards identified above; and
- An evaluation of the likelihood and risk for hazards with the potential for off-site impact.

Of particular note, this section specifically applies to atypical and abnormal major hazardous events and conditions. It is not intended to apply to continuous or normal operating impacts (e.g. such as emissions of air or water pollutants, visual impacts or noise) which are dealt with in other sections of the EIS.

The RISQUE assessment as detailed in Appendix FF includes a summary of all identified risks to people, property and the environment and an evaluation of all the risks to assign a risk quotient. These risk profiles are also diagrammatically represented for the top 50 risk events. Pipeline, facility and storage vessel ruptures, loss of containment, explosions and fires have all been identified as potential risks and evaluated accordingly. This PHA (which focuses on risks to people and property) then analyses all the relevant people and property related risks (refer PHA report in App. FF). The following Section 10.3.2 provides a further summary of these findings (refer specifically to Tables 10.3.5, 10.3.6 and 10.3.7) including management measures.

10.3.2.1 Methodology

The scope of this assessment included the CSG fields, gas transmission pipeline and LNG facility including up to the point of transfer onto LNGC. The assessment did not include the ship or marine transport activities. The assessment considered potential hazards during construction, life of operations and decommissioning. The hazards and risks were derived as part of the RISQUE assessment process.

The method of assessment of hazards for the CSG fields, gas transmission pipeline and LNG facility differ significantly in approach due to the difference in the various standards required to be referenced for those components.

The risk assessment for the whole project was undertaken in accordance with Australian Standard (AS) 4360:2004 Risk Management. In addition, for the CSG fields and gas transmission pipeline the assessment was also consistent with the risk assessment requirements of AS 2885, the Australian Standard for pipelines - gas and liquid petroleum.

To determine the base case of the PHA for the project components the following assumptions were made. That is, the hazard and risk assessment was undertaken assuming all of the below assessments and measures had been implemented. Santos takes the management of hazard and risk seriously and has committed to undertake these measures at the appropriate junctures of the project development timeline. Additional information on these assumptions is presented in the PHA report in Appendix FF.

A series of risk assessments will be undertaken over the life of the project, particularly in the project development to identify the possible hazards and to feed them into the design, construction and operational phases of the project. The risk assessment commenced with a PHA (undertaken as part of this EIS) which identified the hazards with off-site risk impacts, affecting people and property. Following this, these results will take effect on the design of the project, which is an iterative process. As the project develops throughout the detailed design phase, the PHA will evolve into a detailed process hazard analysis which will ultimately determine the macroscopic process safety management requirements of the project. In addition to the process hazard analysis, detailed hazard and operability studies (HAZOP) will be performed, fire studies and emergency plans will be completed and the design will evolve toward finalisation.

As the GLNG Project is still in the FEED stage it is considered premature to develop specific risk management plan/s; however Tables 10.3.5 to 10.3.7 provide the basis for a risk management plan, which will be completed prior to field development and in accordance with applicable legislative requirements at the time.

At the design stage of the development project, when detailed design information is available, HAZOP studies will be performed as an integral part of the design process. This examination identifies possible deviations from normal operating conditions which could lead to hazardous occurrences. The consequences and likelihood of such deviations are examined. Also, the adequacy and relevancy of available safeguards to detect such deviations and prevent and/or protect against their resultant effects have been evaluated in detail. This process enabled a comprehensive evaluation of hazard control systems and produces recommendations for any necessary modifications.

Other risk assessment tools that may be applied as the need arises will include safety integrity level (SIL) for process control and emergency systems survivability analysis (ESSA). Both of these analyses are focused on the robustness and survivability of process control and process safety systems in the event of a process incident.

10.3.2.2 Safety Management in Engineering and Design

The detailed engineering design of the project will initially be founded on the basis of industry best practice and regulatory standards. The design and construction of the project will be primarily in accordance with all relevant Australian Standards. However, other pertinent standards and codes will be considered. Santos in accordance with its safety policy is committed to comply with or exceed all relevant legislation and standards (refer to Section 10.3).

Training and Awareness of Personnel.

Santos will employ skilled operators in LNG facilities for the commissioning and operation of the facility. Santos has already employed a senior operator, experienced in the operation of other LNG facilities who is part of the design team at this time. Over the development of the project, Santos will work with the various engineering contractors involved in the design of the gas transmission pipeline and LNG facility to develop operating procedures for the entire operation. These will include the steps for start-up, normal operations, process deviation and shut-down. Specific procedures will be developed for emergency situations and shut-down. Santos will engage and work with the engineering contractors for commissioning. Prior to commissioning, a full commissioning safety plan will be developed and operators will be fully trained in this particular facility.

10.3.2.3 Coal Seam Gas Field Hazard Analysis

The people and property related hazards identified in the CSG fields are provided in Table 10.3.3. As all operational risks identified with the CSG field are pipeline related, the method of risk assessment outlined in the Australian Standard for natural gas pipelines has been applied. This does not call for a quantitative risk assessment for the purpose of this study and hence no risk contours have been developed.

Table 10.3.3 CSG Field Hazards

Hazard	Cause	Consequence	Safety Management
Underground pipe rupture of a pipeline in the gathering system	• Excavation • Earthquake • Corrosion/mechanical failure	• Jet fire • Severe heat and radiation flux at the point of rupture • Potential fatalities / serious injuries to Third Parties	• Selection and placement of pipeline easement • Materials of construction • Where applicable design standards for potential earthquake loads • Depth of cover • Pipeline markers and signage • Remote monitoring of pressure and flow • Isolation at mid line valves

Hazard	Cause	Consequence	Safety Management
			• Emergency response procedures
Pipe rupture at compressor or inspection stations	• Mechanical failure of pipe / flanges / valves • Vehicle impact • Earthquake • Bush fire	• Jet fire • Severe heat and radiation flux at the point of rupture • Serious injury to Third Party observing from boundary of secured area • Potential fatality of operational or maintenance staff attending to a the plant	• Quality assurance of installed equipment • Design standards for potential earthquake loads • Inspection and condition monitoring program • Secured area around compressor and inspection stations • Area around compressor and inspection stations cleared of vegetation • Remote monitoring of pressure and flow • Remotely operated isolation upstream and down stream of compressor and • Emergency response procedures
Uncontrolled detonation of explosives	• Vehicle engine fire as an ignition source leading to detonation • Vehicle collision/roll-over • Misfire • Premature detonation • Over charge	• Potential Fatality/Serious injury to workers • Potential impact to Third Parties involved in a collision • Potential rupture of adjacent gas pipeline (Refer risk called "Rupture of adjacent pipeline".	• Suitably qualified explosives operator (giving consideration to equipment maintenance, training and procedures) • Designated routes for the transportation of dangerous goods • Appropriate controls for transportation as specified in the QLD Dangerous Goods Safety Management Act.
Blow-out of gas at a well head and subsequent fire	• During construction drilling • Mechanical failure of the well head • Vehicle impact • Earthquake • Bush fire	• Jet fire • Severe heat and radiation flux at the well head • Serious injury to Third Party observing from boundary of secured area • Potential fatality of operational or maintenance staff attending to a well head	• Quality assurance of installed equipment • Inspection and condition monitoring program • Secured area around well heads • Area around well heads cleared of vegetation • Remote monitoring of pressure and flow • Adequate isolation at downstream of the well. • Emergency response procedures, including well control response plan.
Gas leak from pipeline infrastructure	• Faulty valve • Faulty flange/seal • Earthquake	• Fire • Serious injury to Third Party	• Design standards for potential earthquake loads, where applicable. • Gas leak detection • Quality assurance of installed equipment • Inspection and condition monitoring program • Secured area around aboveground pipeline infrastructure • Emergency response procedures • Materials of construction. • Engineering design.
Accommodation fire involving combustible construction, LPG or Diesel	• Electrical fault • Naked flame • Hot oil or surfaces in kitchen	• Loss of a number of buildings at the accommodation facility • Injury/death of workforce accommodation facility occupant	• Smoke detection in accommodation buildings • Manual fire fighting equipment • Separation of diesel storage • Emergency response procedures
Diesel fire involving	• Vehicle engine fire as an ignition source to the fuel	• Vehicle fire / fire ball • Potential explosion	• Suitably qualified fuel transport operator (giving consideration to

Hazard	Cause	Consequence	Safety Management
mobile fuel tanker	tank • Naked flame • Vehicle collision/roll-over	• Potential Fatality/Serious injury to driver • Potential impact to Third Parties involved in a collision	vehicle maintenance, driver training and procedures)

10.3.2.4 Gas Transmission Pipeline Hazard Assessment

Again in this section, a semi-quantitative risk assessment as per the Australian Standard for natural gas pipelines has been applied. This does not call for a quantitative risk assessment for the purpose of this study and hence no risk contours have been developed. However, other project technical reports including the Pipeline Project Pre-FEED Conceptual Hazard Study (GHD, 2008), have undertaken quantitative assessment. The quantitative assessment shows that in the event of a full bore rupture of a pipeline there would be off-site impacts. Further analysis of the safety risk determined that the risk contours for such an event are within the societal tolerance limits set out in the New South Wales Department of Planning's *Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning (Marsh, 2008).*

In terms of property damage, the section of pipeline through the Yarwun Neck is a 'Common Infrastructure Corridor' as defined by the Australian Standard for gas and liquid petroleum pipelines (AS 2885.1, 2007) and a pipeline rupture in this region could impact multiple infrastructures. Coexisting with this section of the pipeline are other third party pipelines, a railway and main road heading north from Gladstone. Power transmission lines also traverse the area. However the proposed design meets all of the requirements of the Australian Standard. Another potential off-site impact could be due to a transportation accident involving explosives which may be used for various parts of construction of the pipeline trench.

The hazards identified along the gas transmission pipeline are outlined in Table 10.3.4.

Table 10.3.4 Main Pipeline Hazards

Hazard	Cause	Consequence	Safety Management
Underground pipe rupture of transmission pipeline	• Excavation • Dredging or anchorage in the channel • Earthquake	• Jet fire • Severe heat and radiation flux at the point of rupture • Potential fatalities / serious injuries to Third Parties	• Selection and placement of pipeline easement • Materials of construction • Design standards for potential earthquake loads • Depth of cover • Pipeline markers and signage • Remote monitoring of pressure and flow • Remotely operated isolation at mid line valves • Emergency response procedures
Pipe rupture at main line valve sites.	• Mechanical failure of pipe / flanges / valves • Vehicle impact • Earthquake • Bush fire	• Jet fire • Severe heat and radiation flux at the point of rupture • Serious injury to Third Party observing from boundary of secured area • Potential fatality of operational or maintenance staff attending to a well head	• Quality assurance of installed equipment • Design standards for potential earthquake loads • Inspection and condition monitoring program • Secured area around main line valve sites. • Area around compressor and inspection stations cleared of vegetation • Remote monitoring of pressure and flow • Remotely operated isolation upstream and down stream of compressor and • Emergency response procedures
Rupture of adjacent gas pipeline	• Use of explosives during construction of	• Jet fire • Severe heat and	• Pipeline survey • Controlled use of explosives by trained and

Hazard	Cause	Consequence	Safety Management
	own pipeline • Impact due to unknown location during excavation or horizontal directional drilling	radiation flux at the point of rupture • Potential fatalities / serious injuries to construction workers • Business interruption to Third Party pipeline operator	licensed contractors • Emergency plan for Third Party pipeline
Uncontrolled detonation of explosives	• Vehicle engine fire as an ignition source leading to detonation • Vehicle collision/roll-over • Misfire • Premature detonation • Over charge	• Potential Fatality/Serious injury to workers • Potential impact to Third Parties involved in a collision • Potential rupture of adjacent gas pipeline (Refer risk called "Rupture of adjacent pipeline".	• Suitably qualified explosives operator (giving consideration to equipment maintenance, training and procedures) • Designated routes for the transportation of dangerous goods
Gas leak from pipeline infrastructure	• Faulty valve • Faulty flange/seal • Earthquake	• Fire • Serious injury to Third Party	• Design standards for potential earthquake loads • Gas leak detection • Quality assurance of installed equipment • Inspection and condition monitoring program • Secured area around aboveground pipeline infrastructure • Emergency response procedures
Drop of pipe from pipe lifts	• Improper lifting technique • Strap/chain failure • Mechanical failure • Operator error	• Injury or death	• Lifting procedures. • Equipment maintenance. • Competent operators
Accommodation fire involving combustible construction, LPG or Diesel	• Electrical fault • Naked flame • Hot oil or surfaces in kitchen	• Loss of a number of buildings at the accommodation facility	• Smoke detection in accommodation buildings • Manual fire fighting equipment • Separation of diesel storage • Emergency response procedures
Diesel fire involving mobile fuel tanker	• Vehicle engine fire as an ignition source to the fuel tank • Naked flame • Vehicle collision/roll-over	• Vehicle fire / fire ball • Potential explosion • Potential Fatality/Serious injury to driver • Potential impact to Third Parties involved in a collision	• Qualified fuel transport operator (giving consideration to vehicle maintenance, driver training and procedures)

10.3.2.5 LNG Facility Hazard Assessment

The PHA report in Appendix FF considered two competing liquefaction processes for the LNG facility design. These included the Optimized Cascade process (OCP) and the Propane Pre-cooled Mixed Refrigerant (C3MR) process. Subsequently the OCP process technology was chosen by Santos (refer Section 2.3.3. for further details).

Plot plans have been provided by the engineering contractor for the OCP design and have been used in the analysis of the hazards. In evaluating the hazards associated with the proposed LNG facility it should be noted that detailed design information is not yet available. Accordingly, a number of assumptions regarding the likely process conditions have been made. These assumptions have been conservative in nature and will almost certainly overestimate the hazards associated with the final design of the facility. Further detailed risk analyses, which are required in order to obtain approvals to operate the facility, will be conducted during the detailed design stage.

Each LNG facility hazard identified is presented in Table 10.3.5.

For the LNG facility, for each of the potential worst case scenarios involving the hazards identified, consequence modelling has been performed. Contours showing the hazard end points have been overlaid on a plot plan (refer to PHA report in Appendix FF). The hazards and potential scenarios modelled to determine the 'hazard end point'[1], are included below.

- Loss of containment of natural gas or liquid natural gas in the process from various points of release, including the product loading facility (PLF);
- Loss of containment of refrigerant gas or liquid from various points of release;
- Fire within the facility involving process or refrigerant liquids in storage; and
- Explosion of an unpurged vessel during decommissioning.

It was found that most of the hazards did not result in an off-site impact with the design parameters that are already set. There were two scenarios where the hazard end-point extended over the site boundary bordered by the coastline in an area which is not occupied and will not be built upon. It is therefore concluded that a significant hazard is not present. The parameters required for modelling of the refrigerant circuit are not all yet known (i.e. pipe sizes), so that the modelling performed here is performed for an assumed pipe size. Depending on the pipe size, it is possible to have an off-site impact for a scenario involving the refrigerant circuit. The modelling undertaken here therefore shows the maximum pipe size before an off-site impact could occur and this risk will be managed through detailed engineering. With regard to a loss of containment on the PLF, the modelling shows that the hazard end point is 186 metres and hence a safety zone of 200 metres radius, centred around the vapour manifold is recommended during LNG transfer onto a ship. A detailed assessment was undertaken and the results (including modelling results) are presented in the PHA report in Appendix FF.

No risk contours have been undertaken in this study because there are no off-site impacts that affect people or property.

Table 10.3.5 LNG Facility Hazards

Hazard	Cause	Consequence	Safety Management
Uncontrolled release of LNG	• Mechanical failure of pipe / flanges / seals / valves • Process control failure • Vehicle impact • Earthquake • Bush fire • Sea surge	• Fire ball / Jet Flame / vapour cloud explosion (VCE) • Potential fatality of workers	• Layout of plant to minimise impact, and passive protection of critical equipment from radiation and overpressure • Safety zone of 200 m around the vapour manifold during transfer of LNG onto a ship. • Establish a safety zone of 200 m radius during transfer, with tug deployed to render assistance to the LNGC in the case of an emergency and to patrol the edge of the zone in order to warn other craft of the existence of the zone and to discourage

[1] The hazard end point is defined as the distance from the source of a hazard to the point at which the impact from the potential consequences is at a level that is considered not to be a threat to human safety. The criteria for hazard end points are set by the relevant design standards as well as the New South Wales Department of Planning, Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning.

Hazard	Cause	Consequence	Safety Management
			vessels from entering the zone. • All support craft will be fitted with spark arrestors • Only essential authorised personnel will be permitted on the PLF during loading • Elevation of site in relation to the risk of sea surge • Design standards for potential earthquake loads • Quality assurance of installed equipment • Inspection and condition monitoring program • Impact avoidance and protection (e.g. Barriers, bollards and curbing) • Area around plant cleared of vegetation • Process monitoring and robust control system • Electrical equipment rating in accordance with hazardous zones • Emergency shut-down system with remote isolation of storage vessels • Emergency response procedures
Uncontrolled release of refrigerant gas	• As above	• As above	• As above
Uncontrolled release of by-product toxic gases (e.g. H_2S, CO, CO_2)	• As above	• Potential localised toxic atmosphere	• As above
Plant fire involving pressure vessel of hydrocarbons	• Uncontrolled release and fire of flammable gas (Refer risks of "Uncontrolled release of LNG")	• Boiling Liquid Expanding Vapour Explosion (BLEVE) • Potential fatality of workers	• Ground level contours to drain dense flammable gases away from vessels of hydrocarbons • Fire protection over pressure vessels of hydrocarbons • Emergency response procedures
Uncontrolled release of product on PLF	• Mechanical failure of pipe / flanges / seals / valves • Connection error • Vessel impact • Earthquake • Sea surge	• Fire ball / jet flame • Potential fatality/serious injury to Third Party in shipping lane, Property damage	• Quality assurance of installed equipment • Inspection and condition monitoring program • Port control and berthing procedures • Port procedures for severe weather and sea surge warning • Design standards for potential earthquake and sea surge loads • Electrical equipment rating in accordance with hazardous zones • Emergency shut-down system with remote isolation of storage vessels • Emergency response procedures
Fire in process plant (e.g. Cable, lubrication oil, transformer, etc.)	• Electrical fault • Hot work	• Impact to Third Parties (considering distance of separation)	• Hot work procedure • Installation of electrical equipment to electrical standards • Fire separation of critical equipment • Condition monitoring of switch gear and transformers • Fire detection in switch rooms • Fire protection in switch rooms and over transformers

Hazard	Cause	Consequence	Safety Management
			• Fire walls shielding critical equipment from transformers • Secondary containment of equipment with liquid combustible materials
Gas explosion during maintenance or decommissioning	• Flammable vapour in unpurged vessel	• Explosion • Fatality of workers	• Decommissioning Plan • Confined space procedure • Hot work procedure

10.3.3 Shipping

The Regional Harbour Master (RHM) and Maritime Safety Queensland (MSQ) pilots have been actively involved in real-time navigation simulation sessions and LNG shipping related workshops. The RHM has also participated in the design of navigational areas and the development of operational procedures. There has been a close working relationship between the two parties and this will continue in the future.

As part of the risk assessment process Lloyd's Register North America Inc (Lloyd's Register) carried out a risk assessment specifically for an LNGC transiting Gladstone Port to/from the proposed berths on Curtis Island. This risk assessment report is presented in the PHA report in Appendix FF.

Lloyd's Register has extensive experience of assessing port risks, particularly in the LNG sector. In addition to the review of industry best practice, Lloyd's Register (in conjunction with industry specialists) carried out a systematic hazard identification exercise (HAZID) of different failures of equipment, people and processes for the ship transit. The purpose of the HAZID was to apply a rigorous format of examination in order to demonstrate that all credible scenarios and accidental events have been considered for operations in the project.

Based on the assessment undertaken the following conclusions have been drawn:

- There are a number of hazards with potential for a major incident should there be a lack of sufficient control in managing the transit of the LNGC to the berth;
- Key hazards include the passage through the South Channel, transit past other facilities at Auckland Point and other berths, and interaction between the LNGC and support vessels during transit. However Gladstone Port is extremely safe, with navigation features, support systems and redundancy all contributing towards a low risk of an incident during transit; and
- The route through the port meets industry criteria for channel draught, angles of turn and turning basin even for large beam LNGCs. It should be noted that the largest vessels transiting through the Port are, and will remain, the Capesize coal carriers and that LNGC are more manoeuvrable and have a higher power to weight ratio than these vessels.

The high level comparison with industry criteria identified that the channel width was less than recommended. However it was accepted that specific modelling of transit through the port could provide acceptable specific requirements for channel width. A reduced channel width is acceptable given a scenario specific risk assessment and implementation of appropriate mitigation measures. Such an assessment and demonstration of acceptability has been undertaken as part of the simulation studies.

The quantitative assessment of incidents occurring during the transit showed that the likelihood was extremely low, being less than 2.2 per 1,000 per LNGC visit. The assessment concluded that the societal risk from the transit of LNGC through Gladstone Port is negligible.

Further to the Lloyd's Register risk assessment, Santos has further mitigated shipping risk through navigation simulations and workshops in regards to: arrival and departure transits through the Port; swinging, berthing and unberthing requirements; operational thresholds; ship manoeuvring procedures; safety zones and interaction with other vessels.

Santos is working with RHM, Gladstone Ports Corporation (GPC), MSQ and the LNG industry to develop risk minimisation measures for LNGC as follows:

- LNGCs will be under active (tethered) tug escort during the transit through the port (inbound and outbound). This provides an increased margin of safety as the tugs can control the ship in the event of emergency. The precise tug strategy is still under development;
- All support craft assisting LNGC will be fitted with spark arresters;
- The LNGC ships manoeuvring operational limits in relation to berthing and departing are currently under development and subject to further navigation simulation tests but will potentially be as follows:
  - Wind in any direction above 25 knots (as measured at the RHM office).
  - Waves up to 2.5 m heights at Pilot Boarding Station. This has been assessed as the safe limit in which a pilot transfer from launch and tug effectiveness in the outer channel can be obtained.
  - Visibility limit presently set to see at least two navigational beacons ahead of the LNGC ship in motion. Studies are currently on-going to establish a better understanding of visibility in the Port and the possible use of electronic chart display information system/portable pilot unit (ECDIS/PPU) to aid in navigation during reduced visibility. Typically the minimum visibility for LNGC ships at other LNG facilities and Ports is one nautical mile.
  - Minimum underkeel clearance (UKC) is 10 % of the LNGC draught under normal operations and a minimum 1 m UKC in the event of an emergency departure.
  - No tidal current or height restrictions expected.
- Water speed restrictions, commensurate with intended tug escorts, are likely to be as below:
  - South Channel and Gatcombe Channel, a speed restriction set at ten knots in waves below 1.5 m and eight knots in waves 1.5 to 2.5 m.
  - Inner channels and Central Port Area, a speed restriction set at eight knots and this speed will be reduced as required when passing Barney Point Wharf.
- Interaction with other vessels is still being assessed. The focus of vessel interaction assessment within the port is the potential speed and distance restrictions for passing ships moored on the existing Boyne Point Wharf, Barney Point Wharf and Clinton Wharfs. Note that the displacement of LNGC is less than that of a Cape Class coal carrier, thus speed and passing restrictions may be relaxed from the present limit of six knots over water depending on the outcome of future assessments;
- Safety zones will be applied to the LNGC while they are on berth. The present port operation rules are as follows:
  - Whilst a LNGC is on berth a safety and security zone will be declared around the vessel through which other craft should not transit. Whilst a LNGC is on berth a standby tug will also be deployed to assist in the event that emergency deberthing is necessary. This tug could also be used to warn other craft of the existence of the zone and to discourage vessels from entering this zone. The tug will also be outfitted with full fire fighting and rescue capability such that it can render assistance in the unlikely event that an incident occurs.
  - The safety zone has been determined by a quantitative risk assessment (QRA) as a circle of radius 200 metres around the LNGC vapour manifold (refer to PHA report in Appendix FF). The need for any additional security zones beyond the safety zone has still to be established.
- Safety measures will be applied to the LNGC while in berth and in transit including:
  - The LNGC will be under active tug escort as they transit through the Gladstone Port. This provides the ability to stop an LNGC within a few ship lengths in the case of an emergency. The present port operation rules set a distance ahead and astern of deep draught (defined as vessels which need to use the dredged channels for transit) moving vessels on the basis of the time taken for the vessel to safely transit the outer channels. Should an incident occur with a vessel in the outer channels then another vessel can abort the transit (abort points are the emergency anchorages located in deep water inside Facing Island for outbound vessels and offshore for inbound vessels). The separation distances are therefore a function of vessel draught and range

between 40 minutes and one hour for deep draught vessels. These present rules will be applied to LNGC.

- With the present channel configuration, it has been agreed with the RHM that no deep draught vessels will be permitted to pass an LNGC (either overtake or move in the opposite direction) whilst it is in transit through the Gladstone Port. This will have an impact on the scheduling of deep draught ship movements.
- In addition to the above it is normal practice to have a moving safety zone around large ships in transit into which other craft should not enter. LNGC are no different to other ships in this regard. The subject of moving safety and security zones is still under discussion with the RHM, but a working assumption is that no other craft should pass with one nautical mile in front of a large ship in transit nor approach closer than the edge of the channel marker buoys (i.e. nominally 100 m off the ship). Although this depends upon the size and heading of the other vessels, which then creates a case by case assessment of vessel interaction. The MSQ pilots will advise the RHM and the Ship's Master if they feel an emergent situation is unsafe.

- Studies are currently on-going to establish improvements to the aids to navigation in the Port (for the benefit of all users), including upgrading of existing aids to navigation and installation of the following new aids to navigation:
  - Electronic Charts.
  - Realtime metocean information and site specific forecasts/predictions being accessible at the RHM office, at the LNG terminal, and on board the vessel.
  - Pilot Portable Units (PPUs) – carried on board by pilots to provide realtime information on the ship's position (present and predicted) overlain on dynamic realtime electronic charts, other vessel movements in the area, and realtime metocean information.
- Full and comprehensive pilot and tug master LNG familiarisation and proficiency training; and
- Shipping also has potential risk to the marine environment including introduction of exotic organisms, ballast water, and ship wastes. To reduce these risks ballast water will be exchanged offshore before the vessel enters the Port and bagged waste will be disposed of at berth.

The GPC is aware of the expected harbour traffic and is planning for the potential cumulative impact of increased shipping from the Santos LNG facility on both the existing ship traffic and that from other proposed Gladstone LNG projects. Santos is supporting the GPC's work on a maritime traffic strategy, which will ensure the harbour can sustain the expected increase in demand for ship movements.

10.3.3.1 Shipping in the Great Barrier Reef Marine Park

Shipping in the Great Barrier Reef Marine Park (the Marine Park) is managed by several government agencies including the Australian Maritime Safety Authority, MSQ, the Great Barrier Reef Marine Park Authority and the Department of Infrastructure, Transport, Regional Development and Local Government. The Great Barrier Reef Marine Park Authority (GBRMPA) is the principal adviser to the Australian Government on the management and development of the Marine Park. GBRMPA's role includes regulating the entry and use of the Marine Park by ships and other vessels through the Great Barrier Reef Marine Park Zoning Plan 2003 (the Zoning Plan).

As prescribed by the Zoning Plan, ships may transit the Marine Park through the general usage zone or through other designated shipping areas by permit.

The shipping area designated in the Zoning Plan is designed to minimise the potential impact on the shipping industry whilst having regard for Australia's international obligations. The placement of the designated shipping area reflects vessel usage patterns in the inner and outer shipping routes, existing recommended tracks, and new routes to allow for growth in shipping (GBRMPA, 2003a).

As described in Sections 3.3 and 3.9, the LNG will be stored and transported as an unpressured liquid in ships specifically designed to transport LNG. LNGC are double-hulled ships and are specially designed to prevent leakage or rupture. For the 3 - 4 Mtpa Train 1 LNG facility (assuming 155,000 m^3 capacity ships), there will be approximately 50 ship loads of LNG exported each year, or about one ship per week. This rate will increase to 160 ships per year or about one ship every two days when the three trains have been constructed and the production rate increases to 10 Mtpa. Using larger ships will involve correspondingly fewer ship movements (see Section 4).

Risks to the Environment

In 2003 the GBRMPA finalised a Great Barrier Reef and Torres Strait Shipping Impact Study. The report identified a series of risks posed to the Great Barrier Reef by shipping. These risks included:

- Maritime incidents in the region - shipping accidents can occur through collisions, groundings, foundering or stranding. Groundings and collisions make up around 45 % of shipping accidents.
- Oil pollution and spills;
- Harmful effects of anti-fouling systems;
- Introduced invasive marine pests - ballast water and hull fouling;
- Discharge of waste at sea;
- Air quality;
- Interaction between trading ships and small craft;
- Anchorages;
- Erosion and bottom disturbance; and
- Heritage and cultural considerations.

The impact study then identified mechanisms for addressing the potential adverse impacts, and these were incorporated as appropriate into the Zoning Plan.

The following describes how the identified risks relate to the shipping activities of the GLNG Project.

Maritime incidents in the region

The LNG industry has had an impressive safety record over the last 47 years (URS, 2007). Since international commercial LNG shipping began in 1959, for example, tankers have carried over 33,000 LNG shipments without a serious accident at sea or in port. Insurance records and industry sources show that there were approximately 30 LNG tanker safety incidents (e.g. leaks, groundings or collisions) through 2002. Of these incidents, 12 involved small LNG spills, which caused some freezing damage but did not ignite. Two incidents caused small vapour vent fires, which were quickly extinguished.

Section 3.9 provides more details on ship design, and Section 3.3 provides more detail on the safety risks associated with an LNG leak.

Oil pollution and spills

According to Lloyd’s Register (2008), all newer ships have double hull protection around the forward and aft bunker fuel tanks. However, on some of the approximately 30 year old LNGC, the engine room bunker fuel tanks are not within the double hull. For fuel efficiency and boiloff rate reasons, many of these older vessels will no longer be carrying LNG cargo by the time Gladstone LNG terminal starts operations.

As described in Section 3.9, the LNGCs are most likely to be powered by gas turbines and will carry no or very limited quantities of bunker fuel.

Given the small number of possible voyages over the first five years of terminal operation using the older LNGC, the likelihood of a bunker spill is almost non-existent the same as a cargo tank breach.

Harmful effects of anti-fouling systems

The International Maritime Organisation has developed a protocol for banning the use of Tributyl tin (TBT) on all ocean going ships by 2008 (GRRMPA, 2009). No TBT is to be applied or reapplied after 1 January 2003 and by 1 January 2008, no ships will have TBT on their hulls, or at the least, any existing TBT must be covered. In Australia, this initiative is being supported through the Antifouling Program as part of Australia's Oceans Policy.

Introduced invasive marine pests - ballast water and hull fouling

In 1998, the Australian Government announced its intention to develop a national system for addressing introduced marine species in Australia's Oceans Policy (GBRMPA, 2009). Since that time, the National Introduced Marine Pests Coordination Group (comprising representatives from the Australian Government and State and Territory Governments, marine industries, scientists and conservation organisations) has been developing a National System for the Prevention and Management of Marine Pest Incursions. The National System has three core elements:

1) **Prevention**: mechanisms to reduce the risk of introduction and translocation of marine pests;
2) **Emergency response**: systems to ensure coordinated emergency responses to any new incursions and translocations; and
3) **Ongoing management and control**: a coordinated management system for the ongoing management and control of introduced marine pests already in Australian waters.

In April 2005, an Intergovernmental Agreement on a National System for the Prevention and Management of Marine Pest Incursions was signed by the Australian Government and several State and Territory Governments (GBRMPA, 2009). The Agreement was developed to ensure that measures to address introduced marine species are coordinated across jurisdictional boundaries, and that they are consistent with current or future international agreements relating to introduced marine species.

International measures are also being taken to prevent the introduction of these species in Australian waters from ballast water (GBRMPA, 2009). An International Convention for the Control and Management of Ships Ballast Water and Sediments 2004 was recently developed to help reduce the risk of harmful aquatic organisms and pathogens being introduced by ships entering ports. Although it has yet to come into force, the Convention specifies that ballast water exchange should occur outside of the Great Barrier Reef Marine Park. When these requirements cannot be met, areas may be designated where ships can conduct ballast water exchange.

Santos will keep abreast of the national and international legislative requirements, and will ensure that charter parties adopt the necessary controls to ensure compliance with any international conventions.

Discharge of waste at sea

The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) regulates the discharge of operational ship-sourced pollutants (GBRMPA, 2009). Within the Great Barrier Reef, MARPOL is implemented through the *Protection of the Sea (Prevention of Pollution) from Ships Act 1983*, *Transport Operations (Marine Pollution) Act 1995* and the *Great Barrier Reef Marine Park Act 1975*.

MARPOL has six technical annexes, each regulating a particular type of pollution. Annexes I and II regulate oil and bulk noxious liquid substances. The MARPOL annexes describe the conditions under which these substances can be discharged, as well as design specifications for ships to minimise these discharges.

In addition, MARPOL places a duty on the ship's Master or operator to report any incident that involves a discharge or probable discharge of oil, noxious liquid substances or harmful packaged substances (GBRMPA, 2009).The ship's Master or operators are also obliged to report any damage, failure or breakdown that affects the safety of the ship or reduces the ship's ability to navigate safely.

Santos will expect charter parties to comply with the requirements specified through MARPOL.

Air quality

Minimising the impact of air pollution is addressed through annex VI of MARPOL (GBRMPA, 2003). The key features of the convention include the prohibition of deliberate emissions of ozone depleting substances, including halons and chlorofluorocarbons (CFCs); limits on emissions of nitrogen oxides (NOx) from diesel engines; and prohibition of the incineration on board ship of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs).

Santos will expect charter parties to comply with the requirements specified through MARPOL.

Interaction between trading ships and small craft

The 2003 GBRMPA impact study identified that between 1991 and mid-2002, the Australian Transport Safety Bureau (ATSB) investigated 12 collisions between trading ships and smaller vessels off the coast of Queensland. Nine of the collisions occurred in the waters of the Great Barrier Reef and in all cases except one, the smaller vessel was a fishing trawler. The ATSB also investigated two reports of close quarters between trading vessels in the Great Barrier Reef.

The reports of the investigations identified non-compliance with aspects of the International Regulations for Preventing Collisions at Sea, 1972 (COLREGS) by both trading ships and fishing vessel crews. Non compliances included inadequate watch keeping, failing to keep a proper lookout, unsafe speed or inappropriate lights and were factors in most of these collisions. Other contributing factors included lack of marine training of crews of fishing vessels and fatigue.

GLNG will expect charter parties to comply with COLREGS.

Anchorages

The 2003 GBRMPA impact study identified that impacts of anchoring can be ameliorated by identification of preferred anchorage sites where anchoring will cause minimal environmental impact, or provision of dedicated public or private mooring points (GBRMPA, 2003). GLNG will expect charter parties to comply with the Zoning Plan, and undertake best environmental practices when anchoring.

Erosion and bottom disturbance

GLNG will expect charter parties to comply with the requirements of the Zoning Plan.

Heritage and cultural considerations

GLNG will expect charter parties to comply with the requirements of the Zoning Plan.

10.3.4 Cumulative Effect

Where there is no off-site impact, the cumulative effect on risk to surrounding land use is unchanged. From the consequence modelling performed, this is shown to be the case for the LNG facility.

In the case of a full bore rupture of the gas transmission pipeline where an off-site impact could occur, the cumulative effect does increase the overall risk due to adjacent pipelines along certain sections of the gas transmission pipeline route and the hazard already present. However, in this case it is considered that not all of the causes of a pipe failure would result in the failure of another or multiple pipelines at the same time. Therefore the cumulative risk is less than the sum of the risk of another or multiple pipelines which is considered to remain low due to the low likelihood of occurrence.

The assessment concluded that the societal risk from the transit LNGC through Gladstone Port is negligible.

10.3.5 Aviation Hazard Assessment

The potential hazards that the GLNG Project operations pose to aviation safety have been assessed in accordance with the Civil Aviation Safety Authority's Advisory Circular 139-05(0) *Guidelines for conducting plume rise assessments* (2004). There are two aerodromes in the vicinity of the LNG facility that warrant consideration due to buoyant stack emissions from the plant; namely the Gladstone Aerodrome and the proposed Kangaroo Island Aerodrome.

Details of the plume rise assessment that has been undertaken for the project are provided in Appendix CC. The potential sources of buoyant plumes in the CSG fields are the field compressor stations. Due to the low heat output, low volume flows and the small stack heights of these sources, these sources will not pose a risk to aviation safety. There are no combustion sources along the gas transmission pipeline corridor; hence no aviation safety assessment has been carried out in this area.

The proposed operations at the LNG facility involve thermal emissions from a range of sources on the site, including gas turbine exhausts, flares, heater flues and cooling towers, with the total rate of heat released being in the range of several gigawatts. Given the quantity, velocity and temperature of these emissions, the resulting plumes have the potential to travel at relatively high vertical velocities.

10.3.5.1 Aviation Safety Requirements

The protection of airspace in the vicinity of an airport is achieved through maintaining the Obstacle Limitation Surface (OLS) free of interference from physical or non-visible (e.g. buoyant plume) intrusion into this region.

Under CASA's regulations, plumes from industrial sources that exceed a vertical velocity of 4.3 m/s at the OLS or higher are considered to be a potential hazard to the safety of operating aircraft. Likewise, physical structures that penetrate the OLS are a hazard to aircraft safety.

For the Gladstone Aerodrome and proposed Kangaroo Island Aerodrome, the lowest OLS applicable at the LNG facility location is 160 m above sea level. The stacks at the LNG facility have a maximum height of 87 m (with base elevation of 16 m) for the flare stacks, and thus do not reach the OLS. However, the release velocities are up to 38 m/s (for the power generation turbines), which require an assessment of the potential hazards to aviation.

10.3.5.2 LNG Facility Assessment

The LNG facility, at both the 3 Mtpa and 10 Mtpa capacities, was assessed using the CASA methodology to determine the frequency and magnitude of the plume vertical velocity and plume horizontal extent. The facility will be constructed as three LNG trains, each with the same equipment.

The emission characteristics for the compressor turbines, power generation turbines, flares, regeneration oil heaters, hot oil heaters and cooling tower assemblies were compiled into a model that simulates the rise of each plume through the atmosphere. The merging of these plumes, with resultant enhancement in the buoyant behaviour of the plumes, has also been evaluated to obtain the worst-case conditions from the facility.

The assessment showed the refrigeration compressor turbine exhausts and associated cooling towers to be the dominant sources of thermal buoyancy, emitting a total of 85 % and 88 % of the total buoyancy flux for the 3 Mtpa and 10 Mtpa designs respectively. The potential plume buoyancy enhancement effects from merging of these buoyant plumes have been evaluated in the assessment.

Maximum critical height of 969 m and 1460 m were predicted for the fully merged 3 Mtpa and 10 Mtpa operations scenarios respectively. The assessment has shown that the buoyancy of the plumes from the LNG facility has the potential to affect the OLS which protects the airspace around Gladstone Aerodrome and the proposed Kangaroo Island Aerodrome.

Whilst this assessment is considered conservative with respect to the plume merging methodologies and operating conditions, consideration should be given for the facility to be designated a potential hazard to aircraft operators in the area. The implementation of such designation is at the discretion of the Civil Aviation Safety Authority (CASA).

10.4 Health and Safety Management

Health and safety for the GLNG Project (as for any Santos project) will be managed in accordance with legislative requirements and Santos' internal Environment, Health and Safety Management System (EHSMS), as described below.

10.4.1 Santos Environment, Health and Safety Management System

The Santos EHSMS applies to all Santos operations. The framework has been developed to ensure that Santos' system is compliant with Australian Standard 4801 2000 Occupational health and safety management systems – Specification with guidance for use, and AS/NZS ISO 14001:1996 Environmental management systems – Specification with guidance for use.

The EHSMS framework consists of multiple layers, the key components being management and hazard standards, as shown below in Figure 10.4.1.

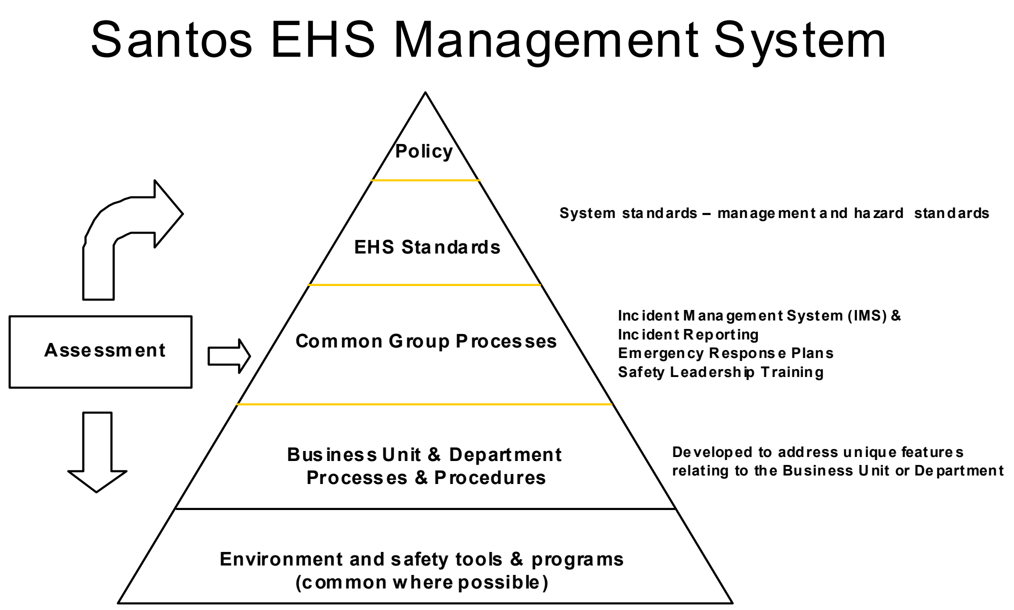

Figure 10.4.1 Santos EHS Management Framework System

The EHSMS is a company-wide system that describes the requirements for effective environmental and safety practice across all of Santos' activities and operations. The EHSMS requirements address the management of risk associated with high frequency / low consequence events (the focus of traditional EHS management systems) as well as low frequency / high consequence events which are typically dealt with by a Process Safety management system. The application of the EHSMS enables us to achieve the objectives detailed in Santos' Environment and Health and Safety policies. The EHSMS standards can be broken down into two basic areas comprising management standards and hazard standards. Management standards are documents which define the requirements necessary to ensure that environmental, health and safety and process safety risk is systematically managed. Hazard standards are documents which detail the controls required to manage the risks of specific hazards to acceptable levels.

The EHSMS provides a clear set of environment, health and safety (EHS) expectations so that there is a consistent, efficient approach across the company.

All Santos employees and contractors are responsible for contributing to a safe and environmentally responsible workplace. This means conducting day-to-day activities according to the EHSMS standards which in part focus on the continual identification of hazards and implementing effective risk control measures. Everyone is encouraged to suggest ways Santos can improve its safety and environmental performance via toolbox meetings, EHS committee meetings or by contacting their Supervisor, their Health and Safety Representative, an EHS adviser or Santos' Corporate EHS&S Department.

The EHSMS is a dynamic system which is continually being improved to ensure it is current and aligned with the changing nature and demands of our business such as our expanding interest in offshore developments. This revision of the EHSMS includes the integration of process safety requirements which now provides a consolidated framework for the management of process safety related risk. This initiative provides a systematic approach to process safety that will enable Santos to further improve on the reliability and integrity of its plant and equipment which in turn will support the ongoing improvement in EHS performance.

10.4.1.1 Santos Health and Safety Policy

Santos' Health and Safety Vision is as follows:

"We all go home from work without injury or illness."

We believe that:

- *No business objective will take priority over health and safety.*
- *All injuries are preventable.*
- *No task is so important or urgent that it cannot be done safely.*
- *Without diminishing management's obligations, the responsibility and accountability for health and safety rests with every individual.*

At Santos we are committed to conducting our business in a matter that prevents injury or illness to employees, contractors, customers and the public who may be affected by our work activities. We encourage best practise in health and safety management within this wider Santos community.

To achieve this we will:

- *Maintain and continuously improve the Environmental, Health and Safety Management System (EHSMS) across the organisation.*
- *Proactively pursue the identification of all hazards and eliminate or, if not possible, manage the risk to as low as reasonably practicable.*
- *Consult with and promote active participation of employees in the management of their own and others' health, wellbeing and safety.*
- *Require that companies providing contract services to Santos manage their health and safety in line with this Policy.*
- *Provide resources to achieve a systematic approach to health and safety management to ensure continuous performance improvement.*

- *Identify performance measures, set improvement targets, measure and report performance at all levels.*
- *As a minimum comply with relevant legal and other requirements.*
- *Develop a culture where all employees and contractors are constantly aware of hazards around them and act accordingly at and away from work.*
- *Include health and safety performance in the appraisal of employees and contractors and recognise accordingly.*
- *Steward the safety performance of Joint Venture activities operated by others. (EHSMS Guide)*

A GLNG Health and Safety Policy has been developed and can be reviewed in Appendix BB.

10.4.1.2 EHSMS Management Standards

Management standards are documents which define the requirements necessary to ensure that environmental, health and safety risk is systematically managed.

Management standards developed as part of this EHSMS are shown in Table 10.4.1.

Table 10.4.1 Management Standards

Standard No	Name of Management Standard
EHSMS 01	EHS Policies
EHSMS 02	Legal and Other Obligations
EHSMS 03	EHS Objectives and Targets
EHSMS 04	EHS Improvement Plans
EHSMS 05	Responsibility and Accountability
EHSMS 06	Training and Competency
EHSMS 07	Consultation and Communication
EHSMS 08	Document and Records Management
EHSMS 09	Hazard Identification, Risk Assessment and Control EHSMS 9.1 Job Hazard Analysis (JHA) and Stepback EHSMS 9.2 Hazard Studies EHSMS 9.3 Workplace Inspections EHSMS 9.4 Behavioural Improvement EHSMS 9.5 Environmental Impact Assessment and Approvals
EHSMS 10	Contractor and Supplier Management
EHSMS 11	Santos Operations EHSMS11.1 Operated by Others EHSMS11.2 Design and Handover of Operating Facilities and Decommissioning and Abandonment EHSMS11.3 Pipeline Management EHSMS11.4 Onshore Well Suspension and Abandonment
EHSMS 12	Management of Change EHSMS 12.1 PandID and Control System Change EHSMS 12.2 Change Management for Operating and Maintenance Procedures EHSMS 12.3 Disablement of Protective Devices (Bridging) EHSMS 12.4 Substitution of Materials and Equipment Components EHSMS 12.5 Acquisition and Divestment of Assets

Standard No	Name of Management Standard
EHSMS 13	Emergency Preparedness EHSMS 13.1 First-Aid and Medical Facilities
EHSMS 14	Monitoring, Management and Reporting
EHSMS 15	Incident and Non-Conformance Investigation, Corrective and Preventative Action EHSMS 15.1 Injury Management
EHSMS 16	Management System Audit and Assessment
EHSMS 17	Management Review

10.4.1.3 EHSMS Hazard Standards

Hazard standards detail the controls required to manage the risks of specific hazards to acceptable levels. These apply to all Santos operations. They contain specific requirements for planning and undertaking activities and include checklists and references to internal and external approvals and controls.

Environment hazard standards have been developed under the Santos EHSMS and are shown in Table 10.4.2.

Table 10.4.2 Environment Hazard Standards

Standard No.	Name of Hazard Standard
EHS01	Land Disturbance
EHS02	Underground and Secondary Containment Systems
EHS03	Produced Water Management[2]
EHS04	Waste Management
EHS05	Air Emissions
EHS06	Greenhouse Gas Management
EHS07	Energy Conservation
EHS08	Contaminated Land Management
EHS09	Weed and Pest Animal Control
EHS10	Water Resource Management
EHS11	Cultural Heritage
EHS12	Noise Emissions

10.4.1.4 Health and Safety Hazard Standards

Several health and safety hazard standards have been developed under the Santos EHSMS and are shown in Table 10.4.3.

[2]Produced water is also known as associated water.

Table 10.4.3 Health and Safety Hazard Standards

Standard No.	Name of Hazard Standard
HSHS 01	Fire Hazard Management
HSHS 02	Land Transportation
HSHS 03	Air Transportation
HSHS 04	Health and Wellbeing
HSHS 05	Working in Hot Environments
HSHS 06	Electrical Safety
HSHS 07	Working at Heights
HSHS 08	Chemical Management and Dangerous Goods HSHS 08.1 Asbestos HSHS 08.2 Synthetic Mineral Fibre HSHS 08.3 Benzene HSHS 08.4 Mercury HSHS 08.5 Vanadium HSHS 08.6 Nitrogen HSHS 08.7 Hydrogen Sulphide
HSHS 09	Radiation
HSHS 10	Food Safety
HSHS 11	Manual Handling and Ergonomics
HSHS 12	Occupational Noise
HSHS13	Working Alone in Remote Locations
HSHS14	Legionella
HSHS15	Personnel Security
HSHS16	Lifting Equipment
HSHS17	Personal Protective Equipment
HSHS18	Entry to Confined Spaces
HSHS19	Excavations

10.4.1.5 StepBack

StepBack is a behaviour based safety system implemented by Santos. The premise of StepBack is to change the culture of Santos employees and use StepBack every day before starting every job. Santos also promotes the use of StepBack when employees return home after work.

The basic steps of StepBack are:

STOP – THINK – IDENTIFY - CONTROL

Before Commencing the Job:

- Stop and think;
- Observe the work area and surroundings;
- Step through in your mind what you are going to do;
- Think about what else is happening today in the area around you;

- Identify the hazards – ask yourself three questions:
  1. What's changed?
  2. What's new?
  3. What could go wrong?
- Ask yourself - How can I control the hazards? and
- Satisfy yourself that the hazards are controlled before commencing the work.

After the Job:

- Observe the work area;
- Take action to control any hazards that may have been created by the work;
- Reflect on how well the job went and the mental planning that you did before the job;
- Did you feel safe doing the job?
- Can any improvements be made next time? (EHSMS09).

10.4.1.6 Safety Management Strategies

The oil and gas industry is dynamic and fluid, constantly changing with new technology and better practices. Santos understands this industry and the challenges, and to be a world class leader in the industry, health and safety is a priority as stated in Santos' Health and Safety Policy. As such, safety management strategies are developed to maintain and continuously improve the EHSMS across the organisation.

The following provides examples of proactive safety management strategies implemented by Santos:

- Mandatory heat stress training recognising the harsh weather conditions that Santos employees endure during the course of their working day. Training has brought heat stress awareness to the Santos workforce and the cases of heat stress illness have dramatically reduced; and
- Mandatory four wheel drive training program. The course is designed to meet Santos' HSHS02 and provide awareness of the capabilities of a four wheel drive vehicle.

10.4.2 Health and Safety Legislative compliance

The health and safety requirements of the construction and operation of the project are governed by a number of legislative requirements, relating to a range of issues. These are detailed in Table 10.4.4, along with the measures to be undertaken to ensure compliance.

Table 10.4.4 Legislative Requirements

Legislation	Requirement	Compliance
Workplace Health and Safety Act 1995 and Regulation 2008	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.	To comply with the obligations and safety requirements set out in the act and regulation. This includes ensuring safety in design and compliance with the EHSMS for relevant work performed in the construction and operational phases.
Petroleum and Gas (Production and Safety) Act 2004 and Regulation 2004	To facilitate and regulate the carrying out of responsible petroleum activities and the development of a safe, efficient	To comply with the safety and technical requirements set out in the act and regulation when performing

Legislation	Requirement	Compliance
	and viable petroleum industry in a way that, among other things, regulates and promotes the safety of persons.	relevant work. This includes compliance with the EHSMS and developing and implementing a principal hazard management plan.
Dangerous Goods Safety Management Act 2001 (DGSM Act) and Regulation 2001 • National Standard for the Control of Major Hazard Facilities (MHF) (NOHSC:1014(2002)) and National Code of Practice (NOHSC: 2016(1996)) MHF(if relevant)	The object of the DGSM Act is to protect people, property and the environment from harm caused by hazardous materials and dangerous goods. 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 act and regulation. This includes ensuring the management of dangerous goods in accordance with relevant Australian Standards for the storage and handling of dangerous goods.
Explosives Act 1999 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.	Contractor to include in JSA during construction.
Radiation Safety Act 1999 and Regulation 1999	To ensure the safe utilisation, storage, handling and disposal of radioactive material so as not to endanger persons, property or the environment.	Chemical management and workplace hazards for construction and operational phases.
Building Act 1975 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. LNG facility safety concept.
Fire and Rescue Service Act 1990 and Fire and Rescue Service Regulation 2001	Establish effective relationships and implementation of 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.
Electrical Safety Act 2002 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. Preventing persons from being killed or injured by electricity; and preventing property from being destroyed or damaged by electricity.	To comply with the safety obligations and requirements in the act and regulation when performing relevant work. This includes ensuring compliance with the EHSMS.
Transport Operations (Road Use Management) Act 1995 and associated regulations for dangerous goods and other relevant aspects	Provide for the effective and efficient management of vehicle and road use associated with all components and stages of the project.	Workplace hazards for construction and operational phases.
Petroleum (Submerged Lands) Act 1982	Among other objects, to secure the occupational health and safety and welfare of persons at or near facilities in adjacent areas as defined by imposing safety duties on certain persons.	To comply with the safety and technical requirements set out in the act and regulation when performing relevant work. This includes compliance with the EHSMS and developing and implementing a principal hazard management plan.

Legislation	Requirement	Compliance
Health Act 1937, Health Regulation 1996 and Health (Drugs and Poisons) Regulation 1996	Ensure a safe and healthy environment so as not to endanger persons, property or the environment.	Santos EHSMS.
Workers Compensation and Rehabilitation (WCR) Act 2003 and WCR Regulation 2003	Ensuring and promoting improved health and safety performance.	Santos EHSMS.

Relevant standards to ensure compliance to the above tables for this project include the following:

- AS 2885.1 – Australian Standard for pipelines; gas and liquid petroleum, part 1 design and construction;
- AS 3961-2005 – Australian Standard for the storage and handling of liquefied natural gas;
- NFPA 59A - National Fire Protection Association (NFPA) for Production, Storage and Handling of Liquefied Natural Gas (LNG) 2001 Edition; and
- EN 1473 - The European Norm standard EN 1473 Installation and equipment for Liquefied Natural Gas - Design of onshore installations evolved out of the British Standard, BS 777730 in 1996.

10.4.3 Occupational Health and Safety Risk Assessment

This section describes the impacts of the project on the health and safety of the workforce, and how these impacts will be prevented through engineering design and managed though effective procedures and practices.

Santos is committed to ensuring that all relevant safety requirements and obligations in the P&G (PSA) Act and Regulation 2004; the Petroleum Act*;* the *Workplace Health and Safety Act 1995* (WHS Act 1995) and *Regulation 2008*; and other relevant safety legislation are complied with during the construction and operational phase of the project.

The Petroleum Act*,* the P&G (PSA) Act and the WHS Act 1995 will be considered and observed during both the construction and operation of the project as relevant. As prescribed in Section 28 of the WHS Act 1995, Santos is committed to ensuring that the project provides a safe and healthy workplace for all employees. This will be achieved through the development and implementation of the Santos EHSMS and an appropriate principal hazard management plan.

An occupational health and safety risk assessment will be undertaken to assess the major hazards and impacts associated with the construction and operation of the project. The risk assessment will form the basis of a comprehensive occupational health and safety plan, which will be developed and customised to address specific issues for each stage and component of the project.

A workers' health surveillance program will be developed in consultation with health professionals and be administered by qualified occupational health specialists. The program will be developed in accordance with current legislation, standards and "best practice" in the industry and will address measures required to mitigate identified health risks.

Contractors working on the site will be required to adhere to Santos' EHSMS. This will be reflected in the Health, Safety and Environment Management Plans (HSEMP) developed and implemented by contractors to address specific workplace hazards that could be encountered during the contractors' work. To prepare the HSEMP, the construction contractor will undertake a risk assessment to address the potential impacts that may occur during normal day-to-day construction activities. The HSEMPs will be approved by Santos to ensure consistency with Santos' EHSMS.

As part of the contractors' HSEMPs and Santos EHSMS, a return to work program will be developed and implemented. This will provide details of injury management and rehabilitation programs, including arrangements for medical assessment of injured staff. Contractors will be required to nominate an injury management/rehabilitation coordinator who will liaise with the nominated medical practitioners and administer all aspects of the contractors' programs. This return to work program will ensure injured employees are capable of performing their tasks when returning to work.

Santos recognises the importance of putting in place effective workplace consultative and communication arrangements to provide a mechanism through which employers, contractors and employees can work together to identify and resolve issues that may affect the health and safety of persons in the workplace. Paramount to the success of the consultative process is the role of the WHS representatives. WHS representatives will be elected by the workforce. Santos will ensure that the role of the WHS representatives is given the necessary profile and support to ensure the success of the consultative.

10.4.4 Workplace Hazards

Santos manages workplace hazards through EHSMS09.1- Job Hazard Analysis and Stepback (refer Appendix BB). Key requirements of EHSMS09.1 include:

- All personnel who carry out work for or on behalf of Santos in field locations will, where required, participate in developing a Job Hazard Analysis (JHA) prior to commencing work and will complete their assigned actions in accordance with the JHA;
- A JHA must be completed prior to performing any task where it is possible that a loss may result and if there is no preapproved standard operating procedure or work instruction that identifies the hazards and controls the risks of the task;
- A new JHA will be developed by the work group or individual performing the task each time a task is conducted;
- The JHA will be approved by the permit holder or supervisor of the task prior to work commencing; and
- Stepback (refer to 10.4.1.5) will be conducted by each individual immediately before any job/task is commenced to ensure that it is safe to carry out the work and that no unacceptable environmental impact will result (EHSMS Guide).

A JHA will identify the workplace hazards for each specific task. The following workplace hazards listed have been identified as general hazards that have been observed at either the CSG fields, gas transmission pipeline, LNG facility or a combination of these in the past. The key workplace hazards will include (but are not limited to):

- Occupation noise;
- Electrical safety;
- Confined spaces;
- Working at heights;
- Fires;
- Vehicle safety;
- Working in hot environments;
- Cryogenic protection;
- Hazardous substances;
- Manual handling;
- Air Quality;
- Waste; and
- Water.

Further details are available in Appendix BB.

10.4.5 Quality Assurance and Quality Control

Contractors working for Santos and suppliers of equipment, materials and goods are required to have appropriate EHS management systems in place so as to prevent harm to Santos and contractor personnel, the public, the environment and Santos' business interests.

Below is a summary of EHSMS10-Contractor and Supplier Management key requirements:

- Equipment, materials and goods assessed as being a potential significant business risk will be recorded in a catalogue which will be used to ensure that appropriate equipment, materials and goods are purchased.
- Safety critical spare parts will be identified as such in the catalogue and will be fully specified and only sourced from the approved Supplier.
- All catalogued equipment and materials will be obtained in accordance with the catalogue specifications.
- A quality control system will be implemented for the procurement and supply of safety critical equipment and spares.
- A risk assessment will be conducted to determine the level of EHS assessment required for new Contractors / Suppliers.
- Where the assessed risk is one and the value of the contract is below $500 K a capability assurance statement will be completed.
- Where the assessed risk is > 1 or the value of the contact is > 500 K a major contract prequalification will be completed.
- EHS prequalification may be waived in defined scenarios if approved.
- Where a major contract is awarded and the assessed risk is 1, an EHS management plan will be developed by the contractor, tailored to the scope of work, and be submitted for approval.
- A Santos site representative will be appointed for a major contract to ensure that work carried out by the contractor is in accordance with the approved EHS management plan.
- Prior to the commencement of work the contractor will complete the Santos level 1 and appropriate level 2 induction inductions. The contractor will then provide to their employees a level 3 induction based on their EHS management plan (where required).
- Contractors will ensure that where required the endorsed EHS management plan is fully implemented and maintained for the duration of the work activity (EHSMS Guide).

10.4.5.1 GLNG Maintenance Philosophy

The level of maintenance applied to a plant or equipment will be related to its:

- Criticality with respect to EHS hazard management;
- Application of statutory requirements;
- Production (commercial) risk; and
- Capital replacement costs.

All levels of maintenance will consider the safety of the employees and contractors as well as the environment without compromise.

A reliability availability and maintainability (RAM) study will be undertaken to identify reliability issues. Computer simulations will explore the relationships between the maximum production rates and design, operational factors, capacity, safety and environmental concerns.

The information from RAM will be used in conjunction with reliability centered maintenance (RCM) principles. The RCM objective is to preserve the systems function and will be the basis of the GLNG maintenance program.

RCM will enable maintenance needs to be determined by a systematic analysis of asset function, functional criticality, failure mode, rate and consequence.

Application of RCM will result in one or a combination of the following maintenance options:

- Re-design to design out the failure mode;
- Condition-based (on-line or off-line) or predictive maintenance;
- Corrective repair (failure) maintenance following breakdown; and/or
- Run to failure.

Fixed plant, equipment and structures which degrade over time through corrosion or frequency dependent degradation will be subjected to risked based inspection (RBI).

The GLNG maintenance philosophy will include the following aspects:

- Plant and equipment provided will be consistent with optimum life-cycle maintenance intervention for plant and equipment systems and supporting utility systems.
- Ensure the results of the safety case and the RAM study drive maintenance requirements.
- Indentify and analyse critical equipment for its ability to meet performance criteria. Equipment sparing, redundancy and insurance spares requirements will be based on reliability and failure consequence modeling.
- Incorporate Human Factor Engineering (HFE) requirements including ergonomics, hazard and effects management tools, and techniques applied to maintenance work activities.
- Integrate requirements of equipment isolation, with regards to maintenance requirements.
- Ensure maintenance can be done safely and can be carried out without compromising the environment.
- Ensure the plant and equipment has appropriate maintenance access.
- Ensure that equipment is laid out for ease of access from roadways or defines access ways to avoid cranes and vehicles from entering the process area proper.
- Ensure procurement evaluation criteria for equipment selection are based on life-cycle cost to reflect value of long term operability and reliability.
- Ensure proven equipment is used.
- Where practicable, standardise materials and equipment design to reduce vendors selection and reduce the stock of spare parts.
- Evaluate all maintenance activities on a full life cycle cost benefit.
- Review potential system conflicts from a maintenance perspective.
- Define all maintenance related lifting requirements so that maintenance activities can be carried out injury free and incident free.

10.4.5.2 GLNG Reliability and Integrity Strategy

To achieve the required performance levels for reliability, availability and integrity, appropriate systems, processes, procedures and skills will be developed and implemented to:

- Maintain the technical integrity of assets at a level that complies with regulatory requirements and will ensure that any foreseeable risk of failure, endangering personnel, the environment or asset value, are reasonable eliminated.

- Ensure the operation of any plant and equipment complies with all legislation and policies regarding the health, safety and environment.
- Ensure the production targets in terms of availability, product quantity, product quality and unit cost are achieved.
- Maintain data and history relevant to equipment and maintenance performance to ensure measurement and auditing requirements are met.
- Record and analyse maintenance data on asset performance, in order to continually optimize the maintenance process and equipment performance.
- Develop and apply equipment maintenance strategies based on equipment criticality along RCM principles. These maintenance strategies will include condition based, time based and failure based strategies.
- Apply RBI techniques and condition monitoring processes while minimising intrusive maintenance.

10.4.6 Training and Competency

Santos provides focused training to ensure that everyone with responsibilities allocated under the EHSMS understands how to fulfil their responsibilities and has the necessary skills. Refer to Santos' EHSMS 06 - Training and Competency attached in Appendix BB which details the key requirements of corroborating the health and safety policy, safety management and emergency plans.

10.4.7 Security

It is Santos' policy to provide a secure working environment, by establishing and maintaining the required security measures to prevent unlawful acts against persons, property, the company and its plant or berthed ships.

Security plans associated with the site will be reviewed and updated on a continuing basis and at a minimum, reviewed annually. Any plans are to be republished upon update or amendment, and copies where applicable will be forwarded to relevant State and Federal regulatory agencies. Elements of the security planning arrangements will also be subject to regular internal and external audit.

Security awareness training will be undertaken by all personnel (includes contractors). Security awareness training will be conducted prior to commencing work on site.

Security drills and exercises will be scheduled and conducted on at least a yearly basis and may be coincide with emergency and safety drills and exercises.

All site security facilities will use electronic and solid-state technology. The overall system plan will include monitoring, detection, and alarms. All systems and equipment will comply with the relevant Australian Standards.

A Maritime Security Plan will be developed for LNGC within Port Curtis. The Maritime Security Plan will be include a map that clearly shows the boundaries of the GLNG site, and location of any existing port security zones, or security zones to be established.

10.4.8 LNG Facility Safety Concept

The LNG industry has a strong safety record due to several factors including:

- The industry has technically and operationally evolved to ensure safe and secure operations;
- The physical and chemical properties of LNG are such that risks and hazards are well understood and incorporated into design technology and operational controls; and
- The standards, codes and regulations that apply to the LNG industry.

Refer also to Section 3.3 and Section 8.8.5.2 for information relating to air emissions during upset conditions.

10.4.8.1 Safety Case

A safety case will be prepared during the design and engineering phase of the project covering the construction and operation of the facility. The safety case will be a comprehensive and integrated safety management system that will be developed to satisfy the regulators, both state and commonwealth.

10.4.8.2 LNG Process Safety

Process safety will be developed and implemented into the LNG facility to protect Santos personnel, contractors, the environment and assets. Process safety will include active and passive fire protection, spill containment, fire detection/alarm systems, emergency shutdown, isolation systems and the required safety report submitted to the relevant authorities.

10.4.8.3 LNG Fire and Gas Philosophy

The LNG facility fire and gas detection and control system will cover all hazardous areas of the facility and provide detection of flammable and toxic gases, and the presence of fire and smoke. On detection of an unsafe condition, the system will give audible and visual signals to warn of the hazard and automatically initiate isolation of potential ignition sources. The process may be shut down automatically or manually at the operator's discretion. The requirement for manual or automatic shutdown in particular areas will be identified during FEED phase.

Manual call points will also be distributed around the facility to provide an alternative means of alerting the control room to emergency situations. The initiation of the fire fighting response (e.g. foam, water monitors, and sprays) will also be manually activated at the operator's discretion.

This system must be robust to mitigate the possibility of false signals causing an emergency trip.

The following hierarchy of the controls will be adopted:

1) Fire prevention;
2) Fire protection; and
3) Fire fighting.

This hierarchy is adopted to achieve the desired degree of fire safety, primarily by fire prevention measures which will also result in the optimum availability of the facilities to produce LNG.

Where potential fire hazards remain despite the preventative measures, fire protection measures will be taken. The objective of fire protection is to limit or prevent the escalation of fire in order to avoid risk to life, the environment and to minimise asset damage.

Due to the isolation of the facility and the relatively small operational workforce, the ability to actually fight a fire will be limited; therefore the installation of fixed fire extinguishing capabilities will be incorporated into the design. Staff will receive fire fighting training as outlined in GLNG's EHSMS Fire Management Plan. Training will comply with the Queensland Fire Safety Act 1990 and Fire Safety Regulation 2008. The LNG facility will have one or more Fire Safety Advisors or equivalent persons with the required competencies as designated by the Queensland regulations. Competencies would include some level of "live fire training" with a petroleum industry focus including LNG.

Fire water will be recaptured with in the surface water run-off design.

10.4.8.4 LNG Safety Devices

Personnel and plant process facilities will be protected from hazardous conditions by appropriate safety devices. An emergency shutdown system (ESS) will be provided to bring the plant or sections of the plant to a safe and steady state from which the plant may be re-started or further shut down as appropriate. The principal aims of the ESS system are to ensure the following:

- Protection of personnel;
- Protection of the environment; and
- Protection of plant and equipment.

An instrumented safety system will provide the automatic shutdown functions. There will be hard-wired switches on the operating consoles within the central control room to manually shutdown large rotating equipment and major process areas. Shutdown switches within the facility will also be provided to shut down large rotating equipment.

An emergency depressurisation system will be provided to allow for rapid evacuation of hydrocarbon inventory to protect vessels and equipment, and eliminate fuel sources in the event of a fire. The system will be required to achieve the following:

- Reduce the uncontrolled release of plant inventory;
- Reduce the flammable or toxic inventory of the plant; and
- Prevent the catastrophic failure of plant equipment through pressure reduction (due to overpressure, fire, etc).

Pressure safety devices will provide protection against over-pressure of equipment and piping systems. Pressure safety devices will have a spare incorporated into the design for isolation and maintenance testing. However, the protective systems will be designed to take preventative action to minimise the probability of reaching relief valve set pressures and to prevent or minimise the uncontrolled releases of hydrocarbon inventories.

10.4.8.5 LNG Chemical Management

A process will be developed to include a series of strict compliance checks prior to using any chemicals in the LNG process and on Curtis Island.

Examples of compliance checks for chemicals could include:

- Health, safety and environmental requirements for the use of chemicals throughout the chemicals life cycle (Manufacturer's Material Safety Data Sheet (MSDS), transportation, use and disposal;
- Consider availability of alternatives;
- Local legislative requirements;
- Chemical performance;
- Cost (life cycle costs including equipment/EHS gear and maintenance);
- Availability of supply;
- Equipment compatibility; and
- Compatibility with other chemicals and processes in the LNG facility.

10.4.8.6 Permit to Work System

A Permit to Work (PTW) system will be used to control all non-routine activities within the LNG facility. The PTW system will control potentially hazardous or unsafe work activities that occur anywhere on the GLNG site. Some of the permits included in the system are as follows:

- Hot work permit - for works involving any ignition source in hazardous area.

- Cold work permit - for use prior to isolation of safety systems (fire and gas, ESD), interruption of the production process, any non hot work in the process area, excavations deeper than 100 cm and all non-routine work in operational areas.
- Confined space entry permit - permit required prior to entry into any confined space. Gas testing of the confined space by qualified personnel is mandatory.

A detailed PTW system procedure will be developed during front end engineering design (FEED) phase. This system will be applied during commissioning and start-up.

10.5 Emergency Management Plan

Santos has an incident management plan (SIMP) which is a dynamic over arching corporate document under which emergency response plans (ERP) are located. The maintenance of the SIMP is the responsibility of Santos corporate, whereas the development and maintenance of project/site specific ERPs are the responsibility of project personnel. There is already a comprehensive and operating ERP for the operating CSG fields, which includes gas transmission pipelines. The LNG facility ERP will be established by the contractor for the construction, start-up and commissioning during FEED and further refined by GLNG for the hand over of the operational phase. This section of the EIS outlines the aims of the project emergency management procedures and the range of situations that they cover.

The development of emergency planning for the GLNG Project has been done in consultation with the Department of Emergency Services (DES). Santos will continue this relationship with DES from the initial stages of the project through to closure to ensure rigorous emergency response systems are developed and maintained for the project.

10.5.1 On-site Emergency Response Systems

10.5.1.1 Emergency Preparedness

Santos' EHSMS13 Emergency Preparedness (Appendix BB) was developed to ensure that relevant equipment and resources are available and personnel are able to effectively respond to any foreseeable emergencies so as to minimise any adverse impact on the safety or health of people or the environment.

A summary of key requirements for EHSMS13 are as follows:

- Document controlled ERPs will be developed and maintained for Santos operating sites, premises and relevant functions to aid in the effective response to foreseeable emergency scenarios.
- The relevant site/activity significant hazard risk register will be used to assist with the validation of the scope of emergency scenarios covered in the ERP.
- Emergency/Incident response plans will be reviewed annually to validate the adequacy of scope (emergency scenarios) and currency/adequacy of content. In addition relevant plans will be reviewed, where improvement opportunities have been identified by post emergency / incident exercise debriefs.
- A document controlled SIMP will be prepared, distributed and maintained by Manager EHS&S to provide additional support and resources in the event that an emergency is beyond the capabilities of a site.
- Where a contractor will manage an emergency situation at a Santos asset the contractor will provide an emergency response bridging document to ensure an effective and co-coordinated emergency response including when and how the SIMP will be activated.
- All operating sites, premises and relevant functions will prepare and maintain an emergency operations centre (EOC) and identify an alternate should the EOC be affected by the emergency.
- Emergency key contact lists will be developed and regularly maintained.

- At sites classified as a major hazard facility, the ERP will incorporate the relevant emergency regulatory requirements.
- Personnel will be competent in their roles defined in emergency and incident response plans.
- Emergency exercises will be conducted regularly to test the effectiveness of plans, competency of personnel and resources.
- Processing facilities will maintain a system that enables timely identification of personnel who are in the facility and who are not accounted for following an emergency evacuation of the facility. (EHSMS Guide).

10.5.1.2 First Aid and Medical Facilities

Santos EHSMS13.1 First-Aid and Medical Facilities (Appendix BB) defines the requirements for first aid, the provision of first aid facilities and the availability of qualified first aid personnel to ensure effective treatment to employees, visitors and contractors.

Santos EHSMS13.1 is summarised below:

- All Santos workplaces will have appropriate first aid facilities readily available for use which as a minimum will meet relevant regulatory requirements.
- The scope of first aid facilities at a workplace will be based on a risk assessment which will consider:
  - Nature of the work;
  - Size and layout of the workplace;
  - location of the workplace; and
  - Number and distribution of workers.
- Sufficient numbers of suitably trained first aid personnel will be available to workers on all shifts consistent with the outcome of the risk assessment and relevant legislation.
- Sufficient numbers of appropriately stocked and maintained first aid kits will be provided at each workplace consistent with the findings from the risk assessment.
- All Santos field vehicles will be fitted with a first aid kit.
- Where paracetamol is kept in first aid kits personnel who need to take such medication will self dispense (EHSMS Guide).

10.5.2 CSG Fields and Gas Transmission Pipeline

The existing Santos CSG fields have ERPs in place (Appendix BB). This emergency response plan will be updated to reflect the expansion of the CSG fields.

The existing Eastern Queensland (EQ) Gas ERP is a comprehensive guide that provides information on site responsibilities, actions, reporting requirements and resources available to ensure an effective timely response is undertaken in any emergency that involves Santos employees, members of the public, contractors or Santos assets.

The ERP achieves the above by:

- Identifying the Santos emergency/incident management structure;
- Displaying notification and escalation criteria;
- Defining roles responsibilities of the emergency operations centre group (EOG);
- Describing scenario based response procedures; and
- Identifying key resource contact details.

The ERP forms part of the Santos emergency response, being supplementary to the SIMP and providing the necessary detailed information required to deal with emergencies at the site and asset level.

10.5.3 LNG Facility

10.5.3.1 Emergency Response Plan

An ERP will be established by the contractor during FEED for the construction, start-up and commissioning phases. It will be further refined by Santos for the hand over and operations phase.

The ERP will outline the emergency procedures and describe the organisation (defining members, tasks, responsibilities and role of emergency response team (ERT)). The development of specific emergency procedures will be driven by the outcomes of hazard and risk assessments during the development of the GLNG operations safety case and EIS. The ERP will take into account the operating and EHS philosophy requirements.

The ERP will contain at least the following:

- List of actions to be undertaken in the event of an incident or emergency. This will be a scenario-based assessment, per incident or emergency situation possible and per zone. Typical scenarios include explosions, BLEVE, collisions, spills, pool and jet fires;
- Organisation for emergency response in the event of an emergency. Designation of ERT members and task/responsibility allocation; and
- Co-ordination of emergency response. Aspects to consider include:
  - Evaluation of emergency severity for initiation of emergency activities including evacuation;
  - Communication to external and internal parties;
  - Assignment of actions to be undertaken being either corrective (including fire fighting), containment (e.g. oil booms), or evacuation; and
  - Provision of first aid.

Synergy with the other facilities on Curtis Island and the region will be investigated to provide an integrated approach for emergency coordination and emergency response resource sharing.

The goal will be to arrive at a coordinated response to any emergency situations on Curtis Island while recognising the commercial and other interests of the stakeholders.

In the unlikely event of an emergency at the LNG facility, an assessment of businesses affected by the emergency will be contacted by Santos to discuss strategies to mitigate the impacts to that particular business on a case by case basis following the emergency response.

Incident Response

A well trained first intervention team will be part of each shift. The primary incident response capability will consist of the facility's fire prevention and protection systems. Both the first intervention team and a back up team will also have personnel trained as senior first aiders.

Pre-incident Planning

During commissioning the operations team will develop a series of pre-incident plans for emergency scenarios at the facility. The plans will identify the initial response to each situation and mitigation plans for any escalation.

ERP Training

Training in fire fighting and emergency rescue techniques will be identified by Santos and incorporated as competency requirements for those personnel in either the first intervention team or the back up team.

10.5.3.2 LNG Facility Design for Emergency Response

The following design elements will be incorporated into the ERP.

Fire Protection

Fire Fighting Equipment

There will be a fire station adequately equipped with mobile foam vehicle, (foam) concentrate transport vehicle, material transport vehicle and a number of mobile foam/water monitors. There will be a first response fire fighting vehicle that will allow the fighting of grass fires etc at locations remote from a ready source of fire water. The fire station will also be equipped with a facility to store, maintain and fill breathing apparatus.

Fire Response

In the event of a significant loss of containment and fire, it is assumed that the operators will take the following actions:

- Immediately shutdown the LNG facility;
- Isolate LNG facility inventories;
- De-inventory of the system and identify the source of the leak and systems threatened by a fire, using available equipment including de-inventory pumps and depressurization valves;
- Activation of fixed firewater systems; and
- Deployment of additional mobile fire fighting equipment.

Passive Fire Protection

A fire hazard analysis (FHA) will be completed to identify where exposure from excessive heat flux exists and where fire proofing will be implemented. These measures will reduce the risk to operating personnel and the escalation of an emergency.

Fire and Gas Detection System

Fire detection in the facility areas will be via multi spectrum infra red flame detection. The detectors have an approximate horizontal and vertical field of view of 90 degrees and a range of 30 m. Detectors will be placed in areas where jet fires from flanges, valves and small bore connections are considered possible. Activation will sound an alarm and require investigation from operators to determine the cause and the appropriate action.

Dry pilot systems will be provided to detect fire around the refrigerant storage vessels, NGL storage drums, at the propane accumulator and at the PLF. Activation will result in alarm and the activation of the associated water spray system.

The primary means of detecting flammable gas will be line-of-sight detectors. These detectors will be placed around the perimeter of the liquefaction area, the upper deck compressor area and around the gas turbine area. Activation will sound an alarm and require investigation from operators to determine the cause and the appropriate action.

Point gas detectors will be used at the air intake inlet of fired equipment. Detection of gas will sound an alarm and shutdown the equipment of concern.

Spill detection for cryogenic liquid will include temperature detectors located within trenches and sumps. Cold temperature detectors will also be installed within drainage paths between major cryogenic liquid process inventories. Activation will sound an alarm and require investigation from operators to determine the cause and the appropriate action.

All buildings will be fitted with fire detection and alarms.

Firewater System

A fire water system will be provided for the LNG facility and associated marine facilities. Firewater demand is estimated to be 500 m^3/hr. The firewater system includes the firewater tanks, firewater main pumps, firewater jockey pumps, firewater mains, isolation valves, deluge valves, firewater hydrants and monitors. A steel firewater main line will connect the facility firewater to the grid and to the PLF. The main line will be sized accordingly to provide sufficient flow and pressure for the maximum demand scenario.

The firewater system will be designed to be compliant with NFPA 59A and AS2419.

LNG Tank Relief Valve Vent Fire Suppression

Automatic fixed dry chemical extinguishing system will be installed at the relief valve vents to extinguish any fire resulting from a relief vent fire.

Gas Turbine Fire Protection

Gas turbines for power generation or refrigerant compression will have gas and fire detection. In the unlikely event of a fire the system will sound an alarm, shutdown the equipment and activate a suppression system to extinguish the fire. Detection of gas will result in an alarm, if flammable gas is detected at the air intake point detection the turbine will shutdown.

Process and Storage Layout

Spacing criteria for the facility will follow Santos standards and AS 3961 and NFPA 59A for LNG specific issues. For equipment not specifically covered by these, contractor design guides will be used.

LNG tank spacing will be based on the following:

- Design the fire case to be a full tank top fire;
- Tank to be located so that the radiant heat flux from the design fire case does not exceed:
  - 5 kW/m^2 at the property boundary (per Australian risk criteria guidelines, HIPAP); and
  - 10 kW/m^2 at the processing areas of Trains 1, 2 or 3 (per AS 3961, clause 2.6.2 (c) (iii)).

The location and design criteria for occupied process buildings will follow the evaluation criteria established in API 752.

Temporary or portable buildings that may be used by contractors during commissioning and early operation will be located with API 752.

Buildings will be located such that special design criteria will be not be required, where practicable. The current layout for the facility requires the following buildings to be designed for an explosion overpressure level:

- Compressor control / substation building; and
- Propane condenser substation building.

Building blast resistance requirements will be confirmed during the FEED phase.

Spill Prevention and Containment

Containment Integrity

All process piping will be welded where practicable, with an emphasis on minimising flange connections.

Screwed piping will not be used in any service, including water, air or other utility services.

Any potential leak on the roof of the LNG storage tanks from the piping connecting the submerged pumps to the piping system will be collected via a drain-pan and directed away from the tank. Cold temperature detection devices will provide a signal to enable prompt shutdown to limit leak duration.

Secondary Containment

For storage areas, 110 % secondary containment will be provided for flammable, combustible or toxic materials, as required by relevant Australian Standards (including but not limited to: AS-3961; AS-1940).

Containment of LNG storage will be via full containment tanks and containment for flammable and combustible liquids will be via bunding.

Measures will be taken to ensure that any leaks or spills will not endanger adjacent property, the public or waterways by following the applicable codes for the products used on site. These measures include:

- Bunding of storage tanks (other than LNG), including: amine surge tank; amine make-up tank; diesel tank; waste oil tank;
- Bunding of compressor/turbine lube oil skids; and
- Paving the process area, this will include drainage to a remote spill sump, complete with first-flush system. The paved area will include the CO_2 absorber and amine flash drum.

The process area remote spill sump and collection drains will be sized to adequately contain ten minutes of potentially contaminated rain water runoff (i.e. “first-flush”) from the paved process areas.

Drainage Collection

Flammable liquid hydrocarbons process areas and storage areas will have a drainage system designed to remove the spill as quickly as possible in order to minimise heat flux damage to equipment if an ignition occurs. Containment trenches will be constructed with low-thermal concrete and will be designed to minimise surface area to lower volatility of LNG if a spill were to occur.

Emergency Shutdown

Emergency shutdown and isolation will be provided to achieve the following:

- Safe, orderly shutdown of the facility in any foreseeable emergency; and
- Isolation of inventories to limit potential leaks.

The system will be capable of operation during fire or other emergencies and will fail to a safe condition under foreseeable failure scenarios.

The overall control and shutdown systems will consist of the following:

- **Distributed control system (DCS)** - Is used for normal process control and monitoring functions;
- **Process shutdown system (PSD)** - Implements instrument protective functions associated with the LNG facility;
- **Emergency shutdown system (ESS)** - Implements a high level total plant shutdown; and
- **Safety instrumented system (SIS)** - The PSD and ESS are discrete systems but they intercommunicate to comprise of the overall SIS.

High Integrity Protective System (HIPS)

To ensure that feed gas does not overpressure the LNG facility in the event that relief and flare capacity may be insufficient HIPS may be required. Further studies will be conducted during FEED.

Isolation Strategy

Emergency Isolation Valves (EIVs) will be located at the process boundaries or dictated by inventory isolation requirements. Pumps and pressure vessels will have EIVs to contain flammable liquids and aid in depressurization. THE EIVs will be operated by the SIS or manually from a remote location (i.e. control room).

Relief System and Depressurization

The LNG facility relief system design which includes flaring, overpressure protection, relief devices and disposal systems will be completed in accordance with API 520, 521, 2000 and AS 1210 as part of FEED.

The LNG facility will be designed to have the capability to vent discrete systems of equipment and piping to flare in the case of a fire, loss of containment or other emergency to reduce the flammable inventory and potential escalation of an emergency. The depressurization system will be designed in accordance with API521 to achieve 690 kPa(g) or 50 % of the vessels design pressure, whichever is lower, within approximately 15 minutes. The depressurization system will be further developed during FEED.

Emergency Evacuation

A helipad will be available for emergency use.