Conclusions and recommendations 27

Enter ▶ Go back to contents ▶

Contents

Tables

27 Conclusions and recommendations

27.1 Introduction

This section outlines the conclusions of the impact assessments undertaken for this EIS on environmental and social values. The residual impacts after implementing mitigation and management measures from each impact assessment are provided and discussed. There is further supporting information on how the conclusions were reached presented in each of the corresponding sections of this EIS.

27.1.1 Assessment framework

The assessment of the potential environmental, social and economic impacts of the GFD Project was based on the predicted impacts at the project scale using a maximum development scenario. The assessment considered the application of constraints analysis, field planning and the application of Santos GLNG management plans that have been approved and implemented over the last four years for the GLNG Project. Section 5: Assessment framework provides a complete discussion of the assessment framework.

There were three different impact assessment methodologies used in this EIS. The relevance of each methodology and the values to which they apply are summarised in Table 27-1.

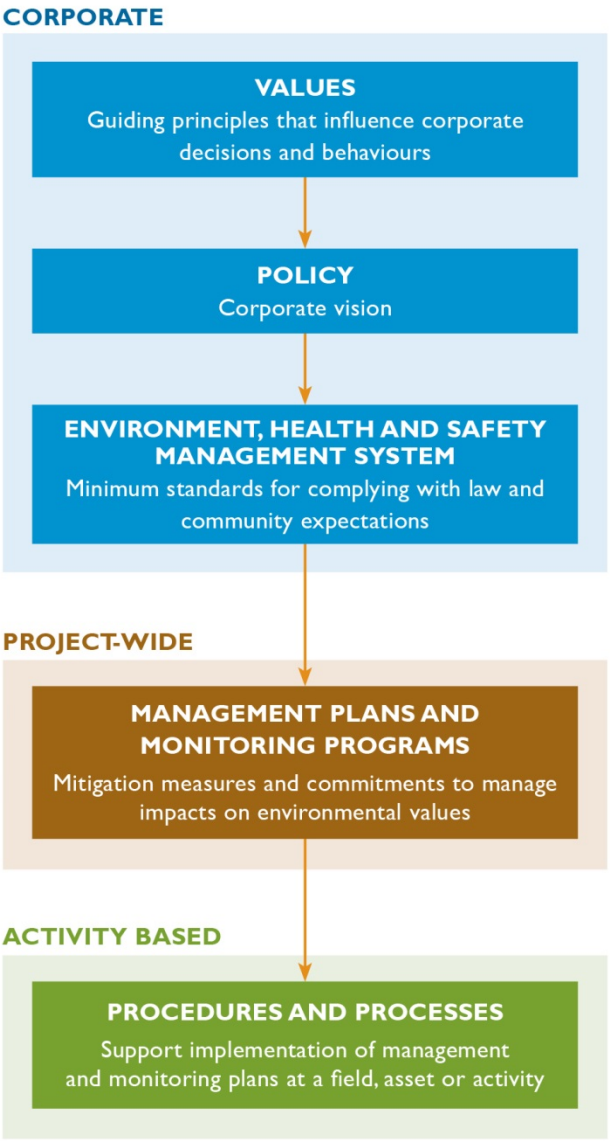
Table 27-1 Assessment methodologies

Methodology	Relevance	Values
Compliance assessment	Used where compliance with a known guideline or standard is required. Impacts are measured by the degree to which the GFD Project complies with published limits or thresholds or the extent of mitigation and management measures that need to be applied to comply.	• Air quality • Greenhouse gases • Noise and vibration.
Risk assessment	Used where the impact depends on how aspects or materials are managed. Impacts are measured by considering the likelihood and consequence of a potential impact to assess its level of risk.	• Climate • Cultural heritage • Hazard and risk • Land contamination • Social • Waste.
Significance assessment	Used where there are no quantitative guidelines, an impact will occur and it is the sensitivity or the vulnerability of the environmental value that is important. Impacts are measured by considering the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.	• Ecology • Groundwater • Land use • Soils and geology • Surface water • Traffic and transport • Visual amenity.

27.1.2 Management framework

The environmental management framework successfully used for the GLNG Project will also be applied to the GFD Project. It includes the systems and procedures that will be applied to the GFD Project to achieve predictable and sustainable outcomes. An overview of the framework is given in Figure 27-1 and a detailed description of the associated components is provided in Section 6: Management framework. This management framework was used in determining the residual environmental and social risks for the GFD Project.

Figure 27-1 Overview of management framework



27.2 Climate and climate change

Climate hazards, such as extreme temperatures, bushfires, droughts and severe storms, can damage infrastructure and present a risk to the health and safety of the general population living in the region as well as the GFD Project workforce. As part of this EIS, the existing climate hazards in the GFD Project area and their potential to increase in intensity, duration and frequency based on published climate change modelling were assessed.

The impact assessment found that after implementing mitigation and management measures, the residual impacts that may arise from climate and climate change hazards are expected to be very low to medium, as presented in Table 27-2. The residual risk of most impacts can be reduced further to very low to low based on the ability of Santos GLNG's existing management framework to reduce the likelihood of the impact occurring or the potential consequence. For example, Santos GLNG is able to reduce the potential for an increase in extreme temperatures from affecting its workforce through a workplace health and safety measures that decrease the likelihood heat-related health impacts.

An increase in the intensity and frequency of storm events has been assessed to have a medium residual risk relating to the potential for an increase in workforce injuries and damage to infrastructure. These potential impacts retain a medium level of risk after applying mitigation and management strategies due to:

- The unpredictable nature of extreme storm events
- The high value placed on personal safety by the assessment framework - the potential for injury is assessed as having a high level of consequence.

Additional information on the climate and climate change is provided in Section 7: Climate and climate change.

Table 27-2 Residual risks relevant to climate

Hazards	Potential impacts	Residual risk		
		Construction	Operations	Decommissioning
Extreme temperatures and heatwaves	Heat-related health impacts	Low	Low	Low
	Increase in energy demand	Very low	Low	Low
	Heat-induced damage to infrastructure	Very low	Very low	Very low
	Increase in risk of bushfire	Very low	Low	Low
	Changes in range of invasive weed and pest species	Low	Low	Low
Increase in rainfall intensity	Exceedance in capacity of water management facilities resulting in localised flooding and increased erosion risk	Very low	Low	Low
	Degradation and failure of essential infrastructure	Very low	Low	Low
More frequent droughts	Water shortage	Very low	Very low	Very low
	Increase in dust	Very low	Very low	Very low
	Soil shrinkage and movement	Very low	Low	Low
	Less effective rehabilitation	Low	Low	Low
Increase in intensity and frequency of extreme storms events and cyclones	Increase in damage to infrastructure	Low	Medium	Medium
	Increase in workforce injuries	Medium	Medium	Medium
	More frequent and prolonged interruptions to operations	Very low	Low	Low

27.3 Land use and tenure

The GFD Project area contains a range of land uses and tenure classifications, including areas of agricultural production, resource extraction, Native Title, and protected areas with conservation and recreation values. Additionally, the GFD Project area includes a number of urban areas, including larger rural centres and smaller localities. As expected with the area's association with agricultural production, there are also rural residences outside of the urban areas.

The impact assessment indicated that there are a range of potential impacts that may occur where the GFD Project infrastructure or activities disturb existing land uses. The impact assessment found that after implementing mitigation and management measures, the residual significance of the potential impacts to land use and tenure values is expected to reduce further to very low to moderate, as presented in Table 27-3.

The majority of the potential impacts of the GFD Project on land use and tenure values were assessed to be low. This is a reflection of the fact that the disturbance footprint reduces significantly from the construction phase to the operations phase, with a subsequent reduction in the level magnitude of impact on land use and tenure values as rehabilitation occurs progressively. In essence, after the completion of construction activities, it is expected that most land uses will be able to continue in the area with limited restrictions resulting from GFD Project operations activities. The key mitigation in areas of agricultural land use is the discussions and negotiations and that occur with landholders pursuant to the land access process and regulations.

The highest residual impacts that may occur involve disturbance to vegetation and the restriction of other extractive industries on tenure during the construction period. While both of these impacts retain a medium level of significance, both are expected to be limited to the construction phase.

Additional information on land use and tenure is provided in Section 8: Land use and tenure.

Table 27-3 Residual significance – land use and tenure

Existing land use	Potential impacts	Residual significance		
		Construction	Operations	Decommissioning
Agriculture and primary production	Loss of productive land	Low	Low	Low
	Diminished productivity	Low	Low	Low
	Disturbance of soil structure	Low	Low	Low
	Changes to surface water and irrigation flow patterns	Low	Low	Low
	Disruption to landholder operations	Low	Low	Low
	Weed and pest introduction	Low	Low	Low
Forestry resources	Restrictions of access to forestry resources	Low	Low	Low
	Loss or premature harvesting of millable timber	Low	Low	Low
	Reduction of the amount of land available for growing timber	Low	Low	Low
	Interference with logging operations	Low	Low	Low
	Additional traffic on logging tracks	Low	Low	Low
Residential areas – urban	Shortage of accommodation facilities	Low	Low	Low
	Shortage of residential land	Low	Low	Low
	Increased demand for retail, commercial and industrial uses	Low	Low	Low

Existing land use	Potential impacts	Residual significance		
		Construction	Operations	Decommissioning
Residential areas – rural	Noise and vibration	Low	Low	Low
	Dust	Low	Low	Low
	Increased traffic on local roads	Low	Low	Low
	Lighting	Low	Low	Low
Mining, petroleum and extractive industries	Restrictions to the extraction of other resources	Moderate	Low	Low
	Restrictions to the exploration for other resources	Low	Low	Low
Conservation, tourism and recreational values	Disturbance to vegetation and/or habitats	Moderate	Low	Low
	Reduced amenity affecting existing tourism and recreational values	Negligible	Negligible	Negligible
Transport infrastructure	Disturbance to or interference with the operations of transport infrastructure, such as roads, rail activities, aerodromes and landing grounds and stock routes	Low	Low	Low
Utilities and services	Disturbance to or interference with existing high voltage transmissions lines, gas pipelines, water pipelines or telecommunications facilities	Low	Low	Low

27.4 Land resources

The land resources section is split into the sub-components of geology, topography and soils; resource and reserves; and contaminated land. Additional information on all of these components is provided in Section 9: Land resources.

27.4.1 Geology, topography and soils

The primary coal seams in the GFD Project area are the Jurassic age Walloon Coal Measures (Surat Basin) and the late Permian Bandanna Formation (Bowen Basin); these will be targeted by the GFD Project. No known sites of paleontological significance or geomorphological significance occur in the GFD Project area.

The topography of the GFD Project area includes areas that are characterised by low-relief undulating low hills that dominate in the east. Mesas feature at the border of the GFD Project tenements in the east, north and south-west. Alluvial plains are present across the GFD Project area with the most extensive associated with major watercourses and their tributaries.

Soils include uniform coarse textured (sandy) soils, uniform and gradational medium-textured (loamy) soils (in particular uniform loams), gravelly loams, red and yellow earths, and lateritic red earths. A number of soils that are considered to be 'problem' soils because they are either highly susceptible to erosion, have high salinity or are highly reactive occur throughout the GFD Project area.

Reflective of the region's agricultural history, good quality agricultural land occurs in parts of the GFD Project area, along with strategic cropping areas.

The impact assessment found that after implementing mitigation and management measures, the residual significance of the potential impacts to geology, soils and topography are expected to range between negligible to low, as presented in Table 27-4.

The residual significance is able to be reduced to this level by applying the Constraints protocol when locating GFD Project infrastructure and then applying the established management plans (such as the Erosion and sediment control plan) to further minimise the potential impacts. This is particularly relevant for some land resource components (such as the conservation of soil resources) that if not adequately managed have the potential to have elevated impacts due to loss or degradation.

Table 27-4 Residual impacts – geology, topography and soils

Potential impact	Residual significance		
	Construction	Operations	Decommissioning
Altered geological setting	Low	Low	Low
Change to landform	Low	Low	Low
Aquifer depressurisation resulting in subsidence	Low	Low	Low
Loss of soil resources	Low	Low	Low
Degradation of soil resources	Low	Low	Low
Restricted access to productive (agricultural or forestry) land	Low	Low	Low
Authorised release to soil	Low	Low	Low
Uncontrolled release to soil	Low	Low	Low
Sterilisation of coal reserves	Low	Low	Low
Damage to fossils	Negligible	Negligible	Negligible

27.4.2 Resource and reserves

Potential impacts to resources and reserves within the GFD Project area include:

- Resource sterilisation – the concern that extracting gas from coal seams prevents mining of coal seams.
- The underdevelopment of resources – where GFD Project infrastructure is located on coal mining tenements, there is the potential for infrastructure to impact on coal mining operations.

The significance of the residual impacts after the implementation of management and mitigation measures was assessed to be low. The low residual rating recognises that extracting gas does not preclude coal extraction. Rather, gas extraction is often required prior to coal extraction (particularly for underground mining) to reduce the potential of incidental mine gas concentrations to safe levels for mining. Further, Santos GLNG has experience managing resources and reserves as part of its ongoing operations, including establishing agreements with other resource extraction proponents.

27.4.3 Contaminated land

The GFD Project has the potential to encounter pre-existing contaminated land. In addition, GFD Project activities without adequate controls have the potential to impact land and water resources. Encountering existing contaminated land or introducing a new source of contamination both could pose a risk to health and safety and impact on existing environmental values and land use.

The impact assessment found that after implementing mitigation and management measures, the residual risk for potential contaminated land impacts is expected to be very low to low, as presented in Table 27-5. The low residual risk rating is reflective of the fact that:

- Existing contamination is likely to be limited in frequency and extent, due to largely agricultural nature of the GFD Project area, where land has been populated and used sparsely. Contamination is most likely to occur from old cattle dips.
- Santos GLNG has an established environmental health and safety management system that provides a structured framework for preventing any new contamination
- Where contamination occurs or is encountered, Santos GLNG's contaminated land framework provides a detailed process to identify steps to further reduce the risk of contaminated land impacting on existing environmental and health and safety values.

Table 27-5 Residual impacts – contaminated land

Potential impact	Residual risk		
	Construction	Operations	Decommissioning
Disturbance of existing contaminated soil or groundwater during construction, operational or decommissioning activities leading to migration of contaminants through soil/groundwater or increased human health risks through ingestion/dermal contact to contaminants.	Low	Very low	Low
Leaks or spills leading to migration of contaminants through surface water/soil/groundwater or increased human health risks through ingestion/dermal contact to contaminants from: • Permanent/mobile fuel/chemical storage • Waste storage areas/facilities (including storage tanks, dams, ponds, sewerage, drilling mud ponds, wash out fluids in flare pits) • GFD Project infrastructure (e.g. pipelines, water management facility, fluid/ brine storage, etc.).	Low	Low	Low
Transport or movement of existing contaminated soil/groundwater leading to migration of contaminants to previously un-impacted soil/groundwater or increased human health risks through ingestion/dermal contact to contaminants.	Low	Very low	Low

27.5 Landscape and visual amenity

The landscape within the GFD Project area includes broad flat plains and river valleys, undulating hills, rugged ridges, narrow valleys and plateaux. Residents and visitors experience a rural landscape with a mix of broad long distance vistas, mountain ranges, natural forests and woodlands, rural roads and small townships. Oil and gas fields have operated in this area since the early 20th century and have become a part of the area's historical and visual landscape.

Visual impacts may be generated by GFD Project activities and the establishment of long-term or permanent infrastructure can create a contrast in the landscape. The GFD Project activities that have the potential to impact visual amenity include:

- Clearing
- Construction/decommissioning (including earthworks)
- Traffic
- Night lighting (including lighting from vehicles)
- Operating activities (presence of infrastructure).

Visual impacts will be at their highest during construction; thereafter, the visual effects are expected to reduce. For example, the footprint required for each component during construction reduces during operation. Similarly, night lighting is most often required during the construction phase.

The impact assessment found that after implementing mitigation and management measures, the residual significance of the potential impacts to landscape and visual amenity is expected to be negligible to moderate, as presented in Table 27-6.

The majority of potential impacts are expected to be reduced to very low levels of significance based on Santos GLNG's management framework, which contains measures that will protect visual amenity — either through preventing development in sensitive landscapes or through reducing the duration and extent of high visual impacts activities such as vegetation clearing. Importantly, where GFD Project components are located on a landholder's property, Santos GLNG will engage with the landholder to determine the infrastructure location and the extent of visual mitigation if necessary.

Additional information on landscape and visual amenity is provided in Section 10: Landscape and visual amenity.

Table 27-6 Summary of residual impacts – landscape and visual amenity

Activity	GFD Project component	Residual significance		
		Construction	Operations	Decommissioning
Vegetation clearing	Wells	Low	Low	Low
	Gathering lines / transmission pipelines	Moderate	Moderate	Moderate
	Gas compression facilities	Low	Low	Negligible
	Water management facilities	Low	Negligible	Negligible
	Accommodation facility	Moderate	Low	Low
	Access tracks	Low	Low	Low
	Laydown and storage areas	Low	Low	Low
	Borrow pits and quarries	Low	Low	Low
	Power lines and communications	Moderate	Moderate	Moderate
Construction / decommissioning activities (including earthworks	Wells	Low	NA	Low
	Gathering lines / transmission pipelines	Moderate	NA	NA
	Gas compression facilities	Low	NA	Low
	Water management facilities	Low	NA	Low
	Accommodation facility	Low	NA	Low
	Access tracks	Low	Low	Low
	Laydown and storage areas	Low	NA	Low
	Borrow pits and quarries	Low	Low	Negligible
	Power lines and communications	Low	NA	Low
Traffic	Wells	Low	Low	Low
	Gathering lines / transmission pipelines	Negligible	Negligible	Negligible
	Gas compression facilities	Low	Low	Negligible
	Water management facilities	Low	Negligible	Negligible
	Accommodation facility	Moderate	Moderate	Low
	Access tracks	Low	Low	Low
	Laydown and storage areas	Moderate	Low	Low
	Borrow pits and quarries	Low	Negligible	Negligible
	Power lines and communications	Negligible	Negligible	Negligible

Activity	GFD Project component	Residual significance		
		Construction	Operations	Decommissioning
Night lighting	Wells	Low	NA	NA
	Gas compression facilities	NA	Negligible	NA
	Water management facilities	NA	Negligible	NA
	Accommodation facility	NA	Negligible	NA
	Access roads and tracks	Negligible	NA	NA
	Laydown and storage areas	NA	Low	NA
	Borrow pits and quarries	Negligible	NA	NA
	Wells	NA	Low	NA
Operating infrastructure (presence of component)	Gathering lines / transmission pipelines	NA	Low	NA
	Gas compression facilities	NA	Low	NA
	Water management facilities	NA	Negligible	NA
	Accommodation facility	NA	Low	NA
	Access tracks	NA	Low	NA
	Laydown and storage areas	NA	Negligible	NA
	Borrow pits and quarries	Negligible	Negligible	NA
	Overhead power lines	NA	High	NA

27.6 Traffic and transport

The GFD Project area is serviced by an extensive transport network including road, rail and aviation facilities that link the region internally and to surrounding regions. This transport network supports community connectivity and the regional economy.

The impact assessment included the development and application of a model to identify quantitative impacts of the GFD Project's predicted traffic. The quantitative assessment concluded that the GFD Project traffic would increase traffic to the extent that:

- The pavement on a number of State-controlled roads may require additional maintenance or rehabilitation
- A number of intersections may require upgrading, including the intersections of the following State-controlled roads: Leichhardt Highway/Dawson Highway, the Warrego Highway/Duke Street (Roma Southern Road) and the Warrego Highway/Leichhardt Highway
- A number of road sections would reach capacity earlier than they otherwise would and would require upgrading.

Santos GLNG has a demonstrated commitment to managing its impacts on the regional road network and has already contributed over $50 million towards upgrading and maintaining roads impacted by the GLNG Project's traffic. Santos GLNG will assist the Department of Transport and Main Roads with the costs associated with residual road impacts, as outlined within the *Guidelines for Assessment of Road Impacts of Development*.

This assessment also included a significance assessment to consider the potential impacts of the GFD Project-generated traffic on the efficiency, safety and amenity of the traffic and transport values in the GFD Project area. The assessment found that after implementing mitigation and management measures, the residual significance of the potential impacts to traffic and transport values are expected to be further reduced to negligible to moderate, as presented in Table 27-7.

As shown, the expected impact to highways is considered to be negligible based on the existing high volume of traffic and the limited extent that the GFD Project associated traffic volumes will alter these baseline volumes. The residual significance of moderate for all other road types is reflective of higher proportion that the GFD Project traffic will have on these road types.

Additional information on traffic and transport is provided in Section 11: Traffic and transport.

Table 27-7 Residual significance – traffic and transport

Environmental value	Potential impact	Residual significance by road type			
		Highway	Regional connecting road	Rural connecting road	Rural access road
Efficiency	Reduced efficiency related to increased traffic volumes and reduced standard of pavement and intersection control	Negligible	Moderate	Moderate	Moderate
Safety	Reduced safety related to bridges, cattle grids, rail crossings, school bus routes, traffic composition and driver fatigue controls.	Negligible	Moderate	Moderate	Moderate
Amenity	Reduced amenity related to stock route co-location, sensitivity of adjacent land uses, potential for dust nuisance and light glare issues.	Negligible	Moderate	Moderate	Moderate

27.7 Waste

Solid and liquid wastes in the GFD Project area are generated from domestic and commercial premises as well as agricultural, industrial and resource extraction activities. The GFD Project area contains both regional council and commercial facilities for waste management and collection. The GFD Project will generate solid, liquid and gaseous wastes that may impact on environmental values and receptors should the GFD Project generate excessive waste or manage its waste improperly. The values that waste may be affected include:

- Natural environment, including land, water resources, air quality, fauna and flora
- Productive capability of land i.e. its potential for use for agricultural, forestry or other uses
- Health and safety i.e. the life, health and wellbeing of people, including the GFD Project workers
- Sustainability of natural resources (e.g. construction materials, fuel, electricity, water)
- Available landfill capacity for waste disposal
- Visual amenity.

The impact assessment found that after implementing mitigation and management measures, the residual risk of the potential impacts to environmental values and receptors is expected to be very low to low, as outlined in in Table 27-8. These residual risks take into account that Santos GLNG has a Waste management plan and will continue to use a sustainable approach to waste management that follows the waste management hierarchy, consistent with the *Waste Reduction and Recycling Act 2011* (Qld).

Additional information on waste is provided in Section 12: Waste.

Table 27-8 Residual impacts – waste

Potential impact	Residual risk		
	Construction	Operations	Decommissioning
Excessive use of natural resources (disposed as waste)	Low	Low	Very low
Waste to be disposed to landfill (additional to current levels)	Low	Very low	Very low
Uncontrolled release of waste (may cause contamination of land, surface or ground waters and dependent ecosystems)	Low	Low	Low
Controlled release of waste (may cause contamination of land, surface or ground waters and dependent ecosystems)	Low	Low	Low
Increase in vermin and pest populations.	Low	Low	Low

27.8 Surface water

The GFD Project is located across three catchments: the Dawson River catchment (located within the Fitzroy Basin), the Comet River catchment (located within the Fitzroy Basin) and the Condamine-Balonne River catchment (located within the Condamine-Balonne Basin). These catchments include watercourses, wetlands, springs and ecosystems dependent on groundwater.

Watercourses in the GFD Project area are mostly ephemeral, meaning that they do not flow all year and only exist for short periods following rainfall. The exception to this is major watercourses such as the eastern portion of the Dawson River and parts of the Condamine River. A number of these water courses are recognised as having high ecological value under the *Environmental Protection Policy (Water) 2009*.

In general, the following water uses are considered to be the most sensitive to impacts within the GFD Project area:

- Livestock water
- Impound water (e.g. agricultural dams, emergency fire-fighting water supply)
- Domestic supply
- Water harvesting
- Industrial use
- Town water supply.

The significance assessment found that the residual impacts of the GFD Project are expected to be low to moderate and that the management framework (including Water resource management plan) would appropriately manage and reduce the majority of impacts to surface water values, as presented in Table 27-9. Impacts with a low level of significance are generally localised and temporary. Impacts with moderate significance may result in further degradation of surface water environmental values; however, as the environmental values are generally abundant throughout the region, the impacts are likely to be localised in nature and unlikely to result in irreversible change.

Additional information on surface water is provided in Section 13: Surface water.

Table 27-9 Residual significance – surface water

Potential impacts	Residual significance		
	Construction	Operations	Decommissioning
Increased sedimentation (adverse impacts on water quality and geomorphology)	Low	Low	Low
Decreased water quality due to erosion of stream banks	Low	Low	Low
Surface water contamination (adverse impact on surface water quality)	Moderate	Moderate	Low
Altered surface water flow regime (risk to infrastructure, riparian vegetation, terrestrial ecosystems and environmental flow regime)	Moderate	Low	Low
Altered geomorphic character (e.g. increased lateral instability; significant alteration of geomorphic units)	Low	Low	Low

27.9 Groundwater

Groundwater in the GFD Project area continues to be used extensively for stock, agricultural, domestic, town, and industry uses. There are around 21,000 water bores in the region that extract about 215, 000 ML per year mainly for agricultural use.

Water is extracted from a number of regional aquifers in the Great Artesian Basin hydrogeological system and from locally important alluvial systems and volcanic rocks of the Surat Basin and the upper Bowen Basin. Water quality varies from fresh to brackish.

A quantitative assessment of the potential impacts on groundwater was undertaken for the GFD Project and more development proposed by another coal seam gas proponent. This model considers cumulative impacts to bores and springs including existing gas projects and the GFD Project. The assessment concluded that an additional 73 private water bores in the Surat CMA, 48 of which are in the GFD Project tenures, are predicted to be impacted (modelled drawdown greater than 5 m) by the GFD Project. Of these 48, investigations (which include site inspections) have revealed:

- 66% (32) were observed to be in use by the landholder
- 23% (11) could not be located by the landholder, or else were not in use or were abandoned
- 10% (5) of private water bores could not be surveyed.

In relation to predicted impacts on springs and watercourse spring, the model concluded that there is a risk of impact (drawdown greater than 0.2 m) to 13 spring complexes and 19 watercourse springs under the EIS scenario. Among these, 8 spring complexes and 12 watercourse springs are located within or near GFD Project tenures.

Overall, based on the outcomes of the modelling, the cumulative impact to springs is considered to be high (based on the high probably and duration of the impact their high sensitivity) and moderate for bores.

This assessment also included a significance assessment to consider the potential impacts of the GFD Project on groundwater values in the GFD Project area. The impact assessment found that after implementing mitigation and management measures the residual significance of the potential impacts to groundwater values are expected to be low to moderate, as presented in Table 27-10. There is an extensive legislative framework in place to monitor and protect groundwater resources.

As detailed, the majority of potential impacts are expected to have a residual significance of low due to the low magnitude of the impact to the identified environmental value. The potential impacts that have retained a moderate significance include:

- Reduced spring flow and loss or degradation of MNES dependent ecosystems
- Subsidence, altering groundwater flow paths and aquifer storage.

These residual sensitivities are not able to be further reduced due to the high sensitivity of the MNES dependent ecosystems related to the springs and the limited available management measures in relation to the possible subsurface changes during operations. Additional information on groundwater is provided in Section 14: Groundwater.

Table 27-10 Residual significance – groundwater

Potential Impacts		Residual significance		
		Construction	Operations	Decommissioning
Aquifer depressurisation	Decline in groundwater levels/pressure in bores and reduced supply to groundwater users	Low	Low	Low
	Reduced stream baseflow (watercourse spring flow) and loss or reduction of supply to downstream surface water users	Low	Low	Low
	Reduced spring flow and loss or degradation of MNES groundwater dependent ecosystems	Moderate	Moderate	Moderate
	Reduced stream baseflow (watercourse spring flow) and loss or degradation of dependent aquatic ecosystems	Low	Low	Low
	Subsidence, altering groundwater flow paths and aquifer storage	Low	Moderate	Low
	Subsidence, causing ground surface displacement and altering surface water flow paths	Low	Low	Low
Changes to water quality	Degradation of the beneficial use of groundwater supplies	Low	Low	Low
	Loss or degradation of MNES ecosystems dependent on springs sourced from affected aquifers	Moderate	Moderate	Moderate

27.10 Air quality

Air quality that is conducive to human health, agricultural production and land use amenity is defined through the *Environmental Protection (Air) Policy 2008* (Qld). This policy outlines air quality guidelines for a number of pollutants including nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matters (PM_{10} and PM_2). These guidelines were used to model the GFD Project's air emissions and establish the distance at which sensitive receptors are likely to be impacted. The sensitive receptors that are expected to be relevant to the GFD Project are scattered rural dwellings, agricultural land and protected areas.

The air quality assessment established that particulate matter (dust) emissions arising from pre-mitigated construction, demolition and rehabilitation works occurring within 500 m of sensitive receptors may result in nuisance impacts requiring mitigation and management. Where such activities are undertaken greater than 500 m from receptors, potential dust impacts will generally be low and compliant with the adopted air quality assessment objectives and unlikely to require specific mitigation and management. Through the implementation of existing management and mitigation controls from the Santos GLNG management framework, it is expected potential impacts from particulate emissions from the GFD Project can be mitigated to comply with relevant air quality objectives.

The assessment of gaseous emissions during operations focused on NO_2 and CO from gas compression facilities as these will be the key emission sources. Other emissions would be emitted at very low and minor levels that would comply with the air quality assessment objectives. Dispersion modelling for NO_2 and CO determined that predicted concentrations from gas compression activities under normal operations and during flaring (commissioning and emergency) would comply with the relevant objectives for the preservation of health and wellbeing and biodiversity of ecosystems. These air emissions will have a low impact. Potential impacts on regional air quality are expected to be minimal with the GFD Project operations not a dominant contribution to regional NO_2 levels.

Additional information on air quality is provided in Section 15: Air quality.

27.11 Greenhouse gases

Santos GLNG's greenhouse gas (GHG) emissions were addressed in the 2009 EIS and 2010 supplementary EIS for the GLNG Project. This assessment gave consideration to GHG emissions from the gas fields, pipelines, LNG facility on Curtis Island, shipping and product end-use associated with the GLNG Project. GHG emissions from the GLNG Project were calculated based on the volume of gas required to supply the LNG facility, rather than the number of wells required (which may vary). Therefore, the GHG emissions associated with the operation of the additional production wells included in the GFD Project were already accounted for in the 2009 EIS and the 2010 supplementary EIS. It estimated that the total annual GHG emissions would be up to 7.2 million tonnes of carbon dioxide equivalent ($MtCO_2e$).

While the GHG emissions from the operation of the GFD Project's wells has already been included in the previous estimates, emissions from the construction and decommissioning of the GFD Project's production wells were not. The total incremental emissions from construction and decommissioning of the wells over the lifetime of the GFD Project are estimated to be 4.5 Mt carbon dioxide equivalent. These incremental emissions include emissions from land clearing, drilling and well completions, and transport during construction and decommissioning.

Fugitive emissions are minor intentional or unintentional GHG releases that occur during natural gas exploration, production and processing. Based on Santos Limited's reported 2011/12 emissions, minor unintentional releases are approximately 0.3% of total upstream emissions or 0.04% of total lifecycle emissions.

Additional information on greenhouse gases is provided in Section 16: Greenhouse gases.

27.12 Noise and vibration

The environmental values defined in the *Environmental Protection (Noise) Policy 2008* (Qld) (EPP Noise) aim to preserve or enhance qualities of the acoustic environment that protect human health and wellbeing (i.e. by ensuring suitable environments to sleep, study, be involved in recreation and conversation, and protect the amenity of the community), as well as the health and biodiversity of ecosystems. The *Petroleum and Gas Noise Assessment guideline* (EHP, 2012) established noise criteria to achieve the acoustic quality objectives of EPP Noise, which were used in the quantities assessment undertaken for this impact assessment.

The noise assessment established that the highest noise levels from the GFD Project will occur during construction and are associated with drilling activities. During operations, the highest noise levels associated will be emitted from hub gas compression facilities.

An assessment of the noise generated by the GFD Project's predicted traffic was also undertaken. Based on current predictions of the GFD Project's traffic and existing traffic, the noise criterion will be met on State-controlled roads as well as on council-controlled roads and access roads. The modelling has shown that an increase in traffic volumes of up to approximately 50% would comply with the incremental change noise criterion for existing council-controlled roads.

There are no significant vibrations generated by the GFD Project and no significant impacts are expected.

This noise and vibration assessment has established the potential for noise impacts at various propagation distances associated with the major project activities and noise generating infrastructure. This information will be incorporated into the planning process for the GFD Project so that project's noise sources are located at distances from noise sensitive receptors greater than those at which the relevant noise criteria will be met. If during project planning a risk of noise impact at a sensitive receptor above the relevant criteria is identified and the separation distance cannot be increased, mitigation activities such as detailed modelling and/or physical, engineering or other mitigation controls will be implemented in consultation with the landholder.

Additional information on noise and vibration is provided in Section 17: Noise.

27.13 Terrestrial ecology

The GFD Project area is situated in the Brigalow Belt bioregion, which has experienced a long history of human disturbance mainly as a result of agricultural practices. Consequentially, at a regional level, most remaining areas of vegetation are now fragmented, occurring on the rockier hilly areas of ranges, as roadside vegetation, or as relatively small isolated remnants.

The GFD Project gas fields contains Category A, B and C environmentally sensitive areas as defined under the *Environmental Protection Act 1994* (Qld). The category A areas are Expedition National Park, Humboldt National Park, Luke Murphy Conservation Park and the Carraba Conservation Park. The category B environmentally sensitive areas include 'endangered' regional ecosystems (REs) and state forests are present as category C environmentally sensitive areas.

The majority of the area of the GFD Project gas fields contains non-remnant vegetation. However, there are some extensive areas of remnant regional ecosystems mapped (approximately 315,610 ha). There are 42 'endangered' and 53 'of concern' regional ecosystems communities present. The most prevalent regional ecosystems are:

- Regional ecosystem 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains)
- Regional ecosystem 11.3.25 (*Eucalyptus tereticornis* or *Eucalyptus. camaldulensis* woodland fringing drainage lines)
- Regional ecosystem 11.9.5 (*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks)
- Regional ecosystem 11.9.10 (*Eucalyptus populnea, Acacia harpophylla* open forest on fine-grained sedimentary rocks).

There are 79 conservation significant flora species that have been identified to potentially occur within the terrestrial ecology study area; of these, 74 are known to occur. Nine of these have been recorded during Santos GLNG Project's field assessments. Additionally, essential habitat for ten conservation significant flora species have been mapped in the GFD Project terrestrial ecology study.

There are 48 conservation significant fauna species that have been identified to potentially occur within the terrestrial ecology study area; of these, 33 are known to occur there. The gas fields contain essential habitat for eight conservation significant fauna species, including the large-eared pied bat (*Chalinolobus dwyeri),* collared delma (*Delma torquate),* squatter pigeon (*Geophaps scripta scripta),* Brigalow scaly-foot (*Paradelma orientalis*), Yakka skink (*Egernia rugosa),* Painted honeyeater (*Grantiella picta),* Imperial hairstreak (*Jalmenus eubulus*), and Greater long-eared bat (*Nyctophilus corbeni*).

Eight introduced flora species declared as pests were identified in the terrestrial ecology study area; the most abundant of these are *Lycium ferocissimum* (African boxthorn) and *Opuntia stricta* (Prickly pear).

The environmental values for terrestrial ecological identified for the GFD Project area are:

- Endangered vegetation
- Of concern vegetation
- Essential habitat
- Conservation significant flora and fauna species
- Wetlands
- Category A, B and C environmentally sensitive areas
- EPBC Act Threatened ecological communities
- EPBC Act threatened and migratory fauna species
- EPBC Act threatened flora species.

Following impact assessment and implementation of the applicable mitigation and management measures (including the Significant species management plan, Rehabilitation management plan and Pest and weed management plan), the residual impacts to terrestrial ecology were assessed and are presented in Table 27-11. The significance assessment found that the residual impacts to terrestrial ecology values over the life of the project are mainly low or negligible. Impacts with a negligible or low level of significance are generally localised and temporary. There are some instances of high impacts related to vegetation clearing for construction. Impacts with high significance may result in impacts that extend beyond the area of disturbance to the surrounding area but are contained within the GFD Project area. Replacement of unavoidable losses from these impacts is possible through biodiversity offsets. There are some instances of impacts with moderate significance. This means the environmental value is generally already abundant throughout the region and the impact is unlikely to result in irreversible change.

Additional information on terrestrial ecology, environmentally sensitive areas and matters of national environmental significance is provided in Section 18: Terrestrial ecology.

Table 27-11 Residual significance – terrestrial ecology, environmentally sensitive areas and matters of national environmental significance

Environmental value	Potential impact	Residual significance		
		Construction	Operations	Decommissioning
Endangered vegetation (Regional Ecosystem and High Value Regrowth)	Habitat loss from vegetation clearing/removal	Moderate	Low	Low
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a
Of concern vegetation (Regional Ecosystem and High Value Regrowth)	Habitat loss from vegetation clearing/removal	High	Low	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a
Essential habitat	Habitat loss from vegetation clearing/removal	Moderate	Low	n/a
	Fauna species injury or mortality	Moderate	Moderate	Moderate
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Noise, dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a

Environmental	Potential impact	Residual significance		
High Ecological Significance wetlands	Habitat loss from vegetation clearing/removal	Moderate	Moderate	n/a
	Fauna species injury or mortality	Moderate	Moderate	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Noise, dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a
	Degradation of water quality due to increased sedimentation	Low	Low	Moderate
High Value Regrowth flora	Habitat loss from vegetation clearing/removal	High	Low	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	n/a
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a
Nature refuges	Habitat loss from vegetation clearing/removal	Low	Low	n/a
	Fauna species injury or mortality	Low	Low	Low
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Noise, dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a

Environmental	Potential impact	Residual significance		
Resource reserves	Habitat loss from vegetation clearing/removal	Low	Negligible	n/a
	Fauna species injury or mortality	Negligible	Negligible	Negligible
	Reduction in biological viability of soil to support growth due to soil compaction	Negligible	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Negligible	Negligible	Negligible
	Reduction of biodiversity corridors	Negligible	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Noise, dust and light	Negligible	Negligible	Negligible
	Increase in litter (waste)	Negligible	Negligible	n/a
State forest and timber reserves	Habitat loss from vegetation clearing/removal	Low	Negligible	n/a
	Fauna species injury or mortality	Low	Low	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Negligible	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Negligible	Negligible	Negligible
	Reduction of biodiversity corridors	Negligible	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Negligible	Negligible	Negligible
	Increase in litter (waste)	Negligible	Negligible	n/a
Threatened ecological community - Brigalow (*Acacia harpophylla* dominant and co-dominant)	Habitat loss from vegetation clearing/removal	Moderate	Low	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a

Environmental	Potential impact	Residual significance		
Threatened ecological community - Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Habitat loss from vegetation clearing/removal	High	Low	n/a
	Fauna species injury or mortality	Moderate	Moderate	Moderate
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a
Threatened ecological community – Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions Threatened ecological community - Weeping Myall Woodlands	Habitat loss from vegetation clearing/removal	High	Low	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Moderate	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Moderate	Low
	Increase in litter (waste)	Low	Moderate	n/a
Threatened ecological community - Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin Threatened ecological community - Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	Habitat loss from vegetation clearing/removal	Moderate	Low	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a

Environmental	Potential impact	Residual significance		
EPBC Act threatened and Migratory fauna species habitat	Habitat loss from vegetation clearing/removal	High	Low	n/a
	Fauna species injury or mortality	Moderate	Moderate	Moderate
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Noise, dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a
Cattle egret, Great egret, Squatter pigeon and Rainbow bee-eater habitat	Habitat loss from vegetation clearing/removal	Moderate	Low	n/a
	Fauna species injury or mortality	Moderate	Moderate	Moderate
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Noise, dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a
EPBC Act threatened flora species habitat	Habitat loss from vegetation clearing/removal	High	Low	n/a
	Reduction in biological viability of soil to support growth due to soil compaction	Low	n/a	n/a
	Displacement of flora and fauna species from invasion of weeds and pest species	Low	Low	Low
	Reduction of biodiversity corridors	Low	n/a	n/a
	Edge effects			
	Habitat fragmentation			
	Barrier effects			
	Dust and light	Low	Low	Low
	Increase in litter (waste)	Low	Low	n/a

27.14 Aquatic ecology

Aquatic ecology values in the GFD Project area include watercourses, wetlands, springs and groundwater ecosystems. As discussed in Section 27.8: Surface water, watercourses in the GFD Project area are mostly ephemeral (with the exception of major watercourses such as parts of the Dawson River and Condamine River) and many are in a moderate to poor ecological condition. The decline of ecological conditions are a result of impacts associated with historic vegetation clearing, cattle grazing, river flow regulation and watercourse crossings for roads and other linear infrastructure.

Despite these impacts, watercourses in the GFD Project area continue to provide habitat for aquatic biota that is representative of the wider regional area, including aquatic plants, macroinvertebrates, fish, turtles and platypus. Wetlands, deep watercourse pools and springs in the GFD Project area provide permanent aquatic habitat. Many wetlands and springs have also been impacted by clearing, modification of drainage patterns, and cattle access; although some of these sensitive ecosystems are classified as being in good ecological condition and provide habitat for conservation significant species.

The impact assessment found that after implementing mitigation and management measures, the residual significance of the potential impacts to aquatic ecology values are expected to be low to moderate, as presented in Table 27-12. Potential impacts that are expected to have low level of significance are generally localised and temporary — meaning that the impact will affect a limited area for a short period of time. Impacts with moderate significance may result in further degradation of aquatic environmental values; however the environmental value is generally already abundant throughout the region and the impact is unlikely to result in irreversible change.

Additional information on aquatic ecology is provided in Section 19: Aquatic ecology.

Table 27-12 Residual significance – aquatic ecology

Potential impacts	Residual significance		
	Construction	Operations	Decommissioning
Sediment to water	Low	Low	Low
Chemicals to water	Moderate	Moderate	Moderate
Altered flow regime	Low	Low	Low
Disturbance of stream channel and associated habitat	Low	Low	Low
Loss of abundance and diversity of riparian vegetation and aquatic biota, including groundwater dependent ecosystems	Moderate	Low	Low

27.15 Matters of national environmental significance

Matters of national environmental significance are environmental values are controlling provisions under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). Specifically, the controlling provisions are:

- Wetlands of international importance
- Listed threatened species and communities
- Listed migratory species.

In October 2013, Santos GLNG was advised by the Commonwealth Department of the Environment (successor of SEWPaC) that an additional controlling provision relating to the impact of coal seam gas development on water resources also applied to the GFD Project.

In this EIS, matters of national environmental significance were considered under two broad groupings: terrestrial ecology and water resources. The conclusions drawn for each category are presented below.

27.15.1 Terrestrial ecology

Conclusions regarding impacts on terrestrial ecology are also considered in 27.13. Six threatened ecological communities were identified as potentially occurring in the GFD Project area including:

- Brigalow (*Acacia harpophylla* dominant and co-dominant)
- Coolibah-Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions
- Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin
- Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions
- Community of native species dependent on natural discharge of groundwater from the Great Artesian Basin
- Weeping Myall Woodlands.

The presence of these communities was confirmed during field assessments, with the exception of the Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin, and Weeping Myall Woodlands.

Twenty-five EPBC Act listed conservation significant flora species were identified as potentially occurring within the GFD Project terrestrial ecology study area. Of these, 20 species are known to occur. Only two of these (Xerothamnella and Ooline) have been recorded during the Santos GLNG field surveys.

Twenty-six EPBC listed conservation significant fauna species were identified as potentially occurring in the Terrestrial Ecology Study area. This includes 11 birds, 1 fish, 1 gastropod, 6 reptiles and 7 mammals. Of these, 14 are known to occur. Only five of these (Red goshawk, Squatter pigeon, Brush-tailed rock-wallaby, Koala and South-eastern long-eared bat) have been recorded during the Santos GLNG field surveys.

Twenty-three migratory species were identified as potentially occurring in the terrestrial ecology study area. Of these, 19 are known to occur. Only six of these (Cattle egret, Fork-tailed swift, Rainbow bee-eater, Satin flycatcher, Spectacled monarch and Glossy ibis) have been recorded during the Santos GLNG field surveys. It is likely that the terrestrial ecology study area contains suitable habitat for other migratory species during locally favourable conditions or when episodic dry conditions prevail further inland.

Without adequate controls, potential impacts to matters of national environmental significance that may occur as a result of the GFD Project include:

- Habitat loss from vegetation clearing/removal
- Fauna species injury or mortality from project activities
- Reduction in soil viability to support plant growth due to soil compaction
- Displacement of flora and fauna species by weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects to habitat (e.g. weed invasion and reduction of biodiversity)
- Habitat fragmentation from vegetation clearing
- Barrier effects (e.g. loss of species' migration pathways)
- Disturbance to fauna and flora from noise, dust, and light
- Degradation of habitat from an increase in litter (waste)
- Increased sedimentation

- Erosion of stream banks
- Surface water contamination
- Altered surface water flow regime
- Altered geomorphic character
- Aquifer depressurisation leading to reduced spring flow or degradation of groundwater dependant ecosystems
- Altered water quality in aquifers leading to loss or degradation of ecosystems dependent on springs.

The potential impacts to matters of national environmental significance (ecology) were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.

The significance of the residual impacts after the implementation of Santos GLNG mitigation measures was assessed as ranging from negligible to high. Most of the impacts were assessed as having a negligible or low level of significance. These are generally localised and temporary. There were some instances of impacts with moderate significance may result in degradation of terrestrial ecology values; however, the impacts are unlikely to result in irreversible change. The high significance residual impacts relate to construction phase clearing of any of the following:

- EPBC Act threatened flora or fauna species habitat
- Threatened ecological communities (Coolibah-black box woodlands, Weeping myall, Semi-evergreen vine thicket).

Replacement of unavoidable losses from these impacts is possible through biodiversity offsets.

27.15.2 Water resources

Water resources in relation to coal seam gas projects are considered a matter of national environmental significance in accordance with the requirements of the EPBC Act. In relation to the GFD Project, water resources include surface water and groundwater resources in and surrounding the GFD Project area. Conclusions regarding impacts on surface water and groundwater are considered in 27.8 and 27.9.

The GFD Project area is located across three catchments: the Dawson River catchment, the Comet River catchment, and the Condamine-Balonne River catchment. Aquatic habitats in the GFD Project area include watercourses, wetlands, springs and groundwater ecosystems. Watercourses in the GFD Project area mostly ephemeral, meaning that they do not flow all year and generally only exist for short periods following rainfall. The aquatic environmental values of watercourses within the GFD Project area are low to moderate and consistent with those of the wider catchments, and consistent with a slightly to moderately disturbed ecosystem.

There are no Ramsar wetlands of international significance within the GFD Project area or in close proximity. The nearest Ramsar wetland is the Narran Lake Nature Reserve approximately 320 km downstream of the GFD Project area in the Condamine-Balonne River catchment.

Lake Murphy and part of the Palm Tree and Robinson Creek wetland complex located in the Lake Murphy Conservation Park (within GFD Project tenure ATP803) are listed as nationally important (Environment Australia, 2001). This area is mapped as having high ecological value (referrable) wetlands in the Great Barrier Reef catchments – Lake Murphy Conservation Area. These wetlands contain species and regional ecosystems (REs) of conservation significance under both the EPBC Act and the NC Act.

Natural discharge from Great Artesian Basin aquifers may feed spring vents and watercourse springs. A spring vent is a single point in the landscape where groundwater is discharged at the surface. A group of spring vents located in close proximity to each other is called a spring complex. Wetlands and springs in the GFD Project area provide permanent or semi-permanent aquatic habitat, and are therefore likely to support a greater diversity of aquatic flora and fauna than the ephemeral watercourses. There are 11 spring complexes within the GFD Project gas fields. Of these, three (Lucky Last, Yebna 2 and Abyss) are listed in the EPBC Act as having conservation significance.

The following four EPBC Act listed aquatic ecology species and communities have the potential to occur within the GFD Project area:

- Fitzroy river turtle
- Murray cod
- Salt pipewort
- Community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.

However, no near-threatened or threatened species of aquatic fauna have been recorded in the watercourses in the GFD Project area. However, the watercourses in the Condamine-Balonne River Catchment may provide suitable breeding or dispersal habitat for Murray cod, and the Dawson River upstream of Taroom contains suitable habitat for the Fitzroy River Turtle, and may support this species. Salt pipewort has been recorded at springs in the Dawson River catchment. The critically endangered Boggomoss snail was not identified within the GFD Project area, although are known to occur within the Dawson River and the Boggomoss springs complex downstream of Taroom.

An assessment of the matter of national environmental significance for water resources was undertaken in accordance with the Independent Expert Scientific Committee (IESC) guidelines and is presented in Appendix U2: Reports on Matters of National Environmental Significance (water). Potential impacts to water are managed through the Water resource management plan.

27.16 Cultural heritage

The GFD Project area contains a variety of cultural heritage places, reflective of its Indigenous history and early European settlement. There are numerous areas and artefacts relevant to Indigenous peoples present, which are protected under established cultural heritage management plans (CHMPs). In regards to non-indigenous cultural heritage, the GFD Project area played host to early European exploration in Queensland and thus contains places reflective of exploration, early settlement and European-Indigenous frontier interaction and conflict.

The impact assessment found that after implementing mitigation and management measures, the residual risk of the potential impacts to cultural heritage values is expected to be very low to medium, as presented in Table 27-13.

As shown, the majority of potential impacts have a residual risk rating between very low and low. This reflects the fact that:

- Santos GLNG has a solid understanding of the heritage landscape within the GFD Project area, established by an history of heritage investigations undertaken by resource proponents, including Santos GLNG
- The majority of non-Indigenous heritage places in the GFD Project area are located within urban areas, which will not be subject to disturbance by GFD Project activities.
- The Indigenous heritage across the GFD Project area is protected and managed in accordance with established CHMPS, which have been developed with each relevant Aboriginal Party under the *Aboriginal Cultural Heritage Act 2003* (Qld).

- The strength of Santos GLNG's cultural heritage management framework, which defines the processes to avoid, where practicable, or otherwise minimise impacts to cultural heritage from Santos GLNG operations and to ensure that relevant statutory cultural heritage requirements are complied with.

The potential impacts that have retained a medium level of risk after mitigation is primary associated with the inability to implement controls for unknown or unassessed places; however, Santos GLNG's management framework does include processes for pre-clearance surveys and actions to be taken should an unknown heritage place be identified.

Additional information on cultural heritage is provided in Section 20: Cultural heritage.

Table 27-13 Residual risks – cultural heritage

Potential impact	Heritage classification	Residual risk		
		Construction	Operations	Decommissioning
Disturbance/encroachment on known cultural heritage	State	Low	Low	Low
	Local	Low	Very low	Very low
	Unassessed	Medium	Low	Low
Disturbance/encroachment on unknown cultural heritage	National	Medium	Medium	Medium
	State	Medium	Low	Low
	Local	Low	Very low	Very low
Disturbance/encroachment on significant heritage landscape	N/A	Medium	Medium	Medium

27.17 Social

The GFD Project's gas fields are located across the four local government areas of Banana Shire Council, and the Central Highlands, Maranoa and Western Downs Regional Councils. Local towns include Taroom, Wandoan, Rolleston, Injune, Roma, Wallumbilla and Yuleba.

This region has historically had a strong rural industry base with grazing being the predominant land use. However, especially in the past decade, the region has experienced population and economic growth as a result of the development and expansion of the resources sector. The resources industry has partly offset subdued economic activity in the agricultural sector during periods of drought and low commodity prices. Recent gas field development has built upon the long history of gas production in the region, particularly in the vicinity of Roma.

The potential for social impacts to occur on non-indigenous communities was assessed within each gas field individually (Arcadia, Fairview, Roma and Scotia). However, the Fairview and Roma gas were assessed together, recognising that both these gas fields have considerable linkages between the primary towns, which are both located in the Maranoa Regional Council. The impact assessment found that after implementing mitigation and management measures, the residual risk of the potential impacts to social values is expected to be very low to medium, as presented in Table 27-14.

As detailed, the majority of potential impacts have a residual risk rating between very low to low. The low level of risk predicted is based on the experience in many of these communities to date with the Santos GLNG Project and the application of the existing Social impact management plan and Social impact action plans developed for this project, where Santos GLNG has been successful in mitigating and managing potential social impacts.

Two potential impacts have retained a medium level of risk after mitigation:

- The potential for project traffic on local roads has a number of flow-on impacts, such as the potential for an increase in accidents with an in turn increase in the workload of police and emergency services and a change in amenity. Although Santos GLNG has implemented a suite of management processes to manage traffic safety, the likelihood that traffic will increase remains high.
- The perception that gas extraction may impact on water availability for agriculture has been a noted concern in the Scotia gas field area. Given the existing concern it is likely that any emerging perception of adverse impact will generate concern around agricultural production.

The existing social conditions and potential social impacts on the Indigenous communities were assessed separately. The impact assessment found that after implementing mitigation and management measures, the residual risk of the potential impacts to social values is expected to be very low to medium, as presented in Table 27-15.

The majority of potential impacts to the Indigenous population across the GFD Project area are expected to be range between very low and low. For the most part, Santos GLNG's activities offer potential employment and has strengthened understanding of Indigenous heritage across the GFD Project area.

The exception to this is the potential impacts that are connected to an increased demand on housing. Where the affordability of housing is affected it is likely to affect the Indigenous community to a greater extent due to the higher proportion of households in low income ranges compared to non-indigenous households. Further, it can have flow-on effects, such as out-migration of family groups, which may reduce the liveability of the community for those family members remaining.

Additional information on social values is provided in Section 21: Social.

Table 27-14 Residual risks – social (non-indigenous)

Social value	Potential impact	Phase	Residual risk – gas field		
			Arcadia	Roma and Fairview	Scotia
Liveable community	Workforce demand on public health facilities and services	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low
	Intra-community conflict	Construction	Very low	Very low	Very low
		Operations	Very low	Very low	Very low
		Decommissioning	Very low	Very low	Very low
	Project traffic on local roads and in the town areas	Construction	Medium	Medium	Medium
		Operations	Medium	Medium	Medium
		Decommissioning	Low	Low	Low
	Presence of a younger, predominantly male workforce in social venues and general town area	Construction	Very low	Very low	Low
		Operations	Very low	Very low	Low
		Decommissioning	Very low	Very low	Very low
	Demand on public physical infrastructure	Construction	Very low	Low	Low
		Operations	Very low	Low	Low
		Decommissioning	Very low	Very low	Very low

Social value	Potential impact	Phase	Residual risk – gas field		
			Arcadia	Roma and Fairview	Scotia
Affordable lifestyle	Increased demand for housing	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low
	Increased wage pressures on local businesses	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low
Community identity and spirit	Local employees working extended shift hours and rosters	Construction	Very low	Very low	Very low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low
	Visible presence of gas industry workers in local community venues, and the presence and scale of project facilities, including camps	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Low	Low	Very Low
	High occupancy of short-term accommodation by gas industry contractors, displacing visitors to communities when project workforce accommodation facilities are not available	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low
	Out-migration of primary producers from high-impacted properties	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low
Capacity for sustainable economic activity	Disruption to agricultural production through field operations	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low
	Construction activity deters local tourism and highway trade	Construction	Very low	Very low	Very low
		Operations	Very low	Very low	Very low
		Decommissioning	Very low	Very low	Very low
	Perception that gas extraction creates uncertainty around water availability for agriculture	Construction	Low	Low	Medium
		Operations	Low	Low	Medium
		Decommissioning	Very low	Very low	Very low
	Inward movement of larger enterprises to local area	Construction	Low	Low	Low
		Operations	Low	Low	Low
		Decommissioning	Very low	Very low	Very low

Table 27-15 Residual risks – social (Indigenous)

Social value	Potential impact	Phase	Residual risk
Liveable community	Uncertainty with regard to environmental impact of GFD Project	Construction	Low
		Operations	Low
		Decommissioning	Low
	Lack of cultural awareness of in-migrating construction and operations workforce	Construction	Low
		Operations	Very Low
		Decommissioning	Low
	Tension between different segments of Indigenous populations over access to project benefits	Construction	Very Low
		Operations	Very Low
		Decommissioning	Very Low
	Out-migration of elements of family groups due to inability to afford housing	Construction	Medium
		Operations	Low
		Decommissioning	Very Low
Affordable lifestyle	Increased housing costs	Construction	Medium
		Operations	Medium
		Decommissioning	Low
Community identity and spirit	Inadvertent interference with cultural heritage during well and facilities development	Construction	Low
		Operations	Very Low
		Decommissioning	Low
	Increased Indigenous employment presents staffing difficulties for Indigenous organisations	Construction	Low
		Operations	Low
		Decommissioning	Low
	General level of development marginalises Indigenous presence in community	Construction	Low
		Operations	Low
		Decommissioning	Very Low
	Resentment at perceived landholder benefit from the occupation of traditional land	Construction	Low
		Operations	Low
		Decommissioning	Very Low
Capacity for sustainable economic activity	High-paying, short-term construction work draws higher-level students from schooling or training	Construction	Low
		Operations	Low
		Decommissioning	Low
	Unsupportive workplace environment for local Indigenous employees	Construction	Low
		Operations	Low
		Decommissioning	Low

27.18 Economics

The economies of the local government areas across the GFD Project area are highly reliant on resource production (mining and oil/gas) and agriculture. These primary industries are supported by a range of services, concentrated in the urban centres of Roma and Blackwater.

Modelling to understand the potential economic impacts of the GFD Project has been undertaken for the period 2013 to 2040 for three specific economic regions:

- GFD Project area — includes all of the Banana Shire Council and Central Highlands, Maranoa and Western Down regional council areas
- Queensland — includes the GFD Project area in the context of the rest of the State
- Australia — examines the impact of the GFD Project from a national perspective.

A range of potential direct and flow-on economic benefits resulting from the GFD Project have been identified. These benefits which will greatly outweigh localised negative impacts will result from:

- Capital investment in upstream gas production, processing facilities and other supporting infrastructure
- Export revenues generated from additional LNG production as the GFD Project supplies the existing LNG facility at Curtis Island in Gladstone
- Additional employment activity
- Increased fiscal receipts to the Queensland and Commonwealth Governments in the form of taxes and royalties.

The economic analysis indicates that the GFD Project would have a significant positive impact on the regional, State and national economies. A summary of the economic impacts is provided in Table 27-16.

Table 27-16 Summary of the cumulative economic impacts

Economic region	Economic output (net present value, $M)				Employment average (FTE[1])
	2020	2030	2040	2013–2040	2013–2040
Moderate scenario					
GFD Project area	622	1,505	1,298	9,795	616
Queensland	740	1,952	1,519	12,059	1,123
Australia	729	1,748	961	10,951	929
Maximum scenario					
GFD Project area	1,114	2,392	2,931	16,882	1,337
Queensland	1,354	2,786	3,574	20,047	2,182
Australia	1,277	2,533	2,772	18,301	1,904

[1] Full time equivalent

[2] Moderate scenario taking into account commercial sensitivities related to gas development that may result in a reduced well count and number of support facilities

[3] Maximum scenario based upon the development of the full 6,100 wells for which approval is being sought

Other economic impacts from the GFD Project could include:

- Increase in the non-resident workforce which can lead to “economic leakage” of economic activity away from the GFD Project area to the workforce’s home areas
- Increase in the cost of living within the GFD Project area
- Increased participation opportunities for local industries.

Additional information on economics is provided in Section 22: Economics.

27.19 Health and safety

The overarching environmental values derived for the health and safety aspects of the GFD Project are the health and safety of communities, particularly vulnerable members of the community, as well as the GFD Project workforce. For the purposes of the impact assessment, the relevant values were nominated as:

- Air quality that is conducive to human health and agricultural production
- Acoustic environment that is conducive to human health and agricultural production
- Water quality that is conducive to human health and agricultural production.
- Transport networks that are well maintained with the capacity for their traffic volume
- Health, safety and wellbeing of workers associated with the GFD Project.

The impact assessment found that after implementing mitigation and management measures, the residual risk of the potential impacts to health and safety values is expected to be low to high, as presented in Table 27-17. Those potential impacts that have been assessed to have a residual risk of low have achieved this rating based on the low potential for the impact to occur and the strength of Santos GLNG's ability to avoid and manage the consequence of these impacts upon the health and safety of the population and workforce. Indeed, the separate assessments undertaken in this EIS for air, noise and water quality have ascertained that the GFD Project is unlikely to breach quality objectives.

The potential impacts that have a residual rating higher than low reflect the consequence of injury to the surrounding population or workforce, particularly in regard to the potential for industrial accidents. While Santos GLNG's health and safety management framework is robust, the assessment found that the likelihood of traffic accidents will remain possible throughout the life of the GFD Project, given the range of resource project activities occurring in the area.

Additional information on health and safety is provided in Section 23: Health and safety.

Table 27-17 Residual risks – health and safety

Impact	Residual risk		
	Construction	Operations	Decommissioning
Exceedance of air quality objectives	Low	Low	Low
Exceedance of noise and vibration criteria	Low	Low	Low
Potential for traffic incidents	High	High	High
Water quality objective exceedance	Low	Low	Low
Potential for industrial incidents	Medium	Medium	Medium
Workplace health and safety	High	Low	Medium

27.20 Preliminary hazard and risk

A range of potential hazard and risks resulting from the GFD Project have been identified. Following impact assessment and implementation of the applicable mitigation and management measures, the residual impacts to hazard and risk were assessed and are presented in Table 27-18.

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

Medium risks levels are acceptable provided they can be demonstrated to be as low as reasonably possible (ALARP). Risks will be managed to ALARP level using existing Santos GLNG controls.

Additional information on hazard and risk is provided in Section 24: Preliminary hazard and risk.

Table 27-18 Residual risks – hazard and risk

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

[1] Satisfies relevant quantitative risk criteria

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

27.21 Decommissioning and rehabilitation

Decommissioning and rehabilitation activities will occur throughout the life of GFD Project. They will be implemented for shorter term or temporary construction related activities (such as temporary camps) as well as for longer term or more permanent infrastructure (such as compressor stations and water management facilities).

The intent of the decommissioning and rehabilitation of the GFD Project is to facilitate the return of the land to a stable state, where either the former land use or another land use agreed by the Government and/or landholder can occur. Rehabilitation objectives include ensuring that the remaining landform is safe to humans and wildlife, non-polluting, stable and able to sustain the agreed land use. Risks imposed by the rehabilitated land will not exceed the risks posed by the surrounding undisturbed land use.

Residual risks following the decommissioning and rehabilitation of the GFD Project will be low. Additional information on decommissioning and rehabilitation is provided in Section 25: Decommissioning and rehabilitation.

27.22 Cumulative impacts

When numerous projects occur in a region they can cause cumulative impacts, which may differ from those of an individual project when considered in isolation. Cumulative impacts may be positive or negative, and their severity and duration will depend on the extent of the overlap of the projects' size, locations and timing.

The potential cumulative impacts that may occur across the GFD Project cumulative impact area through the interaction of GFD Project impacts with other proposed projects was assessed. Residual cumulative impacts were assessed following the application of GFD Project mitigation and management measures and are summarised in Table 27-19. The assessment found that the residual cumulative impacts to environmental and social values within the GFD Project cumulative area (with the exception of groundwater springs) have a low to medium significance. The groundwater springs have a high significance due to the probability and duration of the impact and the springs' environmental sensitivity.

Additional information is provided in Section 26: Cumulative impacts.

Table 27-19 Residual cumulative impact significance – summary

Environmental value	Residual cumulative impact
Land use and tenure	Low
Land resources	Low
Landscape and visual amenity	Low
Traffic and transport	Medium
Waste	Low
Surface water	Low
Groundwater (springs)	High
Groundwater (bores)	Medium
Air quality	Low
Greenhouse gases	Low
Noise and vibration	Low
Terrestrial ecology (including MNES)	Medium
Aquatic ecology	Medium
Cultural heritage	Medium
Social	Low
Economics (benefits)	Medium