Cumulative impacts 26

Enter ▶ Go back to contents ▶

Contents

Tables

Figures

26 Cumulative impacts

26.1 Introduction

This section describes the cumulative impacts of the GFD Project.

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 spatial and temporal overlap of multiple projects. Existing developments are considered part of the existing environment in Sections 7 to 24 of this EIS and have already been accounted for in the assessment of the GLNG Project's residual impacts. This section assesses the impact of the GFD Project together with the residual impacts of projects within the region that are proposed or under construction but not yet fully operational.

The objective of the cumulative impact assessment is to assess the potential for GFD Project impacts to interact with similar impacts from other projects proposed within the GFD Project cumulative impact area. For the purposes of this assessment the GFD Project cumulative impact area is assumed to be the GFD Project area plus a surrounding 50 km buffer area[1].

The GFD Project cumulative impact area contains a number of resource projects that have the potential to generate cumulative impacts. They include major gas projects (other than the GFD Project) which are contiguous in the southeast of the GFD Project cumulative impact area. In addition to these, coal mining, power and rail projects are proposed across the GFD Project cumulative impact area.

This section has been prepared in accordance with sections 4, 5.5 and 8 of the *Terms of reference for an environmental impact statement* issued March 2013. The index to locate where each ToR requirement is met within this EIS is included in Appendix B: Terms of reference cross-reference.

26.2 Regulatory context

This EIS has been prepared in accordance with the State and Commonwealth regulatory context as provided within Appendix C: Regulatory framework. The legislation, policies and best practice guidelines related to cumulative impacts are presented within Table 26-1.

Table 26-1 Regulatory context of the GFD Project – cumulative impacts

Legislation, policy or guideline	Relevance to the GFD Project
State Development and Public Works Organisation Act 1971 (Qld) (SDPWO Act) The Act facilitates timely, coordinated and environmentally responsible infrastructure planning and development to support Queensland's economic and social progress. The SDPWO Act is one of a number of pieces of legislation in Queensland under which the environmental impacts of development projects can be assessed.	The SDPWO Act provides the Queensland Coordinator-General the power to declare a project to be a 'coordinated project' and to require an EIS to be prepared. The assessment of cumulative impacts is a standard requirement in the ToR for 'coordinated projects'.

[1] This area was selected to assist in screening the proposed projects most likely to interact spatially with the GFD Project, acknowledging some visual amenity, water, transport, social and economic impacts may extend further.

Legislation, policy or guideline	Relevance to the GFD Project
Water Act 2000 (Qld) The Act regulates the development of water resource plans (WRPs) and resource operations plans (ROPs) for major river catchments in Queensland. WRPs establish a framework for sharing water between human consumptive needs and environmental values. ROPs are developed in parallel with WRPs and provide a framework for implementing WRPs.	The Water Act makes provision for the declaration of a cumulative management area where an area contains two or more petroleum tenures where there may be cumulative impacts on groundwater. The GFD Project falls within the Surat Cumulative Management Area. The declaration of the Surat Cumulative Management Area means that the Queensland Water Commission will be preparing a groundwater impact report for the area. The report will identify likely future impacts on groundwater from the water extraction associated with the petroleum tenures and provide appropriate strategies for managing these impacts.

This EIS seeks to obtain primary approvals for the project including the Queensland Government Coordinator-Generals Report and Commonwealth Government Environmental Protection and Biodiversity Act approval.

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

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

26.3 Assessment method

In Queensland, there is no standard methodology for assessing the cumulative impacts of development projects. The methodologies used for EISs have therefore generally been developed on a project-specific basis.

The methodology used to assess the GFD Project's cumulative impacts consisted of the following tasks:

- Identify the residual impacts of the GFD Project using existing baseline conditions (these impacts have been described in detail in the relevant sections of the EIS)
- Identify the proposed projects to be considered in the cumulative impact assessment and their residual impacts
- Identify appropriate spatial boundaries for the analysis of cumulative impacts
- Identify appropriate temporal boundaries for the analysis of cumulative impacts
- Determine the relevance and significance of the cumulative impacts for each relevant environmental value
- Develop suitable mitigation measures for the significant cumulative impacts.

In assessing the significance of potential cumulative impacts, the extent of compliance with established standards or guidelines was used where the impacts could be expressed quantitatively. Where the impacts were expressed qualitatively, the probability, duration, and magnitude/intensity of the impacts were considered as well as the sensitivity and value of the receiving environmental conditions. The significance of the impact was then determined according to the assessment matrix presented in Table 26-2.

Table 26-2 Assessment matrix

Aspect	Relevance factors		
	Low	Medium	High
Probability of impact	1	2	3
Duration of impact	1	2	3
Magnitude/intensity of impact	1	2	3
Sensitivity of receiving environment	1	2	3

The resultant significance of the impact was determined by using professional judgement to select the most appropriate relevance factor for each aspect and summing the relevance factors. The resultant impact significance and consequence are summarised below in Table 26-3.

Table 26-3 Impact significance

Impact significance	Sum of relevance factors	Consequence
Low	1-5	Negative impacts need to be managed by standard environmental management practices. Special approval conditions are unlikely to be necessary. Monitoring to be part of general project monitoring program.
Medium	6-9	Mitigation measures likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring program required.
High	10-12	Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring program necessary.

The aspects of the environment which have been considered for this cumulative impact assessment are as follows:

- Land use and tenure
- Land resources
- Landscape and visual amenity
- Traffic and transport
- Waste
- Surface water
- Groundwater
- Air quality
- Greenhouse gas
- Noise and vibration
- Terrestrial ecology (including matters of national environmental significance)
- Aquatic ecology
- Cultural heritage
- Social
- Economics.

26.4 Proposed projects

Proposed projects for inclusion in the cumulative impact assessment are those within the GFD Project cumulative impact area that:

a. Are currently being assessed under Part 1 of the Chapter 3 of the *Environmental Protection Act 1994* (Qld) (EP Act) and, as a minimum, have an initial advice statement (IAS) available on the Queensland Department of Environment and Heritage Protection's (EHP) website
b. Have been declared a 'coordinated project' by the Coordinator-General under the SDPWO Act and an EIS is currently being prepared or is complete, or an IAS is available on the Queensland Department of State Development, Infrastructure and Planning (DSDIP) website
c. May use resources located within the region (including materials, groundwater, road networks or workforces) that are the same as those to be used by the GFD Project
d. Could potentially compound residual impacts that the GFD Project may have on environmental or social values.

Projects that are excluded from the GFD Project's cumulative impact assessment are:

- Existing or historic projects within the GFD Project cumulative impact area as these are considered to be a part of the baseline environment
- Proposed projects that have not been developed to the point that their environmental assessment process has been made public.

Based on the above criteria, the proposed projects that have been included in this cumulative impact assessment are presented in Table 26-4. The status of these proposed projects is as they were on November 2013 and the details may have since changed. The very challenging economic environment for new projects in the resource industry means many of the projects are on hold, but this assessment takes the conservative approach that the projects will proceed.

The approximate location of each of the proposed projects is shown on Figure 26-1.

Table 26-4 Proposed projects relevant to the GFD Project cumulative impact assessment

Project and *Proponent*	Location	Description	EIS status[1]	Construction dates	Construction jobs	Operations jobs	Lifespan (years)	Relationship to GFD Project	Selection criteria [2]
Australia Pacific LNG (APLNG) *Origin Energy and Conoco Phillips*	Gas fields: stretching from Injune to Millmerran. Pipeline: from gas fields to Gladstone. LNG plant and export terminal: Curtis Island, near Gladstone.	Development of ~10,000 production wells over ~5,700 km^2. 450 km gas transmission pipeline. LNG plant and export facility	Approved Nov 2010	Gas fields: 2010 to 2027 Pipeline: mid-2012 to late-2013. LNG facility: 2011 to 2014	Gas fields: 2,100 Pipeline: 800 LNG facility: 2,100	Gas fields: 700 Pipeline: 20 LNG facility: 100 for 1 train and 75 for each additional train.	30	APLNG tenures lay northwest to southeast within the GFD Project cumulative impact area. Gas fields' development periods will overlap.	b)
Arcturus Coal Mine Project *Springsure Creek Coal*	~40 km south of Emerald and 60 km southwest of Blackwater	Open cut and underground mine	EIS in preparation	NA	300	150	30	Located ~50 km west of Arcadia gas field.	a)
Blackwater to Emerald power line Replacement *Ergon Energy*	Between Blackwater and Emerald.	Upgrade power line from Blackwater to Emerald to 66 kV or 132 kV dual circuit concrete pole line.	Draft design underway	2014	NA	NA	30-40	Northwest of Arcadia gas field.	c)
Blythedale, Fairview and Fairview South Substations Project *Powerlink*	Three locations between Wandoan and Injune.	Three 132 kV substations to supply Santos GLNG's Roma and Fairview gas fields.	EIS completed in July 2013, released for public comment.	2014	NA	NA	40-50	Located near and will supply electricity to facilities within Roma and Fairview gas fields.	c)
Bowen Gas Project *Arrow Energy*	Extends from Blackwater north to near Glenden	Gas project. 6,625 production wells and associated infrastructure over ~8,000 km^2	EHP issued public notification of EIS	2015. Well drilling commencing 2016, and commence production 2017.	1,540	597	40	ATP 1025 is located ~40 km north of Arcadia gas field. Gas field development period will overlap.	a)

Project and *Proponent*	Location	Description	EIS status[1]	Construction dates	Construction jobs	Operations jobs	Lifespan (years)	Relationship to GFD Project	Selection criteria [2]
Bundi Coal Project *Metro Coal*	~20 km southwest of Wandoan	Underground coal mine and associated infrastructure. 5 Mtpa of product coal.	EIS in preparation	2013. Operations to commence 2015.	300	150	20	Located ~20 km south of Scotia gas field.	a)
Dingo West Coal Mine *Dingo West Coal*	~6 km west of Dingo and ~120 km east of Emerald	Open cut coal mine. 1 Mtpa of product coal	EIS in preparation	Unknown	220	120	30	Located ~45 km northeast of Arcadia gas field.	a)
Elimatta Project *Taroom Coal*	~45 km south-west of Taroom	Open cut coal mine. 5 Mtpa product coal	EHP issued public notification of EIS	Mid-2013 to mid-2015	500	300	40	Located ~25 km west of Scotia and ~25 km south of Scotia gas field.	a)
Eurombah to Fairview Transmission Line Project *Powerlink*	From the proposed Eurombah Substation to the proposed Fairview Substation via the proposed substation at Fairview South	Transmission line to supply power to proposed substations at Fairview and Fairview South to supply power to future gas processing facilities.	Draft EIS has been prepared. Submissions being reviewed before final EIS is prepared.	2014	NA	NA	30-40	Located near and will supply power to facilities within Roma and Fairview gas fields.	c)
Gladstone LNG Project *Santos GLNG*	Gas fields: extend from Rolleston in the north to Roma in the south and Taroom to the east. Pipeline: from gas fields to Gladstone. LNG facility: Curtis Island, near Gladstone	Development of ~2,650 production wells over ~6,900 km^2. 435 km gas transmission pipeline. LNG facility of ~10 Mtpa capacity	CG approved May 2010	Commence construction 2010 to 2022	Gas fields: 960 Pipeline: 1,000	Gas fields: 820 Pipeline: 20	25	Included in the development area of GFD Project. Gas field development periods will overlap.	b)

Project and *Proponent*	Location	Description	EIS status[1]	Construction dates	Construction jobs	Operations jobs	Lifespan (years)	Relationship to GFD Project	Selection criteria [2]
Minyango Coal Project *Blackwater Coal*	Directly south of Blackwater	Underground coal mine. 7.5 Mtpa of product coal	EIS in preparation for submission to EHP	NA	NA	NA	40	Located 40 – 45 km north of Arcadia gas field.	a)
Nathan Dam and Pipelines *Sunwater*	Dam: 35 km north-east of Taroom Pipeline: from dam, through the Surat Basin to Dalby	888,000 megalitre (ML) dam, with an annual yield of 66,000 ML. 260 km trunk pipeline	CG website states that SEIS is in preparation but it has been announced that the project has been shelved.	Commence construction July 2013 to June 2016.	425	5	100	Dam: Located 30 km east of Scotia gas field. Pipeline: runs from dam, through Scotia gas field to Dalby.	b)
Norwood Coal Project *Metro Coal*	~30 km south-west of Wandoan-	Underground coal mine. 5 Mtpa of product coal	EIS in preparation for submission to EHP	2015. Operations commencing 2017	300	150	20	Located 5 to 10 km north of Roma and 45 km south of Fairview gas field.	a)
North Surat - Collingwood Coal Project *Cockatoo Coal Limited*	12 km north-east of Wandoan and 340 km south-west of Rockhampton.	Open cut coal mine. 6 Mtpa thermal coal.	EIS in preparation for submission to CG	Q2 2014 to Q4 2015	1,000	400	20	Located immediately east of Scotia gas field.	b)
North Surat Taroom Coal Project *Cockatoo Coal Limited*	3 km south-east of Taroom and 310 km south-west of Rockhampton.	Open cut coal mine. 8 Mtpa thermal coal.	EIS in preparation for submission to CG	Q4 2013 to Q2 2015	1,000	550	25	Located 10 km east of Scotia gas field.	b)

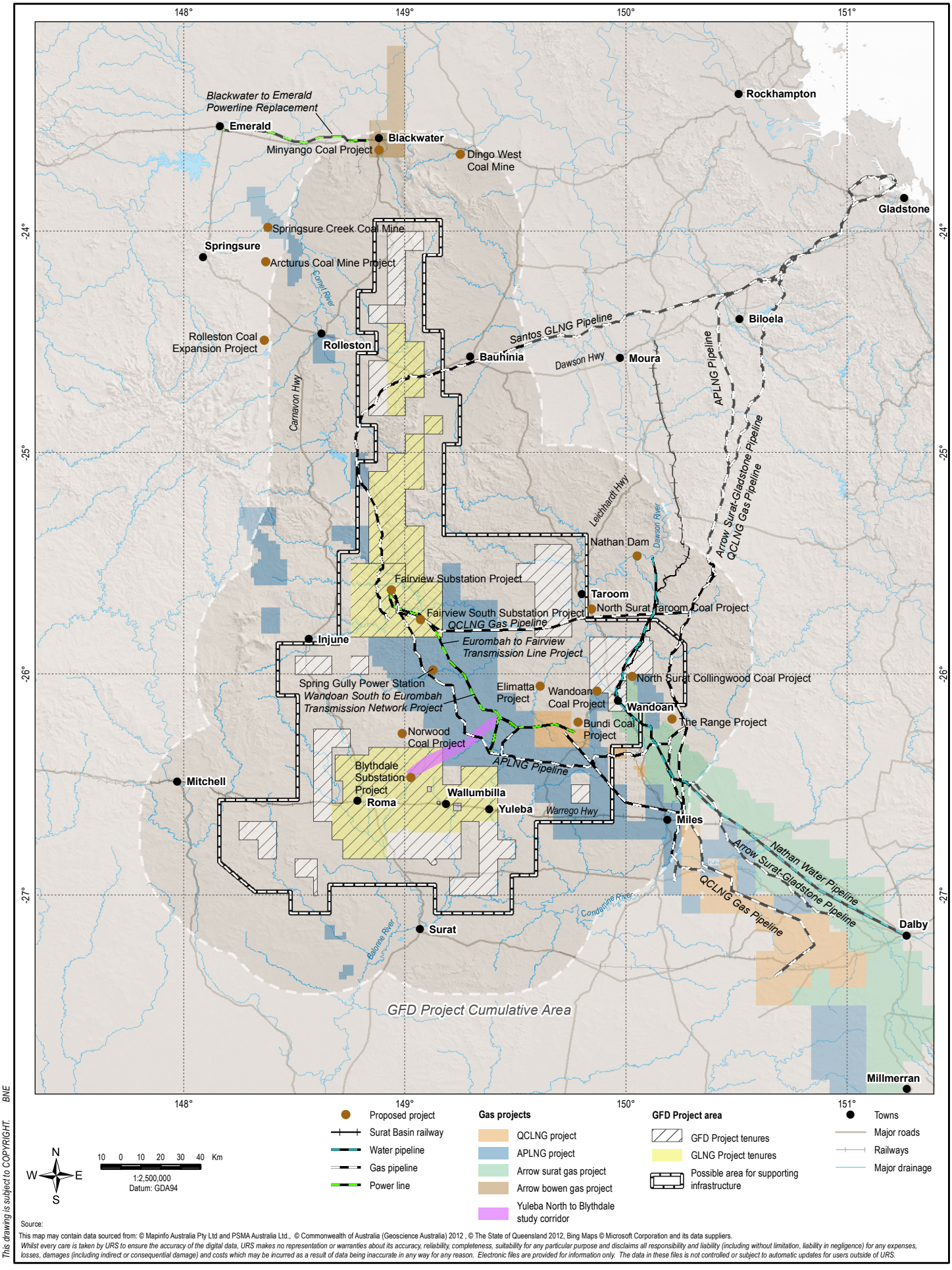
Project and *Proponent*	Location	Description	EIS status[1]	Construction dates	Construction jobs	Operations jobs	Lifespan (years)	Relationship to GFD Project	Selection criteria [2]
Queensland Curtis LNG (QCLNG) *Queensland Gas Company*	Gas fields: extend from ~30 southwest of Wandoan to ~30 km west of Dalby. Pipeline: transmission pipeline from gas fields to Gladstone. LNG facility: Curtis Island, near Gladstone	Development of ~6,000 production wells over ~4,700 km^2. 380 km of gas transmission pipeline. LNG facility on Curtis Island with operating capacity of 12 Mtpa.	CG approved Jun 2010	Q2 2010 to Q3 2013.	4,000	1,000	20	Located ~30 km south-west of Scotia gas field and ~25 km north-east of Roma gas field. Gas field development period will overlap.	b)
Rolleston Coal Expansion Project *Rolleston Coal Joint Venture*	~25 km west of Rolleston, 270 km west of Gladstone and 120 km southeast of Emerald.	Expansion of existing Rolleston Coal mine. 10 open cut pits Expansion from 10 Mtpa to 20 Mt/y.	EIS in preparation for submission to EHP.	NA	NA	NA	NA	Located ~50 km west of Arcadia gas field.	a)
Spring Gully Power Station *Origin Energy Power Limited*	80 km northeast of Roma	A 1,000 MW combined-cycle gas-fired power station, constructed in two 500 MW stages	CG approved 14 Sep 2009	Unknown	400	17	NA	Located ~25 km south of Fairview gas field.	b)
Springsure Creek Coal Project *Springsure Creek Coal*	~40 km southeast of Emerald	Underground coal mine. 9 Mtpa	EHP issued public notification of EIS	NA	350	585	30	Located ~50 km northwest of Arcadia gas field.	a)

Project and *Proponent*	Location	Description	EIS status[1]	Construction dates	Construction jobs	Operations jobs	Lifespan (years)	Relationship to GFD Project	Selection criteria [2]
Surat Gas Project *Arrow Energy*	Gas fields: Extending from Wandoan (north) to Dalby and Millmerran (east) and Goondiwindi (south)	Gas project 7,500 production wells and associated infrastructure over ~8,600 km^2.	SEIS in preparation for submission to EHP	2013 to 2035	1,000	400	35	Located immediately adjacent to Scotia gas field and extends southeast towards Dalby. Gas field development period will overlap.	a)
Surat Basin Railway *Surat Basin Rail*	To run from just outside Wandoan to just outside Banana	A 214 km railway in the Surat Basin that will connect the Western Railway system to the Moura Railway system.	CG approved 9 Dec 2010	NA	1,000	NA	50	Rail line commences in the southern portion of Scotia gas field and runs northeast through Scotia gas field.	b)
Surat to Gladstone Pipeline Project *Arrow Energy*	Near Dalby to Gladstone	470 km long pipeline from Dalby to Gladstone.	EHP approved Jan 2010	NA	300	10	40	Located ~5 to 10 km east of Scotia gas field.	a)
'The Range' Project *Stanmore Coal*	25 km south-east of Wandoan	Open cut coal mine. 7 Mtpa product coal	EHP issued public notification of EIS	NA	300	500	25	Located ~25 km southeast of Scotia gas field.	a)
Wandoan Coal Project *Wandoan Joint Venture*	5 km west of Wandoan	Open cut thermal coal mine. 30 Mtpa	CG approved Nov 2010	NA	1,375	50	30	Located in southwest corner of Scotia gas field.	b)
Wandoan South to Eurombah Transmission Network Project *Powerlink*	From Yuleba, transmission line to run west to Wandoan (Section 1), south to Clifford Creek (Section 2) and northwest to Eurombah (Section3).	Yuleba North Substation and a 275 kV transmission line from the proposed substation to Powerlink's substations at Wandoan, Clifford Creek and Eurombah.	Final EIS released	2014	NA	NA	30-40	Located near Scotia gas field.	c)

Project and *Proponent*	Location	Description	EIS status[1]	Construction dates	Construction jobs	Operations jobs	Lifespan (years)	Relationship to GFD Project	Selection criteria [2]
Yuleba North to Blythedale Transmission Line Project Powerlink	To run southwest from the proposed Yuleba North Substation to a proposed substation at Blythdale (25 km northeast of Roma).	Proposed 132/275kV transmission line to supply power to future gas processing facilities.	EIS released May 2014	2015	NA	NA	30-40	Located near and will supply power to facilities within Roma and Fairview gas fields.	c)

[1] Status as at November 2013

[2] See section 26.4



Source:

Santos GLNG Project

GFD PROJECT EIS

GFD PROJECT CUMULATIVE AREA

URS

CUMULATIVE IMPACTS

Figure: **26-1**

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26.5 Cumulative impact assessment

The outcomes of the cumulative impact assessment conducted for the project are summarised below.

26.5.1 Land use and tenure

The GFD Project cumulative impact area supports a variety of land uses including agriculture, resource extraction, urban and rural residences, as well as conservation, tourism and recreational activities. These land uses are supported by transport infrastructure and a variety of utilities and services. They are discussed in detail within Section 8: Land use and tenure.

The potential land use and tenure impacts of the GFD Project are identified in Table 26-5 according to the land use value that that may impact upon.

Table 26-5 Land use and tenure – values and potential impacts

Existing land use	Potential impacts
Agriculture and primary production	Loss of productive land
	Diminished productivity
	Disturbance of soil structure
	Changes to surface water and irrigation flow patterns
	Disruption to landholder operations such as tilling, planting, irrigation and harvesting
	Weed infestation
Forestry resources	Restrictions of access to forestry resources
	Loss or premature harvesting of millable timber
	Reduction of the amount of land available for growing timber
	Interference with logging operations
	Additional traffic on logging tracks
Residential areas – urban	Shortage of accommodation facilities
	Shortage of residential land
	Increased demand for retail, commercial and industrial uses
Residential areas – rural	Noise and vibration
	Dust
	Increased traffic on local roads
	Lighting
Mining, petroleum and extractive industries	Restrictions to the extraction of other resources
	Restrictions to the exploration for other resources
Conservation, tourism and recreational values	Disturbance to vegetation and/or habitats
	Reduced amenity affecting existing tourism and recreational values
Transport infrastructure	Disturbance to or interference with the operations of transport infrastructure, such as roads, rail activities, aerodromes and landing grounds and stock routes
Utilities and services	Disturbance to or interference with existing high voltage transmissions lines, gas pipelines, water pipelines or telecommunications facilities

The potential for the impacts of the GFD Project to interact with those of other development projects in the region is primarily based on the similarity of project activities. As can be seen in Figure 26-1, the GFD Project cumulative impact area includes three other gas projects, which can be expected to have similar potential impacts to those of the GFD Project. The combined potential impact of these projects will further extend the area of the land that is potentially affected by cumulative impacts. In this sense, the widespread nature of gas tenures within the GFD Project cumulative impact area, particularly in the southeast of this area, has the potential to:

- Disrupt landholder agricultural operations
- Result in the loss or premature harvesting of millable timber
- Reduce the amount of land available for growing timber
- Restrict the extraction of other resources.

However, as discussed in sections 8.5 to 8.8 of Section 8: Land use and tenure, the remainder of the residual land use and tenure impacts of the GFD Project are expected to be low after the application of Santos GLNG's environmental management framework. This includes the GFD Project Environmental protocol for constraints planning and field development (Constraints protocol), which will be used to ensure that GFD Project infrastructure with potentially high to medium impacts will be generally avoided in no-go and surface development exclusion areas, as well as in areas of high to medium land use constraints. In addition, other management plans and strategies will reduce the footprint and duration of land use changes caused by the GFD Project and will provide a framework for co-existence with agricultural uses.

The proposed mining projects across the GFD Project cumulative impact area will have different land use and tenure impacts to those discussed above. Mines have a concentrated footprint and are considered unlikely to contribute to significant cumulative changes to regional land use.

Whilst the proposed linear infrastructure projects across the GFD cumulative impact area could potentially generate a cumulative impact on land use and tenure, these impacts are considered to be localised.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on land use and tenure is assessed as low.

26.5.2 Land resources

The land resources section of the EIS (Section 9: Land resources) presents an overview of the environmental values attributable to geology, topography and soils of the GFD Project area. The GFD Project is situated in the Surat and Bowen basins. The topography of these areas includes undulating low hills and mesas in the east, mesas to the north and southwest, and alluvial plains predominantly associated with major watercourses and their tributaries across the GFD Project area.

Soils in the GFD Project area include sandy soils, loamy soils, 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 and occur throughout the GFD Project area.

Soils in the GFD Project area include sandy soils, loamy soils, gravelly loams, red and yellow earths and lateritic red earths. A number of soils are considered to be 'problem' soils because they are either highly susceptible to erosion, have high salinity or are highly reactive.

Reflective of the GFD Project cumulative impact area's agricultural history, good quality agricultural land (GQAL) and strategic cropping areas (SCA) occur within the GFD Project cumulative impact area. It is these values that are most likely to be potentially impacted in a cumulative sense by the GFD Project and the other proposed resource projects. As with the GFD Project, the other gas projects use a phased development approach and a constraints methodology to minimise the potential impacts to soil resources. The avoidance of the soil resource values is emphasised in the Central Queensland and Darling Downs regional plans, which aims to protect priority agricultural land uses (PALU) while supporting co-existence opportunities for the resources sector. Priority agricultural areas (PAAs) are also identified in these plans and comprise strategic areas containing highly productive agricultural land uses. Considering the spatial extent of the soil resources including SCA (section 9.2.4 of Section 9: Land resources), the application of constraints methodologies and the regional planning controls, the potential cumulative impact on soils is considered to be low.

The proposed linear infrastructure projects across the GFD Project cumulative impact area could potentially generate a cumulative impact on land resources, through a reduction to SCA and GQAL. However the impacts from linear infrastructure are considered to be localised and have minimal disturbance areas. Therefore the cumulative impact is considered to be minimal.

The other potential cumulative impacts that could occur from the proposed projects listed in Table 26-4 include:

- Loss of soil resources through erosion, compaction or contamination
- Restricted access to productive (agricultural or forestry) land.

The development of large scale projects, such as mining and linear infrastructure projects, could result in the potential for soil loss through erosion processes, compaction of soil through the movement of vehicles and equipment, and contamination of soil resources through spills of contaminants to land. The implementation of the required control measures would limit the potential for these impacts to be material in nature. As a result, the cumulative impacts from erosion, compaction and soil contamination are expected to be low.

The nature of the gas projects means that the construction activities at each construction area would have a short term impact on property access. This impact would be limited to the construction and decommissioning phases. As the impacts are short term and a conduct and compensation agreement would be negotiated with the landholder, the cumulative impacts on property access are considered to be low.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on land resources is assessed as low.

26.5.3 Landscape and visual amenity

Landscape and visual amenity within the GFD Project cumulative impact area encompasses broad flat plains and river valleys, undulating hills, rugged ridges, narrow valleys and plateaux. The general character is that of broad acre agricultural and grazing areas, interspersed with commercial forestry and natural woodland. The landscape values change considerably across the GFD Project gas fields according to who is viewing the landscape – referred to here as receptors.

The receptors identified most likely to be affected by the GFD Project are users of the following:

- Houses or homesteads
- Tourist/recreational areas and designated tourist roads
- Main roads/regional roads and rail lines
- Minor local roads in rural zone
- Broad acre rural lands
- Urban and industrial areas
- State forests (noting that protected areas such as national parks, conservation parks and forest reserves are designated as a no-go area by the Constraints protocol).

Further, the impacts of development will be mediated by the capacity of the landscape to absorb changes. This is discussed further in section 10.3 of Section 10: Landscape and visual amenity.

Cumulative impacts to the visual amenity of the GFD Project cumulative impact area will be a product of the residual impact of the following components of the GFD Project and the proposed projects identified in Table 26-4:

- Transport and workforce presence, which presents the highest potential for cumulative visual impacts
- Project infrastructure occurring in the viewshed of sensitive receptors. The potential for this to occur is greater for projects whose infrastructure has limited ability to integrate into the landscape, either through height such as power lines or overall size such as mines
- Night lighting.

The potential for cumulative visual impacts from transport and workforce presence is highest where construction periods of adjacent projects overlap but it reduces considerably during operations. Based on currently available information, the greatest level of construction overlap for the projects will be around the Scotia and Roma areas. During the operations phase of these projects, viewsheds in the Scotia gas field are expected to have the potential to experience the greatest (but smaller than the construction phase) cumulative visual impact from the presence of traffic and workforces.

The potential for components of the GFD Project and components from other projects to appear in the same viewshed of sensitive receptors is generally considered to be low, due to the fact that the components will be broadly spread over vast areas. In instances where infrastructure such as above ground power lines servicing the GFD Project and other projects interact, there is potential for cumulative visual impact.

Where there is the possibility of viewing linear corridors in a sequence (such as views along gas transmission pipeline and transmission lines easements from roads) the potential for cumulative visual impacts increases.

Night lighting from the GFD Project and other proposed projects will be localised. As the GFD Project's night lighting is limited, the potential for the GFD Project to interact with night lighting of another project is therefore also limited. The contribution of these sources to cumulative visual impacts will depend on their location in relation to viewsheds such as those from homesteads and major road corridors.

The consequence of the cumulative residual impacts in the GFD Project cumulative area and surrounds are summarised in Table 26-6.

Table 26-6 Significance of cumulative residual impacts – visual amenity

Key residual impacts	Consequence
Increase in transport and workforce presence	Moderate
Increase in frequency of views to project components	Low
Increase in night lighting	Low

The most effective visual impact mitigation strategy for minimising cumulative visual impact is avoidance through location selection during the planning and field development phase. Effective placement of GFD Project infrastructure away from the viewsheds of sensitive receptors will reduce the cumulative visual impacts.

Most visual impact mitigation strategies are part of existing standard management practices. They include:

- Avoiding unnecessary disturbance
- Co-locating linear elements to minimise easement clearances
- Limiting the extent of vegetation clearing
- Rehabilitating disturbed areas as soon as practicable.

In addition and as needed, treatments at viewing points in high exposure areas can further reduce visual impact.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on landscape and visual amenity is assessed as low.

Details are provided in section 6 of Appendix L: Landscape and visual amenity.

26.5.4 Traffic and transport

Section 11: Traffic and transport establishes three key traffic and transport values that may be impacted by increased traffic volumes associated with the development of the GFD Project, as outlined in Table 26-7. Growth attributable to the other major projects has been considered by collating the cumulative traffic generated by the proposed projects included in Table 26-4 and the GFD Project's traffic.

The cumulative impacts of the traffic from the GFD Project and the other proposed projects in addition to the existing traffic volume on the roads within the GFD Project cumulative impact area are shown in Table 26-7. These impacts are residual, meaning that they provide the potential impact after the effective implementation of management and mitigation strategies. Santos GLNG has a proven framework for managing its impact upon the traffic and transport values within the GFD Project cumulative area that has been implemented for the GLNG Project. This includes the implementation of an agreement with infrastructure operators concerning Santos GLNG's obligations in relation to road infrastructure works and a Regional Rules code of conduct, which governs the behaviour of the GFD Project's workforce and contractors in regional areas.

Table 26-7 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	Low	Medium	Medium	Medium
Safety	Reduced safety related to bridges, cattle grids, rail crossings, school bus routes, traffic composition and driver fatigue controls.	Low	Medium	Medium	Medium
Amenity	Reduced amenity related to stock route co-location, sensitivity of adjacent land uses, potential for dust nuisance and light glare issues.	Low	Medium	Medium	Medium

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on traffic and transport is assessed as medium.

Details are provided in section 4 of Appendix M: Traffic and transport.

26.5.5 Waste

The GFD Project will generate a variety of solid wastes, many of which will be reused or recycled. However, there will also be selected wastes that will be disposed of in local landfills or licensed waste management facilities. Similarly, the proposed projects identified in Table 26-4 have the potential to generate wastes that will also be disposed of in local landfills or licensed waste management facilities. The level of waste produced by these projects will be greatest during their construction phases. This has the potential to reduce the availability of landfill and treatment capacity of waste management facilities in the GFD Project cumulative impact area.

Santos GLNG will minimise the volumes of solid wastes to go to the regional waste facilities through using the waste management hierarchy, which is detailed in Section 12: Waste. Further, Santos GLNG will work closely the local government authorities to ensure that adequate capacity is available. Alternative waste management facilities will be used if necessary. Similar initiatives are likely from the proponents of the other proposed projects.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on waste is assessed as low.

A detailed assessment is provided in Section 12: Waste.

26.5.6 Surface water

Water quality that is suitable for human consumption, agricultural production and land use is defined through the *Environmental Protection (Water) Policy 2008* (Qld) (EPP Water). This policy stipulates water quality guidelines and water quality objectives to enhance or protect these values. Existing human uses of surface water resources throughout the GFD Project area are identified in Section 13: Surface water. In general, the following water uses are considered to be the most sensitive within the GFD Project area:

- Livestock water
- Impounded water (e.g. farm dams, emergency fire-fighting water supply)
- Domestic water
- Industrial water
- Town water.

The primary watercourses of the GFD Project area include the Dawson, Hutton, Balonne, Comet and Condamine rivers and numerous tributaries. The surface water environment of the GFD Project area is generally slightly to moderately disturbed as a result of existing land use (such as agricultural production and resources extraction).

The GFD Project's construction and operations activities have the potential to impact on downstream water quality and environmental flows. Existing Santos GLNG gas extraction operations within the GFD Project area, as well as those of the other gas companies who are operating in the GFD Project cumulative impact area, have the potential to impact the surface water environment. In addition, a number of the proposed mining projects within or adjacent to the GFD Project cumulative impact area have the potential to impact receiving waters of the area.

While at a regional level gas extraction activities will have a certain cumulative impact on the river systems of the GFD Project area, these impacts are judged to be small, temporary and reversible. The impacts on the surface water environment associated with the GFD Project and the other gas projects will be smaller than the impacts from other existing land uses in the catchments. This is indicated by the elevated concentrations of nutrients found in surface waters of the catchments assessed as part of the EIS.

For linear infrastructure projects, the impacts on water quality tend to be minor, localised and temporary (limited to the construction phase). Any impacts would be managed through construction environmental management plans and procedures. Therefore, there is unlikely to be any cumulative impacts from these projects on the GFD Project cumulative impact area.

The GFD Project has numerous mitigation and control strategies to responsibly manage coal seam water and to protect the surface water environment. It is expected that the other gas and mining projects within the GFD Project cumulative impact area will have similar control and mitigation measures.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on surface water is assessed as low.

Further details are provided in section 9.4 of Appendix N: Surface water.

26.5.7 Groundwater

26.5.7.1 Groundwater modelling

The GFD Project cumulative impact area is underlain by a number of aquifers that provide water supply for agriculture and industry, and sustain numerous springs and watercourses. Major aquifers are associated with the Great Artesian Basin (GAB) which comprises groundwater bearing units of the Surat Basin and the upper Bowen Basin.

The Surat Cumulative Management Area (CMA) was established in 2011 for the Surat Basin and the southern Bowen Basin, where natural gas from coal is being extracted by multiple companies.

The Office of Groundwater Impact Assessment (OGIA) is responsible for assessing cumulative impacts and establishing integrated management arrangements through the preparation of an Underground Water Impact Report (UWIR). In preparing the UWIR, numerical groundwater modelling was undertaken to predict potential impacts on water pressure.

The numerical groundwater model for the Surat CMA has been used to assess potential cumulative aquifer depressurisation and drawdown associated with the GFD Project and the other gas projects. It should be noted that the scale of a number of these other projects has been reduced (economic gas has not been identified in some areas) and as a result the model is considered highly conservative. Depressurisation is a reduction in groundwater pore pressure (pressure head) in a confined groundwater system due to the extraction of groundwater. Drawdown is a decline in groundwater level in a bore, or a decline in water table elevation in an unconfined groundwater system, due to the extraction of groundwater. A bore is defined as an artificially constructed or improved groundwater cavity used for the purpose of accessing or recharging water from or to an aquifer.

The results of the cumulative modelling indicate that depressurisation has the potential to result in drawdown and potential impact at bores and springs.

26.5.7.2 Cumulative depressurisation impacts

Depressurisation impacts in the Surat CMA

Model results indicate there will be no increase in maximum depressurisation in aquifers underlying the Surat CMA. However, the area of impact will increase due to the expansion of areas being developed. The largest increases in depressurisation-impacted areas occur within the two target coal formations (the Walloon Coal Measures and the Bandanna Formation). There are also increases in the extent of the depressurisation impacted areas within the overlying Springbok Sandstone, the Hutton/Marburg Sandstone and the Gubberamunda Sandstone.

Depressurisation in GFD Project tenures

Model results indicate that maximum cumulative depressurisation impacts in GFD Project tenures will occur within the target coal formations where water extraction for production of gas is undertaken. Maximum depressurisation in the coal formations will occur towards the end of the GFD Project life, between 2020 and 2030. There will be a lag in the time to maximum depressurisation (area of extent) in overlying and underlying formations, with the timeframes dependent on how directly connected the formation is to the target coal formations (i.e. dependent on vertical hydraulic conductivity).

Depressurisation effects on aquifers are expected to persist for prolonged periods after extraction of gas has ceased. The rate of recovery will be greatest in the years after water extraction ceases, but will reduce exponentially with time. It is estimated that for the coal measures and the significantly affected aquifers there will be a 50% recovery from maximum impact 30 to 80 years after maximum impact. Aquifers with limited connectivity may take several hundred years to reach 50% recovery. Due to the aquifers being poorly connected, any potential impacts are assessed as being localised and low.

Cumulative impacts to landholder bores

The UWIR in 2012 predicted that 528 landholder bores would potentially be cumulatively impacted due to petroleum and gas development in the Surat CMA. Due to cumulative petroleum and gas development in the Surat CMA, an additional 73 private water bores are predicted to be impacted by a decline in groundwater pressure of 5 m or more for the consolidated aquifers at some time in the future.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on groundwater is assessed as medium.

Impacts to springs

The majority of spring complexes and watercourse springs assessed were found to be at low risk of impact. The UWIR identified a total of 329 spring vents and 43 watercourse springs within the Surat CMA. There are 45 spring complexes and 33 watercourse springs located within the Surat CMA that have been recognised as springs of interest. Springs of interest are defined as springs underlain by a formation (including the coal seams) where the long-term maximum predicted impact on water pressures at the location of the spring (but not necessarily in the source aquifer of the spring) exceeds 0.2 m, or is within 10 km of 0.2 m of depressurisation. Out of the identified springs of interest, 13 spring complexes and 19 watercourse springs have been identified as being at risk of impacts based on the output of the cumulative numerical groundwater model.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on groundwater is assessed as high.

A detailed assessment is provided in section 7 of Appendix O: Groundwater.

26.5.8 Air quality

Environmental Protection (Air) Policy 2008 (Qld) (EPP Air) is the guiding policy that identifies the qualities of air that are conducive to human and ecosystem health, the appearance of natural and developed structures, and agricultural use of the environment.

This policy stipulates air quality guidelines for a number of pollutants that are associated with the GFD Project including nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matters (PM_{10} and $PM_{2.5}$). Proposed projects with the potential to contribute to NO_X and CO emissions within the GFD Project's airshed were included in the modelling of representative background NO_2 and CO concentrations across the GFD Project area. Section 15: Air quality provides a complete description of the modelling and assessment undertaken.

The dispersion modelling results indicate that potential NO_X and CO emissions from the GFD Project gas compression facilities would be dispersed within 1 km to 5 km. At this distance, levels would approach background levels. On this basis, the distances are such that it is unlikely that the emissions associated with the GFD Project would accumulate with emissions from the proposed projects listed in Table 26-4. The potential for cumulative impacts is therefore low and can be managed through appropriate siting of the GFD Project facilities.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on air quality is assessed as low.

A detailed assessment is provided in section 6.4 of Appendix P: Air quality.

26.5.9 Greenhouse gas

The major sources of greenhouse gases from the GFD Project are described in section 16.3.1.2 of Section 16: Greenhouse gases (GHG). The sources include:

- Combustion of diesel fuel for drilling, equipment, transportation, power generation and rehabilitation
- Land clearing
- Well completion flaring
- Combustion of gas for self-generated electricity production
- Combustion of gas for compression
- Flaring during abnormal conditions at facilities
- Fugitive emissions (other than flaring and venting)
- Generation of electricity purchased from grid for pumps, gas compression, water management and camps.

Whilst the proposed linear infrastructure projects across the GFD Project cumulative impact area could potentially generate a cumulative impact on greenhouse gases, these impacts are considered to be localised and are expected to be temporary. Emissions from these projects are expected to be very low and will not contribute to any cumulative impact.

Similar greenhouse gas sources can be expected from the other gas projects considered in the cumulative impact assessment. Table 26-8 summarises the highest annual Scope 1 and Scope 2 greenhouse gas emissions estimated for other gas projects and the GFD Project. Note that infrastructure projects have not been included in this table, as impacts are considered to be extremely small and minor and would not contribute to cumulative greenhouse gas emissions.

Table 26-8 Scope 1 and 2 greenhouse gas emissions (Mt/a) (CO_2-e)

Project	Greenhouse gas emissions
Queensland Curtis LNG (QCLNG)	4.5
Australia Pacific LNG (APLNG)	5.5
GLNG[1] project	7.2
Arrow Surat gas project	3.5
Arrow Bowen gas project	3.1

[1]: GLNG Project includes the GFD Project

The contribution of the GFD Project to cumulative annual greenhouse gas emissions is estimated to be 2.6 Mt CO_2-e. This is smaller than other gas projects in Queensland which range from 3.1 to 7.2 Mt CO_2-e per year.

Santos GLNG has a strong record of working with government, industry and the community to address GHG emissions with specific focus on addressing energy efficiency, the transition to lower emission technologies and reporting transparency.

Santos GLNG has its own corporate climate change policy which reflects a commitment to energy efficiency and reducing emissions across its operations, including the GFD Project.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on greenhouse gases is assessed as low.

26.5.10 Noise and vibration

Environmental Protection (Noise) Policy 2008 (Qld) (EPP Noise) is the guiding policy that identifies the acoustic quality objectives and indicators (criteria) that are conducive to human and ecosystem health.

Modelling was used to estimate the distances at which noise from typical GFD Project noise sources would comply with the selected criteria at sensitive receptors. Should sensitive receptors be located closer to the noise sources, noise management and mitigation measures would be required. This is described further in Section 17: Noise.

The approach adopted for the cumulative noise impact assessment has been to predict the cumulative increase in noise levels at various distances between GFD Project facilities and the major noise sources of the other proposed projects. To assess this, cumulative noise levels at various distances between facilities were predicted, assuming a sensitive receptor is located in the middle. The distance required between GFD Project facilities and similar facilities of another project to ensure that the noise criteria would be met at a centrally located sensitive receptor are shown in Table 26-9.

Table 26-9 Predicted cumulative impact distance – noise and vibration

Weather conditions	Scenario	Cumulative impact distance (m)
Neutral	Hub gas compression facility (non-electrified)	9,800
	Hub gas compression facility (electrified)	8,300
	Nodal gas compression facility	7,900
	Accommodation camp	6,400
Adverse	Hub gas compression facility (non-electrified)	13,000
	Hub gas compression facility (electrified)	11,300
	Nodal gas compression facility	10,700
	Accommodation camp	8,500

The potential for cumulative impacts from multiple GFD Project sources was also assessed, including:

- Multiple well leases
- Well lease(s) adjacent a gas compression facility
- Co-location of water treatment facilities and gas compression facilities.

The cumulative noise assessment of multiple well leases showed a marginal cumulative noise build-up within the low density well configuration for non-electrified wells. High density gas fields with electrified or free flowing wells do not show a cumulative build-up of the predicted noise levels. Effective placement of wells (in accordance with the Constraints protocol) will help mitigate potential impacts on sensitive receptors.

The predicted cumulative noise emissions associated with well leases that are located adjacent to gas compression facilities will have no impact to sensitive receptors where the sensitive receptors are located at a greater distance than:

- 130 m (electrified or free flowing well) to 450 m (non-electrified well), for a well lease located between 4,000 m and 5,000 m from a non-electrified hub gas compression facility
- 130 m (electrified or free flowing well) to 450 m (non-electrified well), for a well lease located between 2,500 m and 3,000 m from a nodal or electrified hub gas compression facility.

Proposed linear infrastructure projects across the GFD Project cumulative impact area are unlikely to cause any significant cumulative noise impact. These projects are expected to be localised. Noise emissions from these projects are expected to be low and will not contribute to any cumulative impact.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on noise and vibration is assessed as low.

A detailed assessment is provided in sections 5.7, 6.6 and 8.2 of Appendix Q: Noise and vibration.

26.5.11 Terrestrial ecology

This EIS identified that that GFD Project cumulative impact area contains a number of terrestrial ecological values of conservation significance under both State and Commonwealth legislation (section 6 of Appendix R: Terrestrial ecology). The key ecological values identified as having the greatest potential for cumulative impacts are outlined in Table 26-10.

Table 26-10 Key ecological values within the GFD Project cumulative assessment area

Legislation	Receptor
Vegetation Management Act 1999 (Qld)	• Endangered vegetation (regional ecosystems and high value regrowth) • Of concern vegetation (regional ecosystems and high value regrowth) • Essential habitat
Nature Conservation Act 1992 (Qld)	• Regional parks (formerly resource reserves) • State forest and timber reserves
Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act)	• Brigalow (*Acacia harpophylla* dominant and co-dominant), which is listed as endangered • Semi-evergreen vine thickets of the Brigalow Belt (north and south) and Nandewar Bioregions, which is listed as endangered • Natural grasslands of the Queensland Central Highlands and the Northern Fitzroy Basin, which is listed as endangered • Weeping myall woodlands, which is listed as endangered

These key ecological values have the potential to be affected by a number of activities of both the GFD Project and the proposed projects considered in the cumulative impact assessment (Table 26-4). The activities include:

- Habitat loss from vegetation and topsoil removal
- Species injury or mortality from operations activities
- Reduction in soil viability to support plant growth due to compaction
- Displacement of native flora and fauna species from weed invasion and incursion of pest species
- Reduction in the connectivity of regional biodiversity corridors
- Edge effects to habitat (e.g. weed invasion and reduction of biodiversity)
- Habitat fragmentation from vegetarian clearing
- Barrier effects, (e.g. loss of species migration pathways)
- Disturbance to fauna and flora from noise, dust and light incursion
- Impact on habitat from an increase of litter in the waste stream.

The overall maximum predicted cumulative disturbance of land within the cumulative impact area from the proposed projects listed in Table 26-4 is approximately 297,441 ha of vegetation (including non-remnant vegetation and non-native pastures). The total predicted maximum cumulative disturbance as a result of the proposed projects assessed and the GFD Project is approximately 361,532 ha (including non-remnant vegetation and non-native pastures). The predicted maximum vegetation disturbance estimate for the GFD project (including non-remnant and non-native pastures) represents approximately 17% of the maximum predicted cumulative disturbance of land within the cumulative impact area from all the proposed projects listed in Table 26-4.

The greatest potential predicted cumulative impact as a result of the GFD Project and the other proposed projects would be upon the following ecological receptors:

- Endangered vegetation (RE and HVR)
- Of concern vegetation (RE and HVR)
- Resource Reserves
- Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions listed as Endangered under the EPBC Act
- Natural grasslands of the Queensland Central Highlands and the Northern Fitzroy Basin, listed as Endangered under the EPBC Act
- Weeping Myall Woodlands, listed as Endangered under the EPBC Act.

Cumulative impacts are most appropriately considered at the bioregional scale. Within the Brigalow Belt Bioregion, the ecological receptors considered to have the highest likelihood of potential cumulative impacts are direct impacts to:

- Resource reserves (approximately 13.4% of the total cumulative impact area in the bioregion)
- State forest and timber reserves (approximately 4.75% of the total cumulative impact area in the bioregion).

The application of the Constraints protocol and mitigation contained in management plans including offsets limits the likelihood of impact to terrestrial ecology receptors for the GFD Project. It is expected that similar protocols will be followed by the other companies operating in the cumulative impact area. This is likely to result in many terrestrial ecology values being either avoided or mitigated.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on terrestrial is assessed as medium.

Details of the potential cumulative impact assessment, including a detailed significance assessment of activities and impacts is provided in section 6 of Appendix R: Terrestrial ecology.

26.5.12 Aquatic ecology

The GFD Project is located across three catchment areas: those of the Dawson River, the Comet River and the Condamine-Balonne River. Aquatic habitats in the GFD Project cumulative impact area include watercourses (mostly ephemeral), wetlands, springs and groundwater ecosystems.

Existing Santos GLNG gas development and operations within the GFD Project area, as well as those of other gas proposed projects, have the potential to impact the aquatic environment.

While at a regional level resource industry activities have the potential to generate a cumulative impact on the water quality and hence the aquatic ecology of the river and spring systems of the GFD Project cumulative impact area, these impacts are considered to be small, temporary and reversible. Further, these impacts will be smaller than the impacts from other land uses in the catchments and from other projects such as linear infrastructure projects.

Of all aquatic ecology receptors, springs and their related aquatic ecology are potentially at the most risk from coal seam water extraction. The UWIR identified a total of 330 spring vents and 43 watercourse springs within the Surat CMA.

Groundwater model results for the EIS scenario were used to conduct an initial screening to identify springs of interest; defined as springs underlain by a formation (including the coal seams) where the long-term maximum predicted impact on water pressures at the location of the spring (but not necessarily in the source aquifer of the spring) exceeds 0.2 m, or is within 10 km of 0.2 m of depressurisation. There are 45 spring complexes and 33 watercourse springs located within the Surat CMA that have been recognised as springs of interest.

A risk-based methodology was employed to assess the likelihood of the springs of interest experiencing impacts due to the cumulative development of gas in the Surat CMA under the EIS scenario. The methodology was developed in consultation with the OGIA and follows a similar approach to that used in the UWIR for the Surat CMA. A total of 13 spring complexes and 19 watercourse springs have been identified as being at risk of impacts due to the cumulative development of gas in the Surat CMA under the EIS scenario.

In addition to the gas projects discussed above, a number of proposed mining projects have the potential to impact aquatic ecosystems in receiving waters of the GFD Project cumulative area. The degree of cumulative impact from these projects will be dependent on the following:

- Project planning resulting in reduction of watercourse catchment areas
- Constraints planning and field development to minimise impacts on local watercourses
- Erosion and sediment control management techniques to minimise impacts caused by sediment laden surface runoff
- Decommissioning techniques that allow for progressive rehabilitation.

The GFD Project had numerous mitigation strategies to responsibly manage potential impacts to the aquatic environment. It is expected that the proposed mining project within the GFD Project cumulative area have similar control and mitigation measures.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on aquatic ecology is assessed as medium.

A detailed assessment is provided in section 5.6 of Appendix S: Aquatic ecology.

26.5.13 Cultural heritage

The GFD Project cumulative impact area contains a variety of cultural heritage places reflective of its Indigenous settlement and early European exploration and consequent settlement. The cultural heritage vales within the GFD Project cumulative impact area include both known and unknown heritage places of national, State and local significance. The characteristics of the known cultural heritage within the GFD Project area are discussed in Section 20: Cultural heritage.

The GFD Project and the proposed projects listed in Table 26-4 have the potential to impact upon known and unknown cultural heritage through disturbance and encroachment. These projects have the cumulative potential to change the character of the region through a reduction in the number and type of historic places and to incrementally impact on the number and diversity of cultural heritage places within the GFD Project cumulative impact area.

Santos GLNG has committed to managing the potential for disturbing and encroaching on cultural heritage across the GFD Project area through the implementation of the Constraints protocol and *Environmental hazard standard 11 Cultural heritage*. In addition, Santos GLNG works directly with Aboriginal Parties in developing cultural heritage management plans to develop reasonable and practicable measures to ensure that the GFD Project's activities do not harm Indigenous cultural heritage. It is expected that the proposed projects listed in Table 26-4 will implement similar controls.

The residual significance of this cumulative impact has been assessed using the criteria set out in Table 26-2 and Table 26-3. The significance of this impact is summarised in Table 26-11.

Table 26-11 Residual cumulative significance – cultural heritage

Residual Impact	Impact significance
Impact to known heritage places	
State	Medium
Local	Low – Very Low
Unassessed	Low - Medium
Impact to unknown heritage places	
National	Medium
State	Low - Medium
Local	Low – Very Low

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on cultural heritage is assessed as medium.

A detailed assessment is provided in section 7.3 of Appendix T: Non-indigenous cultural heritage.

26.5.14 Social

The social impact assessment for the GFD Project (Section 21: Social) established four key social values and indicators of their presence and strength within the GFD Project area, as outlined within Table 26-12. The potential for the GFD Project to generate social impacts was assessed based on an understanding of how resource projects impact upon social values within regional communities. The impacts of the GFD Project have the potential to add to those of the other proposed projects where their workforces overlap.

Table 26-12 Social values, indicators and potential impacts

Social value	Indicators	Potential impacts
Liveable community	• Access to, and proximity of, quality services (health, education, aged care, childcare, retail) • Balanced demographic profile • Harmonious relationships, lack of conflict • Respect for law by community members • Adequate infrastructure that is well maintained (roads, airport, power, water & sewerage, telephone, internet) • Effective local governance • Opportunity for recreational, cultural and sporting pursuits • Safe social and physical environment.	• Workforce demand on public health facilities and services • Intra-community conflict • Project traffic on local roads and in general town areas • Presence of a male-dominated workforce • Demand on public physical infrastructure.
Affordable lifestyle	• Cost of land and housing • Local government rates and service charges • Cost of food and other essential items.	• Increased demand for housing • Increased wage pressures on local businesses.
Community identity and spirit	• Level of volunteering and availability of assistance • Local celebrations • Recognition, preservation and promotion of heritage • Capacity to accommodate visitors • Perceptions of being able to influence community destiny • Employment share by industry.	• Local employees working extended shift hours and rosters • Visible presence of gas industry workers in local community venues, and the presence and scale of project facilities, including camps • High occupancy of short-term accommodation by gas industry contractors, displacing visitors to communities when project workforce accommodation facilities are not available • Migration of long-term residents from high-impacted properties.
Capacity for sustainable economic activity	• Viability, vitality and diversity of local industry • Workforce participation and employment • Job creation and the retention of young people • Supportive business environment (e.g. availability of serviced industrial land, adequate zoning, provision of information on opportunities etc.) • On-going environmental integrity (e.g. surface water, groundwater and land) • Willingness of businesses to invest.	• Disruption to agricultural production through field operations • Construction activities deters local tourism and highway trade • Perception that gas extraction creates uncertainty around water availability for agriculture • Inward movement of larger enterprises to local area.

Given the large extent of the GFD Project area, the potential for cumulative social impacts to occur between the GFD Project and the proposed projects listed in Table 26-4 has been assessed at a gas field level rather than project wide. The exception to this is the Roma and Fairview gas fields, which have been assessed together as they are located close together within the same local government boundaries.

26.5.14.1 Arcadia gas field

In the Arcadia gas field area the following factors have been considered in the cumulative assessment:

- The Springsure Creek Project EIS indicates that Springsure's population will grow by 8% as a result of the project, requiring around 28 houses over 10 years. Negative impacts may include increased traffic on the Carnarvon and Capricorn highways, and upward pressure on housing costs in Springsure. However, it is likely that construction will be finished prior to the construction of the Arcadia gas field for the GFD Project; although the operations impacts due to population growth will overlap
- The Rolleston Coal Mine Expansion Project aims to extend the life of mine by 30 years. As part of that project, an additional 100 rooms have been added to the existing accommodation village for construction and operations.

26.5.14.2 Roma-Fairview gas field

In the Roma-Fairview gas field area, the following factors have been considered in the cumulative assessment:

- The major facility construction for the APLNG Project will be completed prior to the commencement of the GFD Project
- Construction of the Spring Gully Power Station may overlap with the construction period for the GFD Project; however, the construction workforce will be accommodated in a camp and operations workforce numbers are likely to be low. Impacts are likely to include elevated traffic and heavy vehicles during the construction period, though the significance of this is expected to be low given the existing traffic on the Warrego and Carnarvon Highways.

26.5.14.3 Scotia gas field

In the Scotia gas field area, the following factors have been considered in the cumulative assessment:

- Construction of the main components of the APLNG and QCLNG projects will be completed prior to the commencement of the GFD Project
- The coal projects in the vicinity of the Scotia gas field area have a high level of uncertainty.
- The Norwood Coal Project is located adjacent to and west of the Bundi Coal Project. Both projects are components of MetroCoal's Surat Basin coal tenements The project development proposes the shared use of infrastructure aligned toward Wandoan and the proposed Surat Basin Rail link to the Moura system to the north.

26.5.14.4 Indigenous

Recent experience in Queensland and across Australia has shown that areas where multiple projects are developed typically incur increased housing costs and that these market changes reduce the availability of housing for minority groups such as Indigenous people. However, these may be offset by the increased opportunities for employment.

The range of potential projects in the GFD Project cumulative area raises the potential for multiple Indigenous Land Use Agreements for Aboriginal Parties. This may have a positive effect on community identity and spirit, while providing opportunities for businesses development, training and employment.

26.5.14.5 Infrastructure projects

The proposed linear infrastructure projects across the GFD Project cumulative impact area are not expected to generate a significant cumulative social impact. They are not expected to generate large construction workforces and therefore the cumulative impact of such projects within the GFD Project cumulative impact area is assessed as low.

26.5.14.6 Mitigation

Santos GLNG will explore opportunities for collaboration in cumulative impact management through existing arrangements in consultation with State and local governments, industry and communities. Through its existing and ongoing engagement with key stakeholders, Santos GLNG will provide relevant information on workforce projections and housing requirements once the GFD Project is further defined which can inform better planning for infrastructure and services in the communities in the GFD Project cumulative impact area. The SIMP and GFD Project Social Issues Action Plans (Appendix AC: Social issues action plans) include a number of planning and consultation mechanisms which Santos GLNG will consider in mitigating potential cumulative impacts of the GFD Project.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative impact on social is assessed as low.

A detailed assessment is provided in section 7 of Appendix V: Social.

26.5.15 Economics

The economic assessment provided in Section 22: Economics has been undertaken with the use of a computable general equilibrium model (CGE model), which is the most widely accepted method for this type of study. CGE models take a whole of industry approach rather than using individual mining and resource projects to build a baseline for activity levels and hence they incorporate cumulative impacts.

The economic impact modelling undertaken specifically for this EIS has been conducted for two different production scenarios for the GFD Project:

- Moderate scenario taking into account commercial sensitivities related to gas development that results in a lower well count and number of support facilities
- Maximum scenario based upon the development of the full 6,100 wells for which approval is being sought.

To gauge the economic impacts of varying levels of gas production, each scenario is compared against a reference case. The reference case describes how the economy would have evolved over time in the absence of the GFD Project. Other planned and approved developments in proximity to the GFD Project area have been considered to form part of the baseline i.e. the cumulative effects of other proposed projects have been included in the modelling.

A summary of the cumulative economic impacts is provided in Table 26-13. The results for Queensland are inclusive of the impacts across the GFD Project area and rest of Queensland, while Australia results are inclusive of impacts to the GFD Project area, Queensland and the rest of Australia.

Table 26-13 Summary of the cumulative economic impacts

Economic region	Economic output (NPV, $M)				Employment average (FTE)
	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

Source: Deloitte Access Economics, 2013
Note: NPVs have been calculated using a discount rate of 7%. Values are in real 2012–13 terms.

Other cumulative economic impacts 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.

Santos GLNG is committed to working with government, industry and the community to manage economic impacts with specific focus on addressing issues around workforce and housing through its social impact management plan and on increasing local industry participation through its adoption of the QRC Code of Practice for Local Content.

Based on the assessment methodology given in section 26.3, the significance of the overall cumulative economic benefit is assessed as medium.

A detailed economic assessment is provided in section 4.2 of Appendix W: Economics.

26.6 Conclusions

This section has considered the potential for cumulative impacts to occur across the GFD Project cumulative impact area through the interaction of GFD Project impacts with those of the listed proposed projects. The cumulative impacts that remain after the application of mitigation and management measures are summarised in Table 26-13. The assessment found that the residual cumulative impacts to environmental values within the GFD Project cumulative area are predicted to have a low to medium significance.

Table 26-13 Residual cumulative significance – summary

Environmental value	Residual cumulative significance
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