# Chapter 10

## Approach to the impact assessment

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# Chapter 10 Approach to impact assessment

## 10.1 Overview

This chapter outlines the assessment framework that has been utilised to identify and categorise the project's potential environmental, social and economic impacts across the technical disciplines. It also explains how the application of mitigation and management measures reduces the level of risk of impacts to protect the identified environmental values.

The assessment framework has been designed to provide a structured and objective approach to identifying the project's environmental, social and economic impacts, and developing effective mitigation and management measures. It addresses both the (then) Commonwealth Minister for the Environment's and the Secretary of the NSW Department of Planning and Environment's environmental assessment requirements that form the scope for assessing the project. It is also consistent with the approach of the NSW Chief Scientist and Engineer in identifying risks associated with coal seam gas activities (NSW Chief Scientist and Engineer 2013 and 2014). A copy of the Secretary's requirements is included in Appendix A including a reference to where each requirement is addressed in the EIS.

The planning and placement of infrastructure in the field is an ongoing activity. Decisions on the placement of wells and associated infrastructure are dependent on ongoing assessment of gas resources within the underlying coal seams, the data for which is continually increased through the exploration and appraisal program. The siting of wells and infrastructure is also undertaken in consultation with the landholder and with consideration of environmental constraints.

To address this issue, development of the project includes the implementation of a Field Development Protocol (refer Appendix C), which incorporates the constraints and disturbance limits for the project and, therefore, the rules by which field infrastructure can be sited (refer to Section 10.3), being:

- unless a written agreement is in place with the relevant landholder, no project infrastructure will be located within 200 metres of an occupied residence on that property
- no surface infrastructure within, and a 50 metre buffer area around, the Brigalow State Conservation Area
- the Brigalow Nature Reserve is excluded from the project area
- no surface infrastructure within 200 metres of Yarrie Lake
- production well pads would be spaced at least 750 metres apart.
- maximum ecological disturbance limits by vegetation community and for individual threatened flora
- surface development exclusion areas for the 90 known Aboriginal sites
- surface development exclusion areas for identified historic heritage sites
- major facilities, non-linear field infrastructure and large ponds and dams are excluded from watercourses and a watercourse buffer zone, with widths determined by Strahler stream order
- large ponds and dams will be located outside of the one percent annual exceedance probability flood extent
- compliance with noise criteria at occupied residences, unless otherwise agreed with the landholder.

The assessment of environmental, social and economic impacts has been based on the maximum field development scenario so that the maximum potential impacts can be assessed, which is an inherently conservative approach.

Each technical chapter provides an assessment of compliance, potential risk, or significance of the impacts of the project, in addition to details of the mitigation and management measures to be implemented to manage those impacts. Comparisons of the potential (pre-mitigated) and the residual (mitigated) impact provides an indication of the effectiveness of the mitigation measures. A number of monitoring plans would also be developed to monitor residual impacts (refer Chapter 30).

Chapter 31 provides project commitments, which are the consolidated list of measures that would be implemented to mitigate and manage the potential impacts of the project.

## 10.2 Impact assessment

The impact assessment approach involved:

- identifying existing environmental, social and economic conditions through a baseline assessment
- completing an initial compliance, risk, or significance assessment giving consideration to field development constraints that would form the basis of the Field Development Protocol
- refinement of the project and identification of additional constraints for the project
- identification of additional mitigation, management or monitoring measures to manage residual impacts.

The environmental assessment process is illustrated in Figure 10-1.

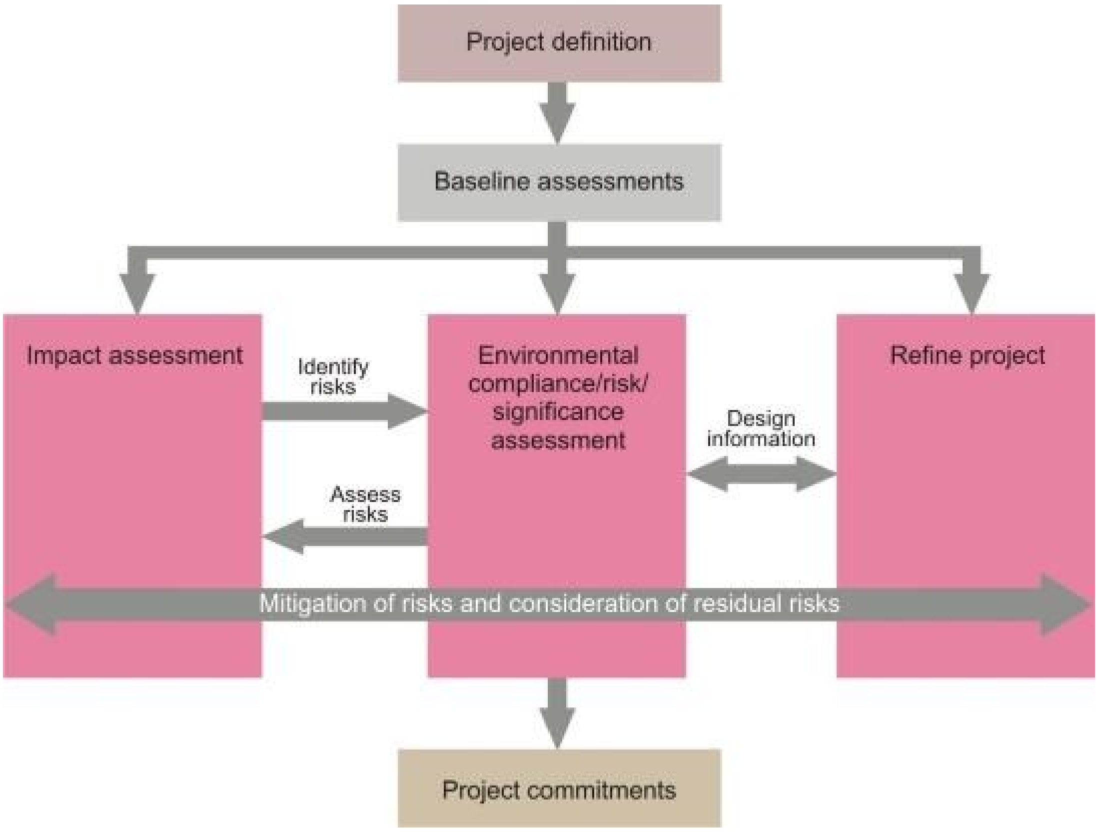


Figure 10-1 Environmental assessment process

The existing (or baseline) conditions for the project area were derived using a combination of desktop and field investigations. The field investigations included:

- over 13,000 person hours of ecology fieldwork
- three months of baseline air quality data collection
- water monitoring activities dating back to 2010
- a total of 24 stakeholder meetings were held between February and August 2014 for the social impact assessment; the majority of which were conducted face to face, with a very small number being conducted over the telephone
- a large range of historic and ongoing community and stakeholder activities including:
  - over 4,000 visitors to Santos shopfronts in Narrabri and Gunnedah
  - engagement with around 2,800 individual stakeholders and stakeholder groups between July 2013 and June 2016
  - two rounds of formal consultation with over 550 Registered Aboriginal Parties, including a total of 10 meetings in Narrabri, Gunnedah and Wee Waa
  - more than 420 attendees at Narrabri Gas Project briefings hosted by the Narrabri Chamber of Commerce
  - over 1,000 visitors to our information stand at AgQuip
  - 40 meetings to date for the Santos Narrabri Community Committee which became the Narrabri Community Consultative Committee (CCC)
  - more than 350 field site tours and community events in the project area
  - the Narrabri Gas Project brochure has been distributed by mail to over 6,500 Narrabri Shire residents and to around 130 clubs and community groups
  - the NSW pages of the Santos website has attracted over 60,000 views and the Narrabri Gas Project website was created and has had approximately 59,000 page views since it was created in September 2014
  - the Santos Energy NSW Facebook page was created in February 2015 and has had 262 posts since that time with a combined reach of approximately 1,100,000 people
- in excess of 1,400 hours of background noise monitoring data
- approximately 30 hours for to undertake the visual impact assessment baseline and take representative landscape photographs for the photomontages used in this EIS
- almost 250 person hours of baseline soil sampling
- 30 hours of site reconnaissance for the purposes of undertaking a contaminated land assessment
- some 50 hours of fluvial geomorphology field mapping
- approximately 200 person hours collecting baseline historic heritage information.

The existing conditions for each discipline are documented in Chapters 11 to 29 and discussed in more detail in the relevant appendices. The baseline conditions also informed the constraints to be applied in the Field Development Protocol. These constraints were then adopted as the project.

### 10.2.1 Assessment methodologies

This EIS has used different impact assessment methodologies for different environmental, social and economic values. The particular methodology used depended on the nature of the regulatory regime that applied to the particular value, the sensitivity or vulnerability of the value, the nature of the impact, and how mitigation measures would be applied. The relevance of each methodology and the values to which they apply are summarised in Table 10-1.

A general explanation of how each assessment methodology was applied is given below. In some cases, more than one methodology could be applied to meet the needs of a particular study, particularly where quantified guidelines exist for some aspects of the assessment. For example, SEPP 33 identifies trigger values for hazardous chemicals, and a risk assessment approach was undertaken in order to identify other risks that don't have a quantified guideline, and / or to assess aspects of the project that may lead to the relevant guideline not being met. Details of the assessment for each value are provided in the corresponding EIS chapters (chapters 11 to 29).

Table 10-1 Environmental and social assessment methodologies

| Methodology | Relevance | Values |
|---|---|---|
| Compliance assessment | Used where compliance with a known guideline or standard (e.g. published limits or thresholds) can be quantitatively assessed | • Air quality<br>• Greenhouse gas<br>• Noise and vibration |
| Risk assessment | Used where an impact may occur, and the impact depends on how aspects or materials are managed | • Aboriginal cultural heritage<br>• Historic heritage<br>• Hydrology and geomorphology<br>• Terrestrial ecology[a]<br>• Aquatic ecology[a]<br>• Hazard and risk<br>• Social and health<br>• Waste<br>• Traffic and transport |
| Significance assessment[a] | Used where an impact will occur and it is the sensitivity or the vulnerability of the value that is important | • Surface water quality<br>• Groundwater and geology<br>• Property and land use (including agricultural impact)<br>• Soils and land contamination<br>• Landscape and visual amenity |

[a] The term 'significance assessment' is defined under the NSW *Environmental Planning and Assessment Act 1979* (EPA Act), the NSW *Threatened Species Conservation Act 1995* (TSC Act), NSW *Fisheries Management Act 1994* (FM Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Significance assessments were undertaken for State-listed threatened biota in accordance with Section 5A of the EPA Act and for Commonwealth-listed threatened and migratory biota in accordance with the EPBC Act Significance Assessment Guidelines and are provided in Appendix J1 (for terrestrial ecology) and Appendix G1 (for aquatic ecology). (Threatened biota' is a collective term for 'threatened species, populations and ecological communities'). In addition, a risk assessment was also undertaken in the EIS for terrestrial and aquatic ecology consistent with the assessments of other environmental attributes. The compliance and risk assessment processes used also assess the significance of an environmental impact; they simply use alternative descriptors in the process.

An assessment of economic impacts was also prepared for the project. This included:

- a cost benefit analysis evaluation undertaken consistent with current state and national guidelines (as described in Appendix U1)
- a computable general equilibrium model (as described in Appendix U2) that looks at the broader macroeconomic impacts of the project in terms of gross regional state product, real income and job creation.

The economic assessment uses an accounting approach to present the project costs and revenue. The findings of the economic assessment were utilised as part of the social impact assessment.

## Compliance assessment

For the air quality, greenhouse gas and noise and vibration studies, quantified guidance have been established under NSW and Australian Government policies and guidelines developed to protect environmental values. The degree to which the project would comply with these guidelines was used as a measure of the level of impact.

The compliance assessment methodology generally used computer modelling to predict impacts from the project activities. This enabled an assessment of the extent to which the project would comply with the published limits or thresholds or the extent of mitigation and management measures that need to be applied to comply. In relation to the greenhouse gas assessment, published guidelines and calculation factors were used to quantify the emissions for the purpose of assessment.

As noted above, where an assessment could be considered as compliance or risk based, a risk assessment approach was generally adopted.

## Environmental risk assessment

For the Aboriginal cultural heritage, historic heritage, hazard and risk, hydrology and geomorphology, terrestrial ecology, aquatic ecology, social and health, waste and traffic and transport studies, the level of impact was determined by how each particular aspect would be managed as in all these cases an impact may occur. A qualitative risk assessment was used which was based on *AS/NZS 31000:2009 Risk Management – Principles and Guidelines.*

The criteria and terminology used in Table 10-2 to Table 10-9 inclusive represent a standard approach to environmental risk assessments to ensure a range of potential risks are assessed objectively. Such assessment tools are routinely used when assessing environmental impacts for developments and are appropriate for use in this EIS.

The assessment of hazard and risk was based on SEPP 33 guidelines but also quantified risks through the risk assessment process using an expanded risk matrix consistent with the proponent’s operational risk matrix. The assessment of traffic and transport was based on the on the criteria set out in the *Austroads Guide to Road Safety, Part 6: Road Safety Audit* (Austroads 2009).

Criteria used to rank the likelihood and consequences of potential impacts are set out in Table 10-2 and Table 10-3 respectively.

Table 10-2 Likelihood criteria

| Likelihood criteria | Description |
|---|---|
| **Almost certain**<br>Common | Will occur, or is of a continuous nature, or the likelihood is unknown. There is likely to be an event at least once a year or greater (up to ten times per year). It often occurs in similar environments. The event is expected to occur in most circumstances. |
| **Likely**<br>Has occurred in recent history | There is likely to be an event on average every one to five years. Likely to have been a similar incident occurring in similar environments. The event will probably occur in most circumstances. |
| **Possible**<br>Could happen, has occurred in the past, but not common | The event could occur. There is likely to be an event on average every five to twenty years. |
| **Unlikely**<br>Not likely or uncommon | The event could occur but is not expected. A rare occurrence (once per one hundred years). |
| **Remote**<br>Rare or practically impossible | The event may occur only in exceptional circumstances. Very rare occurrence (once per one thousand years). Unlikely that it has occurred elsewhere; and, if it has occurred, it is regarded as unique. |

Table 10-3 Consequence criteria

| Consequence category | Description |
|---|---|
| **Critical**<br>Severe, widespread long-term effect | Unauthorised destruction of sensitive environmental features. Severe impact on ecosystem. Impacts are irreversible and/or widespread. |
| **Major**<br>Wider spread, moderate to long term effect | Unauthorised long-term impact of regional significance on sensitive environmental features (e.g. wetlands). Environmental harm either temporary or permanent, requiring immediate attention. |
| **Moderate**<br>Localised, short-term to moderate effect | Unauthorised short term impact on sensitive environmental features. Significant changes that may be rehabilitated with difficulty. |
| **Minor**<br>Localised short-term effect | Unauthorised impact on fauna, flora and / or habitat but no negative effects on ecosystem. Easily rehabilitated. |
| **Negligible**<br>Minimal impact or no lasting effect | Unauthorised negligible impact on fauna / flora, habitat, aquatic ecosystem or water resources. Impacts are local, temporary and reversible. |

The level of risk of each environmental impact was assessed by combining the likelihood and consequences criteria in a risk assessment process as shown in Table 10-4. Field development constraints and disturbance limits (that is, maximum extents of disturbance), design standards / codes (that is, drilling to be in accordance with the NSW *Code of Practice for Coal Seam Gas Well Integrity* – DTIRIS 2012) and operational rules and / or protocols (that is, Bohena Creek managed release) were taken into consideration prior to assigning the initial risk ratings.

Consistent with the requirements of *AS/NZS 31000:2009 Risk Management – Principles and Guidelines* and its companion documents, there were some instances where the technical specialists for particular studies revised the categories and descriptions to better reflect the needs and specific objectives of the studies.

Table 10-4 Risk matrix

| Consequence | Likelihood | | | | |
|---|---|---|---|---|---|
| | **Almost certain** | **Likely** | **Possible** | **Unlikely** | **Remote** |
| **Critical** | Very High | Very High | High | High | Medium |
| **Major** | Very High | High | High | Medium | Medium |
| **Moderate** | High | Medium | Medium | Medium | Low |
| **Minor** | Medium | Medium | Low | Low | Very Low |
| **Negligible** | Medium | Low | Low | Very Low | Very Low |

Modified definitions of likelihood and consequence were followed for the hazards and risk assessment, the social impact assessment and the traffic and transport assessment; consistent with the relevant technical standards or approach for these disciplines.

The hazards and risk assessment used an expanded risk matrix consistent with the proponent's operational risk matrix. This was adopted as it includes better definition of consequence regarding personal safety (rather than environment risk). The expanded consequence descriptors are provided in Table 10-5.

Table 10-5 Consequence criteria for hazard and risk assessment

| Level | Description |
|---|---|
| **Critical** | Multiple fatalities or significant irreversible effects on tens of people. |
| **Major** | Single fatality and/or severe irreversible disability to multiple people. |
| **Moderate** | Extensive injuries or irreversible disability or impairment to one person. |
| **Minor** | Medium term reversible disability to one or more persons.<br>Significant medical treatment, disabling or lost time injury. |
| **Negligible** | Injury requiring medical treatment with no lost time.<br>Minor injury, minor medical / first aid treatment or no effect. |

The social impact assessment considered both positive and negative impacts as informed by the social impact assessment against baseline conditions, and the results of other technical studies from this EIS. The consequence criteria used for the social impact assessment is provided in Table 10-6.

Table 10-6 Consequence criteria for social impact assessment

| Level | Description |
|---|---|
| **Critical** | Irreversible changes to social characteristics and values of the communities of interest or community has no capacity to adapt and cope with change. |
| **Major** | A long-term recoverable change to social characteristics and values of the communities of interest or community has limited capacity to adapt and cope with change. Long-term opportunities emanating from the project. |
| **Moderate** | Medium-term recoverable changes to social characteristics and values of the communities of interest or community has some capacity to adapt and cope with change. Medium term opportunities emanating from the project. |

| Level | Description |
|---|---|
| **Minor** | A short-term recoverable change to social characteristics and values of the communities of interest or community has substantial capacity to adapt and cope with change. Short-term opportunities emanating from the project. |
| **Negligible** | Local, small-scale, easily reversible change on social characteristics or values of the communities of interest or communities can easily adapt or cope with change. Local small-scale opportunities emanating from the project that the community can readily pursue and capitalise on. |

In accordance with the *Austroads Guide to Road Safety, Part 6: Road Safety Audit, t*he traffic and transport assessment assigned risk levels within the study area based on the frequency and severity of the risk. Summaries of the different levels of frequency and severity have been reproduced in Table 10-7 and Table 10-8 below from the Austroads Guide.

Table 10-7 Summary of frequency descriptions

| Frequency | Description |
|---|---|
| **Frequent (F)** | Once or more per week |
| **Probable (P)** | Once or more per year (but less than once a week) |
| **Occasional (O)** | Once every five or ten years |
| **Improbable (I)** | Less often than once every ten years |

Table 10-8 Summary of severity description

| Severity | Description | Examples |
|---|---|---|
| **Catastrophic (C)** | Likely multiple deaths | High speed, multi vehicle crash on congested roads<br>Bus and fuel vehicle collide<br>Vehicle runs into bus stop |
| **Serious (S)** | Likely death or serious injury | High or medium speed vehicle / vehicle collision<br>High or medium speed collision with road-side object<br>Pedestrian or cyclist hit by a vehicle |
| **Minor (Mi)** | Likely minor injury | Some low speed collisions<br>Left-turn rear end crashes |
| **Limited (Li)** | Likely trivial injury or property damage only | Some low speed vehicle collisions<br>Vehicle reversing into an object |

The Austroads' *Guide to Road Safety, Part 6: Road Safety Audit*, provides the risk matrix shown in Table 10-9, which was applied for the traffic and transport assessment.

Table 10-9 Summary of levels of risk

| Severity | Frequency | | | |
|---|---|---|---|---|
| | **Frequent** | **Probable** | **Occasional** | **Improbable** |
| **Catastrophic** | Intolerable | Intolerable | Intolerable | High |
| **Serious** | Intolerable | Intolerable | High | Medium |
| **Minor** | Intolerable | High | Medium | Low |
| **Limited** | High | Medium | Low | Low |

# Significance assessment

For the groundwater and geology, surface water quality, property and land use (including agricultural impact), soils and land contamination and visual amenity studies, there will be an impact and it is the sensitivity or vulnerability of the environmental value and the magnitude of the impact that are important. For these studies, a significance assessment methodology was applied.

The process applied was similar to the risk assessment process described above, but the criteria applied related to sensitivity and magnitude rather than to likelihood and consequence. These criteria are summarised in Table 10-10 and Table 10-11 respectively.

The surface water quality assessment considered the ANZECC/ARMCANZ (2000) water quality guidelines.

Table 10-10 Sensitivity criteria

| Sensitivity | Description |
|---|---|
| High | The environmental value is listed on a recognised or statutory state, national or international register or database as being of conservation significance. The environmental value is intact and retains its intrinsic value.<br>The environmental value is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region, territory, country or the world.<br>It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. Project activities would have an adverse effect on the value. |
| Moderate | The environmental value is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers or databases. The environmental value is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements.<br>It is relatively well represented in the systems / areas in which it occurs but its abundance and distribution are limited by threatening processes.<br>Threatening processes have reduced its resilience to change. Consequently, changes resulting from project activities may lead to degradation of the prescribed value.<br>Replacement of unavoidable losses is possible due to its abundance and distribution. |

| Sensitivity | Description |
|---|---|
| Low | The environmental value is not listed on a recognised or statutory register or database; however, might be recognised locally by relevant suitably qualified experts or organisations.<br>The environmental value is in a poor to moderate condition as a result of threatening processes, which have degraded its intrinsic value.<br>It is not unique or rare and numerous representative examples exist throughout the system or area. It is abundant and widely distributed throughout the host systems or area.<br>There is no detectable response to change or change does not result in further degradation of the environmental value.<br>The abundance and wide distribution of the environmental value ensures replacement of unavoidable losses is achievable. |

Table 10-11 Magnitude criteria

| Magnitude | Description |
|---|---|
| High | An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact. |
| Moderate | An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls. |
| Low | A localised impact that is temporary or short term and either unlikely to be detectable or could be effectively mitigated through standard environmental management controls. |

For some studies, the sensitivity and magnitude criteria used were varied to better reflect the nature of the environmental value being assessed.

Study-specific changes made to the assessment methodology are described in the relevant technical assessment reports and EIS chapters (for example terrestrial ecology in Chapter 15 and visual impact in Chapter 23).

The significance of each impact was determined by combining the sensitivity and magnitude criteria as shown in Table 10-12.

Table 10-12 Significance matrix

| Magnitude | Sensitivity | | |
|---|---|---|---|
| | High | Moderate | Low |
| High | Major | High | Moderate |
| Moderate | High | Moderate | Low |
| Low | Moderate | Low | Negligible |

The significance classifications used in Table 10-12 (major, high, moderate, low and negligible) are defined in Table 10-13.

Table 10-13 Significance classifications

| Significance | Description |
|---|---|
| Major | Arises when an impact will potentially cause irreversible or widespread harm to an environmental value that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation. |
| High | Occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the environmental value. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status. |
| Moderate | Results in degradation of the environmental value due to the scale of the impact or its susceptibility to further change even though it may be reasonably resilient to change. The abundance of the environmental value ensures it is adequately represented in the region, and that replacement, if required, is achievable. |
| Low | Occurs where an environmental value is of local importance and temporary or transient changes will not adversely affect its viability provided standard environmental management controls are implemented. |
| Negligible | Does not result in noticeable change and hence the proposed activities will have negligible effect on environmental values. This typically occurs where the activities are located in already disturbed areas. |

## 10.2.2 Mitigation and management measures

Mitigation and management measures were applied to reduce the level of impact identified for the pre-mitigated, or potential, impacts. These measures aim to protect the identified environmental values and to achieve established environmental objectives. Mitigation and management measures would be applied, as appropriate, during the planning and design, construction, operations, and decommissioning and rehabilitation phases of the project.

Details of the mitigation and management measures to be used to protect the environmental values within the project area are given in the relevant technical reports and EIS sections.

## 10.2.3 Residual impacts and environmental management planning

An assessment of the residual impacts remaining after application of the mitigation and management measures was undertaken. Comparison of the potential (pre-mitigated) and the residual (mitigated) impacts provided an indication of the effectiveness of such measures.

Where changes to the project occurred either through modifying the design to avoid or minimise impacts, including additional field development constraints / limits for the project, technical specialists re-evaluated relevant compliance, risk or significance within their area of expertise.

Where a proposed management or mitigation measure did not lower the residual compliance, risk or significance level, alternative and / or additional management and mitigation measures were identified to lower the residual risk rating. A number of monitoring plans would also be developed to monitor residual risks (refer Chapter 30).

# 10.3 Field Development Protocol

The Field Development Protocol incorporates the physical constraints and disturbance limits for the project outlined in the EIS, and therefore, the rules by which field infrastructure including wells, access tracks, gas and water gathering lines, water storages and telecommunication towers can be sited under the project. It therefore forms an integral part of the project description on which the impact assessment is based. The inputs into, and the context of, the Field Development Protocol within field planning are summarised in Figure 10-2.

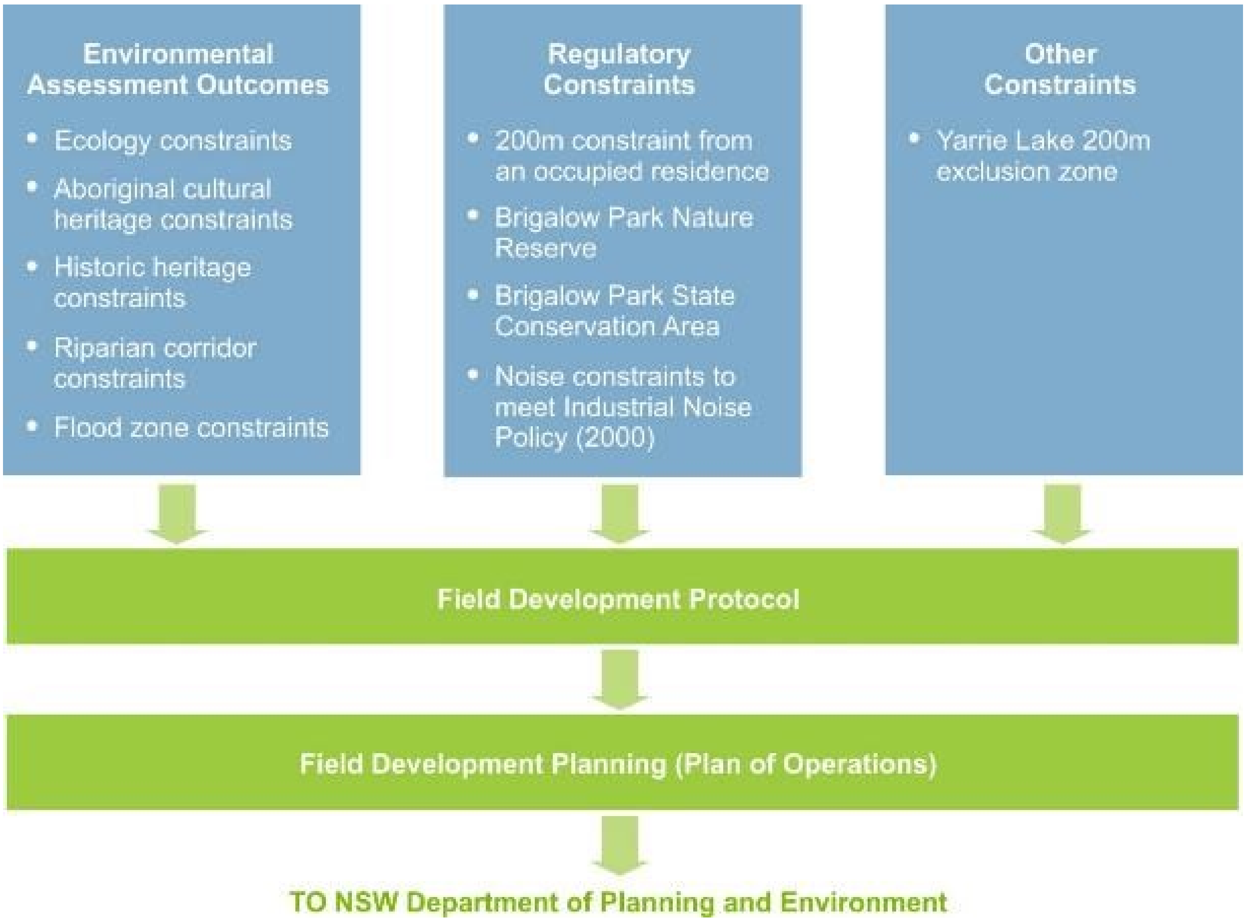


Figure 10-2 Field Development Protocol inputs and context within field planning

The Field Development Protocol aims to ensure that the development of the project, particularly the siting of infrastructure, minimises the impact of the project on the environment in accordance with those predicted within the EIS.

The Field Development Protocol has been designed so that the project avoids areas with specific environmental attributes within the project area, maximises avoidance of the most sensitive features, and includes a number of siting constraints as discussed in Section 10.3.2.

An iterative process was used when developing the Field Development Protocol that required inputs from technical assessments. The process involved:

- identification of sensitive features / sites as a result of initial baseline assessments
- development of possible field development constraints and / or disturbance limits and inclusion of these in the Field Development Protocol where appropriate.

With the implementation of the Field Development Protocol, in particular the in-field micro siting and pre-clearance surveys, field infrastructure would be located to maximise avoidance of the most sensitive ecological features and complete avoidance of the most sensitive Aboriginal heritage sites. Therefore, potential impacts that may normally be associated with the siting of infrastructure would be substantially reduced, or eliminated altogether.

The Field Development Protocol is included as Appendix C. Prior to development; this would be amended to incorporate the conditions of approval for the project.

The process for developing constraints and disturbance limits are further discussed below. A summary of constraints and disturbance limits is provided in Table 10-16.

## 10.3.1 Developing constraints and disturbance limits

Constraints analysis is a key input to the Field Development Protocol and increases certainty about potential impacts by identifying those areas that are not amenable to development, or if they were to be developed, how development should proceed. This occurs by identifying the constraints to development that exist within the project area and the environmental management controls to be applied to project activities in these constrained areas.

In this way, the project can optimise environmental outcomes by avoiding sensitive sites and receptors wherever practicable. Where avoidance is not practicable, a range of management and mitigation measures would be used to ameliorate impact. Constraint classifications were established according to the potential for the proposed activities to cause adverse impacts on the identified environmental values. These classifications are set out in Table 10-14.

Table 10-14 Constraint classification

| Constraint category | Prohibited activities | Permitted activities |
|---|---|---|
| No-go area | Petroleum activities are prohibited in this area. | Nil |
| Surface development exclusion area | Linear infrastructure[a]<br>Non-linear infrastructure[b]<br>Large ponds and dams | Support for planning – Monitoring activities including air quality, noise, ecological surveys, pests and weeds and cultural heritage surveys |
| High constraint area | Large ponds and dams | Support for planning<br>Linear infrastructure<br>Non-linear Infrastructure |
| Moderate constraint area | Large ponds and dams | Support for planning<br>Linear infrastructure<br>Non-linear infrastructure |
| Low constraint area | No prohibited activities. | Support for planning<br>Linear infrastructure<br>Non-linear infrastructure<br>Large ponds and dams |

[a] Linear infrastructure would include access tracks, and gas and water gathering lines for example.
[b] Non-linear infrastructure would include gas wells and other surface facilities.

# Ecology

A very important element of the Field Development Protocol is the research that underpins the disturbance limits. Extensive ecology surveys have been undertaken in the project area since 2002, including over 13,000 hours by field ecologists mapping vegetation communities, fauna habitat and threatened species in the forest and its surrounds. The robustness of the land disturbance probabilistic calculations for the project allowed the testing of numerous development scenarios by applying a repeatable methodology, which provides confidence that the project constraints and disturbance limits are achievable.

The potential constraints of the project area from an ecological perspective are complex and involve a number of unique ecological values including threatened flora, threatened fauna habitat, endangered ecological communities (EECs), high quality vegetation, regional vegetation significance and large patch size.

To determine the ecological constraints for the project, an ecological sensitivity analysis was developed as part of the ecological impact assessment for the project to identify the degree of ecological sensitivity and hence constraint to development. The ecological sensitivity analysis would be used to inform the initial selection of locations for field infrastructure.

The ecological sensitivity analysis used available spatial data as well as data collected through field investigations and spatial data developed specifically for the project (as part of the ecological impact assessment in Appendix J1) to identify areas of sensitivity. The full methodology for the ecological impact assessment is included in Appendix J1, with the full methodology for the ecological sensitivity analysis included in the attachments to Appendix J1.

Ecological decision criteria were identified as shown in Table 10-15. These decision criteria were based on major values for biodiversity and conservation and available information.

Table 10-15 Biodiversity conservation values and decision criteria

| Major value | Decision criteria | Indicator data set |
|---|---|---|
| Statutory / conservation value | Endangered ecological communities and locally significant communities | Vegetation communities |
| | All identified threatened flora records | Field survey data |
| | Identified threatened fauna habitat (Pilliga mouse) | Vegetation communities; field survey data; fauna databases |
| | Areas within 50 m of drainage lines | Drainage |
| Landscape conservation value | Areas of rare vegetation within the region | Vegetation communities and percentage cleared in the region |
| | Consolidated habitat | Vegetation patch size |
| Condition | Terrestrial biodiversity | Vegetation communities and field survey data (biometric score) |
| | Areas of high quality vegetation / fauna habitat | Vegetation communities; field survey data; fauna databases |

An analytical hierarchy process was adopted to rank and weight the identified criteria for ecological sensitivity across the study area. This multi-criteria analysis process is a recognised process for complex decisions where some elements are difficult to quantify and rank. Each of the criteria was ranked from one to five in order of ecological sensitivity to biodiversity conservation significance, with five being the highest.

The sensitivity analysis then combined scores for the data, applied weightings, and modelled sensitivity indices. Five ecological sensitivity classes were modelled ranging from low (areas subject to previous disturbance) to high (areas that contain significant ecological values). These ecological sensitivity classes are discussed further in Chapter 15. Certain project activities and / or components of the project are either prohibited or permitted within each of these sensitivity classes (refer to Table 7-1 of Appendix C).

Taking into consideration prohibited or permitted activities within particular sensitivity classes, an estimate of the maximum disturbance limits of the project was completed. Two key methodologies were used for this task:

- a probabilistic methodology for defined ecological communities using a range of development scenarios
- association modelling for specific flora and fauna species.

A probabilistic model was developed to provide a robust, clear and repeatable methodology for assessment of impacts to terrestrial ecology. A range of possible development scenarios with consideration of differences in vegetation and habitat densities and infrastructure density was developed.

This enabled calculation of the maximum disturbance (of the total 988.8 hectares of disturbance area) for each native vegetation community or threatened flora species that is proposed to be cleared. The maximum disturbance limits for flora and fauna are defined in Chapter 15 and the Field Development Protocol (Appendix C). Project development footprints must be within these disturbance limits. The ecological impact assessment took a conservative approach and therefore the environmental outcome would be equal to, or better, than this predicted impact.

To comply with these maximum disturbance limits, micro-siting would be implemented in the field to further direct the project infrastructure away from sensitive ecological areas or features such as endangered ecological communities, threatened flora species, hollow-bearing trees or significant fauna habitat where practicable. A hierarchical structure would be applied to the relocation of infrastructure to avoid or minimise impacts on key features and attributes identified during micro-siting.

## Aboriginal cultural heritage

Aboriginal heritage constraints for the project were developed after consideration of:

- the data audit
- sensitivity mapping of the full range of site types in the project area
- field investigations undertaken as part of the Aboriginal cultural heritage assessment for the project.

The methodology for the Aboriginal cultural heritage assessment is provided in Appendix N1 and is summarised in Chapter 20.

The Aboriginal cultural heritage assessment identified 90 known Aboriginal heritage sites within the project area. These sites were initially identified through searches of the Aboriginal Heritage Information Management System (AHIMS) database and review of other fieldwork and assessments completed in the region.

The initial field verification program examined 45 sites, while five could not be inspected due to weather and access conditions. The remainder of known sites within the project area would be verified within 12 months of project approval.

Landscape sensitivity mapping was also developed as part of the Aboriginal cultural heritage assessment. This identified three Aboriginal cultural heritage zones (and nine sub-zones) for the project area. These are:

- zone 1 – identified Aboriginal cultural heritage places (broken into two sub-zones consisting of AHIMS or other sites)
- zone 2 – previously surveyed and / or developed areas (where no Aboriginal cultural heritage has been identified)
- zone 3 – Aboriginal cultural heritage sensitivity (broken down into six sub-zones ranging from very high to very low) taking into consideration a number of landscape features.

These zones are illustrated in Chapter 20. The landscape sensitivity mapping and cultural heritage zones can then be used to inform project planning.

The project has committed to avoiding all currently known Aboriginal sites and the complete avoidance of the most sensitive Aboriginal site types, as detailed in The Aboriginal Cultural Heritage Assessment Report (refer to Appendix N1). This is also discussed further in Chapter 20 and in the Cultural Heritage Management Plan (refer to Appendix N2). Sites known at the time of EIS submission would be a surface development exclusion zone. Following completion of the ecological micro-siting component (discussed above), a cultural heritage pre-clearance survey would be conducted with the Aboriginal community within the refined infrastructure footprint.

If Aboriginal cultural heritage sites are encountered in the refined infrastructure footprint, then the commitments in the assessment report and procedures outlined in the Aboriginal Cultural Heritage Management Plan would be implemented.

## Additional constraints and disturbance limits

In addition to ecology and Aboriginal cultural heritage, other field development constraints and disturbance limits were developed in an iterative process for the following aspects:

- Noise – noise impacts are considered a constraint at occupied residences unless a written agreement is in place with the landholder (refer to Table 10-16). The noise impacts associated with Leewood and Bibblewindi were assessed as part of the noise and vibration assessment for the project (refer to Chapter 19 and Appendix M).
- Historic heritage – 53 potential historic heritage sites were identified within the project area, primarily associated with past logging activities. Information on each of the sites can be found in the Historic Heritage Impact Assessment (refer to Appendix O). The majority of sites were found to be of local significance as part of a collection, referred to as the Pilliga East Logging Cultural Landscape, that can demonstrate the pattern and course of the development of logging in the forests. In order to preserve the Pilliga East Logging Cultural Landscape, particular sites are surface development exclusion areas. Due to the similarities of the timber extraction areas and logging ramps across the project area, if impacts are unavoidable, another site of the same type may be substituted as a surface development exclusion area without impacting the heritage significance. Potential historic heritage sites that are identified during site surveying or micro-siting would be managed in accordance with an unexpected finds procedure that would be developed for the project.

- Hydrology – watercourses in the project area were mapped and a stream order assigned in accordance with the Strahler (1952) system. To account for the need to include channel widths as part of the total riparian corridor width, top of bank was digitised for watercourses with larger channels or an average channel width was applied based on their stream order. Riparian corridors were determined based on the NSW Office of Water's *Guidelines for riparian corridors on waterfront land* (NoW 2012). Constraints are identified in Table 10-16.
- Flooding and geomorphology – flood analysis over the project area was carried out for a one per cent annual exceedance probability flood (refer to Chapter 13 and Appendix H). Constraints are identified in Table 10-16.

The air emissions from the major facilities at Leewood and Bibblewindi were assessed as part of the air quality impact assessment (refer to Appendix L and Chapter 18) and are not considered as part of the Field Development Protocol. Based on the size and specifications for remaining project infrastructure, the potential air emissions from these sources are insufficient to exceed applicable air emission limits. On this basis, no constraints are proposed for air emissions.

Similarly, no biophysical strategic agricultural land (BSAL) is located within the project area (refer to Chapter 14 and Appendix I2). On this basis, no soil constraints are proposed for siting gas wells; however, soils would be managed through construction and rehabilitation consistent with the findings of the Interpretative Spoils Report (refer Appendix I1).

## 10.3.2 Summary of constraints and disturbance limits

Table 10-16 presents a summary of constraints and disturbance limits that were taken into consideration for the technical assessments. These are included in the Field Development Protocol and would be implemented as part of the project.

Table 10-16 Summary of constraints and disturbance limits

| Constraints | Description |
|---|---|
| Nature reserves, national parks and Aboriginal areas | No activities would be undertaken in nature reserves, national parks and Aboriginal areas.<br>Brigalow Park Nature Reserve has specifically been excluded from the project area. |
| State conservation areas | There would be no surface development activities in Brigalow State Conservation Area or within a 50 metre buffer zone. The Brigalow State Conservation Area is gazetted to a depth of 100 metres. Drilling activities under the State Conservation Area would be at least 110 metres deep. |
| Occupied residences | Unless a written agreement is in place with the relevant landholder, no project infrastructure will be located within 200 metres of an occupied residence on that property. |
| Yarrie Lake | Surface infrastructure would be excluded from Yarrie Lake and a buffer of at least 200 metres around Yarrie Lake. |
| Noise constraints | Noise constraints associated with the construction and operational periods of the project are summarised in Section 10.5 of the Field Development Protocol and would apply at occupied residences unless a written agreement is in place with the landholder. Noise levels would be measured in accordance with the Industrial Noise Policy (NSW EPA 2000). |

| Constraints | Description |
|---|---|
| Watercourses | Gas field non-linear infrastructure and large ponds and dams would be excluded from these riparian corridors (based on Strahler stream order with first order being the smallest tributaries):<br>• first order: 20 metres on each side of the watercourse plus channel width<br>• second order: 40 metres on each side of the watercourse plus channel width<br>• third order: 60 metres on each side of the watercourse plus channel width<br>• fourth order and greater: 80 metres on each side of the watercourse plus channel width. |
| Flooding and geomorphology | Large ponds and dams will be located outside of the one percent AEP to ensure long term protection of these assets and to minimise impact from the project on surface flow during large flood events.<br>Where other infrastructure and activities occur within the 1 % annual exceedance probability, there would be negligible modification of flows, necessary sediment and erosion controls would be implemented, and there would be no ongoing impacts on geomorphology. Activities within the 1 % annual exceedance probability would be planned and constructed in accordance with the commitments and mitigations in Appendix H of the EIS, and the erosion and sediment control plan. |
| Ecological features | Limits of disturbance for native plant communities total 988.8 hectares, and there are also individual limits for threatened flora. These are defined in Chapter 15 and Table 8-1 of the Field Development Protocol (refer Appendix C). |
| Aboriginal cultural heritage | Avoid all currently known Aboriginal sites.<br>Additional avoidance measures (for currently unknown sites that may be identified during pre-clearance surveys) would be implemented as defined in Chapter 20 of this EIS and the Cultural Heritage Assessment Report in Appendix N1. |
| Non-Aboriginal cultural heritage | The following sites are surface development exclusion areas:<br>• Cowallah Parish Plan Sawmill<br>• Logging Camp 7<br>• Cowallah Sites Complex<br>• Hardy’s Hut<br>• Pilliga 1 Oil Well<br>• SUGAR pits located at the Leewood site and the intersection of Plumb Road and No Name Road.<br>If impacts are unavoidable at a site listed below, another site of the same type may be substituted as a surface development exclusion area without impacting the heritage significance:<br>• Timber extraction areas 1, 2, 3, 4, 6, 10, 12, 18, 19 and 21<br>• Timber loading ramp 1, 5, 6, 9 and ramp associated with timber extraction area 19. |