Narrabri Gas Project Supplementary response to submissions

Santos

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Supplementary response to submissions

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Chapter 1 Introduction

1.1 Overview

In February 2017, the Environmental Impact Statement (EIS) for the Narrabri Gas Project (the project) was submitted to the NSW Department of Planning and Environment (DPE) for consideration as part of development application number SSD 14_6456.

Consistent with requirements under the NSW *Environmental Planning and Assessment Act 1979*, the EIS was placed on public exhibition from 21 February to 22 May 2017, during which period the DPE received 23,007 submissions.

Submissions were received from a wide range of stakeholders including government institutions, special interest groups, organisations and individuals.

The proponent (Santos) was required to respond to the submissions. The response to submissions report (RTS) summarised the submissions and responded to the matters raised. The structure and contents of the RTS reflected the draft guideline *Responding to Submissions* (NSW DPE 2017). The RTS was placed on public exhibition in April 2018.

Several statutory bodies, including state and local Council, provided further questions upon reviewing the RTS. This supplementary RTS (SRTS) document provides responses to those questions.

The RTS and SRTS, along with the EIS, will be considered in the determination of the project under the NSW *Environmental Planning and Assessment Act 1979*.

1.2 Report structure

The structure and content of the SRTS is as follows:

- Chapter 1 provides a brief introduction to the SRTS as it relates to the EIS and legislation.
- Chapter 2 responds to submissions from Government Agencies, including council, with the matters raised in each submission responded to individually.
- Chapter 3 provides a conclusion and evaluation of the project in light of matters raised.
- Chapter 4 provides the references cited in this document.

Chapter 2 Response to Agency submissions

2.1 NSW Department of Industry – Lands and Water Division

2.1.1 Analysis of data in the Water Baseline Report

The submission requested further analysis of the baseline data in the Water Baseline Report. Attachment A of the submission prescribed the analysis sought. The submission also stated that not all Gunnedah-Oxley Basin bores were used in the water quality summarised in the EIS.

Data presented in the Water Baseline Report (EIS Appendix G4) satisfies the requirements of the Secretary's Environmental Assessment Requirements (SEARs).

The revised Water Baseline Report provided as Appendix D of the RTS document addresses the additional data requests made in response to the submission on the EIS by the Department of Industry — Lands and Water Division (Lands and Water).

Appendix A to this report provides the following data in response to the most recent Lands and Water submission:

- Groundwater quality for the Gunnedah-Oxley Basin where produced water samples were collected at the well head (refer to Table A1 in Appendix A). The samples were collected over approximately 20 years across a broad geographic area. There were in excess of 300 data points for certain analytes, with no long-term trends identified. Percentiles were therefore used as a guide to variability in values.
- Treated water quality (refer to Table A2 in Appendix A), which provides a further update of Table 7.1 from the revised Water Baseline Report, being Appendix D of the RTS document.

2.1.2 Groundwater Monitoring and Management Plan

The submission has recommended that the proponent prepares a Groundwater Monitoring and Management Plan (GWMMP), including a Groundwater Dependent Ecosystem Monitoring Plan, to provide clear direction on the scale and approach of monitoring and management required should the project be approved.

Additional detail on this recommendation is provided below.

Minimum requirements for the GWMMP

The submission recommended the following minimum requirements for the GWMMP:

- Provision of a groundwater specific monitoring plan (including groundwater dependant ecosystems (GDEs)) to be developed as a standalone document

- Updating the management response triggers and response actions for each water source
- Specific requirement for model updates
- Provision of a plan for adding the additional monitoring sites proposed in this document.

The GWMMP would include a schedule of sites to be installed and operational by set dates post-approval as a condition of consent.

The proponent is committed to implementing a groundwater monitoring program capable of early detection of impacts of the project on groundwater resources and dependent users (including the environment and GDEs). The existing Water Monitoring Plan (EIS Appendix G3) includes a groundwater monitoring plan founded on the principle of early detection monitoring (Section 3.1).

The Water Monitoring Plan:

- Defines groundwater monitoring 'triggers', 'early warnings' and 'thresholds' for relevant groundwater resources (Section 3.7)
- Proposes a monitoring regime that protects groundwater resources and GDEs
- Includes various management responses to monitoring including the revision and recalibration of the model groundwater model if warranted.

The proposed groundwater monitoring will assess potentially significant impacts in the low-value Gunnedah-Oxley Basin Groundwater Source (providing leading resource indicators – Level 1 monitoring targets) as well as non-significant impacts in the high-value water sources of the GAB and Namoi Alluvium (lagging resource condition indicators – Level 2 monitoring targets).

Monitoring of Level 1 targets acknowledges that *"unexpected impacts on groundwater condition at these depths would occur well in advance of adverse impacts occurring in the shallow, high-value groundwater sources."* A response in monitored bores will allow for validation of modelling and confirmation of conceptualisations of the groundwater systems. The collection of additional monitoring data from bores outside the project area will not provide suitable data for monitoring of Level 1 or Level 2 targets. Any data from these bores would not inform review of, or revision to, the existing groundwater model for several decades, if not hundreds of years (refer Table 2-1) as no response is predicted in bores in these areas prior.

The identification and prioritisation of groundwater receptors (economic and environmental), analysis of the action-pathway-response, and consideration of the risk profile of the project has been undertaken through multiple independent studies (e.g. various reports under the *Namoi Subregion of the Northern Inland Catchments Bioregional Assessment* (https://www.bioregionalassessments.gov.au/assessments/namoi-subregion; the *Namoi Catchment Water Study* (Schlumberger 2012) and the Gas Industry Social and Environmental Research Alliance (GISERA) https://gisera.csiro.au/project/impacts-of-csg-depressurisation-on-the-great-artesian-basin-gab-flux/). Results from these studies will be considered in the design of the groundwater monitoring framework.

The risk of impact to GDEs will be monitored and managed throughout the life of the project, with the Water Monitoring Plan focussed on early detection of a specific and measurable change in groundwater condition related to the proposed project activities. This is appropriate as the main GDEs in the project area are the Type 2 waterholes on Bohena Creek and farm dams managed for agricultural production. The Bohena Creek potential GDEs are associated with shallow groundwater/surface water interactions and not associated with deeper groundwater resources at risk of experiencing influences associated with depressurisation of the target coal seams.

Groundwater modelling indicates that there is an insignificant risk of impact to GDEs due to the large physical separation from the project water extraction, both vertically in the sub-surface and horizontally

at the surface. This means there is a lack of connectivity between the target coal seams and aquifers supporting potential GDEs. As no impact is predicted, the Water Monitoring Plan does not propose to monitor at the GDE sites. Similarly, monitoring is not proposed at (potential) GDEs that are managed as farm dams for agricultural production.

Nevertheless, the groundwater monitoring is designed to allow management responses, including potential monitoring at or nearer to GDEs, to occur many years, and potentially decades, in advance of measurable change to aquifers that support GDEs. As such, should conditions change or new data become available in the long term, the Water Monitoring Plan would be revised to include monitoring closer to GDEs, where supported by evidence.

The proponent confirms its previous commitment to work with Lands and Water and relevant Commonwealth and State Government agencies to review the Water Monitoring Plan during the project life as necessary based on available evidence.

Minimum requirements for groundwater trigger response management

The submission stated that Management Response Triggers (MRTs) are to monitor and manage impact propagation based on groundwater impacts (drawdown and timing) being no greater than those predicted from the 'Base Case' modelling scenario as documented in the EIS. The triggers and responses are grouped into three tiers, with each tier referring to a connected, or group of connected, water sources.

The submission recommends that the monitoring program and responses will be reviewed and updated once the groundwater model has been reviewed, and that all bores proposed for MRTs must be equipped with telemetry.

The trigger response tiers proposed by Lands and Water mimic the level response triggers contained within the existing Water Monitoring Plan included in the EIS (Appendix G3), with proposed Tier 1 equivalent to Level 2 and proposed Tiers 2 and 3 equivalent to Level 1 in the Water Monitoring Plan.

The proponent proposes reviews of the model if the Level 1 or Level 2 response triggers are met. To meet the Level 1 response trigger requires three or more years in which cumulative water production exceeds that published in the EIS. The Level 2 response trigger involves exceedance of the predicted maximum drawdown in the Triassic age strata of the Gunnedah-Oxley Basin. If this trigger were met, additional investigations would be conducted to determine if impacts were likely to propagate to shallow higher value groundwater sources and evaluate potential responses.

It is emphasized that the Groundwater Impact Assessment (EIS Appendix F) found there was low risk to shallow higher value groundwater sources. The groundwater monitoring program is designed to allow for detection and management responses many years, and potentially decades, in advance of measurable change to higher value shallow aquifers.

Minimum additional monitoring sites

The submission prescribes additional monitoring sites and targeted aquifers across the region. Specifically, all formations are to be monitored and all cardinal points surrounding the project are to be included.

As noted in section 3 of the Water Monitoring Plan (EIS Appendix G3), the proponent is committed to delivering a groundwater monitoring network that "informs to the extent possible, an understanding of whether or not the project is contributing to changes in water quantity or quality within water assets, particularly the high-value groundwater sources in the Great Artesian Basin and alluvial aquifers".

Independent modelling by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for the GISERA program (e.g. Sreekanth *et al*. 2018a) has demonstrated that highest worth monitoring is that within the potential project impact area as shown in Figure 2-1.

Figure 2-1 Indicative locations (stars) of additional monitoring locations to provide the highest worth monitoring (*cf*. Sreekanth *et al*. 2018a).

The light grey region in Figure 2-1 represents the 30 km buffer region of modelled interest, while the dark grey constrains the extent of potentially observable drawdown in layer 6 of the model, representing the Pilliga Sandstone.

Greatest data worth is achieved by monitoring formations immediately above the target coal seams within the project area. Optimal additional monitoring locations for Upper Gunnedah-Oxley Basin and Lower Great Artesian Basin formation targets (Sreekanth *et al*. 2018a).

Figure 2-2 shows the proposed GISERA monitoring sites (*Ibid.*) and the monitoring sites proposed by the proponent in the Water Monitoring Plan (EIS Appendix G3). As shown, sites in targeted formations in the upper Gunnedah-Oxley Basin and lower Great Artesian Basin sequences and existing government bores (labelled DPI) are used to augment the alluvial network. The proponent acknowledges the network requires some location-specific refinement and is committed to working with the regulator to determine specific monitoring locations.

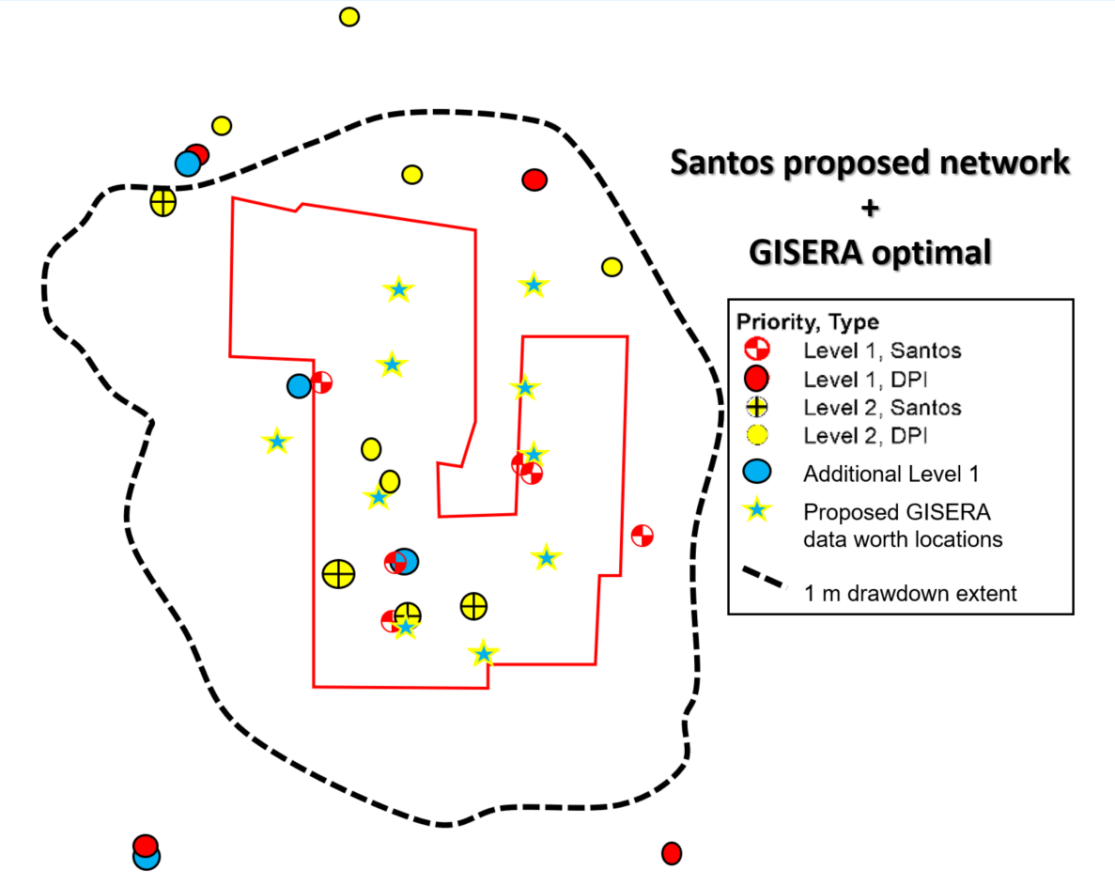

Figure 2-2 Comparison of the proponent-proposed network (EIS Appendix E3) and GISERA-modelled optimal data worth locations (Sreekanth *et al*. 2018a)

Any requirement to increase the number of monitoring locations in future would be informed by subsequent reviews of the groundwater model triggered by data obtained during field development. The timing of predicted impacts is sufficiently long to confirm adequate baseline data can be acquired in parallel with field development.

Comparing the current proposed monitoring network with the monitoring sites proposed in the Lands and Water submission, fewer monitoring locations are required but greater data worth and model confidence is achieved. The additional monitoring bore sites proposed in the submission are not expected to provide data of value over and above that provided by the existing monitoring network proposed in the Water Monitoring Plan (EIS Appendix G3). In particular, any additional data generated would not increase the confidence level of risk assessments or provide information relevant to trigger levels that would give rise to a model review. This is because any response in bores outside the project

area would be delayed and data suitable to inform review of the groundwater model would not be generated for several decades, if not hundreds of years.

It is noted that the proponent's proposed monitoring network is consistent with the monitoring philosophy recently adopted by Lands and Water in installing additional bores to monitor the project. Consistent with the Water Monitoring Plan and response triggers, these recently installed bores target the Triassic age strata.

2.1.3 Groundwater Modelling Plan

The submission recommended the proponent should prepare a Groundwater Modelling Plan to detail how the EIS groundwater model and the groundwater impact assessment will be reviewed over the life of project should the project be approved.

The submission requires the Groundwater Modelling Plan to include details about how the reviews will improve confidence in the model's ability to predict impacts on water sources, the environment and other users.

The proponent is committed to preparing a Groundwater Modelling Plan (GWMP) for the project that considers the requirements for review of the groundwater model and Groundwater Impact Assessment (EIS Appendix F).

The 2015 Lands and Water review of the Groundwater Impact Assessment modelling confirmed it met the requirements of the SEARs, including in relation to future review of modelling. Lands and Water advice regarding the updated 2016 SEARs also required inclusion of a program for review of the groundwater modelling as more data became available.

The proponent confirms that review of the groundwater model and Groundwater Impact Assessment will follow the approach presented in the published EIS. Accordingly, the groundwater model and Groundwater Impact Assessment (EIS Appendix F) will be reviewed as new data becomes available through the groundwater monitoring program if the data indicate this is necessary.

The current Groundwater Impact Assessment (EIS Appendix F) includes:

- A description of the relationship between the Groundwater Impact Assessment (EIS Appendix F) and Water Monitoring Plan (EIS Appendix G3), including how monitoring will inform reviews of the Groundwater Impact Assessment and groundwater model
- A five-step methodology (Section 7.7.3) for conducting reviews of the groundwater modelling based on monitoring data, potentially involving recalibration of the model and re-running of predictive scenarios based on the realised field development.

The Groundwater Impact Assessment will also be reviewed if the Level 1 or Level 2 triggers in the Water Monitoring Plan (Appendix G3 of the EIS) are met.

The Level 1 threshold is triggered if cumulative water production exceeds cumulative water production volumes as published in the Water Monitoring Plan (EIS Appendix G3, Table 3-12) for three or more consecutive years. The Level 2 threshold is triggered if pressure decline in Triassic Age strata exceed, or are likely to exceed, the predicted maximum drawdown published in the Water Monitoring Plan (EIS Appendix G3, Table 3-13).

Update of the EIS groundwater model to confidence level Class 2 and 3

The submission recommended mandatory modelling updates to elevate the existing Class 1 groundwater model in the published EIS to successively higher confidence level classes, as follows:

- A first update of the model at three years post-project determination to achieve a Class 2 model, as defined in the *Australian Groundwater Modelling Guidelines*
- A second update of the model six-years post project determination to achieve a Class 3 model, with the timing of delivery of a Class 3 model being negotiable with Lands and Water if insufficient data exist after six years.

The proponent is committed to review the existing groundwater model using the best available data and as described in the EIS. As described below, it is not technically feasible for this to result in a Class 2 or Class 3 model.

The *Australian Groundwater Modelling Guidelines* (Barnett *et al.* 2012) explain that a Class 1 model is best suited to managing low-value resources (i.e. few groundwater users with few or low-value groundwater dependent ecosystems) and for assessing impacts of low-risk developments. A Class 1 model is appropriate for assessing potentially significant impacts in the low-valued Gunnedah-Oxley Basin Groundwater Source and for assessing non-significant impacts in the high-valued water sources of the Great Artesian Basin (GAB) and Namoi Alluvium. A Class 1 model is also consistent with the project risk profile and applicable groundwater policy.

In relation to achieving a Class 2 model:

- Considering the criteria listed in Table 2-1 of the *Australian Groundwater Modelling Guidelines*, and due to the predicted low impact of the project, not all of the criteria for a Class 2 model can be achieved within three years post-determination, or within the project lifetime.
- A critical restriction on achieving a Class 2 model is transient calibration of the EIS groundwater model in high-valued water sources. A transient calibration cannot be attempted without pressure responses to CSG water extraction occurring in the high-valued water sources. Measurable depressurisation responses in the GAB and Namoi Alluvium are not predicted for tens to hundreds of years after the start of CSG production.
- In this situation, meaningful model recalibration and elevation to a Class 2 model is unlikely to be possible during the project lifetime.

In relation to achieving a Class 3 model:

- Elevation to a Class 3 model requires the predicted stress-response relationship of the project to be within the historical stress-response relationships of groundwater activities in the Gunnedah Basin and connected water sources. For example, to achieve a Class 3 model would require an existing CSG project in the Gunnedah Basin of comparable magnitude and duration to the project and accurate calibration of the EIS groundwater model to that stress-response history. Meeting this requirement for the project is not possible now or in the future as no other gas project exists in the basin.
- Criteria from the modelling guidelines for a Class 3 model that cannot be achieved by the project include:
  - Level and type of stresses included in the predictive model are within the range of those used in the transient calibration (i.e. they are within historical experience and the model is successfully calibrated to that history).
  - Model predictive time frame is less than three times the duration of the transient calibration (a transient calibration is not currently possible and will not be possible until depressurisation responses occur in high-valued water sources – i.e. in hundreds of years).

  - Modelled stresses in predictive simulations are not more than two times greater than those included in the model calibration (i.e. historical groundwater stresses in the Gunnedah Basin must be of comparable magnitude to those of the project).

More generally, the following observations are made in relation to the requirement for mandatory model updates to Class 2 and 3 over time:

- The *Australian Groundwater Modelling Guidelines* note that not all criteria of a particular model class must be met, but key aspects of the model class that can be achieved should be discussed and agreed between the modelling proponent, model reviewer and regulators.
- The *NSW Aquifer Interference Policy* (NSW Government 2012) requires groundwater modelling to be undertaken in a manner consistent with the *Australian Groundwater Modelling Guidelines* but does not specify the model confidence level class to be achieved.
- The Lands and Water submission to the EIS, which recommended model updates but did not specify a confidence class to be achieved.
- The Independent Expert Scientific Committee's (IESC's) submission on the EIS, which discussed potential improvements in model confidence but did not specify a model class to be achieved.
- The IESC information guidelines for CSG and large coal mines recommend groundwater modelling should be undertaken in accordance with the Australian Groundwater Modelling Guidelines but do not discuss or specify the model confidence level class to be achieved.
- GISERA groundwater modelling and reporting of potential impacts of CSG development in the Gunnedah Basin is presented without reference to model confidence level class (e.g. Sreekanth *et al*. 2017, 2018a and 2018b).
- In Queensland, the Surat 2012 and 2016 *Underground Water Impact Reports* and their supporting groundwater modelling reports (OGIA 2012 and 2016) - used to assess cumulative impacts in the Surat Basin - are presented and assessed without reference to the model confidence level class.

In relation to the published EIS groundwater modelling, the existing model is acknowledged to be Class 1 and potential impacts predicted using the model are acknowledged to be indicative. Notwithstanding the above, the Groundwater Impact Assessment (EIS Appendix F) conducted for the EIS, and other independent assessments of the potential for groundwater impacts from CSG development in the Gunnedah Basin (e.g. the *Namoi Catchment Water Study* (Schlumberger 2012) and recent modelling conducted by CSIRO for GISERA (Sreekanth *et al*. 2017, 2018a and 2018b), have been consistent in concluding there is a low potential for significant impacts on high-valued water sources.

The Class 1 status of the EIS groundwater model therefore reflects low confidence in the accuracy and location of small impacts but does not reflect uncertainty in the order-of-magnitude of these impacts. After extensive study by independent research efforts, there are no predictions of anomalous large impacts on high-valued water sources in the existing assessments of CSG development in the Gunnedah Basin.

In summary, the low risk of significant impact stems from the depth of the target coal seams and the relatively small volumes of proposed extraction from the Gunnedah Basin compared to the larger existing uses extracting directly from the overlying high-values water sources.

Mandatory modelling updates at 3- and 6 years post-determination

The submission has recommended mandatory model updates at three and six years post-determination.

The published Groundwater Impact Assessment (EIS Appendix F) and Water Monitoring Plan (EIS Appendix G3) presents the following five steps for reviewing the groundwater modelling:

- Steps 1 to 3 are used to assess whether there is a basis for reviewing the model design and predictions.
- Steps 4 and 5 are iterative and designed to establish consistency between model design, model calibration and data acquired through the groundwater monitoring program.

The published Water Monitoring Plan also requires reviews of the modelling if the Level 1 or level 2 response triggers are met.

Periodical data reviews and reporting will be conducted to support Steps 1 to 3 above. The supporting data reports are proposed to be produced three years post-determination and every five years following (i.e. years 3, 8, 13, 18 and 23). This approach ensures that model reviews are made when required based on the available data.

It is understood that the timing of the recommended mandatory modelling reviews is based on an expectation that enough data will be available after three years to achieve a Class 2 model and after six years to achieve a Class 3 model. As described above, achieving a Class 2 or Class 3 model is not technically feasible due to an absence of measurable depressurisation responses in the GAB and Namoi Alluvium for tens to hundreds of years and an absence of historical gas development in the basin.

Minimum requirements for the GWMP

Lands and Water has recommended the GWMP must include the following as a minimum:

- Data requirements
- Model update and impact assessment update requirements
- Model review requirements
- Plan review requirements
- Provision of model reports to agencies and the public
- Stakeholder consultation.

The published Groundwater Impact Assessment (EIS Appendix F) identifies data sources that will be used for conducting modelling updates. Section 7.7.3 of the Groundwater Impact Assessment (EIS Appendix F) states that model updates will be informed by hydrogeological data collected for the field development program, groundwater monitoring program, drilling of groundwater monitoring bores and data from coal seam gas appraisal activities such as hydrogeological interpretations. The proponent is committed to conducting periodic data reviews as the basis for assessing project performance and the need for modelling updates (refer to the Water Monitoring Plan as EIS Appendix G3, Section 4.3).

The published EIS presents a methodology for conducting updates of the groundwater modelling and impact assessment. The proponent is committed to conducting periodic reviews of model predictions against project performance as the basis for assessing the need to undertake model updates (refer to the Groundwater Impact Assessment as EIS Appendix F, Section 7.7.3). Under this approach, the

groundwater model will be reviewed as new data becomes available through the groundwater monitoring program, and updated if the data indicate that this is necessary.

The proponent will engage suitably qualified and experienced persons to undertake peer reviews of model updates. The proponent is committed to making modelling reports and updates available to government.

Minimum requirements for groundwater model updates

The submission recommended the following minimum requirement for updates of the EIS groundwater model:

- Updates to be undertaken by a suitably qualified and experienced groundwater modeller with experience in building complex models utilising the most suitable code applicable at the time
- Transient calibration to water levels, drawdowns and volumes in all main groundwater systems
- Incorporation of all available drilling, pumping and monitoring data
- An independent peer review by a suitably qualified modelling expert
- A range of sensitivity scenarios both including and excluding cumulative impacts of other mining development in the area and to be agreed to in consultation with Lands and Water
- Provision of modelling reports developed for each model update to Lands and Water for review.

The proponent will engage a suitably qualified person to undertake groundwater modelling updates.

Transient model calibration will not be possible in water sources with no detectable depressurisation responses.

Section 7.7.3 of the published Groundwater Impact Assessment (EIS Appendix F) states that model updates will be informed by hydrogeological data collected for the field development program, groundwater monitoring program, drilling of groundwater monitoring bores and data from coal seam gas appraisal activities such as hydrogeological interpretations.

The proponent will engage suitably qualified and experienced persons to undertake peer reviews of model updates.

The proponent will make modelling reviews available to the government as required.

Requirements for updating the Groundwater Impact Assessment

The submission recommended the following requirements for updating the Groundwater Impact Assessment (EIS Appendix F) after a modelling update has been conducted:

- Application of the updated model to re-quantify potential impact of project on water sources during the project's operation and post production
- Update of the Groundwater Impact Assessment with the revised modelling results, including an assessment of potential impacts against the *NSW Aquifer Interference Policy*
- Update of the hydrogeological conceptual model
- Update all groundwater usage data
- Address the incorrect assumption that groundwater usage during 1996 to 2000 is representative.

Present all hydrographs in future reporting with water intake information i.e. screened intervals and screened formation and/or water source on the hydrograph.

The proponent is committed to conducting periodical reviews of model predictions against project performance, and if the Level 1 or Level 2 thresholds in the Water Monitoring Plan (EIS Appendix G3) are triggered, as the basis for assessing the need to undertake modelling updates (Groundwater Impact Assessment (EIS Appendix F, Section 7.7.3)). Should this occur, a modelling update will involve application of the updated model to re-predict potential impacts of the project during and post-production.

The proponent is committed to conducting updates of the Groundwater Impact Assessment when the groundwater modelling is updated, including an updated assessment of predicted impacts against the *NSW Aquifer Interference Policy*, and updating of the hydrogeological conceptual model and groundwater usage data.

The proponent notes the published Groundwater Impact Assessment (EIS Appendix F) does not state that groundwater usage data from 1996 to 2000 are 'representative' of either historical or current extraction. Section 5.5.3 of the Groundwater Impact Assessment (EIS Appendix F) identifies the period between 1996 and 2000 as having a relatively constant rate of extraction, which exhibited less variation than other periods. In Section 6.5.1 of the Groundwater Impact Assessment (EIS Appendix F), the year 2000 is identified as being a reasonable point in time for choosing the target for steady-state model calibration because it comes at the end of a period of relatively constant extraction from the alluvium.

All future hydrographs presented in the groundwater reporting will include the screened intervals and screened formation of the monitored bores.

2.1.4 Provision of detailed cross sections of the whole geological / hydrogeological profile

The submission requested detailed cross sections of the whole geological / hydrogeological profile.

Cross-sections were provided in the Groundwater Impact Assessment (Refer to Figure 6-3, Figure 6-4 and Figure 6-5 in EIS Appendix F).

2.1.5 Water entitlements acquisition

Water Access Licences

The submission raised a number of matters in relation to the requirement for the proponent to hold water access licences (WALs) for the project, including:

- Timing of the need to hold a WAL
- The amount of entitlement required
- The strategy for acquisition of WALs where required.

Specifically, Point 5 of the submission sought a plan of when the proponent intended to acquire the necessary water entitlements from relevant water sources if the project was approved. Point 13 (post-approval recommendation) then stated that the proponent should acquire sufficient water access licences to account for the maximum predicted take for each water source prior to production. Points 5, 13 and 14 are reproduced below.

Information required to determine the project application:

Point 5: *A plan of when and how the proponent intends to acquire the necessary water entitlements from relevant water sources if the project is approved. This must include an analysis of availability and potential to purchase in the water sources that are fully allocated and therefore require entitlement to be purchased from the open market.*

Recommended measures should the project be approved:

Point 13: *Acquire sufficient water access licence/s to account for the maximum predicted take for each water source prior to production. The rules of the relevant water sharing plans must be complied with*.

Point 14: *For groundwater sources at a risk of reduction in Available Water Determination into the future (including the Lower Namoi, Upper Namoi Zones 2, 4 and 5) the proponent should hold more water entitlement than has been predicted by the model to provide a buffer against reduced Available Water Determinations should the Long Term Average Annual Extraction Limit compliance rules be breached. The total entitlement required to be held should be described in the Groundwater Management Plan and approved by Lands and Water*.

The proponent acknowledges in the EIS that water access licences will be required for the type of water take contemplated by the project.

Table 2-1 summarises the EIS Base Case modelled predicted water take for each relevant groundwater source including the time of commencement of water take and the peak water take.

Table 2-1 Peak induced flows (maximum take) and time to flow >1 ML/y for the EIS Base Case

Groundwater Source	ML/y	Time (years after start of Field Development Protocol, to nearest model time step)	Time to flow >1 ML/y (years after start of FDP, to nearest model time)
Gunnedah-Oxley Basin	3,553	3	1
GAB Southern Recharge	57.3	190 - 200	19
GAB Surat	0.16	950 – 1,000	Not exceeded
Lower Namoi Alluvium	4.19	250 – 300	56
LNA Trade Area 1	4.17	250 - 300	74
LNA Trade Area 2	0.01	500 - 550	Not exceeded
LNA Trade Area 3	0.01	550 - 600	Not exceeded
Upper Namoi Alluvium (UNA)	1.00	250 – 300	250-300
UNA Zone 2	0.16	550 – 600	Not exceeded
UNA Zone 5	0.90	250 - 300	Not exceeded

The *Water Management Act 2000* requires an operator to hold an access licence for any water taken in the course of carrying out a 'mining activity'. However, the requirement to hold a licence is drafted on the basis of a water access licence being required at the time of take, and not in respect of future or anticipated take.

The proponent notes that the *NSW Aquifer Interference Policy* states that the preferred approach of Lands and Water is that the project be approved on the condition that the proponent hold water access licences for the maximum of the predicted annual water quantities from the commencement of the

project regardless of when water will actually begin to be taken.

Based on the requirements of the Act, and in consideration of the *NSW Aquifer Interference Policy*, the proponent suggests that the conditions of approval should require the proponent to:

- Hold the necessary water access licence for the actual take from the Gunnedah-Oxley Basin in a particular year
- Obtain a water access licence for take from the GAB – Southern Recharge Groundwater Source within five years after the production commences
- Obtain water access licences (as required) for the GAB – Surat Groundwater Source and for water sources within the Upper and Lower Namoi Groundwater Sources no later than year 25 of the project (subject to the data collected from the final Water Monitoring Plan over the life of the project and the comments below).

Such conditions are consistent with the *NSW Aquifer Interference Policy* and exceed the requirements of the *Water Management Act 2000*.

The proponent over the course of the project will have been required to monitor and measure the effect of the project on the relevant groundwater systems. As understanding of the groundwater systems builds over the life of the project, uncertainty will be reduced and more accurate modelling of the likely future water draw down will be possible, based on the actual volume of water extracted. This will enable a more precise estimate of what licensed allocation, if any, will be required by the proponent for a particular water source.

The Lands and Water submission seeks to ensure that sufficient licenced entitlement is obtained to take account of reductions in Available Water Determination due to Long Term Average Annual Extraction Limit compliance. The future drawdown from the GAB Surat and Upper and Lower Namoi Groundwater systems are not modelled to commence for decades (and possibly hundreds of years). The water sharing plans for the various water sources last 10 years. The Basin Plan is to be reviewed in 2026 and the sustainable diversion limits may change. This uncertainty is addressed by the proponent's suggested conditions of approval presented above.

The actual entitlement required should be based on the conditions contained in the relevant water sharing plan at that future time (including the environmental water requirements, the bulk access regime, the extraction limits and rules for managing access licences). Further, conditions imposed on a licence associated with induced flows should take into account the requirements of the water sharing / resource plan(s) at that future time.

The other matter raised in the *NSW Aquifer Interference Policy* is the risk of there being insufficient market depth from which to obtain the necessary water entitlements at a point in time in the future.

The proponent notes that AITHER (2017), a report commissioned by Lands and Water, concluded that:

- Water markets are delivering important benefits for New South Wales
- Trade has increased substantially and is continuing
- Water markets are working as expected
- In an environment of increasing scarcity, climate variability, demand and investment, the gains from trade will increase.

The report concluded that there is a well-developed groundwater market in the Namoi groundwater systems. The NSW Water Register shows that although there is limited trade in the GAB water sources, nevertheless there is trade occurring and there are no reasons to suspect in the case of there being a willing buyer that there would be no willing sellers. The modelled requirements of the project are relatively small and there is more than sufficient market depth to meet them.

The water market and trading regimes fulfil an important role in the overall policy context and those markets are working effectively.

One of the matters identified by AITHER (2017) in the Hunter region was mining and electricity generation taking water from the market, but not actually using the entitlements (pp 274-275). The report notes that this requirement may be preventing productive reallocation of water and potentially acts as a supply constraint, increasing allocation prices.

To ensure the project does not unnecessarily impact the water market and to enable continued use of entitlements in the GAB and Namoi groundwater systems for productive agricultural purposes, the proponent intends to acquire an allocation only when and if water is required. Under this approach there is a demonstrated need for the water once an allocation is sought.

Amount of entitlement required

The submission sought details of the water entitlements proposed to be acquired by the proponent and recommends that the proponent should acquire sufficient water access licence/s to account for the maximum predicted take for each water source prior to production. The submission states that the rules of the relevant water sharing plans must be complied with.

In relation to those groundwater sources at a risk of reduction in Available Water Determination into the future (including the Lower Namoi, Upper Namoi Zones 2, 4 and 5) the submission stated that the proponent hold more water entitlement than has been predicted by the model to provide a buffer against reduced Available Water Determinations should the Long Term Average Annual Extraction Limit compliance rules be breached.

In the following, each groundwater source will be assessed based on relevance and requirements with regard to the Act.

<u>For the Gunnedah-Oxley Basin Groundwater Source:</u>

The modelled maximum annual take is 3,553 ML.

The Water Sharing Plan (WSP) for the NSW Murray-Darling Basin Porous Rock Groundwater Sources commenced on 16 January 2012 with the relevant water source being the Gunnedah–Oxley Basin MDB (Other) Management Zone. The available water determinations each year are to be 1 ML per unit share (rule 29), unless there is to be an adjustment because the extractions have exceeded the long-term annual extraction limit (measured over a three-year period and subject to a 5 percent tolerance: see rules 26 and 27). The account management rules provide in summary that in a particular water year, water taken under an aquifer access licence in this source must not exceed the AWD for that year + carryover (limited to 0.25 ML/per unit share) + water assigned under s71T + water returned under s76 (water return flow rules).

Based on the current modelling and the rules in the WSP, the proponent will hold water access licences at least equivalent to the amount extracted in a particular year and ultimately this may be as high as 3,600 ML.

<u>For the GAB – Southern Recharge Groundwater Source:</u>

The modelled maximum annual take is 57.3 ML with take expected to commence at greater than 1 ML per-year in year 19.

The Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008 took effect on 1 July 2008. Rule 34 provide that the available water determinations for both water sources at the commencement of the Plan are to 1 ML per unit of share component. In future years the AWD must not

cause total extractions to exceed the annual extraction limit. The account management rules are set out in rule 36. Carryover of up 0.6 ML per unit of access licence share component is allowed. The maximum amount of water that may be taken in a particular year may not exceed 1.3 ML per unit of share component.

Based on the current modelling and the rules in the WSP, the proponent proposes to acquire up to 60 ML.

For the GAB – Surat Groundwater Source:

The proponent proposes that the project conditions (subject to the points below) require the proponent and Lands and Water to assess this requirement in year 25 of the project based on the knowledge at that time.

For the Upper and Lower Namoi Groundwater Sources:

The proponent proposes that the project conditions (subject to the points below) require the proponent and the Lands and Water to assess this requirement in year 25 of the project based on the knowledge at that time.

Strategy for acquisition of WALs where required

The submission requested a plan of when and how the proponent intends to acquire the necessary water entitlements from relevant water sources if the project is approved. The plan must include an analysis of availability and potential to purchase in the water sources that are fully allocated and therefore require entitlement to be purchased from the open market.

For the Gunnedah-Oxley Basin Groundwater Source:

According to the NSW Water Register, most of the licences in this water source are for relatively small entitlements; the largest entitlement is 641 ML. There is some limited trade taking place in this water source. Taking into account the small number of licences currently issued and the size of the entitlements allocated to them, it is likely that the proponent is going to find it difficult to purchase enough entitlement to meet its needs on the open market.

The water sharing plan allows for, and there have been, controlled allocation orders under s65 of the Act. The most recent minimum bid price is $650 per unit share. The quantity of unit shares available was 17,175.

If the project is approved the proponent is likely to source most of the required water under the controlled allocation order.

For the GAB – Southern Recharge Groundwater Source:

According to the NSW Water Register for the period 2016/2017 the number of aquifer access licences for the Southern Recharge Groundwater Source was 150 with 25,403.5 ML share component. There is only very limited trading, however, the amount of entitlement required is very small and the proponent would expect that there would be a willing vendor amongst the 150 licence holders.

The proponent intends to apply for a zero WAL.

The proponent will then look to find a vendor(s) for the share entitlement required. There are water brokers able to assist with this purchase. There are water brokers who undertake water sales acting

not just as a broker but an intermediate purchaser / vendor. The proponent will then enter into contract(s) for the purchase of the necessary entitlement no later than 15 years after production commences.

Management of WALs / Management of WALs following project completion

The proponent anticipates that Lands and Water will seek conditions of consent that relate to certain WALs held by the proponent at the completion of the project, and conditions of consent that relate to WALs that will be held by the proponent immediately following completion of the project.

For the Gunnedah-Oxley Basin:

It is anticipated that the water take will peak during the first five years of the project. The proponent may choose to sell entitlement that is no longer required during the project. At the completion of the project, water extraction from the Gunnedah-Oxley Basin will cease and Gunnedah-Oxley Basin entitlements will no longer be required.

For the GAB – Southern Recharge Groundwater Source:

Following the completion of the project the proponent proposes holding a water access licence of up to 60 ML for the peak GAB Southern Recharge modelled take.

Clause 2.2 of the *NSW Aquifer Interference Policy* states a preference for a licence to be surrendered to the Minister where the licence was obtained to take into account the post-closure continued take of water until an aquifer system reaches equilibrium over an extended period of time.

The proponent has modelled the effects of the surrender of the proposed entitlement to the Minister, where retirement of 60 ML of entitlement at the completion of the project (year 26 of the modelling) is significantly in excess of the modelled take from the GAB Southern Recharge at that time. From year 26, all entitlement over and above what is required to offset the actual take from the GAB Southern Recharge is water that, if it had not been acquired by the proponent and surrendered to the Minister, would otherwise have been extracted annually in accordance with the terms of the WAL. Therefore, the effect of the retirement of 60 ML of entitlement in year 26 is that there is less extraction from, and additional pressure in, the GAB Southern Recharge.

The effect of the retirement of a volume of entitlement greater than the extraction by the project has been modelled. Based on this modelling the effect of the retirement of this entitlement is that the flux or take from the GAB Surat and Upper Namoi (Zone 5) and Lower Namoi Groundwater sources is reduced to nil. There is still a very minor peak in over 350 years (0.12 ML/y) for Upper Namoi Zone 2.

The proponent accepts that where the production of gas (an aquifer interference activity) requires taking water from a groundwater source, and this take then results in flux from an adjacent or overlying water source, that a separate access licence is required for the overlying groundwater source. The proponent is of the view, however, that the entire effect of the project should be taken into account. Where the surrender of a licence means that this effect is negated in overlying water sources then no WAL is required.

Such a policy approach is consistent with the Act (the Act allows for return flows to be considered – refer to sections 75 and 76) and consistent with the broader water policy framework (see for example, https://www.mdba.gov.au/managing-water/return-flows).

Proponent's suggested strategy for dealing with non-material water take

The submission has not considered that for a range of groundwater sources the maximum take of the project is inconsequential or non-material, for example Lower Namoi Alluvium Trade Areas 2 and 3 where the modelled peak annual take is 0.01 ML in over 500 years.

The modelled take of water from the GAB – Surat and the Upper and Lower Namoi groundwater sources predicts a very low take of water in the distant future. Specifically:

- Surat Groundwater Source - 0.16 ML (950-1,000 years)
- Lower Namoi (trading zone 1) - 4.17 ML (250-300 years)
- Lower Namoi (trading zone 2) - 0.01 ML (500-550 years)
- Lower Namoi (trading zone 3) - 0.01 ML (550-600 years)
- Upper Namoi Zone 2 - 0.16 ML (550-600 years)
- Upper Namoi Zone 5 - 0.9 ML (250-300 years).

Further, there are 15,100 units of share component in the Surat Groundwater source; 16,092 units of share component in zone 5 of the Upper Namoi; 7,141 units of share component in zone 2 of the Upper Namoi and 81,586 units of share component in the Lower Namoi. The modelled predicted take represents a non-material share of all the water sources, being at the most 0.005 percent of the share component issued.

The proponent acknowledges that the Act does not prescribe a minimum use of water before a licence is required. However, the regulations may prescribe for categories of people to be exempt from the requirement to hold a water access licence.

Relevantly, the regulations currently allow for the take of up to 3 ML/y of water for petroleum exploration (prospecting and fossicking) but this does not extend to actual petroleum production itself: see regulation 18 & Part 1 Schedule 5, clause 17.

Prior to 2011, prospecting and fossicking activities were exempt altogether from the requirement to hold a water access licence. This amendment to the regulations was made as it was recognised that once water take reaches a certain level, that take of water should be accounted for.

The proponent acknowledges the need for water extraction in the course of petroleum production to be accounted for. However, in the case of very minor (modelled) incidental diversions of water in the distant future, the impact on the aquifer and other users is negligible. It would be appropriate for a similar exemption from the requirement to hold an access licence for water diversions up to three megalitres in a single water year to be introduced for petroleum production.

Such an amendment would be consistent with the current regulations. As pointed out by section 8.3 of the *Water Management (General) Regulation 2017* - Regulatory Impact Statement (August 2017), the objective of providing for exemptions from the Act's requirements for access licences is to minimise the regulatory burden on minor water users commensurate with the small volume of water take and the low level of associated impact and to allow the regulatory authorities to manage their responsibilities in a cost-effective and practical manner.

2.1.6 Government Stakeholder Consultation Plan

The submission requests provision of a Government Stakeholder Consultation Plan prior to approval with the express assurance that consultation would be undertaken with Lands and Water on water-related matters.

The proponent has committed to engage with and consult with Lands and Water on all water-related matters that fall within its mandate. In addition, the NSW Land and Water Commissioner is the Chair of the Narrabri Gas Project Community Consultative Committee.

2.1.7 Other matters

Recommended consent conditions

The submission raised other matters that are procedural in nature, or advice regarding conditions of approval. Such matters include:

- All approved Plans to be implemented once the project is approved.
- All works within waterfront land to be managed in accordance with *Guidelines for Controlled Activities on Waterfront Land* (NRAR 2018).
- A site water balance to be updated yearly and made available through annual reporting.

These matters were described and assessed in the EIS in accordance with the SEARs.

Surface water

The submission also made several recommendations concerning surface water (post-approval), including:

- Preparation of a Monitoring and Mitigation Plan to address ecological and water quality impacts to Bohena Creek and other surface water sources
- Upgrade (or replacement) of a suitable gauging station to accurately detect the managed release volume proposed from the water treatment plant.

Matters relating to potential surface water impacts were assessed in detail in the EIS in accordance with the SEARs, including provision of mitigation strategies. Critically, the managed release (of up to 12 ML/day) to Bohena Creek will only occur when recorded flow (at Gauging Station 419905) is equal to, or greater than, 100 ML/day. While this station appears to have been operating with reduced functionality since 2005, it is at the ideal location to monitor Bohena Creek flow rate, and the proponent will discuss restoration of this station with Lands and Water.

While Gauging Station 419905 is at the ideal location to monitor Bohena Creek flow rate, the treated water to be released into Bohena Creek will be measured prior to the diffuser, when the treated water is in a pipe. The water balance will be monitored by the proponent, including the use of a series of flow gauges in the water treatment plant.

Managed release protocols were developed in accordance with the SEARs and relevant NSW EPA policies. No material impact is predicted beyond 10 m from the diffuser (including toxicity) and will not be detectable under natural conditions. The performance of the water treatment plant has been verified since the EIS was submitted, with treated water quality data summarised in Appendix A.

Management and monitoring of the managed release to Bohena Creek has been proposed by the proponent in accordance with the SEARs and relevant State policies, and the proponent anticipates that the framework of management and monitoring will be reflected in the Environment Protection Licence for the project.

The proponent has also committed to the development of a Biodiversity Management Plan. The proponent proposed that this Plan include the monitoring of biodiversity values, and therefore, the effectiveness of mitigation measures.

2.2 Division of Resources and Geosciences

2.2.1 Resource sterilisation

The Division requests that it is consulted by the proponent before biodiversity offset sites have been finalised, to assist in the identification of areas that are not likely to impact or sterilise extractive, coal or other coal seam gas resources.

The proponent will consult with the Division about potential biodiversity offset sites prior to their finalisation.

2.3 NSW Environment Protection Authority

2.3.1 Waste management

Waste classification of salt

Should the project be approved, the EPA recommends including a consent condition requiring the proponent to develop a Waste Management Plan, in consultation with the EPA. This should include requirements for an ongoing monitoring program to ensure consistency with waste guidelines and to confirm the classification of waste over the life of the project.

The proponent has committed to preparing a Waste Management Plan for the project to be prepared in accordance with consent conditions.

Waste salt disposal

The EPA recommends that the DPE requests further information detailing the criteria that will be used when selecting disposal facilities for waste salt prior to project determination. This information should

include the measures that will be used to evaluate landfill capacity and capability. The EPA requests that DPE require an assessment of salt disposal options at different scales, including:

- An assessment of the capacity and capability of landfills located within 200 kilometres of the project to take the quantities and types of waste proposed to be generated by the project
- An assessment of the capacity and capability of landfills at a regional scale to take quantities and types of waste proposed to be generated by the project
- An outline of contingencies.

The RTS confirmed there are a substantial number of waste facilities available within NSW, including government and privately owned facilities, which are licensed by the NSW EPA to receive general solid waste in the order of hundreds and thousands of tonnes per annum. As stated in the EIS and RTS, the project will produce an average of 47 tonnes of salt per day. This compares to around 1,000 tonnes disposed of from the Murray-Darling salt collection scheme per day. The average volume of salt produced annually by the project would make up only a very small proportion of the overall capacity of any single existing licenced facility.

The proponent will continue to explore opportunities to beneficially re-use brine and reduce waste to landfill.

Drill cuttings

The EPA recommends that DPE request from the proponent:

- Further information that fully describes the 'mix, turn, bury' strategy, prior to project determination
- Further detail regarding determining the suitability of using non-coal cuttings at drill pad sites
- That ongoing monitoring of this material be conducted over the life of the project to continually assess the suitability of using this material at drill pad sites as part of a Waste Management Plan.

The RTS describes the mix, turn, bury strategy that has been used for rock based drill cuttings on a number of existing appraisal well pads in the project area. This involves applying natural material excavated during the drilling process and reapplying topsoil to the well pad ahead of rehabilitation works. Inspection of existing well pads over more than four years has found that rehabilitation is progressing well at these well pads and is consistent with conditions required for successful vegetation re-establishment. This demonstrates the use of non-coal cuttings as part of the mix, turn, bury strategy is suitable. There is no scientific basis for the ongoing monitoring of this material over the life of the project. Drill cuttings management, including measures to confirm their suitability, would be documented as part of the Waste Management Plan.

Waste risk assessment and management plan

The EPA recommends DPE request further information from the proponent on mitigation strategies to manage potential impacts associated with waste for the project, prior to project determination:

- Proposed mitigation and management measures to manage risks as identified in the risk matrix
- Proposed contingencies if the preferred mitigation and management measures cannot be achieved.

Should the project be approved, the EPA recommends that DPE include development of a Waste Management Plan as a condition of consent and that the Waste Management Plan include the above information.

In recognition of the waste management hierarchy, the proponent will implement a number of general waste management practices. These practices would confirm that the types and quantities of wastes generated, received and / or disposed and the risks associated with the handling, transporting and disposing of these wastes, are identified for all of the proponent's assets and activities.

All assets and / or activities that generate, store or manage waste would use a waste inventory to record the details of waste products. This would enable the accurate assessment of waste data and assist in implementing waste avoidance and reduction principles. Inventory information would include:

- Type and volume of each waste
- Source of the waste
- Destination / fate of the waste.

Wastes requiring transportation for recycling and / or disposal would be stored within designated waste storage areas. Wastes would be segregated into general, recyclable and regulated waste types, with further segregation within each category (as required) for ease of identification and collection and to avoid contamination.

General wastes would typically be stored within mixed general waste bins for removal. Putrescible wastes would be stored in covered containers wherever practicable, to minimise odours, exposure to personnel and access to fauna.

General domestic recyclables would be stored within mixed recycling bins for removal. Other recyclable waste types, such as certain plastics, scrap metals and containers would be segregated separately for ease of collection and management at a recycling facility.

Regulated wastes require more specific storage and handling requirements due to their potential to cause environmental harm and / or health and safety matters. Regulated wastes would be stored in appropriate containers / tanks that are appropriately labelled and where applicable, in accordance with the recommendations of relevant Safety Data Sheets, AS1940:2004: *The storage and handling of flammable and combustible liquids* and other relevant dangerous goods standards.

Examples of mitigation measures, including contingency measures, for the risks outlined in the EIS (Table 28-8) are provided in Table 2-2.

The proponent has committed to preparing a Waste Management Plan for the project in accordance with consent conditions.

Table 2-2 Example mitigation measures and contingencies for risks relating to waste identified in the Environmental Risk Matrix (Table 28-8 of the EIS)

Risk from Environmental Risk Matrix	Examples of mitigation and management measures, including contingencies
Waste to be disposed constrains capacity at receiving landfills.	• Implement Waste Management Plan based on the waste hierarchy principles, and explore opportunities to continue to reduce waste to landfill. • Regular review to confirm landfills receiving waste have capacity within nominated Environment Protection Licence limits to receive the volume and nature of waste proposed for disposal. • Annual waste forecasting.
Uncontrolled release of waste (may cause impact to land, surface or groundwater and dependent ecosystems).	• All above ground tanks containing material likely to cause environmental harm must be bunded or have an alternative spill containment system in place. • Produced water and brine will be stored in purpose built state of the art water management facilities located at Leewood and Bibblewindi. • Temporary storage of salt awaiting transport for disposal will be in a weatherproof structure. • Chemicals will be stored and handled in accordance with relevant Australian Standards, including AS 1940-2004: *The storage and handling of flammable and combustible liquids*. • Lined pits will be utilised during drilling. Drilling fluids and drill cuttings that are not appropriate for beneficial reuse will be removed after the completion of drilling. • Wet and dry batteries will be properly cleaned and sealed and stored in separate containers at a waste transfer station for collection by contractor for recycling. • Waste will be classified in accordance with the NSW EPA *Waste Classification Guidelines* (NSW EPA 2014) prior to dispatching from the premises. • Waste identified for recycling will be stored separately from other waste.
Controlled release of waste (may cause impact to land, surface or groundwater and dependent ecosystems).	• Treated sewage will only be released to the designated irrigation area. • Treated water will be released to Bohena Creek at the managed release point only during periods when the flow in Bohena Creek is equal to, or greater than, 100 ML/day as measured at the Newell Highway gauging station. • The managed release to Bohena Creek will utilise a diffuser designed to promote mixing of water at the release point.
Increase in vermin and pest populations.	• Food scraps in kitchen and eating areas will be separated and stored in labelled bins. • All bins on site will have lids that are closed at all times.

Waste aspects of produced water production

The EPA requests the proponent provide additional information outlining available options to lawfully dispose of the produced water from the water treatment plant, prior to project determination. This should include developing in principal agreement with the EPA on these disposal options. Specifically, this would include in principal agreement on the contents of a Resource Recovery Order and Resource Recovery Exemption.

Options to lawfully dispose of treated produced water from the water treatment plant include:

- Authorising the use of treated produced water that meets specified water quality requirements, for irrigation and dust suppression, construction, drilling and rehabilitation, by a Resource Recovery Order and Exemption made under the *Protection of the Environment Operations (Waste) Regulation 2014*
- Authorising the use of treated produced water that meets specified water quality requirements for irrigation of a nominated property (or properties) by an Environment Protection Licence (EPL) issued under the *Protection of the Environment Operations Act 1997*.

Irrigation of the Leewood property with treated amended water from Santos' existing activities is approved under Part 5 of the EP&A Act and authorised by EPL 20350. Condition M2 of EPL 20350 requires groundwater and soil quality monitoring of the Leewood irrigation area. Monitoring to date indicates that irrigation of the property has not adversely affected groundwater or soils (refer Appendix B of this document for monitoring locations and results).

If the Narrabri Gas Project is approved, the proponent intends to continue to irrigate treated water at Leewood under the development consent for the project until such time as a Final Investment Decision is made and construction of the gas processing facility is due to commence.

The proponent would then apply for a Resource Recovery Order and Exemption.

2.3.2 Groundwater management

Water quality, water baseline and water monitoring

Should the project be approved, the EPA recommends a condition of consent requiring the proponent develop a Water Monitoring Plan, in consultation with EPA and Lands and Water that contains:

- Trigger action response plans for changes in groundwater quality
- Thresholds for water quality impacts considering baseline data collected.

Should the project be approved, EPA recommends a condition of consent requiring the proponent update the Water Monitoring Plan, prior to commencement of works, in consultation with the EPA and Lands and Water to:

- Commit to installation of monitoring bores as the gas field is progressively developed
- (Enable) ongoing collection of baseline dataset.

The EPA recommends the proponent further develops a conceptual Water Monitoring Plan, in consultation with the EPA and Lands and Water, prior to project determination. The Plan must:

- Enable validation of current and future model simulations and associated predictions
- Be capable of detecting water level and quality impacts from coal seam dewatering before they propagate into beneficial aquifers
- Better incorporate water level impact findings presented in the EIS
- Enable validation of current and future model simulations and associated predictions
- Demonstrate that sufficient data will be collected to enable significant improvements in the certainty of regional groundwater flow model simulations and regular intervals over the lifetime of the activity
- Be capable of detecting water level and quality impacts from coal seam dewatering before they propagate into beneficial aquifers.

Should the project be approved, the EPA recommends a condition of consent requiring the proponent to develop a Water Monitoring Plan based on this conceptual Water Monitoring Plan agreed to with EPA and Lands and Water.

The proponent is committed to implementing a groundwater monitoring program capable of early detection of impacts of the project on groundwater resources and dependent users. The Water Monitoring Plan (EIS Appendix G3) is founded on the principle of early detection monitoring (refer specifically to Section 3.1) and identifies monitoring thresholds and trigger levels and associated management actions for mitigation of potential impacts (refer to Section 3.7).

The proponent's proposed water monitoring network thus includes sentinel monitoring bores that are strategically located both within deeper formations close to target coal seams as well as centralised around the first phase of production. The Water Monitoring Plan (EIS Appendix G3) includes trigger values for early warning and threshold actions for impacts to local receptors. It therefore achieves the aims recommended by the submission.

Regular review and reporting of all monitoring data, provided for in the Water Monitoring Plan, will ensure that any additional monitoring requirements are identified as the project develops. The Water Monitoring Plan will be updated to reflect required changes.

The Water Monitoring Plan includes a management action trigger to update the groundwater modelling predictions. Model updates occur if either the Level 1 or Level 2 response trigger is exceeded. The Level 1 response trigger would be exceeded if there are three or more years in which realised cumulative water extraction exceeds cumulative water production in the EIS and would require updating of modelling predictions. The Level 2 response trigger would be exceeded if pressure decline in Triassic Age strata (early detection monitoring) exceeds or is likely to exceed the predicted maximum drawdown published in the EIS and would require revision and re-calibration of the model. Either could occur in a particular year following commencement of water production (i.e. more or less frequently than every five years).

2.3.3 Produced water management

Water balance

Should the project be approved, the EPA recommends a condition of consent requiring the proponent to develop a Produced Water Management Plan, in consultation with the EPA, prior to produced water being generated, that includes:

- Clear identification of access to sufficient irrigation area and offsite storage, and / or clear processes and milestones to do so, to sustainably irrigate effluent in the lead up to peak water production, during peak water production, and for the remaining years of water production
- Contingency irrigation areas (i.e. In addition to the nominated 500 hectares)
- Confirmation of agreements with third parties receiving effluent to establish the commercial responsibilities of the supplier and user of effluent and ensure the water balance is achieved
- Details on how landowners will coordinate optimal cropping regimes to ensure the water balance is maintained throughout a year and throughout the project
- How amended and unamended water would be distributed to the various reuse options
- A process for annual review and reporting of the water balance based on actual release locations, water volumes treated, reuse volumes, and rainfall
- Procedures and management triggers for use of produced water storages as upstream storage for excess irrigation or discharge
- Procedures and triggers for ceasing produced water production if water is more than all available management options.

The proponent has committed to developing a Produced Water Management Plan in accordance with consent conditions.

Agricultural irrigation

Should the project be approved, the EPA recommends a condition of consent requiring the proponent to develop a Produced Water Management Plan in consultation with the EPA and Lands and Water that includes:

- A procedure for the collection of site-specific soil surveys and / or baseline monitoring of irrigation sites to develop management requirements that ensure the sustainability of irrigation. This must include but not be limited to:
  - Representative soil baseline data relevant to an operational scale irrigation scheme
  - Sampling to cover key soil parameters such as salinity, exchangeable sodium percentage (ESP), sodium adsorption ratio (SAR) values, and permeability / water logging risk
  - Adequately detailed soil profile descriptions
  - An initial electromagnetic interference (EMI) survey of all potential irrigation areas so that a common baseline data set is established
  - An inland acid sulfate soil risk assessment, including testing of soil materials from lower slope and drainage line locations for titratable acidity and acid-base accounting
  - Use of a standardised soil classification system across all irrigation areas
  - An appropriate basis for identifying and managing key differences between Vertisols and Sodosols, including profile textural ranges and volume expansion to allow the two soils types to be effectively differentially managed
  - Appropriate ongoing soil monitoring of each risk factor (to be implemented based on baseline assessments), including, at a minimum: salinity, ESP / SAR, permeability / water logging and pH.
- Clearly defined Trigger, Action and Response Plans
- Protocols for dust suppression and stock water use.

The quality of treated and amended water to be used in irrigation meets or exceeds the ANZECC / ARMCANZ (2000) guidelines for irrigation. Based on the quality of the water to be used, the proponent has proposed sufficient soil monitoring in the EIS and RTS to monitor and protect soil quality

over the life of the project. The recommendations in the submission go beyond what is required where water of this quality is used in other irrigation operations. The proponent has committed to developing a Produced Water Management Plan for the project to be developed in accordance with consent conditions.

Bicarbonate and un-amended effluent Sodium Absorption Ratio risk assessment including stock water supply

Should the project be approved, the EPA recommends a condition of consent that requires:

- The use of amended effluent for all reuse activities (except for fire-fighting)
- Proposals for reuse of unamended effluent, such as stock water use, must be adequately assessed in consultation with the EPA and Lands and Water prior to undertaking the reuse activity
- There must be no irrigation in forested areas other than amended effluent used for dust suppression on roads, access tracks and project construction and operational areas.

The proponent will beneficially re-use treated water in accordance with the EIS, RTS and supplementary RTS, and relevant consent conditions.

Bohena Creek managed release

Should the project be approved, the EPA recommends conditions of consent that require:

- The proponent to develop a Produced Water Management Plan in consultation with the EPA and Lands and Water that includes:
  - Identification and consideration of all downstream water uses and values in operational plans regarding potential exceedances of water quality guidelines, including homestead water use, stock water, irrigation, recreation and aquatic ecosystems
  - Consideration of all relevant downstream environmental values in commissioning monitoring and monitoring to validate the mixing zone.
- The monitoring location for the managed release trigger of 100 ML/day to be at or immediately upstream of the proposed discharge point, or, if not located upstream; the proponent to provide evidence of why this is not a practical site and provide an alternative that will ensure the same outcomes can be met
- The proponent to develop a release protocol in consultation with the EPA that clearly indicates the trigger(s) to commence and stop discharging to Bohena Creek.

The proponent has committed to developing a Produced Water Management Plan for the project. This will be developed in accordance with consent conditions.

Mixing zone assessment

Should the project be approved, the EPA recommends a condition of consent requiring the proponent:

- Conduct an updated modelling assessment prior to discharge that:
  - Provides the additional CORMIX information requested by EPA in its submission on the EIS

  - Considers potential ionic risks, osmotic impacts of low salinity, bicarbonate, ammonia, hydrocarbons, treatment chemicals and the full range of analytes assessed in commissioning monitoring for the Leewood Water Treatment Plant (the commissioning analytes are set out in the document entitled *Santos Energy NSW Leewood Phase 2, Water Treatment Plan* (Document No: 7056-465-PLA-0001, dated 19 November 2015).
- Monitoring of the mixing zone occurs in conjunction with commissioning assessment to validate model predictions of dilution.
- Initial direct toxicity assessment of representative effluent during the commissioning stage to assess combined impacts of different chemicals in the discharge water, including biocides and treatment chemicals. Toxicity testing can then be used as a future monitoring tool if there are significant departures in chemical quality and should be based on the most sensitive test species identified during the initial test. A trigger value system should be developed in a Discharge Management Plan to identify the need for future toxicity testing.

Since the original managed release study, including the mixing zone analysis and direct toxicity assessment was undertaken (refer EIS Appendix G1), the proponent commenced treating produced water from its exploration and appraisal activities at the Leewood water treatment plant.

Actual water quality data from the plant (refer to Table A2 in Appendix A of this document) indicates that the treated water is of far better quality than originally anticipated, with chemical concentrations being the same or lower than the estimates used in the original studies. Given the original study results, there are no ecological nor toxicity risks associated with the managed release to the creek.

The lower salinity of treated water compared to background levels in Bohena Creek is acceptable given there would be a dilution factor of at least eight (based on a maximum release of 12 ML/day when the creek has natural flows of at least 100 ML/day).

Provided that treated water from the plant is monitored and chemical constituents remain within target levels, further monitoring of the mixing zone is not required.

Monitoring and reporting

Should the project be approved, the EPA recommends a condition of consent requiring the proponent to include information in the Produced Water Management Plan on water treatment to ensure the treatment process meets the requirements for the proposed end uses or disposal options for treated water. This should include but not be limited to:

- A commissioning monitoring program and report for the water treatment plant that must:
  - Be developed in consultation with the EPA prior to commencing full scale operations
  - Be consistent with commissioning monitoring requirements and analytes set out the document entitled *Santos Energy NSW Leewood Phase 2, Water Treatment Plan* (Document No: 7056-465-PLA-0001, dated 19 November 2015)
  - In addition to the commissioning analytes in Document No: 7056-465-PLA-0001, include hydrocarbons and chemicals used in the Water Treatment Plant that may have a non-trivial impact on water quality
  - Consider all end-uses of effluent
  - Propose ongoing water quality monitoring, including monitoring to be required under the Environment Protection Licence.
- Ongoing operational monitoring requirements for discharge and reuse (subject to results from the treatment plant commissioning monitoring). Note that monitoring requirements for pollutants may be removed, added or amended in an Environment Protection Licence

- Maintenance, operational triggers and responses to ensure that the treatment process is functioning in a proper and efficient manner
- Procedures for water discharges that do not meet specifications, treatment failure, spills, and communication with downstream water users.

The proponent has committed to developing a Produced Water Management Plan for the project. This will be developed in accordance with consent conditions.

Discharge monitoring

Should the project be approved, the EPA recommends a condition of consent requiring the proponent to:

- Conduct ambient upstream and downstream monitoring
- Conduct sampling during or immediately after discharges (and not 'within 5 to 7 days')
- Include a downstream monitoring point close to the edge of the modelled near-field mixing zone.

The proponent prepared a Water Monitoring Plan for the project (EIS Appendix G3) which addresses monitoring at the managed release point in Bohena Creek. Should the project be approved, the Water Monitoring Plan will be revised, to comply with conditions of consent.

2.3.4 Air Quality

Emission estimation, types, cumulative impact assessment, background concentration and impact assessment results

Should the project be approved, the EPA recommends conditions of consent requiring:

- Additional assessment of all processes and emission sources associated with the project. This must include the Leewood gas processing plant and the gas field. The revised assessment must:
  - Be completed prior to the commencement of project construction
  - Be based on final plant design, engineering parameters and emission performance
  - Provide detailed description of all processing plant including but not limited to gas processing and treatment systems such as the triethylene glycol dehydration systems
  - Demonstrate that the plant design and emission performance is consistent with best practice emission performance
  - Account for cumulative impacts.
- A construction Air Quality Management Plan is to be developed
- The assessment of well head locations and well head emission sources prior to construction through the design phase. An ongoing assessment of the final well head locations and sources must be incorporated into these conditions.

Additionally, the EPA recommends further cumulative assessment required by conditions of consent be in accordance with methods listed in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005), or a method otherwise agreed to in writing by the EPA, if the project is approved.

The Air Quality Impact Assessment (EIS Appendix L) was undertaken in accordance with the SEARs and the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005). The assessment accounted for all pollutants considered to have the potential to be emitted by the operation of the project and found there would be no exceedance of the relevant air quality criteria. Additional information was provided in the Air Quality Addendum (RTS Appendix I) in the form of ground level concentrations of all pollutants that demonstrated compliance. The proponent has committed to preparing an Air Quality Management Plan for the construction and operational phases of the project which will include an air quality monitoring program and a suite of measures that could be implemented to prevent or minimise emissions. The Plan will be developed in accordance with consent conditions.

Fugitive emissions

Prior to determination of the project, the EPA requests that the proponent provide further information to inform the assessment of fugitive emissions for methane, trace volatile organic compounds (VOCs) and air toxics. As a minimum, the proponent should provide:

- Project specific gas composition data to inform a risk evaluation of air toxics/trace VOCs
- Additional information that demonstrates that the proposed leak detection and repair program adequately:
  - Minimises the potential for significant fugitive emissions of air toxics / trace VOCs from all gas infrastructure
  - Manages potential impacts from residual emissions.

The Air Quality Impact Assessment (EIS Appendix L) was undertaken in accordance with the SEARs and the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005). The assessment accounted for all pollutants considered to have the potential to be emitted by the operation of the project, including volatile organic compounds and air toxics, and found that all pollutants would comply with the relevant air quality criteria. Additional information was provided in the Air Quality Addendum (RTS Appendix I) in the form of ground level concentrations of all pollutants, including volatile organic compounds and air toxins, which demonstrated compliance.

The findings of the Air Quality Impact Assessment and Air Quality Addendum are consistent with the findings of the CSIRO (Day *et al.* 2016) on methane and other gaseous emissions, which found:

- Methane levels attributed to coal seam gas operations were low relative to other sources.
- Measurements of volatile organic compounds considered as major precursors to the formation of ozone in the atmosphere were shown to be lower at coal seam gas sites than in the vicinity of other source types such as animal feedlots or waste facilities.
- Measurements of volatile organic compounds prioritised under the United States Environmental Protection Agency ambient air quality guidelines for human and other environmental health were shown to be lower at coal seam gas sites than in the vicinity of other source types.

The submission from NSW Health on the RTS acknowledged that the Air Quality Impact Assessment and Air Quality Addendum examined VOCs, NO_2, dioxins, heavy metals, ozone and other emissions, and none were predicted to exceed air quality criteria at nearby residences.

The proponent has committed to preparing an Air Quality Management Plan for the construction and operational phases of the project which will include an air quality monitoring program and a suite of measures that could be implemented to prevent or minimise emissions. The Air Quality Management Plan will be developed in accordance with consent conditions. Further, the proponent's Leak Detection

and Repair Program has been demonstrated to be effective over the last 4 years. The proponent proposes to continue this program into the development and operation of the project.

2.3.5 Noise

Drilling activities and tonal noise

Should the project be approved, the EPA recommends a condition of consent requiring the proponent to meet the relevant noise criteria for operational activities, including cumulative impacts from the operation of existing pilot wells and Wilga Park Power Station, and construction outside standard construction hours, unless a written agreement is in place with the landholder.

Additionally, the EPA recommends a condition of consent requiring the proponent to implement additional noise mitigation measures to address low frequency, tonal or other problematic noise characteristics from operational equipment, including drill rigs, if the project is approved.

The proponent's operational activities will meet the relevant noise criteria at occupied residences unless a written agreement is in place. The proponent has committed to implementing a Noise Management Plan for the project to be developed in in accordance with consent conditions.

Seismic surveys

The EPA requests further detail from the proponent on how long and how often seismic surveys are expected to occur near sensitive receiver locations, prior to project determination.

Seismic surveys would be relatively infrequent, in the order of every four to five years, and of short duration when they do occur. Seismic surveys have already been carried out in the project area as part of the exploration phase without significant impacts occurring at receiver locations.

During seismic surveys, vibroseis trucks travel along the survey line at a slow speed, stopping momentarily at each set location where the pad is lowered to the ground and the seismic signal is delivered, generally for a period of around five to ten seconds. The resulting energy from the seismic signal is reflected back from interfaces below the surface and recorded using an array of geophones that are set on the ground surface. The pad then retracts and the truck moves forward to the next location on the seismic line. The distance between survey locations is set depending on the survey requirements, and is generally a distance of at least 15 metres.

In most cases the seismic survey would occur at distances from residences such that noise and vibration impacts would be insignificant. In the unlikely scenario that an occupied residence is located in close proximity to a seismic line, it may receive vibration impacts above the criteria for a cumulative period of a few minutes whilst the truck is located within the area modelled to exceed the criteria.

Seismic lines may be undertaken in various orientations depending on operational requirements, and a single location may be in the vicinity of more than one seismic line. However, based on the very short duration of potential impact as set out above, a location in the vicinity of more than one seismic line would not be significantly impacted by the activities.

Finally, seismic surveys would occur only on private land where a Land Access Agreement is in place with the landholder, including agreement on when and where the surveys would be carried out.

Drilling noise

The EPA requests further detail from the proponent on the 'standard mitigation measures' to be applied to drilling unit pump engines, generators and power units, prior to project determination.

The proponent's operational activities will meet the relevant noise criteria at occupied residences unless a written agreement is in place. Standard noise mitigations to be applied during drilling include:

- Mufflers installed on diesel generator exhausts
- Sound insulation installed on compressors and generators
- High efficiency engines to maximise load use which reduces air and noise emissions
- Non-tonal reverse alarms (quackers) on front-end-loaders.

Noise levels

The EPA requests further detail from the proponent on the expected error in maximum noise level (LA_{max}) adjustments applied to operating equipment.

The expected error in the source LA_{max} adjustment is estimated at between +/- 2 dBA for typical construction equipment. The LA_{max} levels will be confirmed during compliance monitoring which will be implemented as part of the Noise and Vibration Management Plan.

Blasting

The EPA requests further information from the proponent on what additional measures will be considered if blasting is required, prior to project determination.

The use of blasting would only be considered if traditional excavation or boring methods were not feasible. Given the nature of the project and the dominant soil types and topography within the project area, blasting is considered unlikely to be necessary. In the event that some blasting is required, measures such as blasting mats could be used to contain the blast and minimise noise and expulsion of dust and rock fragments.

2.4 Heritage Council of NSW

2.4.1 Recommended consent conditions

The Heritage Council of NSW stated that the recommendations made in its submission dated 22 May 2017 (during the EIS exhibition period) remain valid. This included the recommendation that an unexpected finds protocol be incorporated into the Historic Heritage Management Plan.

Other recommendations related to consent conditions, including:

- The recommendations contained in Section 8 of the Historical Heritage Impact Assessment (EIS Appendix O) should form the basis of a condition of consent to manage historic heritage.
- A future consent condition should modify the recommended mitigation measures in Section 8 of the Historic Heritage Impact Assessment (EIS Appendix O) to incorporate mapping and recording of Johnston's Albion Sawmill.

The proponent has committed to developing an unexpected finds procedure for incorporation into the Historic Heritage Management Plan.

2.5 NSW Health

2.5.1 Acknowledgment and recommended consent conditions

NSW Health identified air quality as its primary issue of concern. It noted that no exceedances of air quality criteria beyond the boundaries of the development are predicted, except for an exceedance of the 24-hour PM_{10} standard on one day of the year at one receiver during construction. It acknowledged that the RTS document included contours for $PM_{2.5}$ concentrations and an assessment of NO_2, VOCs, dioxins, heavy metals, ozone and other emissions and none were predicted to exceed air quality criteria at nearby residences.

NSW Health recommended the following actions should the project be approved:

- Emission reductions measures including watering exposed areas to prevent air quality exceedances
- Dedicated air and water monitoring to ensure that the modelling in the EIS is correct and that no risks to human health are presented by the development
- Validation of emissions estimates once design specifications are finalised
- Monitoring of surface and groundwater engineering controls to ensure effectiveness
- Design of air and water monitoring network in consultation with community stakeholders and taking into account learnings from the air monitoring network in the Surat Basin, Queensland.

The proponent has committed to developing an Air Quality Management Plan for implementation during construction and operation of the project. The Plan will include an air quality monitoring program and emissions reductions measures and will be developed in accordance with consent conditions. The air quality monitoring program will be carried out by suitably qualified air quality practitioner(s) and will serve to validate predictions of the Air Quality Impact Assessment (EIS Appendix L).

2.6 NSW Office of Environment and Heritage

2.6.1 Plant community types

Ground truthing

The submission recommends that all impact areas be ground-truthed to determine whether the Plant Community Types (PCTs) mapped at the impact sites are correct. All variances from the mapped PCTs should be reported.

Vegetation mapping undertaken for the project included aerial photographic interpretation of high resolution 10 cm aerial imagery supported by high resolution Light Detection and Ranging (LiDaR) datasets including canopy height modelling. Validation and attribution of the vegetation mapping included the detailed survey of 327 full floristic plots and approximately 1,300 rapid data points. Approximately 250 of the rapid data points (20 per cent) were withheld for an accuracy assessment. All of the survey data (over 1,600 data points) collected were utilised in the development of vegetation mapping.

Plant Community Types (PCTs) were attributed based on expert allocation following the NSW Vegetation Classification (Benson *et al*. 2010) and based on a quantitative analysis of floristic data, landscape position and known occurrence of the plant communities in the Pilliga. The final mapped product is accurate at a 1:10,000 scale and is the most detailed and accurate vegetation map of the region.

The vegetation mapping provides the State and Commonwealth regulators with certainty of the upfront assessment of the impacts of the project and recording of impacts against the upper disturbance limits as the project is developed over its 25-year lifespan.

Requiring the PCTs to be progressively ground-truthed introduces a high level of uncertainty and risk including:

- Differences in scale between the 1:10,000 fine-scale vegetation map, and on-ground assessments focusing solely on narrow linear corridors and relatively small one hectare well pads without the local, regional and landscape context
- Changes through natural disturbance events such as fire
- Changes to Government databases of PCTs.

To provide further confidence to DPE and NSW Office of Environment and Heritage (OEH), the proponent has committed to ensuring no adverse outcomes on Threatened Ecological Communities (TECs) outside of mapped areas. As discussed in the Field Development Protocol (RTS Appendix C), if a TEC is identified that was not mapped at that particular location, the proponent will seek to avoid the community. If avoidance is not possible, then the impact would count toward the upper disturbance limit for that TEC. For all other impacts, the upper clearing limits will be assessed as per the mapped PCT.

Tracking disturbance limits against vegetation class

The submission recommended that should the Plant Community Type (PCT) not be as mapped, the impact may be tracked against the upper disturbance limits for the mapped PCT should it be in the same vegetation class as the impacted PCT.

Vegetation Classes are a high order classification of vegetation in NSW. Of the more than 1,500 PCTs currently described, there are only 97 Vegetation Classes to which each PCT is assigned.

A review of the Upper Disturbance Limits for direct impacts has been undertaken by PCT and Vegetation Class Combinations (refer Figure 2-3). Of a total 988.8 hectares, 85.8 per cent occurs within the Western Slopes Dry Sclerophyll Forests Vegetation Class which includes 10 of the 19 PCTs directly impacted by the project.

Only two other Vegetation Classes, namely Brigalow Clay Plain Woodlands (5.7 per cent) and Pilliga Outwash Dry Sclerophyll Forests (7.2 per cent), have more than one per cent of the Upper Disturbance Limit for direct impacts for the project. Six Vegetation Classes in the project area are represented by only one PCT each, and the combined Upper Disturbance Limit for these Vegetation Classes is only seven per cent of the total Upper Disturbance Limit for direct impacts.

There are a number of Vegetation Classes which are structurally and floristically related, namely North-west Slopes Dry Sclerophyll Woodlands, Pilliga Outwash Dry Sclerophyll Forests and Western Slopes Dry Sclerophyll Forests. There is limited material available (only Keith 2004) which would allow a field ecologist to accurately assign a Vegetation Class in the field.

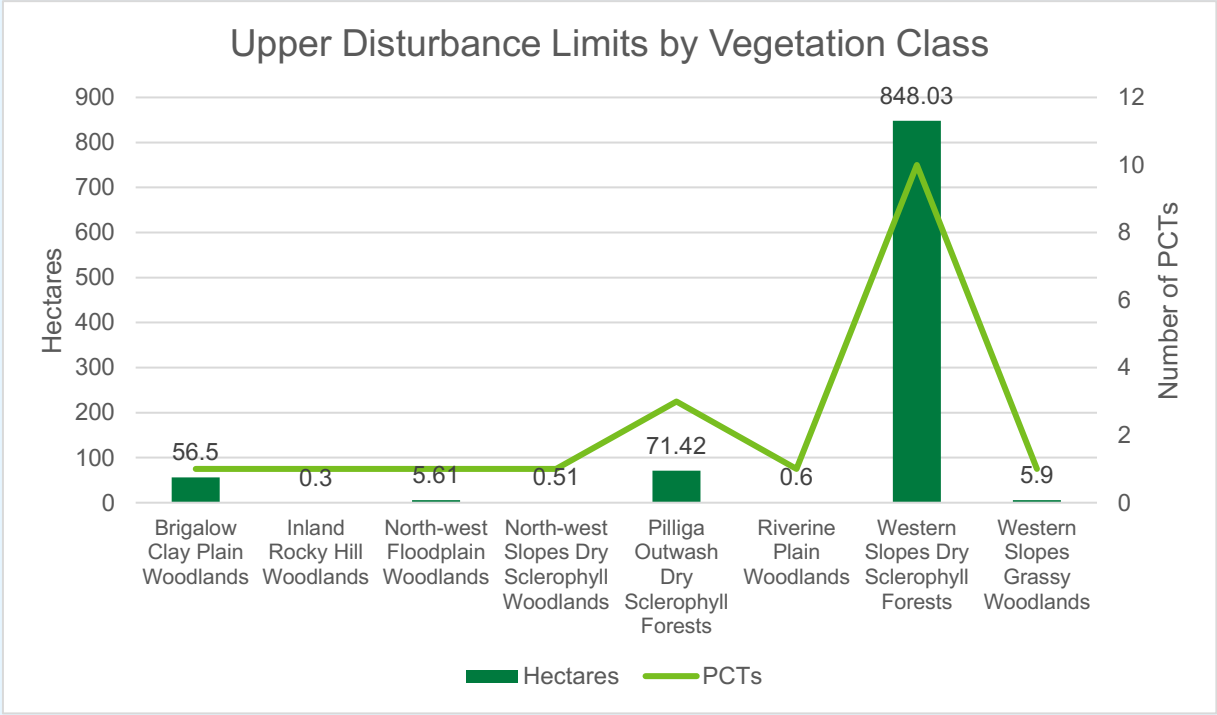

Figure 2-3 Upper disturbance limits by vegetation class

The floristic components of the Vegetation Class descriptions in many cases do not accurately represent the PCTs to which they have been assigned. For example, the description available on OEH's website of the most common Vegetation Class in the project area, Western Slopes Dry Sclerophyll Forests, does not include the dominant canopy species of seven of the ten PCTs assigned to the Vegetation Class. Additionally, one PCT assigned to this class does not fit the structural description, it being a Shrubland rather than a Forest (PCT 425). These matters will result in incorrect assignment of Vegetation Class if undertaken by ecologists in the field. Subject to project approval, the proponent will be required to secure offsets for the project by PCT.

The proponent has committed to offsetting the full impact of the Upper Disturbance Limit (including direct, indirect and cumulative impacts), despite the Upper Disturbance Limit for direct impacts for all PCTs (988.8 hectares) will not be realised. The Upper Disturbance Limit represents the maximum area

of each PCT that the project can disturb and is an effective, peer reviewed methodology for impact assessment. Impact modelling has taken a conservative approach and is based on substantial field surveys, desktop reviews and technical expertise. This provides certainty for the regulator to assess the project based on the vegetation mapping undertaken for the project.

Clarification on the location of 25 individual plots

The submission sought clarification around the placement of some plots and the inclusion of these plots in vegetation zones for PCTs.

A detailed response on the stratification of vegetation zones and condition class combinations was included in the RTS.

The additional 25 vegetation plots identified by OEH for review fall within the following broad categories:

- Plots on ephemeral drainage lines which have naturally low tree cover
- Plots located in road reserves with widely spaced remnant trees
- Plots in native vegetation with wide spaced canopy and variable midstorey including *Callitris* (Cypress Pine) and *Acacia* species
- Plots located on well pads and linear infrastructure which have been subject to rehabilitation (mapped as 'cleared', assigned to 'derive native vegetation').

In considering the effect of low canopy cover on potential offset requirements, it is important to note that canopy cover equates to a maximum of 10 per cent of the site value score. The majority of these sites had other site attributes which meet or exceed benchmarks including; high native plant richness, hollow-bearing trees, length of fallen logs and occurrence of regeneration. Additionally, these sites are not the sole input for each vegetation zone, rather, they form part of the suite of data utilised for the assessment. Modification to this data will have negligible effect on the offset requirements for the project.

Detailed justification for each plot has been included in Appendix C to this document.

Clarification of known or likely impacts to Threatened Ecological Communities

The submission seeks clarification around the potential location of infrastructure where it is known, or likely, that impacts to Endangered Ecological Communities may occur while special interest groups also continue to raise their concern regarding Box Gum Woodland.

Specific locations for impacts on TECs will be determined in accordance with the Field Development Protocol (RTS Appendix C). The proponent has committed to maximise avoidance and minimise impacts on TECs through the Field Development Protocol and Ecological Scouting Framework.

To provide further confidence to DPE and OEH, the proponent has previously committed to ensuring no adverse outcomes on TECs outside of mapped areas. As discussed in the Field Development Protocol, if a TEC is identified that was not mapped at that particular location, the proponent will seek to avoid the community. If avoidance is not possible, then the impact would count toward the upper

disturbance limit for that TEC. For all other impacts, the upper clearing limits will be assessed as per the mapped PCT.

With respect to the TEC White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland / White Box Yellow Box Blakely's Red Gum Woodland (commonly referred to as Box Gum Woodland), no meaningful new information has been presented by the special interest groups. Therefore, this community is still not considered to occur in the project area for the reasons presented in the EIS and the Box Gum Woodlands analysis (Appendix E of the RTS). Previous claims about the presence and relative abundance of *Eucalyptus melliodora* (Yellow Box) on Bohena Creek in the project area by special interest groups have not been supported with data.

2.6.2 Impact assessment

Duration of indirect impacts

The submission sought clarification whether identified indirect impacts may extend beyond 30 years.

The *Framework for Biodiversity Assessment* (NSW OEH 2014) requires proponents to demonstrate minimisation of indirect impacts on biodiversity values using reasonable onsite measures. There is no requirement under the *Framework for Biodiversity Assessment* to offset the indirect impacts of the project on biodiversity values.

Both the Ecological Impact Assessment (EIS Appendix J1) and Biodiversity Assessment Report (EIS Appendix J2) describe the likely indirect impacts of the project and proposed mitigation measures. The proponent has committed to offset a proportion of the indirect impacts as if they were direct impacts. A detailed methodology was proposed for calculating indirect impacts which contribute to the total quantum of offsets for the project (refer to Section 4.11.2 of EIS Appendix J1).

The methodology for calculating indirect impacts assesses the likely maximum extent of indirect impacts pre-mitigation and post mitigation. The post mitigation indirect impact extent is then assessed as equivalent to direct impact. The total area assessed as indirectly impacted was 181.1 hectares, or 18 per cent of the directly impacted area (of 988.8 hectares).

For the purposes of offsetting, calculations were constrained to a 30-year period for indirectly impacted areas (20 years during development i.e. the estimated lifespan of a production well, followed by a 10-year rehabilitation period), after which, indirect impacts will cease to function and the indirectly impacted area will be equivalent to areas not affected by the project (i.e. remnant native vegetation and habitat). As such, a 30 per cent multiplier was applied to indirectly impacted areas when determining final credit liability. This approach exceeds the statutory requirements for the project and is part of an overall commitment to avoid, minimise, rehabilitate and offset impacts.

Adherence to survey guidelines

The submission recommended adherence to OEH survey guidelines, particularly in relation to survey periods, when calculating impact for all threatened species.

The surveys, estimates of threatened flora abundance and impact assessment detailed in the Ecological Impact Assessment (EIS Appendix J1) and Biodiversity Assessment Report (EIS Appendix J2), were undertaken in accordance with the SEARs and relevant guidelines. Disturbance

limits for threatened flora, as described and assessed in accordance with the EIS, cannot be exceeded given disturbance will be no more than the Upper Disturbance Limit for each PCT. As described above, actual total disturbance of native vegetation will be less than the upper limit.

The Field Development Protocol (RTS Appendix C) which incorporates the Ecological Scouting Framework, focuses on threatened flora species and ecological communities, with habitat for threatened fauna species addressed through habitat surrogates such as hollow-bearing tree size classes, nests and foraging resources such as mistletoe as well as mapped Pilliga Mouse habitat.

The methodology proposed in the Ecological Scouting Framework involves a detailed survey within buffered infrastructure areas to identify key biodiversity values, maximising avoidance through micro-siting. In practise, this method is generally consistent with OEH guidelines for surveying threatened plant species which requires parallel field traverse surveys at maximum distances considered appropriate for detecting various life forms in open or dense vegetation. Micro-siting has been demonstrated to reduce impacts to biodiversity values by approximately 40 per cent.

Impacts to PCTs and threatened flora individuals will be tracked over time against their respective Upper Disturbance Limit consistent with the mapping and modelling undertaken in the EIS. The proponent is committed to undertaking ecological scouting to avoid and minimise impacts to threatened biodiversity at a site scale, despite potential gain (in terms of reducing impacts and therefore also offsets) from avoidance.

2.6.3 Koala research proposal

Inclusion of biodiversity offset areas and reasons for occupancy/absence

The submission stated that the Koala research project should include biodiversity offset areas and investigate why apparently suitable areas of habitat may not be occupied by Koalas.

The regional Koala assessment (Appendix F7 of EIS Appendix J1) was undertaken by Pilliga Koala experts. It identified a number of current Koala refuges (principally Baradine and Etoo Creeks in the west of the Pilliga) along with likely reasons for the contraction of both populations (including drought, fire and the frequency of hot temperatures). Koala presence in current refuges such as permanent waterholes were also discussed.

The Koala research proposal, as part of the Biodiversity Offset Strategy contained in the RTS (Appendix F), will be updated to include offset areas once they are identified, and also investigate features which determine current presence / absence of Koalas to ascertain preferences and refuges.

Active management of Koala habitat and a Koala Management Plan

To more adequately meet the offset requirements for the Koala, the submission recommended that active management actions in areas where Koalas are identified be implemented. The submission also recommended that a Koala Management Plan be prepared.

Under the *Framework for Biodiversity Assessment* (NSW OEH 2014), 'species credit' requirements for Koala have been calculated. This will require the proponent to secure at least part of the offset obligation for this species through land-based offsets. As is required under the current Biodiversity

Assessment Methodology (BAM), a Biodiversity Stewardship Site would require the active management of potential and known Koala habitat to be undertaken to generate credits.

The proponent has committed to large, land-based offsets required under the *Framework for Biodiversity Assessment*, including active management of this land for Koala. The proponent does not propose to actively manage the additional areas identified in the Koala research proposal. However, the proponent will provide information regarding the presence of koala to the relevant land manager.

Refuge populations of Koalas are expected to be largely outside the project area and primarily on public tenure such as National Parks estate and State Forest. The responsibility for management of those lands rests with the respective Government departments and it is not proposed to prepare a Koala Management Plan for those areas.

2.6.4 Biodiversity offsets

Cost of supplementary measures

The submission requested that the cost of the individual supplementary components of the strategy should be presented in order to determine the contribution of these measures.

The Biodiversity Offset Strategy for the project included in the RTS (Appendix F) includes both supplementary (nil-tenure feral animal control strategy) and compensatory measures (Koala research).

The nil-tenure feral animal control strategy is a Tier 1 (like for like) supplementary measure as it directly targets and provides positive biodiversity outcomes for all ecosystem and species credits impacted by the project.

Contribution of money to research, survey and community education programs is capped at 10 per cent of the total offset liability under the *Biodiversity Offset Policy for Major Projects* (NSW OEH 2014a), therefore, the Koala research proposal cannot exceed 10 per cent of the total offset liability.

A detailed cost estimation has been undertaken using the guidance material in the *Biodiversity Offset Policy for Major Projects*, average credits generated on BioBank sites, rural land values and management costs to determine the total offset cost for the project.

The cost estimate for the total offset liability for the project has been estimated at up to approximately $26 million. The total offset liability been apportioned into the composite parts of the Biodiversity Offset Package, including:

- $18 million for land-based offsets
- $8 million for supplementary measures (nil-tenure feral animal control strategy)
- $260,000 for compensatory measures (Koala research proposal) although this may increase when the proposal is updated in accordance with the submission.

The relative contribution may change across these three elements as required by conditions of consent.

Financial contribution limits for supplementary measures

The submission recommended that an upper limit be applied to the supplementary measures with consideration to the general principles of the *Biodiversity Offsets Policy for Major Projects*.

The *Biodiversity Offset Policy for Major Projects* (NSW OEH 2014a) includes an interim calculation method for supplementary measures which includes an assessment of the cost of other offsets purchased for the project and the proportion of credits remaining to be fulfilled by supplementary measures. In effect, this is a formula to calculate the total cost of the offset liability for the project, and therefore, the contribution that supplementary measures make as part of the total offset liability.

The *Biodiversity Offset Policy for Major Projects* specifies an upper limit of 10 per cent only for contribution of money for research, survey and community education programs. The only supplementary measure proposed which falls into this category is the Koala Research proposal which currently makes up much less than 10 per cent of the total offset liability for the project.

The nil-tenure feral animal control strategy is capped at up to 30 per cent of the total offset liability, which is considered to provide an adequate and effective budget over a 20-year lifespan. The nil-tenure feral animal control strategy is a direct management intervention which will improve biodiversity values within the region.

Therefore, all proposed measures fall within the financial limits outlined in the *Biodiversity Offset Policy for Major Projects*.

Feral animal control strategy, mitigation and current management practices

The submission requested that the proponent demonstrate how the feral animal control strategy is above and beyond the expected mitigation measures for the project, mandated management of biodiversity offset areas and current management practices of Forests NSW.

The proponent has committed to the development of a nil-tenure feral animal control strategy as part of the Biodiversity Offset Strategy contained in the RTS (Appendix F). The strategy is based on detailed assessment of threatened species in the project area that identified feral animals as a significant threat.

Monitoring of feral animals has been undertaken since 2015 at a number of sites within the Pilliga Forest as part of existing environmental approvals. Feral animal populations are currently large within the project area. Control of feral animals within State Forest currently rests with Forestry Corporation of NSW as the landholder. The precise nature of feral animal control undertaken annually by Forestry Corporation in the Pilliga is unknown, however, this commitment will provide resources that are likely to be magnitudes higher.

Mitigation measures proposed as part of the EIS include management of indirectly impacted areas (approximating 10 per cent of the directly impacted area). This is a different area than what is proposed as part of the nil-tenure feral animal control strategy (181 hectares, compared to over a 95,000 hectare project area). Therefore, the nil-tenure feral animal control program is above and beyond existing obligations placed on the landholders within the project area, and requirements to mitigate the impacts of the project.

A regional scale, nil-tenure feral animal control strategy such as that proposed in the EIS is likely to be effective in reducing feral animal populations and promoting biodiversity conservation. It is based on a

thorough literature review for all threatened species in the project area which identified feral animals as a significant threat to threatened biodiversity in the Pilliga.

The proponent has committed to develop the nil-tenure feral animal control strategy in consultation with landowners including private landowners, the NSW National Parks and Wildlife Service and Forestry Corporation of NSW.

Monitoring of supplementary measures

The submission recommended that the DPE include an approval condition requiring the monitoring of supplementary measures to ensure that credits for the relevant target species are realised.

Monitoring and an adaptive management framework are essential components of the nil-tenure feral animal control strategy. A successful feral animal strategy requires a monitoring program to evaluate the effectiveness of control measures.

A baseline survey will be undertaken against which follow-up surveys can be compared, and to inform adaptive management.

Generation of species credits from rehabilitation

The submission stated that further justification is required before rehabilitation is deemed to be able to generate species credits. Special interest groups also raised concerns regarding the effectiveness of rehabilitation.

Species credits are only proposed to be generated for those 'species credit' species known or expected to respond positively to rapid progressive rehabilitation as part of the project.

This includes six of the nine threatened flora species credit species and only one of the six threatened fauna species, namely, Black-striped Wallaby. All of the threatened flora species have been directly observed responding positively to disturbance in the project area, principally as a result of roadworks with large populations frequently observed on and adjoining graded roads.

Considering the rehabilitation methods proposed as part of the project, where topsoil is either maintained *in situ* (linear infrastructure) or stripped and respread within a relatively short period following construction (well leases), these species will respond in a positive manner, as they have done to similar disturbance elsewhere in the project area. The rationale for inclusion of each species is stated in the Biodiversity Offset Strategy (RTS Appendix F).

The RTS stated that rehabilitation sites approximate 72 per cent of the condition of reference sites. These sites are those which have been ‘partially rehabilitated’ using the methodology proposed in the EIS. This statement was confirmed most recently through monitoring undertaken in 2018 demonstrating the progression of rehabilitation areas towards self-sustaining PCTs.

Monitoring of rehabilitation for species credits

The submission recommended that the DPE include an approval condition requiring the monitoring of rehabilitation areas to ensure that the relevant species credits are realised.

The Rehabilitation Strategy included in the EIS (Appendix V) included detail on a proposed two-tiered monitoring program including monitoring methods (including reference sites), data analysis and reporting and preliminary completion criteria. The proposed monitoring will capture expected gain in habitat for 'species credit' species.

Ability to meet credit liability

The submission stated that while the proponent has presented a Biodiversity Offset Strategy, there is insufficient information to determine whether the strategy has the capacity to meet the credit requirement for the project, particularly species credits.

Based on experience in the Pilliga, including detailed threatened species survey and population modelling which extends well outside the project area, there is a high degree of confidence in 'species credit' species being available at offset sites where the PCTs and habitats present are the same as those being impacted by the project (as is required by the *Framework for Biodiversity Assessment* (NSW OEH 2014)).

The Biodiversity Offset Strategy for the project (RTS Appendix F) has demonstrated that there is more than 280,000 hectares of suitable 'like for like' vegetation to meet the credit liability of the project through the BioBanking public register, expressions of interest, properties for sale, and an analysis of freehold land in the region.

Contribution of land-based offsets

The submission stated that the Biodiversity Offset Strategy does not indicate to what extent land-based offsets will contribute to the total offset package.

Land-based offsets will make a significant contribution to the offset liability of the project. Up to 30 per cent of the offset liability has been allocated to the nil-tenure feral animal control strategy and much less than 10 per cent has been allocated to the Koala Research Proposal. The remaining offset liability will be met through land-based offsets.

Spotted-tailed Quoll

The submission stated that the Spotted-tailed Quoll is listed as an EPBC Act-listed threatened species in the referral documentation received from the Department of the Environment and Energy (DoEE). It stated that under the Bilateral Agreement with the DoEE, the OEH will need to assess impacts and potential offsets for this species.

Spotted-Tail Quoll is nominated as an 'ecosystem credit' under the *Framework for Biodiversity Assessment* (NSW OEH 2014), and therefore, specific offset requirements are not required (and are unable) to be determined for this species.

As an 'ecosystem credit' species, impacts to Spotted-tail Quoll have been quantified through association with PCTs in the project area. In accordance with the *Framework for Biodiversity*

Assessment, land-based offsets secured by the project will also provide potential habitat for Spotted-tail Quoll through association with the PCTs at the offset area as like for like offsets are required.

Detailed assessment of the project has shown that there is unlikely to be a residual adverse significant impact on Matters of National Environmental Significance (MNES) following implementation of the Field Development Protocol and proposed avoidance, minimisation and mitigation measures. As such, specific offsets for Matters of National Environmental Significance are not required under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) *Environmental Offsets Policy* (Commonwealth Department of Sustainability, Environment, Water, Population and Communities 2012).

Calculations of impacts on Lepidium species

The submission said it was unclear how the impacts on *Lepidium aschersonii* and *Lepidium monoplocoides* have been calculated.

A detailed report titled *Supplementary Targeted Surveys for Spiny Peppercress and Winged Peppercress and Revision of Upper Disturbance Limits* was included in the RTS (Appendix H). This report describes how impacts to both *Lepidium aschersonii* and *Lepidium monoplocoides* have been calculated.

To summarise, the density of each individual per square metre of suitable habitat and the proportion of habitat occupancy were determined (with 95 per cent confidence intervals). These results were then applied to the Upper Disturbance Limits for respective habitat types to ascertain Upper Disturbance Limits for each species. Disturbance limits for threatened flora, as described and assessed in accordance with the EIS, cannot be exceeded given disturbance will be no more than the proposed Upper Disturbance Limit for each PCT.

Reasonable equivalence

The submission advised that the project credit liability, which has been determined under *Framework for Biodiversity Assessment*, will need to be converted to reasonably equivalent credits as prescribed under Clause 22 of the *Biodiversity Conservation (Savings and Transitions) Regulation 2017.*

The submission stated that the offset liability (in credits) for the project will need to be converted from the former *Framework for Biodiversity Assessment* (NSW OEH 2014) which utilises the former Biodiversity Banking (BioBanking) Offset Scheme to the new Biodiversity Offset Scheme operating through the Biodiversity Assessment Method. This process is described as 'reasonable equivalence' and formulas to be utilised by OEH to undertake this conversion are published on their website.

Some critical considerations include:

1. The methodology under which the project has been assessed is substantially different from the new Biodiversity Offset Scheme. The Biodiversity Assessment Method is strongly metric driven and highly dependent on the quality of background datasets and is subject to observer variability.
2. The metrics used by OEH to undertake the 'reasonable equivalence' conversion (i.e. site value scores / vegetation integrity scores) are based on different site data and benchmarks and are therefore by nature, not equivalent.
3. The 'reasonable equivalence' conversion only considers how the impact credits between the former *Framework for Biodiversity Assessment* / BioBanking Assessment Methodology (BBAM) are

potentially equivalent to the new Biodiversity Offset Scheme and fails to consider 'equivalence' in terms of the number of credits able to be generated on Biodiversity Stewardship Sites (formerly BioBank Sites). Offsets under the Biodiversity Assessment Method have the potential to be an order of magnitude larger than the BioBanking Assessment Methodology.

4. Offset ratios generated under the new Biodiversity Assessment Method can theoretically be in the order of 40:1 (hectares offset:hectares impacted) for good condition Threatened Ecological Communities. Typical offset ratios under the *Framework for Biodiversity Assessment* / BioBanking Assessment Methodology were generally in the order of 4:1 to 6:1.
5. Many of the issues previously identified and communicated with OEH in the *Framework for Biodiversity Assessment* / BioBanking Assessment Methodology remain unresolved and have been transferred to BAM as they have the same data source (i.e. Bionet).
6. There are functionality issues with the Biodiversity Assessment Method Credit Calculator which are producing adverse outcomes. These issues have been identified and raised with OEH. It is currently unclear what the process is for issues to be resolved. Until the Credit Calculator is fully operational, it is effectively operating in 'beta' mode currently, the outcomes are highly variable for the same project when very minor adjustments are made within the calculator.
7. A number of species credits under the *Framework for Biodiversity Assessment* are no longer species credits under BAM or are now split species / ecosystem credit species. These species require detailed consideration as to future offset requirements.
8. The metrics for determining the number of flora species credits have changed for eight of the nine flora from a count of individuals to an area of individuals. The proponent has not been able to identify policy or other guidance regarding the conversion between counts and areas for threatened flora.
9. Acquitting offset liability through a one-off payment to the Biodiversity Conservation Fund is constrained for a number of reasons including prices being set based on BioBanking credit trades (a different metric) of which there have been few. Based on experience, current prices to acquit liability through a one-off payment are too low on the coast, and up to ten times too high in the west.

It is therefore proposed that the BioBanking Assessment Methodology be used to demonstrate the adequacy of land-based offsets against the credit liability of the project, with BAM being used to secure and fund the management of land in perpetuity through the registration of Biodiversity Stewardship Sites regardless of the type and number of credit produced.

2.6.5 Other matters

Monitoring framework

OEH recommends that DPE include a condition of consent requiring annual reporting of disturbance, with a focus on tracking against the upper disturbance limits.

The RTS described a reporting framework to manage and document upper disturbance limits is included in the Field Development Protocol (RTS Appendix C). The framework includes the following safeguards:

- A Plan of Operations, including direct impacts on vegetation communities, to be prepared and submitted to the DPE and the Commonwealth Department of Environment and Energy prior to implementation
- An annual review to confirm compliance with the Field Development Protocol, management Plans and procedures, the Plan of Operations, and State and Commonwealth approvals

- An independent third-party environmental audit every three years from commencement to confirm compliance with the Field Development Protocol, Plan of Operations, State and Commonwealth approvals, management Plans, relevant licences and the annual compliance review.

Vegetation clearing window

The submission recommended clearing of native vegetation be scheduled through the life of the project to avoid key breeding seasons for threatened bat and bird species known to reside in the impact area.

The EIS included the following commitment:

Vegetation clearing would be managed to minimise clearing during sensitive breeding periods for fauna. A hierarchical timing for clearing from most to least preferred is: March to June; February and July / August; and September to January.

The upper disturbance limit for direct impact on native vegetation is 988.8 ha. To minimise clearing during sensitive periods, less than 50 per cent (494 ha.) of the disturbance will be outside the most preferred period from March to June, and less than 20 per cent (197 ha.) of this disturbance will be during the least preferred period from September to January (Chapter 31 of the EIS).

Clearing or disturbance of native vegetation in accordance with this commitment was described and assessed in the EIS, and impacts on threatened species are unlikely to be significant.

Cultural Heritage Management Plan annual reporting and ongoing communication with the Aboriginal community

The Cultural Heritage Management Plan annual reporting must include a summary of matters raised in the Register of Decisions by the Aboriginal cultural heritage working group. The proponent must also ensure that communication of project activities to the community, through the Aboriginal Working Group, is adequately resourced and supported.

Cultural Heritage Management Plan (CHMP) annual reporting will include a summary of matters raised in the Register of Decisions by the Aboriginal Cultural Heritage Working Group. The Aboriginal Cultural Heritage Working Group is central to the CHMP. The working group, including representatives of two land councils and the Gomeroi Applicant, will be regularly provided with information regarding execution of the CHMP and they will be provided with all correspondence received by the proponent regarding the CHMP. In addition the Community Consultative Committee agenda and minutes are made available to all of the community. The Narrabri Local Aboriginal Land Council is a member of the Community Consultative Committee.

The two land councils and the Gomeroi applicant have structured governance that the proponent anticipated will be used to disseminate information about the project as required.

The five-year CHMP review process will be undertaken by a third party auditor, and a Review Notice will be placed in a local paper in accordance with the terms of the CHMP. While the auditor's report and proposed revisions to the CHMP will be provided to the Aboriginal Cultural Heritage Working Group, the five-year review process provides the opportunity for members of the Aboriginal community to participate.

Sensitivity mapping and landform data

OEH had raised matters regarding interpretation of landform data. OEH has suggested that differences of interpretation can be addressed by annual updates of the sensitivity mapping.

The Aboriginal Cultural Heritage Assessment (EIS Appendix N1) noted that updating of the sensitivity mapping would be informed by results of work undertaken in the project area. Given the relatively large size of the project area and sensitivity mapping, it is unlikely that sufficient new information will be available in a particular year to inform an update of the sensitivity mapping.

However, the proponent proposes to review the sensitivity mapping prior to the first five-year review of the CHMP. This initial update to the sensitivity mapping will be undertaken when the results of the Additional Research Program are available. The following update will be undertaken as a part of the five-year review of the CHMP.

Site avoidance and site boundaries

The submission accepted the avoidance principle for sites but queried the methods for determining the boundaries around sites. OEH is satisfied that this issue can be managed through observing the progress of the pre-clearance surveys and the updating of sensitivity mapping.

The sizes of the proposed buffers are considered conservative and adequate particularly given the accuracy of current field GPS equipment. The boundaries of stone artefact scatters will be addressed on a case by case basis as circumstances require, and informed by results of a program of sub-surface testing implemented at these locations.

It is also important to note the results of the site verification program for 45 of the 90 known sites in the project area. Around half of the validated sites closely matched the location and description currently recorded in the NSW Aboriginal Heritage Information Management System (AHIMS). Despite searching an area extending out to 100 metres from the location recorded in AHIMS, at 38 per cent of locations nothing matching the AHIMS site description was found nor was anything else located. Verifying the description and location of sites with modern GPS equipment is essential for long-term protection. The proponent has committed to completing the site verification for the remaining 45 sites within 12 months of project sanction.

The proposed buffers will be based on the field verified Aboriginal heritage sites, including the 90 known sites identified in the assessment, and those identified through pre-clearance surveys.

The proponent concludes that the buffers proffered are acceptable until such time as results of subsequent work demonstrate amendments are required.

Pre-clearance surveys

The submission recommended that (due to the uncertainty of the sensitivity map) that all pre-clearance surveys include an archaeologist. The submission stated that expertise is needed to ensure that the project activities avoid harm to ACH values, in the first instance and develop reasonable and proportionate mitigation to minimise harm in appropriate circumstances.

The majority view of the Aboriginal community expressed during consultation prior to the submission of the EIS is that they are experts in their heritage and that they, through the Aboriginal Cultural Heritage Working Group, should select the appropriate cultural heritage officers to walk country and the appropriate technical expert as required for implementation of the CHMP. Under the terms of the CHMP, a technical expert is a suitable qualified archaeologist or a person appointed by the Aboriginal Cultural Heritage Working Group.

During consultation with the Aboriginal community following publication of the RTS, the majority view, as expressed to the proponent, remains that they should be able to select the appropriate technical expert, and that this may or may not be an Archaeologist. It is the proponent's experience that while certain submissions raised concerns about the adequate expertise needed to undertake the actions of the CHMP, this is a view held by a small proportion of the Aboriginal community in that region.

The proponent has been urged by majority of the Aboriginal community to maintain the proposed arrangements in the CHMP regarding the technical expert. Similar arrangements have been demonstrated to be effective in other jurisdictions. The purpose of pre-clearance surveys is the identification of cultural heritage (and the complete avoidance of most site types in accordance with the terms of the CHMP), where use of the information obtained from these surveys for academic or scientific endeavours is a secondary outcome.

Additional research program

The CHMP Additional Research Program must include appropriate skills to assist the community develop and implement additional research. A suitably qualified anthropologist and or historian must be made available to the Aboriginal community to advise and progress research pertaining to the project area.

An anthropologist will be engaged to assist in conduct of the Additional Research Program.

2.7 Resources Regulator

2.7.1 Decommissioning and rehabilitation

The Resources Regulator determined that sustainable rehabilitation outcomes can be achieved as a result of the project and that identified risks or opportunities can be effectively regulated through conditions of the approval and the conditions of petroleum authorities issued under the *Petroleum (Onshore) Act 1991*.

The Resources Regulator advised that pre-disturbance vegetation communities (or land capability class targets for agricultural land) would be reported as part of the Plan of Operations, rehabilitation or other Plans regulated under the conditions of a petroleum lease. The specific details of Plan requirements would be subject to further negotiations between the Resources Regulator and the DPE. Such Plans would also cover off on topsoil management protocols for extended periods.

The Resources Regulator recommended the following matters be addressed through consent conditions:

- Well decommissioning and suspension protocols that ensure petroleum wells can only be suspended for a limited time before decommissioning and rehabilitation commences, unless prior approval from the Secretary is obtained

- Final landform for the produced water storage ponds and retention of infrastructure
- Removal and rehabilitation of Leewood and Bibblewindi infrastructure (or alternative use of this infrastructure post-closure, provided appropriate approval processes are followed)
- Removal of infrastructure (gas and gathering lines).

As detailed in the RTS document, the proponent has committed to developing Rehabilitation and Decommissioning Management Plans in accordance with relevant consent conditions. The two Plans will incorporate the matters raised by the Resources Regulator.

2.8 NSW Roads and Maritime Services

2.8.1 Recommended consent conditions

Roads and Maritime Services recommended the following actions should the project be approved:

- Upgrading of the intersection of the Newell Highway and X-Line Road to include Auxiliary Left turn Short [AUL(s)] and Basic Right (BAR) turn treatments in accordance with Figures 8.3 and 7.5 of *Austroads Guide to Road Design 2010* (the Austroads Guide) and relevant Roads and Maritime Services' supplements, and road widening to accommodate these treatments
- Completion of intersection upgrades prior to construction of the project
- Submission of Work as Executed plans of the pipeline crossing of the Newell Highway at the completion of the project.

Figure 7-4 of the Traffic Impact Assessment (EIS Appendix P) shows that the forecast number of project related southbound vehicles turning left from the Newell Highway into X-Line Road during peak construction approaches the requirement for a sealed Auxiliary Left turn treatment (AUL(s)) as detailed in the Austroads Guide.

Consideration of the Austroads Guide in relation to forecast traffic volumes and warrant criteria will guide the need for the timing of the provision of the AUL(s) at this intersection. The AUL(s) upgrade will be undertaken prior to the activities that are forecast to generate the peak assessed level of traffic (i.e. 70 vehicles per hour). It is noted that other activities associated with the project's construction may be well underway (for example, construction activities at Leewood) prior to activities generating the peak assessed level of traffic at the Newell Highway / X-Line Road intersection.

Project vehicle access to X-Line Road from the Newell Highway will be predominantly from the north, i.e. vehicles travelling south along the Newell Highway. The number of vehicles associated with the project turning right into X-Line Road is forecast to be minimal. As such, a BAR treatment for northbound Newell Highway traffic is not required in accordance with Figure 7.5 of the *Austroads Guide to Road Design Part 4 Intersections and Crossings General 2009* (now Figure A.2 of the *Austroads Guide to Road Design Part 4 Intersections and Crossings General 2017*).

2.9 Rural Fire Service

2.9.1 Coal seam fire risk

The submission raised concerns regarding the impact of a bush fire on the coal and gas resources under the ground, including ignition of coal seams targeted by the project for extraction of the gas. The submission's concerns included the proposed wells providing a pathway for bush fire from the surface to the coal seam, and the difficulties that may be encountered extinguishing a fire in a coal seam.

It is not possible for underground coal ignition to occur as a result of development of natural gas from coal seams. Gas production and transport infrastructure is in place all around Australia and fire risks and management have been addressed in accordance with industry leading practice.

The project proposes to extract gas from coal seams that are up to 1,200 metres below ground level. The reduction of pressure resulting from the extraction of water from within coal seams allows natural gas to flow to the surface via the gas wells. The gas in the coal seams is almost entirely comprised of methane, carbon dioxide and nitrogen. For a fire to occur in the well casing up to 1,200 metres underground near the coal seam, in addition to the presence of methane (a combustible gas), oxygen must also be present. Given the absence of oxygen at the coal seam, combustion would not be possible.

The maximum concentration of methane that will burn in air is 15 per cent. It is expected that around 90 per cent of the gas extracted from the coal seam (and therefore the gas present in the well casing), will be methane. Therefore, the ignition of methane at the concentration within the coal seam is also not possible.

While the project proposes to extract naturally occurring methane from the coal seam by reducing the groundwater pressure, underground coal gasification is not proposed. The production of natural gas from coal seams should not be confused with underground coal gasification. Underground coal gasification converts the coal *in situ* to 'syngas' through combustion. The air or oxygen required for this combustion is injected into the coal seam. Unlike underground coal gasification, there is no risk of a fire in the coal seam associated with coal seam gas development.

2.9.2 Infrastructure

The submission states that impact of flame and radiant heat exposure on CSG surface extraction and transport infrastructure have not been addressed, instead relying on well head shut off valves and an acceptance that periodically facilities may be damaged by bushfire.

The submission also states that there appears to be a reliance on prescriptive limits for exposure and asset protection zones (e.g. compliance with the NSW RFS *Telecommunications Towers Practice Note*) rather than addressing the risk from a first-principles approach.

Using a first principles approach, the priority bush fire risks associated with the project have been identified and assessed. The project is proposed on land where bushfires occur; the land is therefore currently exposed to bush fire risk. However, the proposal does not add elements (e.g. fuel) to increase the intensity of the bushfire itself or the rate at which a fire may spread. Importantly, the likelihood of a bushfire ignition from a project related activity has been assessed as remote.

In other areas of the state where bushfires occur, telecommunication towers can be effectively protected with shielding in accordance with the relevant policies. The submission does not suggest that appropriately designed shielding is ineffective.

The longest flame length predicted under a catastrophic bushfire danger level (FFDI 120) is approximately 18 metres. It is not realistic or necessary to have all above ground facilities separated from forests by distances up to 18 metres. This exceeds typical infrastructure protection measures applied in NSW as most will have components that do not require bushfire protection or are simply repaired in the event of bushfire damage. The NSW Rural Fire Service's (2012) *Fast Fact for Telecommunication Towers* (a far more vulnerable facility) allows major flame impingement onto structures located on steep forested slopes. Telecommunication towers have protection redundancy measures, as do the proposed wells e.g. shut-in values.

Other bushfire protection measures provide a more pragmatic and appropriate response, these include:

- Acceptance that periodically facilities may be damaged by bushfire
- Operational protocols effective in the total absence of firefighter response
- Shielding of critical components of higher value facilities
- Asset protection zones that are likely to be effective in the majority of fires.

As part of the Bushfire Management Plan and facility design, the radiant heat exposure will be determined using the current proposed asset protection zone, and a prioritised risk management response applied that will include construction design measures, operational protocols etc.

2.9.3 Fire-fighter risk

The submission states that the risk to fire-fighters, with respect to managing and extinguishing a forest fire in State Forest, has not been addressed.

The submission also states that the risks to fire-fighters are increased whether or not they are protecting project infrastructure.

The project is proposed on land where bushfires occur and firefighter risk exists in the forest. The proponent is committed to working with the NSW Rural Fire Service to finalise the Bushfire Management Plan, including consideration of matters that relate to fire-fighter safety.

In relation to wells, the Hazard and Risk Assessment (EIS Appendix S) found that worst case scenario consequence effect distances (up to 50 metres downwind of the release point) are contained within the fenced well pad area. As discussed in the RTS, there is no obligation or expectation that firefighters will protect project infrastructure. As such, it is expected that firefighters would be outside the well pad and worst case scenario consequence effect distances.

The infrastructure downstream of the well head, including the gas gathering lines and vents or drains, will be depressurised to the gas compression units or flare system and, as such, the operating pressure in the gas gathering network would rapidly approach atmospheric pressure. As a result there would be no increased fire intensity expected due to this downstream infrastructure.

2.9.4 Westport workers' accommodation

The submission states that the Expansion of Westport workers' accommodation shall be to the requirements of Special Fire Protection Purpose developments including Emergency Evacuation Plan and water supplies.

The proposed expansion of the Westport workers' accommodation is not a Special Fire Protection Purpose (SFPP) development. The project is State Significant Development and is exempt under section 4.41 and 4.14(1B) of the *Environmental Planning and Assessment Act 1979* and does not require a Bush Fire Safety Authority under the NSW *Rural Fires Act 1997*. It is, however, recognised that the project would be situated on bush fire prone land and that *Planning for Bushfire Protection* (NSW Rural Fire Service 2006) is an important guideline in the design of bushfire protection measures.

The accommodation buildings proposed are donga-style i.e. small self-contained single bedroom spaces within a larger building. In the event that refuge is required on site, it will be provided in the general use buildings of the site and these buildings are / will be constructed to their Bushfire Attack Level appropriate for a refuge building.

All occupants / users are fully briefed on bushfire risks and the appropriate bushfire response required in the event of a bushfire. Most occupants will be regular users of the accommodation and will receive appropriate training and awareness of bushfire risks and responses. This is unlike SFPP development involving more vulnerable occupants e.g. aged, unfamiliar with area, poorly equipped etc.

Westport workers' accommodation would provide accommodation for up to 200 people and would warrant proportionate bush fire protection. The existing accommodation was granted a bush fire safety authority that prescribed bush fire protection specifications and requirements including asset protection zones, water supplies for firefighting and emergency procedures. It is expected that a similar level of bush fire protection will be provided to the expanded facility. An updated Bushfire Response and Evacuation Plan will also be prepared.

2.9.5 Gas flaring

The submission recommends that no gas flaring shall be undertaken on extreme and / or catastrophic fire weather days. The submission also recommends that gas flaring infrastructure shall not exceed a radiant heat generation of 10 kW/m^2 on surrounding unmanaged vegetation and shall include no exposed naked flame and spark arresters.

Flares act as a safety systems and are therefore required to be available to operate at all times. As described in the RTS and Chapter 6 (Project description) of the EIS, safety flares at Leewood and Bibblewindi will be surrounded by a safety zone of up to 60 metres radius and a vegetation free zone of up to 130 metres radius. Pilot flares will be surrounded by a safety zone of up to 15 metres radius and a vegetation free zone of up to 40 metres radius. The maximum radiant heat flux at the nearest vegetation would be 6.31 kW/m^2 at both ground level and at the tree canopy under a catastrophic bushfire danger level (FFDI 120).

The proponent has confirmed that the design standards for flares will result in substantially less than 10 kW/m^2 regardless of bushfire danger level. Considering the relevant policies, flare design and overall risks from a first principle approach, flares are able to operate safely regardless of the bushfire danger levels.

2.10 Siding Spring Observatory

2.10.1 Acknowledgement

Siding Spring Observatory accepts that flaring during routine and emergency operations will not have a detrimental impact on the observing conditions at the Observatory. It requests that the proponent consider performing routine maintenance activities requiring flaring when the moon is more than 50 per cent illuminated (i.e. a gibbous moon).

The Observatory requests that the proponent continue liaising with it particularly in relation to material changes to operations that may affect the sky background at the location of the Observatory.

The proponent is committed to continuing consultation with Siding Spring Observatory throughout the construction and operation of the project and will schedule routine maintenance activities requiring flaring during periods when the moon is more than 50 per cent illuminated.

2.11 Narrabri Shire Council (NSC)

2.11.1 Chemical composition of produced and amended water

The submission requested that during assessment of the project, the EPA satisfies itself that the chemical composition and water quality of produced and amended water associated with the project is safe and will not negatively impact the environment.

The submission also requested that should development consent be granted, the EPA be responsible for the monitoring of produced and amended water associated with the project and monitoring results be published on the EPA website.

The EPA has addressed these matters through recommended conditions of consent.

2.11.2 Bohena Creek managed release point and Newell Highway gauging station

The submission requested that during assessment of the project, Lands and Water satisfies itself that the proposed hydrological gauging stations will be located so as to be representative of conditions at the Bohena Creek managed release point and will have the capacity to detect flows in the order of 100 ML/day

A response to matters raised on management of impacts to Bohena Creek by Lands and Water is provided in Section 2.1 of this document.

2.11.3 Bohena Creek managed release and predicted cadmium levels

During assessment of the project, NSC requests that Lands and Water satisfies itself that the managed release of treated water to Bohena Creek will not impact on the ecological health of Bohena Creek.

The submission requested that, should development consent be granted, the EPA be responsible for monitoring the managed release of treated water to Bohena Creek to ensure that it is safe and does not negatively impact the environment, and that the monitoring results be published on the EPA website.

The managed release of treated water to Bohena Creek will be undertaken in accordance with relevant conditions of consent, and these conditions will be reflected in the Environment Protection Licence issued by the EPA.

2.11.4 Water quality monitoring

During assessment of the project, NSC requests that the proposed groundwater monitoring network and plan be amended as necessary to obtain the endorsement of the Commonwealth's Independent Expert Scientific Committee (IESC).

Should development consent be granted, NSC requests that the proponent:

- Review the groundwater model two-to-three years after commencement of water production
- Undertake validation and recalibration of the groundwater modelling
- Review and revise relevant management Plans to ensure early prediction of impacts and the implementation of adequate monitoring, management and contingency measures.

The submission also requested that the proponent be required to obtain endorsement of the above by the IESC.

Please refer to responses regarding groundwater monitoring and modelling matters, as raised by Lands and Water, in Section 2.1 of this document.

2.11.5 Monitoring of natural gas wells and gathering lines

The submission requested, that should development consent be granted, the proponent be required to pay for independent third-party monitoring of decommissioned coal seam gas wells indefinitely, and that the monitoring of same be overseen by the EPA with results published on the EPA website.

As discussed in the RTS, wells that have reached the end of their functional life will be plugged and decommissioned in accordance with the *NSW Code of Practice for Coal Seam Gas – Well Integrity* (NSW Trade and Investment 2012), or the applicable code in place at the time of decommissioning.

Final rehabilitation will take place, with sites relinquished, in accordance with processes set out under the *Petroleum (Onshore) Act 1991*.

2.11.6 Rehabilitation fund

Should development consent be granted, NSC requests the proponent:

- Pays a security deposit in the form of a cash bond or bank guarantee of an appropriate amount that covers the true cost of rehabilitation
- Holds pollution legal liability insurance that covers pollution and natural resources damage both on-site and off-site including groundwater contamination and for the benefit of the insured, third parties and contractors
- Contributes to an Environment Fund established to cover off-site remediation and rehabilitation including groundwater contamination and other long term, gradual onset damage.

Should development consent be granted, NSC also requests that the DPE:

- Publish details of the financial assurance that the State will hold to cover the cost of on-site and off-site remediation and rehabilitation in the event of sudden accidental pollution and from unforeseen and long term impacts of the project including groundwater contamination
- Explains the methodology used to determine that this amount is sufficient to ensure no costs are passed on to the public.

The proponent is required to lodge a security deposit covering the full cost of rehabilitation as outlined in Sections 5.7 and 5.17 of the RTS document.

2.11.7 Principles of land access

The submission asks, that should development consent be granted, the proponent be bound by the *Agreed Principles of Land Access*.

As discussed in Chapter 17 of the EIS and various locations within the RTS document, the proponent is a signatory of the *Agreed Principles of Land Access* (DRE 2015).

2.11.8 Air quality impacts near Leewood

During assessment of the project, NSC requests that the EPA and NSW Health satisfies itself that the Air Quality Impact Assessment, and measures to mitigate and manage the emissions, are acceptable.

The submission requested, that should development consent be granted, NSC requests that the:

- EPA be responsible for the monitoring of air quality prior to, and during, the project to ensure that it is safe and will not negatively impact the environment or human health
- Monitoring results be published on the EPA website.

Please refer to Sections 2.3 and 2.5 of this document, respectively, for responses to air quality matters raised by the EPA and NSW Health.

2.11.9 Air Quality Management Plan

Should development consent be granted, NSC requests that the proponent be required to liaise with sensitive receptors and NSC in the preparation and annual review of the Air Quality Management Plan.

The proponent has committed to developing an Air Quality Management Plan for implementation during construction and operation of the project. The Plan will include an air quality monitoring program and emissions reductions measures and will be developed in accordance with consent conditions.

2.11.10 Road maintenance agreement

The submission requested, that should development consent be granted, the proponent be required to enter into a road maintenance agreement with NSC.

As discussed in Section 6.22 of the RTS document and the Traffic Impact Assessment (EIS Appendix P), the level of impact on proposed access routes for which Narrabri Shire Council is the road authority (including Yarrie Lake Road, Kiandool Lane and Cains Crossing Road) would be limited and are not considered to warrant a road maintenance agreement being put in place.

2.11.11 Light at Siding Spring Observatory

The submission asks, that during assessment of the project, the proponent be required to obtain endorsement of the Gas Flare Light Assessment and proposed mitigating practices by the Siding Spring Observatory.

Siding Spring Observatory confirmed in a letter to the DPE dated 15 May 2018, that it had read the proponent's response to the submission from the Dark Sky Committee of Siding Spring Observatory and found that it addressed the matters previously raised. The Observatory confirmed that it accepts that flaring during routine and emergency operations will not have a detrimental impact on the observing conditions of Siding Spring Observatory. Refer to Section 2.10 of this document.

2.11.12 Social impacts on vulnerable groups

The submission asks, that during assessment of the project, the proponent be required to demonstrate to the satisfaction of NSW Health how social impacts on vulnerable groups will be managed.

Social impacts, including on the Aboriginal community, were addressed in the EIS (Chapter 26 and Appendix T1) and the RTS (Section 6.26) documents. The proponent notes that NSW Health did not raise social impacts on vulnerable groups as a concern in their submission dated 6 September 2018 on the RTS document.

2.11.13 Monitoring of social impacts

The submission requested, that should development consent be granted, the proponent be required to:

- Engage with the public and NSC and community in the preparation and review of the Social Impact Management Plan
- Review the Social Impact Management Plan annually in consultation with NSC and community to ensure it is fit for purpose.

The proponent has committed to implementing a Social Impact Management Plan for the project. The Plan will be developed in accordance with consent conditions.

2.11.14 Capacity of local waste facilities for waste salt

The submission requested, that during assessment of the project, the EPA satisfies itself that the facilities to be utilised for waste salt disposal have long-term capacity to accept it, and adequate contingency planning is in place for disposal of waste salt.

The criteria that will used to assess the suitability of waste facilities to accept waste from the project are outlined in the response to the EPA's submission in Section 2.3 of this document.

2.11.15 Composition and classification of waste salt

During assessment of the project, NSC recommends that the EPA satisfies itself that the waste salt would not contain other contaminants, and would therefore classify as general solid waste.

The EPA, in its submission dated 4 July 2018 on the RTS document, stated that it:

is satisfied with the additional information that the proponent provided with regard to the current potential for contamination of the waste salt.

2.11.16 Waste management

The submission requested, that during the assessment of the project, the EPA satisfies itself that the Waste Management Plan is acceptable.

The EPA has recommended a condition of consent requiring the proponent prepare a Waste Management Plan for the project in consultation with the EPA.

2.11.17 Environmental management plans

The submission requested, that should development consent be granted, the proponent be required to:

- Engage with the public and NSC in preparation and review of all environmental management plans
- Review all environmental management plans annually to ensure that they are fit for purpose.

The proponent will prepare all management plans in accordance with relevant consent conditions.

2.11.18 Independent monitoring

The submission requested, that should development consent be granted, the EPA be responsible for the monitoring of environmental and human health compliance, including though not limited to:

- Air quality – including particulate matter, volatile organic compounds, hydrogen sulphide, nitrogen dioxide, sulphur dioxide, sulfuric acid mist, molecular weight of stack gases and odour.
- Noise – including annual monitoring of premises and flaring events in accordance with the NSW *Industrial Noise Policy* (NSW EPA 2000) and AS 1055.1-1997: *Acoustics – Description and measurement of environmental noise General procedures*.
- Soil – including cation exchange capacity, electrical conductivity, pH, petroleum hydrocarbons, polyaromatic hydrocarbons, heavy metals, sodium adsorption ratio, boron, sodium, calcium, potassium, benzene, toluene, ethylbenzene and xylene.
- Sediment (Bohena Creek) – including cation exchange capacity, electrical conductivity, pH, petroleum hydrocarbons, polyaromatic hydrocarbons, heavy metals, sodium adsorption ratio, boron, sodium, calcium, potassium, benzene, toluene, ethylbenzene and xylene.
- Water quality – including suspended solids, biochemical oxygen demand, oil and grease, polyaromatic hydrocarbons, phenols, organic carbon, petroleum hydrocarbons, recoverable hydrocarbons, electrical conductivity, pH, sodium adsorption ratio, boron, sodium, calcium, potassium, heavy metals (particularly cadmium), benzene, toluene, ethylbenzene and xylene.

The submission also requested that the monitoring results be published on the EPA website.

The proponent will submit monitoring data, including an annual return, to the relevant authorities as required by the Environment Protection Licence issued under the *Protection of the Environment Operations Act 1997* for the project.

2.12 Gunnedah Shire Council

2.12.1 Social impact assessment review

Council requests that the Social Impact Assessment (EIS Appendix T1) be reviewed after 12 months and that it includes a requirement to implement recommendations from the review.

As detailed in Section 7.1 of the Social Impact Assessment (EIS Appendix T1), and in Section 6.26 of the RTS document, the proponent plans to monitor and review social impacts and management strategies at regular intervals and report on them through an annual reporting process.

Chapter 3 Project evaluation

In February 2017, the Environmental Impact Statement (EIS) for the Narrabri Gas Project (the project) was submitted to the NSW DPE for consideration as part of development application number SSD 14_6456.

Consistent with requirements under the NSW *Environmental Planning and Assessment Act 1979*, the EIS was placed on public exhibition from 21 February to 22 May 2017, during which period the DPE received 23,007 submissions.

Submissions were received from a wide range of stakeholders including government institutions, special interest groups, organisations and individuals.

The proponent (Santos) was required to respond to the submissions. The RTS summarised the submissions and responded to the matters raised. Since the lodgement of the EIS, additional assessment activities have been undertaken to assist with responding to submissions. These include assessments in relation to terrestrial ecology (RTS Appendices E, G and H), air quality (RTS Appendix I) and landscape and visual impacts (RTS Appendix K).

The structure and contents of the RTS reflected the draft guideline *Responding to Submissions* (NSW DPE 2017). The RTS was placed on public exhibition in April 2018.

Several statutory bodies, including State and local Councils, provided further questions upon reviewing the RTS. This supplementary RTS (SRTS) document provides responses to those questions.

The RTS and SRTS, along with the EIS, will be considered in the determination of the project under the NSW *Environmental Planning and Assessment Act 1979*.

At completion of the SRTS, and giving consideration to the additional assessment activities undertaken for the RTS as described above, there are no substantial changes to the project from what was described in Chapter 6 (Project description) of the EIS. Results of the additional assessment activities in the RTS confirmed the overall low social and environmental impact of the project as assessed in the EIS, with manageable residual risk. The significant social and economic benefits of the project are as described in the EIS.

The content of this SRTS, being entirely consistent with the EIS and RTS, re-confirm the findings of the RTS with regard to the overall low social and environmental impact of the project as assessed in the EIS, with manageable residual risk.

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Appendix A

Water baseline report addendum

Santos

Table A1: Groundwater quality for the Gunnedah-Oxley Basin, samples taken at well-heads across the project area

Parameter	Units	LOR	Number of analyses	Average	16th percentile	84th percentile
Physicochemical						
pH			321	8.0	7.3	8.6
Electrical Conductivity	µS/cm		319	14,836	11,284	18,653
Solids (Dissolved)	mg/L	2	252	9,765	7,083	13,000
Solids (Dissolved) @180˚C	mg/L	2	82	11,675	7,971	14,815
Dissolved anions						
Alkalinity (CO_3)#	mg/L	1	227	378	1	779
Alkalinity (HCO_3)	mg/L	1	335	8,518	5,157	11,800
Bromide	mg/L	0.005	41	4.44	3.04	5.51
Chloride	mg/L	2	335	1,396	1,000	1,673
Fluoride	mg/L	0.05	75	4.86	2.51	6.00
Sulphur as SO_4	mg/L	0.1	258	45	1	34
Dissolved cations						
Calcium (Total)	mg/L	0.1	284	19	5	31
Magnesium (Total)	mg/L	0.01	166	6	3	7
Potassium (Total)	mg/L	0.2	331	213	41	156
Sodium (Total)	mg/L	1	334	4,360	2,858	5,955
Hardness (Total)	mg/L	1	105	88	26	147
Nutrients						
Ammonia-Nitrogen	mg/L	10	57	10	4	16
Nitrate-Nitrogen	mg/L	0.1	167	2.56	0.05	3.00
Nitrite-Nitrogen	mg/L	0.01	75	0.04	0.01	0.02
Nitrogen (TKN)	mg/L	1	54	25.6	6.0	33.6
Nitrogen (Total)	mg/L	1	60	23.6	4.9	30.8
Ortho-Phosphorus	mg/L	0.18	34	<0.18	<0.18	<0.18
Phosphorus (Total)	mg/L	0.02	58	0.28	0.04	0.22
Total metals & trace elements						
Aluminium (Total)	mg/L	0.01	60	3.35	0.02	2.73
Antimony (Total)	mg/L	0.0001	59	0.0008	<0.0001	0.0011
Arsenic (Total)	mg/L	0.0001	57	0.0106	0.0047	0.0126
Barium (Ba)	mg/L	1	60	8.5	4.2	14.4
Beryllium (Total)	mg/L	0.001	55	<0.001	<0.001	<0.001
Boron (Total)	mg/L	0.2	60	0.6	<0.2	1.2
Cadmium (Total)	mg/L	0.0001	60	0.0107	<0.0001	0.0204
Chromium (Total)	mg/L	0.0005	60	0.0116	0.0008	0.0201
Cobalt (Total)	mg/L	0.0001	56	0.0017	<0.0001	0.0027
Copper (Total)	mg/L	0.0005	60	0.0503	0.0046	0.0438
Iron (Total)	mg/L	0.01	106	17.17	0.26	6.00
Lead (Total)	mg/L	0.0005	17	0.0199	<0.0005	0.0252
Lithium (Total)	mg/L	0.1	17	1.7	1.3	2.0

Parameter	Units	LOR	Number of analyses	Average	16th percentile	84th percentile
Manganese (Total)	mg/L	0.001	61	0.266	0.003	0.062
Mercury (Total)	mg/L	0.0001	58	0.0005	<0.0001	0.0005
Molybdenum (Total)	mg/L	0.0001	59	0.0047	0.0001	0.0043
Nickel (Total)	mg/L	0.0001	60	0.0065	<0.0001	0.0125
Selenium (Total)	mg/L	0.0005	58	0.0206	0.0039	0.0413
Strontium (Total)	mg/L	0.001	86	2.521	0.603	4.361
Tin (Total)	mg/L	0.0005	17	0.0018	<0.0005	0.0027
Uranium	mg/L	0.0001	58	0.0004	<0.0001	0.0005
Vanadium (Total)	mg/L	0.005	53	0.009	<0.005	0.012
Zinc (Total)	mg/L	0.0005	60	0.0531	0.0041	0.0575

Hydroxide (OH) alkalinity reported below laboratory limit of reporting (LOR) for all samples.

Table A2: Treated water quality - Updated Table 7.1 from Water Baseline Report (Appendix D of the RTS)

Parameter	Australian Drinking Water Guidelines (NHMRC 2011)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (Short Term < 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water[a,c]	Amended water[b,c]	Treated water[c]	Amended water[c,d]	RO brine[c,e]
				Target values		Leewood WBTP (3 samples)	Leewood WBTP (16 samples)	Leewood WBTP (6 samples)
			All values mg/L unless stated					
pH (pH units)	6.5 – 8.5	6.0 -9.0	Not referenced	7.1	7.1	7.9	pH (Field) – 7.4 pH (Lab) – 7.2	8.5 (Lab)
Electrical conductivity (laboratory) (µS/cm)	Not referenced	Crop specific – Lucerne (2,700 in loamy soils)	Not referenced	357	566	n/a	90.1	85,267
Total dissolved solids	Health: Not referenced Aesthetic as follows: <600 Good quality 600-900 Fair quality 900-1,200 Poor quality >1,200 Unacceptable	Crop specific – Lucerne (1,273 – 3,015)	No adverse effects to: Beef cattle, pigs and horses 4,000, sheep 5,000	232	368	51 (at 180°C)	99 (Field) 54.2 (at 180°C)	86,700 (calc.)

Parameter	Australian Drinking Water Guidelines (NHMRC 2011)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (Short Term < 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water[a,c] Target values	Amended water[b,c] Target values	Treated water[c] Leewood WBTP (3 samples)	Amended water[c,d] Leewood WBTP (16 samples)	RO brine[c,e] Leewood WBTP (6 samples)
Sodium Adsorption Ratio	Not referenced	<1 Excellent 1-2 Good 2-4 Fair 4-8 Poor 8-15 Very poor >15 Unacceptable	Not referenced	130	3.3	7	1.6	1,020
Sodium (filtered)	Health: Not referenced Aesthetic: 180	Crop specific – Lucerne (230 - 460)	Not referenced	77	77	13.2	11.17	36,350
Magnesium (filtered)	Not referenced	Not referenced	Not referenced	<0.01	<0.01	<1	<1	43.2
Aluminium	Health: Not referenced Aesthetic: 2	20	5	<0.001	<0.001	<0.005	<0.005	<0.05
Silica (SiO_2) (µg/L)	900	Not referenced	Not referenced	23	0.15	<0.1	<0.1	135
Potassium (filtered)	Not referenced	Not referenced	Not referenced	0.8	0.8	<1	<1	651

Parameter	Australian Drinking Water Guidelines (NHMRC 2011)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (Short Term < 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water[a,c]	Amended water[b,c]	Treated water[c]	Amended water[c,d]	RO brine[c,e]
				Target values		Leewood WBTP (3 samples)	Leewood WBTP (16 samples)	Leewood WBTP (6 samples)
Calcium (filtered)	Health: Not referenced Aesthetic as follows: <60 Soft 60-200 Good quality >200 Increased scaling	Not referenced	1,000	0.01	40.01	<1	3.8	24
Chromium (III+VI)	0.05	1 (Cr^{VI})	1	<0.001	<0.001	<0.001 (Cr^{VI})	<0.001 (Cr^{VI})	0.01
Manganese	0.5	10	Not sufficiently toxic	<0.001	<0.001	<0.001	0.001	0.014
Iron	<1	10	Not sufficiently toxic	<0.001	<0.001	<0.05, <0.002	<0.05, <0.002	0.27
Boron	4	Crop specific 0.5 (sensitive) to 15 (very tolerant)	5	0.12	0.12	0.1	0.072	3.38
Cobalt	Not referenced	0.1	1	<0.001	<0.001	<0.001	<0.001	<0.005
Nickel	0.02	2	1	<0.001	<0.001	<0.001	<0.001	<0.005
Copper	2	5	0.4 (sheep) 1 (cattle) 5 (pigs)	<0.001	<0.001	<0.001	<0.001	<0.005

Parameter	Australian Drinking Water Guidelines (NHMRC 2011)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (Short Term < 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water[a,c]	Amended water[b,c]	Treated water[c]	Amended water[c,d]	RO brine[c,e]
				Target values		Leewood WBTP (3 samples)	Leewood WBTP (16 samples)	Leewood WBTP (6 samples)
Zinc	Health: Not referenced Aesthetic: 3	5	20	<0.001	<0.001	<0.005, <0.001	<0.005, <0.001	<0.025
Arsenic	0.01	2	0.5 – 5	<0.001	<0.001	<0.001	<0.001	0.018
Selenium	0.01	0.05	0.02	<0.001	<0.001	<0.01, <0.0002	<0.01, <0.0002	<0.05
Molybdenum	0.05	0.05	0.15	<0.001	<0.001	<0.001	<0.001	0.006
Cadmium	0.002	0.05	0.01	<0.001	<0.001	<0.0001	<0.0001	0.001
Barium	2	Not referenced	Not referenced	<0.001	<0.001	<0.001	0.002	12.6
Mercury	0.001	0.002	0.002	0.0000067	<0.001	<0.00004, <0.0001	<0.00004, <0.0001	<0.0005
Lead	0.017	5	0.1	<0.001	<0.001	<0.001	<0.001	<0.005
Uranium	0.017	0.1	0.2	<0.0028	<0.0028	<0.001	<0.001	<0.005
Alkalinity (total as $CaCO_3$)	Not referenced	Not referenced	Not referenced	139	139	31.7	22.6	73,500
Ammonia (as N)	Health: Not referenced Aesthetic: 0.5	Crop specific as N (25 – 125)	Not referenced	0.005	0.005	0.24	0.19	3.3
Nitrate (as N)	50	Crop specific as N (25 – 125)	400	0.005	0.005	0.04	0.25	0.54
Total N	Not referenced	25 - 125	Not referenced	0.005	0.005	0.23	0.42	n/a
Sulfate	500	Not referenced	1,000	0.003	95.9	<1	1	356

Parameter	Australian Drinking Water Guidelines (NHMRC 2011)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (Short Term < 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water[a,c]	Amended water[b,c]	Treated water[c]	Amended water[c,d]	RO brine[c,e]
				Target values		Leewood WBTP (3 samples)	Leewood WBTP (16 samples)	Leewood WBTP (6 samples)
Chloride	Health: Not referenced Aesthetic: 250	Crop specific – Lucerne (350 – 700)	Not referenced	15	15	7.3	14.211	9,232
Fluoride	1.5	2	Not referenced	0.08	0.08	<0.01, <0.1	0.182	48
Total phosphorous	Not referenced	Crop specific – (0.8 – 12)	Not referenced	0.01	0.01	<0.01	0.02	n/a

n/a - not analysed

[a] theoretical composition based on manufacturer's specifications

[b] calculated composition based on theoretical treated water and amendment with 1 mole gypsum

[C] all values reported as maximum recorded values, except pH reported as average; multiple values reflect different laboratory limits on reporting (LOR)

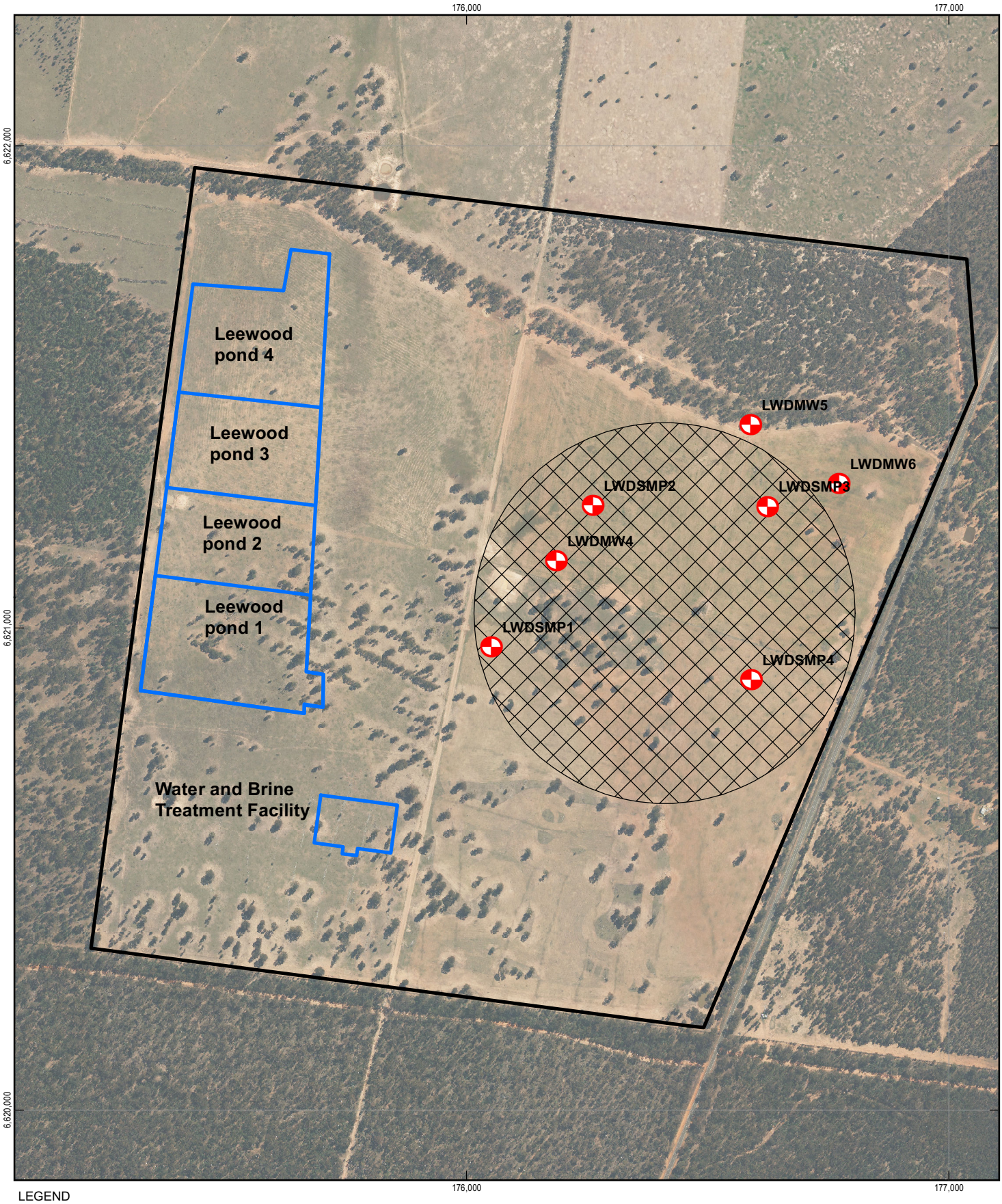
[d] treated water amended with calcium chloride

[e] laboratory limits raised due to high salinity

Appendix B

Groundwater and soil monitoring points at Leewood irrigation area and 2017-2018 monitoring results

Santos



LEGEND

- Leewood property boundary
- Monitoring locations
- Indicative irrigation area
- Existing facilities

Paper Size A4

0 37.5 75 150 225 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Santos
Narrabri Gas Project

Job Number	21-22463
Revision	A
Date	31 Jan 2019

Leewood Monitoring Locations

Figure B1

180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com

G:\21\22463\GIS\Maps\21_22463_Z163_Leewood.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:afoddy

Table B1 Soil monitoring data (2017) — 1 of 2

Location	Start depth	End depth	Sampled date	Ammonium Nitrogen	Boron	Chloride	Electrical Conductivity	Hydraulic conductivity	Nitrate Nitrogen	Organic Carbon	Organic Matter	pH (1:5 $CaCl_2$)	pH (1:5 Water)	Phosphorus Colwell	Potassium Colwell	Sodium Adsorption Ratio	Sulphur (KCl-40)	Total Aluminium
	mm	mm		mg/kg	mg/kg	mg/kg	µS/cm	metres/second	mg/kg	%	%			mg/kg	mg/kg		mg/kg	mg/kg
LWDSMP1	0	250	18/07/2017	1.7	0.31	24	160	4.17×10^{-6}	1.1	0.23	0.40	6.8	7.9	<5.0	48	2.1	27	25,000
LWDSMP1	250	500	18/07/2017	3.1	0.23	21	140	1.85×10^{-6}	2.3	0.43	0.74	5.3	6.3	7.4	46	6.0	55	14,000
LWDSMP1	500	750	18/07/2017	1.8	0.30	93	220	1.96×10^{-6}	1.7	<0.15	0.26	6.6	7.5	<5.0	40	3.8	32	27,000
LWDSMP1	750	1,000	18/07/2017	1.5	0.17	310	340	1.96×10^{-6}	5.7	<0.15	0.26	6.1	7.0	<5.0	46	8.8	34	23,000
LWDSMP1	1,000	2,000	18/07/2017	1.1	0.10	430	440	1.96×10^{-6}	5.9	<0.15	0.26	5.4	6.2	<5.0	48	7.3	26	29,000
LWDSMP1	2,000	3,000	18/07/2017	1.7	0.08	430	430	1.23×10^{-6}	3.5	<0.15	0.26	4.7	5.7	<5.0	66	15.0	32	32,000
LWDSMP2	0	250	18/07/2017	2.1	0.17	87	230	1.33×10^{-6}	1.7	0.5	0.86	5.7	6.6	<5.0	48	9.0	63	20,000
LWDSMP2	250	500	18/07/2017	1.8	0.20	260	350	3.09×10^{-6}	2.0	0.24	0.41	5.7	6.7	<5.0	46	6.3	46	31,000
LWDSMP2	500	750	18/07/2017	1.2	0.46	500	530	1.33×10^{-6}	0.75	0.20	0.34	6.9	7.8	<5.0	75	18.0	75	34,000
LWDSMP2	750	1,000	18/07/2017	1.4	0.42	590	630	core failed	0.57	0.17	0.29	7.2	8.0	<5.0	98	19.0	86	30,000
LWDSMP2	1,000	2,000	18/07/2017	1.1	0.21	460	500	3.27×10^{-6}	2.0	<0.15	0.26	7.1	7.9	<5.0	120	20.0	64	30,000
LWDSMP2	2,000	3,000	18/07/2017	Core refusal	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LWDSMP3	0	250	18/07/2017	1.9	0.30	25	300	8.33×10^{-6}	0.7	0.79	1.40	4.6	5.1	5.7	51	3.7	130	18,000
LWDSMP3	250	500	18/07/2017	1.3	0.26	100	240	8.33×10^{-6}	<0.50	0.31	0.53	5.6	6.8	<5.0	36	2.2	32	27,000
LWDSMP3	500	750	18/07/2017	1.9	0.21	310	470	6.41×10^{-6}	1.0	<0.15	0.26	7.2	8.1	<5.0	95	18.0	110	35,000
LWDSMP3	750	1,000	18/07/2017	1.3	0.22	290	410	1.79×10^{-6}	<0.50	0.20	0.34	6.8	7.9	<5.0	46	16.0	76	35,000
LWDSMP3	1,000	2,000	18/07/2017	2.5	0.16	310	520	1.75×10^{-6}	2.4	0.15	0.26	7.4	8.1	<5.0	86	18.0	120	33,000
LWDSMP3	2,000	3,000	18/07/2017	Core refusal	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LWDSMP4	0	250	18/07/2017	1.2	0.36	13	500	1.67×10^{-5}	1.4	1.10	1.90	5.7	6.1	5.3	170	2.7	300	15,000
LWDSMP4	250	500	18/07/2017	1.5	0.63	45	200	4.39×10^{-6}	0.59	0.59	1.00	5.8	6.9	<5.0	74	3.3	52	19,000
LWDSMP4	500	750	18/07/2017	1.1	0.91	130	280	2.08×10^{-6}	<0.50	0.20	0.34	6.4	7.5	<5.0	91	4.7	50	35,000
LWDSMP4	750	1,000	18/07/2017	1.6	0.90	180	310	1.25×10^{-6}	<0.50	<0.15	0.26	6.8	7.9	<5.0	100	6.4	44	39,000
LWDSMP4	1,000	2,000	18/07/2017	2.0	0.75	120	300	core failed	2.3	0.17	0.29	6.8	7.9	<5.0	120	4.0	50	36,000
LWDSMP4	2,000	3,000	18/07/2017	2.1	0.57	100	260	5.95×10^{-6}	1.2	<0.15	0.26	6.5	7.6	<5.0	93	2.8	42	34,000

Table B2 Soil monitoring data (2017) — 2 of 2

Location	Start depth	End depth	Sampled date	Total Cadmium	Total Calcium	Total Chromium	Total Copper	Total Iron	Total Lead	Total Magnesium	Total Manganese	Total Nickel	Total Phosphorus	Total Potassium	Total Sodium	Total Sulphur	Total Zinc
	mm	mm		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LWDSMP1	0	250	18/07/2017	0.13	100	19	4.3	17,000	7.3	1,800	56	9.3	38	610	720	73	9.3
LWDSMP1	250	500	18/07/2017	<0.13	240	13	2.6	10,000	5.4	810	28	4.9	46	340	210	91	5.6
LWDSMP1	500	750	18/07/2017	<0.13	100	20	4.8	18,000	6.9	1,900	35	8.6	33	650	910	78	9.8
LWDSMP1	750	1,000	18/07/2017	<0.13	100	18	4.9	15,000	6.3	1,800	24	9.1	27	580	1,000	69	9.6
LWDSMP1	1,000	2,000	18/07/2017	0.14	100	24	6.2	21,000	8.3	2,300	23	9.1	32	750	1,400	77	16.0
LWDSMP1	2,000	3,000	18/07/2017	0.17	100	27	5.3	23,000	8.1	2,500	24	8.9	32	770	1,400	66	14.0
LWDSMP2	0	250	18/07/2017	<0.13	580	18	4.2	14,000	6.7	1,200	33	6.9	55	490	550	120	9.0
LWDSMP2	250	500	18/07/2017	0.15	100	25	6.4	20,000	9.1	2,400	38	11.0	51	800	1,200	130	15.0
LWDSMP2	500	750	18/07/2017	0.16	100	27	8.8	22,000	9.7	3,400	77	17.0	54	1,000	1,700	120	17.0
LWDSMP2	750	1,000	18/07/2017	0.13	130	23	8.4	19,000	8.2	3,400	91	14.0	42	810	1,600	130	16.0
LWDSMP2	1,000	2,000	18/07/2017	0.18	100	24	8.8	21,000	8.1	3,300	76	10.0	50	1,100	1,500	120	19.0
LWDSMP2	2,000	3,000	18/07/2017	Core refusal	-	-	-	-	-	-	-	-	-	-	-	-	-
LWDSMP3	0	250	18/07/2017	<0.13	540	16	4.5	12,000	5.7	930	67	6.8	100	520	290	250	7.6
LWDSMP3	250	500	18/07/2017	<0.13	100	22	4.7	18,000	7.1	2,000	29	9.9	50	610	810	96	11.0
LWDSMP3	500	750	18/07/2017	0.14	100	28	9.3	23,000	9.6	4,400	190	21.0	66	1,000	1,600	170	18.0
LWDSMP3	750	1,000	18/07/2017	0.16	100	28	8.4	22,000	9.6	3,500	120	18.0	62	1,000	1,500	130	17.0
LWDSMP3	1,000	2,000	18/07/2017	0.17	100	27	9.0	24,,000	10.0	4,300	220	16.0	64	1,200	1,500	200	18.0
LWDSMP3	2,000	3,000	18/07/2017	Core refusal	-	-	-	-	-	-	-	-	-	-	-	-	-
LWDSMP4	0	250	18/07/2017	<0.13	210	14	4.3	10,000	5.6	930	110	6.1	92	630	220	330	9.0
LWDSMP4	250	500	18/07/2017	<0.13	480	17	4.3	13,000	6.6	1,400	49	6.8	55	530	530	100	8.9
LWDSMP4	500	750	18/07/2017	0.16	210	28	7.2	23,000	9.5	2,900	38	14.0	47	900	1,200	98	17.0
LWDSMP4	750	1,000	18/07/2017	0.19	100	31	10.0	25,000	11.0	3,700	42	19.0	57	1,100	1,600	110	22.0
LWDSMP4	1,000	2,000	18/07/2017	0.16	130	29	10.0	24,000	9.0	3,700	48	15.0	42	1,200	1,600	140	22.0
LWDSMP4	2,000	3,000	18/07/2017	0.15	100	28	8.3	23,000	8.8	3,300	40	13.0	40	1,200	1,500	94	19.0

Table B3 Soil monitoring data (2018) — 1 of 2

Location	Start depth	End depth	Sampled date	pH (1:5 Water)	pH (1:5 $CaCl_2$)	Electrical Conductivity (1:5 water)	Chloride	Nitrate Nitrogen	Ammonium Nitrogen	Boron (Hot $CaCl_2$)	Sulphur (KCl-40)	Organic Carbon (W&B[a])	Sodium Adsorption Ratio	Organic Matter (W&B[a] * 1.72)	Phosphorus Colwell	Potassium Colwell	Total Aluminium	Total Cadmium
	mm	mm				µS/cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%		%	mg/kg	mg/kg	mg/kg	mg/kg
LWDSMP1	0	250	26/06/2018	5.7	5.0	100	17	2.7	1.8	0.23	40	0.76	1.4	1.3	12	47	8,600	<0.13
LWDSMP1	250	500	26/06/2018	6.9	5.6	110	20	2.3	1.3	0.38	26	0.41	3.8	0.7	6	31	13,000	<0.13
LWDSMP1	500	750	26/06/2018	8.0	6.6	180	50	3.0	1.3	0.45	26	0.25	3.1	0.4	<5	33	19,000	<0.13
LWDSMP1	750	1,000	26/06/2018	7.5	6.1	260	210	5.5	1.9	0.20	35	0.33	16.0	0.6	<5	38	20,000	<0.13
LWDSMP1	1,000	2,000	26/06/2018	6.9	5.8	350	340	6.0	1.5	0.10	34	0.24	17.0	0.4	9	40	17,000	<0.13
LWDSMP1	2,000	3,000	26/06/2018	6.4	5.4	360	300	4.3	2.0	0.15	54	0.42	15.0	0.7	15	50	15,000	<0.13
LWDSMP2	0	250	26/06/2018	6.0	5.1	220	37	20.0	1.5	0.26	72	1.50	5.4	2.6	17	49	14,000	<0.13
LWDSMP2	250	500	26/06/2018	6.5	5.1	180	61	8.1	1.4	0.35	24	0.29	4.8	0.5	7	38	30,000	<0.13
LWDSMP2	500	750	26/06/2018	8.0	6.6	150	52	7.5	0.7	0.40	18	<0.15	5.2	0.3	9	89	28,000	<0.13
LWDSMP2	750	1,000	26/06/2018	8.7	7.1	150	46	6.5	1.1	0.48	18	<0.15	9.4	0.3	8	110	28,000	<0.13
LWDSMP2	1,000	2,000	26/06/2018	8.2	7.0	310	110	14.0	2.3	0.43	56	0.27	16.0	0.5	20	140	26,000	<0.13
LWDSMP2	2,000	3,000	26/06/2018	7.7	6.6	400	270	3.4	1.1	0.09	57	<0.15	21.0	0.3	9	150	27,000	<0.13
LWDSMP3	0	250	26/06/2018	6.4	6.1	370	<10	2.1	1.6	0.26	230	0.68	1.2	1.2	13	75	13,000	<0.13
LWDSMP3	250	500	14/08/2018	6.9	6.1	240	23	9.3	2.1	0.48	110	0.45	6.1	0.8	8	63	13,000	<0.13
LWDSMP3	500	750	26/06/2018	8.1	7.0	420	200	8.2	1.0	0.28	84	0.17	17.0	0.3	11	40	24,000	<0.13
LWDSMP3	750	1,000	26/06/2018	8.5	7.4	510	320	5.0	1.5	0.22	110	<0.15	16.0	0.3	9	66	35,000	<0.13
LWDSMP3	1,000	2,000	26/06/2018	8.3	7.2	350	150	3.2	1.0	0.11	65	0.18	16.0	0.3	14	85	21,000	<0.13
LWDSMP3	2,000	3,000	26/06/2018	7.7	6.6	390	300	2.3	1.1	0.03	78	<0.15	19.0	0.3	8	110	18,000	<0.13
LWDSMP4	0	250	26/06/2018	6.4	6.2	530	19	17.0	1.6	0.28	300	0.63	1.9	1.1	17	110	10,000	<0.13
LWDSMP4	250	500	14/08/2018	7.1	6.1	230	<10	3.5	2.1	0.41	85	0.54	7.8	0.9	11	110	13,000	<0.13
LWDSMP4	500	750	26/06/2018	7.5	6.2	250	96	4.0	0.8	0.48	31	<0.15	9.0	0.3	10	51	30,000	<0.13
LWDSMP4	750	1,000	26/06/2018	8.2	6.9	210	110	4.0	0.9	0.38	19	<0.15	9.9	0.3	14	96	30,000	<0.13
LWDSMP4	1,000	2,000	26/06/2018	7.8	6.9	320	55	6.0	1.4	0.36	130	0.46	12.0	0.8	19	140	17,000	<0.13
LWDSMP4	2,000	3,000	26/06/2018	8.4	6.8	120	76	2.7	0.9	0.10	11	<0.15	4.3	0.3	11	82	17,000	<0.13

[a] Walkley-Black chromic acid wet oxidation method

Table B4 Soil monitoring data (2018) — 2 of 2

Location	Start depth	End depth	Sampled date	Total Calcium	Total Chromium	Total Copper	Total Iron	Total Lead	Total Magnesium	Total Manganese	Total Nickel	Total Phosphorus	Total Potassium	Total Sodium	Total Sulphur	Total Zinc	Phosphorus (Sat. Ext.)	Sulphur	Hydraulic conductivity
	mm	mm		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/L	mg/L	metres/second
LWDSMP1	0	250	26/06/2018	800	8.9	2.5	7,000	4.5	500	72	4.2	100	300	<300	100	4.7	0.18	180	8.6×10^{-10}
LWDSMP1	250	500	26/06/2018	200	13.0	2.9	10,000	6.0	1,100	57	6.4	100	400	300	100	6.2	0.50	92	9.3×10^{-11}
LWDSMP1	500	750	26/06/2018	<100	18.0	4.5	14,000	8.2	1,900	110	11.0	0	600	800	100	9.3	4.40	18	2.9×10^{-10}
LWDSMP1	750	1,000	26/06/2018	<100	19.0	5.3	15,000	8.4	2,000	85	12.0	0	600	1,000	100	10.0	1.20	150	7.7×10^{-10}
LWDSMP1	1,000	2,000	26/06/2018	300	18.0	4.3	21,000	9.6	1,700	54	9.9	100	500	800	100	11.0	0.10	150	7.1×10^{-10}
LWDSMP1	2,000	3,000	26/06/2018	500	16.0	3.6	13,000	6.4	1,300	43	7.9	100	400	600	100	8.9	0.10	180	2.1×10^{-10}
LWDSMP2	0	250	26/06/2018	2,600	14.0	5.6	10,000	6.5	1,100	59	6.7	100	500	200	100	8.1	0.16	310	2.0×10^{-09}
LWDSMP2	250	500	26/06/2018	500	26.0	6.7	19,000	10.0	2,300	48	12.0	100	800	800	100	15.0	5.20	4	2.8×10^{-10}
LWDSMP2	500	750	26/06/2018	300	25.0	7.3	19,000	9.0	2,500	82	13.0	100	800	1,000	100	14.0	4.80	62	8.2×10^{-10}
LWDSMP2	750	1,000	26/06/2018	200	24.0	8.6	18,000	9.6	3,000	120	14.0	100	900	1,100	100	15.0	7.50	6.3	5.2×10^{-10}
LWDSMP2	1,000	2,000	26/06/2018	700	24.0	8.3	17,000	8.7	3,000	70	12.0	100	900	1,100	100	16.0	0.82	210	8.3×10^{-10}
LWDSMP2	2,000	3,000	26/06/2018	200	25.0	6.4	21,000	9.2	3,100	54	13.0	0	1,200	1,300	200	15.0	0.18	210	1.0×10^{-10}
LWDSMP3	0	250	26/06/2018	2,300	15.0	4.7	11,000	6.0	800	100	7.6	100	500	200	500	8.1	0.21	710	1.2×10^{-09}
LWDSMP3	250	500	14/08/2018	2,100	17.0	15.0	11,000	5.9	1,200	33	7.4	100	400	400	1,200	9.1	0.11	380	1.6×10^{-09}
LWDSMP3	500	750	26/06/2018	100	24.0	6.6	17,000	9.8	2,500	140	13.0	100	700	900	100	13.0	0.97	290	3.9×10^{-10}
LWDSMP3	750	1,000	26/06/2018	<100	28.0	11.0	23,000	10.0	5,200	200	22.0	100	1,200	1,600	200	21.0	0.23	230	1.5×10^{-10}
LWDSMP3	1,000	2,000	26/06/2018	500	22.0	6.2	18,000	9.0	2,800	100	13.0	100	1,000	800	100	13.0	0.28	290	5.6×10^{-10}
LWDSMP3	2,000	3,000	26/06/2018	<100	23.0	6.1	22,000	11.0	2,200	52	8.6	100	800	900	100	13.0	<0.10	250	4.6×10^{-10}
LWDSMP4	0	250	26/06/2018	1700	12.0	3.1	8,100	5.2	700	60	5.5	100	500	200	300	7.5	0.21	810	6.8×10^{-09}
LWDSMP4	250	500	14/08/2018	500	14.0	28.0	9,900	5.5	1,300	28	6.5	0	400	300	200	8.3	0.89	270	5.5×10^{-10}
LWDSMP4	500	750	26/06/2018	<100	29.0	7.7	21,000	10.0	3,000	34	15.0	0	900	1,300	100	17.0	5.70	120	2.9×10^{-09}
LWDSMP4	750	1,000	26/06/2018	<100	28.0	10.0	21,000	9.9	3,500	48	20.0	100	1,000	1,400	100	19.0	4.80	100	8.0×10^{-10}
LWDSMP4	1,000	2,000	26/06/2018	1100	18.0	6.4	13,000	6.6	1,800	75	11.0	100	700	600	200	12.0	0.58	400	1.3×10^{-09}
LWDSMP4	2,000	3,000	26/06/2018	<100	19.0	2.7	16,000	8.0	1,800	17	11.0	0	700	700	0	8.2	5.80	19	9.5×10^{-11}

Table B5 Groundwater monitoring data (LWDMW4)

Chemical name	Unit	Limit of detection	28/03/2017	2/05/2017	27/06/2017	13/09/2017	5/12/2017	14/03/2018	6/06/2018	25/09/2018	3/12/2018
Total Dissolved Solids (Calc.)	mg/L	1	—	—	—	—	—	—	—	—	—
Ionic Balance	%	0.01	4.10	3.33	—	1.14	—	6.04	—	0.46	—
Total Anions	meq/L	0.01	11.4	13.7	—	14.8		17.5	—	15.6	—
Total Cations	meq/L	0.01	10.5	12.9	—	14.4	—	15.5	—	15.5	—
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	102	229	—	257	—	275	—	208	—
Carbonate Alkalinity as $CaCO_3$	mg/L	1	7	< 1	—	< 1	—	< 1	—	< 1	—
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	< 1	< 1	—	< 1	—	< 1	—	< 1	—
Total Alkalinity as $CaCO_3$	mg/L	1	109	229	—	257	—	275	—	208	—
Electrical Conductivity @ 25°C	µS/cm	1	1,180	1,380	—	1,610	—	1,510	—	1,720	—
Total Dissolved Solids @180°C	mg/L	10	696	953	—	867	—	—	—	—	—
Total Dissolved Solids @180°C	mg/L	10	—	—	—	—	—	965	—	925	—
Mercury	mg/L	0.0001	< 0.0001	< 0.0001	—	< 0.0001	—	< 0.0001	—	< 0.0001	—
Calcium	mg/L	1	16	28	—	15	—	8	—	6	—
Magnesium	mg/L	1	4	9	—	10	—	10	—	11	—
Potassium	mg/L	1	20	18	—	16	—	17	—	17	—
Sodium	mg/L	1	204	236	—	286	—	318	—	318	—
Bromide	mg/L	0.010	0.524	0.519	—	0.775	—	0.625	—	0.673	—
Chloride	mg/L	1	255	292	—	327	—	416	—	404	—
Fluoride	mg/L	0.1	0.3	0.2	—	0.3	—	0.2	—	0.2	—
pH – Lab	pH Unit	0.01	8.49	7.71	—	7.61	—	7.22	—	7.08	—
Ammonia as N	mg/L	0.01	0.01	0.03	—	0.06	—	0.03	—	0.02	—
Nitrite as N	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Nitrate as N	mg/L	0.01	< 0.01	0.09	—	< 0.01	—	0.03	—	0.04	—
Reactive Phosphorus as P	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Sulfate as SO_4^{2-}	mg/L	1	98	45	—	19	—	12	—	3	—
Dissolved Oxygen - Field	mg/L	—	0.83	—	3.2	4.2	5.6	1.0	1.6	1.02	3.31
Electrical Conductivity - Field	µS/cm	—	1,206	—	1,291	1,533	1,536	1,641	1,639	1,619	1,629
pH – Field	pH unit	—	8.51	—	7.6	7.4	6.9	7.0	6.94	6.72	6.48
Redox - Field	mg/L	—	—	—	—	-263	-111	-220	-165.4	-208.1	-86
Redox - Field	mV	—	-218.8	—	142	—	—	—	—	—	—
Standing Water Level - Field	mbTOC	—	23.54	—	23.60	23.17	23.45	23.54	23.45	23.53	23.45
Total Dissolved Solids - Field	mg/L	—	786.5	—	863	994	994	—	—	—	—
Turbidity - Field	NTU	—	53.2	—	81	—	—	—	—	—	—
Volume Pumped - Field	L	—	1	—	—	—	1	1	1	1	1
Water Temperature	°C	—	25.1	—	20.4	24.7	22.44	23.2	21.6	20.8	28.6
Methane	µg/L	10	< 10	< 10	—	29	—	1,150	—	—	—
Methane	mg/L	0.01	—	—	—	—	—	—	—	1.11	—
Aluminium	mg/L	0.01	0.03	< 0.01	—	0.04	—	< 0.01	—	< 0.01	—
Arsenic	mg/L	0.001	< 0.001	< 0.001	—	0.002	—	0.002	—	0.001	—
Barium	mg/L	0.001	0.188	0.263	—	0.315	—	0.340	—	0.367	—
Beryllium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—

Chemical name	Unit	Limit of detection	28/03/2017	2/05/2017	27/06/2017	13/09/2017	5/12/2017	14/03/2018	6/06/2018	25/09/2018	3/12/2018
Boron	mg/L	0.05	< 0.05	0.07	—	0.08	—	0.12	—	0.09	—
Cadmium	mg/L	0.0001	< 0.0001	< 0.0001	—	< 0.0001	—	< 0.0001	—	< 0.0001	—
Chromium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Cobalt	mg/L	0.001	< 0.001	< 0.001	—	0.003	—	< 0.001	—	< 0.001	—
Copper	mg/L	0.001	< 0.001	0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Iron	mg/L	0.05	< 0.05	1.00	—	4.64	—	2.83	—	4.15	—
Lead	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Manganese	mg/L	0.001	0.037	0.272	—	0.465	—	0.260	—	0.200	—
Molybdenum	mg/L	0.001	0.034	0.012	—	0.002	—	< 0.001	—	< 0.001	—
Nickel	mg/L	0.001	< 0.001	< 0.001	—	0.002	—	0.001	—	< 0.001	—
Rubidium	mg/L	0.001	0.029	0.025	—	0.019	—	0.020	—	0.019	—
Selenium	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Strontium	mg/L	0.001	0.380	0.306	—	0.133	—	0.093	—	0.081	—
Uranium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Vanadium	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Zinc	mg/L	0.005	< 0.005	< 0.005	—	< 0.005	—	< 0.005	—	< 0.005	—

Table B6 Groundwater monitoring data (LWDMW5)

Chemical name	Unit	Limit of detection	28/03/2017	2/05/2017	27/06/2017	13/09/2017	5/12/2017	14/03/2018	6/06/2018	25/09/2018	3/12/2018
Total Dissolved Solids (Calc.)	mg/L	1	—	—	—	—	—	—	—	—	—
Ionic Balance	%	0.01	4.21	3.68	—	1.85	—	7.75	—	0.24	—
Total Anions	meq/L	0.01	12.4	13.0	—	13.7	—	16.2	—	14.5	—
Total Cations	meq/L	0.01	11.4	12.1	—	13.2	—	13.8	—	14.6	—
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	187	192	—	220	—	222	—	170	—
Carbonate Alkalinity as $CaCO_3$	mg/L	1	< 1	< 1	—	< 1	—	< 1	—	< 1	—
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	< 1	< 1	—	< 1	—	< 1	—	< 1	—
Total Alkalinity as $CaCO_3$	mg/L	1	187	192	—	220	—	222	—	170	—
Electrical Conductivity @ 25°C	µS/cm	1	1,270	1,320	—	1,510	—	1,420	—	1,600	—
Total Dissolved Solids @180°C	mg/L	10	760	1260	—	837	—	—	—	—	—
Total Dissolved Solids @180°C	mg/L	10	—	—	—	—	—	897	—	822	—
Mercury	mg/L	0.0001	< 0.0001	< 0.0001	—	< 0.0001	—	< 0.0001	—	< 0.0001	—
Calcium	mg/L	1	4	2	—	4	—	3	—	3	—
Magnesium	mg/L	1	7	5	—	5	—	5	—	5	—
Potassium	mg/L	1	13	12	—	12	—	12	—	13	—
Sodium	mg/L	1	236	260	—	283	—	298	—	314	—
Bromide	mg/L	0.010	0.786	0.675	—	0.871	—	0.766	—	0.853	—
Chloride	mg/L	1	304	326	—	330	—	414	—	390	—
Fluoride	mg/L	0.1	0.5	0.4	—	0.5	—	0.3	—	0.3	—
pH – Lab	pH Unit	0.01	7.35	7.26	—	7.51	—	6.98	—	7.12	—
Ammonia as N	mg/L	0.01	< 0.01	0.02	—	0.03	—	0.03	—	0.02	—
Nitrite as N	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	0.01	—	< 0.01	—
Nitrate as N	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	0.08	—
Reactive Phosphorus as P	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Sulfate as SO_4^{2-}	mg/L	1	3	1	—	1	—	2	—	4	—
Dissolved Oxygen - Field	mg/L	—	1.56	—	3.9	1.01	0.65	0.2	0.82	1.07	3.19
Electrical Conductivity - Field	µS/cm	—	1,304	—	1,196	1,446	1,445	1,575	1,567	1,534	1,550
pH - Field	pH unit	—	7.31	—	7.1	7.8	6.9	6.7	6.94	6.67	6.33
Redox - Field	mg/L	—	—	—	—	-320	-115	-161	-143.6	-166	-85
Redox - Field	mV	—	-138.1	—	101	—	—	—	—	—	—
Standing Water Level - Field	mbTOC	—	25.24	—	25.2	25.19	25.27	25.20	25.23	25.24	25.2
Total Dissolved Solids - Field	mg/L	—	845	—	777	942	942	—	—	—	—
Turbidity - Field	NTU	—	26.7	—	62	—	—	—	—	—	—
Volume Pumped - Field	L	—	—	—	—	—	1	1	1	1	1
Water Temperature	°C	—	24.1	—	21.2	25.0	25.27	22.7	20.4	20.9	29.2
Methane	µg/L	10	19	136	—	437	—	555	—	—	—
Methane	mg/L	0.01	—	—	—	—	—	—	—	0.526	—
Aluminium	mg/L	0.01	< 0.01	< 0.01	—	0.03	—	< 0.01	—	< 0.01	—
Arsenic	mg/L	0.001	< 0.001	0.003	—	0.002	—	0.002	—	0.002	—
Barium	mg/L	0.001	0.395	0.193	—	0.395	—	0.352	—	0.314	—
Beryllium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—

Chemical name	Unit	Limit of detection	28/03/2017	2/05/2017	27/06/2017	13/09/2017	5/12/2017	14/03/2018	6/06/2018	25/09/2018	3/12/2018
Boron	mg/L	0.05	0.08	0.10	—	0.10	—	0.15	—	0.13	—
Cadmium	mg/L	0.0001	< 0.0001	< 0.0001	—	< 0.0001	—	< 0.0001	—	< 0.0001	—
Chromium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Cobalt	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Copper	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Iron	mg/L	0.05	5.34	6.35	—	6.38	—	4.95	—	4.61	—
Lead	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Manganese	mg/L	0.001	1.01	0.408	—	0.710	—	0.471	—	0.320	—
Molybdenum	mg/L	0.001	0.004	0.003	—	0.001	—	< 0.001	—	< 0.001	—
Nickel	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	0.002	—	< 0.001	—
Rubidium	mg/L	0.001	0.013	0.012	—	0.012	—	0.013	—	0.013	—
Selenium	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Strontium	mg/L	0.001	0.061	0.041	—	0.046	—	0.043	—	0.039	—
Uranium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Vanadium	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Zinc	mg/L	0.005	< 0.005	< 0.005	—	0.007	—	< 0.005	—	< 0.005	—

Table B7 Groundwater monitoring data (LWDMW6)

Chemical name	Unit	Limit of detection	28/03/2017	2/05/2017	27/06/2017	13/09/2017	5/12/2017	14/03/2018	6/06/2018	25/09/2018	3/12/2018
Total Dissolved Solids (Calc.)	mg/L	1	—	650	—	—	—	—	—	—	—
Ionic Balance	%	0.01	3.72	2.19	—	5.05	—	7.08	—	1.44	—
Total Anions	meq/L	0.01	11.1	11.4	—	11.6	—	13.6	—	12.2	—
Total Cations	meq/L	0.01	10.3	11.0	—	12.8	—	11.8	—	11.8	—
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	120	99	—	109	—	93	—	75	—
Carbonate Alkalinity as $CaCO_3$	mg/L	1	< 1	< 1	—	< 1	—	< 1	—	< 1	—
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	< 1	< 1	—	< 1	—	< 1	—	< 1	—
Total Alkalinity as $CaCO_3$	mg/L	1	120	99	—	109	—	93	—	75	—
Electrical Conductivity @ 25°C	µS/cm	1	1,170	1,200	—	1,340	—	1,240	—	1,380	—
Total Dissolved Solids @180°C	mg/L	10	657	—	—	738	—	—	—	—	—
Total Dissolved Solids @180°C	mg/L	10	—	—	—	—	—	744	—	692	—
Mercury	mg/L	0.0001	< 0.0001	< 0.0001	—	< 0.0001	—	< 0.0001	—	< 0.0001	—
Calcium	mg/L	1	5	4	—	5	—	4	—	4	—
Magnesium	mg/L	1	8	6	—	7	—	6	—	6	—
Potassium	mg/L	1	13	14	—	15	—	14	—	14	—
Sodium	mg/L	1	208	228	—	267	—	248	—	248	—
Bromide	mg/L	0.010	0.770	0.772	—	1.06	—	0.901	—	0.912	—
Chloride	mg/L	1	302	328	—	327	—	406	—	370	—
Fluoride	mg/L	0.1	0.2	0.2	—	0.2	—	0.2	—	0.1	—
pH – Lab	pH unit	0.01	7.03	6.81	—	7.15	—	6.70	—	6.75	—
Ammonia as N	mg/L	0.01	< 0.01	< 0.01	—	0.06	—	0.02	—	0.03	—
Nitrite as N	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	0.01	—	< 0.01	—
Nitrate as N	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	0.08	—
Reactive Phosphorus as P	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Sulfate as SO_4^{2-}	mg/L	1	8	11	—	9	—	16	—	12	—
Dissolved Oxygen - Field	mg/L	—	0.52	—	4	0.5	0.4	0.5	1.00	1.49	2.71
Electrical Conductivity - Field	µS/cm	—	1,200	—	1,200	1,303	1,226	1,368	1,343	1,330	1,335
pH – Field	pH Unit	—	6.94	—	6.8	7.7	6.7	6.5	6.71	7.17	6.18
Redox - Field	mg/L	—	—	—	—	-329	-119	-157	-104.6	153	-105
Redox - Field	mV	—	-130.8	—	58	—	—	—	—	—	—
Standing Water Level - Field	mbTOC	—	20.29	—	20.50	20.21	20.08	20.26	20.28	20.28	20.19
Total Dissolved Solids - Field	mg/L	—	780	—	784	845	800	—	—	—	—
Turbidity - Field	NTU	—	23.1	—	85	—	—	—	—	—	—
Volume Pumped - Field	L	—	—	—	—	—	1	1	1	1	1
Water Temperature	°C	—	24.8	—	20.5	24.1	20.08	24.1	20.8	26.1	29.5
Methane	µg/L	10	< 10	44	—	169	—	147	—	—	—
Methane	mg/L	0.01	—	—	—	—	—	—	—	0.106	—
Aluminium	mg/L	0.01	< 0.01	< 0.01	—	0.04	—	< 0.01	—	< 0.01	—
Arsenic	mg/L	0.001	< 0.001	0.001	—	0.001	—	0.001	—	0.002	—
Barium	mg/L	0.001	0.371	0.229	—	0.380	—	0.282	—	0.250	—
Beryllium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—

Chemical name	Unit	Limit of detection	28/03/2017	2/05/2017	27/06/2017	13/09/2017	5/12/2017	14/03/2018	6/06/2018	25/09/2018	3/12/2018
Boron	mg/L	0.05	0.05	0.06	—	0.10	—	0.09	—	0.08	—
Cadmium	mg/L	0.0001	< 0.0001	< 0.0001	—	< 0.0001	—	< 0.0001	—	< 0.0001	—
Chromium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Cobalt	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Copper	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Iron	mg/L	0.05	7.62	10.2	—	8.46	—	5.57	—	4.73	—
Lead	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Manganese	mg/L	0.001	0.695	0.429	—	0.412	—	0.193	—	0.131	—
Molybdenum	mg/L	0.001	0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Nickel	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Rubidium	mg/L	0.001	0.013	0.012	—	0.016	—	0.014	—	0.015	—
Selenium	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Strontium	mg/L	0.001	0.073	0.050	—	0.064	—	0.053	—	0.052	—
Uranium	mg/L	0.001	< 0.001	< 0.001	—	< 0.001	—	< 0.001	—	< 0.001	—
Vanadium	mg/L	0.01	< 0.01	< 0.01	—	< 0.01	—	< 0.01	—	< 0.01	—
Zinc	mg/L	0.005	< 0.005	< 0.005	—	0.014	—	< 0.005	—	< 0.005	—

Appendix C

Clarification on the location of 25 individual plots

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Table C1: Clarification of the location of the 25 individual plots

Plot No.	Biometric Vegetation Type	OEH Notes	Justification
295	NA117	-	While over-storey was recorded at 0.5 per cent, mid-storey was recorded at 6.7 per cent at this plot. There were only occasional mature trees (>10 m), with most trees being between five and 10 m in height. Data was recorded in accordance with the FBA which states that over-storey is 'the tallest woody stratum present (including emergent)'. This plot is more representative of 'native vegetation' than 'derived native grassland' and has been assigned appropriately.
48	NA121	-	This plot is located in 'Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion' which is a shrubland community with occasional emergent trees. No emergent trees were recorded at this plot and therefore no canopy was recorded in accordance with the FBA. Furthermore, the PCT description for this community only includes trees in the upper stratum which were not recorded at this plot location (but are known from the broader patch).
298	NA179	Very open location	This plot has a recorded canopy of five per cent. The plot is located in a roadside remnant and has been appropriately assigned to the 'native vegetation' condition state.
316	NA179	Very open location	This plot is located within an open grassy woodland with both canopy cover (four per cent) and mid-storey cover (13 per cent) recorded. This plot has been appropriately assigned to the 'native vegetation' condition state.
221	NA179	House paddock	This plot is located in a patch of native vegetation adjoining a farmhouse. Whilst recording low overall canopy cover (two per cent), the scattered trees present are approximately 18 m in height. With a high diversity of native species and remnant canopy present, this plot has been appropriately assigned to the 'native vegetation' condition state.
91	NA179	Thick cypress	This plot is located in a patch of native vegetation with scattered trees approximately 20 m in height with a dense Cypress Pine mid-storey. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
20	NA255	Creek bed	This plot is located on the floodplain of Bohena Creek. At this particular location, mature trees are naturally wide-spaced (20 to 30 m) which means very few trees were present within the 20 by 50 m plot. The low canopy cover is representative of a single canopy observation of 50 per cent cover at one point (out of 10) along the 50 m transect. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
267	NA255	Creek bed	This plot is located in the creek bed of Bohena Creek and was positioned to sample the instream vegetation. Despite not having a canopy or mid-storey present, the plot is in good condition with a high diversity of native species, high cover of grasses, fallen logs and a hollow-bearing tree within the broader 20 by 50 m plot. The vegetation at this plot is not derived, but part of the broader native plant community type associated with Bohena Creek and has therefore been appropriately assigned to the 'native vegetation' condition state.

Plot No.	Biometric Vegetation Type	OEH Notes	Justification
175	NA255	Creek edge	This plot is located on the banks of an ephemeral creek (Cowallah Creek). Canopy in this location is naturally sparse, with mature trees largely confined to the banks of the channel. This plot has a moderate diversity of native species, high grass cover, high length of fallen logs and a hollow-bearing tree which represents good condition vegetation. This plot has been appropriately assigned to the 'native vegetation' condition state.
268	NA255		This plot is located on the bed of an ephemeral creek (a side channel of Bohena Creek) which has very few mature trees present. Despite the low over-storey cover (three per cent), the plot has a moderate diversity of native species, high grass and other ground cover, as well as a large number of hollow-bearing trees in the broader 20 by 50 m plot which represents good condition vegetation. This plot has been appropriately assigned to the 'native vegetation' condition state.
269	NA255	Creek bed	This plot is located on the bed of Bohena Creek which has very few mature trees present. Despite the low over-storey cover (0.5 per cent), the plot has a mid-storey cover of four per cent, a high diversity of native species and moderate grass, shrub and other groundcover which represents good condition vegetation. This plot samples natural variation which occurs in this community across the landscape. This plot has been appropriately assigned to the 'native vegetation' condition state.
119	NA307	Single tree on roadside	This plot is located in remnant vegetation in a road reserve with trees at approximately 30 m spacing which represents the average tree spacing within this community in the project area. Despite the wide tree spacing, a high diversity of native species, moderate grass and other ground cover, and fallen logs within the broader 20 by 50 m plot were recorded which represents good condition vegetation. This plot has been appropriately assigned to the 'native vegetation' condition state.
105	NA314	Roadside	This plot has a canopy cover of 31.6 per cent. The plot is located in a roadside remnant and has been appropriately assigned to the 'native vegetation' condition state.
11	NA314	Thick bush (no large trees)	This plot is located in a patch of native vegetation with scattered trees approximately 15 to 20 m in height with a dense *Acacia* mid-storey. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
15	NA314	Thick bush	This plot is located in a patch of native vegetation with scattered trees approximately 20 m in height with a dense Cypress Pine mid-storey. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.

Plot No.	Biometric Vegetation Type	OEH Notes	Justification
06	NA314	No overstory	While this plot has low canopy cover (1.5 per cent), it has high mid-storey cover (10.6 per cent) which is indicative of the vegetation in the broader patch which has widely spaced canopy trees (>25 m) and a dense Cypress Pine mid-storey. Despite the low cover, the plot had a high diversity of native species, high grass, shrub and other ground cover as well as a large length of fallen logs in the broader 20 by 50 m plot which represents good condition vegetation. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
14	NA314	Thick bush near well pad	While this plot has no canopy cover recorded, it has high mid-storey cover (13.5 per cent) which is indicative of the vegetation in the broader patch which has widely spaced canopy trees (approximately 50 m spacing) and a dense Cypress Pine mid-storey. Despite the lack of canopy cover, the plot has a high diversity of native species, high grass, shrub and other groundcover as well as hollow-bearing trees and logs in the broader 20 by 50 m plot which represents good condition vegetation. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
96	NA314	No overstory	While this plot has no canopy cover recorded, it has high mid-storey cover (12.2 per cent) which is indicative of the vegetation in the broader patch which has been subject to intense wildfire and is in a state of recovery. The plot has a dense mid-storey cover of regenerating Eucalypts and *Acacia* species. Despite the lack of canopy cover, the plot has a high diversity of native species, high grass, shrub and other groundcover as well as a large length of logs in the broader 20 by 50 m plot which represents good condition vegetation. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
165	NA314		This plot has a recorded canopy cover of 19 per cent. While it is likely to have been subject to disturbance in the past, it has a moderate diversity of native species, a moderate cover of grasses and shrubs and a high length of logs in the broader 20 by 50 m plot which represents good condition vegetation. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
46	NA 390	No overstory	While this plot has low canopy cover (0.2 per cent), it has moderate mid-storey cover (6.7 per cent) which is indicative of the vegetation in the broader patch which has widely spaced canopy trees (30 to 50 m) and a dense low shrub layer. Despite the low cover, the plot had a moderate diversity of native species, high grass and shrub cover as well as a number of hollow-bearing trees and a large length of fallen logs in the broader 20 by 50 m plot which represents good condition vegetation. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.

Plot No.	Biometric Vegetation Type	OEH Notes	Justification
250	NA 390	No overstory	While this plot has low canopy cover (two per cent), it has high mid-storey cover (18.5 per cent) which is indicative of the vegetation in the broader patch which has widely spaced canopy trees (>50 m) and a dense Cypress Pine mid-storey. Despite the low cover, the plot had a high diversity of native species, and moderate grass, shrub and other ground cover as well as fallen logs in the broader 20 by 50 m plot which represents good condition vegetation. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
98	NA 390	No overstory	While this plot has low canopy cover (two per cent), it has moderate mid-storey cover (11.5 per cent) which is indicative of the vegetation in the broader patch which has widely spaced canopy trees (>50 m) and a dense Cypress Pine mid-storey. Despite the low cover, the plot had a high diversity of native species, and moderate grass, shrub and other ground cover as well as hollow bearing trees and fallen logs in the broader 20 by 50 m plot which represents good condition vegetation. Data has been recorded in accordance with the FBA at this site. This plot has been appropriately assigned to the 'native vegetation' condition state.
260	40X DNG	Well pad – assigned to DNG	This plot has been mapped as 'cleared' and has been subject to previous approval and development. The vegetation present is actively being regenerated. Data from this plot has been used as part of the 'derived native grassland' credit calculations for this PCT. Due to a high diversity of native species, high grass, shrub and other ground cover as well as a large length of fallen logs in the broader 20 by 50 m plot, data from this site is likely to have increased the value of derived native grassland assessed for this PCT within the project area.
109	401 DNG	Road	This plot has been mapped as 'cleared' and has been subject to previous approval and development. The vegetation present is actively being regenerated. Data from this plot has been used as part of the 'derived native grassland' credit calculations for this PCT. Due to a high diversity of native species, as well as hollow-bearing trees and fallen logs in the broader 20 by 50 m plot, data from this site is likely to have increased the value of derived native grassland assessed for this PCT within the project area.
108	398 DNG	Road	This plot has been mapped as 'cleared' and has been subject to previous approval and development. The vegetation present is actively being regenerated. Data from this plot has been used as part of the 'derived native grassland' credit calculations for this PCT. Data from this plot is considered equivalent with other derived grasslands from this PCT in the project area.

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