TERRESTRIAL ECOLOGY ISSUES WITHIN THE RESPONSE TO SUBMISSIONS DOCUMENTATION FOR THE NARRABRI GAS PROJECT.

Including

1. Review of biodiversity matters within Response to Submissions
2. Expert Report on adequacy of response to issues within submissions from Upper Mooki Landcare Inc

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Review: Biodiversity issues within the Response to Submissions documentation for the Narrabri Gas Project.

By David Paull

This report includes a review of the relevant sections of the Narrabri Gas Project (Project) Response to Submissions (RtS) documents. The report has been prepared in accordance with the Code of Conduct and Division 2 of Part 31 of the *Uniform Civil Procedure Rules 2005*.

Outstanding issues and further observations will be discussed in relation to submissions made to the Environmental Impact Statement (EIS) for the Project on behalf of the Upper Mooki Landcare Inc (UML). These include the following:

- Expert Review: Narrabri Gas Project, Terrestrial Ecology
- Survey of Bohena Creek riparian plant communities (Ethical Ecology)
- Koala survey within PEL 238, October/November 2016 and assessment of significance of impact (Ethical Ecology)
- OWAD Environmental (2016). Pilliga East State Forest Koala Survey. Report to Western Woodlands Alliance.

One additional supporting document with new data is attached to this review, "Study on the success of rehabilitation at gas infrastructure within PEL238" (Pilliga Environment Group, June 2018).

Key outstanding issues

There are many unresolved issues for Terrestrial and Aquatic Ecology in RtS. The main new observations or those key issues raised by the RtS are, in my view:

- The question of whether **Box Gum Woodland** exists in the Project area relies on Santos' interpretation of the applicability of the listing criteria to the ecological community in question. This interpretation warrants further scrutiny.
- Offset liability for **Koala** was increased to cover the entire modelled footprint. This may have been in response to issues raised by submissions to the EIS about the habitat suitability for this species. I do not believe this approach deals with the outstanding issues of lack of baseline data, particularly for the Koala, and lack of due diligence. There is also a failure to deal with specific assessment requirements for a number of other **species credits** and **matters for further consideration**.
- Claims in the RtS on the success of **rehabilitation** has prompted Santos to claim more offset credits from rehabilitation to offset Project impacts. Work detailed in the attached report shows that the soil conditions and the overall observed levels of native regrowth at well rehabilitation and spill sites is poor. My view is that many false and misleading statements have been made about the success of rehabilitation in the EIS and RtS. This information requires further verification and independent expert review.
- The proposed **offset strategy** has failed its objectives to show some feasibility, with no actual offset areas to date identified and credits tabled. The issue of the value of biodiversity credits generated by the site rehabilitation raised in the RtS and the efficacy of the feral control program weaken the transparency of the strategy.
- The **Stygofauna and Bohena Groundwater Dependent Ecosystem (GDE)** issues remain unresolved. Santos has questioned the need to accurately describe the Bohena Creek stygofauna and alluvium, associated with the most important water way in the Project area. Santos have also stated they have no intention to monitor the surface GDEs because they don't anticipate any impact, despite modelling expected drawdown.

1. Review of RtS Documents

Comments on RtS "Executive Summary"

1. The RtS Executive Summary identifies that the most commonly raised issues in the submissions were groundwater/geology and terrestrial ecology, reflecting the concern of the public for these issues. Aquatic ecology issues did not feature highly in public submissions, but this does not mean the shortcomings in Santos' aquatic ecology assessment are not significant.

2. The submissions have prompted Santos to undertake a number of additional ecological studies to fill gaps identified.

3. The presence/absence of Box Gum Woodland Critically Endangered Ecological Community (CEEC)/ Endangered Ecological Community (EEC) is a significant issue for the Project because its critically endangered status makes it a Commonwealth matter of national environmental significance (MNES). Recognition of an additional CEEC/EEC along Bohena Creek (additional to the Fuzzy Box and Carbeen Forest EECs identified in the RtS) also has consequences for how GDEs are described and assessed in this system.

4. The Executive Summary states unequivocally that Box Gum Woodland is not present in the Project area and that Yellow Box is also either absent or '… *occurs at such a low abundance to be meaningless in terms of plant composition*'.

   It can be shown by new site data and within submissions received by Santos in response the EIS that Box Gum Woodland is present in the Project area and Yellow Box is also present. Details are discussed below.

5. Extra Biometric Plots were undertaken by Santos in the RtS to fill some gaps in the EIS coverage of different ecosystem data, in order to satisfy the requirements of the Framework for Biodiversity Assessment (FBA) for the Project Offset Strategy. The Strategy has been updated in the RtS. Though a revised offset requirement has been calculated, there is still no offset lands identified in the Strategy and the ability to retire the necessary credits has not been demonstrated.

6. Additional surveys in the RtS for the two *Lepidium* species has led to an upwards revision of the predicted upper disturbance limit, reflecting the relatively high densities of these species.

7. The conclusions that the Project will cause a low environmental impact with low levels of residual impacts is challenged in this report, given the gaps in the assessment that are still outstanding, question marks concerning the effectiveness of the Rehabilitation Strategy and the additional impacts not considered in the EIS.

Comments on RtS "The Project"

8. While justifying the location of the Project, Santos has tried to address concerns about gas activity in and around Yarrie Lake and the two Brigalow State Conservation Areas. These locations remain in the Project area with a commitment not to conduct any activities inside the SCAs and to establish a buffer of at least 50 m around Yarrie Lake Reserve (presumably around the boundary).

9. These assurances should be embedded in any consent conditions, though these commitments fall below the standard which should apply, in that **buffers** around wetlands should be much more substantial (at least 80m according to NSW Office of Water (NOW) Guidelines 2012) and no buffers are being proposed for the SCAs. These critically endangered Brigalow remnants support a population of the endangered Black-striped Wallaby as well as a number of threatened plant species. Significant buffers for gas activity should be established for these sensitive patches of vegetation.

10. The RtS states on one hand that there are no changes in the description of the Project yet go on to describe **additional** 'drilling support facilities' at Bibblewindi and Leewood. Perhaps the fact that these facilities are to be constructed on already cleared lands has lead Santos to claim there is no change to the Project, however in my opinion, other impacts may potentially arise due to noise, air and water environments. These will be additional to those impacts considered in the EIS.

Comments on RtS Response to Forestry Corporation of NSW

11. It is interesting to note that Santos is still in discussions with the **Rural Fire Service** (RFS) on 'bushfire management' with respect to gas operations in the Pilliga. Santos is 'committed' but can shed no light on how this management may reduce fire risk posed by the proposed gas operations. While a 'Bushfire Management Plan' currently exists, it seems this will be upgraded following further collaboration with Forestry and the RFS.

12. Santos' visible understanding and consideration of past **activities and current operations** in the Pilliga Forests is very limited. This may create issues in the future for Santos as there is the potential that they have under-estimated fire risks associated with wood dumps and other forestry residues. A lack of allowance for forestry activities means unaccounted for, possible restrictions to gas field activities. Forestry Corp are still conducting operations within the Project area.

13. For **asset protection** measures, Santos provide the statement, "*It is not expected that Forestry Corp would carry out bushfire management activities for the protection of project infrastructure. As a result, it is not expected that the project would restrict bushfire management activities undertaken by Forestry Corp*." Forestry Corp manage their forest through hazard reduction burning when and where appropriate, this is to manage bushfires. The fact that a large area of forest will be hatched with wells and infrastructure will add logistical issues those Forest Corp need to consider when undertaking hazard reduction burns.

14. Buffers of retained vegetation to protect sensitive sites from indirect impacts have been applied in the EIS. However, it is clear that a 50m buffer as proposed would be insufficient to protect the viability of currently occupied **Barking Owl roosting/breeding sites**, based on other scientific studies. Kavanagh (2002) show how forest prescriptions for protecting known areas of owl occupancy should use a buffer of 2 km from the nest-site. The 50 m distance is also found in the forestry prescriptions to protect any hollow bearing trees which could be suitable roosting sites for owls, but are applied only to sites which are not currently being occupied by owls.

15. A review of rehabilitation matters is outlined in the Rehabilitation section below.

Comments on RtS Response to Local Land Services

16. Local Land Services (LLS) make the important point that approving a project such as this, without other stakeholders knowing where the impacts will occur, is a great concern for land managers in the region. While networks of new tracks and infrastructure can cause declines in

biodiversity in large remnants, fragmenting small, often linear, remnants of native vegetation such as that found in **Travelling Stock Routes** has a proportionately bigger effect.

17. The way in which Santos have approached the development consent (not identifying the gas field footprint), creates great **uncertainty** in the community. It also means that future impacts cannot be properly anticipated which can lead to future unplanned management issues.

Comments on RtS Response to Office of Environment and Heritage

18. Office of Environment and Heritage (OEH) had posed changes to the **plant community identity** for several plots, but Santos it seems has rejected all suggested changes. This should be questioned given inaccuracies on the identity of Box Gum Woodland in the Project area (see further discussion of this below).

19. Santos have contended that changes to the **ecological sensitivity analysis** as suggested by OEH will make a negligible difference to the quantum of the result. This may be the case, however changes to an analysis which would provide a more accurate weighting (i.e. more scientifically robust) should be adopted regardless of whether the Proponent suggests the differences in values would be 'negligible'.

20. Santos have clarified that the credits they generate at rehabilitation sites are to be used to reduce the overall **impact liability** of the Project. On request from OEH that these credits be included in the offset strategy, Santos have said they intend to generate biodiversity credits from rehabilitation efforts over half the impact area (500 ha). Santos estimate the credits generated by this to be approximately one third of the total offset liability of the Project. In addition, Santos have requested a further 15% credit benefit from their rehabilitation program.

21. However, the quantum of credits being claimed for rehabilitation sites by Santos is based on the assertion that sites currently show a similarity of 74% to the natural benchmark conditions and are on a trajectory for becoming natural communities. Santos provide no verifiable data to support their claim in the Rehabilitation Plan (Appendix V of EIS) or in the RtS other than Figure 5 of the Plan which shows differences in 'site quality' for a number of sites. How this indice was calculated is not clear. Site inspections of well sites in PEL238 undertaken independently (Pilliga Environment Group 2018) show that species diversity on the whole is low compared to biometric benchmarks, as is vegetation cover, particularly at ground-storey and understorey layers. Weeds at well sites are also common but absent from nearby bushland and soil conditions at well sites are sub-optimal for the growth of native vegetation. See review of rehabilitation section below.

22. The use of modelled '**upper disturbance limits**' is a substitute for a more precise indication of where infrastructure is to be located, which is typically how major projects are assessed. How these limits are calculated uses a likelihood of impact approach based on the proportion of land that community occupies in the Project area. This approach does not include consideration of avoidance, and as such, is not consistent with the current assessment and offset set of principles in use by the NSW Government.

23. The **Scouting Framework** also gives no surety that avoidance of threatened communities and habitat of threatened species can be undertaken, due to the ambiguous way the Framework is worded. On the one hand, Santos claim to follow avoidance principles, yet also state that there may be limited ability to relocate sites. Once the site location has been established, the scope to move equipment within the site for avoidance is very limited. The NSW Government should reject the use of upper disturbance limits as being contrary to the principles of avoidance.

24. OEH state that the credit liability for **indirect impacts** should be calculated over the whole buffer area and not a 'likely maximum extent' as determined by Santos. In the past it has been the practice to use buffer widths to describe a likely extent of indirect impact. Santos' however have used their own 'extents' based on a number of quantified assumptions. They have used a 'reduced extent' which is based on some assumptions on the effectiveness of mitigation measures as a means to calculate indirect biodiversity credit liability. While some of these assumptions are questionable, Santos have stated that they are under no legal requirement to provide an indirect impact credit liability for the Project. In my opinion, accepting that position must be considered an oversight for an adequate consideration of the impacts of this Project, particularly as, while Secretary's Environmental Assessment Requirements (SEARs) from the NSW Government did not specifically require such as assessment, the conditions provided by the Commonwealth did.

25. In their submission to the EIS, OEH requested Santos provide "*further assessment and offset credit liability for the Koala or an expert report to further assess the potential for Koala to be present in the project area*". Santos have not undertaken any further surveys to verify the true extent of preferred **Koala** habitat in the Pilliga or if indeed there are any Koala present in the project area as contended by OEH and UML submissions. They were also given the option to provide a further expert report on the matter but have failed to do so.

    Instead they have calculated the offset liability without using the guidance provided for Koala habitat preferences in the Biometric threatened species database or the available literature. The RtS states that 988 ha of potential habitat will be impacted, this is in fact the total area of ALL communities directly impacted by the Project and not just potential Koala habitat. This creates an overly cautious yet inaccurate estimate of koala habitat directly impacted.

    Santos have not fulfilled OEH's request for further information in an accurate or transparent manner.

26. Santos are correct to point out that the **Spotted-tailed Quoll** is an ecosystem credit species and so does not require specific targeted survey effort other than what was undertaken in routine fauna surveys, according to the FBA. It was also not identified as a 'matter for further consideration' by OEH.

27. However, the **Rufous Bettong** is a species credit species and should have been subject to specific targeted surveys. Santos claim that they are not known from the Project area and so not worth attempting a specific effort. This is not a convincing argument, as bettongs have in fact been sighted in the Pilliga in the last 10 years with a reliable account by Ford and McAlpine (2008) and with BioNet records in the last few years from the Dandry Creek area. The fact that they have never been sighted in the Project area may be because they are very

rare and threatened, not because they are not present. Santos stated they undertook eight times the minimum survey effort for the baseline fauna surveys using techniques that would have detected this species. However, targeted surveys are not designed to catch the most number of species (as baseline surveys are) but are guided by specific targeting of habitat suitable for the species in question. A large baseline survey effort therefore may miss key habitat for the target species, reducing chances of detection. Santos compounds this problem by incorrectly identifying what constitutes Rufous Bettong habitat in their EIS. They clarify the habitat preferences of the Rufous Bettong on Page 5-117 of the RtS at the request of OEH but all this suggests that (a) Santos never properly undertook targeted surveys for this species and (b) were mistaken about what constitutes Rufous Bettong habitat so that targeted surveys could not have been properly undertaken.

28. No additional effort was put into investigating further records of ***Myriophyllum implicatum*** despite request from OEH to justify the statement that this species would not be impacted.

Comments on RtS "Rehabilitation"

29. Santos have repeatedly stated that current rehabilitation is on track to meeting **completion targets**, in terms of species composition and vegetation structure at the sites, for example: "*Rehabilitation to date shows similar numbers of native species to reference sites, is dense shrub layer, relatively low weed cover and regeneration of overstorey through coppice regrowth*." These and other statements have been examined in the attached independent study of the soil and vegetation conditions currently found at existing well sites in PEL238 (Pilliga Environment Group 2018).

30. In terms of both vegetation cover and species diversity, two thirds of the well sites are currently in a poor quality with low to no vegetation cover and a poor species diversity. Many sites are supporting weeds.

31. Twenty well sites show a high plant cover in at least one layer, generally the mid-storey, which is usually dominated by *Acacia spectablis* and/or *A. deanii.* Groundstorey is usually the poorest component, though some sites show good recovery. Only one site DH09 was found to be on a trajectory to become self-sustaining and meeting benchmark criteria. The soil conditions at this site were normal.

32. Most sites showed sub-surface pH levels above the background levels of the reference system. High levels of pH at well sites will inhibit the development of the naturally occurring community. Double the background levels of salt in some samples from the sub-surface soil at the spill sites may also inhibit the recovery in these areas. Site rehabilitation should also include soil restoration with targets to achieve more acidic top-soils.

33. Sites subject to active regeneration are young and given constraints associated with soil conditions at these spill sites, their success remains unresolved.

34. Top-soil management is regarded as a priority for successful rehabilitation, and many assertions are provided here and in the Rehabilitation Plan on the ability of Santos to promote regeneration through good top-soil management. Even though Santos are proposing to strip and stock-pile the top-soil at the well sites and then use this material to restore the site, this

has never been attempted before in the Pilliga to my knowledge and questions about the longevity of the seedbank and biotic components of the soil remain.

35. The claim by Santos that they have achieved success at some sites because of coppiced growth is also very misleading because at most sites all stumps have been removed and so cannot be used as a standard approach for overstorey generation. Use of canopy species as indicators of success should always include the presence of all canopy dominants, including White and Black Cypress Pine and Bull Oak when present at reference sites. These species are conspicuously absent from current rehabilitation sites.

36. In my opinion, it is likely that there will be some spillage of produced water and/or drilling fluids on sites as a result of routine activities associated with gas exploration, testing and production. Results of Pilliga Environment Group 2018 show elevated soil pH levels at most well sites tested. Even if stripping and stock-piling of topsoil occurs, the exposed soil horizons following stripping will be subject to contamination. Removal of contamination in the clayey B horizons may be problematic. The introduction of produced or treated water can diminish the soil properties and plant growth potential (Echchelh et al, 2018).

37. Claims made by Santos as to the effectiveness of their current rehabilitation at well sites should be rejected by consent authorities pending independent assessment.

38. Santos' request for additional biodiversity credits for their rehabilitation activities should not be supported if claims made in the EIS cannot be verified.

Comments on RtS "Terrestrial ecology"

39. Santos have generally adhered to the **FBA** in applying their survey effort and design and through the RtS have filled several gaps present in the EIS. However, there are still a number of outstanding deficiencies as follows:
    - Lack of targeted Rufous Bettong survey
    - Lack of verification surveys for *Myriophyllum implicatum* and Koala as required by OEH
    - Failure to identify Yellow Box and Box Gum Woodland
    - Previous submission by UML also identifies deficiencies in survey effort for matters identified for further consideration in the SEARs, Five-clawed Worm-skink and Regent Honeyeater (see below).

40. Impact on **hollow-bearing trees** remains difficult to quantify because of the approach taken by Santos to not identify the impact footprint prior to any development consent. This habitat resource is particularly sensitive because of the high number of threatened species dependent on hollow-use. This is another reason for the NSW Government to reject the 'upper disturbance limit' approach and insist that the footprint for the Project be identified with more certainty.

41. In their baseline general surveys, Santos included the **Koala** in their survey design in a way consistent with the FBA Methodology. However, despite being a species credit and given the critical state for local Koala populations in the Pilliga, Santos did not take due care to maximise detection for this species in its targeted survey (Niche 2014). This targeted survey actually spent little time in the Project area (<10%) and focussed on the Baradine and Etoo Creeks

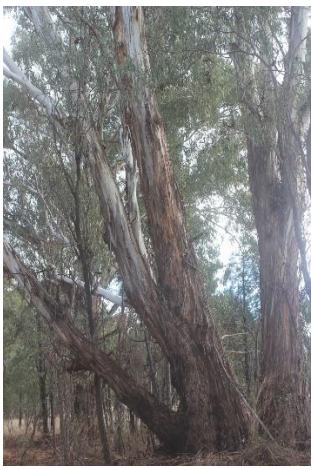
where a thorough survey was undertaken. It is worth noting that this part of the Pilliga is regarded as the strong-hold for the Koala in the Pilliga, and certainly has the highest density of historic records (BioNet 2018). However, despite the targeting of this area, only 14 animals were detected (Niche 2014) suggesting numbers of Koalas in the Pilliga are critically low.

As pointed out in the submissions from OEH and UML, there were concerns that the survey in the Project area did not include all habitat types selected by the Koala, particularly the Pilliga Box woodlands in the north of the forest. This species of tree is identified in the scientific literature for being important for the Pilliga Koalas (Kavanagh et al, 2007; Niche 2014). Santos have still not acknowledged this, inappropriately using the *Statement Environmental Planning Policy 44* (SEPP 44) to guide their determination of which tree species should be considered primary and secondary Koala feed trees. Using this old guide which does not contain Pilliga Box (the new Draft SEPP 44 does include this as a preferred species) cannot substitute for checking the existing scientific literature.

Despite this lack of targeted effort, Santos claimed there were no Koalas in the Project area. Subsequent observations has shown this not to be true (UML submissions, and Koalas have been reported in the north of the forest by in recent surveys by the Australian Wildlife Conservancy). However, Santos have not attempted to fill this gap in survey effort as it currently stands. Therefore, their statement of having no significant impact on the Koala cannot be relied on.

42. The **Box Gum Woodland** issue will be dealt with in more detail below. In summary, the main points here are that:

- The UML submission provided new survey data to show that areas of grassy woodland along Bohena Creek containing Blakley's Red Gum as a dominant in the canopy are consistent with the definition of the EEC/CEEC. These sites are in areas mapped as Plant Community Type (PCT) 399 indicating this mapped unit is composite containing both shrubby forest wetland and grassy woodland formations. The data gathered by Santos in this community is similar in detail to that gathered by UML. The issue of whether Box Gum Woodland is present, however, lies in the differing interpretation of the listing criteria.
- Santos have denied the presence of Yellow Box in any meaningful ecological way in the RtS, but its presence has been further verified, though at very low densities (see below). Whether or not this makes it 'ecologically meaningless' as stated by Santos is conjectural. Its presence or absence does not define whether the community in question is an EEC/CEEC.



Eucalyptus melliodora, Jacks Creek State Forest

43. Santos claim the impacts of the Project to be 'non-significant' for a number of general mitigating factors:
    - **The amount of habitat removal is relatively small**. Not a factor of merit when considering specific impacts on specific species or ecologic communities. Does not take into account indirect impacts.
    - **Will not result in isolation or fragmentation**. Applying a gridwork of linear clearings within a larger remnant of bushland is known as 'internal fragmentation'. This includes not just clearing itself (even narrow roads can be barriers for some animals), but the associated indirect impacts such as increased feral predator activity, weed dispersal, noise, dust etc. In terms of isolation, the small brigalow reserves and Yarrie Lake may be surrounded by gas infrastructure. Fencing and other gas-related activity in the vicinity of these reserves would inhibit the ability of some fauna to disperse.
    - **The field development protocol will avoid and minimise impacts**. Modelled upper disturbance limits are not a mechanism of avoidance as they allow for clearing of threatened communities. The placement of well sites and linear infrastructure may not be able to avoid threatened communities. Once placed the scope to minimise impact at the well site by re-arranging the layout of site equipment is limited.
    - **Up to half the impacted area will be rehabilitated**. The claims by Santos on the likelihood of good rehabilitation outcomes are not substantiated with verifiable data.
    - **Measures such as feral animal control strategy**. It is doubtful if the Project will do anything other than increase the threat of feral predators even with a new strategy because even if baiting rates are increased, so will the extent of increased predator activity.

44. Santos claim all species performed well in an assessment of significance test but these tests have used the modelled upper disturbance limits giving much uncertainty to the actual impacts. Following a review of the effort undertaken for particular species, I question the following tests of significance:
    - **Koala**. Because assessments did not include all potential preferred habitat and erroneous assumptions were made about Koala presence.
    - **Pilliga Mouse.** Broombush was not recognised as preferred habitat. Increased predation and interference to daily movement patterns under-estimated.
    - **Rufous Bettong**. Habitat characterisation, survey effort and likelihood of occurrence are all deficient.

45. Santos are correct in saying that quantification of **indirect impacts** is not required in the FBA nor were indirect impact specifically mentioned in the SEARs.

46. Habitat for the **Pilliga Mouse** has been inaccurately represented in that Broombush types should be mapped as 'primary' (see below).

47. According to the National Recovery Plan for the **Regent Honeyeater** (DoE 2016), the two most important trees for the honeyeater are Mugga Ironbark and Yellow Box. Both species are present in the Project area, despite claims to the contrary by Santos, often as scattered individuals. But Yellow Box dominant stands also occur along Bohena Creek (not mapped in EIS). Santos have under-estimated the extent of critical habitat for the Regent Honeyeater in the forest and Project area. They have therefore not targeted these areas during surveys. The

Regent Honeyeater is also a matter for further consideration and should have warranted a more comprehensive survey of potential sites.

48. The UML submission outlined the ways in which the surveys and the habitat characterisation for the **Five-clawed Worm-skink** were deficient. None of these matters have been addressed in any substantive way in the RtS. This species was identified as a matter for further consideration.

49. Santos admit that the **cumulative impact** of Narrabri Underground Mine upon groundwater systems in particular has not been included. This is because they claim that it is on the Liverpool Plains, when actually it's operations are under the Pilliga forest and overlap with the Santos PEL 238.

50. It is stated in the RtS that **offset sites** have been identified but remain confidential for privacy reasons. This would be a first time that this reason has been given in NSW at the consent stage to my knowledge. Usually, offset sites on private land can be secured by an agreement with the landowner which does not require any public disclosure on ownership or even location other than what biodiversity credits are generated at each site. Given that discussions with OEH on this issue are not completed, there can be no surety in the mind of the consent authority that the credits can be retired appropriately.

51. The issues raised by submissions regarding the efficacy of the proposed **feral predator control** program have not been addressed adequately, particularly of issue of the increase in effective hunting area for predators as a result of the impacts vs increase in baiting intensity under a control program. The contention made in the UML submission was that the negative impact would out-weigh the positive outcome.

Comments on RtS "Aquatic ecology"

52. Additional **stygofauna** sampling was recommended by the IESC within the Bohena Creek Alluvium. Santos have contended that this isn't necessary because, "*taxa in Bohena Creek Alluvium, however, are also likely to be in the Namoi Alluvium, and not new species, or endemic*." However:
    - The Bohena Creek Alluvium lies squarely through the Project area for a large proportion of its extent and is the main stream. Failure to sample this area is a serious shortcoming of the EIS.
    - Clearly, making the assertion that there is 'no new taxa' without taking the trouble to find out is a scientific nonsense. Santos have failed to consider the potentially new endemic taxa and the species diversity collected within the Project area from alluviums but also colluvial and sandstone aquifers where unconsolidated material occurs (Serov 2017).

53. That a landowner denied access to **Hardy and Eather Springs** is unfortunate however, the fact that there is no current data from these sites is a big shortcoming. This would make monitoring and impact assessment for these sensitive environmental features severely compromised as a good baseline should include current conditions.

54. The type 2 **waterholes** of Bohena Creek were not sampled adequately. From over 30 identified waterholes on Bohena Creek (D. Paull, Aquatic Ecology submission), only one was sampled (Toms Hole) which was regarded as being of a 'poor quality' in the EIS despite being found to have the highest Riparian and Channel Environment (RCE) score in the Santos Aquatic Ecology study – 83%. Santos have partially acknowledged the significance of the Bohena GDE, though contend that the waterholes are surface water only, and that any perched aquifers under the creek area are no connected to deeper aquifers. This interpretation of the nature of the hydrology of the GDE continues to be misleading in the RtS.

55. The impact assessment for the **GDE matters** should be considered to be inadequate, particularly as there is confusion about the types of GDEs and extent in the Project area. The IESC did not recognise the presence of the Box Gum Woodland community, Yellow Box Grassy woodland (PCT421) which is present along Bohena Creek in southern parts of the Project area as it was not recognised in the EIS or RtS. The presence of this CEEC/EEC has been substantiated with new data included in this report. Being an endangered community it would be considered a high priority GDE along with Fuzzy Box Woodland and Carbeen Forest EECs.

56. "*The Water Monitoring Plan does not propose to monitor GDEs because they are not predicted to be impacted*." The EIS in fact predicts up to a 0.5 m drop in groundwater over time. Given this prediction, sensitive surface GDEs (particularly those located in the vicinity of Bohena Creek) would require monitoring data to demonstrate the claims made in the RtS, that *there is no impact* otherwise such a claim cannot be substantiated.

Comments on RtS Appendix F - Draft biodiversity offset strategy

57. As mentioned above, the absence of offset sites and an analysis of Santos' ability to retire the credits required means the suitability of the offset strategy cannot be demonstrated prior to consent being sought. It is my contention that Appendix F merely describes the biodiversity credit liability and has done little else to determine feasibility of offset options.

    The SEARs required a '*strategy to offset any residual impacts of the development …*". It is arguable that this has not been done, just to identify your liabilities is not a strategy to retire them.

58. In my opinion, there are some unusual habitat extent designations for some species credits, particularly, the Koala and the Black-striped wallaby. Both have their affected habitat as the entire extent of the direct impact area, which seems ecologically imprecise and Regent Honeyeater has only 48 affected hectares. This does not take into account Yellow Box Woodland in the south of the Project area.

59. A particular concern are the assumptions made about the restoration potential of the well sites and their ability to generate ecosystem credits. Also, due to Santos' claim of good current site data, Santos are asking for an increase in credit benefit by 17%. These claims by Santos can be shown to be misleading in my view.

60. It is interesting to note that in the list of three properties on the Biobank site expression of interest register, one belongs to the author of this report. I can say I would not be interested

in any agreement with Santos. This is telling of how little effort has been put into investigating the feasibility of any of the strategy.

61. Most work was done by Santos on a desktop analysis and by doing a one-off check of the local real estate. Santos say they have identified 282,000 ha of potentially suitable offset but that is just the amount of remnant vegetation on freehold land in the Project area. It is not a figure which describes any offset site which may be suitable or available. No follow up on the real estate checks has been undertaken in the strategy. Santos admit the feasibility of the strategy is unclear (p. 18).

62. Their ability to predict likelihood of retirement of species credits is very unclear. Usually this would require a site inspection.

63. Santos did undertake a threat analysis to prioritise species for recovery action potential and funding as part of their supplementary measures. They identified feral animal control and weed control as the main priorities and then provide some general costings. However, no actual pest control plan has been initiated.

64. In their Statement of Commitments, Santos say they have effective offset liability under the *Environment Protection and Biodiversity Conservation* Act *1999* (EPBC Act) because they claim there is no significant impacts on MNES. For some matters, ie. Koala, Rufous Bettong, Box Gum Woodland, this remains unclear.

65. Santos are claiming one third of their offset liability to be retired through their 'regional control program'. In my opinion, this claim is unsupported given the extent of increased foraging habitat for feral predators and vectors for weed dispersal that will be created in a functioning gas field.

References

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2. Expert Report on adequacy of response to Upper Mooki Landcare Inc submissions

1. The submission made on behalf of Upper Mooki Landcare Inc (UML) made the following findings with regard deficiencies of the EIS.

Finding	Resolved in RtS?
1.The adequacy of the methodology used to describe direct impacts is questionable. The lack of a development footprint by which impact could be measured according to 'whole of government' guidelines gives uncertainty to the ecological outcomes.	NO.
2.Levels of indirect impact have been significantly under-estimated. Using fox predation as a measure, pre-mitigation levels of indirect impact should be at least doubled in magnitude, based on available evidence.	NO.
3.Survey effort for some key fauna species appears to be deficient and would have adversely affected the ability of the EIS to adequately account for some species.	NO.
4.A NSW and Commonwealth-listed threatened ecological community *White Box Blakely's Red Gum-Yellow Box Woodland (and derived native grassland*) has been mis-identified and presumed to be not present in the Project area. New data confirms its presence along Bohena Creek.	NO.
5.The description of important habitat for a number of key fauna species, such as the Regent Honeyeater, Pilliga Mouse, Koala, Black-striped Wallaby and Five-clawed Worm-skink is not accurate.	NO.
6.New information regarding the presence of the Koala in the Project area discounts the assertion made in the EIS that it is not currently present.	In Part.
7.Due to deficiencies in the survey and assessment for two 'matters for further consideration' (MFFC) (namely Regent Honeyeater and Five-clawed Worm-skink), the Secretary's Requirements and requirements under the NSW Biodiversity Offset Policy have not been met. The Black-striped Wallaby also meets the requirements of being a MFFC.	NO.
8.Direct impacts upon Brigalow Park State Conservation Area remains uncertain as do the magnitude of indirect impacts upon the adjacent Nature Reserve and existing biodiversity corridors.	In Part.
9.A Biodiversity Offset Strategy does not provide any surety for how well it will 'retire' the impact of the Project because the strategy provided in the EIS does not provide any like-or-like land-based offsets apart from an unproven rehabilitation plan and rests on the hypothetical efficacy of a feral animal control proposal. The suitability of the offset package with respect to the statutory requirements under the NSW Biodiversity Offset Policy is poor. The offset proposal is also not consistent with the requirements of the Commonwealth Offset Policy.	NO.

2. Not all of the above issues will be addressed in detail here as some have been dealt with in the review of the RtS. Priority issues are discussed in more detail, including any new observations. **But clearly the RtS has not addressed the majority of issues raised in the UML submissions.**

1. Methodology adequacy

3. Not resolved. The use of upper disturbance limits and a scouring framework with limited avoidance ability only provides a low level of certainty as to the modelled impact. No proposition to trial methodology. Still remains outside FBA and BAM guidance on impact assessment.

2. Indirect Impacts

4. Indirect assessment requirements from the NSW Government are absent for this Project. However, Santos were required to provide any estimate of indirect impacts for this Project for the Commonwealth's conditions of approval. Given that the indirect impacts from the type of industry being proposed are likely to be relatively high, it appears to be a significant oversight of the assessment process. Santos have presented their indirect impact assessment in the RtS presumably to address the Commonwealth conditions. Nevertheless, issues with the indirect impact assessment provided in the EIS were addressed in my submission to the EIS (UML submission), none of which have been responded to directly in the RtS.

3. Survey effort for key species

5. Not resolved. Koala, Rufous Bettong, Regent Honeyeater and Five-clawed Skink remain under assessed as they species credit species. OEH recommended further surveys for Rufous Bettong and Koala, this has been discussed in the RtS review.

6. Targeted surveys for the Koala (Niche 2014) did not focus in the survey area and missed key habitat. In addition, scat surveys for Koalas during the baseline surveys was poor, only shows four Scat Assessment Technique survey locations are shown in the EIS, three of which are clustered. This has not been addressed in the RtS.

7. For the critically endangered Regent Honeyeater *Anthochaera phrygia,* only one survey (October 2012) appears to have been undertaken over the five years of the field survey period prior to the submission of the EIS. Commonwealth guidelines (DEWSaP 2010) recommend surveys take into account eucalypt flowering events and should amount to at least 20 hours over five days. This has clearly not been accounted for in the EIS. Similarly, surveys for the Swift Parrot *Lathamus discolor*, with only one survey conducted, in July 2013, should also be linked to flowering events for 20 hours over eight days.

   81 'trap nights' were used for a 'Song Meter' to record birdcalls, supposedly targeting the Regent Honeyeater, though without appropriate call playback, this method is unlikely to yield results. The large amounts of data this methodology creates would need a Regent Honeyeater song algorithm (a digital call signature), from local animals in order to be able to maximise the detection of this species.

8. Targeted surveys for the endangered Five-clawed Worm Skink *Anomalopus mackayi* were undertaken in April 2014. The Commonwealth guidelines (DEWSaP 2011) for this species state that:

"Peak activity is likely to be late spring and early summer under warm but not overly dry conditions. Not active on the ground surface by day and would only be active between sheltering sites at night."

Surveys should be conducted at this time of year. The methods used should meet the following requirements:

"*Appropriate survey methodology for detecting the presence of the long-legged worm skink is searching sheltering sites in combination with pitfall trapping at a time of year when the species is most likely to be active. If the survey is a targeted search for this species, a series of pitfall trap lines each comprising six 10 litre buckets spread along a 15 metre fence could be employed, however the species is more likely to burrow between the soil and the bucket. A successful technique has been to deploy artificial structures, such as bales of hay of different thicknesses, over a long period (over 6 months) and periodically check underneath*."

The EIS shows that 57.1 hours of 'reptile surveys' were undertaken for this species. If undertaken at the wrong time of year, the efforts are bound to be fruitless, even if taken after a 'significant rainfall event' (Table 15-6). A map of the survey effort shows that only 12 of the 30 reptile surveys were conducted in areas north of the forest more likely to support habitat for this species (Figure 9, Appendix J1). So less than half of the total effort in reptile surveys could have targeted this species, although p. 74 of Appendix J1 states only three sites had habitat potentially suitable for the Five-clawed Worm-skink, R21, R27, R31.

4. Box Gum Woodland - Yellow Box Occurrence

9. Santos do not refer to the data and analysis presented in the UML submission describing a survey of riparian habitats along Bohena Creek which used a Biometric approach and an assessment of the correspondence with listed definitions of Box Gum Woodland EEC/CEEC. Instead in their Appendix E of the RtS, Santos attempt to refute data gathered in 2011 during a community biodiversity survey which amounted to 3 sites in the Project area (Milledge 2012).

10. Santos have not addressed the issue of whether PCT399 is in fact a composite community type and the mapping Santos has used contains both grassy woodland and shrubby dry sclerophyll forest formations on the ground. PCT399 is classified as both in the current Biometric system, being a shrubby sclerophyll forest Keith Formation and has been given grassy woodland Biometric Vegetation type designations by Santos. The fact that grassy woodland is present along some creeklines in the Project area is acknowledged widely in the text of the EIS (Appendix E, p. 6), for example:

    "*Grassy woodland in the study area is predominately distributed adjacent to riparian habitat along Bohena Creek with small patches associated with patches also found along Cowallah Creek and Bibblewindi Creek*."

11. Santos sampled the PCT399 mapped unit in the EIS but sampled from both grassy woodland and shrubby forest (wetland) communities. The RtS presented new data on the Bohena Creek riparian community (RtS Appendix E) based on rapid survey plots and supplemented this with the plot data from previous surveys to refute claims made in the UML submission on the presence of Box Gum Woodland. However, the two sets of data show a strong similarity, both in terms of species composition and vegetation structure. The difference of opinion in the Santos and UML submissions as to whether the community in question is Box Gum Woodland lies in

the differing interpretations of how well the community matches the listing criteria and descriptive characteristics in the NSW and Commonwealth determinations.

12. It is still contended here that the grassy woodland found in the Project area which is dominated by Blakey's Red Gum and Rough-bark Apple and is found on creek flats and terraces is consistent with the definition of the Box Gum Woodland both at state and Commonwealth levels. The appropriate classification of this community is still contested by Santos in the RtS and is reviewed again below.

    Other grassy woodland associations previously identified in the Bohena/Borah/Yaminbah system (Benson 2010) – include both Fuzzy Box and Yellow Box types. While Fuzzy Box (PCT202) is acknowledged in the EIS as occurring in the Project area (and has been mapped separately), Yellow Box (PCT421) is not. The description of *Yellow Box - White Cypress Pine alluvial terrace flats grassy woodland in the Pilliga forests to Warialda region, BBS Bioregion*, as found in the Bohena/Borah/Yaminbah creek system from Benson (2010) show it is a Box Gum Woodland EEC/CEEC according to VIS database and Benson (2010). Data used by Benson (2010) to describe this vegetation community include data taken from plots upstream (just south) of the Project area.

Points of dispute with NSW Box Gum Woodland definition

13. The description and identification criteria for the NSW listed White Box Yellow Box Blakely's Red Gum Woodland EEC is described below via the OEH website:

    http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10837

    Santos' response to the listing criteria which define this community are reviewed below:

    a) The determination states that, "*Relatively fertile soils may be defined as those soils with a moderate or higher inherent soil fertility"*. Santos state that the Bohena Creek riparian zone does not have a 'relatively fertile soil' as it does not have a moderate or better fertility, if you consider the generally good fertility this community is commonly found on. However, the description also includes the phrase, "*or a higher inherent soil fertility*". This should be taken to mean a higher inherent soil fertility than the surrounding landscape. While Santos characterise the 'top-soil' of the creek flats and terraces as low to moderately-low fertile silicious sands, the Department of Mineral Resources (DMR) geological mapping (2003) describes Bohena Creek lithology as being "*unconsolidated silt and clay, minor sand. Commonly carbonaceous and flat to cross-laminated*". The OEH soil fertility mapping (2013) referred to in the EIS and RtS is very course and does not make allowance for alluvial activity although major streams are indicated by blue lines. Yellow Box and Fuzzy Box Woodland in the Project area occur on "*brown clay loam to light clay alluvial soils*' on creek terraces in the Project area (Benson 2010).
    b) Santos did not record Yellow Box, though the report previously submitted by UML does, recording it at two sites. Yellow Box is present in the Project area though whether it is 'ecologically meaningless' is conjectural. Its presence or absence does not define whether the community in question is the EEC.
    c) Santos claim the number of characteristic species at survey sites is insufficient for the community to be the EEC. Santos found total plant diversity at PCT399 sites to range between 12-47 species. Number of Box Gum Woodland characteristic species at plots were found to be 4-11 (25-30%). UML found of the 69 species identified as being part of the

riparian woodland community, 25 (36.7%) of these are listed as characteristic species, very similar to Santos who found 28 characteristic species in total. Santos compare each site against the 95 characteristic species listed in the determination and claim that the characteristic species are lacking, however if all the characteristic plant species detected in that community is compared to the total list in the determination, 28.7% were found within the targeted sites. Both measures in fact suggest a good correspondence with the EEC.

d) The determination states, "*Drier woodland areas dominated by Eucalyptus albens often form mosaics with areas dominated by Eucalyptus blakelyi and Eucalyptus melliodora occurring in more moist situations*". Santos attempt to say this is not consistent with what is found in the Pilliga because there are no White Box Woodlands forming mosaics. While White Box is not present in the Project area, it is true to say that " *… areas dominated by Eucalyptus blakelyi and Eucalyptus melliodora*" do occur in "*more moist situations*" in the Pilliga.
e) The sites in question have a have understorey species more characteristic of more northern communities in this species range – not contentious
f) The ecological community in question has Blakeley's Red Gum as a dominant in the canopy, as do other Box Gum Woodland communities.
g) The sites in question do not support these other canopy species as listed in the determination – not contentious.
h) Santos are not correct to assert riparian woodlands are in a pristine condition, as the grassy woodlands of the streams through the Pilliga were historically grazed, including the Bohena system (Rolls 1981).
i) Some grazing-sensitive species, eg *Dianella revoluta, Templetonia stenophylla* were detected at plots by both Ethical Ecology and Santos showing consistency with the determination.
j) Sites were found to be generally in a moderate to good condition, though some areas show signs of die-back or drought stress and have a lower diversity and higher weed cover. As well feral cattle persist in the southern part of the Project area and cause locally significant damage. Santos have not considered this.
k) The sites in question vary in condition though still meet the state-listing criteria.
l) The listing identifies Warrumbungle National Park as containing this EEC. Benson (2010) records the Box Gum Woodland type PCT421 within the Pilliga East State Conservation Area and Pilliga Nature Reserve. Its distribution was noted as being Warrumbungle, Narrabri and Moree Shires.
m) Santos do not consider the characteristic fauna species listed as occurring in this EEC, but of the fauna species listed as being of conservation significance in the determination, most (20) are known from the Pilliga forest (Date and Paull 2000). The plant species of conservation significance*, Pterostylis spp* and *Swainsona spp* are known from the Pilliga area and have been recorded from PCT399 (given as BVT197) according to Santos (*P. cobarensis* identified in p. 6 ; F4 Flora Modelling Technical report of the EIS). All bushland areas are subject to feral animal predation – a key threatening process.

14. The two strongest points Santos use to support their claim that Box Gum Woodland EEC is not present in the Project area is the supposed lack of "*relatively fertile soils*" and the poor contribution of characteristic species to the community. Both assertions can be countered easily as discussed below. While the site data from Santos and from Ethical Ecology studies show similar results, it is the interpretation of these criteria where Santos have erred.

15. The soils along the drainage lines of Bohena Creek may be described as being **relatively fertile**, particularly when compared to the low fertility sands comprising the bulk of the Pilliga forest.

The creek terraces on Bohena Creek may carry surface sand, particularly on the areas closest to the stream, but evidence presented by DMR (2003) and other sources (eg. Benson 2010), suggests the creek banks and terraces are mainly comprised of alluviums including clay, silts and loams. The major creeks, like anywhere in drier parts of the country, are receivers of water and nutrient. These areas support the highest density of large trees in the forest (Date et al. 2002). The supporting information provided by Santos on soil fertility (OEH 2013) is very coarse and proves or disproves nothing in relation to creek side soils.

16. The **characteristic species** analysis has been undertaken in a way which attempts to disprove any correspondence with Box Gum Woodland, but is quite misleading. Characteristic species are a list of typically occurring species in the woodland which varies in its species composition considerably throughout its range. The determination lists ALL species from northern, southern and drier parts of the community's range. Therefore, comparing the relative proportion of species in particular plots against the total list (95 species) is not that informative by itself.

    The best measure of the contribution of characteristic species to the community in question is to identify what proportion of the species found at each site and the community as whole are listed characteristic species in the NSW determination. Santos found that the proportion of characteristic species at plots ranged from 4 to 11 (21-45%), with 28 characteristic species within the whole PCT399 community (n=16). Ethical Ecology found the characteristic species at plots, undertaken using the same Biometric methodology, numbered from 4-12 (n=14) with a total number of 25. The results between the two studies are consistent, it is hard to understand how Santos could regard the level of characteristic species correspondence (up to 45% as a proportion of total species detected in that community and 29% as a proportion of the total list in the determination) as not being consistent with the determination. Santos claimed to not find *Oxalis perrenans*, a characteristic species, at most sites, while Ethical Ecology found it to be common. In fact, Santos have listed this as a weed species.

17. Santos go to some detail attempting to show that at sites with higher groundstorey diversity, the area covered by the characteristic species at the survey sites is smaller than that covered by non-characteristic species. The question of dominance by cover however, does not form part of the criteria in the determination which is focussed on diversity.

Points of dispute with Commonwealth Box Gum Woodland definition

18. The description of the EPBC-listed *White Box - Yellow Box - Blakely's Red Gum Grassy Woodlands and Derived Native Grasslands* is found at the Commonwealth website below.

    http://www.environment.gov.au/biodiversity/threatened/conservation-advices/white-box-yellow-box-blakely%27s-red-gum-grassy-woodlands-derived-native-grasslands

    The description of this CEEC is slightly different to that of the NSW listing and is more descriptive. Interestingly, the Commonwealth flagged the possible presence of Box Gum Woodland CEEC in the Project area in their response to the referral submitted in 2014. But in the SEARs, the OEH have removed this community as a 'matter for further consideration'

    The responses of Santos in the RtS to meeting of the EPBC characterisation of Box Gum Woodland CEEC are reviewed below:

Santos Comment	Response
"Box – Gum Grassy Woodland and derived grasslands are characterised by a species-rich understorey of native grasses, herbs and scattered shrubs, and the dominance, or prior dominance of White Box, Yellow Box or Blakely's Red Gum … The tree cover is generally discontinuous and consists of widely spaced trees of medium height in which the canopies are clearly separated."	Santos recorded 12-47 species/plot in this community, whereas Prober and Thiele (1993) identify understoreys in this community with up to 63 species per plot. This is a high diversity, however, these conditions are not in the determination and so are not a benchmark that needs to be adhered to qualify as the CEEC. The specific understorey criteria for the CEEC are outlined below. Santos also contend that the fact that the trees in this community are not always widely spaced is a key issue. The canopy cover in this community was found to range from 5-30%. Not all communities listed as CEECs have a widely spaced canopy, for example the Yellow Box tall woodland in the study often has mature trees which are touching. creekside environments will have a higher tree density than non-creekside, mainly because higher levels of nutrients and water.
"*In its pre-1750 state, this ecological community was characterised by:* • *a ground layer dominated by tussock grasses;*	Some importance is placed by Santos on the contention that the groundlayer is not "*dominated by tussock grasses*". Many of the grasses present in this community such as wire grasses, wallaby grass, spear grass are regarded as 'tussock grasses'. While the overall cover of these grasses does not constitute a majority of cover, the groundcover may be described as a mixture of forbs, grasses and leaf litter. The tussock grasses are the dominant type of cover in the groundlayer in that they are taller and more conspicuous. Other taller species such as Bladey Grass *Imperata major* and Reed Grass *Arundinella nepalensis* occurred in patches, though were not present at all sites. Other grasses present at most sites were the damp loving species Couch and Weeping Grass. Santos also include the species *Lomandra longifolia* as a groundstorey but may also be regarded as a low shrub, due to their large size (up to a metre). The Yellow Box woodland in the area (PCT421) which is identified as a CEEC in the VIS database and in Benson (2010) has a groundcover dominated by leaf litter/bare ground.
• *an overstorey dominated or co-dominated by White Box, Yellow Box or Blakely's Red Gum, or Grey Box in the Nandewar bioregion; and,*	The CEEC is found in two types, one where Blakely's Red Gum is dominant with Yellow Box as an occasional species and the other where Yellow Box is dominant, sometimes with Fuzzy Box.
• *a sparse or patchy shrub layer.*	Not contentious

"Associated, and occasionally co-dominant, trees include, but are not restricted to: Grey Box (Eucalyptus microcarpa), Fuzzy Box (E. conica), Apple Box (E. bridgesiana), Red Box (E. polyanthemos), Red Stringybark (E. macrorhyncha), White Cypress Pine (Callitris glaucophylla), Black Cypress Pine (C. enderlicheri), Long-leaved Box (E. gonicalyx), New England Stringybark (E. calignosa), Brittle Gum (E. mannifera), Candlebark (E. rubida), Argyle Apple (E. cinerea), Kurrajong (Brachychiton populneus) and Drooping She-oak (Allocasuarina verticillata) (Austin et al. 2002; Beadle 1981; Fischer et al. 2004; NSW National Parks & Wildlife Service 2002; Prober & Thiele in press).	Fuzzy Box, Black Cypress Pine and Kurrajong also occur in the community in question.
This ecological community occurs in areas where rainfall is between 400 and 1200 mm per annum, on moderate to highly fertile soils at altitudes of 170 metres to 1200 metres (NSW Scientific Committee 2002).	The community in the Project area matches both rainfall and soil criteria. The soil fertility issue is addressed in the NSW-listing analysis above.
In general, White Box is more prevalent in the west, and Yellow Box-Red Gum in the east… Yellow Box and Blakely's Red Gum are generally dominant on the Tablelands and form mosaics with White Box on the eastern slopes (Beadle 1981; Prober & Thiele in press). The understorey shows a more consistent pattern with the overstorey, with understorey species composition on the Tablelands differing to that on the slopes.	The Project area being outside the zone mapped by Prober and Thiel (1995) by itself does not constitute a reason why the community here should not be regarded as the CEEC, nor should presence or absence of White Box. Santos have confused the term '*eastern slopes*' with the slopes east of the divide. This was not the intention of this term which is referring to the slopes on the eastern side of the western slopes. The Pilliga is regarded as being partially within the general 'slopes' region.
Kangaroo Grass (Themeda triandra, syn. T. australis) and Snow Grass (Poa pauciflora) were originally the dominant grasses across a large part of the ecological community's range and are particularly sensitive to grazing pressure (Cole et al 1974). Grazing tends to cause the loss of these grasses, along with other grazing-intolerant forbs, grasses, sedges and shrubs, etc …	The discussion in the EPBC determination about Kangaroo Grass and Snow Grass is made in the context of their grazing susceptibility. It clearly states in the determination that these species were, "*originally the dominant grasses across a large part of the ecological community's range*" not the whole range of where this community is found. There should be no expectation from Santos that these species are found in this community in the Project area.
At least one of the understorey species should be an important species (e.g. grazing-sensitive, regionally significant or uncommon species; such as Kangaroo Grass or orchids) in order to indicate a reasonable condition. Areas with both an overstorey and understorey present are also considered of sufficiently good condition to be part of the listed ecological community if the understorey meets any of the conditions above, or if they have a predominantly native understorey, are two hectares	The understorey in this community is characterised by grazing sensitive species including Kangaroo Grass and orchids, such as *Pterosylis cobarensis*. The understorey meets a number of the conditions mentioned above, including levels of plant diversity at half the sites. All sites had more than 20 trees/ha.

or above in size, and have either natural regeneration of the overstorey species or 20 or more mature trees per hectare."	
Shrubs can occur naturally in grassy woodlands, and can form an important part of the Box – Gum Grassy Woodland and Derived Grassland ecological community… In shrubby woodlands, the dominance of native tussock grasses in the ground layer of vegetation is lost. Therefore, a remnant with a continuous shrub layer, in which the shrub cover is greater than 30%, is considered to be a shrubby woodland and so is not part of the listed ecological community. Remnant attributes, such as shrubbiness, should be measured on a scale of 0.1 hectares or greater.	Shrub cover in the Santos study was about 5% overall. Ethical Ecology found a range of 5-30% shrub (understorey) cover. All measurements by Ethical Ecology were taken over a 0.1 ha area.

19. Of note is that Santos did not utilise the condition assessment for Box Gum Woodland CEEC, found under section 4 of the Determination:

    (http://www.environment.gov.au/system/files/pages/dcad3aa6-2230-44cb-9a2f-5e1dca33db6b/files/box-gum.pdf).

    This is the only key diagnostic character guide in the Determination for this community:

    "In order for an area to be included in the listed ecological community, a patch must have a predominantly native understorey. The size and life-form of understorey species are such that viable populations can exist in very small areas (Prober & Thiele 1993). Therefore, in order to be the listed ecological community, an understorey patch, in the absence of overstorey trees, must have a high level of native floral species diversity, but only needs to be 0.1 hectares or greater in size. A patch in which the perennial vegetation of the ground layer is dominated by native species, and which contains at least 12 native, non-grass understorey species (such as forbs, shrubs, ferns, grasses and sedges) is considered to have a sufficiently high level of native diversity to be the listed ecological community. At least one of the understorey species should be an important species (e.g. grazing-sensitive, regionally significant or uncommon species; such as Kangaroo Grass or orchids) in order to indicate a reasonable condition."

    When used, this guide shows that at the grassy woodland community in question, with an groundstorey diversity ranging from 20 to 35 species per plot, are not species-poor habitats. Some variation in condition was encountered by Ethical Ecology, with half the plots lacking sufficient diversity to meet the conditions in the EPBC definition. However rather than being evidence of being a 'species-poor' community, as Santos contend, is more likely to reflect differences in site condition.

20. Santos summarise their argument that the community in question is not the CEEC by four main points:
    - **Soils are not suitable as they are not *moderate to highly fertile soils***. I comment on this above. There is no direct measures of soil fertility of the creek side environment that have been used to support Santos' argument. However, we do have reliable descriptions of this environment as being alluvial in nature with a clayey/silty lithology (DMR 2003).

- **The groundlayer is in a natural condition and is not dominated by tussock grasses**. Dry conditions and grazing by feral cattle were observed along Bohena Creek. The condition of this community may be 'largely intact' but is locally affected by poor ground conditions including weed encroachment. With regard to tussock grasses, tussock grass species are present (11 of 14 species of grass in this community can be regarded as being of a 'tussock' form), though the understorey of this community is often dominated by leaf litter and forbs, as well as clumps of *Lomandra longifolia*. Other CEEC communities do have a relatively low level of grass cover, eg Yellow Box Woodland (PCT421)
- A variation in the condition of this community along Bohena Creek was observed by Ethical Ecology, only 8 of the 14 sites sampled in the Ethical Ecology study met the EPBC **groundstorey diversity criteria**. The sites which failed to meet the definition of the EPBC Box Gum Woodland were due to a lack of forb and herb species (<12 species as required in the definition above). Disturbing factors at the sites were grazing by feral cattle and drought-like conditions. Santos did not use the diagnostic groundstorey test in their assessment, instead relied on qualitative interpretations of the Commonwealth criteria.
- The grassy woodland community in question does occur in **riparian areas** and adjacent to sandy creek beds, but the landform they occupy is creek terraces and banks. The shrubby community within PCT 399 naturally occurs in lower order streams in the forest and does also occupy the Bohena creek-bed.

21. In conclusion, three of the four points Santos make about the lack of correspondence with the CEEC can be substantively refuted. The third point concerning the groundstorey has some weight, given the variation in groundstorey diversity observed at the sites by Ethical Ecology. However, the fact that some plots in the PCT399 community do meet the CEEC criteria lends weight to the view that the other grassy woodland sites which do not qualify as CEEC is most likely due to adverse, dry conditions and feral cattle grazing.

5. Habitat descriptions

Pilliga Mouse

22. Despite questions raised in the UML submission about why the heath community Broombush scrub is not classified as a primary habitat type for the Pilliga Mouse, this issue has been overlooked in the RtS. The Pilliga Mouse habitat technical report (Appendix F5 of the EIS) identifies 8,595 ha of primary habitat in the Project area and 14,609 ha of secondary habitat. These figures appear not to have been altered.

23. There is a persistent mis-understanding on the value of Broombush for the Pilliga Mouse:

    "*Pilliga Mouse has previously been recorded in heath, although the clay loam substrate is not considered suitable to burrow in*." (p. 7 Appendix E of EIS)

    "*the soil substrate (of heaths including Broombush) is deep sandy soils*" (p. 8 Appendix E of EIS)

    Both of these descriptions are inaccurate. Santos failed to consider that Paull (2009) showed Broombush communities were characterised as having a duplex soil with a sandy A horizon (usually about 30cm deep) over a clay dome B horizon. Pilliga Mice showed a significant preference for this habitat type above all others sampled through the central Pilliga. The depth

of the sandy A horizon is enough for Pilliga Mice to construct burrows in this community, the depth of Pilliga Mouse burrows in Broombush is up to 22 cm (Paull 2006).

Like other heaths, Broombush areas are a flat plain, prone to waterlogging. The clay dome stays wet under these conditions providing water and nutrient for the vegetation. This is why these areas support few trees yet have a diverse understorey of shrubs. Pilliga Mice congregate in these heaths over winter (Paull 2009), presumably to retrieve underground fungi which is an important part of their diet in Winter (Jeffries and Fox 2001). In summary, Pilliga Mice use Broombush all year round for breeding and foraging purposes.

24. Another factor overlooked by Santos is the effect of fire on habitat suitability. Specifically, within Broombush communities, Pilliga Mice showed a significant preference for early post-fire regrowth and mature stands, avoiding intermediate age stands (Paull 2009). This and other specific details about habitat preference such as vegetation cover density and height and key floristic species could have enhanced the accuracy of the Santos model as described in Paull (2009) and Paull et al. (2014).

25. Some of the communities in the habitat modelling require further investigation because of the limitations of the Lidar analysis. It is unclear if this has been accomplished.

Koala

26. In the EIS, Santos contend that Koala habitat in the Project area amounts to some 30,000 ha if the 'secondary' habitat is taken into account. However, in the RtS, there has been no clarification of the amount of primary or secondary habitat in the Project area, just a credit liability calculated across the entire direct impact area (988 ha).

Black-striped Wallaby

27. In a similar fashion to the Koala, Black-striped Wallaby offset liability has been calculated across the whole impact area.

6. Status of Koala

28. Issues relating to the failure of Santos to acknowledge current presence in the Project area have not been resolved in the RtS. The problem with this approach was discussed in the UML submissions. Santos have committed to another Koala survey in the future, but the information provided regarding current presence should have prompted immediate surveys or expert assessment so as to inform the consent authorities of the true status of the Koala in the Project area. Santos had erroneously indicated in their EIS that Koalas are not currently present.

7. Matters for further consideration

29. The two 'matters for further consideration' (MFFC) have not received 'special attention' as required under s.9.2.5.2 of the FBA, in my view. The inadequacies of targeted surveys for these species is outlined above, being species-credit matters under the FBA. However, the fact that these species were also identified as being MFFC in the SEARS should also have warranted a targeted assessment of the presence and habitat suitability in the Project area.

30. Mugga (or Red) Ironbark, *Eucalyptus sideroxylon* and Yellow Box are identified as key tree species for the Regent Honeyeater. Both are present in the project area. The Recovery Plan (DoE 2016) states that 'habitat critical to the survival of the Regent Honeyeater' includes:

- *Any breeding or foraging habitat in areas where the species is likely to occur; and*
- *Any newly discovered breeding or foraging locations.*

While there are no records of this critically endangered bird in the Project area, the red gum angophora woodlands of the Bohena Creek (which contains occasional Yellow Box) and adjacent areas of Mugga Ironbark could potentially be 'habitat critical to the survival'.

"Key areas include the Bundarra-Barraba, Pilliga Woodlands, Mudgee-Wollar and the Capertee Valley and Hunter Valley areas in New South Wales, and the Chiltern and Lurg-Benalla regions of north-east Victoria." The Recovery Plan regards the Pilliga as a breeding area for the Regent Honeyeater.

Given the confusion about the definition of breeding habitat for this species and a lack of sufficient effort to detect this species, in my view, the Secretary should determine that specific assessment conditions outlined in s.9.2.5.2 of the FBA have not been adhered to.

31. For the Five-clawed Worm-skink, the RtS and EIS have denied suitable habitat exists in the Project area. This is not consistent with the survey effort descriptions provided in the EIS which show suitable habitat for this species was encountered in the Santos surveys. The issue of inadequate survey effort for this MFFC species has not been refuted by Santos in the RtS.

8. State Conservation Areas

32. Santos have dealt with these issues in part. Santos have made some commitments to buffer these areas, though has not given sufficient care to potential impacts on sensitive communities and species.

9. Lack of offsets

33. Not dealt with sufficiently by Santos in RtS. The UML submission concentrated on the deficiencies in relation to using site rehabilitation gains and a feral animal control program to reduce biodiversity credit liability for the project. Issues relating to feasibility of land-based offsets; value of current site rehabilitation and a flagged feral animal control program combine to make this strategy's effectiveness questionable.
34. The Commonwealth offset requirements for this Project have not been addressed by Santos in the EIS or RtS. Santos do make an assertion that offset strategies accepted by the NSW Government are generally accepted by the Commonwealth. However, this offset strategy should not be accepted by the NSW Government as being adequate. Any Commonwealth requirement should be addressed in the consent as per the terms of the Bilateral Agreement.
35. Appendix 3 of the EPBC Act Environmental Requirements for the NGP outlines the information requirements for EPBC Act offset proposals. The offset strategy outlined still has a low level of compliance with these requirements, as it does not provide any detail regarding the following, necessary under the Bilateral approval:

    i. the location of any offsets as the location of well sites is not known, though it is estimated that each well pad will be 2 ha in size. The only land-based offsets Santos have provided are the rehabilitation undertaken at the well-pads.

    ii. maps for each offset site are not available.

    iii. confirmed records of presence (or otherwise) of relevant protected matter(s) on the offset site(s) cannot be determined nor can details of studies and surveys used to confirm the

presence of individuals and or likely habitat within offset site(s). The quality of habitat cannot be assessed.

iv. information and justification regarding how the offsets package will deliver a conservation outcome that will maintain or improve the viability of the protected matter(s) consistent with the EPBC Act Environmental Offsets Policy (October 2012) has not been undertaken other than via a rehabilitation methodology provided by the NSW Government.

v. the risk of damage, degradation or destruction to any proposed offset site(s) in the absence of any formal protection mechanism is high considering the risks posed by ongoing mining leases and future development applications in the area. State Forests are open to mining and gas activities in NSW and no formal protection measures have been proposed for rehabilitation sites.

vi. it is unclear whether the rehabilitation of mine sites be regarded as being 'additional' to existing requirements by the Commonwealth. Such activities are usually obligations contained within a Mine Plan, though now the NSW Government has determined that rehabilitation on mine sites can generate biodiversity credits.

vii. no costings of the proposed offsets package in the EIS.

36. Considerably more information is required by the Commonwealth before any decision can be made about the efficacy of the offset package.

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Study on the success of rehabilitation at gas infrastructure within PEL238

Bohena 11 regeneration site

Pilliga Environment Group

25 June 2018

Summary

Results of an examination of all well sites (63) within forested areas of PEL238 show:

- In terms of both vegetation cover and species diversity, two thirds of the well sites subject to natural regeneration are currently in a poor quality with low to no vegetation cover to speak of and a poor species diversity. Many sites are supporting significant amounts of weeds.

- 20 well sites show a high plant cover in at least one layer, generally the mid-storey, which is usually dominated by *Acacia spectablis* and/or *A. deanii.* Groundstorey is usually the poorest component, though some sites show good recovery. Only one site Dewhurst (DH) 09 was found to be on a trajectory to become self-sustaining and meeting benchmark criteria. The soil conditions at this site were normal.

- Most sites showed sub-surface pH levels above the background levels of the reference system. High levels of pH at well sites will inhibit the development of the naturally occurring ecological community. Double the background levels of salt in the sub-surface soil at the spill sites may also inhibit the recovery in these areas. Site rehabilitation should also include soil restoration with targets to achieve more acidic top-soils.

- Sites subject to active regeneration are young and given constraints associated with soil conditions at these spill sites, their success remains unresolved.

- Claims made by Santos in the environmental assessment documentation for the Narrabri Gas Project (Project) as to the effectiveness of their current rehabilitation at well sites should be rejected by consent authorities pending independent assessment.

- Santos' request for additional biodiversity credits for their rehabilitation activities as part of the Project should not be supported.

Background

Claims have been made in the Santos Narrabri Gas Project (Project) Environmental Impact Statement (EIS) Rehabilitation Strategy and the Response to Submissions documentation about the high 'site quality' observed at well sites in PEL238. The Pilliga Environment Group Inc (PEG) has subsequently investigated vegetation and soil conditions associated with well sites in the Project area to test these claims.

Santos have repeatedly stated that current rehabilitation is on track to meet completion targets, in terms of species composition and vegetation structure at the sites, for example;
"*Rehabilitation to date shows similar numbers of native species to reference sites, is dense shrub layer, relatively low weed cover and regeneration of overstorey through coppice regrowth.*"

The only evidence presented in the EIS to support these claims (with no further evidence presented in the RtS) is Figure 5 in Appendix V of the EIS (reproduced below). It shows a graph comparing 'site quality' against reference values at 11 sites. The meaning of 'site quality' is unclear, though shows, for example at site DH9, site quality is approximately 75% of the reference site quality. Overall, it is stated by Santos that naturally revegetated well sites on average are about 74% of the quality of reference sites (Santos 2017).

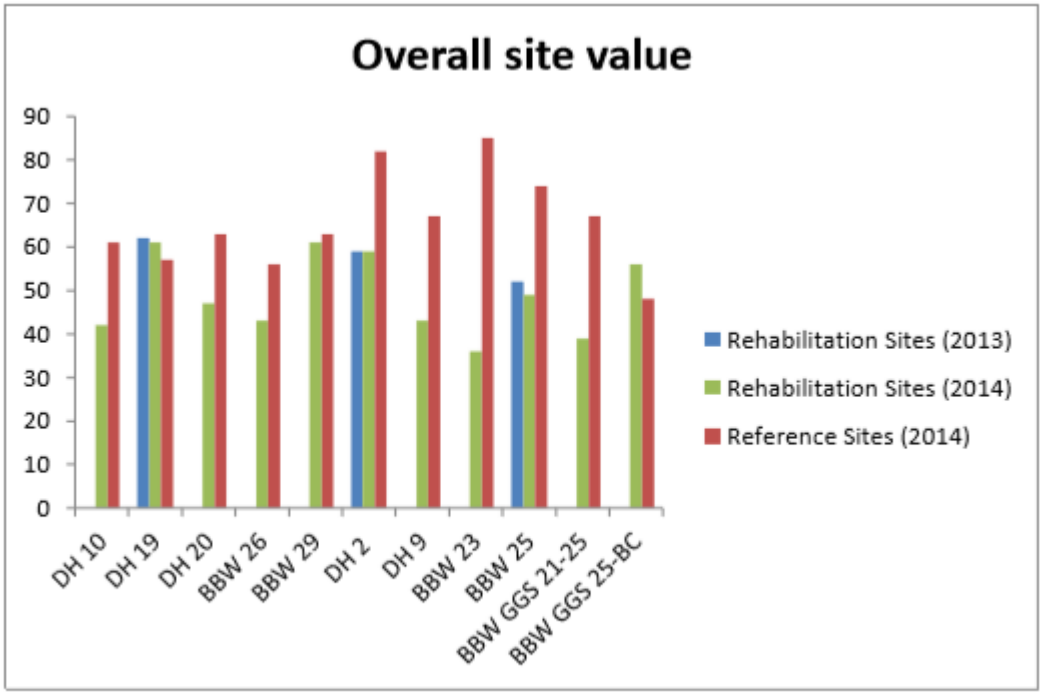

Figure 5: Overall site value in rehabilitation areas compared to nearby reference sites not disturbed by the project (2013-14)

This apparent success has led to Santos to request an additional 15% credit from rehabilitation for their offset strategy and to claim that credits generated by rehabilitation will account for some 30% of the total credit liability of the Narrabri Gas Project.

Review of existing information

The NSW Government's Sharing and Enabling Environmental Data (SEED) database shows there are 24 active production, 29 inactive (not producing), and 31 permanently sealed wells in PEL 238 (Appendix 1). A further three sites (Bohena 8, 10 and 11) are not recorded on the SEED database, though according to management plans prepared by Santos and Eastern Star Gas and obtained under the *Government Information (Public Access) Act 2009* (GiPA Act) , these have undergone rehabilitation activities over the last 20 years.

From the documents obtained, it was possible to identify six sites which have significant and recognised offsite produced water spill zones. The documents indicate a further five sites have minor offsite or onsite areas affected by spillage. All are indicated as being 'full rehabilitation' sites in the plans. The actual extent of on-site spillage within the well sites is not known.

According to the documents, since 2012, 11 sites have been subject to 'full rehabilitation' and 'soil restoration', a further 15 have been subject to 'lease size reduction' with five of these to 'partial rehabilitation'. In 2012, rehabilitation entailed removal of contaminated top-soil and sump-pits and covering the whole site with mulch and logs. This was also referred to as 'soil treatments'. 'Partial' referred to rehabilitation of only a part of the well site, leaving the rest of the site in use. Two sites in the 2012 plans (Bohena 4 and 6) were subject to 'supplementary actions' noting the failure of previous plantings at these sites (Santos 2013), entailing further mulching and soil removal at these sites.

For the most part, plant growth at well and spill sites has been due to natural regeneration and results are highly varied. 'Lease size reduction' generally incorporates areas of regrowth that have been fenced off from the rest of the site.

More recently, there has been a program of irrigation and plantings undertaken at some sites which have experienced legacy spills, (Bohena 2, 5, 6 and at the Bibblewindi facility). The detailed management plans for these activities are not publicly available though it is assumed they are being undertaken in a way consistent with the Rehabilitation Strategy as submitted in the EIS. This work has entailed a different approach of intensive irrigation, plantings and surface raking of mulch and topsoil. Gypsum is added to the irrigated water in attempt to apparently breakdown shallow clay layers. A number of other legacy sites have been subject to irrigation activity, though no plantings have yet occurred (Bohena 4, 7 and 11).

The key questions that this study will address are:

1. *Is the species composition of naturally regenerated sites consistent with bushland which occurs in adjacent bushland?*

2. *Have past revegetation efforts been successful?*

3. *Are there differences in soil condition between old and newer sites?*

4. *What, therefore, are the implications for Santos' ability to regenerate sites to a natural condition'?*

Methodology

In order to gain a better understanding of the rehabilitation at the well and spill sites in PEL238, assessments were undertaken on the vegetation cover at 63 well sites and sub-surface soil conditions at 12 sites as of June 2018.

Native vegetation

All well sites in the forest were assessed for the quality of regeneration taking into consideration vegetation cover and plant diversity. The results are shown in the last column of Appendix 1. Site inspections were generally qualitative and considered the whole site by either (a) undertaking traverses across the site or (b) walks around the perimeter of fenced sites. Overall cover of vegetation and species diversity were assessed. Sites were observed to fall within five categories of growth or site quality:

1 Little growth, weeds, poor diversity

2 Small patches of wattle and/or tree growth, low diversity

3 Partial cover of wattle and/or tree growth, some diverse understorey

4 High cover native growth, moderate-good diversity

5 Active regeneration using tubestock

How well each category meets Biometric benchmark criteria is also assessed. Santos state in their Rehabilitation Strategy that each site has as yet to be assigned a reference community, however the predominant overstorey species in the Project area are *Eucalyptus crebra* (Narrow-leaved Ironbark), *Callitris glaucophylla* (White Cypress Pine), *Allocasuarina luehmannii* (Bull Oak), *Eucalyptus chloroclada* (Dirty Gum), *Corymbia trachyphloia* (Brown Bloodwood) and *Eucalyptus pilligaensis* (Pilliga Box), probably representing a number of different communities. For this report observed site conditions, comparisons were made with the ironbark-cypress pine-bulloak community BVT398: *Narrow-leafed ironbark – White Cypress Pine – Buloke tall*

open forest on lower slopes and flats in the Pilliga scrub and surrounding lands in the central north BBS bioregion, one of the most widespread communities in the Project Area

Soil analysis

A key component of the Rehabilitation Strategy is site soil management. Santos appear to recognise that health of the top and sub-surface soil environments and the biological activity associated with those layers are key for rehabilitation success.

Sites that Santos have cleared since taking over as owners of the Project infrastructure include the latest Dewhurst well series (26-29). However, while Santos may have stockpiled the top-soils at some of these sites, there is no documents that show how successfully these soils have been repatriated to the site. So, the proposal to do so in future Rehabilitation Strategy is not based on previous experience.

The soils in the Project area are predominately a duplex sodic type with contrasting A and B horizons. The predominately loamy A horizons are not deep, generally around 10-30cm and overlay a clay 'dome' which is the primary water-holding component of the soils.

Well site construction can heavily impact the structure of the soils. In the past, clearing of the sites scraped the top- and sub-soil, often leaving the clay layer exposed. Sites where produced water has spilled outside the well area have had their top-soils removed completely and disposed of offsite. Subsequent rehabilitation of these areas has generally involved the addition of organic matter and mulching straight on top of the clayey B Horizon, along with an intensive irrigation program, using gypsum as an additive to break down the exposed clay layer. within irrigation water applied to these sites.

The aim of this part of the study is to assess the soil health and its suitability to promote plant growth within the well sites. This assessment was undertaken by sampling the structure, pH, electrical conductivity and salinity as currently exists in the vicinity of a number of well and spill sites.

12 well sites were selected with a range of disturbance histories, including nine wells sites and three 'spill zones' and soil samples were taken (Appendix 2). At each well site, three samples were taken at equal distance (20m) from the location or likely location of the well head. At the spill zones, three samples were taken in a linear transect along the length of the disturbed area. All samples were sampled with a space of at least 20m between each. A 'control' sample was taken at each site in adjoining bushland where natural conditions were observed to exist.

In an attempt to achieve consistency in the soil samples, the loamy sub-surface at a depth of 5 cm below the surface was targeted. At well sites however, the depth of A horizon was found to be variable and so many samples contained higher levels of clay. The soil at the spill sites under

rehabilitation were found to be very different, having little of the surface loam left, these sites were found to have a highly organic and clayey sub-surface components.

pH was measured in each of the samples using the soil pH meter PH:-220S (Lutron). Electrical conductivity and associated measurements of the samples were made using the H198192 Meter (Hannah Instruments) within 24 hours of the samples being gathered.

Results: Native vegetation at the well and spill sites

Excluding the well sites subject to current active regeneration, 63 well sites located within bushland settings (mainly state forest) have been left largely to natural regeneration. Some sites have had 20 years since gas activities were undertaken at the site, though most have more recent activity, mostly 8-14 years ago. In most cases, the time since last activity has little to do with quality of existing vegetation cover with many older sites showing poor natural regeneration.

Table 1. Quality of well site rehabilitation in forested areas of PEL238

Quality	Description	Tally	%
1	Little growth, weeds, poor diversity	21	33
2	Small patches of wattle growth, low diversity	22	35
3	Partial cover of wattle and tree growth, some diverse understorey	19	30
4	High cover native growth, mod-good diversity	1	2
5	Active regeneration with tubestock	4	

1 Little growth, weeds

About one third of well sites in the forest (n=21) are largely devoid of vegetation, with scattered grasses and shrubs at some sites. These sites are also prone to weed infestation which can be significant. Various levels of mulching were observed at the sites.

DH28 typical of sites with little vegetation growth, but with some mulch.

2 Small patches of wattle and/or tree growth, low diversity

About a third of all sites (n=22) show some growth of wattles and trees in small patches. Understorey was generally found to be poor, as are overall levels of diversity. Wattles are often good colonizing species, and a few species were found to be present at the sites particularly the locally occurring Mudgee Wattle *Acacia spectablis* and Deans Wattle *Acacia deanii.*

Bohena 11 with wattle growth, some grassy patches.

3 Partial cover of wattle and/or tree growth, some understorey

Another third of well sites in the forest (n=19) show significant stands of wattle and tree growth, providing high levels of mid-storey cover. The quality of these sites varied considerably, with some showing good understorey development with a moderate diversity, while others had only scattered grasses and shrubs.

Bohena 3 with thick stands of wattle growth but with a depauperate understorey.

4 High cover native growth

Only one well site had what may be described as a good level of recruitment of locally occurring species, on a trajectory to achieve benchmark standards for composition and diversity, namely DH09 on Garlands Road. Good levels of recruitment of canopy, mid-story and groundstorey species was evident, including Bull Oak and Cypress Pine. This site had an overall good plant diversity.

DH09 showing good canopy and understorey recruitment.

5 Sites subject to active rehabilitation efforts (irrigation and plantings)

Four sites where spillage of produced water has occurred were currently found to be subject to an active rehabilitation program. This has been conducted over the last 18 months at the Bohena 2 and Bibblewindi spill sites and only recently commenced at the Bohena 5 and 6 sites.

Irrigation system at Bohena 2 spill zone

This has consisted of an irrigation system installed at each site consisting of holding tanks and a reticulated watering system. Watering of the sites has been conducted over the last 18 months, accompanied by plantings of various species.

Bohena 2 spill zone covers over 3 ha of bushland and currently shows significant effort in terms of plantings and irrigation. Prior to this current program this site would have been categorized as having a low diversity and cover. There has been significant weed removal from this site. It is too early to judge the success of this program, though some dieback is occurring, perhaps as a result of current dry conditions.

In regard to the Bibblewindi spill site, page 310 (6-122) of the Response to Submissions claims, "*Targeted surveys and monitoring at the Bibblewindi rehabilitation site undertaken by a suitably qualified ecologist during autumn and spring of 2017 have found the revegetated area is generally in a good condition and progressing on a trajectory towards self-sustaining plant communities*".

Assessment of this site in spring 2017 and June 2018 showed the 'spill area' at this site has been subject to intensive irrigation over the last year. Sedge and other wetland species have been planted which are not present in the surrounding forest community. In my opinion, if the irrigation is turned off, this 'community' is unlikely to persist. These plantings bear no resemblance to the reference community.

Results: Soil condition at the well and spill sites

Control conditions

The structure of the sub-surface' A horizon at control sites was generally a 'loam' often with a coarser sandy component on the surface of the top-soil. This merges into a 'clayey loam' the closer the contact with clay horizon. Some sites had very shallow A horizons and so samples containing clay were also obtained. At the 'spill' control sites, samples were obtained to include elements of clay so as to closer match the conditions in the rehabilitation zones.

The control sites (n=12) indicate that the loamy A horizon generally has a pH of between 5-6, with a higher pH for samples containing clay, up to about 6.3. The background electrical conductivity (EC) ranges from approximately 10-40 μs/cm and Total Dissolved Solids (TDS) at about 8-21 ppm. Background salinity levels of the soil in control areas lie in the range of 0-0.1%.

Well Sites

Some of the samples taken from well sites (n=27) showed some good retention of the top-soil, though mostly, A horizons have been lost to some extent, with shallow clay layers at some sites. This has elevated the pH readings taken at the well sites, with no sites, except two, showing a pH of less than 6 (DH09 and DH19). Sub-surface soil samples from all well sites ranged from pH 6.4 - 7.8, regardless of the clay content of the sample.

EC in the sub-surface samples from the well sites were mostly within the background levels recorded from within the control sites (9-40 μm/cm) though two samples showed double the background levels of EC and TDS. These sites also had an overall salinity level of 0.2%.

Spill Sites

At the three spill sites, the soil samples may be described as a loamy clay with very level of high organic matter. These sites all displayed a relatively high pH (6.4 - 6.9) in the 'top-soil'. EC levels varied considerably, with five of the nine samples showing double the background levels of EC and TDS with overall salinity levels of 0.2%. The rest of the samples were still seen to be higher than the normal range.

Discussion

Importance of soils in rehabilitation

Soils, especially top-soils, are key components of the ecosystem, as they supply nutrients and act as a medium for other biota, particularly bacteria and fungi needed for healthy soils and the

breakdown and transmission of nutrients. Plants form symbiotic relationships with these soil fauna and flora that assist them to utilize inorganic elements.

Soil conditions (pH, EC, structure) are important to maintain this biotic-inorganic cycle which takes place in the soil. Germination is also affected by soil condition and tolerances to pH levels can affect germination potential of many species, with a variety of tolerance between species. The biggest issue which faces ecosystem restoration efforts is the biological health of soils which are stockpiled as the stockpiling process changes normal chemical and nutrient cycles and the normal growth and behavioural patterns of soil biota, such that effective soil death is usual.

Data from this and other studies show the soils of the Pilliga forest to be acidic in nature, though usually regarded as nutrient poor (OEH 2013), underlying clay layers retain water and nutrient for plant growth. The movement of nutrient through the clay layer also occurs and there it becomes available to shrub and tree growth, however, the nutrient cycle in these soils is very slow (Hart 1992). As a consequence, the vegetation communities have evolved on a nutrient poor and acidic soil. For example, the Cypress Pine can only tolerate acidic soils (Lacey 1973). It appears even with the influence of clay, which will increase pH, pH levels of the surface and sub-surface soils in the Pilliga are rarely over 6. The control site soil results obtained here compare favorably with those found by Goldey and Associates (2012) who also found an average sub-surface pH of 5.5 and an EC of <20 µS/cm at unaffected sites.

Components of produced water

The chemical composition of produced water as held in the Leewood Ponds is shown in Table 6-1 of the Water Baseline Report, provided in the Response to Submissions. pH levels of this water was found to be in the range of 8.6 – 9.8, with EC levels of 4,223 – 28,399 µS/cm and TDS of 14,000 – 40,000 ppm. The 'spill zones' were exposed to this type of water, albeit in a diluted form. The soil results shortly after the incident at Bibblewindi show a sub-surface soil pH of 8-9 and an EC up to 6,000 µS/cm (Goldey and Associates 2012). The chemical composition of this water is certainly toxic to biotic matter, judging by the rapid way vegetation die when in contact (personal observation). But produced water may also be spilled within the well-site, during routine activities while the gas well is in pilot or productive use.

While levels of pH and EC found in the samples of this study are not high when compared to raw produced water, the residual impact of this water upon the chemical nature of the soil needs to be considered. While most of the badly affected soil has been removed at the spill sites, there is still persistence of areas of relatively high sub-surface soil EC (2-3 times background levels), as demonstrated in this study.

This study showed a consistent pattern of elevated pH at well and spill sites, regardless of age since drilling completion. The highest pH readings were recorded at Bohena 3 and 2, where spill incidents have been documented and where drilling activity occurred 20 ago. While sub-

surface soils at these sites have higher levels of clay on average than control sites, elevated pH (greater than 6.4) were detected regardless of it being loam or clay. Exceptions were Dewhurst 9 and 19 which had normal sub-surface readings (less than 6).

For EC and TDS, the highest levels observed were 2-3 times the control range (80 - 100 µS/cm and 40 - 50 ppm respectively) at two well sites and all three of the spill sites. The samples from the Bohena 2 and Dewhurst 19 well sites that contained these high levels were taken from surface depressions, possibly old sump pits or other water holding areas. The higher salt samples from the spill zones were taken from areas with no particular surface feature attached such as depressions.

These soil constraints are not favourable for the growth of locally occurring plant communities which tolerate a much more acidic soil and raises further questions concerning the ability of Santos to produce self-sustaining and locally occurring plant communities. Because of the water-holding capacities of the clay layer, contamination of the B horizons is problematic when attempting to remove these substances from the site. Spillage of produced or treated water at well sites may diminish the soil properties and plant growth potential (Echchelh et al, 2018).

Rehabilitation trajectories and completion criteria

Santos claims of a rehabilitation site quality on average being 74% that of reference site condition should be treated with caution given the following factors:

a) Figure 5 of the Rehabilitation Strategy show Santos have selectively used a number of sites with relatively good results to support their argument for wide rehabilitation success in the Project Area. However, if all sites in the PEL subject to natural regeneration are considered, success rates cannot be considered to be high, with approximately two thirds of all well sites with a low site quality, including some sites which are up to 20 years old.
b) Two sites subject to active irrigation and planting are only two years old, and given the issues associated with watering at levels greater than would be experienced naturally, species selection and high soil pH, the success of these areas remains unresolved. The Society for Ecological Restoration state that ecosystems can only be considered to be restored if they are self-sustaining to the same degree as their reference ecosystem and have the potential to persist indefinitely under existing environmental conditions. Planted systems need to demonstrate this persistence and regenerative ability, particularly under abnormal conditions associated with significant changes to the nature of the top-soil.

The benchmark conditions of Biometric Vegetation Type 398: *Narrow-leafed ironbark – White Cypress Pine – Buloke tall open forest on lower slopes and flats in the Pilliga scrub and surrounding lands in the central north BBS bioregion* specify the following criteria:

Benchmark criterion	Median Values
Native plant diversity	➢ 32±10
Overstorey cover	➢ 8.6±7.9%
Mid-storey cover	➢ 10.7±10.5%
Ground-cover (grasses)	➢ 25.2±17%
Ground-cover (shrubs)	➢ 14.6±19.2%
Ground-cover (other)	➢ 10.8±11.1%
Exotic plant cover	➢ 0.2±1.3%
Litter	➢ 52.1±28.9%
Bare ground/rock	➢ 10.3±11.6%
Cryptogram	➢ 0.6±1.2%
No trees with hollows	➢ 0.5±0.8
Length of fallen logs	➢ 45.2±31.2m

For the purposes of this report, is assumed that median levels indicated above will be the close to the approximate completion targets, though Santos have stated they will use reference sites from within the study area to create a local benchmark.

For two-thirds of the sites surveyed for this report, few if any of the benchmarks have been achieved. Of the 20 well sites where good vegetation cover was observed, very few matched the extent of groundcover specified above, while mid-storey is generally over-represented. While some sites showed good species recruitment at various levels, many did not, instead showing species and cover poor ground-storeys.

Overstorey recovery was also patchy from site to site, locally occurring eucalypt species sometimes showed good germination rates, though no site was found to have trees much over two meters. Santos also mention that coppicing stumps will provide good overstorey cover, however, most sites were observed to have their stumps removed to facilitate site activity and this component should not be relied on as a way of achieving benchmark overstorey conditions. A shortfall on relying on the Biometric benchmark approach for achieving a self-sustaining community is no specification exists for ensuring that the composition of the overstorey remains intact, and there is no requirement that all the species present in the reference sites be present at the rehab sites. During inspection of the well sites, regenerating Cypress Pine and Bull Oak were both found to be absent, except at a few sites, such as at DH09, a site with natural levels of soil pH.

In order to address some of the issues identified here, which may be particular to the type of operation being proposed, it is recommended that rehabilitation completion criteria for coal seam gas (CSG) activities specify soil pH and *Callitris* recruitment requirements.

More importantly, it is recommended that assertions made by Santos in their Project EIS and RtS regarding their rehabilitation success at well sites be independently verified prior to any approval being granted, as rehabilitation issues are key to meet specific sign-off and offset requirements in the EIS.

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Appendix 1: Site history and rehabilitation data

Site	Completion Date	Status	Depth	Impacted offsite area	Time since activity	Remediation Date	Past Actions	Rehab Rating/5
Bohena South Ponds				0.9 ha		2012	Soil Restoration, Full Rehab	3
Bibblewindi facility				1.2 ha	7 years	2014, 2017, current	Soil Restoration, Full Rehab	New plantings
Bohena 2	9-Jun-98	Permanently sealed	908m	3.1 ha	20 years	2014, 2017, current	Soil Restoration, Full Rehab	New plantings
Bohena 4/4L	15-Aug-98	Permanently sealed	910/1622m	1 ha	20 years	?, 2012, current	Soil Restoration, Full Rehab + Supplementary- irrigation	1
Bohena 5	27-Dec-98	Permanently sealed	936m		20 years	2012, current	Full Rehab - irrigation and plantings	New Plantings
Bohena 6/6H	29-Dec-98	Permanently sealed	976/691m		20 years	?, 2012	Full Rehab / Supplementary actions - irrigation and plantings	New Plantings
Bohena 8	?	Abandoned				2012	Full Rehab	3
Bohena 10		?				2012	Full Rehab	1
Bohena 11		?				2012, current	Full Rehab - irrigation	2
Bohena 14	14-Apr-10	Permanently sealed	1026.3m		8 years			1
Bibblewindi 1	8-May-00	Permanently sealed	950m		18 years			Facility
Bibblewindi 2	11-Jul-06	Permanently sealed	997m		12 years			Facility
Bibblewindi 11	24-Nov-07	Permanently sealed	1035m		11 years	2012	Lease Size Reduction	2
Burrawarna 1 e	1-Jun-00	Permanently sealed	832m		18 years			
Jacks Creek 1 e	29-Jun-00	Permanenty sealed	792m		18 years			3
Yallambee 1 e	26-Aug-09	Permanently sealed	894m		9 years			
Yallambee 2 e	21-Apr-11	Permanatly sealed	1082m		7 years			
Dewhurst 2	21-Apr-	Permanently sealed	975 m					3

Dewhurst 3	22-May-08	Permanently sealed	885m		10 years			1
Dewhurst 5	8-Oct-08	Permanently sealed	822m		10 years			1
Dewhurst 4	8-Jul-08	Permanently sealed	1038m		10 years			1
Dewhurst 7	10-Sep-08	Permanently sealed	1099m		10 years			1
Dewhurst 8/8A	20-Nov-13	Permanently sealed	1027m		5 years			1
Dewhurst 11	10-Nov-09	Permanently sealed	1038m		9 years			1
Dewhurst 19	15 May 2011	Permanently sealed	660m		7 years			4
Brigalow Park 1 e	15-Oct-04	Permanently sealed	910m		14 years			
Brigalow Park 2 e	15-Nov-10	Permanently sealed	752m		8 years			
Rosevale 1/1A e	23-Nov-10	Permanently sealed	636m		8 years			
Coonarah 2 e	20-Jan-11	Permanently sealed	1011m		7 years			
Coonarah 9 e	11-Nov-09	Permanently sealed	1023m		9 years			
Tintsfield 1	9-Oct-09	Permanently sealed	988m		9 years			
Wilga Park 4	8-Jan-99	Permanently sealed	821m		19 years			
Wilga Park 5	17-Dec-98	Permanently sealed	841m		20 years			
Bohena 3	28-Dec-98	Not producing gas	925m	0.9 ha	20 years	2012, current	Soil Restoration, Full Rehab - irrigation	3
Bohena 7	26-Dec-98	Not producing	941m	1.2 ha	20 years	2012, current	Soil Restoration, Full Rehab - irrigation	2
Bohena 9	6-Sep-04	Not producing	913m		14 years	Current	irrigation	2
Bohena South 1	19-Sep-04	Not producing	909m		14 years			3
Bibblewindi 3	20-Jun-06	Not producing	987m		12 years			2
Bibblewindi 4	1-Jul-06	Not producing	987m		12 years			2
Bibblewindi 5	28-Apr-06	Not producing	997m		12 years			1
Bibblewindi 6	25-May-06	Not producing	996m		12 years			1
Bibblewindi 7	10-Apr-06	Not producing	1005m		12 years			1
Bibblewindi 8	4-Jun-06	Not producing	997m		12 years			1
Bibblewindi 9	14-May-06	Not producing	997m		12 years			2

Bibblewindi 10	26-Mar-06	Not producing	990m		12 years	2012	Lease Size Reduction	3
Bibblewindi 14	7-Feb-09	Not producing	1100m		9 years	2012	Lease Size Reduction	1
Bibblewindi 20	12 Jul 2009	Not producing,	1004m		9 years	2012	Lease Size Reduction	2
Bibblewindi 26 H	4-Jul-09	Not producing			9 years			3
Dewhurst 6	7-May-09	Not producing	1005m		9 years			2
Dewhurst 9	24 Jun 09	Not producing	1032m		9 years			3
Dewhurst 10	30 Jul 2009	Not producing	976m		9 years			3
Dewhurst 13	12-Nov-09	Not producing	1225m		9 years			2
Dewhurst 14	4-Nov-09	Not producing	1220m		9 years			1
Dewhurst 15	25-Oct-09	Not producing	1205m		9 years			1
Dewhurst 16H	18-Dec-09	Not producing	2106m		9 years			2
Dewhurst 17H	7-Dec-09	Not producing	2048m + 1 Station		9 years			2
Dewhurst 18H	26-Nov-06	Not producing	2035m + 2 laterals and 8 stations		12 years			2
Dewhurst 22	10-Dec-13	Not producing	1022m		5 years			2
Dewhurst 23	8-Feb-14	Not producing	1104m + 1 DW ~ 2km		4 years			1
Dewhurst 24	23-Dec-13	Not producing	999m		5 years			2
Dewhurst 25	17-Jan-14	Not producing	967m + 1DW ~1.8km		4 years			1
Wilga Park 3	17-Dec-98	Not producing	814m		20 years			
Bibblewindi 12	39821	Producing	1002m			2012	Lease Size Reduction	2
Bibblewindi 13	39835	Producing	1036m			2012	Lease Size Reduction, Partial Rehab	2
Bibblewindi 15	39900	Producing	1050m			2012	Lease Size Reduction	3
Bibblewindi 16	39866	Producing	1100m			2012	Lease Size Reduction, Partial Rehab	1
Bibblewindi 17	39909	Producing	1076m			2012	Lease Size Reduction, Partial Rehab	2
Bibblewindi 18 H	39888	Producing	2121m + 2 laterals, 10 stations					2
Bibblewindi 19 H	39929	Producing	2296m + 2 laterals, 6					3

			stations					
Bibblewindi 21 H	40078	Producing	2378m + 9 stations					3
Bibblewindi 22	39960	Producing	895m					3
Bibblewindi 23	39974	Producing	905m					3
Bibblewindi 24	39967	Producing	920m					3
Bibblewindi 25	39980	Producing	912m					3
Bibblewindi 27	40032	Producing	1185m			2012	Lease Size Reduction, Partial Rehab	1
Bibblewindi 28 H	40061	Producing	2364m + 3 stations					2
Bibblewindi 29	40047	Producing	1207m			2012	Lease Size Reduction	3
Tintsfield 5	40215	Producing	870m					
Tintsfield 4H	40274	Producing	1713m + 3 stations ?m					
Tintsfield 2H	40258	Producing	11712m + 4 stations					
Tintsfield 3H	40243	Producing	1492m					
Tintsfield 6	40223	Producing	871m					
Tintsfield 7	40232	Producing	870m					
Dewhurst 26	41701	Producing	1060m					2
Dewhurst 27	41733	Producing	1217m					2
Dewhurst 28	41691	Producing	1065m					1
Dewhurst 29	41779	Producing	1170m + 4DW ~ 2km					3
Core holes								
Bohena 3c	28-Dec-98	Permanently sealed	925m					
Bohena 12c	23-Jul-07	Permanently sealed	1008m					
Bohena 13c	27-Oct-07	Permanently sealed	942m					
Bohena 14c	14-Apr-10	Permanently sealed	1026m					
Bohena South 2c	26-Aug-07	Permanently sealed	906m					
Bohena South 1c	19-Sep-04	Permanently sealed	909m					
Bibblewindi 11c	24-Nov-07	Permanently sealed	1035m					

Bibblewindi North 1c	11-May-07	Permanently sealed	855m					
Bibblewindi West 1c	13-Dec-07	Permanently sealed	888m					
Wilga Park 1c	21-May-99	Permanently sealed	653m					
19 3, 22 1, 22 2, 1 4								

Appendix 2: Sub-surface soil sample data

	Site	Status	Factors	Control	1	2	3
				loam	loam	loam	clayey loam
1	Bo11	?	pH	5.65	6.88	7.73	7.03
			EC (µS)	35.5	11.6	34.21	21.41
			Res (kΩ)	28.5	86.4	27.5	46.2
			TDS (ppm)	17.52	5.8	18.91	10.88
			salinity (%)	0.1	0	0.1	0
				loam	clayey loam	clayey loam	clayey loam
2	Bo7	Sealed	pH	5.23	6.15	6.13	6.38
			EC (µS)	47.33	47.39	55.31	44.19
			Res (kΩ)	22.9	20.7	16.3	21.3
			TDS (ppm)	21.72	24.91	31.09	23.67
			salinity (%)	0.1	0.1	0.1	0.1
				loam	clayey loam	clayey loam	clayey loam
3	Bo3	Inactive	pH	5.66	7.38	7.23	6.9
			EC (µS)	29.34	21.74	25.78	13.22
			Res (kΩ)	35.8	45.5	39.2	75.8
			TDS (ppm)	13.77	11.05	12.88	6.6
			salinity (%)	0.1	0	0	0
				loam	clay	clayey loam	clayey loam
4	Bo9	Inactive	pH	5.74	6.39	6.49	7.1
			EC (µS)	22.21	11.72	9.73	23.83
			Res (kΩ)	45.1	85.5	104	41.9
			TDS (ppm)	11.1	5.84	4.83	11.93
			salinity (%)	0	0	0	0
				loam	clayey loam	clayey loam	clay
5	Bo6	Sealed	pH	5.24	6.87	6.71	6.53
			EC (µS)	32.46	22.57	22.62	9.68
			Res (kΩ)	30.3	43.7	43.4	99.6
			TDS (ppm)	17.36	12.21	11.53	4.99
			salinity (%)	0.1	0	0	0
				loam	clayey loam	clayey loam	clayey loam
6	Bo2	Sealed	pH	5.87	7.16	6.73	6.96
			EC (µS)	17.33	58.26	81.8	23.68
			Res (kΩ)	57.3	17.2	12.2	41.9
			TDS (ppm)	8.64	30.44	41.45	12.04
			salinity (%)	0	0.1	0.2	0

				loam	loam	loam	clayey loam
7	B04	Sealed	pH	6.02	6.61	6.94	6.74
			EC (µS)	24.65	19.85	28.44	25.89
			Res (kΩ)	40.3	50.6	34.5	38.6
			TDS (ppm)	12.43	9.86	14.6	13.15
			salinity (%)	0	0	0.1	0
				loam	loam	loam	clayey loam
8	DH09	Sealed	pH	5.64	5.42	5.56	6.21
			EC (µS)	33.24	25.55	56.72	15.25
			Res (kΩ)	30.1	39	17.6	65.6
			TDS (ppm)	16.49	12.87	28.67	7.58
			salinity (%)	0.1	0	0.1	0
				loam	clayey loam	clayey loam	loam
9	DH19	Inactive	pH	5.71	6.73	5.35	5.81
			EC (µS)	16.17	16.6	96.12	10.17
			Res (kΩ)	61.8	60.7	10.4	96.9
			TDS (ppm)	8.01	8.24	48.21	5.19
			salinity (%)	0	0	0.2	0
				loamy clay	organic/clay/ loam	organic/clay/ loam	loamy clay
10	BO7spill	Sealed	pH	6.14	6.44	6.54	6.67
			EC (µS)	23.79	37.06	88.13	72.67
			Res (kΩ)	43.2	27	11.4	13.7
			TDS (ppm)	11.54	19.01	43.66	39.71
			salinity (%)	0	0.1	0.2	0.1
				clayey loam	organic/clay/ loam	organic/clay/ loam	organic/clay/ loam
11	BO2spill	Watering &	pH	5.81	6.4	6.65	6.53
		planting	EC (µS)	19.56	31.36	90.3	83.62
			Res (kΩ)	51.4	30.9	11.1	11.7
			TDS (ppm)	9.67	16.41	45.81	43.74
			salinity (%)	0	0.1	0.2	0.2
				loam	organic/clay/ loam	organic/clay/ loam	organic/clay/ loam
12	Bibspill	Watering &	pH	5.91	6.43	6.84	6.5
		planting	EC (µS)	16.86	50.9	41.88	84.09
			Res (kΩ)	59.6	19	24.1	11.8
			TDS (ppm)	8.37	27.4	20.66	42.47
			salinity (%)	0	0.1	0.1	0.2