Issue	Response/reference
management?	Native Title Services, which is the native title representative body for NSW, in respect to this matter. Santos has also had preliminary discussions with the Gomeroi Native Title Applicants in the lead up to a native title agreement. Refer Sections 5.1.2 and 6.5.
4.6 Historic cultural or natural heritage impacts	
What is the impact on places, buildings, landscapes or moveable historic heritage items?	Nil. Two identified items of potential European heritage significance (i.e. SUGAR pits) have been identified on Leewood. The proposed activity will avoid impacts to the items. Refer Section 6.6.
Is any vegetation of cultural landscape value likely to be affected (e.g. gardens and settings, introduced exotic species, or evidence of broader remnant land uses)?	No. There is no vegetation of cultural landscape value within the site. This has not been addressed further in this REF.
4.7 Matters of National Environmental Significance	
Is the proposed activity likely to impact on MNES under the EPBC Act?	No. The proposed activity will not impact of any MNES. Refer Section 6.7.
4.8 Cumulative Impacts	
Is the proposed activity likely to have any significant cumulative impacts?	No. Refer Section 6.8.

6.1 Physical and chemical impacts

6.1.1 Soil quality and land stability

6.1.1.1 Impacts

Construction of the proposed activity will require vegetation clearing and land disturbance (see Section 6.2.1). These works, while temporary, have the potential to cause soil degradation and loss of topsoil, soil compaction and soil erosion, including sedimentation of waterways.

Should topsoil to be stockpiled at Leewood be stored for an extended period (i.e. greater than 12 months), impacts to the structure, biological activity, chemical properties and organic content may be affected.

During construction and operation, the proposed activity could result in soil contamination as a result of spilled or leaked chemicals, fuel or oil. Spills or leaks could occur during handling, use, storage or transit of chemicals, fuels and oils. Spills or leaks may also occur during refuelling or maintenance of plant or equipment. Any incidence of spills or leaks on-site would likely be minor. Measures to reduce the risk of contamination as a result of the proposed activity are identified in Section 6.1.1.2.

Loss of containment of untreated produced water from WBTP units, pipes or manifolds could result in an uncontrolled release to the environment and subsequent soil contamination. The design and operation of the Leewood WBTP will ensure that the risk of any uncontrolled release from the plant is minimised. Comprehensive control and alarms systems which monitor and account for the volume of water pumped and processed throughout the entire system will assist in leak monitoring and prevention. Incident management measures to prevent leakages are outlined in Section 2.7.4.

During operation, the main potential impacts to soil will occur across the irrigation area. As stated in Section 4.3.1, the soils within the irrigation areas of the site were grouped into two management classes – A and B.

The irrigation system design and operations would treat these as different management zones, as outlined in the irrigation concept design report (Appendix 3). Therefore irrigation infrastructure, cropping and irrigation scheduling would vary according to the irrigation management class of the soil to minimise potential impacts.

As outlined in Section 4.3.2, the soil on-site has a number of inherent limitations due to its sodic nature. Without chemical dosing, the addition of irrigation water to the sodic soil could present the following issues:

- limiting of leaching, which could cause salt to accumulate over time and the development of saline subsoils, as sodicity reduces flow of water through soil
- crusting and sealing of the soil, which could impede water infiltration leading to potential increased runoff, as sodicity causes dispersion in the soil surface
- acceleration of erosion, which could cause the appearance of gullies and tunnels, as sodicity increases dispersion in the subsoil
- a dense, cloddy and structureless soil as it destroys aggregation.

However, as discussed in Section 2.6.3.2, prior to being used for irrigation purposes, water from the WBTP will be treated to a level that conforms with the *Environmental Guidelines: Use of Effluent by Irrigation* (DEC, 2004). The addition of chemicals to the treated water will make the water suitable for the intended soils and will serve to maintain or improve soil structure stability. This will be closely monitored as outlined in 2.7.1.2.

As outlined in Table 2-10 of Section 2.6.2.1, the following soil preparation activities will be undertaken during construction:

- application of gypsum – displaces the sodium within the soil, reducing its sodicity and dispersivity
- application of lime – neutralises soil acidity, and additional calcium would also ameliorate sodium
- deep ripping – breaks up the hard, coarse subsoil to assist in water infiltration
- application of fertiliser (during soil preparation, and continuing on throughout operation) – increases the nitrogen levels in soils, a limiting nutrient onsite.

The salinity of the treated water to be applied to the irrigation area would be rated as ‘low’ according to the DEC Guidelines (2004), as described in Section 2.6.3.4. Most irrigation waters carry a salt load that presents a risk of accumulation in the rootzone, particularly in arid regions or where high water tables exist. The annual rainfall of approximately 650 millimetres onsite will assist in offsetting salt deposition by irrigation water.

The expected EC of the treated water is 1.0 mS/cm. The total annual salt load to the soils over the irrigation area, based on an irrigation application rate of 372 millimetres per hectare or 3.7 ML/ha, is expected to be 2,320 kg/ha. The calcium ions will have a positive effect on soil quality so are not of concern. Annual salt inputs of sodium chloride from 644 mm rainfall are fairly small, estimated to be about 31 kg/ha. Whereas the permeate would add 490 kg/ha sodium and 440 kg/ha of chloride annually.

At an annual irrigation application rate of 372 millimetres or 3.7 megalitres per hectare, the annual salt input from irrigation is shown in Table 6-2.

Table 6-2 Annual salt or ion loading from application of treated irrigation water

Salt or ion added	Annual salt load (kg/ha)
Sodium	490
Calcium	190
Chloride	440
Sulphate	0
Bicarbonate	1,200
Total salts	**2,320**

The calcium ions typically have a positive effect on soil quality. Sodium chloride can impact soil stability (i.e. increased dispersibility), so the proposed irrigation system would provide control sensitivity such as deep drainage. Regular soil sampling and monitoring of salt accumulation in and beneath the rootzone would also be implemented.

The proposed irrigation area within the site is also prone to becoming waterlogged in the surface soil and would be untrafficable following extended rainfall periods, i.e. periods where continuous rainfall events exceed 50 millimetres. Land preparation and operational activities would be restricted during these periods. The irrigation schedule (application of the treated water) would be managed to minimise waterlogging and runoff. Traffic would also be kept to a minimum in the irrigation area to reduce soil compaction.

To gain a better understanding of the potential effects of irrigation of this site, three irrigation management schemes were modelled for comparison to the current rain-fed pasture setting. Details of this modelling are provided in the concept irrigation design report, provided in Appendix 3.

The four irrigation scenarios that were modelled using the HowLeaky modelling program were:

- Scenario 1 (baseline) – current dryland pasture under natural rainfall. This was simulated to compare the natural erosion, deep drainage and runoff from the site
- Scenario 2 – even irrigation of all 97.8 hectares, simulation based on an average year with one megalitre per day treated irrigation water
- Scenario 3 – even irrigation of all 97.8 hectares, simulation based on an average year with unlimited treated irrigation water
- Scenario 4 (likely management approach for the proposed activity) – irrigation split between Class A (68 ha) and B soils (30 ha), with priority given to watering Class B soils from October to May, and no irrigation of Class B soils from June to September. One megalitre per day treated irrigation water supply.

Irrigation events were set at 12 millimetres per application. An irrigation event was triggered once the soil water deficit reached 50 millimetres or 36 per cent of the 140 millimetre plant available water capacity (PAWC).

Three parameters having potential environmental impacts were modelled – runoff, deep drainage, and erosion and site sediment loss. The results of the modelling for these parameters are provided in Table 6-3.

Table 6-3 Water losses from system with potential environmental impacts = HowLeaky model output

Water loss mechanism	Scenario 1	Scenario 2	Scenario 3	Scenario 4 – Class A soils	Scenario 4 – Class B soils
Deep drainage (mm/yr)	4.0	3.9	16.9	4.3	5.7
Runoff (mm/yr)	14.2	13.5	39.6	14.6	17.6
Erosion and site sediment loss (t/ha-yr)	0.22	0.22	0.70	0.24	0.30

Discussions on the potential impacts of the proposed activity in relation to deep drainage and runoff are provided in Sections 6.1.2 and 6.1.3, respectively.

Under all four scenarios the paddocks were in permanent vegetative cover and the erosion and site sediments losses were predicted to be quite low at less than one tonne per hectare annually. The International Erosion Control Association best practices manual (IECA, 2008) states that erosion losses less than one tonne per annum are a desirable target and should result in less than 50 mg/L suspended solids which is necessary for maintaining pristine waterways.

6.1.1.2 Mitigation measures

The following measures will be implemented to avoid and/or minimise impacts on soil quality and land stability:

- Erosion and sediment controls will be implemented where necessary, in accordance with the guidelines, principles and recommended minimum design standards contained in *Managing Urban Stormwater, Soils and Construction – Volume 1* (the Blue Book). These controls will be maintained until disturbed areas of the site are stabilised
- A specific erosion and sediment control plan (ESCP) will be developed during detailed design and implemented for the proposed activity
- Any spills or leaks will be contained and cleaned up immediately. Contaminated material (such as contaminated soil or absorbent materials) will be removed from the site for disposal at a licensed waste facility
- Plant and equipment installed at the premises or used in connection with the licensed activity will be maintained and operated in accordance with condition O2.1 of EPL 20350
- A soil sampling and monitoring program, inclusive of the irrigation area will be implemented, as outlined in Section 2.7.1.2
- Soil amelioration, crop management and irrigation scheduling will occur generally as described in the concept irrigation design report (Appendix 3), to prepare and maintain the irrigation area throughout operation
- The site will be rehabilitated in accordance with Section 2.6.4 of the REF.

6.1.1.3 Potential impact category

The proposed activity will result in a negligible impact on soil quality and land stability. Construction related impacts will be temporary and managed using measures such as those outlined in *Managing Urban Stormwater*: Soils and Construction (Landcom 2004) ('the Blue Book'). While the total area of disturbance is 99.6 hectares, the majority of this will be for cropping and irrigation purposes. Soil amelioration will improve the productivity and structure of the soil over this area. The proposed soil monitoring program will ensure that there is no longer term degradation of the soil, including those caused by increased soil salinity and soil erosion and sediment loss.

6.1.2 Groundwater

6.1.2.1 Impacts

Minor impacts to groundwater may be associated with the construction and operation of the proposed WBTP and associated infrastructure, as well as the irrigation area.

Groundwater impacts during construction are considered to be highly unlikely, as the maximum depth of excavation for the proposed activity is approximately five metres and the known depths of those aquifers regulated by the WM Act is greater than 10 metres.

Under the irrigation scenarios that were modelled for the conceptual design irrigation report, deep drainage would increase slightly for the likely management approach for the proposed activity (Scenario 4 within Table 6-3) when compared to the current land use. The change in deep drainage is considered minimal as the greatest change modelled was an increase by 1.7 mm/yr. Therefore, no significant increase in groundwater level beneath the proposed irrigation site is likely to occur as a result of the proposed irrigation scheme.

Since deep drainage is minimally influenced by the proposed managed irrigation system, there is little likelihood of impacts on groundwater quality, including movement of salts and heavy metals.

The predicted salt concentrations of the treated irrigation water (TDS of less than 650 mg/L) indicates that it would not impact significantly upon groundwater quality as it would be similar to the highest quality groundwater (TDS of 631 mg/L) found on the site (refer to Appendix 3). Leaching of salts to maintain salinity levels within the soils of the irrigation area, as outlined in Section 6.1.1, may result in some additional release of ions to the soil solution with the input of irrigation water. This may lead to a negligible increase in salts entering groundwater.

Naturally occurring metals within the soils on-site were identified as low level and below *National Environment Protection (Assessment of Site Contamination) Measure 1999* (amended 2013) thresholds (Appendix 3), while the treated water is unlikely to contain heavy metals. The pH of applied treated water is also expected to be neutral and therefore not anticipated to result in any additional dissolution of heavy metal ions into the unsaturated zone and ultimately to groundwater.

6.1.2.2 Mitigation measures

The measures identified in Section 6.1.1.2 will also minimise potential impacts to groundwater. In addition, groundwater monitoring as per Section 2.7.1.5 will be implemented.

6.1.2.3 Potential impact category

The proposed activity will result in a negligible to low adverse impact on groundwater. With similar drainage rates as those associated with more vigorous vegetation under intensively managed irrigation activities, and good quality water being applied to the land, the risk of heavy metal and salinity movement to groundwater or changes in groundwater levels is considered unlikely. Ongoing groundwater monitoring on-site will ensure any adverse changes are able to be identified and are quickly addressed so that there is no significant impacts to the groundwater.

6.1.3 Water body, watercourse, wetland and natural drainage systems

6.1.3.1 Impacts

The potential impacts on surface water bodies associated with construction and operation of the proposed activity include erosion and sedimentation, surface water contamination due to chemical/fuel release, increase in runoff from the irrigation area, and impacts to flooding downstream of Leewood.

The likelihood of impacts due to erosion and sedimentation are discussed in Section 6.1.1.1. There is the risk that surface water contamination could occur during both construction and operation due to spills of oil, fuels or chemicals if not cleaned up appropriately.

Under the irrigation scenarios that were modelled for the conceptual design irrigation report (see Appendix 3), runoff would increase slightly for the likely management approach for the proposed activity (Scenario 4 within Table 6-3) when compared to the current land use. Scenario 4 shows runoff of 14.6 and 17.6 millimetres per year for Class A and B soils respectively, compared to 14.5 millimetres per year of runoff for Scenario 1 (pasture baseline).

Although the slopes are moderate and perennial cover will be maintained, the modelling indicates that some water will run off the irrigated area. The runoff will most likely be driven by rainfall events and is predicted to carry small amounts of sediment and possibly nutrients. As the irrigation schedule will be driven by crop water demand and availability of treated water, less (or no) water will be applied during periods of extended rainfall.

A key environmental performance objective of beneficial use of treated water for irrigation is to ensure that ground and surface waters do not become affected by any flow from irrigation areas. As the treated irrigation water is classified as medium strength effluent (refer to Section 2.6.3.4), it will be appropriately managed without a material change to the overland flow path.

Approximately one-third of the proposed irrigation area is located within flood-prone land (100 year ARI affected land, as shown in Figure 4-5), as well as a small section of hardstand area around the treated water storage tank. The irrigated land located within the flood-prone extent (Class B soil type) will occasionally be naturally inundated during prolonged rain events. However, the implementation of subsurface drip irrigation technology and targeted irrigation scheduling on this soil type will minimise the likelihood of inundation caused by the proposed irrigation activity. This has been demonstrated through the modelling, which indicates minimal changes in surface water runoff for the Class B soils (Table 6-3). It is considered unlikely that the proposed activity will cause significant changes to the downstream flood regime, or that the proposed activity will be significantly impacted by flooding.

Only treated water will be used for dust suppression and in rehabilitation activities. Management of these activities, as outlined in Section 2.7.2, will minimise the likelihood of ponding and runoff.

No surface water will be extracted for either the construction or operational phases of the proposed activity.

6.1.3.2 Mitigation measures

Implementation of the mitigation measures identified in Section 6.1.1.2 will ensure impacts in relation to erosion and sedimentation are minimised. Additional mitigation measures to minimise impacts to surface water include the following:

- Scheduling of irrigation activities will be managed generally in accordance with the concept irrigation design (Appendix 3), to minimise inundation and runoff
- During construction in the event that prolonged, severe wet weather or flooding is predicted, appropriate measures will be put in place to mitigate impacts of the wet weather
- The treated water storage tank will have high level alarms, or other appropriate controls, implemented to prevent overflows
- A surface water monitoring program will be implemented, as outlined in Section 2.7.1.4.
- Management measures for dust suppression and in rehabilitation activities will be implemented, as outlined in Section 2.7.2
- All above ground tanks containing material that is likely to cause environmental harm will be bunded or have an alternative spill containment system in place.