9 Soils

Soils and Groundwater – the EA shall include consideration of existing soil conditions, the suitability and sustainability of long-term recycled water application, including measures to avoid soil degradation and inappropriate nutrient loading. An assessment of groundwater impacts must be provided, focussing specifically on the potential for accessions to groundwater of recycled water and salinity impacts. Consideration must also be given to the impact of trenching and other underground work on groundwater and subsurface flows.

This chapter presents the assessment undertaken to address the Director-General's Requirements (DGRs) in relation to soil (refer to Chapter 10 for groundwater). It includes the findings of a study by Agsol Pty Ltd to assess the potential impacts relating to the application of recycled water on soils (refer to Appendix D).

The key findings of the assessment are that:

- The main construction impacts on soil would include soil erosion and soil contamination. These potential impacts would be adequately mitigated through standard measures detailed in this chapter.
- During operation, the soil salinity risks were the most significant risks. However, with prevention and management these risks were deemed to be acceptable.

A summary of the soil impact assessment is presented below.

9.1 Scope of the soil impact assessment

Potential soil impacts of the Project have been assessed in accordance with the DGRs at concept level, with impacts relevant to Stage 1 of the Project assessed at project level.

In relation to the concept plan for the Project, the assessment has focussed on the use of recycled water throughout the study area, particularly with regards to:

- The capability of soils within the study area to manage irrigation with recycled water.
- The potential salinity impacts relating to the recycled water.
- A Stage 1 contamination survey of the study area to identify areas of environmental concern.
- Soil erosion across the study area.

For Stage 1 of the Project, the above were assessed in more detail. In addition, further assessment is provided for:

- A detailed Stage 2 contamination assessment in relation to existing uses of the site (agricultural land use).
- Soil erosion during construction of Stage 1 of the Project, based on soil landscapes.

Future assessments under the EP&A Act, potentially under Part 3A project application(s) or Part 4 development applications, would need to be undertaken for elements of the concept plan that are not part of Stage 1 of the Project. In terms of soil assessments, these would need to consider:

- The potential impacts of mains pipework within neighbourhoods 2, 3, 4 and 5 of the township (refer to Figure 5.1 for the indicative pipework routes). While the current study identifies that there are unlikely to be any significant impacts as a result of the Project, future studies should include an assessment of:
  - The existing environment at the time of the study, as the Googong township development would proceed progressively over the next 25 years and the ecology has the potential to change over that time.
  - The context of the pipework in relation to the developing urban landscape of the Googong township and the impacts of the road network that pipelines would be associated with.
- The specific locations of sewage pumping stations 3 and 4, once these are determined, as well as any other sewage pumping stations or other water cycle infrastructure that may be required.

Approaches to addressing salinity have also been assessed at concept level in Section 9.3.2. A key management approach is the monitoring of salt to assist with further project applications.

9.2 Assessment methodology

Agsol has conducted a Recycled Water Irrigation Land Capability Assessment (refer to Appendix D), which assesses the potential impacts relating to recycled water on soils. In this assessment, a series of water balance analyses were undertaken to estimate the re-use, discharge volumes and irrigation volumes under various water-saving scenarios being considered for the Googong township. From this, impacts on the salinity and sodicity of the soils can be assessed, with mitigation measures provided.

9.3 Existing environment

9.3.1 Local geological setting and structural aspects

Most of the study region is underlain by the Colinton Volcanics, a late Silurian volcanic unit within the Canberra block. The Colinton Volcanics are described as a combination of limestone, dolomitic limestone and siltstone beds, tuffaceous shale, dacitic, rhyodacite and rhyolite lava flows, and ash fall deposits.

The north-eastern corner of the site is underlain by the Googong Adamellite, a locally significant intrusive body that is described as a medium-to-coarse-grained, moderately weathered, buff-coloured porphyritic adamellite. It is located between the eastern boundary of the site and the western side of Googong Reservoir. It has an area of about three square kilometres and forms a number of lower slopes and plains enclosed by more resistant dacitic ignimbrites of the Colinton Volcanics. It is well exposed in a number of cuttings along the Googong Dam Road and also in a number of reaches along Montgomery Creek.

In the south-eastern corner of the site, two small granitic intrusions have been emplaced in the Colinton Volcanics. These units form two small north-north-east to south-south-west elongated stocks that, like the Googong Adamellite, have been derived from the melting of oceanic crustal material.

Although no major fault zones were detected at the dam site, there is a north-south orientated normal fault located in close proximity to the eastern abutment. Fractured zones and associated deep weather, possibly caused by the intrusive effect of the granite and associated hydrothermal activities are also known to exist in the dacite.

It is understood that the rocks within the Canberra block have undergone significant folding and faulting, all of which is associated with the development of the Lachlan Fold Belt. The predominant structural trend in the region is orientated approximately north-north-east to south-south-west.

Figure 9.1 Typical landscape of the study area

9.3.2 Electromagnetic survey results

Electromagnetic surveying is a key tool to identify the variability in soil characteristics. The technology is routinely used to identify the variability in soil characteristics by measuring the soil's apparent conductivity. It is influenced by soil porosity, soil moisture, the concentration of dissolved salts and the amount and type of clay within the soil profile.

Under normal conditions, the highest conductivity readings will represent soils with the highest overall clay content and lowest drainage, indicating potentially saline conditions; the lowest conductivity readings indicate relatively coarse textured soils with lower electrolyte levels and typically having increased relative drainage characteristics.

Figure 9.2 shows the electromagnetic survey results for the study area, conducted by Agsol in February 2009. Generally, the conductivity readings were low to very low over the site, which is consistent with non-saline and well drained soils. The lowest readings are in areas dominated by rocky soil. The higher readings generally occur along the drainage lines and may be an indicator of deeper or damp soil.

9.3.3 Soil landscapes

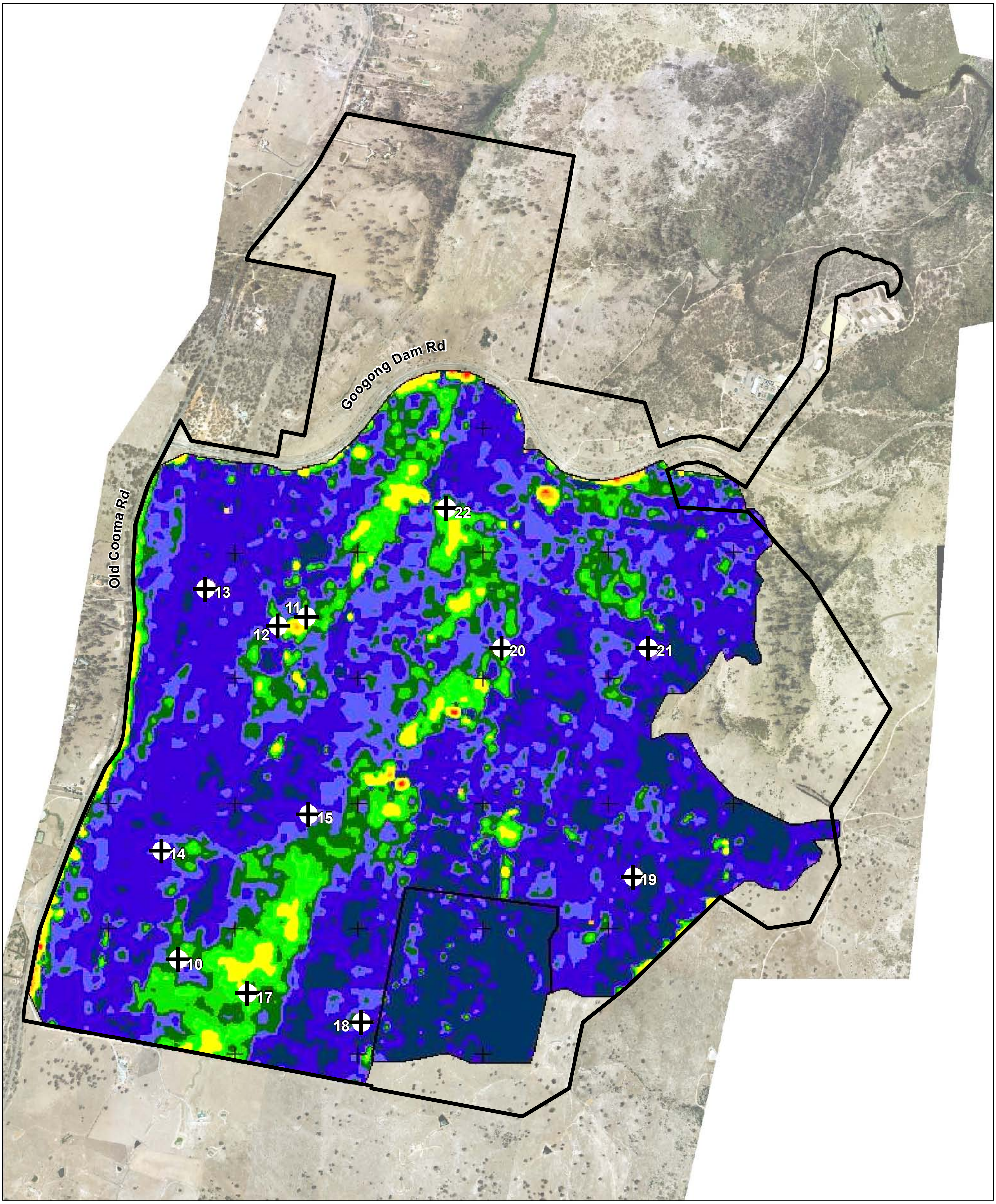
The majority of the study area is located within the Burra soil landscape. The northern part of the study area (north of Googong Dam Road) is located within the Campbell soil landscape. These areas comprise the steepest and least accessible portions of the study area with high erosion potential. Soils from the Campbell and Round Hill soil landscapes are located near Googong Creek. There are two small outcrops of the Celeys Creek soil landscape in the south-eastern side of the study area and a small area of the Anembo soil landscape is located near the proposed water recycling plant. Anembo soils are characterised by shallow, well-drained earthy sands over granite.

Figure 9.3 illustrates the location of these soil landscapes in relation to the study area and also identifies groundwater features, which are discussed in Section 10.3. Table 9.1 summarises the key characteristics of the soil landscapes.

Table 9.1 Soil landscape characteristics

Soil landscape	Characteristics
Burra	This landscape is characterised by undulating to rolling hills and alluvial fans associated with the weathering of the underlying Silurian volcanic units, with the ground surface almost completely cleared of woodland. The soils are described as strongly acidic with low fertility and low available water-holding capability. Subsoils also have low permeability.
Campbell	This landscape is characterised by rounded steep to rolling volcanic mountains and hills of the Murrumbidgee Valley. The ground surface typically exhibits rock outcrops and open forest to low woodland on exposed crests and frost hollows. Clearing is evident on lower slopes. Soils are shallow, infertile and acidic. Subsoils have low permeability and are hard-setting. The site for the proposed potable and recycled water reservoirs is within this landscape.
Celeys Creek	This landscape is characterised by rolling hills over granitic rock. Rock outcrops in the form of large tors are common on slopes and crests. Elsewhere, the ground surface is typified by extensively cleared open forest. Soils are infertile, locally shallow and non-cohesive. Topsoils are acidic and highly permeable. Subsoils are hard-setting with low available water-holding capacity.
Round Hill	This landscape is characterised by steep and often isolated hills on granitic material. The ground surface is typified by steep hill slopes with abundant rock outcrop in the form of tors and mostly uncleared open forest with occasional low woodland on exposed crests. The area of Round Hill soil landscape within the study area has been cleared. Soils are shallow, acidic, of low fertility and with low available water-holding capacity.
Anembo	This landscape is characterised by undulating rises and flats over granitic material. The ground surface typically exhibits extensively cleared, open to tall open forest with woodland and low woodland in frost hollows. The area of Anembo soil landscape within the study area has been extensively cleared. Soils are of gravely low fertility and low water-holding capacity and are prone to waterlogging. Some subsoils have very low permeability.

Source: Googong Willana, 2007



Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig09-2

Source Terrabyte Services, Brown Consulting

EM31 mS/m

-15 - 15
16 - 20
21 - 24
25 - 29
30 - 35
36 - 43
44 - 52
53 - 63
64 - 76
77 - 90
91 - 107
108 - 135

Proposed sampling site

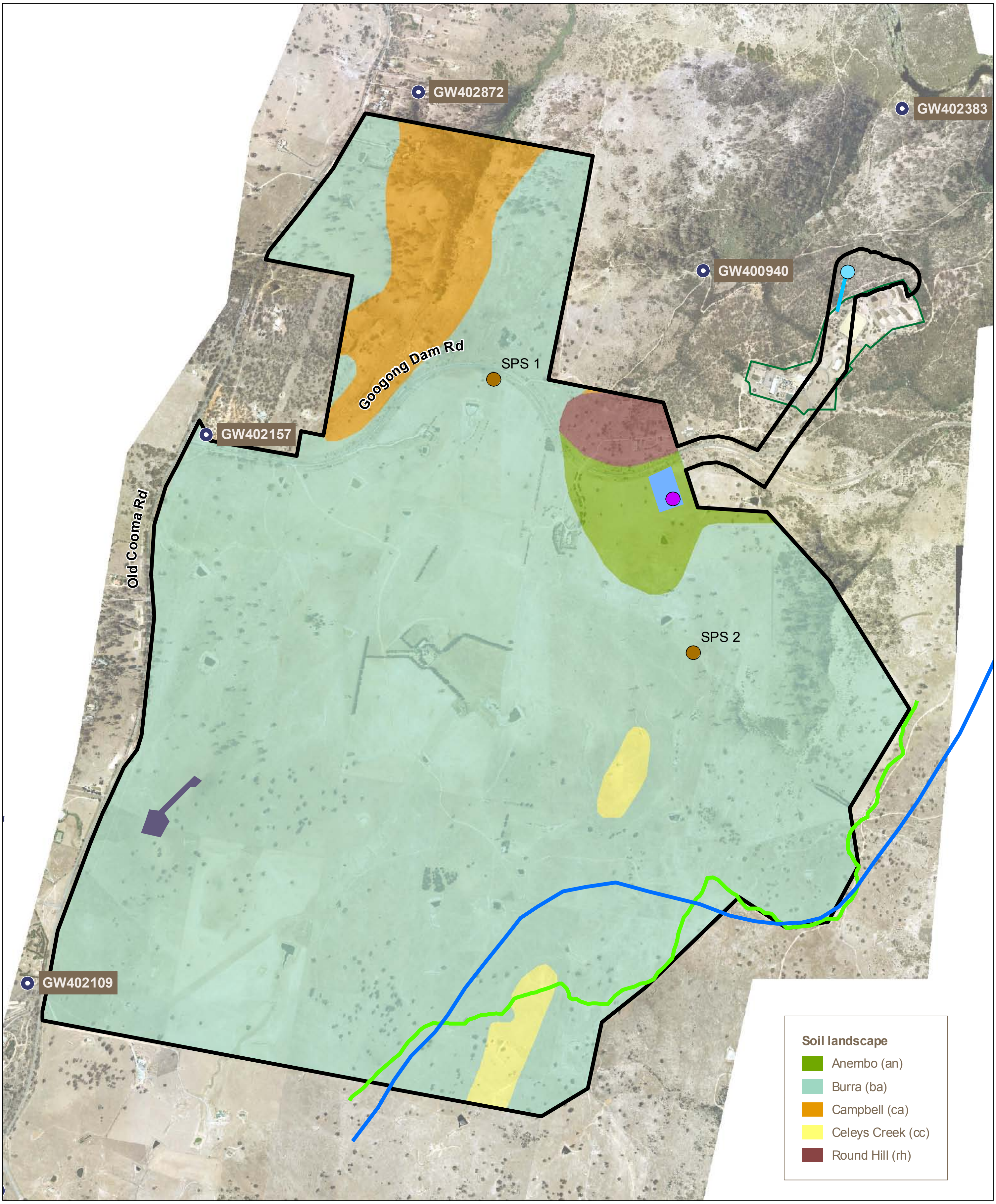
Study area

1:20,000

0 150 300 450 600m

Figure 9.2 Electromagnetic survey and proposed sampling sites

Manidis Roberts



Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig09-3

Source Brown Consulting, CSMA

Bulk water pumping station
Recycled water pumping station
Sewage pumping station
Groundwater bore
Groundwater catchment boundary (estimated)
Googong Reservoir surface water catchment boundary
Existing ACTEW Googong water treatment plant site
Reservoir area
Water recycling plant
Study area

1:20,000

0 150 300 450 600m

Figure 9.3 Soil landscapes and groundwater features

MaunsellRoberts

9.3.4 Soil landscape suitability for irrigation with recycled water

Agsol collected soil samples across the study area and their properties were tested and analysed in relation to the sustainability of recycled water re-use. Agsol identified the likely area of irrigation by using the layout of lots and playing fields. The potential area was estimated to be 27.3 hectares for Stage 1 of the Project and 115.3 hectares at ultimate development. These areas were targeted whilst conducting soil suitability analyses.

The results of these tests are found in Table 6.3 of Appendix D. The soils tested were not found to be saline or sodic and generally indicated good water and nutrient holding capacity. Agsol concluded that the soils within the study area would also be an effective barrier to any potential contaminants accessing any sensitive groundwater table due to the good water and nutrient holding capacity of the soils.

At one site, the soil was found to be slightly saline at depth, but Agsol notes in its report that the salinity appears to be caused by calcium and magnesium salts, not sodium salts.

The suitability of soils within the study area for irrigation can be determined using two topographic and soil suitability tables (DEC, 2004). The tables are located in Appendix 4 of Appendix D and extracted into this EA as Table 9.2. The parameters used for recycled water production are based on an average dry weather flow (ADWF) of 0.7 megalitres per day for Stage 1 of the Project and three megalitres per day for the Project. The estimates are based on an effluent production rate per 'equivalent person'. Furthermore, in wet periods, the recycled water production would increase due to stormwater infiltration into the gravity sewerage system. This was estimated using the Anderson Ruge algorithm (Anderson and Ruge, 1994) assuming that the entire system has a relatively 'low' propensity for stormwater infiltration consistent with the intended provision of a reduced infiltration sewerage system.

Table 9.2 shows the results of the topographic suitability assessment for irrigation with recycled water within the study area. It shows there are no significant topographic limitations to irrigation.

Table 9.2 Topographic suitability assessments for recycled water irrigation (DEC 2004)

Feature	Details of this scheme	Limitation rating for the study area
Slope gradient (%)	<10% Areas where slopes exceed 10% have generally been excluded from the proposed housing development and irrigated open space areas.	Slight (for spray irrigation)
Flooding	Areas affected by flooding have been excluded from the proposed housing development. However, they may be included in proposed irrigated landscape areas.	Slight
Landform element	Hill slopes and ridges. Home sites and some active playing fields would be modified to make them more suitable for irrigation.	Slight
Surface rock outcrop	This feature is significant in some locations, but is not necessarily a concern for irrigated home gardens or passive recreational areas. Rocks would be removed or covered in playing fields.	Moderate

Source: Table 6.4 Googong Land Capability Study, Agsol (Appendix D of this EA)

Table 9.3 details the soil suitability assessment results from within the study area in relation to the DEC 2004 suitability tables.

Table 9.3 Soil suitability assessments for recycled water irrigation (refer to Table 6.5 in Appendix D)

Soil characteristic	Typical soil result	Limitation rating for the study area
pH topsoil	5.0–7.8	Slight
ESP (%) 0–40 cm	<5	Slight
ESP (%) 40–100 cm	<10	Slight
Elec. Cond (EcE) dS/m 0–20 cm	<1	Slight
Elec. Cond (EcE) dS/m 20–100 mm	<4	Slight
Caption exchange capacity (0–40 cm)	<12	Slight to moderate
Depth to seasonal water table	>3m on hill slopes and crests. May rise to within 1m in low lying areas.	Slight
Depth to hardpan or bedrock	50cm–1m	Slight to moderate
Hydraulic cond – surface	80mm/hr	Slight
Hydraulic cond – subsoil	<5mm/hr	Moderate
Available water holding capacity (mm/mm)	100	Slight
EAT (0–100 cm)	3(1)	Slight
P sorption	Good	–

Agsol concludes that the analysis of the suitability of the soil landscape for irrigation suggests there are no significant limitations to irrigation with recycled water.

In conclusion, the soil survey confirmed that the typical soils within the study area are not saline or sodic and soils have good water and nutrient holding capacity to about 50cm. The soils also have a high capacity to absorb phosphorus. The typically well-drained soils over much of the area lower the potential risk of concentrating salts within or near irrigation areas. Furthermore, the modification of gardens should have a positive impact through the addition of topsoil mulches etc.

9.3.5 Existing soil contamination

Coffey Geosciences undertook an initial contamination investigation (Stage 1 investigation) of the Local Environmental Study area in 2004 to identify Areas of Environmental Concern (AECs). The Stage 1 investigation resulted in 12 AECs. Those located within the current study area are listed in Table 9.4 and their locations are shown in Figure 9.4. (AECs 7, 8, 9, 11, 12 identified in the Stage 1 investigation are located outside the study area and are therefore not discussed further.)

Table 9.4 Summary of the Stage 1 investigation

Areas of Environmental Concern	Comments
AEC1	Farm storage shed – there is the potential for the storage of fuels and chemicals of concern.*
AEC2	Farm works shed, fuel dispenser, underground storage tank and farm chemicals – there are possible leaks from the underground storage tank, dispensers, vehicles and batteries. There is also the potential for chemicals of concern.
AEC3	Waste dump, building and garden waste – there is the potential for contamination from asphalt and garden wastes, as well as the potential for chemicals of concern.
AEC4	Farm shed and above ground oil tank – there is the potential for contamination from leaks and the potential for chemicals of concern.
AEC5	Spray sheep-dip site, sheering shed and yards adjacent to woolshed – arsenic and organochlorine pesticides are commonly associated with this use.
AEC6	Five above ground oil tanks – there is the potential for contamination from leaks and the potential for chemicals of concern.
AEC10	44-gallon drum fuel storage and car batteries – there is the potential for leaks from the drum and batteries and potential for chemicals of concern.

** Chemicals of concern may include hydrocarbons, polycyclic aromatic hydrocarbons, heavy metals, organochlorine pesticides, and poly chlorinated bi-phenyls.*

Source: Coffey Geosciences (2004)

A detailed contamination investigation (Stage 2 survey) is necessary when a Stage 1 investigation indicates that AECs are present, or that the land is, or was, formerly used for an ‘at risk' activity and a land use change is proposed that has the potential to increase the risk of exposure to contamination.

A Stage 2 survey has been conducted for the area relating to Stage 1 of the Project.

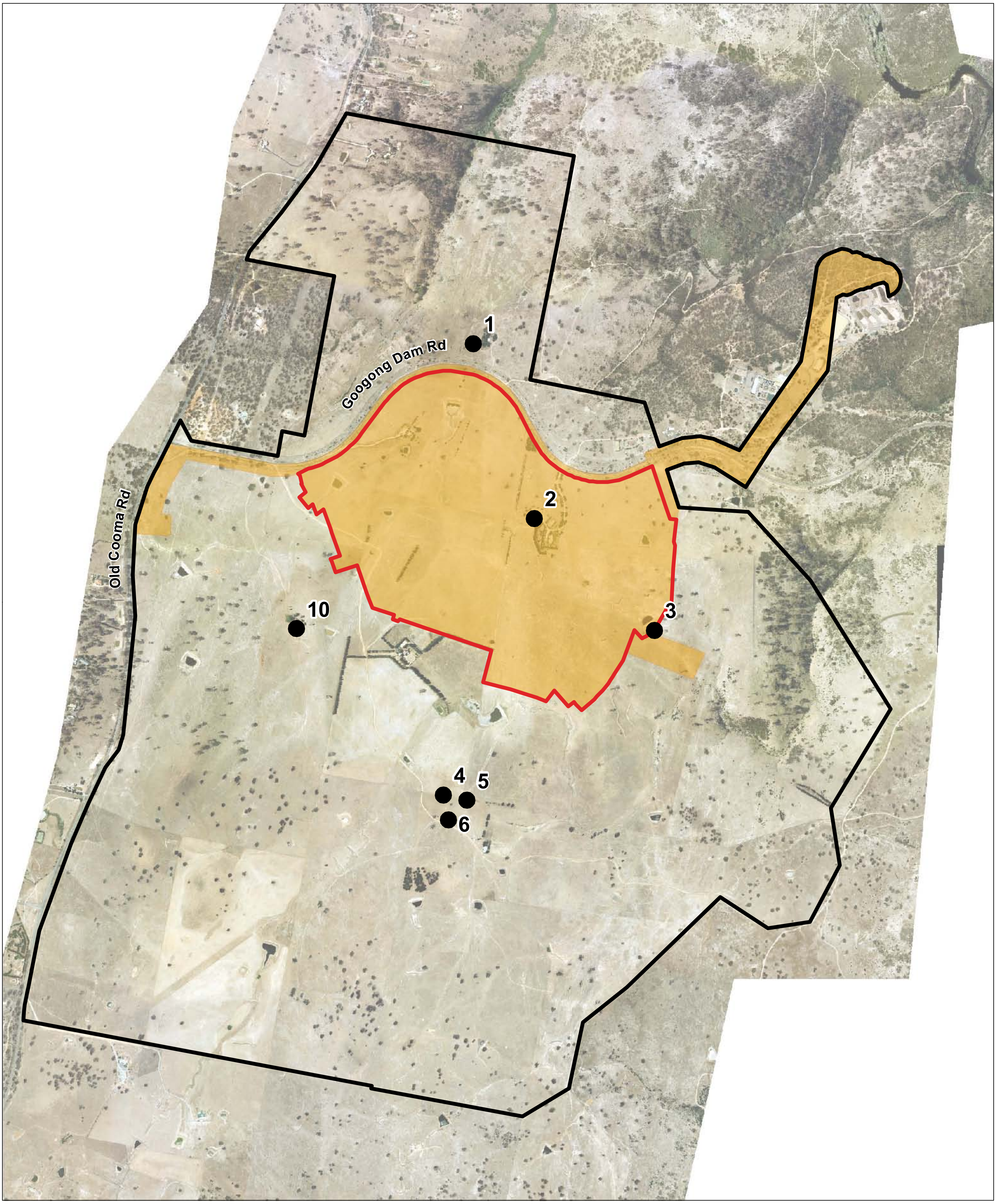
Agsol has undertaken a more detailed Stage 2 survey for Stage 1 of the Project, focusing on sites AEC2 and AEC3. The Stage 1 investigation also noted the potential for contamination of the rest of the subject site due to its previous land use as grazing land. Agsol has therefore confined the Stage 2 survey to the agricultural land within or near the subject site as well as AEC2 and AEC3 (refer to Figure 9.4).

The objectives of the Agsol report were to:

- Define the nature, extent and degree of contamination.
- Assess the potential risk posed by contaminants to health and the environment.
- Obtain sufficient information to develop a remedial action plan if necessary.

The Stage 2 survey conducted soil testing at 10 sites; six tests were taken within the region of AEC2 and AEC3, and four were taken randomly in the area used for grazing. The sites are shown in Figure 9.5. It should be noted that a full Stage 2 investigation was not completed on AEC2 at the request of the owner at the time of the survey, but observations and samples were taken around AEC2.

The sampling strategy reflected the risk of finding contamination. Therefore, the sampling conducted close to the AECs was more intensive than the sampling in the general grazing areas. Agsol also identified a potential AEC close to AEC2 in the Stage 2 survey, which is represented as ‘Analysis 1 – site 3' in Figure 9.5. This site was still in use at the time of the Stage 2 Survey, and Agsol recommends that further investigations are required to determine the significance and extent of the contamination once the current use of this site ceases.



Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig09-4

Source Coffey Geosciences (2004)

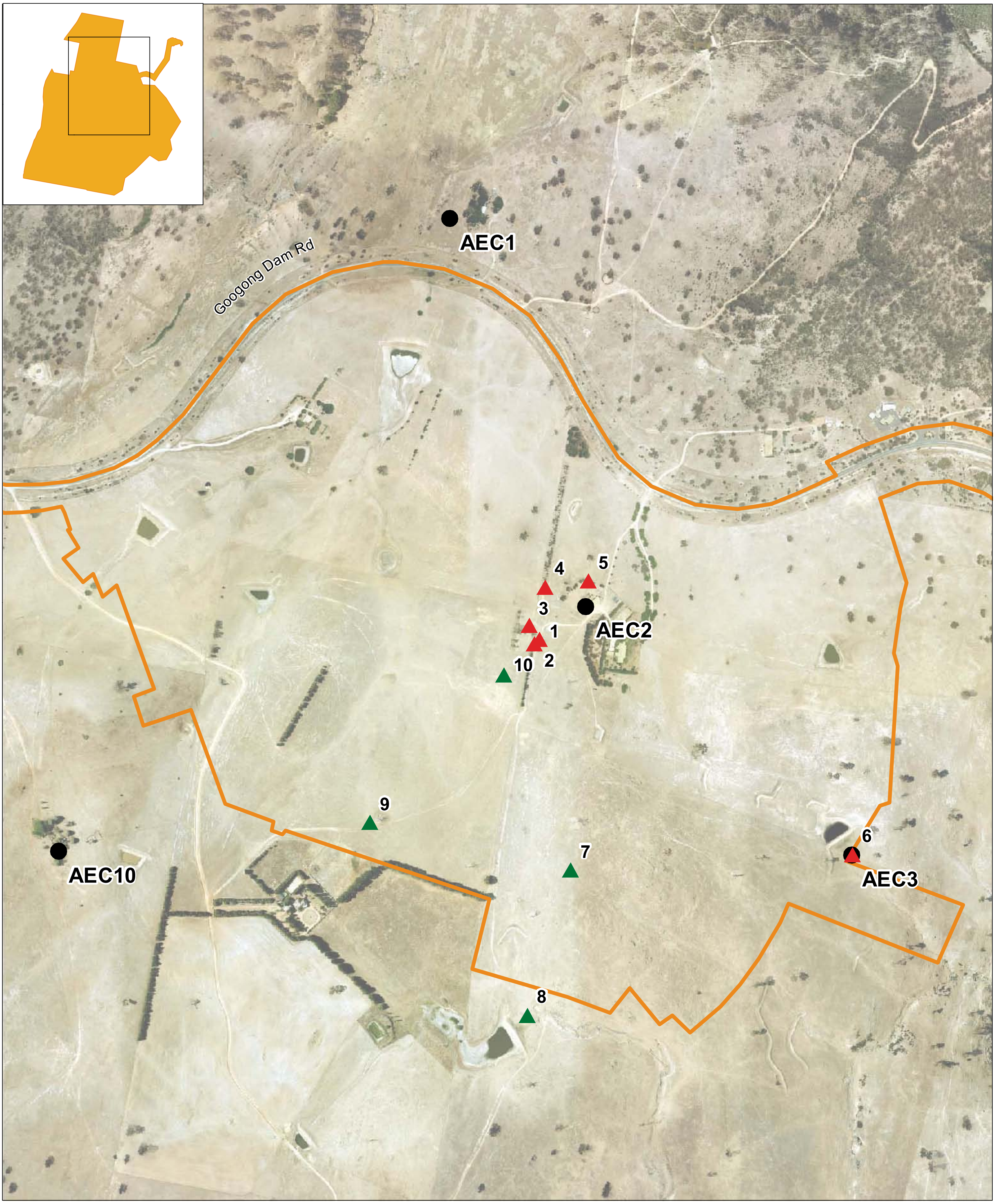
Area of Environmental Concern (AEC)
Neighbourhood 1A
Subject site
Study area

1:20,000

0 150 300 450 600m

Figure 9.4 Contaminated land investigation overview

Manidis Roberts



Googong Environmental Assessment

Proponent CIC Australia

Date 20 August 2010

Drawing no. 08003g_ea_fig09-5

Source Coffey Geisciences (2004), Agsol (2009)

Analysis 1 - Soil sampling in identified AECs and other potential contaminated sites

Analysis 2 - Soil sampling in grazing or cultivated areas

Area of environmental concern

Subject site boundary

1:9,000

0 70 140 210 280m

Figure 9.5 Soil contamination survey locations within or near NH1A

Maunsell Roberts

Table 9.5 summarises the process undertaken to assess the potential contaminated sites within or near the subject site.

Table 9.5 Soil contamination assessment process in relation to the subject site

Stage 1 results	Stage 2 methodology	Stage 2 results and further recommendations
AEC2 • Possible leaks from an underground storage tank and dispensers, vehicles and batteries. • Potential chemicals of concern include hydrocarbons, polycyclic aromatic hydrocarbons, heavy metals, OCP and PCB.	• On-site observations were conducted. • Site AEC2 was still in use at the time of the survey; at the request of the owner, no investigations were undertaken at the site. However, observations and soil samples were taken in the surrounding areas. • The nature of soil sampling was consistent with samples that are taken for areas considered to be possible contaminated sites. Sites 1–4 (refer to Figure 9.5) were sampled from various facilities to the west of AEC2. These include a shed currently housing a boat, sheep yards where old chemical bottles were found and a hayshed. An additional sample was taken (site 5) from the top 15 cm of the upper drainage line feature below AEC2 machinery shed.	• Agsol recommends that once the current use of the site ceases, detailed investigations are required to determine the extent of the contamination and appropriate remediation if the site is to be developed for residential purposes. • The potential AEC (referred to as 'Analysis 1 – site 3' in Figure 9.5), a sheep and cattle yard that was still in use at the time of the Stage 2 survey to the west of AEC 2, showed some evidence of contamination with petroleum hydrocarbons. Agsol recommends that further investigations are required to determine the significance and extent of the contamination once the current use of this site ceases.
AEC3 • Potential contamination from asphalt and garden wastes. • Potential contaminates of concern include polycyclic aromatic hydrocarbons, organochlorine pesticides and poly chlorinated bi-phenyls.	• On-site observations were conducted. • The nature of soil sampling was consistent with samples that are taken for areas considered to be possible contaminated sites. Samples were taken from the drainage area immediately below what is thought to be site AEC3. It is noted in the Stage 2 contamination survey that this site appears to have been capped since the Stage 1 contamination investigation (site 6).	• The site has been capped with local soil since the Stage 1 contamination investigation. There was no evidence of contamination in the wet soil immediately downslope of this site (site 6). This area may require an audit by a DECCW approved site auditor, particularly if it is to be disturbed for any residential development program.
Potential for contamination of the rest of the site due to its previous use as grazing land.	• On-site observations were conducted. • The nature of soil sampling was consistent with samples that are taken for general or cultivated areas. Soil samples were taken from the general grazing area in a random fashion (site 7–10).	• The general grazing land within the subject site is not contaminated, so development can proceed in the area without any remediation. • It is likely that general grazing areas on the remaining parts of the study area are also not contaminated, although a topsoil survey should be undertaken using a sampling strategy similar to Agsol's.

9.4 Construction impacts and mitigation measures

Construction of the Project would involve a number of activities that may alter existing soil characteristics.

9.4.1 Soil erosion

Potential impacts

The potential for soil erosion is most likely to occur during excavation works, particularly during any trench construction. Erosion can be from water (creating inter-rill erosion, rill and gully erosion and tunnel erosion) and wind. Potential impacts include the erosion of excavation spoil, fill stockpiles, and the disturbance of topsoil due to loss of vegetation cover.

Soil properties for each soil landscape would be affected differently in relation to erosion potential. Table 9.6 outlines the erosion potential of each respective soil landscape as well as any excavation restraint expected and would be considered further when developing management and mitigation measures.

Table 9.6 Potential erosion hazards and excavation constraints for soil landscape categories

Soil landscape	Erosion potential	Excavation constraints
Burra	• Concentrated flows – moderate erosion potential. • Moderate risk of mass movement caused by damage to surface vegetation by the movement of stock on slopes.	Excavation constraints are likely on upper slopes and crests due to presence of shallow (less than 60 cm) soils.
Campbell	• Non-concentrated flows – high erosion potential. • Concentrated flows – very high gully erosion potential.	Excavation constraints are likely on steep slopes due to presence of shallow (less than 30 cm) and stony soils.
Celeys Creek	• Non-concentrated flows – moderate erosion potential. • Concentrated flows – high to very high erosion potential.	Limited problems are likely on crests and upper slopes associated with shallow (less than 60 cm) soils. Possible soil moisture issues may be encountered on lower slopes and flat ground. Stony ground and the presence of tors may also present constraints.
Round Hill	• Non-concentrated flows – moderate to low erosion potential. • Concentrated flows – moderate to high erosion potential. • Soils are also subject to moderate to high risk from wind erosion.	Excavation constraints are likely on steep slopes and crests associated with shallow (less 15 cm) soils over bedrock. Areas with stony soils and/or tors may also be present. The dispersion and shrink–swell properties of subsoils may limit foundation design.
Anembo	• Non-concentrated flows – moderate erosion potential. • Concentrated flows – high to very high erosion potential.	Limited problems are likely on crests and upper slopes associated with shallow (less than 60 cm) soils. Possible soil moisture issues may be encountered on lower slopes and flat ground. Stony ground and the presence of tors may also present constraints.

The erosion potential and excavation constraints of the soil around major infrastructure sites and easement corridors would be considered during the construction of the Project. The majority of infrastructure is situated on the Burra or Anembo soil landscapes, which have moderate erosion potential.

Mitigation and management measures

Erosion potential for Stage 1 of the Project would be managed by maintaining surface and soil stability at all times during cut-and-fill excavation activities – particularly relating to trenching – and implementing standard erosion and sediment control techniques in construction areas like berms and sedimentation fencing. Erosion within the trench would be mitigated by using trench plugs (ie trench/sack breakers) at appropriate intervals. These measures are in accordance with *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004 – also referred to as 'The Blue Book').

Furthermore, during the restoration and clean-up of construction sites, the following measures would be applied to stabilise the soils:

- Graded soil would be stockpiled separately, so that local soils can be recovered for respreading.
- The site would be re-profiled to achieve soil stability and congruity with the surrounding landscape. This would be done in consideration of the landscape and open space strategy for the Googong township development.
- Re-seeding would be undertaken, and geotextile materials used as required.
- Trenches would be backfilled and compacted in layers.
- Access to the site would be managed (including site restrictions) to assist with site recovery.

9.4.2 Soil contamination

Potential impacts

For Stage 1 of the Project, a stage 2 contamination assessment has been completed (refer to Section 9.3.5).

Trenching and grading activities have the potential to disturb contaminated lands and adversely impact existing soil characteristics if not managed appropriately. In addition, there is the potential during construction to contaminate soils through fuel or chemical spills. Risks include contamination of soil profiles, adverse impacts on human health and consequential affects on the groundwater quality.

Mitigation and management measures

To avoid soil contamination during construction activities, and to manage contamination if it is found during construction, the construction team would:

- Where possible, all refuelling would occur at designated fuel distribution points. These distribution points would be underlain by compacted earth to prevent the significant loss of fuel into the ground in the event of a spill. They would also be bunded to contain any large spills that may occur as a result of machinery or tank failure.
- Chemical transport, storage, handling and disposal procedures would be implemented in accordance with the requirements of dangerous goods and environmental legislation, and industry standards.
- Spill response procedures and equipment for containment and recovery would be available on site.
- Workforce training would be conducted on the transport, storage, handling and disposal procedures relating to chemicals.

- Stop all work in the area if potential or actual contamination is found during earthworks, until a suitably qualified person has inspected the site, the hazard has been assessed and appropriate action has been taken (including delineating areas of concern as required until earthworks can resume safely).
- Conduct the management of contaminated soil disposal or removal from site in accordance with DECCW Waste Classification Guidelines.
- Conduct further investigations at the newly identified AEC (identified as Site 3 in the Agsol report) prior to construction. Further investigation of this area is included as commitment SG4 (refer to Chapter 18).
- Develop a sampling strategy for AEC2 as soon as the existing uses at the site have been decommissioned in consultation with a DECCW accredited site auditor.
- Obtain advice from a DECCW accredited site auditor on the need for further investigations at AEC3, if this site is to be disturbed by the Project.

For concept approval, potential AECs have been identified across the entire study area. For future assessments under the EP&A Act, potentially under Part 3A project application(s) or Part 4 development applications, further stage 2 contamination assessments would need to be undertaken.

9.5 Operation impacts and mitigation measures

9.5.1 Soil erosion

Potential impacts

There is the potential risk that irrigation would generate significantly more runoff and/or percolation in certain locations, leading to soil erosion during operation. However, it is noted in Appendix D that the risk of physical erosion would be the same as if drinking water had been used instead of recycled water. The impacts from the potential erosion risks are not considered to be significant.

Mitigation and management measures

The impacts from the potential erosion risks would be addressed by soil and water management measures in the operational environmental management plan (OEMP). Measures could also be included in the recycled water management plan.

Mitigation and management measures for erosion control would be similar to those detailed for construction, and include bank restoration techniques ,where required (if erosion is identified through monitoring of drainage lines and creeks). Techniques include:

- Stabilising where required by establishing rocks, sandbags, and/or matting to prevent scouring, ensuring that they are placed to conform as far as possible with existing contours.
- Re-spreading topsoil over the area from where it was removed.
- Installing matting that is infused with seedlings to keep the soils stable while it settles.
- Protecting buffer and riparian vegetation zones, and restoring these zones where required.

9.5.2 Salinity

Predicted salt levels

In the Googong township, the irrigation of open spaces and gardens would be a mix of rainwater (both natural and from rainwater tanks), recycled water and potable water (as recycled water is topped up with potable water at different times of the year). Therefore, the precise application rates of salt to the land from a given volume of water would vary on a daily basis. Recycled water is more saline than typical drinking water and rainwater. Table 9.7 outlines the different types of water and their corresponding total dissolved solids concentration values.

Table 9.7 Predicted TDS concentration values and corresponding electrical conductivity values for different types of water in Googong township

Type of water	Total dissolved solids (TDS) concentration values	Electrical conductivity (EC) values
Rainwater	13mg/L	0.02dS/m
Recycled water	660mg/L	1.03dS/m
Potable water	100mg/L	0.16dS/m

Source: Googong Land Capability Study, Agsol 2010 (Appendix D of this EA)

Potential salt impacts

The slightly saline recycled water that would be irrigated onto gardens has the potential to impact on garden soils, garden plants, and soil landscapes. Agsol has conducted an analysis of these risks using salt budgets in its land capability study (Attachment 1 of Appendix D).

As shown in Table 9.7, the average total dissolved solids concentration values for recycled water is 660mg/L, which is comparable to other recycled water schemes in operation. Additionally, soil testing and analysis conducted throughout the study area indicated the soils are well structured, allowing water to easily move through the soil landscape, and limiting the potential for salinity impacts.

Furthermore, the NSW DoP has mapped dry land salinity hazard areas and the study area was not identified as having potential salinity hazards. Two areas in the vicinity of Jerrabomberra Creek and Queanbeyan River have been identified as having potential risks, but these areas would not be impacted upon by any future urban development associated with the Googong township.

Agsol has undertaken salt budgets to assess the degree of risk (refer to Attachment 1 of Appendix D). Two potential impacts within the areas to be irrigated with recycled water (with regard to plant growth) are:

- Foliar injury, where the irrigation water comes in contact with leaves and is of sufficient salinity to damage the tissue.
- An increase in the soil salinity to a level where plant growth is reduced.

The first impact relates to foliar injury when the irrigation water comes in contact with leaves. Water with sufficient salinity to damage foliage depends on the electrical conductivity of the water used. Table 9.8 summarises the assessment Agsol conducted on the sensitivity of plant species in relation to the electrical conductivity of the three water sources within the Googong township outlined in Table 9.7 above (refer to Chapter 9 of Appendix D).

Table 9.8 Assessment of foliar sensitivity to salinity using Googong township water sources

Category of salt sensitivity	Types of species within category	EC range	Risk rating in response to EC range (reference to Table 9.7)	Precautions that will mitigate or eliminate the risk
Highly sensitive	• Fruit such as almond, apples, avocado, citrus fruit, passionfruit, pears, strawberry, raspberry. • Vegetables such as carrot, celery, green beans, onion, parsnip, peas, radish, squash. • Ornamentals such as azalea, bergonia, camellia, fushia, gardenia, ivy, magnolia, primula, rose, star jasmine.	0–0.9dS/m	• There is no risk that the highly-sensitive species will suffer foliage burn from irrigation with rainwater or potable water, however the recycled water (EC = 1.03 dS/m) presents some risk.	• Subsurface or surface drip irrigation will eliminate the risk because the recycled water will not touch the foliage. • Avoiding watering during hot, daylight hours will lessen the risk. • Rinsing the foliage with potable water at the conclusion of watering will considerably lessen the risk.
Mildly sensitive	• Fruit such as grape and mulberry. • Vegetables such as broccoli, cabbage, capsicum, cauliflower, cucumber, lettuce, potatoes, pumpkin, rock melon, sweet corn, tomato, and watermelon. • Ornamentals such as Aster, banana, bauhina, Callistemon viminalis, emu bush, geranium, gladiolus, hibiscus, hop bush, Juniperus chinensis, lantana, pointsettia, Thuja orientalis, zinnia.	0.9–2.7dS/m	• None of the three water sources outlined in Table 9.7 pose a risk to the mildly sensitive species.	N/A
Slightly sensitive	• Turf grasses such as buffalo grass, couch grass, kikuyu grass, and ryegrass. • Fruit such as fig, pomegranate, and olive. • Vegetables such as asparagus, garden beets, kale, and spinach. • Ornamentals such as acacia longifolia, Bangalay, bamboo, boobyally, boungainvillea, carnation, chrysanthemum, coprosma, and false acacia.	2.7–6.35dS/m	• None of the three water sources outlined in Table 9.7 pose a risk to the slightly sensitive species.	N/A
Salt tolerant	• Turf grasses such as saltwater couch, and sand couch. • Fruit such as date palm. • Ornamentals such as canary palm, Melaleuca thyoides, saltbushes, salt sheoaks, salt river gum, and tamarisks.	6.35–23.65dS/m	• None of the three water sources outlined in Table 9.7 pose a risk to the salt tolerant species.	N/A

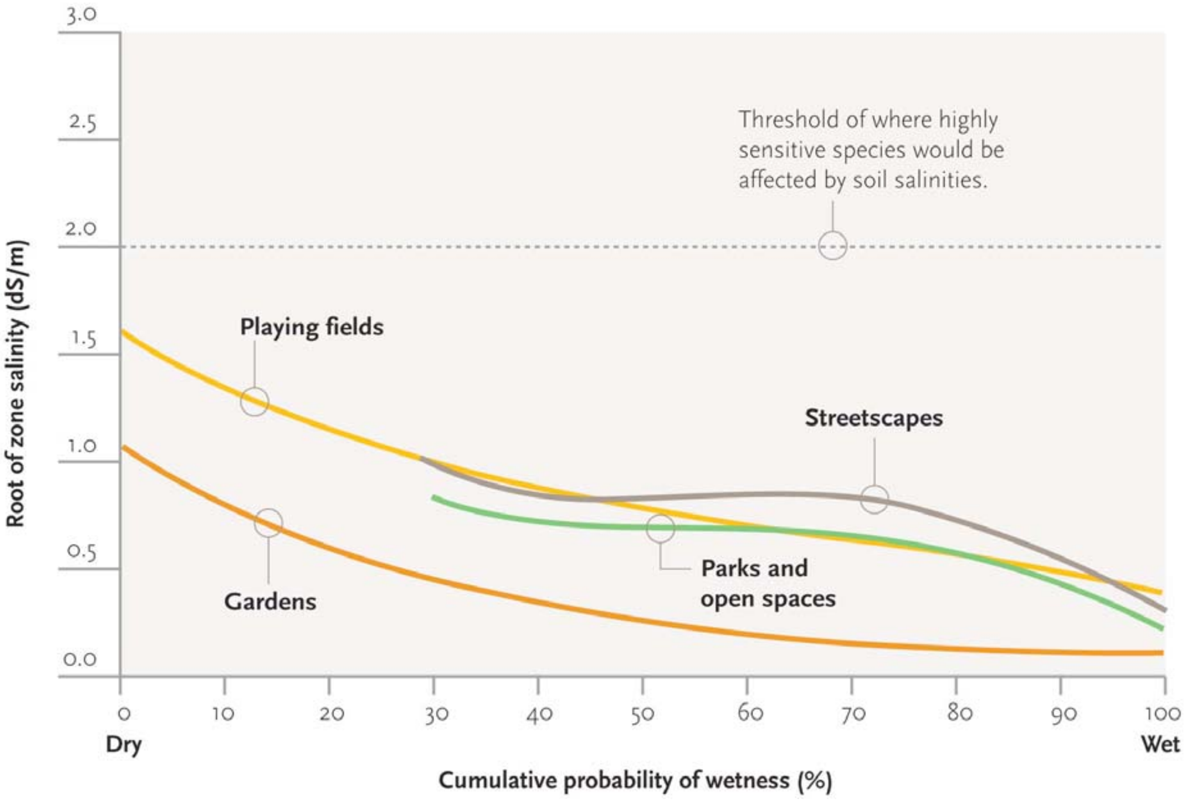
Source: Googong Land Capability Study, Agsol 2010 (Appendix D of this EA)

For the second impact relating to plant growth, there is the potential for salts to accumulate in soil, leading to the retarded growth and possibly the death of some plants. In general, the critical values for soil salinity (the level at which plants would be affected) are as follows:

- The majority of plants are not affected when soil salinity is less than 2 dS/m (deci-Siemens/metre).
- Sensitive plants are affected when soil salinity is 2–4 dS/m.
- Many plants are affected when soil salinity is 4–8 dS/m.
- Only salt-tolerant plants grow satisfactorily when soil salinity is greater than 8 dS/m.

To determine the potential impacts soil salinity may have on plant growth, Agsol calculated the proportion of years when the soil salinity is expected to exceed thresholds of 2 and 3 dS/m. The 2 dS/m threshold was taken as an indication that highly sensitive species would be affected by soil salinities above this value. Figure 9.6 shows the results from this calculation, it indicates the estimated root zone salinity (the zone in which salinity would impact on plant growth in the soil) for the different types of irrigation areas in the Googong township at ultimate development. Agsol found that the estimated soil salinities would never exceed 2dS/m, and therefore concluded that there is no risk of soil salinity increasing to a level that would affect most plant growth. Therefore, the TDS levels in the recycled water produced by the Project are suitable for irrigation use at Googong township.

Figure 9.6 The estimated root-zone salinity on the types of irrigation areas in the ultimate stage



Source: Googong Land Capability Study, Agsol 2010 (Appendix D of this EA)

Other effects that can occur as a result of irrigating with recycled water include an increase in cadmium uptake by plants grown for food and chlorine damage plants. A review conducted by Agsol of typical recycled water qualities in other parts of NSW suggests that impacts relating to cadmium uptake is unlikely, however the monitoring of the recycled water for this impact is recommended over Stage 1 of the Project (refer to Chapter 1 of Appendix D).

Management and mitigation measures

Approach to reducing salt in the system

The proponent, CIC Australia, recognises (from ongoing consultation with the DoP and the NSW Office of Water) that the potential for salinity impacts on soils is a primary concern when recycled water is applied to the environment.

One way to detect salinity is by measuring how much salt is in a solution. This measurement is called total dissolved solids (TDS).

In response to workshops conducted with the NSW Office of Water, the level of total dissolved solids that would be in recycled water from the Project has been significantly reduced, compared to earlier system outcomes, primarily through the use of biological phosphorus removal processes in the treatment system at the water recycling plant. In addition, CIC is committed to reducing salt levels where practical during operation by focussing on mechanisms that would control salt levels in different areas throughout the water recycling system. Three areas are the focus of the salt reduction strategy:

- At the water recycling plant:
  - The treatment process has been optimised to produce recycled water with low salinity, thereby minimising adverse salinity issues.
  - Control mechanisms have been incorporated to ensure salinity of the recycled water can be further reduced if required, either through mandating the specific types of chemicals used in the treatment process and/or reducing the quantity of chemicals used. There is a trade-off between management of phosphorus and management of salinity. If salinity is required to be reduced, changes to the way phosphorus is managed in the treatment process are possible.
  - Management of salt can be adapted as the staging of the water recycling plant and the township progresses. Completing the water recycling plant in stages allows for any lessons learnt in the initial stages to be incorporated and for salt reduction processes to be adopted progressively. The proponent is committed to using the stages as an adaptive management approach as outlined in Section 6.3.
- The system (reticulation infrastructure) – The reticulation infrastructure (eg reservoirs, pipework and sewage pumping stations) has been considered as a further way to influence salt levels. This includes controlling the amounts of chemicals used for odour control and chlorination.
- Users – Education programs for residents would be initiated as another method to reduce salt levels during operation. These programs would aim to inform residents about the risks involved with salinity, especially in relation to impacts on plant growth and foliar damage (as these would be of most concern for residents). Residents would be offered advice and alternative ways to reduce this risk. CIC would run programs to:
  - Encourage (and, if possible, mandate) residents to use detergents low in phosphorus, sodium and salt (these are generally liquid detergents). Education would take place at the time of sale and through structured education sessions planned by CIC's community development officer.
  - Encourage residents to use appropriate organic fertilisers rather than high potency chemical fertilisers on home gardens and lawns.

- Educate residents to grow species that are tolerant of soil salinity, particularly in areas that are considered to be at a high risk of salinity impacts.
- Educate residents about the potential for vegetation damage from salt, which can be reduced through practices such as minimising leaf wetting, especially during hot weather and during daylight.
- Educate residents about appropriate soil mixes for use in garden landscaping to ameliorate the potential impacts of saline water on garden plants.

Furthermore, as the existing soil landscape is characterised by well drained soils (that are not sodic) and there is no evidence of existing salt hotspots. It is likely that salinity moving downslope and impacting on downslope vegetation would be diluted sufficiently with natural rainfall to the extent that salinity issues would also be minor due to the landscape, and complemented by the above measures.

Management and mitigation measures

Although the predicted levels of total dissolved solids would be suitable for irrigation on the study area, management measures are suggested as precautionary measures. These include constructing all buildings in accordance with the relevant building codes for salt-affected landscapes as outlined in *Building in a Saline Environment* (part of the Local Government Salinity Initiative) (DIPNR, 2005).

Even though unlikely, if monitoring indicates that salt is accumulating in downslope areas such that a negative impact is likely, the stormwater system could be retrofitted with subsoil drains within recycled water irrigation areas. In this way, the stormwater system could direct saline subsoil flows (interflows) into the surface stormwater system. While this measure would address soil salinity impacts, it may have the following impacts:

- A reduction in the groundwater recharge. (This reduction must be considered in the context of overall recharge reduction as a result of the Googong township. Refer to Chapter 10 regarding groundwater recharge, and Appendix G).
- An increase in potential surface water salt.

These impacts are generally considered minor in the context of the Project and would be weighed up against not implementing the stormwater changes.

Ongoing monitoring of salt

The adaptive management approach outlined in Section 6.3, allows for management measures to be adaptively implemented through the staging of the Project. Therefore, during the first subdivision stage (NH1A), piezometers would be established to monitor the movement and salinity within and below the NH1A development.

Monitoring is necessary and recommended as salt impacts are considered long term and ongoing, and impacts may not start to arise for decades and/or would be affected by changing climatic patters. If, despite the approach outlined above, monitoring results indicate that there is a risk of detrimental salinity impacts, the following management and mitigation measures would be considered for implementation.

9.6 Conclusion

The key findings of this impact assessment are that:

- The Project would have some potential construction related impacts relating to soil erosion and soil contamination, but these would not be significant and would be adequately managed with the prescribed mitigation and management measures.
- The soil salinity risks from using recycled water in irrigation are acceptable, provided that the irrigation volumes do not exceed what has been modelled and provided that the mitigation and management measures are implemented. Mitigation and management measures are committed to in the statement of commitments (S1–S5 and G7) in Chapter 18.