10 Groundwater

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 outlines the key findings of the groundwater impact assessment by C. M. Jewell & Associates (CMJA) (refer to Appendix E), which addresses the Director-General's Requirements (DGRs).

The major findings of the assessment are that:

- Potential construction impacts are unlikely to be significant, and that risks would be reduced further when managed appropriately with the specified mitigation and management measures.
- Potential impacts during the operation of the Project – particularly in relation to the addition of recycled water into the groundwater system and salinity impacts – are likely to be minor, particularly if suitable salinity management controls and sensible water use practices are adopted.

Although not included in the Part 3A scope, CMJA also investigated potential impacts of the subdivision and the change of the land to urban development at Googong township, and provided recommendations on how potential impacts should be monitored and adaptively managed.

10.1 Scope of the groundwater impact assessment

The potential groundwater 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, the assessment focuses on the use of recycled water throughout the study area. This has been done in consultation with the Department of Planning (DoP) and the NSW Office of Water, particularly with regards to:

- Groundwater quality.
- Groundwater recharge (this is a process whereby water moves down from surface water to groundwater).
- Waterlogging.
- Impacts on groundwater-dependent ecosystems.

In relation to Stage 1 of the Project, the assessment focuses on the potential impacts on groundwater during construction, such as increases to the local recharge and groundwater contamination.

10.2 Assessment methodology

In September 2004, CMJA conducted an initial appraisal of the study area to identify potential groundwater-related impacts from potential development of the Googong township on the Googong Reservoir.

This appraisal concluded that although urbanisation would inevitably result in some changes to the groundwater quality beneath the Googong township development, impacts were likely to be relatively low compared with those experienced beneath traditional developments and there would be no measurable impact on the reservoir.

The design of the Googong township has now progressed and an integrated water cycle management system (the Project) that includes the distribution and reticulation of both potable and recycled water and rainwater tanks is proposed. In light of this, CMJA reassessed the findings of its 2004 report to assess the likely impacts that may result from the installation of both potable and recycled water infrastructure (Appendix E) and to include input from the DoP and other agencies. This appraisal considered the potential for the following groundwater-related risks:

- Isolated waterlogging of soils.
- Changes to the groundwater flow regime.
- Groundwater salinity risks, such as the lateral migration of salts in the shallow zone, accumulation of mobile salts at waterways and the discharge of saline water into streams.
- Risks associated with a decline in recharge of groundwater, such as:
  - The drying of perched water tables beneath developed portions of the site.
  - The lowering of the water table and the possible drying-up of shallow bores in the area.
  - A potential increase in the total dissolved solids content of the groundwater.

The updated CMJA report considers the following key issues:

- Potential impacts related to the construction of the water cycle infrastructure.
- Potential impacts from the use of recycled water within the Googong township as a result of providing the water cycle infrastructure.
- The impacts of the subdivision and the change of land use to urban development (related to Part 4 approvals).

This EA relates only to points one and two above, and details are outlined sections 10.4 and 10.5. Point three is not part of the Part 3A scope, but is intrinsically linked to points one and two, particularly concerning the context of the use of recycled water and the likely rates of groundwater recharge. Therefore, potential impacts are outlined in this EA, and recommendations for further work are provided.

10.3 Existing environment

10.3.1 Bore yields and aquifer hydraulic properties

CMJA completed a desktop review of records held by the Department of Environment, Climate Change and Water (DECCW) of boreholes within a broad six-kilometre radius of the centre of the site. This review indicated that yields for the boreholes drilled throughout the Googong district vary between less

than one litre per second to 10 litres per second. Most bores have been drilled in the Colinton Volcanics where yields are more modest and typically range between 0.5 and one litre per second.

10.3.2 Groundwater quality

The groundwater quality within the study area is considered to have relatively low total dissolved solids (TDS). The TDS (salt) in most of the bores is below 1,200 milligrams per litre, which is considered to be within the acceptable limits for human consumption.

10.3.3 Standing water levels, groundwater flow and gradients

Standing water levels in boreholes for the study area as a whole is generally between 10 and 30m below ground level. Data from existing groundwater bores indicates the standing water level ranging between 11-31m (at the time of drilling), and slightly deeper levels have been noted where the bores have been drilled on ridgelines or hill slopes. The borehole locations are shown in Figure 9.3, which shows that there are no bores within the study area, with the exception of GW402157, which is on the boundary of the study area.

Shallow groundwater flow throughout the study area is heavily influenced by the local topography, with local and regionally significant peaks and ridges delineating local groundwater divides. The majority of groundwater within the study area flows in a northerly direction, into the Queanbeyan River catchment, with most expected to drain to the north-north-east and lower reaches of the river.

A groundwater divide has been estimated using topographic information and available groundwater bore locations to be within the south-east corner of the study area. The groundwater divide is shown in Figure 9.3. Groundwater east of the divide is likely to flow into the Googong Dam catchment.

10.3.4 Groundwater recharge and discharge

Rainfall recharge of fractured rock aquifers occurs through areas of open fracturing, either at the surface or through superficial unconsolidated material. In the latter case, there may be a delay between a rainfall event and the entry of water into the aquifer, due to storage in the unconsolidated material of the recharge zone.

10.3.5 Groundwater utilisation and vulnerability

The DECCW has mapped the vulnerability of groundwater sources to contamination. Five classes of vulnerability ranking are chosen to describe the probability of contamination on groundwater resource. They include: 'low', 'moderate', 'moderately high', 'high', and 'very high'. More than 90 per cent of the study area has been ranked as having moderate vulnerability.

10.3.6 Impacts on groundwater-dependent ecosystems

Specialists in flora and fauna and groundwater have assessed the study area and found no groundwater-dependent ecosystems within the study area or that would be affected by the Project off site (Ecowise, 2008). Furthermore, it has been concluded that there would be no significant changes to the groundwater system.

Therefore, it has been determined that there would be no likely impacts on groundwater-dependent ecosystems resulting from use of recycled water within the Googong township.

10.4 Potential construction impacts and mitigation measures

This section outlines potential impacts that may arise during construction of the water cycle infrastructure. These impacts are not considered significant and the risk of occurring would be reduced further when managed appropriately with the recommended management and mitigation measures.

10.4.1 Increase to the local recharge

There is potential for a slight increase in the localised recharge, if significant rainfall is experienced when there are a large number of trenches and/or excavations open across the site. However, increases in recharge potential are expected to be minor because:

- Trenches are generally expected to be less than five meters deep across the site.
- The depth of groundwater is expected to be around ten to 15 meters beneath the Googong township development area.
- Low to very low hydraulic gradients and conductivities are expected over much of the site..

To mitigate the potential risk of an increase to the recharge during significant rainfall events when the trenches are open, wherever possible, trench construction would be planned for dry periods and an effort would be made to minimise the time trenches are open (this could involve closing the trenching at the end of each day or covering the trenches to prevent infill by rain).

10.4.2 Groundwater contamination

The use of construction equipment at the site carries the associated risk of fuel spills. It is expected that excavation and trenching would encounter slightly weathered to fresh bedrock at relatively shallow depths at most, if not all, construction locations across the site. If a fuel spill were to occur in an area with exposed bedrock, or in an area with very shallow soil cover, it is possible that the spill could move relatively quickly through the fractured bedrock substrate and enter the groundwater table. Over time, this would potentially migrate down from the source point and adversely impact on the quality of groundwater sources.

However, it should be noted that construction would be isolated to the subject site and would not occur on the eastern side of the groundwater divide that has the potential to flow into the Googong Reservoir. Therefore, no detrimental construction impacts are expected on the Googong Reservoir or on any of the existing registered bores around the Googong township development area.

To manage the potential impact of groundwater contamination, the following measures would be implemented:

- 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.

10.5 Potential operational impacts and mitigation measures

This section identifies potential impacts from the use of recycled water within the Googong township, associated with CMJA's assessment of potential impacts from operation of the overall Project and Stage 1 of the Project.

10.5.1 Potential impacts on existing groundwater uses

No detrimental impacts on the water stored in Googong Reservoir are anticipated, as the expected groundwater flow beneath virtually all of the proposed Googong township development area migrates to the north and north-east of the site, away from the reservoir.

No impacts associated with the use of recycled water at the site are expected on any of the existing registered bores around the Googong township development area. Natural declines in water levels may occur in the bores located in the Fernleigh Estate to the west of the site, particularly during prolonged drought conditions. Such changes, however, are expected to be minor and not of a long-term consequence.

10.5.2 Groundwater mounding

Groundwater mounding is a local rise of the water table caused by excess irrigation or leakage from water delivery systems. It is not considered to be of consequence unless it is so severe that it causes local waterlogging and salt migration. Groundwater mounding may be caused by the following factors:

- The over-application of water to unpaved (ie irrigated) areas of the site.
- Leakage from either the potable or recycled water mains.
- Leakage from any other infrastructure (eg reservoirs, WRP), associated with either the recycled or the potable water supply systems.

Potential consequences can be avoided and would not occur through the enforcement of the following measures:

- The irrigation of public areas would be controlled to reduce the possibility of over-application. As noted in Section 7.5.6, an irrigation strategy would be submitted to Queanbeyan City Council to accompany subdivision development applications under Part 4 of the EP&A Act.
- The delivery mains for both the potable and recycled water would be laid in accordance with the approved materials and provisions of Water Services Association of Australia water supply code (WSA) 03-2002, and mechanical fittings would also be designed and installed in accordance with these guidelines. This would minimise the potential for leakage from either the recycled or potable mains, or leakage from any other infrastructure.
- A regular maintenance and inspection routine (to identify whether remedial works are required), and ensuring that if remedial works are required, they are carried out by suitably qualified personnel.

10.5.3 Isolated waterlogging of soils

The potential for isolated waterlogging of soils and the lateral migration of salts in shallow zones is a potential impact on groundwater due to the irrigation with recycled water. Waterlogging is most likely to occur where shallow groundwater migrates just above the bedrock horizon (ie the soil/bedrock interface), with increasing salt loads most likely at the confluence of catchments and streams in the study area.

Soil testing and analysis conducted for the Googong land capability study (refer to Appendix D) indicate that soils within the study area are well structured and not susceptible to salinity impact or waterlogging, allowing water and salt to easily move through the soil landscape. The potential for waterlogging is therefore considered minor and would be further reduced through the design of the stormwater system and the irrigation program to ensure that the study area is not over-watered, and is well drained to prevent waterlogging.

A measure that would be considered in the future if soil salinity issues and waterlogging are found to be posing a negative impact is retrofitting the stormwater system with subsoil drains within recycled water irrigation areas to direct flows into the surface stormwater system. This would need to be considered in the context of potential surface water changes that could result.

10.5.4 Groundwater quality

Impacts relating to groundwater quality relate to the use of recycled water – which has a higher TDS (salt) level than rainwater and potable water – mixing with the groundwater as a result of the Project. There are two ways recycled water may potentially mix with groundwater:

- Where there have been excavations for the water mains, the recycled water may largely bypass the soil horizon and migrate quickly into the water table.
- Salt may migrate towards lower-lying streams and waterways and accumulate there in dry periods. During periods of heavy rain, the accumulated salt may act as saline ‘pulses’, eventually ending up in the water table.

The impacts of salt on the groundwater system are predicted to be minor, as TDS levels (although higher than potable and rainwater) are consistent with comparable recycled effluent systems and significantly lower than the existing groundwater content (an average 660 milligrams per litre compared to 1200 milligrams per litre, respectively).

At a meeting on 19 August 2010 with the DoP and the NSW Office of Water, some concerns were identified regarding the initial TDS levels indicated and discussions were carried out to determine whether reductions could be achieved as part of the value engineering process. As a result, TDS levels have been reduced through the implementation of a biological phosphorus removal process in the treatment process in the water recycling plant. These levels may be reduced further using targeted plant management practices to reduce salt output in effluent, educating residents about implementing suitable salinity management controls. The very high quality of recycled water and the provision of a managed stormwater system preclude most of the risks associated with contamination (by salt) of ground and surface waters (refer to report by Agsol Pty Ltd, 2010 in Appendix D).

CIC is committed to reducing salt levels where practical during operation of the Project by implementing mechanisms to control salt levels at different points in the integrated water cycle management system. Three particular areas are the focus of these salt reduction initiatives:

- At the WRP – TDS levels in recycled water would be maintained at an average of 650–660 so as to not cause significant risks of salinity impacts from irrigation. Furthermore, control mechanisms would be incorporated to ensure salt levels 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. Also, there is an inherent trade-off between management of phosphorus and management of salt. If salt reduction is required, it is possible to change the way phosphorus is managed in the treatment process.

- System (network) – The network infrastructure (eg reservoirs, pipework and sewage pumping stations) could be used to influence salt levels by controlling the amounts of chemicals used for odour control and chlorination.
- Residential users – Education programs for residents would be initiated to reduce salt levels during operation. Education programs would aim to inform residents about the risks involved with salinity, to ensure that residents know they have the potential to affect groundwater quality. The programs would offer advice and alternative ways to reduce this risk, including the need to use low-salt liquid laundry detergents, and the appropriate frequency and volume of irrigation to avoid waterlogging.

10.6 Impacts of subdivision and change of land use

This section relates to the third point in CMJA's scope of assessment outlined in Section 10.2 – the impacts of the subdivision and the change of land use from greenfield site to urban development.

Although this potential impact it is not specifically part of this Part 3A EA, CMJA has looked at potential impacts relating to the development of the Googong township as a whole.

A common outcome from urban development of greenfield land is a higher capture of water away from the established groundwater systems (referred to as 'recharge capture') via the introduction of stormwater management systems. This leads to a lower overall groundwater recharge regime in the new urban development area. Changes to the recharge regime are recognised to be the most significant potential impact on groundwater in the long term from urban development and the provision of related services. The extent of any impacts on groundwater recharge depend on the degree of difference between recharge capture and artificial contributions to recharge from urban activities. Refer to Section 7.6 of Appendix E for more details concerning changes to the recharge regime.

As the Googong township would be transitioning from a greenfield site, the recharge regime would change, which could cause impacts. Although any impacts are expected to be minor, CMJA recommends that certain aspects be considered when monitoring groundwater levels during the operation of the subdivision stages. A monitoring program has been developed in Section 10.7 that captures both the potential impacts of the Project (the overall Project and Stage 1) and the future urban development of the Googong township.

10.7 Proposed monitoring and adaptive management

In light of the long-term considerations outlined in sections 10.5 and 10.6, the following parameters would be measured and monitored as part of the Project's adaptive management regime:

- Water table levels, including bores within the study area, particularly within the eastern and south-western portions.
- Hydraulic gradients across the study area.
- TDS salt levels within the groundwater.
- The potential for impacts on any downstream groundwater-dependent ecosystems.

Table 10.1 outlines the recommended scope of works for the monitoring program. This monitoring program would inform the operational environmental management plan (OEMP) for Stage 1 of the

Project, and assist future assessments under the EP&A Act, potentially under Part 3A project application(s) or Part 4 development applications.

Table 10.1 Recommended scope of works for future monitoring program

Item no.	Detail	Recommended scope of works	Timing
1	Obtain further site-specific baseline data on aquifer characteristics, groundwater levels and groundwater qualities, to monitor trends in groundwater levels and quality, and model the impact of long-term development of the site on groundwater resources.	Carry out groundwater drilling and hydraulic testing across entire study area, aimed at identifying the depth and morphology of the water table, as well as the hydraulic properties and groundwater chemistry of: • The Colinton Volcanics. • The Googong Adamellite. • Any soil horizons and/or discontinuities of interest.	To commence as soon as practical after approval of the Project.
2	Obtain quantitative predictive modelling for parameters across the study area to quantify the impacts of the Project.	Once baseline data have been obtained, a computer model of the area should be compiled using the modular finite-difference flow model package MODFLOW, and the impacts of the development on groundwater levels and water table morphology should be assessed. At this stage, it is recommended that MODFLOW be used to simulate a range of potential climatic conditions (including reduced rainfall at the site as a result of global warming), and a conservative estimate of the changes in the groundwater table depth and morphology be assessed. From this, the impacts on local groundwater users and groundwater-dependent ecosystems can be further assessed, with this information passed on to the ecological consultants involved in assisting with issue 3 below.	When the drilling, sampling and hydraulic testing program is complete.
3	Clarify the position of the groundwater divide, and the effect of recharge changes due to the Googong township on the position of the divide. This is necessary to ensure that recycled water is not applied to groundwater sources for the Googong Dam Reservoir.	Carry out a groundwater drilling and hydraulic testing program aimed at identifying the depth and morphology of the water table in the south-eastern corner of the site, as well as the hydraulic properties of the Colinton Volcanics, and possibly Silurian intrusions, in this area. Once these data have been obtained, the MODFLOW groundwater flow can be used to predict the effect of recharge changes on the position of the divide.	Concurrently with items 1 and 3.
4	Obtain clarity on the position of the groundwater divide, and the effect of recharge changes due to the Googong township on the position of the divide. This is necessary to identify the groundwater source area for the Googong Reservoir within the Googong township development area to ensure that recycled water is not applied to this area.	Carry out a groundwater drilling and hydraulic testing program aimed at identifying the depth and morphology of the water table in the south-eastern corner of the site, as well as the hydraulic properties of the Colinton Volcanics, and possibly Silurian intrusions, in this area. Once these data have been obtained, the MODFLOW groundwater flow can be used to predict the effect of recharge changes on the position of the divide.	Concurrently with items 1 and 3.

Item no.	Detail	Recommended scope of works	Timing
5	Clarify the long-term effects of the Googong township development and climate change. This is necessary so that changes to planning and management of later stages can be introduced if required.	Establish groundwater level and salinity monitoring program, including installation of water-level loggers in monitoring wells, and periodic measurement of salinity in groundwater and in surface watercourses. Also establish a soil salinity monitoring program, using EM31.	Commence once monitoring wells installed. Review results annually.

10.7.2 Other recommendations

It is recommended that a public education program be undertaken to inform Googong township residents on the need to minimise the use of high-concentration unnatural fertilisers on home gardens and public open spaces. Use of these fertilisers presents unnecessary risk of high nutrient and salt transfer to the groundwater system. Such advice would be included in information to residences as described in Section 16.4 and is in keeping with the objectives for Googong township (refer to Section 2.5.5) to provide specific avoidance measures for environmental impacts.

10.8 Conclusion

Potential construction impacts on groundwater are assessed as low risk. They include the potential of altering the local recharge and groundwater contamination. These risks would be managed appropriately with the mitigation and management measures described.

During the operation of the Project, potential impacts from the use of recycled water at the site may include possible changes in the recharge regime, isolated waterlogging of soils, groundwater mounding and groundwater quality. A comprehensive impact assessment for these issues has been provided as part of a precautionary approach to groundwater impacts. It has concluded that any impacts are likely to be minor.

It is recommended that monitoring be conducted as part of the operational management of the Project. Mitigation and management measures, including those suggested in this chapter are committed to in statement of commitments (G1–G7 and S5) in Chapter 18.