Appendix E

Groundwater assessment

Googong Township water cycle project

Environmental Assesment

November 2010

Controlled Copy ___

Groundwater Assessment

Googong, NSW

for CIC Australia
September 2010

J0991.10R-rev4

C. M. Jewell & Associates Pty Ltd

Groundwater Assessment – Googong, NSW
September 2010

J0991.10R-rev4

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Measures

µg/L	micrograms per litre
km	kilometre
L	litre
m	metre
m^2	square metre
µS/cm	microsiemens per centimetre
mS/cm	millisiemens per centimetre
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mm	millimetre

General

AHD	Australian Height Datum
AMG	Australian Map Grid
ANZECC	Australian and New Zealand Environment and Conservation Council
AST	above-ground storage tank
CLM Act	Contaminated Land Management Act
CMJA	C. M. Jewell & Associates Pty Ltd
COPC	contaminants of potential concern
DA	development application
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
DLWC	Department of Land and Water Conservation
DNAPL	dense non-aqueous-phase liquid
DNR	Department of Natural Resources
DP	deposited plan
DQO	data quality objectives
EPA	Environment Protection Authority
ESA	Environmental Site Assessment
GDE	groundwater dependent ecosystems
HDPE	high-density polyethylene
MNA	monitored natural attenuation
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure
PID	photoionisation detector
PQL	practical quantitation limit
ppmv	parts per million volume
PSH	phase-separated hydrocarbons
QA	quality assurance
QC	quality control
RAP	remediation action plan
RL	relative level
RPD	relative percentage difference
SWL	standing water level
TCLP	Toxicity Characteristics Leaching Procedure
THI	target hazard index
TOC	top of casing
TWA	time weighted average
UCL	upper confidence limit
UST	underground storage tank

Analytes – Organic

BaP	benzo(a)pyrene
BTEX	benzene, toluene, ethylbenzene, xylene
OCP	organochlorine pesticides
OPP	organophosphorus pesticides
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
SVOC	semivolatile organic compounds
TPH	total petroleum hydrocarbons
VHC	volatile halogenated compounds
VOC	volatile organic compounds

Analytes – Inorganic

As	Arsenic
Cd	Cadmium
Cr	Chromium
Cu	Copper
Fe	Iron
Hg	Mercury
Mn	Manganese
Ni	Nickel
Pb	Lead
Zn	zinc

EXECUTIVE SUMMARY

This groundwater assessment relates to a proposed integrated water cycle project that would service a new town at Googong. It forms part of an environmental assessment that is being prepared for the project.

An initial appraisal was carried out by C. M. Jewell and Associates Pty Ltd (CMJA) in September 2004 to identify potential groundwater-related impacts of the development on the Googong water supply reservoir. This appraisal concluded that there should be no measurable impact on the Googong Reservoir.

Design of the project has now progressed and a system that includes the distribution and reticulation of both potable and recycled water is proposed. In light of this, CMJA is reassessing the findings of the 2004 report so as to assess the likely impacts that may result from the installation of both potable and recycled water infrastructure.

This report (September 2010) is updated from a previous version (J0991.10R-rev2, dated 30 November 2009) that was included in a draft environmental assessment submitted to the NSW Department of Planning (DoP) in February 2010. Updates to this report have been made to address comments made by DoP and other agencies, as well as to reflect changes and updates to the project design.

Site Setting and Physiography

The proposed site is located approximately 6 kilometres south of Queanbeyan in New South Wales. The site is irregularly shaped, with dimensions of approximately 4 kilometres north-south by 3 kilometres east-west, and has an area of approximately 780 hectares.

The land is presently rural. Some areas have been over-grazed and have sparse grass cover and some trees. Existing improvements within the pastoral areas include a number of houses, farm buildings, dams and dirt tracks.

The physiography of the site is mainly characterised by broad undulating plateaus and plains which have been dissected by drainage channels. Most of the site's surface water drains into the Queanbeyan River catchment, with a small portion of the south-eastern corner of the site draining into the Googong Dam Catchment.

Geology and Soils

Most of the site is underlain by Colinton Volcanics, a late Silurian volcanic unit within the Canberra block. A small portion in the north-eastern corner of the site is underlain by the Googong Adamellite, whilst two small granitic intrusions have been emplaced in the Colinton Volcanics in the south-eastern corner of the site.

At the site the Colinton Volcanics within the vicinity of the site 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–south-south-west. This alignment is evident in all but a handful of outcrops both within and around the site, and is most evident where resistant ignimbrites, shales and tuffs of the Colinton Volcanics outcrop in the vicinity of Hill 800.

Most of the site is located on the Burra soil landscape unit. This landscape consisting of undulating to rolling hills and alluvial fans is associated with the weathering of the underlying Siluran volcanic

units. Other soil landscape units evident across the site include the Campbell unit and the Caleys Creek unit.

Hydrogeology of the Googong District and Surrounds

A desktop review was completed of records held by the New South Wales Office of Water (NOW) covering boreholes within a 6-kilometre radius of the centre of the site. Results of this review indicated that yields for the boreholes drilled throughout the Googong district vary between less than 1 litre per second (L/s) to 10 L/s; most of the bores that were drilled in the Colinton Volcanics reported yields of between 0.5 and 1.0 L/s.

The groundwater quality within the study area is considered to be generally fresh; that is, it has relatively low totalled dissolved salts (TDS). The TDS concentration in most of the bores is typically below 1200 milligrams per litre (mg/L), which is considered to be below the acceptable limit for human consumption.

Rainfall recharge of fractured rock aquifers occurs through areas of open fracturing, either at the surface or beneath 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.

Conceptual Hydrogeological Model

Groundwater at the site is predominantly hosted in a regionally extensive low-permeability fractured-rock aquifer within the Colinton Volcanics. Groundwater is also hosted within the discontinuities within the Googong Adamellite (and accompanying Devonian stocks and intrusions), and within the alluvial aquifers located along the alignments of locally significant waterways; the latter are expected to have minimal storage, and are not of significance to this assessment.

The flow direction of shallow groundwater is influenced by the local topography, with local and regionally extensive peaks and ridges indicating local groundwater divides. There is a groundwater divide beneath the study area, located somewhat further to the west than the surface catchment boundary; groundwater beneath the south-eastern part of the proposed development area thus flows towards Googong Dam.

Potential Impacts of the Installation of the Recycled Water System and Use of Recycled Water at the Site

The recycled water system proposed as part of the development will include infrastructure components such as; a water recycling plant, potable and recycled water mains pipework, sewage rising mains, water pumping stations, sewage pumping stations, and separate reservoirs for potable water and recycled water. Stormwater management and irrigation systems, whilst relevant and integrated to the operation of the system, are not considered part of the Project for Part 3A assessment purposes.

Potential impacts arising from the construction of the project are expected to be minimal. The only significant risk identified during the assessment is related to the potential accidental release of fuel at the site. However, given that construction of the potable and recycled water delivery systems will be isolated to the site, and that management strategies will be employed to minimise the impacts on groundwater should a spillage occur, no detrimental impacts stemming from the construction are expected.

Potential impacts from the use of recycled water at the site may include: isolated waterlogging of soils; lateral migration of salts in the shallow zone; localised waterlogging and accumulation of mobile salts at the confluences of locally significant waterways; discharge of saline water to streams; (minor and localised) groundwater mounding; potential increased baseflow to both Montgomerys Creek and the

unnamed creek in the northern portion of the site; and a very small decline in groundwater quality associated with the mixing and dilution of recycled water at the site.

Any impacts are likely to be minor, provided that appropriate salinity management controls and water use practices are adopted by CIC Australia (CIC) and future landowners. The recharge potential of the Colinton Volcanics will determine the scale of consequent water level changes. Slight decreases in groundwater quality are expected, regardless of whether recharge increases or decreases across the site.

Although some changes to the groundwater flow regime are expected to result from construction of the development and the application of recycled water, no detrimental impacts on the water stored in the Googong Dam reservoir are anticipated.

To manage the risk of groundwater contamination from an accidental fuel release during construction at the site, it is recommended that all refuelling occurs at designated fuel distribution points. These should be bunded and surfaced with compacted soil, in order to prevent loss of fuel to the ground in the event of a spillage.

Other Considerations

In addition to the impacts identified above, there are also potential long-term impacts on the groundwater system associated with the change of the site use from agricultural to residential. Catchment water balance estimates indicate that, post-development, the amount of water available for groundwater recharge at the site may decline by up to 70%. This is considered to be a significant decline in the amount of water available for groundwater recharge – both across the site and throughout the local area, the consequences of which are expected to include:

- 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;
- reduced groundwater discharge to each of the ephemeral waterways in the north and east of the site; migration of the groundwater divide in the south-eastern corner of the site to the east; and
- a likely increase in the total dissolved solids content of the groundwater.

Although the magnitude of the above impacts cannot be qualitatively assessed at this time, it is considered that the most prominent impacts of the development will be the lowering of the watertable beneath most – if not all – of the site, and the reduction in the amount of aquifer storage available to local groundwater users.

Recommendations

In order to better understand whether salinisation is likely to become a significant issue at the site, it is recommended that salt levels in the waterways be regularly monitored during and after the development of Neighbourhood 1A. Groundwater samples should be collected from both the shallow and regional aquifers, and soil conductivity (i.e. salt) mapping carried in areas of inferred impact.

From the statements presented above, it can be seen that whilst qualitative assessments of the likely impacts of the development have been made, it is not possible to provide quantitative predictions of these impacts. CMJA recommends that, following project approval, the scope of works set out below be carried out so that:

- Baseline groundwater levels and groundwater quality beneath the site can be established.
- A quantitative prediction of changes that are likely to occur as a result of the development can be made, using an appropriate modelling approach, based on real hydrogeological data.
- Actual changes that occur during the initial stages of development can be monitored, and compared with both baseline conditions and changes in underdeveloped parts of the site.
- The model can be tuned on the basis of monitoring results, so that changes due to proposed later stages of the development can be made.
- If necessary, appropriate design changes can be made.

TABLE E1
Recommended Scope of Works for Future Investigations

Issue / Data Gap	Reasons for Concern	Recommended Scope of Works	Timing
1. Lack of site-specific baseline data on aquifer characteristics, groundwater levels and groundwater quality.	a) Without site-specific hydrogeological data it is not possible to quantify (model) the impact of the long-term development of the site as a whole on groundwater resources. b) Without baseline data (and the monitoring points from which it is obtained) it is not possible to monitor trends in groundwater levels and groundwater quality to observe the effect of the staged development and calibrate predictions.	Carry out a groundwater drilling, sampling and hydraulic testing program across the entire site, 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; and • any soils horizons and/or discontinuities of interest. Recommended locations as shown on Figure 6.	Because baseline groundwater monitoring needs to cover as much seasonal and cyclical variation as possible, this program should commence as soon as possible after development approval is granted.
2. Lack of quantitative predictive modelling of impact of overall development.	It is necessary to quantify the impacts of the proposed development (as a whole and in stages) on: • groundwater levels beneath the area; • groundwater quality; • quantity and quality of groundwater discharge to surface water bodies; • existing groundwater users throughout the area; and • any other relevant facets of the environment.	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 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 GDEs 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. Lack of detailed quantitative understanding of impact of recycled water use	It is necessary to assess and quantify what the likely effects and impacts of the proposed development and the use of recycled water will be on groundwater at the site, as well as on any GDEs down-gradient of the site.	Carry out an assessment of the presence and condition of any GDEs located both at and down-gradient of the site, and assess what impacts any likely changes in groundwater discharge volume, quality, and geochemistry may have on these GDEs.	When model is available
4. Uncertainty as to the position of the groundwater divide, and the effect of recharge changes due to the development on the position of the divide.	It is necessary to identify the groundwater source area for the Googong Dam Reservoir within the 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.
5. Long-term effects of development, and climate change.	It is necessary to monitor changes that occur during the staged development so that the modelling can be calibrated, and so that changes to planning 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 soil salinity monitoring program using EM31.	Commence once monitoring wells installed, review results annually.

1.0 INTRODUCTION

1.1 Background

A study is currently in progress to assess the feasibility and water cycle management requirements of a proposed new community at Googong, located approximately 6 kilometres south of Queanbeyan in NSW.

The proposed town will utilise contemporary environmental and social sustainability initiatives. These will include the supply and use of recycled water – potentially reducing the use of potable water due to a combination of decreasing the demand as well as looking at source substitution.

The population of the new community will be about 16,000 to 18,000, and there will be 5500 new dwellings. The town will cover an area of about 780 hectares; its location is shown on Figure 1.

An initial appraisal of some likely impacts of the development was carried out by C. M. Jewell & Associates Pty Ltd (CMJA) in September 2004. MWH Australia Pty Ltd (MWH) commissioned the appraisal in order to identify potential groundwater-related impacts of the development on the Googong water supply reservoir. At that time, however, the provision of recycled water to residential and commercial customers was not an option under consideration.

The 2004 appraisal concluded that although urbanisation would inevitably result in some degradation of groundwater quality beneath the project site, impacts were likely to be relatively low compared with those experienced beneath older urban developments, and that there should be no measurable impact on the Googong Reservoir.

The report also recommended the following.

- Any fuel service stations to be constructed in the Googong new community be located well to the west of both the groundwater flow divide and the surface catchment boundary, and
- In keeping with the project's sustainable development and minimal environmental impact philosophy, there be minimal use of artificial fertilisers on public projects and that residents should be educated about the importance of minimising fertiliser use in private gardens.

When the 2004 study was conducted, the water cycling scheme included the provision of water and wastewater services to the proposed residential and commercial allotments. This scheme, however, has since changed. A recycled water scheme is now proposed with recycled water mains and infrastructure mirroring that of the potable water system.

Because of this amendment, Manidis Roberts Pty Ltd (Manidis Roberts) asked CMJA to reassess the findings of the 2004 assessment in light of the proposed addition of recycled water usage at the site, and to assess the likely impacts that may result from the installation of both the potable and recycled water infrastructure.

CMJA subsequently submitted a fee proposal to Manidis Roberts and Canberra Investment Corporation Limited (CIC), outlining the proposed approach and scope of works.

On 18 August 2009, Mr Craig Harris of CIC commissioned CMJA to carry out the abovementioned appraisals in accordance with CMJA proposal J0991.9L-rev0 dated 6 August 2009.

The site visits described in that proposal were conducted on 20 August 2009, and the results of the assessments are presented in this report.

The assessment presented in this report is consistent with the NSW State Groundwater Policy Framework.

1.2 Project Objectives and Scope of Work

The project objectives were to reappraise the proposed development at Googong in light of any amendments since the initial appraisal, with particular emphasis on the following:

- the likely impacts of the proposed water recycling scheme on groundwater beneath the site and on water within the Googong water-supply reservoir; and
- the likely impacts of construction works associated with the recycled water component of the development.

The investigation was also to provide recommendations for any further works considered necessary to address any issues raised during the assessment, including potential drilling targets, borehole depths, and analytical schedules.

In order to achieve the project objectives, the following work was undertaken.

- Review of available geological and topographic mapping, aerial photography and satellite imagery of the Googong district and surrounding areas.
- Review of published literature relating to the history and geology of the Lachlan Fold Belt (LFB) including a number of references and accompanying map sheets published by the Geological Survey of New South Wales.
- Review of the borehole summary worksheets held by the New South Wales Office of Water (NOW) for all registered boreholes in the area.
- Field assessment of the site, including an appraisal of rock outcrops and areas of inferred hydrogeological significance.
- On-ground survey of groundwater resources and infrastructure in the area, including neighbouring groundwater wells and their likely allocations.
- Review of water balance studies carried out by others for the site both pre and post-development.
- Compilation of a hydrogeological model of the area based upon available information and professional judgement.
- Assessment of the potential receptors of groundwater flow.
- Assessment of the likely impacts of the use of recycled water at the proposed development on
    - groundwater;
    - water stored within the Googong Dam catchment; and
    - a number of groundwater bores in the area, including those to the north and south-west of the development.
- Assessment of the likely impacts of the proposed development on groundwater levels and recharge mechanisms at the site.
- Identification of any areas of concern, where further assessment may be warranted.

In addition to the above, a report detailing the findings and conclusions of the assessment was to be prepared, with recommendations for any further investigations also presented if considered warranted.

1.3 Report Format

Section 2 of this report presents an overview of the sources of information used for this assessment, and evaluates the contribution of these sources to the hydrogeological review of the study area.

Section 3 of this report describes the site location and the physiography of the Googong area.

Section 4 of this report presents a summary of the local geological setting, based on a number of sources listed in the references section at the end of this report. Included in this section are detailed descriptions of the main rock types of importance to this investigation, as well as details of the main structural characteristics that define the Googong area.

Section 5 of this report presents a brief summary of the local hydrogeological environment. It has been based on a review of a number of sources, including the borehole summary worksheets for all registered boreholes in the area, the results of the groundwater survey carried out during the site visit, and anecdotal evidence. Where available information was scarce, professional judgement has been used.

The conceptual hydrogeological model of the area – on which the conclusions and recommendations have been based – is presented in Section 6. Also discussed in this section are a number of data gaps identified during this assessment, most of which relate to the hydrogeological characteristics of the site (as opposed to those of the region as a whole).

Section 7 of this report presents an overview of the construction techniques associated with the development of each of the neighbourhood areas at the site. It also provides an appraisal of the likely impacts on groundwater and on water resources in the Googong Dam reservoir and neighbouring bores that may result from the construction of the potable and recycled water supply systems, and from the use of recycled water across the site. A brief overview of the proposed recycled water scheme is also presented in this section.

Conclusions and recommendations are presented in Section 8.

Supporting data and additional information reviewed during the assessment are provided in a series of appendices at the end of this report.

Appendix A presents an overview of the geological aspects of the study area. The information presented in this appendix is based on a number of references describing the Googong and Queanbeyan districts; further details are provided in Section 4.0.

The hydrogeological setting of the Googong area is described in detail in Appendix B. This review has been based on a number of sources including maps and accompanying explanatory notes published by the Geological Survey of New South Wales, the Australian Geological Survey Organisation, the Bureau of Mineral Resources, Geology and Geophysics, the Water Resources Commission of New South Wales, geological and hydrogeological information obtained from a search of the borehole database held by NOW, and an on-ground survey of groundwater resources.

Copies of the borehole summary worksheets held by NOW for all of the registered boreholes located in the Googong district are provided in Appendix C. Information presented on the worksheets includes the depth of boring in the area, geological formations encountered during drilling, depth to and the type(s) of water-bearing zones encountered, and general information relating to the quality of groundwater in the area. A table summarising all of the known bore information – including that obtained during the site visit – is also included in this appendix.

1.4 Limitations and Intellectual Property Matters

This report has been prepared by C. M. Jewell & Associates Pty Limited for the use of Manidis Roberts and CIC, for the specific purpose described in Section 1.1. The project objectives and scope of work outlined in Section 1.2 were developed for that purpose, taking into consideration any client requirements and budgetary constraints set out in the proposal referenced in Section 1.1.

The work has been carried out, and this report prepared, utilising the standards of skill and care normally expected of professional scientists practising in the fields of hydrogeology and contaminated land management in Australia. The level of confidence of the conclusions reached is governed, as in all such work, by the scope of the investigation carried out and by the availability and quality of existing data. Where limitations or uncertainties in conclusions are known, they are identified in this report. However, no liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been assessed or predicted using the adopted scope of investigation and the data derived from that investigation. An information sheet – 'Important Information about your Environmental Site Assessment' – is provided with this report. The report should be read in conjunction with that information sheet.

Where data collected by others have been used to support the conclusions of this report, those data have been subjected to reasonable scrutiny but have essentially, and necessarily, been used in good faith. Liability cannot be accepted for errors in data collected by others.

This report, the original data contained in the report, and its findings and conclusions remain the intellectual property of C. M. Jewell & Associates Pty Ltd. A licence to use the report for the specific purpose identified in Section 1.1 is granted to the persons identified in that section on the condition of receipt of full payment for the services involved in the preparation of the report.

This report should not be used by other persons or for other purposes than those identified in Section 1.1, and should not be reproduced except in full and with the permission of C. M. Jewell & Associates Pty Ltd.

2.0 INFORMATION SOURCES AND DATA AVAILABILITY

2.1 Information Sources

The analysis presented in this report has been based on a number of data sources, including those described below.

- Topographic and landscape data available from 1:25,000 and 1:250,000 scale maps published by the NSW Department of Lands (formerly the Central Mapping Authority of New South Wales) – in particular the Tuggeranong 8727-3-S and Hoskinstown 1:25,000 scale topographic maps.
- Geological data from 1:100,000 and 1:250,000 scale geological and metallogenic maps – and accompanying explanatory notes – published by the Geological Survey of New South Wales and Bureau of Mineral Resources, Geology and Geophysics (Department of Primary Industries and Energy). A number of geological cross-sections and tectonic models presented on these maps were also reviewed as part of this assessment.
- Geological information – including analysis and reinterpretation of structural models of the southern portion of the Lachlan Fold Belt and adjoining structural zones – compiled by the Geological Survey of New South Wales. This included geological, hydrogeological, and geomorphological information relating to the (geological) province to which the site belongs.
- Geological and hydrogeological information from a search of the registered borehole database held by NOW. Information held by NOW includes geological descriptions of rock types, estimates of borehole yields and water quality, and the depth and nature of any water-bearing zone(s) intersected encountered during drilling.

  Whilst the information presented on these records has generally been accepted in good faith, it should be noted that much of this information – including the geological logs and estimates of bore yield and groundwater quality – is based on data supplied by drillers at the time of drilling. These are usually field observations and estimates only. The quality of information recorded on these sheets is variable, and they are often incomplete. It should also be recognised that the current yield and performance of a bore can vary from that of the newly completed bore. In particular, it should be noted that short-term borehole yield tests carried out in fractured rock aquifers often over-estimate long-term yield because their influence does not extend to the continuity limits of the local fracture system, whereas long-term yield is constrained by those limits.
- Geological, hydrogeological and pedological information presented in a number of consultant reports, including those prepared by Agsol Pty Ltd, Agricultural Water Management Pty Ltd, Manidis Roberts and MWH.
- Appreciation of the geological, hydrogeological, pedological and geomorphological setting at the site conducted during the site visit. Additionally, during the site visit, the following work was conducted: measurements of the dip and strike of a number of outcropping units of the Colinton Volcanics and jointing planes in the Googong Adamellite; verification of groundwater wells and surface infrastructure in the area; field measurements of the depth to bedrock; and assessment of the general soil profile across parts of the site.

2.2 Data Coverage

As mentioned in Section 2.1, geological and hydrogeological data for the study area and its surroundings were derived from a number of sources, including maps and references published by the NSW Department of Mineral Resources and the Geological Survey of New South Wales, observations made during the site visit, and information presented on the borehole summary worksheets held by

NOW. These information sources all contributed (in varying degrees) to the conceptual hydrogeological model of the study area presented in Section 6 of this report. Some contributed less than originally hoped.

Table 1 presents an overview of the different data types, and provides an appraisal of their significance to this assessment and to the conclusions presented in this report.

From Table 1 it can be seen that geological information, which is fundamental to a hydrogeological appraisal in any area, was generally limited to broad generalisations and regionally based tectonic assessments. During the assessment, little specific information regarding the structural framework, other than the regional alignment of the metasedimentary units beneath the study area, was identified. Given that groundwater in the area is predominantly hosted in fractured rock aquifers, this lack of information has proved to be a significant issue, because structural features are expected to be the dominant groundwater flow mechanism beneath the site, particularly along the alignment of a fault traversing the site.

Where data were not available, hydrogeological principles and professional judgement were used to define the hydrogeological setting of the study area.

TABLE 1
Overview of Data Coverage

Data Type	Comments
Topographic map sheets	The site – and much of the greater Queanbeyan-Googong district – is shown on the Tuggeranong 8727-3-S and Hoskinstown 8727-2-S 1:25,000 scale published map sheets (elevation data referenced by 10-metre contour lines accurate to the nearest metre relative to Australian Height Datum). Aerial photographs of the site at 1:25,000 scale are published on the reverse of these maps.
Geological map sheets	The site – and much of the greater Queanbeyan-Googong district – is shown on the Canberra 8727 1:100,000 and Canberra 1:250,000 scale published map sheets. Differentiation between the different rock types and formations appears to be well defined and delineated on these map sheets, but structural data are sporadic and generally lacking, partly owing to the scale of the maps and the complexity of the area.
Map notes published by BMRGG[α]	Hydrogeological characteristics of the site, of the Australian Capital Territory (ACT) and of adjacent parts of NSW are provided in the BMRGG publication *Hydrogeology of the Australian Capital Territory and Environ*s. Information included a description of physiographic units in the greater ACT area; detailed summaries of the hydraulic and hydrogeochemical nature of the major groundwater provinces in the area; and a brief synopsis of the geological history of the area. This reference – together with the accompanying mapsheet and the information obtained from the NOW registered borehole database (see below) – formed the basis for much of the assessment presented in this report.
NOW[φ] registered borehole database	Data provided on the borehole summary worksheets constituted the main source of hydrogeological information used during this assessment. Spatial coverage of boreholes was greatest to the south-west and north of the study area, where a number of bores have been drilled in the various units of the Colinton Volcanics. None currently exist at the site, however. Information regarding the wells to the south-west and north of the site has formed the basis of much of the regional geological and hydrogeological information used in this review, together with information published by the Bureau of Mineral Resources, Geology and Geophysics. On many worksheets, information was incomplete, and professional judgement was used to help fill some of these gaps. Geological information presented in the borehole logs was generally consistent with the rock types listed for each of the main formations of interest to this investigation. However, some anomalies existed. Information relating to water-bearing zones – which in most bores lay within fractured basement rocks – was generally well completed, but such information related specifically to conditions existing at the time of drilling only.
Consultants reports[Ψ]	Consultants reports provided detailed information regarding the change on surface water dynamics which will affect groundwater recharge at the site. They also provided sporadic information regarding local geology, locations and characteristics of nearby groundwater monitoring wells, and soil conditions across the site. Information regarding the Googong development – particularly the water and recycled water schemes – was also useful in the assessment of their likely impacts on groundwater beneath the site.
Site visit and field analysis	Work conducted included geological mapping and an appraisal of hydrogeological conditions, including proofing of groundwater infrastructure in the region, measurement of structural features of the Colinton Volcanics and Googong Adamellite, and measurements of the depth to bedrock at selected locations across the site.

Notes: [α] Bureau of Mineral Resources, Geology and Geophysics (Department of Primary Industries and Energy)
[φ] NSW Office of Water
[Ψ] Reports reviewed included those published by Agsol, Agricultural Water Management Pty Ltd, Manidis Roberts and MWH

3.0 SITE SETTING AND PHYSIOGRAPHY

3.1 Site Identification

The proposed Googong new community site is located approximately 6 kilometres south of Queanbeyan in NSW, as shown on Figure 1.

The centre of the site – in Map Grid of Australia (Zone 55H) coordinates – is approximately 702500 metres east (mE) and approximately 6077500 metres north (mN) as shown on the Tuggeranong 8727-3-S and Hoskinstown 8727-2-S 1:25,000 scale map sheets. Old Cooma Road extends north–south along the western boundary, whilst Googong Dam Road forms the northern boundary for the core portion of the site; the Commonwealth-owned Googong Dam area (which includes the dam and the foreshores) limits any further development to the east.

The site is irregularly shaped, with dimensions of approximately 4 kilometres north–south by 3 kilometres east–west. It has an area of approximately 780 hectares, and is bounded by

- Cooma Road in the west,
- the CSR Readymix property to the north,
- private land to the north-east,
- parts of the Googong property and the Googong Reservoir to the east,
- the Fernleigh rural residential development to the south-west, and
- rural land to the south.

The land is presently rural; some areas have been over-grazed, and have sparse grass cover and some trees. Existing improvements within the pastoral areas include a number of houses, farm buildings, dams, dirt tracks and roads.

Areas of denser vegetation and woodland are evident at the site, but are confined to its steeper and less accessible portions. Steep gullies to the north, west and east of the study area limit further development, and the erosion and soil loss make them areas of environmental concern.

3.2 Physiography and Surface Drainage

The site is located on the Mount Campbell uplands, about 6 kilometres south of Queanbeyan. The uplands are characterised by broad undulating plateaus and plains which have been dissected by drainage channels. Along the upland margins there are steeper slopes and heavily incised waterways.

Evans (1987), who compiled an extensive overview of the hydrogeology of the ACT and surrounding environments, identified the higher country south of Queanbeyan as the 'Tinderry-Gourock Highlands' physiographic unit. According to Evans' nomenclature, the highlands constitute one of the four main physiographical units in the ACT–Queanbeyan area, and are characterised by broad open plateaus, subtle ridgelines and moderately inclined hillslopes. Local relief was noted to be of the order of 50 to 350 metres (m), although Evans also noted that the highlands were bounded by a major fault-controlled escarpment to the north, and by deeply incised river channels to the east and west.

According to Jenkins (2000), the site is situated in the Cullarin Upland physiographic unit, which lies immediately to the east of the Canberra Lowlands. He also noted that the undulating hills on the tablelands commonly reach elevations up to 1100 m above Australian Height Datum (AHD), but are generally of the order of 680 to 1000 m above AHD, particularly along the western margin of the unit.

Mount 800, which is located in the south-western portion of the site and about 150 m east of Old Cooma Road, is the highest point in the immediate area, reaching an elevation of 816 m above AHD.

Other significant peaks in the area include Googong Hill (1013 m above AHD) on the eastern side of Burra Road, an unnamed hill (874 m above AHD) on the western side of Old Cooma Road (about 1 kilometre south-west of the site), and two apparently unnamed hills about 2 to 3 kilometres south of the site (which reach elevations of 927 and 891 m above AHD).

The maximum elevation at the site is 816 m; the minimum elevation is 640 m. The maximum difference in elevation across the site is therefore 176 m.

Hillslopes both in and around the site are generally between 5 and 25 degrees (°); the 25° slopes are most prominent around the eastern margin of the proposed development. Steeper slopes are also evident along the alignment of the unnamed tributaries of the Queanbeyan River and the lower reach of Montgomerys Creek, particularly where the latter waterway passes through the Googong Adamellite. Most of these areas have been excluded from development, however, with buffer zones set in place around these waterways.

Most of the area is characterised by poorly developed but relatively continuous blankets of colluvial material, with slopes of the order of 2 to 5°. Occasional outcrops of the underlying Colinton Volcanics protrude through the thin soil horizons, although these are most prominent at higher elevations in the landscape where they mark distinct changes in slope.

Most of the site's surface water drains into the Queanbeyan River catchment, with a small portion in the south-western corner of the site and land west of the Old Cooma Road draining into the Jerrabomberra Creek catchment. A small portion of the south-eastern corner of the site also drains into the Googong Dam catchment, but it is noted that this area has been excluded from development. No impacts to either groundwater or the water resources in the Googong Dam reservoir are expected as a result of the proposed development.

The Queanbeyan River together with its primary tributaries forms the major watercourse through the Googong district. Throughout most of the study area it flows in a north and north-north-westerly direction towards Queanbeyan; from there it meanders to the west and north-west towards Lake Burley Griffin. At the junction of the Queanbeyan and Molonglo rivers, just to the north of the Goulburn–Bombala Railway, the waterway becomes the Molonglo River, and its channel broadens as it flows across more open landforms between Queanbeyan and Canberra.

Jerrabomberra Creek flows through the dissected tablelands to the west of the site. It flows south to north in line with the regional topographic and geological inclinations, and eventually drains into Lake Burley Griffin, some 10 kilometres north-north-west of Lake Jerrabomberra.

Googong Dam – the largest water supply dam in the region – is located about 1.5 kilometres east of the site. This earth and rockfill embankment dam, which is owned by the Commonwealth Government, was built as part of a drought-proofing program for Canberra during the late 1970s, and is one of four reservoirs that supply water to the city of Canberra and its satellite suburbs, including Queanbeyan. It has a water-carrying capacity of about 124 gigalitres (GL), but the higher cost of delivery has meant that its water is only used during periods of water supply stress. The dam is therefore mainly used for recreational purposes (namely sailing and fishing). The reservoir also functions as an additional (external) water storage point; it is used to maintain the level of Lake Burley Griffin during dry periods, and to provide environmental releases for riparian and limited irrigation requirements.

The dam is operated and managed by ACTEWAGL, the ACT's electricity, water and gas utility supplier. Since its construction, lower flows in the river downstream of the dam have modified the river channel – a process assisted by the below-average rainfall of the past decade. Willows and river plants that thrive on low flows have colonised the banks. Management of the river includes management of these weed problems.

Throughout the study area numerous dendritic ephemeral streams and creeks, which are generally first and second order tributaries of the Queanbeyan River and Jerrabomberra Creek, dominate the surface drainage. Both of these waterways meander through relatively tight valley floors, resulting in well-incised channels with limited external-channel features (such as floodplain or bench development), and typically sandy to gravelly beds.

Most rivers in the Googong area appear to zigzag in distinct north to north-north-east directions, reflecting the structure in the underlying geological units.

Given the location and slope of the site, flooding is generally not considered to be of concern, but some localised inundation of land may occur at lower elevations, particularly along the unnamed tributary of the Queanbeyan River in the northern portion of the site.

4.0 GEOLOGY OF THE GOOGONG DISTRICT

This section provides an overview of the geology of the study area. It has been derived from the sources identified in Section 2 of this report.

Further information can be found in Appendix A.

4.1 Local Geological Setting

Most of the study region is underlain by the Colinton Volcanics, a late Silurian volcanic unit within the Canberra block. The Canberra 8727 1:100,000 scale geological map sheet describes the volcanics as a 'dark green dacitic ignimbrite with minor volcaniclastic sediments', although Mitchell (2007) goes on to further describe the volcaniclastic sediments as a number of limestone, dolomitic limestone and siltstone beds, tuffaceous shale, dacitic, rhyodacite and rhyolite lava flows, and ash fall deposits. The latter ash fall deposits are noted as having a similar mineralogy to a lithic or crystal tuff (i.e. ignimbrite).

Unlike most of the development area, 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 the youngest unit in the area, having been intruded into the surrounding Colinton Volcanics, and appears to have faulted boundaries. Its mode of emplacement, however, is not clear.

The Canberra 1:100,000 scale geological map sheet indicates that the Googong Adamellite lies between the eastern boundary of the site and the western side of Googong Dam. It has an area of about 3 square kilometres (km^2) 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, particularly between the Googong Dam front gates and the site offices, and also in a number of reaches along Montgomery Creek; a number of pegmatite and quartz-epidote veins associated with the emplacement of the pluton are also evident in the surrounding country rock.

In the south-eastern corner of the site, two small granitic intrusions have been emplaced in the Colinton Volcanics. These units – which are not defined in any great detail in the literature – form two small north-north-east–south-south-west elongated stocks which, like the Googong Adamellite, have been derived from the melting of oceanic crustal material. Together with the Googong Adamellite, these intrusions represent the last phase of deformation and orogenic processes in the area, and some degree of metamorphism of the surrounding country rock is probable.

In the north-western corner of the site, a small inlier of the Ordovician-aged Pittman Formation outcrops adjacent to Old Cooma Road. The outcrop is described as a black graptolitic siliceous shale, and outcrops over an area of about 1500 m^2.

The foundations of Googong Dam to the east of the site were excavated into three different rock types: the western abutment into the Googong Adamellite; the eastern abutment into an unnamed granitic stock; and the central portion above an unnamed dacite intrusive unit.

Although no major fault zones were detected at the dam site, reference to the Canberra 1:100,000 scale geological map sheet indicates that a north–south orientated normal fault is located in close proximity to the eastern abutment. Fracture zones and associated deep weathering – possibly caused by the intrusive effect of the granite and associated hydrothermal activities – are also known to exist in the dacite.

Much of the Googong Reservoir is underlain by tightly folded – and almost vertically dipping – quartzites, shales, siltstones and phyllites of the Colinton Volcanics, Cappanana Formation and Pittman Formation; the latter also forms a series of regionally extensive metamorphosed turbidite units to the east of the reservoir.

4.2 Structural Aspects

Reference to the Canberra 1:100,000 scale geological map sheet shows 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–south-south-west. This alignment is evident in all but a handful of outcrops both within and around the site, and is most evident where resistant ignimbrites, shales and tuffs of the Colinton Volcanics outcrop in the vicinity of Hill 800.

A left-lateral sinistral strike-slip fault orientated parallel with the regional structural orientation crosscuts the study region, as shown in Figure 2. In the northern portion of the site, the fault is ill-defined, as both the hanging wall and footwall contain metasediments of the Colinton Volcanics. In the centre of the site, however, where there are marked contrasts in the hanging wall and footwall geology, the fault is better defined, and definition is also good further to the south, owing to the dislocation of surface expressions associated with the tuffaceous shale unit of the Colinton Volcanics.

Mitchell (2007) notes that much of the secondary porosity (i.e. the porosity of the rock which is of interest in this assessment) associated with the fault appears to have been infilled with post-deformation quartz mineralisation, most likely derived from the circulating fluids during the emplacement of the Googong Adamellite. He states that groundwater resources at the site are most likely to be associated with the closely-spaced jointing arrays in close proximity to the fault zone, but does not mention whether these too are likely to be influenced by post-deformation quartz mineralisation (or by any other fracture infill material).

4.3 Soils and Regolith

According to the Canberra 8727 1:100,000 scale soil landscape sheet, most of the proposed development is likely to be located on the Burra soil landscape unit. Jenkins (2000) describes this unit as consisting of undulating to rolling hills and alluvial fans associated with the weathering of the underlying Silurian volcanic units. Soils on local crests and upper slopes are described as shallow well-drained lithosols and earthy sands, whilst red podsolics and red earths dominate midslopes and most lower slopes. Moderately deep, slowly to moderately well-drained yellow and brown podsolics and yellow earths are also evident along drainage lines, whilst chernozems were also observed coinciding with the limestone unit of the Colinton Volcanics.

Higher parts of the proposed development will be situated on the Campbell soil landscape unit. In these areas of the site, rock outcrop is common, with numerous outcrops of ‘tombstone’ sized and shaped rows of vertically dipping tuffs (of the Colinton Volcanics) set among shallow colluvial soils. Soils are dominated by shallow lithosols, and red and yellow chromosols are also present. Overall, Jenkins considered that these soils are predominantly shallow, infertile and acidic, with low permeabilities, and localised waterlogging.

In the south-eastern corner of the site, the two small granitic intrusions surrounded by tuffs of the Colinton Volcanics are overlain by soils of the Caleys Creek unit. Soils in this group generally consist of rapidly drained earthy sands and lithosols on upper slopes, and red and yellow podzolics on lower slopes. The red and yellow podzolics are highly infertile. Jenkins also notes that topsoils are

generally highly permeable and acidic, whilst the subsoils are hardsetting with low available water-holding capacity.

As part of his general geological and geomorphological appraisal of the site, Mitchell (2007) provided the following description of soils at the site.

> Almost all of the soil profiles seen in the field have two components: a thin biomantle (A-horizon) the composition of which reflects the coarser fractions of the underlying rock type. This is an active layer of soil moving down slope over varied substrates. This layer has been extensively sheet eroded as a consequence of land clearing and grazing pressure over the last 100-150 years and in many places on the hill slopes it has been completely stripped to expose B-horizons or stony pavements.
>
> The subsoil (B-horizon) varies in thickness and composition depending on the nature of the underlying rock as it has weathered in situ. Where the bedrock is a fine-grained sedimentary rock such as shale the subsoil is pedal clay and may be reasonably deep. These two layers form a texture contrast (duplex) soil profile. Where the bedrock is a very resistant volcanic rock or adamellite the subsoil may be absent and the biomantle will form a simple stony lithosol. On the limestone conditions are different because limestone is soluble and the subsoil of iron rich pedal clay will occur in deep patches and pockets. Traditionally such a profile would be called a *terra rossa* and although it is clay it is well flocculated and highly porous. This material may not be suitable to seal earthworks that are required to hold water.

A ground electromagnetic survey – using EM-31 and EM-38 ground conductivity meters – was carried out at the site by Agsol (2009). The results of the investigation indicated that the conductivity of the ground (and hence salinity) was generally low. Higher values were noted, however, along the alignment of the waterways in Neighbourhood 1A, potentially indicating shallow groundwater and mobile salt discharge in these areas.

Test pitting carried out across Neighbourhood 1A by Douglas Partners Pty Ltd (2009) showed that the soils beneath the site were generally shallow, with depth to bedrock typically between about 0.2 and 1.5 m. Soils generally consisted of three horizons: a mobile silty sand topsoil; a dense (in-situ) clayey sand; and a highly to extremely weathered saprolitic layer of low to very-low strength. All three horizons have been directly or indirectly derived from the weathering of the Colinton Volcanics (including the unnamed shale and limestone units) and/or the Googong Adamellite.

In relation to the migration of surface contamination into the groundwater at the site, Agsol noted that:

> … areas of the site characterised by shallow well drained soils and vertical dipping bedrock would allow contaminants to move to the subsoils or shallow groundwater table. However, the clayey subsoils of the kurosols [red podzolics], chromosols [yellow podzolics], and to a lesser extent the kandosols [yellow earths], would form a natural barrier to downward movement.

Although the above statement can be considered to be broadly true, a more detailed knowledge of the site's hydrogeological features must be gained before the actual magnitude of any impacts can be appropriately assessed. These features include:

- the connectivity of the underlying fracture sets, which are thought to be the primary mechanism of groundwater transport;
- the hydraulic and attenuative properties of the fracture sets; and
- the depth to the water table.

5.0 HYDROGEOLOGY OF THE GOOGONG DISTRICT AND SURROUNDS

This section of the report presents an overview of the key hydrogeological characteristics of the study area. It has been based on a number of sources, as discussed in Section 2.

The information in this section has been extracted from a more extensive assessment, which is presented in Appendix B of this report. It is recommended that this information be read in conjunction with the text of this report.

5.1 Overview

CMJA undertook a desktop review of records held by NOW, covering boreholes within a broad 6-kilometre radius of the centre of the site, and assessed the hydrogeology of the surrounding area.

Table 2 presents a summary of worksheets for the bores located during the search; their locations are shown on Figure 3.

5.2 Aquifer Type

An assessment of the NOW borehole summary worksheets indicates that groundwater in the vicinity of the site is hosted in a regionally extensive and unconfined fractured rock aquifer. Structural features thought to be significant to groundwater flow at the site include (in order of expected importance):

- local and regionally significant faults throughout the area, including the unnamed normal fault that cross-cuts the site;
- joints (either individuals or forming part of a larger joint set or swarm in the country rock);
- parasitic fractures and splays associated with localised brittle deformation features; and
- cleavage arrays and axial trace fractures associated with Silurian deformation events (namely folds and faults associated with the intrusion of the Silurian-aged granitic intrusions, including the Googong Adamellite).

Some enhanced secondary porosity within limestone units may also be of interest, but there is virtually no available information about the geological and hydrogeological properties of these units in the study area.

TABLE 2
Summary Data for Groundwater Bores in the Development Area

Borehole ID[δ]	Registered Use	Drilled Depth (m)	WBZ[*] (m)	SWL[†] (m)	Geology	Salinity (mg/L)[α]	Yield (L/s)[β]
GW020890		19.8	9.1 – 19.8		Porphyry		2.09
GW020892		20.4	6.7 – 18.3	2.1	Porphyry		2.46
GW020893		13.7	6.7 – 8.5		Porphyry		0.19
GW020903	Stock	7.9			Granite, porphyry		
GW020904	Stock	19.8	19.8 – 19.8	1.2	Sand, quartz, porphyry		0.42
GW047361	Industrial	61.0			Sandstone, shale, granite		
GW050004	Domestic	57.5	51.7 – 57.2	14.2	Shale, siltstone	Fresh	0.15
GW050980	Domestic, stock	35.4	32.9 – 33.5	11.6	Granite	Fresh	1.10
GW061449	Domestic	80.0	21.0 – 70.0		Shale, granite	Hard	2.00
GW061599	Domestic, stock	56.1	29.2 – 29.5	11.6	Granite	Good	0.12
GW063668	Domestic	22.9	11.9 – 18.3	4.9	Granite (soft)		4.64
GW064429	Domestic	45.7	18.3 – 27.4		'Volcanic'		1.26
GW067501	Domestic, stock	42.0	33.0 – 37.0	30.0	Shale	Good	0.69
GW069070	Domestic	57.0			Granite		
GW400206	Domestic, stock	39.6	22.8 – 24.4	4.6	Shale	Good	0.76
GW400504	Domestic, stock	60.8	10.6 – 10.9	3.0	Dacite		0.38
GW400530	Domestic			13.0			0.38
GW400534	Domestic	30.0	13.5 – 25.2	2.0	Slate	Good	2.25
GW400714	Domestic, stock	72.0	48.0 – 49.0	16.0	Shale, granite		0.12
GW400813	Domestic, stock	54.0	30.0 – 48.0	22.0	Granite	Fresh	0.20
GW401001	Domestic	80.0	30.0 – 42.0	12.0	Granite – weathered	Good	0.08
GW401068	Domestic	36.0	27.0 – 34.0	10.0	Shale		1.00
GW401428	Stock	53.0		9.0		0.1	0.19
GW401683	Domestic	121.0	75.0 – 115.5	30.0	Granite	Good	0.13
GW401763	Domestic, stock	99.1	54.8 – 55.2	30.5	Granite	Good	0.05
GW401991	Domestic, stock	48.0	42.0 – 44.0	15.0	Granite, dacite	Good	1.10
GW402109	Domestic, stock	23.0	18.0 – 23.0	11.0	Shale, 'volcanic cavity'	370	12.5
GW402157	Domestic	66.0	25.0 – 63.0	20.0	Shale, granite		0.50
GW402298	Domestic	85.0	54.0 – 67.0	51.0	Shale, granite		0.38
GW402348	Domestic	45.0	32.0 – 33.0		Shale		0.44
GW402383	Test bore	122.0	88.0 – 96.0		Shale		0.33
GW402859	Domestic, stock	78.0	68.0 – 70.0		Granite, quartz bands		2.10
GW402872	Domestic	102.0			Slate, dacite		0.38
GW403097	Domestic	100.0			Shale, porphyry		
GW403149	Domestic, stock	42.0		10.0	Granite, shale		9.0
GW403206	Domestic	156.0			Shale		
GW403273	Domestic	83.0			Granite		
GW403321	Industrial	108.0		1.5			1.40
GW403582	Domestic, stock	42.0	16.5 – 34.0	8.0	Volcanics, granite		1.56
GW403879	Domestic, stock	71.0		20.0	Shale		
GW403897	Domestic	128.0	57.0 – 97.0		Granite		0.44
GW404070	Domestic	96.0	60.0 – 76.0	20.0	Shale (black)		0.82
GW404089	Domestic, stock	81.0	0.0 – 75.0	20.0	Shale		
GW404400	Domestic, stock	66.0					
GW404573	Domestic, stock	95.0		85.0[ψ]			2.20
GW404701	Domestic, stock	15.0		10.0		87.0	8.00
GW404883	Domestic, stock	10.0					1.00
GW405005	Domestic, stock	66.0	61.0 – 61.9	10.0	Granite		0.32

Notes: δ NOW borehole registration reference number
* water-bearing zones
† standing water level
α milligrams per litre
β litres per second
ψ thought to be erroneous

Given the lithology of the units at the site and the degree of metamorphism described by Evans, it is expected that primary porosity is very low in the Colinton Volcanics.

It is also expected that perched groundwater may exist within several horizons throughout the rock mass. This is particularly likely in the regolith and soil profiles produced from the weathering of the basement geological units.

5.3 Bore Yields and Aquifer Hydraulic Properties

Yields for the boreholes drilled throughout the Googong district vary – reportedly from less than 0.1 L/s in some of the bores drilled in the Late Silurian Colinton Volcanics, up to about 10 L/s for a few bores drilled in the Colinton Volcanics and into the margins of the Barracks Creek Adamellite. Most of the bores, however, have been drilled in the Colinton Volcanics where yields are more modest and typically range between 0.5 and 1.0 L/s.

When discussing borehole yields, it is important to emphasise the caution noted in Section 2.1, namely, that driller's estimates for borehole yield in fractured-rock aquifers frequently over-estimate long-term yield.

Reference to the borehole summary worksheets supplied by NOW shows that the highest yields encountered during drilling throughout the Googong district were about 10 L/s in a number of boreholes drilled to the north and west of the site. Most of the higher-yielding bores were drilled in the ignimbrite and metasedimentary units of the Colinton Volcanics, although a few higher-yielding bores have also been drilled along the southern margin of the Barracks Creek Adamellite where enhanced fracturing and deeper weathering profiles are thought to exist. Most of the bores in these areas only yield small volumes of water, with a typical yield less than 1 L/s.

Boreholes that have encountered multiple water-bearing zones seem to have markedly higher yields, and in most instances yields appear to increase with depth. The highest-yielding water-bearing zones throughout the area were typically identified at depths of between 20 and 50 m, beyond which the degree of fracturing is thought to decline markedly, particularly in the Silurian intrusions. For example, in Borehole GW63668, which has one of the highest total yields (4.6 L/s) in the Googong district, more than half the yield was derived from a fractured shale unit at a depth of about 18 m.

Although groundwater resource assessments often effectively target the margins of intrusions as well as the country rock immediately surrounding intrusive bodies (as potentially shown by boreholes GW404701, GW404573 and GW61449), it is considered that the low yield reported in many of the bores – particularly some of those drilled in the vicinity of Silurian intrusions – indicates that syn- and post-genetic quartz mineralisation throughout the area has significantly reduced secondary porosity in the aquifer. This reduction in secondary porosity is thought to be most prevalent in close proximity to such intrusions (for example in close proximity to the Googong and Barracks Creek adamellites), where hydrothermal solutions would have been most prevalent during the emplacement of the plutons.

Given the syn- to post-tectonic development of quartz veining throughout the area, yields in the Silurian metasediments are also (generally) expected to be at the lower end of the range shown by similar fractured rock aquifers.

Quartz mineralisation is also expected to have a negative effect on the aquifer's storativity (i.e. the amount of water that a given volume of aquifer will produce in response to unit change in hydraulic head).

In order to assess the likely range of hydraulic conductivities, information from a number of well-completed NOW worksheets in the search area have been utilised. This information includes borehole depth, yield, and thickness of water-bearing zones encountered, and is shown in Table 3.

In order to estimate aquifer thickness (shown in Column 4), it was necessary first to estimate aquifer depth, because the NOW database often lacks detailed hydrogeological data. It was estimated that the bores in this region are drilled to a depth of approximately 5 metres below the depth of the aquifer zone. The thickness of the aquifer zone was then estimated by subtracting from the hole depth the standing water level and the excess drilling depth (5 m).

The estimate of aquifer thickness also constitutes an estimate of the maximum bore drawdown, because the maximum pump installation depth is also approximately 5 m from the base of the bore. When pumping at the reported yield, the actual drawdown may be approximated to the maximum available drawdown, and this assumption may be used to calculate the aquifer's transmissivity.

With this assumption, and an estimate of the aquifer's storativity (0.00001), the aquifer's *transmissivity* (column 6) can then be estimated, employing an analytical approach based on the Theis equation.

The *arithmetic mean and median* of the calculated hydraulic conductivities are 6.8×10^{-5} metres per second (m/s) and 1.5×10^{-6} m/s respectively. The median is considered to be the more representative measure. Note that these values probably overestimate average hydraulic conductivity, because they are based on information from targeted, successful boreholes. Calculations based on information from randomly targeted boreholes, including bores that have negligible groundwater yields, would produce lower average values.

TABLE 3
Hydraulic Conductivity Calculations from Existing Borehole Information

Bore	Hole Depth (m)	SWL (m)	Estimated Aquifer Thickness (m)	Reported Yield (L/s)	Calculated Transmissivity (m^2/s) (S* = 0.0001)	Calculated Hydraulic Conductivity (m/s)
GW050004	57.5	14.2	38.3	0.15	6.3×10^{-6}	1.6×10^{-7}
GW063668	22.9	4.9	13.0	4.54	6.9×10^{-4}	5.3×10^{-5}
GW400206	39.6	4.6	30.0	0.76	4.5×10^{-5}	1.5×10^{-6}
GW400534	30.0	2.0	23.0	2.25	1.8×10^{-4}	7.9×10^{-6}
GW400651	40.0	18.0	17.0	0.63	6.7×10^{-5}	3.9×10^{-6}
GW400940	71.0	31.0	35.0	0.22	1.0×10^{-5}	3.0×10^{-7}
GW401428	53.0	9.0	39.0	0.19	7.9×10^{-6}	2.0×10^{-7}
GW402109	23.0	11.0	7.0	12.5	3.8×10^{-3}	5.4×10^{-4}
GW402157	66.0	20.0	41.0	0.5	2.1×10^{-5}	5.1×10^{-7}
		Mean:	27.0	1.9	1.7×10^{-4}	6.8×10^{-5}
		Median:	30.0	0.5	3.4×10^{-5}	1.5×10^{-6}

Notes: SWL Standing Water Level
L/s litres per second
* Storativity
m/s metres per second

5.4 Groundwater Quality and Geochemistry

Groundwater quality data for the Googong area are available from two sources: first from the DMRGG publication *Hydrogeology of the Australian Capital Territory and Environ*s (Evans, 1987) (including the accompanying map); and secondly from the summary worksheets for each of the registered bores identified during the search. The information obtained from these two sources is summarised below.

The groundwater chemistry data summarised in Evans are subdivided into geological and physiographic provinces. The site lies within the 'D2' geological and physiographic division, and the major ion groundwater chemistry results for that unit are summarised in Table 4.

TABLE 4
Groundwater Chemistry Results for Unit D2 (from Evans 1987)

Sample Location	Ca		Mg		Na		K		HCO_3		SO_4		Cl	
	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD
Hill slopes	218	155	178	150	143	115	2	2	300	163	39	86	202	246
Valley floors	229	152	151	101	120	77	4	4	257	133	94	98	136	97

Notes: mg/L mean concentration in milligrams per litre
SD Standard Deviation in mg/L

Evans assessed that groundwater within the study region is generally dilute – that is, it has relatively low total dissolved salts (TDS). The TDS in most of the bores sampled is 'below the acceptable limit for human consumption' (1200 mg/L). The Evans 'Distribution of Total Dissolved Salts' contoured map has the study site at approximately the '500 mg/L TDS' contour.

From Table 4, other features of the groundwater chemistry include:

- the low potassium concentrations, which most likely reflect the reduced solubility of potassium feldspars in the presence of other mineral phases such as plagioclase,
- the relative stability of potassium layer-silicates such as illite; and
- the low sulphate concentrations, suggesting a lack of sulphide mineralisation in the immediate region.

NOW summary worksheets for boreholes drawing water from fractured rock aquifers throughout the Googong–Queanbeyan districts indicate that water quality is generally good, but each description is usually limited to a single word. All of these boreholes draw water from fractured water-bearing zones, and all but a few are licensed for stock and/or domestic purposes.

Groundwater throughout the greater Googong–Queanbeyan district appears to be of moderate to good quality, with no references to poor quality on the borehole summary worksheets. Groundwater quality is frequently described as 'fresh' and 'good', irrespective of borehole yield or position in the landscape. There does not appear to be any distinction drawn between groundwater quality in different host formations: the same descriptors are used in relation to shale, porphyry, dacite and granite-hosted aquifers. Nor do there seem to be distinctions drawn in relation to depth: the same quality descriptor is used for several bores, regardless of the depth of the water-bearing zones.

Summary worksheets for only two of the boreholes identified during the search provide quantitative information on the concentrations of total dissolved solids (referenced as salinity) in the vicinity of the site. The first of these bores, identified as GW402109, was drilled on the western side of Old Cooma Road, about 60 m west of the site. It was drilled to a depth of 23.0 m, and intersected a single fractured water-bearing zone in the lower 5 m of the bore. Prior to construction, the bore was air-lifted for over an hour and the yield noted to be about 12.5 L/s (an exceptional yield for this area). A sample was then presumably obtained from the bore, and the concentration of total dissolved solids reported to be about 370 mg/L; this concentration is close to the 500 mg/L level suggested in Evans' (1987) 'Distribution of Total Dissolved Salts' contour map.

The second bore identified during the search, GW404701, was drilled on the southern side of Wickerslack Lane just to the north of the site. It was drilled to a depth of only 15 m into the Barracks

Creek Adamellite, and although the depth and type of water-bearing zones are not known, it had a reported yield of 8.0 L/s and a total dissolved solids concentration of just under 90 mg/L.

Overall, it is expected that bores completed within the fractured units throughout the area will draw moderately fresh water from the regional aquifer, with salinities typically less than 1000 mg/L, and occasionally less than 500 mg/L. On the basis of professional experience and judgement, it is also expected that groundwater bores completed within the Silurian intrusions throughout the area will draw upon relatively fresh groundwater reserves as these units are relatively inert in their mineralogical composition – with quartz and relatively inert feldspars dominating the mineral content.

5.5 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 (Evans 1987).

Recharge of the aquifers would occur mainly via infiltration of rainfall, infiltration of slope runoff, and outflow from the Queanbeyan River and Jerrabomberra Creek (and other watercourses) during periods of high flow and flooding events. Leakage from a number of dams across the site is also expected to be a point source for recharge. Overall, recharge in the area is expected to be limited by the generally low rainfall, particularly during winter months.

Discharge from the aquifer is thought to occur primarily through natural flow from springs, both perennial and ephemeral, and from baseflow into perennial watercourses. Other discharges from the aquifer include bore pumping for domestic and stock purposes, whilst some localised irrigation is also likely.

No springs or ‘soaks’ were observed at the site, but it is noted that the assessment was carried out in a relatively dry period. No significant rain had fallen in the area for some time.

Catchment water balance estimates indicate that post development, the amount of water available for groundwater recharge at the site may decline by up to 70%.

This net loss of water available for groundwater recharge will result in declining water levels across most – if not all – of the site, which will in turn result in reduced baseflows to waterways downgradient of the site, and a reduced amount of water stored in the aquifer; this will inevitably result in thinner saturated water-bearing zones throughout the area.

Given that a groundwater divide is expected to be present in the vicinity of the ‘Hill 800’ in the south-western corner of the site, no long-term detrimental impacts on water levels or aquifer yields are expected in any of the bores drilled in the Fernleigh Estate on the opposite side of Old Cooma Road.

5.6 Standing Water Levels, Flow Directions and Gradients

An assessment of the NOW borehole summary worksheets indicates that groundwater is hosted within a number of units in the area, including those of the Colinton Volcanics and associated shales and limestone. Standing water levels in boreholes completed in these formations are generally between 10 and 30 m below ground level, but deeper groundwater has been recorded where boreholes have been drilled on ridgelines or hillslopes. In these areas the vadose zone can be quite thick.

By contrast, borehole summary worksheet data also indicate that shallower water levels have been noted for those boreholes drilled along relatively undulating areas of the uplands as well as in close proximity to local waterways, including the Queanbeyan River and Jerrabomberra Creek, which flows

south to north and does not drain into the Googong Dam catchment. Standing water levels as shallow as 5 to 10 m (at the time of drilling) have been recorded for a few boreholes in these areas, whilst slightly deeper levels have been noted below the high banks.

Shallow groundwater flow throughout the study area is expected to be heavily influenced by the local topography and the orientation of structural discontinuities, with local and regionally significant peaks and ridges delineating local groundwater divides. As mentioned in Section 3.2, groundwater within the study region flows into the Queanbeyan River catchment (both above and below the Googong Dam), with most expected to drain to the north-north-east and lower reaches of the river.

The westernmost limit of the groundwater region that feeds the Googong Dam catchment is the *groundwater divide*. The location of the divide has been estimated from topographic information, together with the available groundwater bore information. Four cross-sections are shown in Figures 4b and 4c, with topographic elevations and the expected depths to groundwater. The locations of these cross-sections – in plan view – are shown in Figure 4a.

Figures 4b and 4c show the groundwater table mounding beneath topographic features. The slope of the groundwater table was assessed using the available bore data; the assessment also assumes that groundwater recharge is homogeneous throughout the site (which is a simplification). When the groundwater divide shown in Figures 4b and 4c is transposed to the plan view map shown in Figure 4a, the position of the groundwater divide may be interpreted as shown on Figure 4a.

It can thus be seen that the divide lies beneath the potential development area.

The location of the groundwater divide is important as it identifies potential groundwater receptors. From Figure 4a, it can be seen that groundwater to the west of the divide will flow to the west and northwest, and will most likely ultimately discharge to the lower reaches of the Queanbeyan River. On the other hand, groundwater on the eastern side of the divide (which is not expected to be impacted by the proposed development) is expected to flow to the east and northeast, and eventually discharge to the Googong Dam reservoir.

It should be noted that during periods of extended drought, the water table may decline to depths greater than anticipated. When this occurs, the morphology of the water table will flatten. Following the development of Neighbourhoods 3, 4 and 5 in the southern portion of the site, the distribution of recharge may change, with less infiltration occurring in western areas due to an increase in the proportion of paved surfaces. This may cause the divide to move to the east, to balance recharge. The amount of movement of the divide to the east will be dependant on the magnitude of change in groundwater recharge in these areas.

The groundwater flow direction in the regional aquifer is considered to be primarily controlled by three factors:

1. the depth of any significant water-bearing zones;
2. the local topography, and to a lesser degree the regional topography; and
3. the structural orientation of the aquifer.

Given these considerations, it is anticipated that groundwater in the Googong–Queanbeyan districts will flow to the north and north-west – consistent with the flow of the Queanbeyan and Molonglo rivers – but there may be a more northerly component of groundwater flow in the Googong area where the regionally significant structural alignment appears to be more imprinted into the landscape.

Owing to the lack of data on groundwater depths in the regional aquifer, it is not possible to provide any further definition of the hydraulic gradient or flow direction.

5.7 Groundwater Utilisation

Groundwater in the area is predominantly used for a combination of domestic and stock purposes. Of the 48 bores located within a 6-kilometre radius of the centre of the site, all but a few are registered for such use, and only a few appear to have achieved yields that would satisfy all the water requirements of a property without some form of reliance on surface water supplies.

No boreholes registered for municipal purposes were identified in the study area.

5.8 Groundwater Vulnerability

Agsol (2009) notes that most of the site is located within an area of moderate groundwater vulnerability. This characteristic is true for much of the surrounding region, including the existing urban areas of Queanbeyan. Factors contributing to this classification include depth to groundwater, soil and aquifer type, topographic factors (namely slope and runoff potential), recharge potential, and the thickness and hydraulic properties of the aquifer and vadose zone.

The central portion of the site is mapped as having a 'moderate to low' vulnerability; this portion of the site is underlain by the Colinton Volcanics, but is differentiated from other areas owing to its low topographic expression.

One area within the study site is mapped as having a 'moderate to high' vulnerability. This area is located in the south-western corner of the site immediately adjacent to Old Cooma Road, and it is thought that this classification was assigned because of the relatively porous nature of the soils in this area and the (expected) shallow depth to bedrock. Agsol notes, however, that no recycled water irrigation will occur in this area.

5.9 Groundwater Flow to the Googong Dam Reservoir

In Section 5.6 the hydrogeological cross-sections in Figures 4b and 4c are discussed, and the groundwater divide along the western margin of the Googong Dam is interpreted as shown in Figure 4a. The flow volume from the area in Figure 4a that is within the Googong Dam groundwater catchment may then be calculated, using Darcy's Equation (Fetter 2001).

Darcy's Equation is an expression relating the discharge (volume rate of fluid flow) through a porous medium to the hydraulic gradient and the hydraulic conductivity of the medium.

For this purpose, Darcy's Law may be written as:

$$Q = - K A (\Delta h / \Delta l) \qquad \text{... Equation 7.1}$$

Where: Q is the groundwater flow rate (m^3/s);
K is the hydraulic conductivity (m/s);
A is the cross-sectional area of the volume through which the groundwater flows (m^2);
Δh is the change in hydraulic head for two points along the groundwater flow path (m); and
Δl is the horizontal distance between these points (m).

The term (Δh / Δl) in Equation 7.1 is known as the hydraulic gradient (i), where the quantity Δh represents the change in head between the two points, and Δl represents the distance between the two measuring points. The negative sign indicates that flow is in the direction of decreasing hydraulic head whilst units are metres divided by metres (i.e. it is dimensionless).

Appropriate parameters for Equation 7.1 are:

- From Table 3, K is assessed to be 1.5×10^{-6} (i.e. the median hydraulic conductivity derived from Column 7).
- The area $\boldsymbol{A}$ is approximated as the average aquifer thickness (27 m, from Table 3) multiplied by the width of the zone (within the study region) that drains into Googong Reservoir (1100 m): 29,700 m^2.
- The change in head (Δh) for the midpoint of the aquifer is approximately 63 m.
- The horizontal distance (Δl) is approximated by the distance from the groundwater divide to the Googong Reservoir: 2500 m.

When these values are incorporated into Equation 7.1, the groundwater flow rate (Q) is calculated to be 1.12×10^{-3} m^3/s, which equates to 35 megalitres (ML) per year or 1.1 L/s. Therefore, during periods of active groundwater flow, the flow of groundwater that originates from the *site* and discharges into the Googong Reservoir is assessed to be about 1 L/s.

The surface area of the Googong Dam groundwater catchment region that is within the study region is 96 hectares. Of these 96 hectares, 39.9 hectares lie within the area identified as possibly suitable for development. These 39.9 hectares represent 0.05% of the total Googong Dam surface catchment area (87,300 hectares).

As stipulated in the draft Googong local environmental plan, however (and as mentioned in Section 3.0) development will not occur in this area – hence no impacts on groundwater or water in the Googong reservoir – associated with either the construction of the potable or recycled water systems or the use of recycled water at the site – are considered likely.

5.10 Surface Catchment Yield to Googong Dam

The Googong Dam, completed in 1979 on the Queanbeyan River in NSW, has a storage capacity of 124 gigalitres, and is fed from an 87,300-hectare catchment.

Although excluded from development, approximately 67 hectares of the study region lie within the Googong Dam's surface water catchment. This area represents approximately 0.077% of the entire surface water catchment.

At a run-off coefficient of 10 per cent of rainfall, the average annual surface catchment yield would be about 57 gigalitres.

If run-off is assumed to be only 1% of average annual rainfall, the surface catchment yield would be 5.7 gigalitres, still over 100 times greater than groundwater inflow from the site.

1% is very much a worst-case example, and assumes rainfall that is well below average.

6.0 CONCEPTUAL HYDROGEOLOGICAL MODEL

6.1 Hydrogeological Model of the Googong District

The following statements summarise the occurrence and nature of groundwater in the area.

- Groundwater is hosted in a regionally extensive fractured-rock aquifer. Minor alluvial aquifers are located along the alignments of locally significant waterways, but these are expected to have minimal storage and not to be of significance to this assessment. Units of importance to this investigation include the Colinton Volcanics (including each of the subunits Svc_1 and Svc_2 shown on the geological map sheet), the Googong Adamellite, and to a lesser degree the occasional granitic stocks scattered about the area.
- Recharge of the aquifers would occur mainly via infiltration of rainfall, infiltration of slope runoff, and outflow from the Queanbeyan River (and other watercourses) during periods of high flow and flooding events. Leakage from dams is also expected to be a source of recharge. Recharge in the area is likely to be limited by the generally low rainfall in the area, and is expected to decline post-development due to the expected decline in recharge across the site.
- Discharge from the aquifer is thought to occur primarily through natural flow from springs, both perennial and ephemeral, and from baseflow into perennial watercourses. Other discharges from the aquifer include bore pumping for domestic, stock and irrigation purposes.
- Groundwater is expected to be hosted in a number of brittle deformation features throughout the host formations in the area, including:
    - local and regionally significant faults throughout the area, including the unnamed normal fault which cross-cuts the site.
    - joints (either individually or as part of a larger joint set or swarm in the country rock);
    - locally significant parasitic fractures and splays associated with localised brittle deformation features;
    - cleavage arrays and axial trace fractures associated with Silurian deformation events (namely folds and faults associated with the intrusion of the Silurian-aged granitic intrusions, including the Googong Adamellite).

  Some enhanced secondary porosity within limestone-bearing units may also be of interest, but information regarding the geological and hydrogeological properties of these units in the study area is virtually non-existent.

  Given the lithology of the units at the site and the degree of metamorphism described by Evans, primary porosity in the metasedimentary units of the Colinton Volcanics (and in its accompanying shale and limestone units) is expected to be very low.
- Yields in the area are expected to be at the lower end of the range shown by similar fractured rock aquifers given the syn- to post-tectonic development of quartz veining throughout the area. Yields throughout the area are usually no more than 3 L/s, and typically less than 1.0 L/s. It does appear, however, that existing bores which have encountered multiple water-bearing zones, particularly at depths between 20 and 50 m, frequently have cumulative yields in excess of 1 L/s, with more prolific bores obtaining yields of up to 10 L/s during drilling. Formations further away from any 'annealed' zones – i.e. away from the Silurian intrusions – may also see yields (as well as storativity and transmissivity) increase.

- Groundwater is expected to be of sufficient quality for general water supply purposes, and it may be suitable for potable use without requiring any form of treatment. This would require confirmation, however.
- The depth to bedrock across much of the site is expected to be between about 1 and 2 m, with fresh bedrock encountered at shallower depths at higher elevations (such as in the vicinity of 'twin peaks'), and marked changes of slope. Shallow groundwater is expected to migrate along the interface between the soil horizons and relatively fresh bedrock, and to discharge to surface water streams across the site.
- Shallow groundwater flow directions are expected to be heavily influenced by the local topography, with local and regionally significant peaks and ridges delineating local groundwater divides.

  Consistent with this interpretation, the shallow groundwater flow direction beneath much of the southern portion of the site is expected to be to the east and north-east, where groundwater is thought to drain to Montgomerys Creek and ultimately the lower reaches of the Queanbeyan River (i.e. below the Googong Dam).

  As shown in Figure 4a, the groundwater flow direction in the south-eastern corner of the site is expected to be to the east, with groundwater ultimately draining to Googong Dam. The majority of the land to the east of the groundwater divide (i.e. land to the east of the surface catchment divide) is excluded from development, thus no impacts are anticipated. It is noted, however, that the anticipated decline of groundwater recharge at the site may result in the groundwater divide in the south-eastern corner of the site migrating to the east of its currently-estimated position, providing an additional buffer to the portion of the site in this area over which recycled water application should be excluded.

  The shallow groundwater flow directions in the northern portion of the site are expected to be better defined, with most – if not all – groundwater flow moving towards the unnamed creekline that dissects the northern portion of the site.

The groundwater flow direction in the regional aquifer is expected to be to the north and north-west – in line with the flow direction of the Queanbeyan and Molonglo rivers – but there may be a more northerly component of groundwater flow in the Googong area, where the regionally significant structural signature appears to be more imprinted into the landscape.

6.2 Data Gaps

As can be seen from the discussion presented in Section 5.0, no measurements were available for the hydraulic characteristics of any of the geological formations of interest. Moreover, there were no data for the depth to groundwater beneath the site, either in perched horizons or in the aquifer itself (i.e. the depth to the watertable).

Other data gaps identified during this assessment are described below.

- No measured data or estimates were available in relation to the hydraulic characteristics (i.e. hydraulic conductivity, permeability, transmissivity, storativity, etc.) of:
  - the metasedimentary units of the Colinton Volcanics, and to a lesser extent the Cappanana and Pittman Formations;
  - the numerous Silurian intrusions in the area, most importantly the Googong Adamellite;
  - major structural features in the area including the unnamed sinistral strike slip fault traversing the site;

  - any significant fracture patterns associated with the axis of the numerous minor folds across the site;
  - other significant discontinuities (such as brecciated zones and cleavage arrays, etc.) which have not been identified in this report;
  - the occurrence and hydraulic properties of the limestone units (of the Colinton Volcanics) in the northern portion of the study area;
  - the influence of post-deformation quartz annealing of fractures on the hydraulic properties of all of the above units and features; and
  - any soil types and horizons evident across the site, particularly those along the lower slopes and channels across the site where potential salinity impacts are expected to be greatest.

- There was no available information regarding the hydraulic connectivity of the units throughout the study area.
- No data were available relating variations in rainfall recharge to standing water levels and aquifer storage, particularly in the Colinton Volcanics and Googong Adamellite.
- No measurements of the depth to the water table beneath the site were available. These data are especially relevant in the south-western corner of the property that is categorised as having a moderate to high groundwater vulnerability.
- No information was available regarding the possible existence of perched water tables at the site, nor the influence of shallow bedrock on occurrences of perched water.

It is considered, however, that the objectives of a preliminary assessment can still be achieved using the information available and professional judgement.

7.0 POTENTIAL IMPACTS OF THE INSTALLATION OF THE RECYCLED WATER SYSTEM AND USE OF RECYCLED WATER AT THE SITE

This section of the report describes the proposed potable and recycled water delivery systems to be installed at the site, and presents an overview of the likely steps involved in the construction of these schemes.

It also discusses the likely impacts, associated with the use of recycled water;

- on groundwater beneath the development;
- on water stored within the Googong Dam catchment; and
- on a number of surrounding groundwater bores in the area, most notably those to the north and south-west of the development.

This assessment of impacts has been based largely on the information presented in Sections 4, 5 and 6 of this report, and also on a number of references provided by Manidis Roberts regarding the proposed new Googong town development.

7.1 Overview of the Proposed Recycled Water Scheme

Because of the water-sensitive nature of the proposed Googong development, the use of recycled water has been nominated as an integral component of water delivery system at the site. CIC hopes that the widespread use of recycled water could lead to a reduction in the dependence of the development's population on potable water supplies, and that potable water use would decline due to a combination of lower demand, as well as potable source substitution. Further reductions are also possible stemming from the use of stormwater harvested from hardstands and roofs.

Integrated water cycle management at the new Googong township will include the following key elements.

- A water recycling plant.
- A potable and recycled water distribution system.
- A wastewater collection system.
- A stormwater management system.
- Water pumping stations.
- Sewage pumping stations.
- Separate reservoirs for potable water and recycled water.

At this stage it is envisaged that potable water savings will be achieved through a combination of measures, including water recycling, rainwater harvesting, and water-sensitive urban design. Recycled water is to be used for flushing of toilets, in washing machines, and for the irrigation of fields and public spaces, and high levels of water efficiency are also planned for each (staged) neighbourhood of the development through mandated low-flow showerheads, clothes washers, taps and commercial urinals.

During periods of high water demand, the potable water supply will be used as a top-up source for the recycled water supply system, and rainwater tanks may also be used for household irrigation purposes. Rainwater is also to be a potential source of cold water for washing machines.

At this stage it is envisaged that the water recycling plant will be located in the north-east corner of the development area, as shown on Figure 5. This location was selected in order to minimise the potential

impact on residents and to optimise the use of Googong Dam Road as a maintenance and service vehicle corridor. The location is, however, situated at one of the higher portions of the site, and therefore a number of pumping stations and rising mains will be required to transport and lift sewage to the plant.

The water recycling plant will be designed to meet the requirements set out in the Australian Guidelines for Water Recycling (NRMMC, 2008), and to meet all licensing conditions relevant to its proposed effluent discharge. At this stage it is understood that the plant may incorporate unit processes for flow balancing, screenings and grit removal, biological treatment, filtration, chemical dosing, disinfection, recycled effluent storage and pumping, odour control, sludge stabilisation, and first-flush containment.

7.2 Potable and Recycled Water Distribution System for Neighbourhood 1A

Although infrastructure and design requirements for the potable and recycled water system have not been finalised for the entire development, the requirements for Neighbourhood 1A are described below, in order to:

- provide an overview of the infrastructure that is likely to be needed to support many of the neighbourhood areas to be developed later; and
- provide an overview of the likely impacts on groundwater at the site that may result from construction of the potable and recycled water systems.

The design of the potable and recycled water systems will be based primarily on the guidelines published by the Water Services Association (WSA) of Australia. Due consideration will also be given to development control plans for the development.

The distribution of potable and recycled water in Neighbourhood 1A will require provision of the following infrastructure.

- Trunk mains (typically between 375 and 600 mm in diameter) which will generally follow road alignments.
- Disinfection facilities.
- Storage reservoirs, which are likely to include:
    - two recycled water reservoirs holding approximately 8.5 and 13.5 ML each; and
    - two potable water reservoirs holding approximately 1 and 2 ML each.
- Small pump control reservoirs (supplying sufficient water pressure so that water can be supplied to properties in elevated areas within the development), which are likely to include:
    - one recycled water reservoir holding around 0.45 ML; and
    - one potable water reservoir holding around 0.08 ML.

  [Manidis Roberts notes that neither of the pump control reservoirs will be required for NH1A, and that they will be constructed at a later stage to service dwellings at higher elevations.]
- Pumping facilities, associated rising mains, and pumping stations connected to the reservoirs.

The bulk potable water pump station will be located at the existing Googong water treatment plant and will deliver potable water to the potable water storage reservoirs. The recycled water pumping station

will be located at the proposed new water recycling plant and will deliver recycled water to the recycled water storage reservoirs.

It is recognised, however, that potable and recycled water infrastructure will be constructed on a needs basis, and that changes to the initial design and infrastructure may eventuate throughout the life of the development.

7.3 Overview of the Construction of the Potable and Recycled Water Delivery Systems

7.3.1 Construction Activities

Construction of the potable and recycled water supply systems is expected to involve predominantly surface works, with trenching and excavation required for the construction of building and infrastructure footprints, the installation of pipework and delivery mains, and the delivery of utilities at key infrastructure points.

An overview of the activities associated with the construction and installation of each of the key components of the potable and recycled water systems is presented below.

Pre-construction activities common to all facets of the water supply systems are expected to include:

- the remediation of any contaminated areas identified during the planning stages;
- identification of the locations of existing underground services;
- surveying to finalise the location and alignment of both above-ground and underground infrastructure and services; and
- the preparation of appropriate environmental assessments and environmental management controls for these activities.

Installation of water mains for both the potable and recycled water supply systems in each neighbourhood area is expected to involve:

- trenching and excavation where necessary, potentially into shallow bedrock;
- stockpiling of spoil materials;
- installation of the mains and accompanying infrastructure for potable and recycled water services from subdivision reticulation mains; and
- backfilling and compaction of fill materials within pipeline trenches.

The clearing of low-value trees may also be necessary, depending on their location at the site.

It is anticipated that the pipeline corridors will be about 10 to 15 m wide in most – if not all – neighbourhoods of the development.

Activities associated with the construction of the water storage reservoirs (for both drinking and recycled water) will include:

- the excavation for footings and foundations, potentially into shallow bedrock:
- construction of reservoirs, associated valve structures and sheds;
- connection of rising and delivery mains to tanks;
- excavation and trenching for the utilities for each reservoir; and
- installation of security fencing.

Construction of the water and sewage pumping station sites will involve:

- excavation for footings and foundations, potentially into shallow bedrock;
- filling using spoil to create flexible pavement all-weather access tracks;
- construction of the sewerage pump station well and associated valve structures;
- installation of pumping equipment in the sewage pumping station well, and installation of associated infrastructure;
- connection of the sewerage pumping station to the rising main reticulation mains;
- trench excavation for electricity and telephone services to control panel; and
- trenching and accompanying excavation for utilities (i.e. electricity, water and telephone service) for water services from subdivision recycled reticulation mains.

Site preparation works for the construction of the new water recycling plant is expected to involve:

- the stripping and stockpiling of topsoil;
- excavation (probably to shallow bedrock) for foundation level structures;
- filling using spoil to create flexible pavement all-weather access / service roads; and
- the construction of kerbs.

The construction of the nominated buildings at the water recycling plant (including chemical stores) is expected to involve:

- construction of above and below-ground reinforced-concrete structures and associated valve structures;
- installation of above-surface electrical control panels;
- construction of service, office, and amenities buildings;
- trenching and excavation for the installation of electricity and telephone services to each of the nominated structures at the plant; and
- installation of security fencing and lighting at the plant.

Installation of internal and external pipelines at the water recycling plant is expected to involve:

- trenching and excavation where necessary, probably into shallow bedrock beneath the site;
- the installation of potable water service from subdivision reticulation mains; and
- the backfilling and compaction of trench fill materials post installation works.

The connection of the rising mains to the relevant water supply will also be carried out, but is not of concern to this assessment.

Construction of recycled water discharge points is expected to involve:

- the installation of pipe lines and control valves;
- the placement of erosion protection material;
- trenching (and possible excavation) for the placement and installation of digital monitoring equipment; and
- reinstatement of topsoil and grassing.

If necessary, vegetation may be cleared and grubbed out during any of the abovementioned phases of construction.

The reinstatement of ground levels and surfaces will also be carried out following excavation works.

7.3.2 Construction Equipment

The machinery to be used during each of the construction activities described above is expected to include excavators, earth-moving bulldozers, trucks, cranes and graders, all of varying sizes.

A number of yards and service areas – where hydrocarbon products and other chemicals are likely to be stored – are also expected to be located at the site. Mobile filling points (i.e. tanker trucks or light-vehicles fitted with external fuel reservoirs) are also likely to be utilised at the site.

7.4 Potential Impacts of the Construction of the Potable and Recycled Water Systems

As mentioned in Section 7.3, construction of the potable and recycled water supply systems will involve a number of activities that may alter the hydrogeological setting at the site, albeit in a very minor way. The most likely change is a variation in recharge, which may occur as a result of excavation and trenching. There may be a slight increase in localised recharge *if* significant rainfall is experienced when there are a large number of trenches and/or excavations open across the site. However, given that the depth to groundwater is expected to be about 10 to 15 m beneath much of the development area, and given that low to very low hydraulic gradients and conductivities are expected over most of the site, a small increase in the recharge potential is expected to be inconsequential, and not of concern.

The use of heavy equipment at the site carries with it the associated risk of fuel spillages. As mentioned above, it is expected that excavation and trenching will encounter slightly weathered to fresh bedrock at relatively shallow depths at most – if not all – 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 spillage could move relatively quickly through the fractured bedrock substrate and enter the groundwater table. From there it could migrate downgradient from the source point. As a result, restrictions on the use of groundwater might be required at the site.

Because of this risk, it is considered that it would be good management practice to ensure that, where possible, refuelling occurs at designated fuel distribution points. These distribution points, which are commonly referred to as ‘fuel farms’ in the mining industry, are easily constructed, and usually underlain by compacted earth in order to prevent significant loss of fuel to the ground in the event of a spillage. They are also bunded in order to contain any spills that may occur as a result of machinery or tank failure. These fuel distribution points are also easily removed (and appropriately validated) once fuel dispensing is no longer required at a site.

Although it is recognised that many earthworks contractors have emergency spill kits and response plans to deal with such events, these are usually intended to deal with small-scale spills from an isolated piece of machinery, and would probably not be adequate for a large-scale spill in an uncontrolled area.

If the distribution of fuel at selected ‘fuel farms’ was incorporated into site management practices, it is considered that any spill of significance could be more easily managed (and remediated if necessary), and that the potential for any associated impact on groundwater would be much reduced.

Given that construction of the potable and recycled water delivery systems will be isolated to the site, and that their impacts on groundwater are expected to be negligible, no detrimental impacts stemming

from the construction of either water system are expected on the water resources in the Googong Dam reservoir, or in any of the existing registered bores around the development area.

7.5 Potential Impacts from the Use of Recycled Water at the Site

Potential impacts from the use of recycled water at the site are similar to those described for the installation of the recycled water system. Changes to the recharge regime of the Colinton Volcanics are expected to constitute the most significant potential impact.

Other potential impacts may include the following.

- Groundwater mounding resulting from:
  - the over-application of water to unpaved (i.e. irrigated) areas of the site;
  - leakage from either the potable or recycled water mains; or
  - leakage from any other infrastructure – buried or otherwise – associated with either the recycled or the potable water supply systems.
- Increased baseflow (due to elevated hydraulic gradients caused by groundwater mounding) of varying-quality groundwater to both Montgomerys Creek and the unnamed creek in the northern portion of the site.
- Isolated waterlogging of soils and lateral migration of salts in the shallow zone. Waterlogging is most likely to occur where shallow groundwater migrates just above the bedrock horizon (i.e. the soil/bedrock interface), with increasing salt loads most likely at the confluence of catchments and streams in Neighbourhood 1A and Neighbourhood 5.
- A small decline in groundwater quality associated with the mixing and dilution of recycled water at the site. This is expected to occur in the regional aquifer, where excavations for the water mains may allow recycled water to largely bypass the soil horizon and migrate quickly into the water table, and also in areas where perched groundwater exists.

For those potential impacts listed relating to leakage from either the potable or recycled water mains, or leakage from any other infrastructure, it is noted that the delivery mains for both the potable and recycled water will be laid in accordance with the approved materials and provisions of Water Services Association of Australia water supply code (WSA) 03-2002, whilst mechanical fittings would also be designed and installed in accordance with these guidelines.

Other measures that can be incorporated during construction of the potable and recycled water delivery mains systems in order to minimise the risk of leakage include ensuring that construction workmanship is of a high standard, maintaining a regular maintenance and inspection routine (in order to identify whether remedial works are required), and ensuring that if remedial works are required, they are carried out by suitably-qualified personnel.

It is also anticipated that any addition to groundwater recharge derived from leaking water supply infrastructure at the site will be significantly less than the net loss of groundwater recharge attributable to the redevelopment of the site, hence any impacts associated with leakage are expected to be minimal, with only localised groundwater mounding expected.

In relation to the use of recycled water at the site, Agsol (2009b) notes that the greatest potential impact relates to the increase in salt concentration in the shallow subsurface (i.e. at the soil/bedrock interface) as a result of garden and landscape irrigation. Agsol also notes that mobile salts at the site – whether natural or otherwise – will migrate towards streams and waterways, and that saline discharges there could act as a saline ‘pulses’ following heavy and/or prolonged rainfall.

CMJA concurs with Agsol's comments, and considers that the increase in salt loading has the potential to negatively impact on water quality

- in any perched groundwater horizons at the site;
- in the regional aquifer (i.e. that hosted within stress-related fractures and other discontinuities of the Colinton Volcanics);
- of water discharged to Montgomery's Creek and/or the unnamed tributary of the Queanbeyan River; and
- in any groundwater dependant ecosystems (GDEs) along the alignment of either of these creeks.

At this stage though, it is difficult to estimate the magnitude of any impacts. They are, however, likely to be minor, particularly if suitable salinity management controls and sensible water use practices are adopted.

It is also noted that any excavations for the potable and recycled water mains cross-cutting the shallow groundwater flow direction have the potential to intercept any shallow saline groundwater flow, particularly that resulting from the application of recycled water at the site. If this were to occur, it would undoubtedly complicate predictions regarding local mobile salt concentrations, particularly along lower slopes and plains across the site, and also in saline discharge points to local waterways. It is therefore recommended that the salt levels in the waterways be regularly monitored during and after the development of Neighbourhood 1A. Groundwater samples should be collected from both the shallow and regional aquifers, and soil conductivity (i.e. salt) mapping carried out where possible in areas of inferred impact.

At this stage it is recommended that this work concentrate on the waterways both in and downgradient of Neighbourhood 1A. These areas should be further defined following any investigative works at the site.

From the above points, it can be seen that the potential consequences of the use of recycled water at the site depend predominantly on the scale of any change to the recharge potential of the Colinton Volcanics. Slight decreases in groundwater quality are expected, regardless of whether recharge increases (owing to the infiltration of recycled water into the aquifer) or decreases (owing to stormwater capture across developed parts of the site).

Although some changes to the groundwater system are expected at the site, no detrimental impacts on the water stored in the Googong Dam reservoir are anticipated. The expected groundwater flow directions beneath much of the proposed development area will see any impacted groundwater migrate to the north and north-east of the site, ultimately draining to the lower reaches of the Queanbeyan River below Googong Dam. Furthermore, impacted groundwater in the eastern portion of the site is expected to drain to Montgomerys Creek (or one of its few tributaries), which forms a type of natural groundwater capture drain through the centre of this portion of the site; again, groundwater in this area discharges to the lower reaches of the Queanbeyan River.

No impacts associated with the use of recycled water at the site are expected on any of the existing registered bores around the development area. As stated above, however, the development – when completed – is likely to result in an unspecified decrease in recharge to the Colinton Volcanics (which is the main aquifer-hosting formation in the area). Some declines in water levels may therefore occur in the bores located in the Fernleigh Estate to the west of the site, particularly during prolonged drought conditions. Such changes, though, are expected to be minor.

7.6 Potential Impacts Stemming From the Urban Redevelopment of the Site

Further, a common outcome of the transition of former 'greenfield sites' to residential developments is a higher capture of water away from groundwater systems (recharge capture via the introduction of stormwater management systems) compared to artificial recharge (i.e. watering gardens, recycled water irrigation, etc.). This leads to a lower overall recharge of the groundwater. Consequences of this – which are expected to be potential impacts at this site – commonly include:

- drying of perched water tables beneath developed portions of the site, particularly any perched water tables that may exist in the eastern and south-western portions of the site;
- the lowering of the water table and the 'drying-up' of shallow bores in the area, including some of the closer bores to the west and south-west of the site;
- the lowering of hydraulic gradients across the site, resulting in:
  - a lower volume of water stored within the aquifer; and
  - a reduction in the volume of groundwater that discharges to each of the ephemeral waterways in the north and east of the site;
- altered baseflows and discharges to local waterways downgradient of the development, as well as any flow-on effects that this may have on GDEs along these reaches;
- an increase in the total dissolved solids content due to longer groundwater residence times in the aquifer; and
- drying of the alluvial aquifers of Montgomerys Creek and the unnamed creek in the northern portion of the site.

The extent of the impacts on groundwater recharge depends upon the degree of difference between recharge capture and artificial contributions to recharge.

The last four bullet points may be significant if any GDEs are located downgradient of the site. This assessment, however, did not include an assessment of GDEs, hence it is recommended that such an investigation be carried out in accordance with the New South Wales State Groundwater Dependant Ecosystems Policy.

As mentioned in Section 5.6, one of the consequences of declining groundwater recharge across the site – whether natural or otherwise – is that the groundwater divide in the south-eastern corner of the site may migrate to the east of its position shown in Figures 4a to 4c. This in turn will see an decrease in the area of that portion of the site beneath which groundwater will flow to the Googong Dam Reservoir, resulting in an additional buffer to the area in the south-eastern corner of the site which will be prohibited from development and/or recycled water application. Unfortunately at this stage it is not possible to estimate how far the groundwater divide may migrate from its current position. This, though, could be estimated following the completion of a detailed groundwater drilling (investigation) program aimed at obtaining the data needed to allow such an estimation.

8.0 CONCLUSIONS AND RECOMMENDATIONS

CMJA has conducted an assessment of hydrogeological conditions beneath the study site and in the area between the study site and Googong Dam.

It has been found that the site is underlain by Silurian-age volcanic, volcaniclastic and sedimentary rocks which host low-permeability fractured-rock aquifers. Googong Dam and part of the area between the site and the dam are underlain by granitic rocks which also host low-permeability fractured aquifers.

There is a groundwater divide beneath the project site; this is located somewhat further to the west than of the surface catchment boundary in the south-eastern corner of the site. Groundwater beneath the south-eastern part of the proposed development area therefore flows towards Googong Dam; it is understood, however, that the area to the east of the surface catchment boundary is excluded from development, and has been set aside for (water) catchment purposes. As such, no impacts are anticipated.

Construction of the proposed potable and recycled water systems at the site is expected to involve predominantly surface works, with trenching and excavation required for the construction of building and infrastructure footprints, the installation of pipework and delivery mains, and the installation of utilities at key infrastructure points.

Construction of the water supply systems at the site is expected to involve a number of activities that may alter the hydrogeological setting in the area, albeit in a very minor way. These relate mainly to the changes in recharge that may occur *if* significant rainfall is experienced when there are a large number of trenches and/or excavations open across the site. Given that the depth to groundwater is expected to be about 10 to 15 m beneath much of the development area, and that low to very low hydraulic gradients and conductivities are expected at the site, a small increase in the recharge potential is expected to be inconsequential.

One point of note concerning the construction of the water supply systems relates to the associated potential risk of significant fuel spillages at the site. As mentioned above, excavation and trenching is expected to encounter slightly weathered to fresh bedrock at relatively shallow depths at most locations across the site. If a fuel spill were to occur in an area with exposed bedrock, the spillage could move relatively quickly through the fractured bedrock and reach the groundwater table. From there it could migrate downgradient from the source point and it would then be necessary to restrict the use of groundwater at the site.

Given that construction of the potable and recycled water delivery systems will be isolated to the site, and that their impacts on groundwater are expected to be negligible , no detrimental impacts stemming from the construction of either water system are expected on either the water resources in the Googong Dam reservoir, or on any of the existing registered bores around the development area.

Potential impacts from the use of recycled water at the site may include:

- isolated waterlogging of soils and lateral migration of salts in the shallow zone;
- localised waterlogging and accumulation of mobile salts at the confluences of locally significant waterways;
- discharge of saline water to streams, particularly in the flatter parts of the site, including those in and around Neighbourhood 1A;
- (minor and localised) groundwater mounding resulting from either the over-application of recycled water to unpaved areas of the site, or leakage from buried infrastructure, or both;

- potential minor increased baseflow of varying-quality groundwater to both Montgomerys Creek and the unnamed creek in the northern portion of the site; and
- a small decline in groundwater quality associated with the mixing and dilution of recycled water at the site.

Any impacts, however, are likely to be minor, particularly if suitable salinity management controls and sensible water use practices are adopted by CIC and future landowners.

It is noted that some excavations for the potable and recycled water mains will cross-cut the shallow groundwater flow direction. These excavations could potentially intercept any shallow saline groundwater flow, particularly where the excavation is deeper than the soil/bedrock interface. Should such an interception occur, it would complicate predictions of local mobile salt concentrations and the location of saline discharge points.

In addition to the impacts associated with the construction of the potable and recycled water supply systems, and those associated with the application of recycled water at the site, there are also potential long-term impacts on the groundwater system associated with the change of the site from agricultural to residential use. These impacts stem from the long-term change in the amount of water entering the groundwater system and will be experienced post-development, when the capture of water that currently recharges the groundwater system (via the introduction of stormwater collection and management systems for the development) is expected to be higher than inputs via artificial recharge (i.e. those inputs associated with activities such as the watering of gardens and public open spaces).

Catchment water balance estimates indicate that, post-development, the amount of water available for groundwater recharge at the site may decline by up to 70%. This is considered to be a significant decline in the amount of water available for groundwater recharge, the consequences of which are expected to include the following.

- Drying of perched water tables beneath developed portions of the site.
- Lowering of the water table and the possible 'drying-up' of shallow bores in the area, including some of the closer bores to the west and south-west of Neighbourhood 3.
- Reduced groundwater discharge to each of the ephemeral waterways in the north and east of the site.
- Migration of the groundwater divide in the south-eastern corner of the site to the east.
- An increase in the total dissolved solids content of the groundwater.
- Possible drying of the alluvial aquifers of Montgomerys Creek and the unnamed creek in the northern portion of the site.

Although the magnitude of these impacts cannot be qualitatively assessed at this time, it is considered that the most prominent impacts of the development will be the lowering of the watertable beneath most of the site, the reduction in the amount of aquifer storage available to local groundwater users, and reduced discharges to local waterways, most notably Montgomerys Creek. The migration of the groundwater flow divide in the south-eastern corner of the site is also considered to be an important issue, albeit from an urban design point of view.

Given that the latter issue has direct consequences for the viability of the proposed water supply schemes in Neighbourhoods 4 and 5 – which are both planned for the south-eastern corner of the site, it is recommended that a data gathering exercise be carried out in order to obtain the information required to further address this issue. At this stage it is envisaged that any investigation would include the provision of an extensive drilling program – aimed at identifying the depth and morphology of the

water table in this portion of the site as well as the hydraulic properties of the Colinton Volcanics, culminating in the development of a 3-dimensional finite-difference groundwater flow model of the area. With this information, it is envisaged that a number of potential recharge scenarios could be modelled – both with and without consideration for climate change, all of which could provide an estimation of the location of the groundwater divide under altered (i.e. modelled) recharge regimes.

Potential consequences of the use of recycled water at the site depend predominantly on the scale of any change to the recharge potential of the Colinton Volcanics. Slight decreases in groundwater quality are expected, regardless of whether recharge increases or decreases across the site. It is possible that a decrease in groundwater quality may also be experienced in the bores drilled at the Fernleigh Estate to the west and south-west of the site, but this is expected to be minor at worst and inconsequential for rural water applications.

Although some changes to the groundwater system are expected to result from construction of the development and the application of recycled water, no detrimental impacts on the water stored in the Googong Dam reservoir are anticipated.

To manage the risk of groundwater contamination from an accidental fuel release during construction at the site, it is recommended that all refuelling occurs at designated fuel distribution points. These should be bunded and surfaced with compacted soil, in order to prevent loss of fuel to the ground in the event of a spillage.

In keeping with the sustainable development and minimal environmental impact philosophy of the entire project, it is also recommended that there be minimal use of artificial fertilisers on public projects, and that residents are educated about the importance of minimising fertiliser use in private gardens.

Finally, in order to better understand whether salinisation is likely to become a significant issue at the site, it is recommended that salt levels in the waterways be regularly monitored during and after the development of Neighbourhood 1A. Groundwater samples should be collected from both the shallow and regional aquifers, and soil conductivity (i.e. salt) mapping carried in areas of inferred impact.

It should be noted that this assessment did not include an assessment of the existence or condition of any GDEs.

From the conclusions presented above, it can be seen that whilst qualitative descriptions of the likely impacts of the development have been assessed, it is not possible to provide quantitative descriptions or assessments of these impacts. The reason why this is the case is the data gaps identified in Section 6.2 of this report, along with the recognition that potential changes to the design are likely, particularly during the final planning and development stages of Neighbourhoods 3, 4 and 5. Because of these limitations, and the recognition that quantitative assessment of the impact of this development is necessary will be required before work can commence on the ground. CMJA recommend that the proposed scope of works presented in Table 5 be carried out in order to provide the regulatory authorities the information that they will require. The proposed monitoring program is also shown on Figure 6.

Table 5 has been structured so that the information that it contains can be readily incorporated into conditions of consent.

TABLE E1
Recommended Scope of Works for Future Investigations

Issue / Data Gap	Reasons for Concern	Recommended Scope of Works	Timing
1. Lack of site-specific baseline data on aquifer characteristics, groundwater levels and groundwater quality.	a) Without site-specific hydrogeological data it is not possible to quantify (model) the impact of the long-term development of the site as a whole on groundwater resources. b) Without baseline data (and the monitoring points from which it is obtained) it is not possible to monitor trends in groundwater levels and groundwater quality to observe the effect of the staged development and calibrate predictions.	Carry out a groundwater drilling, sampling and hydraulic testing program across the entire site, 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; and • any soils horizons and/or discontinuities of interest. Recommended locations as shown on Figure 6.	Because baseline groundwater monitoring needs to cover as much seasonal and cyclical variation as possible, this program should commence as soon as possible after development approval is granted.
2. Lack of quantitative predictive modelling of impact of overall development.	It is necessary to quantify the impacts of the proposed development (as a whole and in stages) on: • groundwater levels beneath the area; • groundwater quality; • quantity and quality of groundwater discharge to surface water bodies; • existing groundwater users throughout the area; and • any other relevant facets of the environment.	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 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 GDEs 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. Lack of detailed quantitative understanding of impact of recycled water use	It is necessary to assess and quantify what the likely effects and impacts of the proposed development and the use of recycled water will be on groundwater at the site, as well as on any GDEs down-gradient of the site.	Carry out an assessment of the presence and condition of any GDEs located both at and down-gradient of the site, and assess what impacts any likely changes in groundwater discharge volume, quality, and geochemistry may have on these GDEs.	When model is available
4. Uncertainty as to the position of the groundwater divide, and the effect of recharge changes due to the development on the position of the divide.	It is necessary to identify the groundwater source area for the Googong Dam Reservoir within the 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.
5. Long-term effects of development, and climate change.	It is necessary to monitor changes that occur during the staged development so that the modelling can be calibrated, and so that changes to planning 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 soil salinity monitoring program using EM31.	Commence once monitoring wells installed, review results annually.

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Important Information About Your Environmental Site Assessment

These notes will help you to interpret your hydrogeological and Environmental Site Assessment (ESA) reports.

Why are ESAs conducted?

An ESA is conducted to assess the environmental condition of a site. It is usually, but not always, carried out in one of the following circumstances.

- As a pre-purchase assessment, on behalf of either purchaser or vendor, when a property is to be sold.
- As a pre-development assessment, if a property or area of land is to be redeveloped, or if its use is to change (for example, from a factory to a residential subdivision) – to meet a requirement for development approval.
- As a pre-development assessment of a 'greenfield' (undeveloped) site - to establish baseline conditions and to assess environmental, geological and hydrological constraints to the proposed development.
- As an audit of the environmental effects of an ongoing operation.

Each type of assessment requires its own specific approach. In all cases, however, the aim is to identify and if possible quantify the risks posed by unrecognised contamination. Such risks may be financial (for example, clean-up costs or limitations on site use), or physical (for example, health risks to site users or the public).

What are the limitations of an ESA?

Although the information provided by an ESA can reduce exposure to these risks, no ESA, however diligently carried out, can eliminate risks altogether. Even a rigorous professional assessment may not detect all contamination on a site. The following paragraphs explain why.

ESA 'findings' are professional estimates

The ground surface conceals a complex 3-dimensional subsurface environment. Subsurface materials, whether placed by geological processes or human activities, are always heterogeneous. Large variations in lithology and hydraulic properties can occur over short distances. Surface observation, and data obtained from boreholes and test pits, can never give us a complete picture of the subsurface.

All data from sampling and laboratory testing must be interpreted by a qualified professional – a geologist, engineer or scientist. They then render an opinion - about overall subsurface conditions, the nature and extent of contamination, its likely impact on the proposed development, and appropriate remediation measures.

Interpretation and professional judgement are thus essential to the assessment process.

Accuracy depends on the scope of work

Site assessment identifies actual subsurface conditions only at those specific points where samples are taken and when they are taken. The accuracy of the entire process depends on sampling frequency and sampling methods - yet the extent of sampling and soil analysis must necessarily be limited.

Sampling generally targets those areas where contamination is considered to be most likely, on the basis of visual observation and the site's history. This approach does maximise the probability of identifying contaminants, but it may not identify contamination in unexpected locations or from unexpected sources.

No professional, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. For example, there may be contaminants in areas not surveyed or sampled; furthermore, they may migrate to areas that showed no signs of contamination at the time of sampling.

Conditions between sample locations can only be inferred – from estimates of geological and hydrogeological conditions, and from the nature and extent of identified contamination. Soil, rock and aquifer conditions are often variable, and so the distribution of contaminants across a site can be difficult to assess. Actual conditions in areas not sampled may differ from predictions.

The accuracy of an assessment is therefore limited by the scope of work undertaken.

Statistical tools can be helpful, but the validity of conclusions still depends entirely on the degree to which the original data reflect site conditions.

Uncertainty is also inevitable when it comes to assessing chemical fate and transport in groundwater and surface water systems, and calculating human health and environmental exposure risks. It is inevitable, too, when estimating remediation performance and time frames.

Your CMJA report includes a statement of the uncertainty associated with this particular project; you should read it carefully.

We can offer solutions

We cannot prevent the unanticipated, but we can minimise its impact. For this reason we recommend that you retain CMJA's services through the remediation and development stages. We can identify differences from predicted conditions, conduct additional tests as required, and recommend solutions for problems encountered on site.

Don't rely on out-of-date information

Subsurface conditions are changed by natural processes and the activity of people. Your ESA report is based on conditions that existed at the time of subsurface exploration. Don't make decisions on the basis of an ESA report whose adequacy may have been affected by time. Speak with CMJA to learn if additional tests are advisable.

If things change, contact us

Every report is based on a unique set of project-specific factors. If any one of these factors changes after the report is produced, its conclusions and recommendations may no longer be appropriate for the site.

Your environmental report should not be used:

- if the nature of the proposed development is changed - for example, if a residential development is proposed instead of a commercial one;
- if the size or configuration of the proposed development is altered;
- if the location or orientation of the proposed structure is modified;
- if there is a change of ownership; or
- for application to an adjacent site.

To help avoid expensive problems, talk to CMJA. We will help you to determine how any factors that have changed since the date of the report may affect its recommendations.

Your ESA report is prepared specifically for you

Every hydrogeological study and ESA report is prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even for another consulting civil engineer. A report should not be used by anyone other than the client, and it should not be used for any purpose other than that originally intended. Any such proposed use must first be discussed with CMJA.

Beware of misinterpretation

Costly problems can occur if plans are based on misinterpretations of an ESA. These problems can be avoided if CMJA is retained to work with appropriate design professionals. We will explain the relevant findings and review the adequacy of plans and specifications.

Logs and laboratory data should not be separated from the report

Final borehole or test pit logs are developed by CMJA's environmental scientists, engineers or geologists, using field logs (assembled by site personnel) and laboratory evaluation of field samples. Our reports usually include only the final logs, which must not under any circumstances be redrawn for inclusion in other documents.

Similarly, our reports often include field and laboratory data, and laboratory reports. These data should not be reproduced separately from the main report, which provides guidance on their interpretation and limitations.

To reduce the likelihood of misinterpretation, only the complete report should be made available for the use of persons or organisations involved in the project, such as contractors. Consult CMJA before distributing reports, and we will assist with any additional interpretation that is required.

Always read responsibility clauses closely

To avoid misunderstandings, our report includes qualifying statements that explain the level of certainty associated with our findings and recommendations, and responsibility clauses that indicate where our responsibilities to clients and other parties begin and end.

These qualifying statements and responsibility clauses are an important part of your report. Please read them carefully. They are not there to transfer our responsibilities to others but to help all parties understand where individual responsibilities lie.

These notes were prepared by C. M. Jewell & Associates Pty Ltd (CMJA) using guidelines prepared by the National Ground Water Association (NGWA) and other sources.

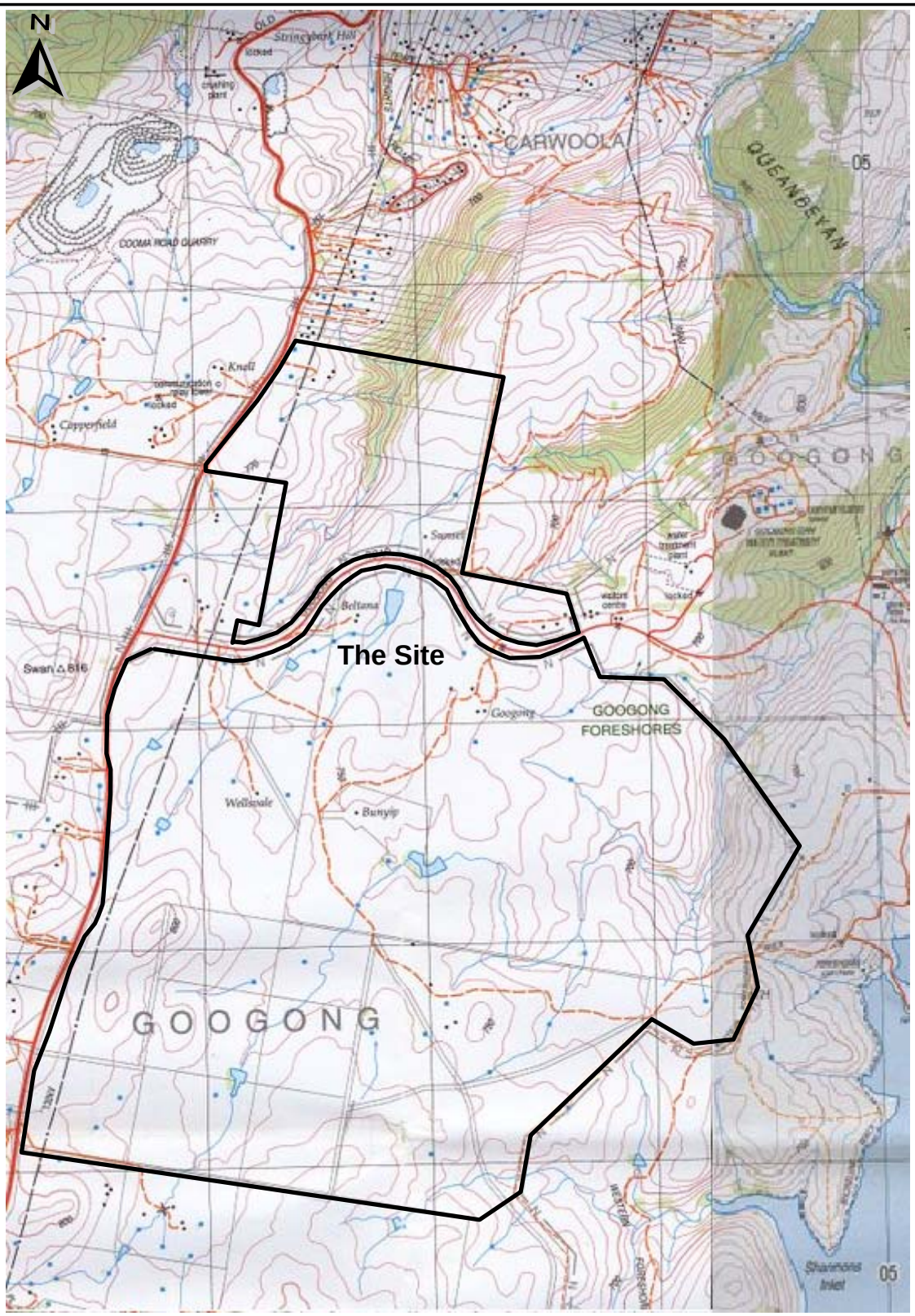
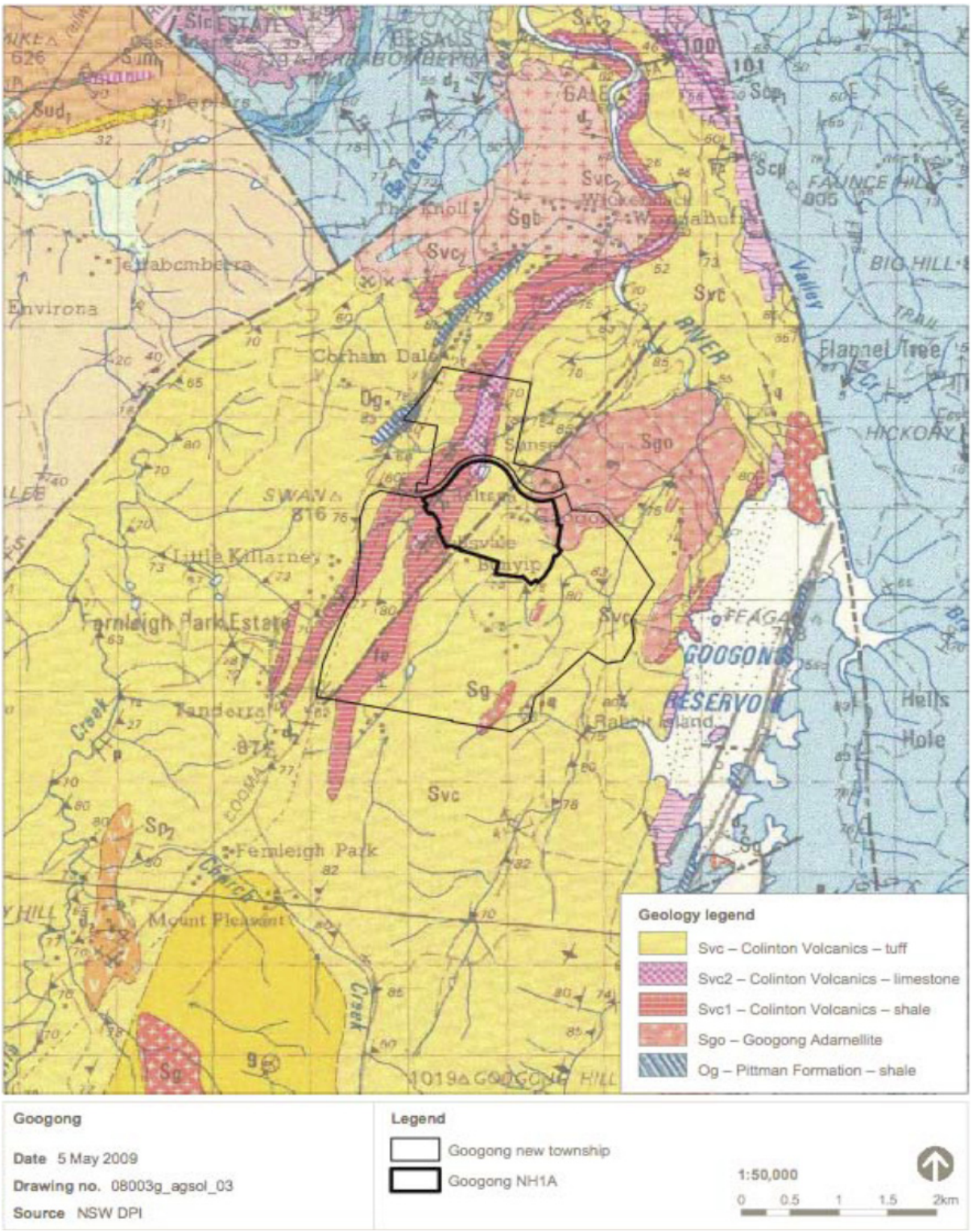
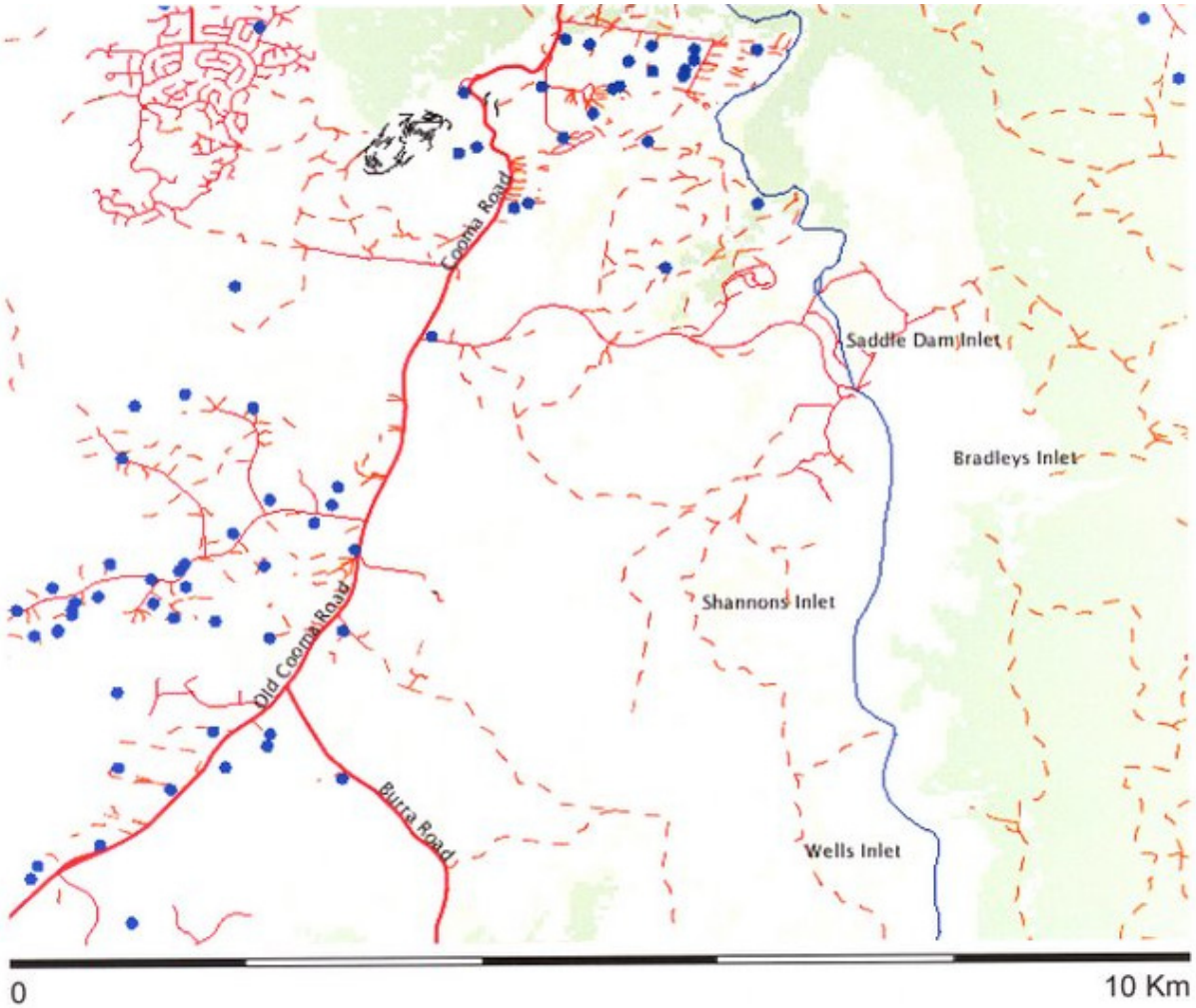


Figure adapted from the Tuggeranong 8727-3-S and Hoskinstown 8727-2-S 1:25,000 scale topographic map sheets published by the Central Mapping Authority of New South Wales, Department of Lands, First Edition (1990).

Figure 1

Site Location and Topographic Setting


Geology legend
Svc – Colinton Volcanics – tuff
Svc2 – Colinton Volcanics – limestone
Svc1 – Colinton Volcanics – shale
Sgo – Googong Adamellite
Og – Pittman Formation – shale
Googong
Date 5 May 2009
Drawing no. 08003g_agsol_03
Source NSW DPI
Legend
Googong new township
Googong NH1A
1:50,000
0 0.5 1 1.5 2km
Environa
Farnleigh Park Estate
Little Killarney
Farnleigh Park
Mount Pleasant
Flannel Tree
Hells Hole
GOOGONG RESERVOIR
Svc
Sgo
Sg
Og
Sp2



Legend

Symbol	Layer	Custodian
	Cities and large towns renderImage: Cannot build image from features	
Cowra	Populated places renderImage: Cannot build image from features	
	Towns	
	Groundwater Bores	
	Catchment Management Authority boundaries	
	Major rivers	

Figure 3

Location of Registered Groundwater Bores

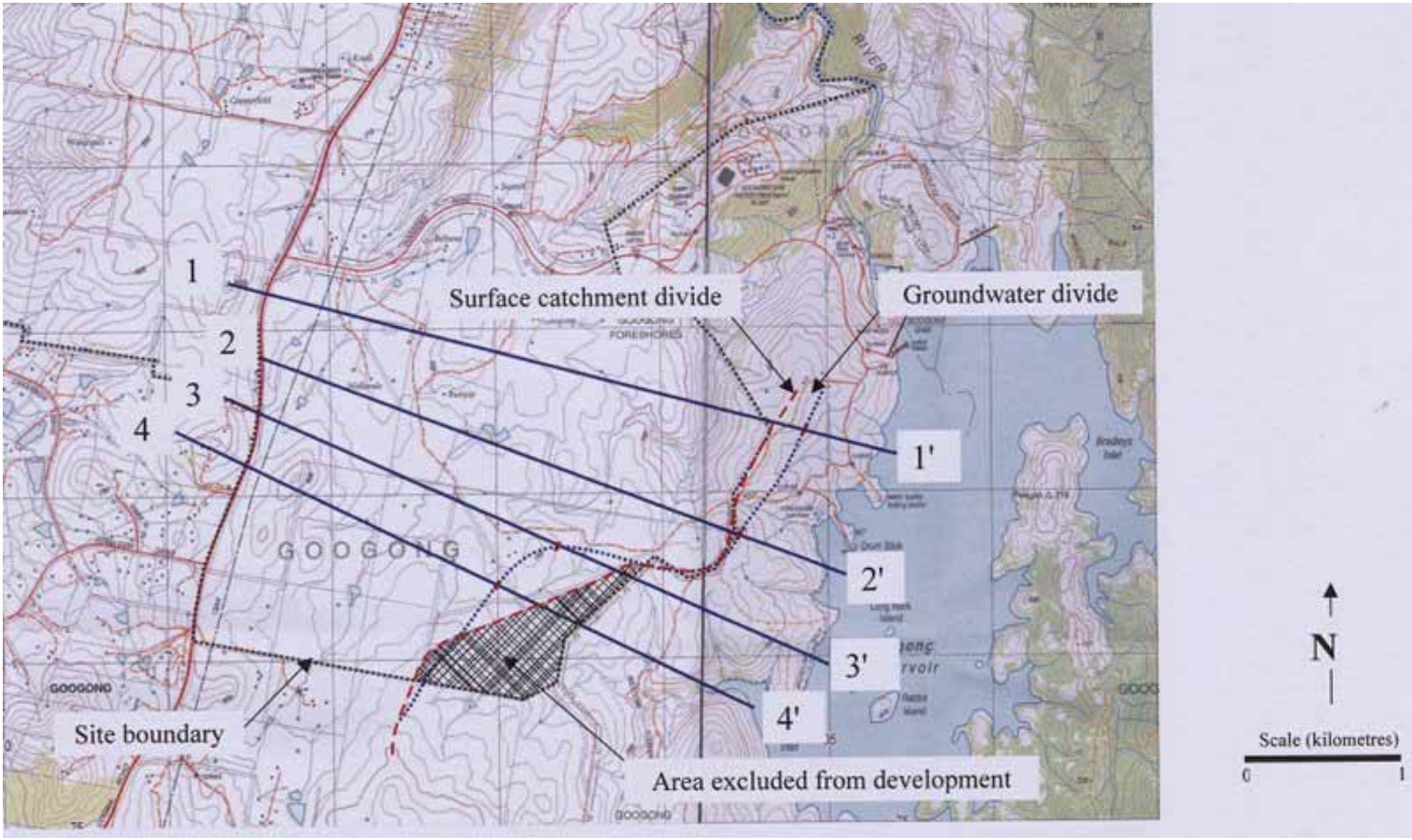


Figure 4a

Predicted Groundwater Catchment Area

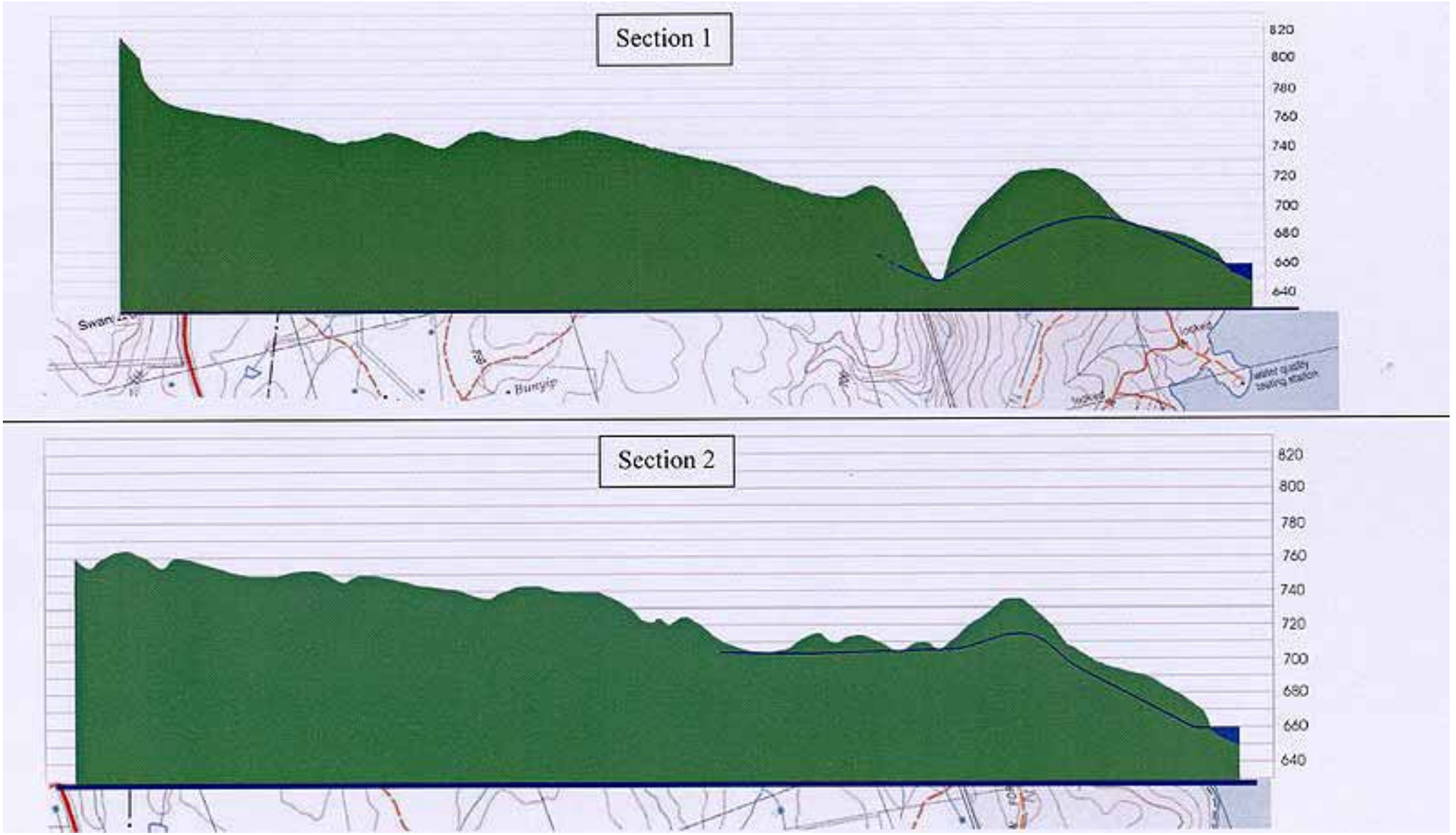
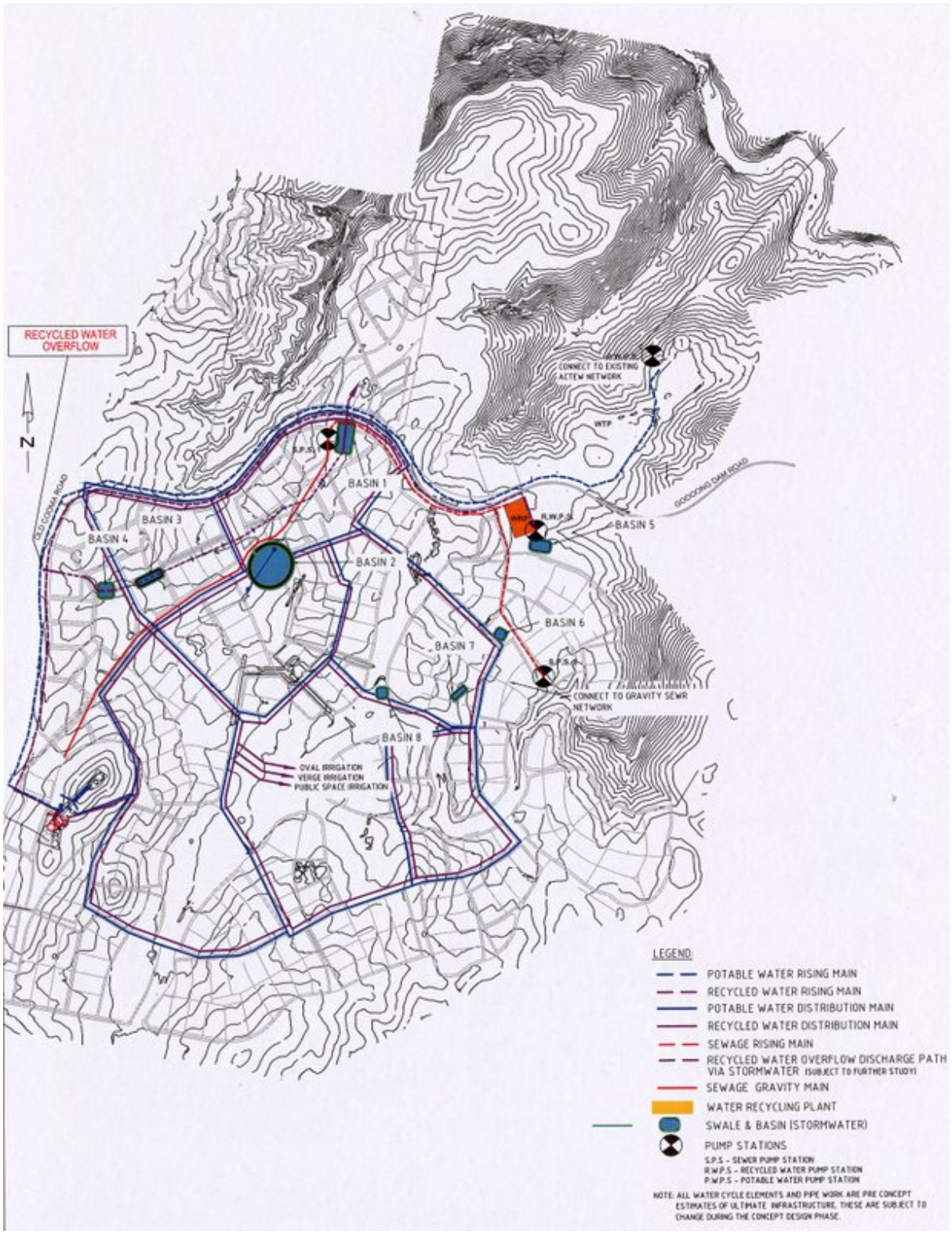


Figure 4b

Topographic and Groundwater Cross-Sections – 1 & 2

Figure 4c

Topographic and Groundwater Cross-Sections – 3 & 4


RECYCLED WATER OVERFLOW
N
OLD CANBERRA ROAD
CONNECT TO EXISTING ACTEW NETWORK
WTP
GOOGONG DAM ROAD
BASIN 1
BASIN 2
BASIN 3
BASIN 4
BASIN 5
BASIN 6
BASIN 7
BASIN 8
CONNECT TO GRAVITY SEWR NETWORK
OVAL IRRIGATION
VERGE IRRIGATION
PUBLIC SPACE IRRIGATION
LEGEND
POTABLE WATER RISING MAIN
RECYCLED WATER RISING MAIN
POTABLE WATER DISTRIBUTION MAIN
RECYCLED WATER DISTRIBUTION MAIN
SEWAGE RISING MAIN
RECYCLED WATER OVERFLOW DISCHARGE PATH VIA STORMWATER (SUBJECT TO FURTHER STUDY)
SEWAGE GRAVITY MAIN
WATER RECYCLING PLANT
SWALE & BASIN (STORMWATER)
PUMP STATIONS
S.P.S - SEWER PUMP STATION
R.W.P.S - RECYCLED WATER PUMP STATION
P.W.P.S - POTABLE WATER PUMP STATION
NOTE: ALL WATER CYCLE ELEMENTS AND PIPE WORK ARE PRE CONCEPT ESTIMATES OF ULTIMATE INFRASTRUCTURE. THESE ARE SUBJECT TO CHANGE DURING THE CONCEPT DESIGN PHASE.

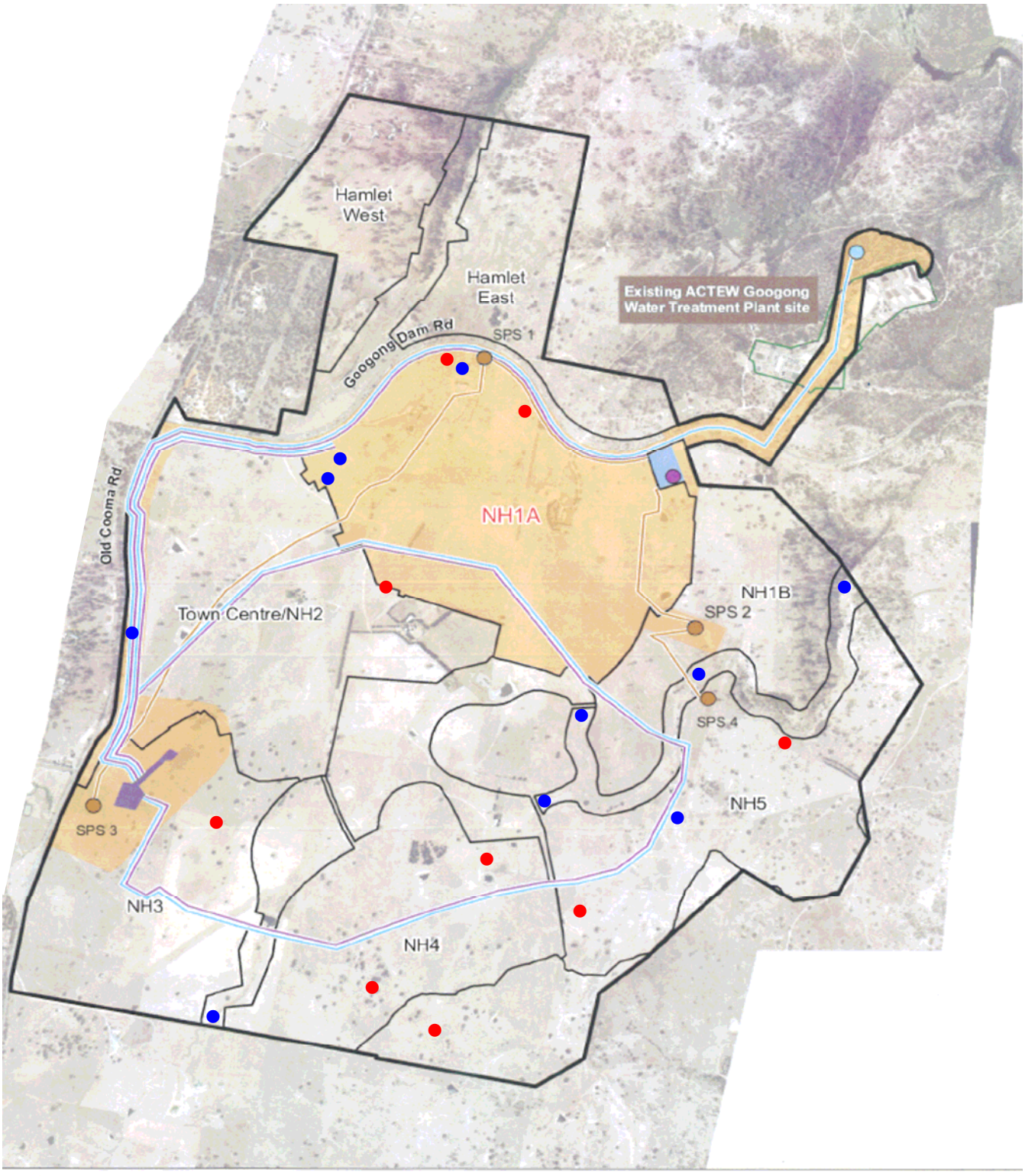


Figure 6

Proposed Groundwater and Surface Water Monitoring

APPENDIX A

Geological Setting of the Googong District

APPENDIX A

GEOLOGICAL SETTING OF THE GOOGONG DISTRICT

The information presented in this appendix has been derived from a number of reports describing various aspects of the development, including those prepared by Agsol Pty Ltd, Groundtruth Consulting Pty Ltd, MWH Global Pty Ltd, and Manidis Roberts Pty Ltd.

This section also refers to a number of sources published by the NSW Geological Survey and the (national) Bureau of Mineral Resources, Geology and Geophysics, including the Canberra 1:100,000 scale geological map sheet and a series of topographic map sheets for the area. A brief description of the Googong Dam foundation geology was provided by ACTEWAGL.

Reference has also been made to the Canberra 1:250,000 scale metallogenic map sheet and to the information provided on the summary worksheets for boreholes and associated works (such as pits, excavations and wells) throughout both the study area and the greater Googong area.

A.1 Regional Geological Setting

The Lachlan Fold Belt (LFB) is a 700-kilometre-wide belt of deformed, Palaeozoic, deep and shallow marine sedimentary rocks, cherts and mafic volcanic rocks. Surface structural elements suggest that it was formed by massive telescoping and strike-slip translation within a continental margin sediment prism along the former eastern margin of Gondwanaland during the mid-Palaeozoic.

The eastern subprovince of the LFB – to which the site belongs – marks an end to the vast deep-water turbidite sequences. This area is characterised by turbidite sequences to the far west but grades into platform carbonates and clastics intermixed with felsic volcanics and extensive granitisation of mainly I-type granites. Rock ages range from Silurian to Lower Carboniferous, with the same trend of younging towards the east that is seen in all parts of the LFB.

This grading into shallow water facies and volcanics marks an important transition to a shallow island arc complex accreting onto the Gondwanan margin. Shallow basins caught between the accreting complex and the continent show multiple sedimentation cycles, each cycle grading upwards from clastic and volcanics into limestones or limey mudstones, with the discordances evident at the bases of sequences indicative of basin subsidence, possibly due to extensional episodes within the overall convergence.

During its long history, the LFB has undergone several stages of deformation, reflecting the change of tectonic environments in the area over this period. Most of the belt was affected by the late Ordovician–early Silurian Brenambran Orogeny, which resulted in the creation of the Wagga–Omeo thrust belt zone. Subsequent crustal extension in the eastern portion of the belt saw the extensive placement of granites and associated plutonic bodies during the Silurian and Devonian periods; this placement caused extensive brittle deformation of the Ordovician, Devonian and Silurian deep to shallow water sediments.

During the Devonian (and to a lesser degree the Carboniferous) the introduction of the granites and associated batholiths – such as the Ellenden, Gibraltar and Rossi Granites of the Bega Batholith to the east and south-east of the study area – marked the LFB's transition from an immature depositional basin comprising poorly sorted volcanoclastic sediments and airfall tuffs, towards a mature continental margin with the development of complex sedimentary deposits and explosive volcanic events.

As a result of the numerous tectonic movements throughout the LFB's 'active' duration, the geological units throughout most of the fold belt have undergone multiple deformation events. In general, a strong regional tectonic inclination – from north-north-west to south-south-east – dominates the alignment of structures and geological units, particularly in the central and northern portions of the

fold belt. In the Googong–Queanbeyan districts, however, the dominant tectonic inclination is north-north-east–south-south-west.

A.2 Local Geological Setting

Rocks across the site – and indeed across much of the Googong area – consist of a number of Ordovician, Silurian and Devonian sedimentary formations, some of which include igneous intrusive and extrusive units. These formations have been intruded by a number of late-stage Silurian intrusions.

As a result of its complex history, the area has undergone quite complex brittle and ductile deformation – marked in the landscape by a strong north–south regional 'print' – whilst some of the sedimentary units have also undergone biotite-grade greenschist facies metamorphism as a result of regionally significant granite emplacement.

Table A1 below presents a simplified summary of local geology and stratigraphy throughout the study area. The local setting is shown on Figure A1.

TABLE A1
Summary of Local Geology

Age	Group and Subgroup		Description
Quaternary	Alluvium (Qa)		Gravel, sand, silt, clay and black organic clay; alluvium
Kanimblan deformation (D4); regional east–west compression and uplift along the entire length of the eastern subprovince of the LFB, resulting in thrust faulting and additional north-south tectonic imprints.			
Tabberaberan deformation (D3); major folding and uplift of the Cullarin Block resulting in very tight folds (both major and minor).			
Bowning deformation (D2); east–west compression and uplift, resulting in much of the north–south folds and faults in the area. Upper greenschist metamorphism also occurred in the Cullarin Block and Canberra Graben owing to the emplacement of the Early Devonian intrusions, and the occurrence of faulting was due to the attachment of continental terrain to the Canberra Block.			
Unconformity (type unknown but thought to be angular and erosional brought on by the emplacement of the Early Devonian intrusions).			
Early Devonian	Federal Golf Course Tonalite		Tonalite (felsic igneous intrusive)
	Barracks Creek Adamellite		Adamellite, leucogranite
	Googong Adamellite		Porphyritic adamellite
	Unnamed granitoid stocks		Granitoid stocks
Hiatus in sedimentation			
Late Silurian	Colinton Volcanics	Svc	Dark-green dacitic ignimbrite and minor volcaniclastic sediments
		Svc_1	Tuffaceous shale
		Svc_2	Limestone and dolomitic limestone
		Svc_3	Massive dacitic ignimbrite
Mid Silurian	Cappanana Formation	Scp	Shale, siltstone, and minor quartzite and tuff
		Scp_1	Limestone
		Scp_2	Calc-silicate hornfels
Mid Silurian	Deakin Volcanics		Rhyodacitic ignimbrite, minor volcaniclastic and argillaceous sediments
Quidongan deformation (D1 – B); regional compression resulting in uplifting and tightly folded strata in the Cullarin Block (to which the site belongs)			
Ordovician	Pittman Formation		Interbedded sandstone, siltstone, shale, chert and impure calcareous sandstone (distal quartz turbidites)
Rifting of the Ordovician basement during the latest Ordovician (?) or early Silurian and deposition of distal deep marine turbidite deposits.			
Benambran deformation (D1 – A); uplift of the Pittman Formation and minor folding as a result of east–west compression resulting from the collision of the (then) east coast of Australia with an unknown continental mass.			

Note: text in *italics* describes tectonic and erosional events

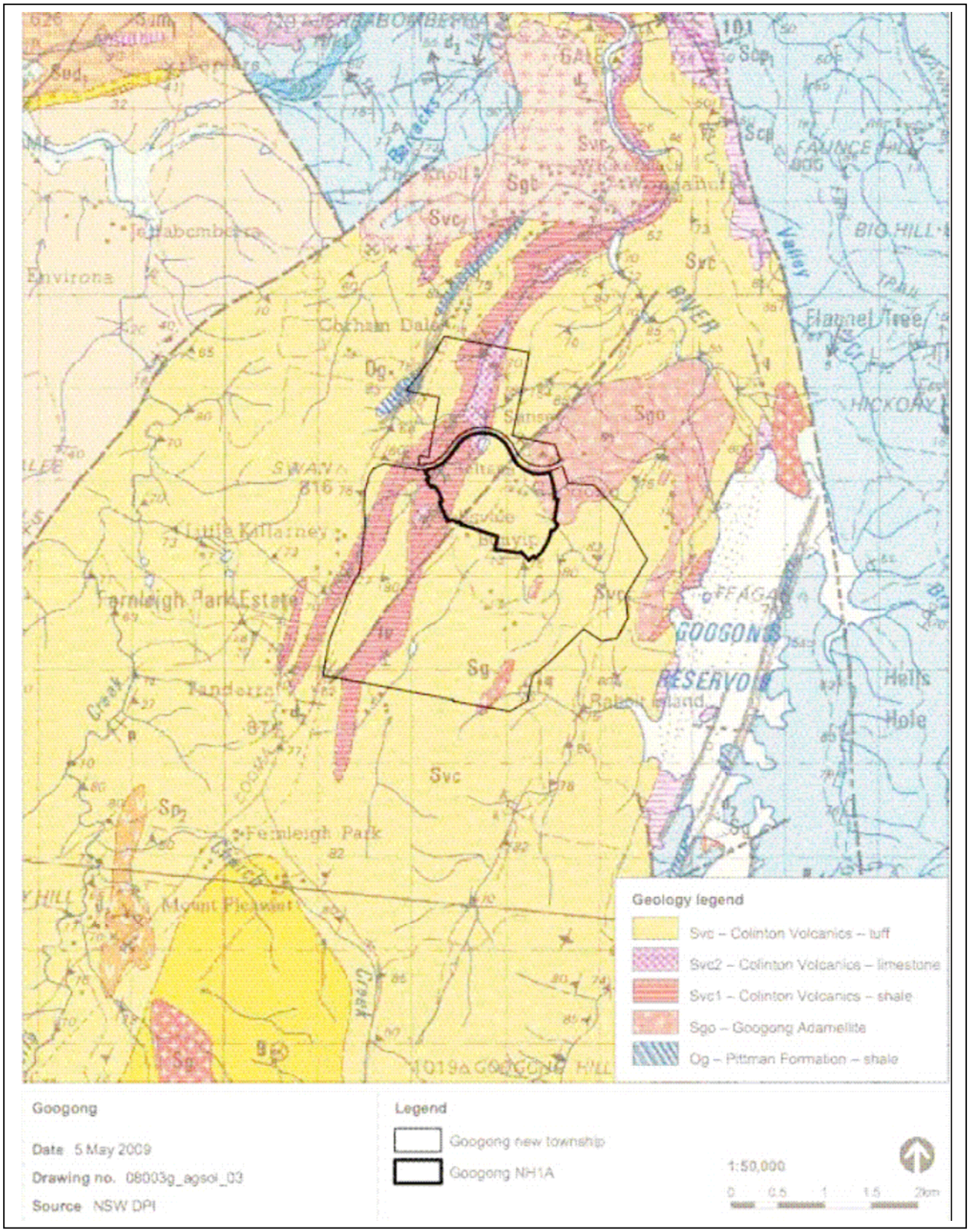


Figure 1A – Geological setting; thin black line traces the boundary of the Googong residential development whilst the thicker heavy-set line shows the outline of Neighbourhood 1A. Figure adapted from Agsol (2009a).

Most of the study region is underlain by the Colinton Volcanics, a late Silurian volcanic unit within the Canberra block. The Canberra 8727 1:100,000 scale geological map sheet describes the volcanics as a 'dark green dacitic ignimbrite with minor volcaniclastic sediments', although Mitchell (2007) goes on to further describe the volcaniclastic sediments as a number of limestone, dolomitic limestone and siltstone beds, tuffaceous shale, dacitic, rhyodacite and rhyolite lava flows, and ash fall deposits. The later ash fall deposits are noted as having a similar mineralogy to a lithic or crystal tuff (i.e. ignimbrite).

It is noted that Mitchell (2007) included the limestone units of the Colinton Volcanics in the underlying Cappanana Formation, contradicting the stratigraphic interpretation presented on the Canberra 8727 1:100,000 scale topographic map sheet. This difference in interpretation is not thought to be of significance, however, for the following reasons:

- the Colinton Volcanics and (marginally older) Cappanana Formation are of similar ages;
- both have been subjected to low to mid-grade greenschist metamorphism during the emplacement of the Googong and Barrack Creek adamellites and during a number of smaller Silurian-aged granitoid intrusions; and
- outcrop and surface expression of these beds is poor.

The sequence was deposited as shallow marine volcanic ash fall deposits and some lava flows. All outcrops are steeply dipping, strongly foliated and crenulated, with quartz commonly present as an infill mineral along fractures and in surface scree deposits.

Mitchell (2007) notes that numerous low outcrops of weathered flaggy stones occur across the site, and states that this material would be well suited to the construction of dry stone walls. He also notes that the Colinton Volcanics would have the best prospects of hosting fractured-rock groundwater resources, and identifies the fracture zones associated with the unnamed fault – which traverses much of the site – as a good starting point for such investigations.

Unlike most of the development area, the north-eastern corner of the site is underlain by the Googong Adamellite, a locally significant intrusive body that is described by Mitchell (2007) as a medium to coarse-grained, moderately weathered, buff-coloured porphyritic adamellite. It is the youngest unit in the area, having been intruded into the surrounding Colinton Volcanics, and appears to have faulted boundaries, but its overall mode of emplacement is not yet clear.

The Canberra 1:100,000 scale geological map sheet indicates that the Googong Adamellite lies between the eastern boundary of the site and the western side of Googong Dam. It has an area of about 3 square kilometres and – geomorphologically – 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, particularly between the Googong Dam front gates and the site offices, and also in a number of reaches along Montgomery Creek. A number of pegmatite and quartz-epidote veins associated with the emplacement of the pluton are evident in the surrounding country rock.

In the south-eastern corner of the site, two small granitoid intrusions have been emplaced in the Colinton Volcanics. These units – which are not defined in any great detail in the literature – form two small north-north-east–south-south-west elongated stocks which, like the Googong Adamellite, have been derived from the melting of oceanic crustal material. They are therefore known as I-type granites. Together with the Googong Adamellite, these intrusions represent the last phase of deformation and orogenic processes in the area, and some degree of metamorphism of the surrounding country rock is probable.

In the north-western corner of the site, a small inlier of the Ordovician-aged Pittman Formation outcrops adjacent to Old Cooma Road. The outcrop is described as a black graptolitic siliceous shale,

outcrops over an area of about 1500 m^2, and has been mapped (possibly erroneously) as the Acton Shale (Mitchell 2007). Like the Colinton Volcanics, the Pittman Formation is strongly folded, with most folds thought to be associated with the Benambran and Quidongan deformation events at the ends of the Ordovician and Early Silurian respectively.

A.3 Structural Aspects

Reference to the Canberra 1:100,000 scale geological maps sheet shows 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–south-south-west. This alignment is evident in all but a handful of outcrops both within and around the site, and is most evident where resistant ignimbrites, shales and tuffs of the Colinton Volcanics outcrop in the vicinity of Hill 800.

A left-lateral sinistral strike-slip fault orientated parallel with the regional structural orientation crosscuts the study region (as shown in Figure 2). In the northern portion of the site the fault is ill-defined, as both the hanging wall and footwall contain metasediments of the Colinton Volcanics. In the centre of the site, where there are marked contrasts in the hanging wall and footwall geology, the fault is better defined, and definition is also good further to the south owing to the dislocation of surface expressions associated with the tuffaceous shale unit of the Colinton Volcanics.

In relation to the fault, Mitchell (2007) notes that much of its secondary porosity (i.e. the porosity of the rock that is of interest to this assessment) has been infilled with post-deformation quartz mineralisation, probably derived from circulating fluids during emplacement of the Googong Adamellite. He also states that groundwater resources at the site are most likely to be associated with the closely spaced jointing arrays in close proximity to the fault zone, but he does not mention whether these features are also likely to be influenced by post-deformation quartz mineralisation (or any other fracture infill material), and potentially therefore to be avoided during groundwater resource assessments.

Reference to the Canberra 8727 1:100,000 scale geological map sheet shows that a weak but definite second generation of folding may exist at the site. This second generation is thought to be delineated by a number of northerly and southerly plunges assigned to fold axes and minor folds. All of these axes and folds are thought to be generally perpendicular to the main structural inclination. They are most prominently marked at the northern end of the site, where the limestone units of the Colinton Volcanics are thought to plunge to the south; a minor fold in the Colinton Volcanics immediately adjacent to the unnamed faultline is also marked and thought to plunge to the south. Unfortunately, however, the hinge locations are not known.

Across much of the site rocky outcrop is common and dominates parts of the landscape. Up to 30% of areas underlain by the Colinton Volcanics is dominated by outcrop, which occurs as vertical sheets of the more durable facies of the unit. Mitchell (2007) noted that outcrops of the Colinton Volcanics are steeply dipping, closely jointed, strongly foliated and crenulated, although numerous fractures and discontinuities in the volcanics have been infilled with quartz, with numerous traces of quartz veins and scree evident across the site.

Other evident fracture trends, summarised by Burton (1977), include diagenetic, orogenic, epiorogenic, and weathering phases, each of which may enhance or reduce the rock's permeability.

Diagenetic structural trends may be due to the cooling of volcanic units, which produces some bedding and cooling joints. Orogenic deformation processes are responsible for the north-north-east–south-south-west structural trend; and epiorogenic processes may have increased the permeability of most

existing joints and faults. Physical weathering processes due to erosion unloading have produced new structures that may be orientated as conjugate pairs.

A.4 Soils and Regolith

According to the Canberra 8727 1:100,000 scale soil landscape sheet, most of the proposed development is likely to be located on the Burra soil landscape unit. Jenkins (2000) describes this unit as consisting of undulating to rolling hills and alluvial fans associated with the weathering of the underlying Silurian volcanic units. Soils on local crests and upper slopes are described as shallow well-drained lithosols and earthy sands, whilst red podsolics and red earths dominate midslopes and most lower slopes. Moderately deep, slowly to moderately well-drained yellow and brown podsolics and yellow earths are also evident along drainage lines, whilst chernozems were also observed coinciding with the limestone unit of the Colinton Volcanics.

Higher parts of the proposed development will be situated on the Campbell soil landscape unit. In these areas of the site, rock outcrop is common, with numerous outcrops of 'tombstone' sized and shaped rows of vertically dipping tuffs (of the Colinton Volcanics) set among shallow colluvial soils. Soils are dominated by shallow lithosols, and red and yellow chromosols are also present. Overall, Jenkins considered that these soils are predominantly shallow, infertile and acidic, with low permeabilities, and localised waterlogging.

In the south-eastern corner of the site, the two small granitoid intrusions surrounded by tuffs of the Colinton volcanics are overlain by soils of the Caleys Creek unit. Soils in this group generally consist of rapidly drained earthy sands and lithosols on upper slopes, and red and yellow podzolics on lower slopes. The red and yellow podsolics are highly infertile. Jenkins also notes that topsoils are generally highly permeable and acidic, whilst the subsoils are hardsetting with low available water-holding capacity.

Along the site's north-eastern boundary are the shallow to moderately deep earthy sands, lithosols and yellow earths of the Anembo and Round Hill soil landscape units. These soils have been derived from the in-situ weathering of the Googong Adamellite, and are considered to have a low water-holding capacity and very low permeability, which is thought to lead to localised waterlogging. Soils associated with the Round Hill soil landscape unit are thought to pose mass movement hazards associated with rocky outcrop along the deeply incised margins of its member intrusions.

As part of his general geological and geomorphological appraisal of the site, Mitchell (2007) provided the following description of soils at the site.

> Almost all of the soil profiles seen in the field have two components: a thin biomantle (A-horizon) the composition of which reflects the coarser fractions of the underlying rock type. This is an active layer of soil moving down slope over varied substrates. This layer has been extensively sheet eroded as a consequence of land clearing and grazing pressure over the last 100-150 years and in many places on the hill slopes it has been completely stripped to expose B-horizons or stony pavements. Some of this recently liberated sediment is held as a layer of post-European sediment along the valley floor but most of it has been exported from the project site to the Queanbeyan River and beyond.
>
> The subsoil (B-horizon) varies in thickness and composition depending on the nature of the underlying rock as it has weathered in situ. Where the bedrock is a fine-grained sedimentary rock such as shale the subsoil is pedal clay and may be reasonably deep. These two layers form a texture contrast (duplex) soil profile. Where the bedrock is a very resistant volcanic rock or adamellite the subsoil may be absent and the biomantle will form a simple stony lithosol. On the limestone conditions are different because limestone is soluble and the subsoil of iron rich pedal clay will occur in deep patches and pockets. Traditionally such a profile would be called a Terra Rossa and although it is clay it is well flocculated and highly porous. This material may not be suitable to seal earthworks that are required to hold water.
>
> Along the streams, particularly in the upper reaches of Montgomery Creek, sediments eroded from the slopes have accumulated and filled the valley floor. The depth of this material is not known but it may be 3 to 5m and may also be sufficiently porous to retain a limited groundwater resource. In a

> few places along the mid-section of Montgomery Creek below the level of the woolshed remnant patches of dark coloured soil and sediment alternate on either side of the stream as small terrace steps. This sediment represents a former stage of valley filling, probably of late Pleistocene age, which occurred in a wet marshy environment.

A ground electromagnetic survey – using EM-31 and EM-38 ground conductivity meters – carried out by Agsol (2009) at the site indicated that the conductivity of the ground (and hence salinity) was generally low. Higher values were noted, however, along the alignment of the waterways in Neighbourhood 1A, potentially indicating shallow groundwater and mobile salt discharge in these areas.

Test pitting carried out by at the site by Douglas Partners Pty Ltd in July 2009 showed that the soils beneath the site were generally shallow, with the depth to bedrock typically between about 0.2 and 1.5 metres. Soils generally consisted of three horizons: a mobile silty sand topsoil; a dense (insitu) clayey sand; and a highly to extremely weathered saprolitic layer containing low to very-low strength, all of which directly or indirectly have been derived from the weathering of either the Colinton Volcanics (including the unnamed shale and limestone units) and/or the Googong Adamellite.

In relation to the migration of surface contamination into the groundwater at the site, Agsol Pty Ltd noted that:

> … areas of the site characterised by shallow well drained soils and vertical dipping bedrock would allow contaminants to move to the subsoils or shallow groundwater table. However, the clayey subsoils of the kurosols [red podzolics], chromosols [yellow podzolics], and to a lesser extent the kandosols [yellow earths], would form a natural barrier to downward movement.

Although the above statement can be considered to be broadly true, a more detailed knowledge of the site's hydrogeological features must be gained before the actual magnitude of any impacts can be appropriately assessed. These features include:

- the connectivity of the underlying fracture sets, which are thought to be the primary mechanism of groundwater transport;
- the hydraulic and attenuative properties of the fracture sets; and
- the depth to the water table.

APPENDIX B

Hydrogeological Setting of the Googong District

APPENDIX B

HYDROGEOLOGICAL SETTING OF THE GOOGONG DISTRICT

The information presented in this appendix has been derived from a number of sources, including:

- maps and accompanying explanatory notes published by the Geological Survey of New South Wales;
- the Bureau of Mineral Resources, Geology and Geophysics; and
- the Water Resources Commission of New South Wales;
- a search of borehole database held by Department of Environment, Conservation, Climate Change and Water NSW (DECCW); and
- an on-ground survey of groundwater resources and infrastructure.

Where information was relatively scarce, the hydrogeological setting has been interpreted on the basis of general hydrogeological principles and professional judgement.

Copies of the borehole summary worksheets held by DECCW for all of the registered boreholes discussed in this appendix are presented in Appendix C. These worksheets provide a range of information, including the depth of boring in the area, geological formations encountered during drilling, depth to and the type(s) of water-bearing zones encountered, and general descriptions of groundwater quality in the area.

Note: Many borehole worksheets stat that bores have been drilled in porphyry. Porphyry is an igneous rock with a volcanic texture consisting of large-grained crystals, such as feldspar or quartz, dispersed in a fine-grained feldspathic matrix or groundmass, and it is recognised that many of the tuffaceous and ignimbrite units of the Colinton Volcanics could easily be mistaken for a quartz or feldspar porphyry, particularly without the aid of fresh cuttings of fresh outcrop. In light of this, where worksheets refer to porphyry units in the area, those bore locations have been cross-checked against the geological units (and descriptions) provided on the Canberra 8727 1:100,000 scale geological map sheet. Where errors where identified, they have been corrected in this report.

A table summarising all of the known bore information – including that obtained during the site visit – is also provided in Appendix C.

B.1 Overview

CMJA undertook a desktop review of records held by DECCW, covering boreholes within a broad 4-kilometre radius of the centre of the site, and assessed the hydrogeology of the surrounding area.

Table B1 presents a summary of worksheets for the bores located during the search; their locations are shown on Figure B1.

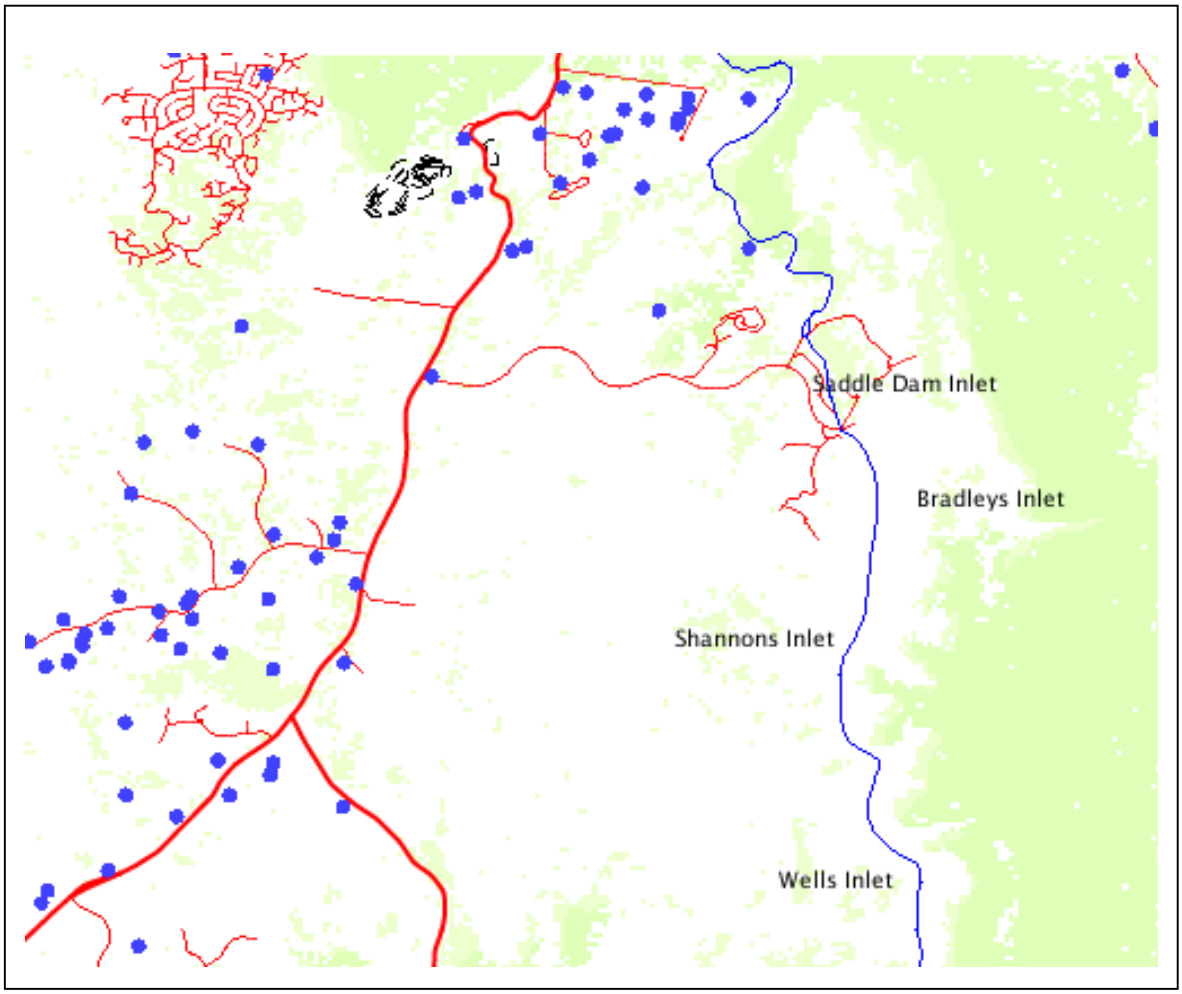


Figure B1 – Locations of registered boreholes within a 6-kilometre radius of the centre of the site (map produced from the DECCW borehole database).

TABLE B1
Summary Data for Groundwater Bores in the Googong District

Borehole ID[δ]	Registered Use	Drilled Depth (m)	WBZ[*] (m)	SWL[†] (m)	Geology	Salinity (mg/L)[α]	Yield (L/s)[β]
GW020890		19.8	9.1 – 19.8		Porphyry		2.09
GW020892		20.4	6.7 – 18.3	2.1	Porphyry		2.46
GW020893		13.7	6.7 – 8.5		Porphyry		0.19
GW020903	Stock	7.9			Granite, porphyry		
GW020904	Stock	19.8	19.8 – 19.8	1.2	Sand, quartz, porphyry		0.42
GW047361	Industrial	61.0			Sandstone, shale, granite		
GW050004	Domestic	57.5	51.7 – 57.2	14.2	Shale, siltstone	Fresh	0.15
GW050980	Domestic, stock	35.4	32.9 – 33.5	11.6	Granite	Fresh	1.10
GW061449	Domestic	80.0	21.0 – 70.0		Shale, granite	Hard	2.00
GW061599	Domestic, stock	56.1	29.2 – 29.5	11.6	Granite	Good	0.12
GW063668	Domestic	22.9	11.9 – 18.3	4.9	Granite (soft)		4.64
GW064429	Domestic	45.7	18.3 – 27.4		'Volcanic'		1.26
GW067501	Domestic, stock	42.0	33.0 – 37.0	30.0	Shale	Good	0.69
GW069070	Domestic	57.0			Granite		
GW400206	Domestic, stock	39.6	22.8 – 24.4	4.6	Shale	Good	0.76
GW400504	Domestic, stock	60.8	10.6 – 10.9	3.0	Dacite		0.38
GW400530	Domestic			13.0			0.38
GW400534	Domestic	30.0	13.5 – 25.2	2.0	Slate	Good	2.25
GW400714	Domestic, stock	72.0	48.0 – 49.0	16.0	Shale, granite		0.12
GW400813	Domestic, stock	54.0	30.0 – 48.0	22.0	Granite	Fresh	0.20
GW401001	Domestic	80.0	30.0 – 42.0	12.0	Granite – weathered	Good	0.08
GW401068	Domestic	36.0	27.0 – 34.0	10.0	Shale		1.00
GW401428	Stock	53.0		9.0		0.1	0.19
GW401683	Domestic	121.0	75.0 – 115.5	30.0	Granite	Good	0.13
GW401763	Domestic, stock	99.1	54.8 – 55.2	30.5	Granite	Good	0.05
GW401991	Domestic, stock	48.0	42.0 – 44.0	15.0	Granite, dacite	Good	1.10
GW402109	Domestic, stock	23.0	18.0 – 23.0	11.0	Shale, 'volcanic cavity'	370	12.5
GW402157	Domestic	66.0	25.0 – 63.0	20.0	Shale, granite		0.50
GW402298	Domestic	85.0	54.0 – 67.0	51.0	Shale, granite		0.38
GW402348	Domestic	45.0	32.0 – 33.0		Shale		0.44
GW402383	Test bore	122.0	88.0 – 96.0		Shale		0.33
GW402859	Domestic, stock	78.0	68.0 – 70.0		Granite, quartz bands		2.10
GW402872	Domestic	102.0			Slate, dacite		0.38
GW403097	Domestic	100.0			Shale, porphyry		
GW403149	Domestic, stock	42.0		10.0	Granite, shale		9.0
GW403206	Domestic	156.0			Shale		
GW403273	Domestic	83.0			Granite		
GW403321	Industrial	108.0		1.5			1.40
GW403582	Domestic, stock	42.0	16.5 – 34.0	8.0	Volcanics, granite		1.56
GW403879	Domestic, stock	71.0		20.0	Shale		
GW403897	Domestic	128.0	57.0 – 97.0		Granite		0.44
GW404070	Domestic	96.0	60.0 – 76.0	20.0	Shale (black)		0.82
GW404089	Domestic, stock	81.0	0.0 – 75.0	20.0	Shale		
GW404400	Domestic, stock	66.0					
GW404573	Domestic, stock	95.0		85.0[Ψ]			2.20
GW404701	Domestic, stock	15.0		10.0		87.0	8.00
GW404883	Domestic, stock	10.0					1.00
GW405005	Domestic, stock	66.0	61.0 – 61.9	10.0	Granite		0.32

Notes:
- [δ] DECCW borehole registration reference number
- [*] water-bearing zones
- [†] standing water level
- [α] milligrams per litre
- [β] litres per second
- [Ψ] thought to be erroneous

Bold text indicates borehole drilled at the site

B.2 Hydrometeorology

According to Evans (1987), average annual rainfall at the site is approximately 650 millimetres. Rainfall is distributed fairly evenly throughout the year; winter months are generally slightly drier. Summer rain is usually from storms, whereas the winter rain is more evenly spread, less intense, and longer lasting. Summer evaporation is about four times that of winter, and – depending on the elevation – usually exceeds rainfall.

Table B2 presents an overview of the mean monthly rainfall and potential evaporation rates at the site. Agsol (2009) estimated overall rates by first calculating the individual rates of plants likely to be grown at the site and then using a multiplication factor based on anticipated crop site.

TABLE B2
Mean Monthly and Potential Evaporation Rates

Month	Rainfall (mm/month$^{\Psi}$)	Evapotranspiration* (mm/month)		
		Gardens	Playing Fields	Landscaping
January	56	167	163	173
February	58	134	130	139
March	48	113	110	117
April	45	72	70	74
May	38	42	38	43
June	40	23	21	24
July	40	22	20	25
August	48	34	31	38
September	52	60	55	66
October	58	106	103	110
November	66	128	125	133
December	49	165	161	171
Annual	*598*	*1065*	*1027*	*1112*

Notes: $^{\Psi}$ millimetres per month
* Evapotranspiration rates were calculated using method described by Agsol (2009)

B.3 Existing Bore Locations

Reference to Figure B1 shows that most of the bores of interest to this study have been drilled throughout the Fernleigh Estate to the south-west of the site. A second cluster of bores have been drilled at the numerous rural–residential allotments immediately to the north of the site, and only a few registered boreholes are scattered throughout the remaining area. No registered boreholes appear to have been drilled at the site.

Given the spatial distribution of bores in the area, there is only a limited amount of information available from the borehole summary worksheets regarding the hydrogeological setting in this area, particularly for the eastern portion of the study area which is underlain by the Googong Adamellite. Consequently, there may be fewer restrictions relating to the locations of any future boreholes (which may be drilled if individuals wish to utilise groundwater in the area).

All boreholes throughout the Fernleigh Estate have been drilled into fractured tuffs, shales and ignimbrites of the Colinton Volcanics, and all are registered for domestic and stock purposes. They have generally been drilled to depths between about 40 and 80 metres, but a few – which appear to be located on topographic high points – have been drilled to depths of about 100 metres.

All bores on the estate have reportedly encountered fractured water-bearing zones, with some of the more productive bores encountering multiple fractured zones; yields are generally low, however, and

typically of the order of 0.5 to 1.0 litres per second (L/s). There are a few exceptions: several bores have exhibited yields as high as 8.0, 9.0 and 12.5 L/s. The highest-yielding bore is located on the opposite side of Old Cooma Road, just to the south-west of the site.

The other bores that are of interest to this investigation are located to the north of the site, within the (lower) Queanbeyan River catchment. Most have been drilled in the Colinton Volcanics, with a handful also drilled along the southern margin of the Barracks Creek Adamellite.

They have had differing degrees of success in tapping good (and sustainable) groundwater yields. Those drilled in the Colinton Volcanics have proved the most promising, with boreholes GWGW061449, GW404530 and GW404701 reporting yields between 2.0 and 8.0 L/s. In these areas, groundwater quality is generally described as 'good', and standing water levels appear to be slightly deeper than in the Fernleigh Estate area, most likely reflecting the heavily dissected nature of the landforms in the Colinton Volcanics due to the incision of a number of first and second order tributaries of the Queanbeyan River.

The coordinates provided on the borehole summary worksheets indicate that no bores in the study area have been drilled in the Googong Adamellite.

B.4 Aquifer Type

An assessment of the DECCW borehole summary worksheets indicates that groundwater in the vicinity of the site is hosted in a regionally extensive and unconfined fractured rock aquifer. Structural features thought to be significant to groundwater flow at the site include (in order of expected importance):

- local and regionally significant faults throughout the area, including the unnamed normal fault that cross-cuts the site.
- joints (either individuals or forming part of a larger joint set or swarm in the country rock);
- parasitic fractures and splays associated with localised brittle deformation features;
- cleavage arrays and axial trace fractures associated with Silurian deformation events (namely folds and faults associated with the intrusion of the Silurian-aged granitoids, including the Googong Adamellite).

Some enhanced secondary porosity within limestone units may also be of interest, but there is virtually no available information about the geological and hydrogeological properties of these units in the study area.

Given the lithology of the units at the site and the degree of metamorphism described by Evans, it is expected that primary porosity is very low in the Colinton Volcanics.

It is also expected that perched groundwater may exist within several horizons throughout the rock mass. This is particularly likely in the regolith and soil profiles produced from the weathering of the basement geological units, and especially those of the Silurian intrusions. As mentioned above, enhanced secondary porosity may also exist in the limestone and dolomitic units of the Colinton Volcanics, but information is scarce and outcropping poor.

In typical fractured-rock aquifers in the area, the depth limit of significantly open fractures is generally about 100 metres (Evans 1987). Below this depth, the aquifer can be considered essentially impermeable. Moreover, most borehole yields are obtained in the first 40 metres, and only rarely has improvement in yield been observed in bores drilled past 100 metres (Evans 1987).

Given the limited development of alluvial channel and exterior channel features along the alignment of the local creeks and rivers, it is understandable that very little use is made of groundwater associated with such units.

B.5 Bore Yields and Aquifer Hydraulic Properties

Yields for the Googong district boreholes range from less than 0.1 L/s up to about 10 L/s.

The borehole summary worksheets supplied by DECCW show that the highest yields were obtained from boreholes to the north and west of the site. Most of these higher-yielding bores were drilled in the ignimbrite and metasedimentary units of the Colinton Volcanics, but some were drilled along the southern margin of the Barracks Creek Adamellite, where enhanced fracturing and deeper weathering profiles are thought to exist.

High yielding boreholes in this district are, however, in the minority. Most yield small volumes of water, typically between 0.5 and 1.0 L/s.

Groundwater quality in these bores is typically quoted as being ‘good’ and ‘fresh’, which is supported by Evans (1987). Reference to the Macquarie River Basin Areas of Low Salinity Groundwater map – which was published by the former Water Resources Commission of New South Wales in 1984 – supports this generalisation, indicating that the fractured rocks throughout the Googong district can only yield low volumes, but that groundwater quality is good.

An overview of the details of some of the higher yielding bores in the area is presented in Table B3.

TABLE B3
Hydrogeological Characteristics of Selected Higher-Yielding Boreholes in the Googong District

Borehole ID[α]	Geological Setting[β]	WBZ[χ] (m[δ])	Elevation[φ] (m AHD[ϕ])	Yield (L/s[ε])	Location
GW020890	Fractured ignimbrites and volcaniclastic sediments of the Colinton Volcanics	9.1 – 9.1 15.5 – 15.5 19.8 – 19.8	775	0.19 1.90	Low rolling hills about 1.5 kilometres south-west of the site; property not identified by name but thought to front Evans Road.
GW020892	Fractured ignimbrites and volcaniclastic sediments of the Colinton Volcanics	6.7 – 6.7 8.5 – 8.5 18.3 – 18.3	785	 0.19 2.27	Low rolling hills about 1.5 kilometres south-west of the site; property is thought to be 'Fernleigh Park' on the eastern side of Old Cooma Road.
GW061449	Fractured ignimbrites and volcaniclastic sediments of the Colinton Volcanics	21.0 – 40.0 41.0 – 56.0 57.0 – 64.0 65.0 – 70.0	710	0.56 0.44 0.33 0.67	Heavily dissected rolling hills about 500 metres north of the site; property not identified by name but thought to front Heights Road; adjacent to graptolitic shales of the Pittman Formation
GW063668	Fractured tuffaceous shale of the Colinton Volcanics	11.9 – 14.9 16.8 – 18.3	765	1.26 3.28	Moderately dissected rolling hills about 450 metres west of the site in the Fernleigh Estate; property not identified by name but thought to be located on the southern side of Fernleigh Drive.
GW400534	Fractured tuffaceous shale of the Colinton Volcanics	13.5 – 14.0 25.0 – 25.2	788	0.75 1.50	At the CSR 'Cooma Road Quarry' on the western side of Old Cooma Road, about 600 metres north-west of the site.
GW402109	Fractured ignimbrites and volcaniclastic sediments of the Colinton Volcanics	18.0 – 23.0	790	12.5	Low rolling hills about 200 metres west of the site in the Fernleigh Estate; property not identified by name but thought to be located on the southern side of Fernleigh Drive.
GW402859	Fractured water-bearing zones of the Barracks Creek Adamellite	54.0 – 55.0 68.0 – 70.0	665	0.21 1.89	Heavily dissected rolling hills about 500 metres north of the site; property not identified by name but thought to front Wickerslack Lane.
GW403149	Fractured ignimbrites and volcaniclastic sediments of the Colinton Volcanics	Unknown	770	9.0[π]	Moderately dissected rolling hills about 1.2 kilometres west of the site in the Fernleigh Estate; property not identified by name but thought to be located on the eastern side of Swan Drive.
GW404573	Fractured water-bearing zones of the Barracks Creek Adamellite	Unknown	620	2.2[π]	Heavily dissected rolling hills about 500 metres north of the site; property not identified by name but thought to front Wickerslack Lane about 50 metres north of the Queanbeyan River.
GW404701	Fractured water-bearing zones of the Barracks Creek Adamellite	Unknown	658	8.0[π]	Heavily dissected rolling hills about 500 metres north of the site; property not identified by name but thought to front Wickerslack Lane.

Notes: [α] DECCW borehole registration number
[β] geological setting (derived from the information presented on the relevant borehole summary worksheets and from general information provided on the Canberra 1:100,000 scale geological map sheet)
[χ] water-bearing zones
[δ] metres
[ε] litres per second
[φ] elevation (derived from the Tuggeranong 8727-3-S 1:25,000 scale topographic map sheet)
[ϕ] metres above Australian Height Datum
[π] cumulative yield quoted on the borehole summary worksheet

Boreholes that have encountered multiple water-bearing zones seem to have markedly higher yields, and in most instances yields appear to increase with depth. The highest-yielding water-bearing zones throughout the area were typically identified at depths of between 20 and 50 metres, beyond which the degree of fracturing is thought to decline markedly, particularly in the Silurian intrusions. For example, in Borehole GW63668, which has one of the highest total yields (4.6 L/s) in the Googong district, more than half the yield was derived from a fractured shale unit at a depth of about 18 metres.

This trend was apparent in several other bores drilled throughout the area, including:

- GW020890 and GW020892 which were drilled in the Colinton Volcanics about 1.5 kilometres south-west of the site;
- GW061449, which was drilled in fractured ignimbrites and volcaniclastic sediments about 500 metres north of the site;
- GW063668, which was drilled in tuffaceous shales of the Colinton Volcanics about 450 metres west of the site in the Fernleigh Estate;
- GW400534, which was drilled in tuffaceous shales of the Colinton Volcanics at CSR's Cooma Road quarry about 600 metres north-west of the site;
- GW402859, which was drilled in fractured water-bearing zones of the Barracks Creek Adamellite about 500 metres north of the site; and
- GW403582, which was drilled in fractured water-bearing zones of the Colinton Volcanics ignimbrites and volcaniclastic sediments, about 2.5 kilometres south of the site.

Most of the other bores drilled in the area have only encountered one reported water-bearing zone, usually between 3 and 5 metres thick.

Although groundwater resource assessments often effectively target the margins of intrusions as well as the country rock immediately surrounding intrusive bodies (as potentially shown by boreholes GW404701, GW404573 and GW61449), it is considered that the low yield reported in many of the bores – particularly some of those drilled in the vicinity of Silurian intrusions – indicates that syn- and post-genetic quartz mineralisation throughout the area has significantly reduced secondary porosity in the aquifer. This reduction in secondary porosity is thought to be most prevalent in close proximity to such intrusions (for example in close proximity to the Googong and Barracks Creek adamellites), where hydrothermal solutions would have been most prevalent during the emplacement of the plutons.

The presence of quartz mineralisation – at times quite extensive and wide – in former fracture apertures is a common feature throughout the study area, and is evident in numerous outcrops, road cuttings and creeklines. The quartz is generally fresh and competent, indicating that its emplacement within the country rock is relatively late-stage. It is prevalent throughout the study area, and not just in close proximity to the igneous intrusions.

Yields in the Silurian metasediments are also (generally) expected to be at the lower end of the range shown by similar fractured rock aquifers, given the syn- to post-tectonic development of quartz veining throughout the area. Borehole yields reportedly obtained from the sedimentary volcaniclastic units are usually very low, and according to the 1:100,000 scale Hydrogeology of the Australian Capital Territory and Environs map (Evans and Moffat, 1984), are commonly between 0.5 and 1.0 litres per second (L/s). The explanatory notes for the map sheet indicate that – at the date of publication – over 160 wells have been drilled in these volcaniclastic sediments, with a mean yield reportedly about 0.8 L/s. Bores that encounter multiple water-bearing zones, particularly at depths between 20 and 50 metres, may have higher than average yields.

Quartz mineralisation is expected to have a negative effect on the aquifer's storativity (i.e. the amount of water that a given volume of aquifer will produce in response to unit change in hydraulic head).

CMJA is not aware of the existence of any information about the hydraulic properties of the colluvial aquifers along the alignment of the creeklines in and to the north of the site. Yields of bores drilled in close proximity to either creek are expected to benefit from leakage from the overlying alluvial aquifers and also from their hydraulic connectivity to structural discontinuities in the area, particularly those that are thought to have influenced the alignment of the waterways.

In general, the highest hydraulic conductivities within such aquifers tend to be found in the shallow parts of the aquifer. The principal exceptions to this occur where there is lithologically controlled porosity or fracturing caused by the deepest structural features such as faults – but these features are rare in the immediate area, and jointing is expected to be the main feature contributing to aquifer transmissivity.

Several boreholes drilled throughout the study area very few have been pump-tested during drilling. All were tested for relatively short periods, however, and few data had been noted on the borehole summary worksheets provided by DECCW. Table B4 summarises the pump test information on the borehole summary worksheets.

TABLE B4
Summary of Pump Test Results

Bore ID[α]	Geology	SWL[β] (m bgl[χ])	Pumping Rate (L/s[δ])	Duration (hours)	Drawdown (m[ϕ])	Final SWL (m bgl)
GW400504	Colinton Volcanics – ignimbrite and volcaniclastic sediments	3.0	0.38	0.6	15.0	unknown
GW500534	Colinton Volcanics – tuffaceous shale	2.0 1.0	0.75 1.50	0.5 0.5	unknown unknown	unknown unknown
GW400813	Colinton Volcanics – ignimbrite and volcaniclastic sediments	22.0 22.0	0.25 0.13	0.5 1.0	32.0 32.0	unknown unknown
GW401068	Colinton Volcanics – ignimbrite and volcaniclastic sediments	10.0	1.0	1.0	unknown	unknown
GW401683	Colinton Volcanics – ignimbrite and volcaniclastic sediments	30.0	0.06 0.06	0.5 0.5	unknown unknown	unknown unknown
GW401991	Colinton Volcanics – ignimbrite and volcaniclastic sediments	15.0	1.10	1.0	42.0	unknown
GW402109	Colinton Volcanics – ignimbrite and volcaniclastic sediments	11.0	12.5	1.0	unknown	unknown
GW402157	Colinton Volcanics – ignimbrite and volcaniclastic sediments	20.0	0.13	0.5	unknown	unknown
GW402298	Colinton Volcanics – ignimbrite and volcaniclastic sediments	unknown	0.19	0.5	unknown	unknown
GW403582	Colinton Volcanics – ignimbrite and volcaniclastic sediments; adjacent to a late Silurian rhyodacite porphyry intrusion	8.0 8.0 8.0	0.06 0.25 1.25	0.25 0.25 1.25	10.0 (?) 6.0 (?) 18.0 (?)	unknown unknown unknown
GW404089	Colinton Volcanics – ignimbrite and volcaniclastic sediments	20.0	unknown	1.0	unknown	unknown

Notes: α DECCW borehole registration reference number
β Standing water level
χ metres below ground level
δ litres per second
ϕ metres

Table B4 indicates that, in general, yields obtained in the pumping tests are sustainable over short timeframes (i.e. a few hours), but may not be sustainable over longer periods. The worksheets provided no information about the aquifer recovery after pumping ceased. There will be exceptions to this lack of sustainability, however, particularly in bores that are hydraulically connected to regionally significant fracture zones. Such bores are expected to benefit from enhanced interconnectivity of the fractured rock aquifer, producing higher than average yields over longer durations, but not necessarily over substantially prolonged periods.

Hydraulic Conductivity Calculations

The hydraulic conductivity of fractured rock aquifers is typically low, anisotropic, and spatially variable. No major zones of enhanced permeability were detected below the Googong Dam wall, despite the occurrence of intense fracturing and jointing.

The assessment of calculated hydraulic conductivity values (presented in Table B5) utilised DECCW information for selected boreholes.

In order to estimate *aquifer thickness* (shown in column 4), it was necessary first to estimate aquifer depth, because the DECCW database often lacks detailed hydrogeological data. It was estimated that the bores in this region are drilled to a depth approximately 5 metres below the depth of the aquifer zone. The thickness of the aquifer zone was then estimated by subtracting from the hole depth the standing water level and the excess drilling depth (5 metres).

The estimate of aquifer thickness also constitutes an estimate of the maximum bore drawdown, because the maximum pump installation depth is also approximately 5 metres from the base of the bore. When pumping at the reported yield, the actual drawdown experienced may be approximated to the maximum available drawdown, and this assumption may be used to estimate the aquifer's transmissivity.

With this assumption, and an estimate of the aquifer's storativity (0.00001), the aquifer's *transmissivity* (Column 6) could then be estimated, employing an analytical approach based on the Theis equation.

The *mean and median* of the calculated hydraulic conductivities are 6.8×10^{-5} metres per second (m/s) and 1.5×10^{-6} m/s respectively. Note that these values probably overestimate average hydraulic conductivity, because they are based on information from targeted, successful boreholes. Calculations based on information from randomly targeted boreholes, including those with negligible groundwater yields, would produce more representative results.

TABLE B5
Hydraulic Conductivity Calculations from Existing Borehole Information

Bore	Hole Depth (m)	SWL (m)	Estimated Aquifer Thickness (m)	Reported Yield (L/s)	Calculated Transmissivity (m^2/s) (S = 0.0001)	Calculated Hydraulic Conductivity (m/s)
GW050004	57.5	14.2	38.3	0.15	6.3×10^{-6}	1.6×10^{-7}
GW063668	22.9	4.9	13.0	4.54	6.9×10^{-4}	5.3×10^{-5}
GW400206	39.6	4.6	30.0	0.76	4.5×10^{-5}	1.5×10^{-6}
GW400534	30.0	2.0	23.0	2.25	1.8×10^{-4}	7.9×10^{-6}
GW400651	40.0	18.0	17.0	0.63	6.7×10^{-5}	3.9×10^{-6}
GW400940	71.0	31.0	35.0	0.22	1.0×10^{-5}	3.0×10^{-7}
GW401428	53.0	9.0	39.0	0.19	7.9×10^{-6}	2.0×10^{-7}
GW402109	23.0	11.0	7.0	12.5	3.8×10^{-3}	5.4×10^{-4}
GW402157	66.0	20.0	41.0	0.5	2.1×10^{-5}	5.1×10^{-7}
		Mean:	27.0	1.9	1.7×10^{-4}	6.8×10^{-5}
		Median:	30.0	0.5	3.4×10^{-5}	1.5×10^{-6}

As a means of assessing the permeability of fracture zones in the study region, the BMR (1972) study is a useful guide. That study was concerned with the foundation rock of the Googong Dam, which it found to be intensely fractured and jointed. Pressure testing in the boreholes revealed no major zones of high permeability, however, suggesting that fractures in the study region do not have significant permeability, and quite possibly have a correspondingly low storativity.

B.6 Groundwater Quality and Geochemistry

Groundwater quality data for the Googong area are available from two sources: first from the DMRGG publication *Hydrogeology of the Australian Capital Territory and Environs* (Evans, 1987) (including the accompanying map); and secondly from the summary worksheets for each of the registered bores identified during the search. The information obtained from these two sources is summarised below.

The groundwater chemistry data summarised in Evans are subdivided into geological and physiographic provinces. This site lies within the 'D2' geological and physiographic division, and the major ion groundwater chemistry results for that unit are summarised in Table B6.

TABLE B6
Groundwater Chemistry Results for Unit D2 (Evans 1987)

Sample Location	Ca		Mg		Na		K		HCO_3		SO_4		Cl	
	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD	mg/L	SD
Hill slopes	218	155	178	150	143	115	2	2	300	163	39	86	202	246
Valley floors	229	152	151	101	120	77	4	4	257	133	94	98	136	97

Notes: mg/L mean concentration in milligrams per litre
SD Standard Deviation in units mg/L

The important factors for groundwater chemistry in the study region are:

- the soluble salt content of the recharge zone;
- the chemistry of the aquifer material; and
- the residence time of the water in the aquifer.

Evans assessed that groundwater within the study region is generally dilute – that is, it has relatively low total dissolved salts (TDS). The TDS in most of the bores sampled is 'below the acceptable limit for human consumption' (1200 mg/L). The Evans 'Distribution of Total Dissolved Salts' contoured map has the study site at approximately the '500 mg/L TDS' contour.

The pattern of solute concentrations is a function of landform features, with the average concentration of groundwater solutes in valley floors generally less than the concentrations from the hill slopes; as shown in Table B6. From this pattern, Evans concluded that for these units recharge is occurring from the base of thick porous alluvium in the valley floors.

The groundwater chemistry data compiled by Evans show that the study site lies within a broad region in which the total hardness – defined as (Ca + Mg)/50 – is mostly in the 'very hard' or 'unacceptable' range (in relation to domestic water use), whilst the adjusted sodium adsorption ratio (SAR) – a measure of the sodium hazard of irrigated water – is low.

Table B1 shows that one borehole identified during the search intersected groundwater that was reported to be 'hard'. This bore, which is identified as GW061449 in the DECCW database, was drilled on the western side of Old Cooma Road about 700 metres north-west of the site, and intersected four fractured water-bearing zones between 21 and 70 metres' depth. According to the borehole summary worksheet, the bore was drilled through alternating 'bands' of shale and granite, but reference to the Canberra geological map sheet indicates that the borehole was actually drilled in dacitic ignimbrite and volcaniclastic sediments of the Colinton Formation.

From Table B6, other features of the groundwater include:

- the low potassium concentrations, which most likely reflect the reduced solubility of potassium feldspars in the presence of other mineral phases such as plagioclase;
- the relative stability of potassium layer-silicates such as illite; and
- the low sulphate concentrations, suggesting a lack of sulphide mineralisation in the immediate region.

Reference to the Murrumbidgee River Basin Areas of Low Salinity Groundwater map published by the former Water Resources Commission indicates that low salinity groundwater can be found in the fractured rocks of the Queanbeyan and Bredbo river catchments to the south of the site. Further abroad, the map indicates that groundwater of moderate quality – presumably with a total salt content greater than 1000 mg/L and less than 3000 mg/L – can be found in the fractured rocks located in the headwaters of these catchments. Yields from the rocks are described as low, but no specific data are provided.

DECCW summary worksheets for boreholes drawing water from fractured rock aquifers throughout the Googong–Queanbeyan districts indicate that water quality is generally good, but each description is usually limited to a single word. All of these boreholes draw water from fractured water-bearing zones, and all but a few are licensed for stock and/or domestic purposes.

Groundwater throughout the greater Googong–Queanbeyan district appears to be of moderate to good quality, with no references to poor quality on the borehole summary worksheets. Groundwater quality is frequently described as 'fresh' and 'good', irrespective of borehole yield or position in the landscape. There does not appear to be any distinctions drawn between groundwater quality in different host formations: the same descriptors are used in relation to shale, porphyry, dacite and granite-hosted aquifers. Nor do there seem to be distinctions drawn in relation to depth: the same quality descriptor is used for several bores, regardless of the depth of water-bearing zones.

Summary worksheets for only two of the boreholes identified during the search provide quantitative information on the concentrations of total dissolved solids (referenced as salinity) in the vicinity of the site. The first of these bores, identified as GW402109, was drilled on the western side of Old Cooma Road, about 60 metres west of the site. It was drilled to a depth of 23.0 metres, and intersected a single fractured water-bearing zone in the lower 5 metres of the bore. Prior to construction, the bore was air-lifted for over an hour and the yield noted to be about 12.5 L/s (an exceptional yield for this area). A sample was then presumably obtained from the bore, and the concentration of total dissolved solids reported to be about 370 mg/L; this concentration is close to the 500 mg/L level suggested in Evans' (1987) 'Distribution of Total Dissolved Salts' contour map.

The second bore identified during the search, GW404701, was drilled on the southern side of Wickerslack Lane just to the north of the site. It was drilled to a depth of only 15 metres into the Barracks Creek Adamellite, and although the depth and type of water-bearing zones are not known, it had a reported yield of 8.0 L/s and a total dissolved solids concentration of just under 90 mg/L.

Overall, it is expected that bores completed within the fractured units throughout the area will draw moderately fresh water from the regional aquifer, with salinities typically less than 1000 mg/L, and occasionally less than 500 mg/L. On the basis of professional experience and judgement, it is also expected that groundwater bores completed within the Silurian intrusions throughout the area will draw upon relatively fresh groundwater reserves as these units are relatively inert in their mineralogical composition – with quartz and relatively inert feldspars dominating the mineral content.

B.7 Standing Water Levels, Flow Directions and Gradients

An assessment of the DECCW borehole summary worksheets indicates that groundwater is hosted within a number of units in the area, including those of the Colinton Volcanics and associated shales and limestone. Standing water levels in boreholes completed in these formations are generally between 10 and 30 metres below ground level, but deeper groundwater has been recorded where boreholes have been drilled on ridgelines or hillslopes. In these areas the vadose zone can be quite thick.

By contrast, borehole summary worksheet data also indicate that shallower water levels have been noted for those boreholes drilled along relatively undulating areas of the uplands as well as in close proximity to local waterways, including the Queanbeyan River and Jerrabomberra Creek; which flows south to north and does not drain into the Googong Dam catchment. Standing water levels as shallow as 5 to 10 metres (at the time of drilling) have been recorded for a few boreholes in these areas, whilst slightly deeper levels have been noted below the high banks.

Shallow groundwater flow throughout the study area is expected to be heavily influenced by the local topography and the orientation of structural discontinuities, with local and regionally significant peaks and ridges delineating local groundwater divides. As mentioned in Section 3.2 of the report text, groundwater within the study region flows into the Queanbeyan River catchment (both above and below the Googong Dam), with most expected to drain to the north-north-east and lower reaches of the river.

The westernmost limit of the groundwater region that feeds the Googong Dam catchment is the *groundwater divide*. The location of the divide has been estimated from topographic information and available groundwater bore information. Four cross-sections are shown in Figures B2 and B3, with topographic elevations and the expected depths to groundwater. The locations of these cross-sections – in plan view – are shown in Figure B4.

Figures B2 and B3 show the groundwater-table mounding beneath topographic features. The slope of the groundwater table was assessed using the available bore data; the assessment also assumes that groundwater recharge is homogeneous throughout the site (which is a simplification). When the

groundwater divide shown in Figures B2 and B3 is transposed to the plan view map shown in Figure B4, the position of the groundwater divide may be interpolated as shown on Figure 4. Note the comments in Figure B4.

It can thus be seen that the divide lies beneath the potential development area.

It should therefore be noted that during periods of extended drought the water table may decline to depths greater than anticipated. When this occurs, the morphology of the water table will flatten, prompting the location of the groundwater divide to move further to the west due to the declining hydraulic gradients between it (i.e. the groundwater divide) and Googong Dam; this is also expected to occur following the development of Neighbourhoods 3, 4 and 5 in the southern portion of the site, with the amount of movement of the divide to the west dependant partially on the magnitude of change in groundwater recharge in these areas.

Furthermore, given the nature of the underlying profile, one or more perched groundwater tables may be present between the ground surface and the underlying aquifer, particularly where the aquifer is relatively deep and the inherited structural features complex.

The groundwater flow direction in the regional aquifer is considered to be primarily controlled by three factors:

1. the depth of any significant water-bearing zones;
2. the local topography, and to a lesser degree the regional topography; and
3. the structural orientation of the aquifer.

Given these considerations, it is anticipated that groundwater in the Googong–Queanbeyan districts will flow to the north and north-west – in line with the flow of the Queanbeyan and Molonglo rivers – but there may be a more northerly component of groundwater flow in the Googong area where the regionally significant structural alignment appears to be more imprinted into the landscape.

Owing to the lack of data on groundwater depths in the regional aquifer, it is not possible to provide any further definition of the hydraulic gradient or flow direction.

B.8 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 (Evans 1987).

Recharge of the aquifers would occur mainly via infiltration of rainfall, infiltration of slope runoff, and outflow from the Queanbeyan River and Jerrabomberra Creek (and other watercourses) during periods of high flow and flooding events. Leakage from a number of dams across the site is also expected to be a point source for recharge. Overall, recharge in the area is expected to be limited by the generally low rainfall, particularly during the winter months.

Discharge from the aquifer is thought to occur primarily through natural flow from springs, both perennial and ephemeral, and from baseflow into perennial watercourses. Other discharges from the aquifer include bore pumping for domestic, stock and irrigation purposes. Leakage is also expected from the overlying alluvial aquifers along locally significant creek alignments into the underlying regional aquifer. It should be noted that leakage may be enhanced in some areas owing to the nature and interconnectivity of solution channels which may exist in some of the limestones in the area, these channels can form quite complex and far-reaching subterranean drainage systems.

As outlined in Section 5.5, groundwater chemistry data suggest that recharge in the surrounding region preferentially occurs from the base of thick porous alluvium in the valley floors, as opposed to hill slope and hilltop regions. Within the study region however, there is minimal alluvium, and most recharge is expected to be derived from the infiltration of rainfall excess across much of the site, where slopes are less than 4 or 5°.

No springs or 'soaks' were observed at the site, but it is noted that the assessment was carried out in a relatively dry period. No significant rain had fallen in the area for some time.

Catchment water balance estimates indicate that post development, the amount of water available for groundwater recharge at the site will decline by up to 70%.

This net loss of water available for groundwater recharge will result in declining water levels across most – if not all – of the site, which will in turn result in reduced baseflows to waterways downgradient of the site, and a reduced amount of water stored in the aquifer. This will inevitably result in thinner saturated water-bearing zones throughout the area, and most likely reduced borehole yields for any bores drilled at the site.

Given that a groundwater divide is expected to be present in the vicinity of the 'Hill 800' in the south-western corner of the site, no long-term detrimental impacts on water levels or aquifer yields are expected in any of the bores drilled in the Fernleigh Estate on the opposite side of Old Cooma Road.

B.9 Utilisation

Groundwater in the area is predominantly used for a combination of domestic and stock purposes. Of the 48 bores located within a 6-kilometre radius of the centre of the site, all but a few are registered for such use, and only a few appear to have achieved yields that would satisfy all the water requirements of a property without some form of reliance on surface water supplies.

Boreholes that have achieved such yields include the following.

- GW063668, GW403149 and GW404701, all of which have been registered for stock and domestic use, and have been drilled at the Fernleigh Estate to the south-west of the site. These bores were completed in fractured water-bearing zones in the tuffs and ignimbrites of the Colinton Volcanics and have reported yields of 4.6, 9.0 and 12.5 L/s respectively; bore depths were between 15 and 42 metres, but the recorded reference to granite in these bores is thought to be erroneous.
- GW020890 and GW020892 which have been drilled on either side of Old Cooma Road about 2 kilometres south-west of the site. These bores were completed in fractured tuffs and ignimbrites of the Colinton Volcanics at depths of less than 20 metres, and had reported yields of 2.1 and 2.5 L/s respectively; again, the recorded reference to porphyry is thought to be erroneous.
- GW061449, GW402859, GW404534 and GW404701, which were drilled to the north of the site at a number of rural residential allotments fronting Heights Road. These bores have all been registered for stock and/or domestic uses, and reportedly intersected water-bearing zones between 15 and 70 metres' depth. They were completed in a number of varying geological units; these were identified as shale, slate and granite on the borehole summary worksheets, but reference to the Canberra geological map sheet indicates that all were completed in varying units of the Colinton Volcanics, including the north-north-easterly orientated tuffaceous shale unit, which runs through the centre of the site. Yields from these bores ranged between 2.0 and 8.0 L/s, and the highest was recorded in GW404701 which was drilled to a depth of only 15 metres. Unfortunately, the summary worksheet for this bore provided no information regarding the geological material encountered or the depth and type of water-bearing zones.

All of the abovementioned bores were drilled to depths of between 15 and 70 metres, were completed in fractured aquifers, and reported yields between approximately 2 and 12.5 L/s. The remaining bores in the study area, however, appear to have achieved only small yields – between approximately 0.2 and 1.0 L/s – and appear to be used predominantly to augment existing surface water supplies on rural or residential properties throughout the area.

Two boreholes (GW047361 and GW403321) identified during the search are registered for industrial purposes. Both are located at the CSR hard-rock quarry, about 1 kilometre north-west of the site (on the western side of Old Cooma Road). They were drilled to depths of 61 and 108 metres respectively. Both bores encountered fractured water-bearing zones in the Colinton Volcanics and possibly the underlying Barracks Creek Adamellite, but only GW403321 has a recorded yield (about 1.4 L/s). Unfortunately no other information of significance was provided on the borehole summary worksheets for these bores.

No boreholes registered for municipal purposes were identified in the study area.

It should be noted that bore yields are invariably estimates, based on information supplied by drillers. This information is often obtained from short-term tests, and often therefore the yields cited is not the true long-term yield of the bore.

Information derived from the DECCW's database, for all of the bores identified in the search is summarised in Table B1.

B.10 Groundwater Vulnerability

Agsol (2009) notes that most of the site is located within an area of moderate groundwater vulnerability. This characteristic is true for much of the surrounding region, including the existing urban areas of Queanbeyan. Factors contributing to this classification include depth to groundwater, soil and aquifer type, topographic factors (namely slope and runoff potential), recharge potential, and the thickness and hydraulic properties of the aquifer and vadose zone.

The central portion of the site is mapped as having a 'moderate to low' vulnerability; this portion of the site is underlain by the Colinton Volcanics, but is differentiated from other areas owing to its low topographic expression.

One area within the study site is mapped as having a 'moderate to high' vulnerability. This area is located in the south-western corner of the site immediately adjacent to Old Cooma Road, and it is thought that this classification was assigned because of the relatively porous nature of the soils in this area and the (expected) shallow depth to bedrock. Agsol notes, however, that no recycled water irrigation will occur in this area.

APPENDIX C

Copies of the NOW Borehole Summary Worksheets for Registered Boreholes in the Googong District

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW404070

Works Details (top)

GROUNDWATER NUMBER	GW404070
LIC-NUM	40BL190823
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	New Bore
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	2007-01-15
FINAL-DEPTH (metres)	96.00
DRILLED-DEPTH (metres)	96.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	20.00
SALINITY	
YIELD	0.82

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-2S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6081362.00
EASTING	704637.00
LATITUDE	35 23' 24"
LONGITUDE	149 15' 11"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	QUEANBEYAN
PORTION-LOT-DP	66 754907

Licensed (top)

COUNTY	MURRAY
PARISH	QUEANBEYAN
PORTION-LOT-DP	66 754907

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter; ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	96.00	200			Rotary Air
1	1	Backfill	Drilled cuttings	89.00	96.00	150			
1	1	Casing	PVC Class 9	-0.30	90.00	150	135.8		Riveted and Glued; Seated on Bottom; Open End
1	1	Casing	GAB Monitoring Point	0.00	96.00				
1	1	Opening	Slots - Vertical	60.00	66.00	150			PVC Class 9; Casing - Hand Sawn Slot; SL: 200mm; A: 2mm; Screwed

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
60.00	66.00	6.00		20.00		0.76			
75.00	76.00	1.00		20.00		0.06			

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	4.00	4.00	CLAY		
4.00	96.00	92.00	SHALE - BLACK		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW404089

Works Details (top)

GROUNDWATER NUMBER	GW404089
LIC-NUM	40BL189055
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	New Bore
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	2007-06-01
FINAL-DEPTH (metres)	81.00
DRILLED-DEPTH (metres)	81.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6079795.00
EASTING	702545.00
LATITUDE	35 24' 17"
LONGITUDE	149 13' 50"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	2//219695

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	2 219695

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	81.00	125			Rotary Air
1	1	Casing	PVC Class 9	0.00	81.00	125	115		(Unknown); Driven into small hole; (Unknown)
1	1	Opening	Slots	51.00	81.00	125			PVC Class 9; (Unknown); Glued

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
0.00	75.00	75.00		20.00				1.00	

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	2.00	2.00	CLAY		
2.00	28.00	26.00	SHALE - BLUE		
28.00	39.00	11.00	SHALE - BLUE-BROWN		
39.00	53.00	14.00	SHALE - BLUE		
53.00	81.00	28.00	SHALE - BLUE-BROWN		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW404400

Works Details (top)

GROUNDWATER NUMBER	GW404400
LIC-NUM	40BL186767
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	New Bore
CONSTRUCTION-METHOD	Rotary - Percussion (Down Hole Hammer)
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1998-03-01
FINAL-DEPTH (metres)	66.00
DRILLED-DEPTH (metres)	
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	LOT 16
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	20.00
SALINITY	
YIELD	0.40

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6077786.00
EASTING	700289.00
LATITUDE	35 25' 24"
LONGITUDE	149 12' 22"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	16//747879

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	16 747879

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	66.00	160			Rotary - Percussion (Down Hole Hammer)
1	1	Casing	PVC Class 9	0.00	16.00	160			(Unknown)

Water Bearing Zones (top)

no details

Drillers Log (top)

no details

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW404573

Works Details (top)

GROUNDWATER NUMBER	GW404573
LIC-NUM	40BL188401
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	New Bore
CONSTRUCTION-METHOD	(Unknown)
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	2001-12-02
FINAL-DEPTH (metres)	95.00
DRILLED-DEPTH (metres)	
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	85.00
SALINITY	
YIELD	2.20

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6081273.00
EASTING	704106.00
LATITUDE	35 23' 28"
LONGITUDE	149 14' 50"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	11//218720

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	11 218720

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	95.00	150			(Unknown)
1	1	Casing	P.V.C.	0.00	95.00	150			(Unknown)

Water Bearing Zones (top)

no details

Drillers Log (top)

no details

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW404701

Works Details (top)

GROUNDWATER NUMBER	GW404701
LIC-NUM	40BL191905
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	Supply Obtained
CONSTRUCTION-METHOD	(Unknown)
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1978-01-01
FINAL-DEPTH (metres)	15.00
DRILLED-DEPTH (metres)	
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	10.00
SALINITY	87.00
YIELD	8.00

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6081275.00
EASTING	703553.00
LATITUDE	35 23' 28"
LONGITUDE	149 14' 28"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	6//220189

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	6 220189

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	15.00	150			(Unknown)
1	1	Casing	P.V.C.	0.00	13.00	150			(Unknown)

Water Bearing Zones (top)

no details

Drillers Log (top)

no details

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW404883

Works Details (top)

GROUNDWATER NUMBER	GW404883
LIC-NUM	40BL143698
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	Supply Obtained
CONSTRUCTION-METHOD	(Unknown)
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1991-11-01
FINAL-DEPTH (metres)	10.00
DRILLED-DEPTH (metres)	
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	1.00

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6075783.00
EASTING	699399.00
LATITUDE	35 26' 29"
LONGITUDE	149 11' 49"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	100//775098

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	100 775098

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	10.00	400			(Unknown)
1	1	Casing	Steel	0.00	10.00	400			(Unknown)

Water Bearing Zones (top)

no details

Drillers Log (top)

no details

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW405005

Works Details (top)

GROUNDWATER NUMBER	GW405005
LIC-NUM	40BL189701
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	Supply Obtained
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	2008-09-22
FINAL-DEPTH (metres)	66.00
DRILLED-DEPTH (metres)	66.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N / A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	10.00
SALINITY	
YIELD	0.32

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6075632.00
EASTING	699568.00
LATITUDE	35 26' 34"
LONGITUDE	149 11' 55"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GPS - Global Positioning System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	99//775098

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	99 775098

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	66.00	200			Rotary Air
1	1	Casing	PVC Class 9	0.40	66.00	140	129		Screwed and Glued; Seated on Bottom; End cap
1	1	Opening	Slots - Horizontal	54.00	60.00	140			PVC Class 9; Casing - Machine Slotted; SL: 200mm; A: 2mm; Screwed and Glued

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
61.00	61.90	0.90		10.00		0.32			

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	2.00	2.00	Topsoil		
2.00	66.00	64.00	Granite, blue		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW020890

Works Details (top)

GROUNDWATER NUMBER	GW020890
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	NOT KNOWN
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1952-10-01
FINAL-DEPTH (metres)	19.80
DRILLED-DEPTH (metres)	19.80
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6074441.00
EASTING	699866.00
LATITUDE	35 27' 12"
LONGITUDE	149 12' 8"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	62

Licensed (top)

no details

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Threaded Steel	0.00	20.50	127			(Unknown)
1	1	Opening	Perforations		6.30	127		1	Slotted On Site; SL: 0mm; A: 0mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
9.10	9.10	0.00	Fractured			0.19			(Unknown)
15.50	15.50	0.00	Fractured						(Unknown)
19.80	19.80	0.00	Fractured	0.00		1.90			(Unknown)

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	5.79	5.79	Clay Yellow		
5.79	12.19	6.40	Porphyry Decomposed Water Supply		
12.19	16.76	4.57	Porphyry Water Supply		
16.76	18.29	1.53	Porphyry Hard		
18.29	19.81	1.52	Porphyry Water Supply		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW020892

Works Details (top)

GROUNDWATER NUMBER	GW020892
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	NOT KNOWN
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1952-11-01
FINAL-DEPTH (metres)	20.40
DRILLED-DEPTH (metres)	20.40
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6074069.00
EASTING	699959.00
LATITUDE	35 27' 24"
LONGITUDE	149 12' 12"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	48

Licensed (top)

no details

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Threaded Steel	0.00	20.00	127			(Unknown)
1	1	Opening	Perforations		6.20	127		1	SL: 0mm; A: 0mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
6.70	6.70	0.00	Fractured			0.00			(Unknown)
8.50	8.50	0.00	Fractured			0.19			(Unknown)
18.30	18.30	0.00	Fractured	2.10		2.27			(Unknown)

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	2.13	2.13	Clay Yellow		
2.13	12.80	10.67	Porphyry Decomposed Water Supply		
12.80	14.63	1.83	Porphyry		
14.63	17.68	3.05	Porphyry Decomposed		
17.68	20.42	2.74	Porphyry Water Supply		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW020893

Works Details (top)

GROUNDWATER NUMBER	GW020893
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	NOT KNOWN
WORK-TYPE	Bore
WORK-STATUS	Collapsed Bore
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1952-10-01
FINAL-DEPTH (metres)	0.00
DRILLED-DEPTH (metres)	13.70
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6073924.00
EASTING	700940.00
LATITUDE	35 27' 28"
LONGITUDE	149 12' 51"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	48

Licensed (top)

no details

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Backfill	Backfill	0.00	13.70	0			

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
6.70	6.70	0.00	Fractured			0.00			(Unknown)
8.50	8.50	0.00	Fractured			0.19			(Unknown)

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	2.13	2.13	Clay Yellow		
2.13	4.57	2.44	Gravel		
4.57	12.50	7.93	Porphyry Decomposed Water Supply		
12.50	13.72	1.22	Porphyry		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW020903

Works Details (top)

GROUNDWATER NUMBER	GW020903
LIC-NUM	40BL027544
AUTHORISED-PURPOSES	STOCK
INTENDED-PURPOSES	STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1953-01-01
FINAL-DEPTH (metres)	0.00
DRILLED-DEPTH (metres)	7.90
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	FERNLEIGH PARK
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6074400.00
EASTING	700345.00
LATITUDE	35 27' 13"
LONGITUDE	149 12' 27"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	62

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	62

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Backfill	Backfill	0.00	7.90	0			

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	4.88	4.88	Clay Yellow Some Sand		
4.88	7.01	2.13	Granite		
7.01	7.92	0.91	Porphyry Very Hard		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW020904

Works Details (top)

GROUNDWATER NUMBER	GW020904
LIC-NUM	40BL025372
AUTHORISED-PURPOSES	STOCK
INTENDED-PURPOSES	STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1953-02-01
FINAL-DEPTH (metres)	19.80
DRILLED-DEPTH (metres)	19.80
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	FERNLEIGH PARK
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6074277.00
EASTING	700317.00
LATITUDE	35 27' 17"
LONGITUDE	149 12' 26"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	62

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	62

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Threaded Steel	-0.30	10.70	152			Driven into Hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
19.80	19.80	0.00	Fractured	1.20		0.42			(Unknown)

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	1.83	1.83	Clay Yellow Sand		
1.83	9.45	7.62	Clay Yellow Some Sand		
1.83	9.45	7.62	Quartz		
9.45	10.36	0.91	Clay Yellow Sand		
10.36	11.28	0.92	Porphyry Decomposed		
11.28	19.81	8.53	Porphyry Water Supply		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW047361

Works Details (top)

GROUNDWATER NUMBER	GW047361
LIC-NUM	40BL107457
AUTHORISED-PURPOSES	INDUSTRIAL
INTENDED-PURPOSES	INDUSTRIAL
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1978-03-01
FINAL-DEPTH (metres)	61.00
DRILLED-DEPTH (metres)	61.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6080431.00
EASTING	702246.00
LATITUDE	35 23' 56"
LONGITUDE	149 13' 37"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	103

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	103

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil		
0.30	7.30	7.00	Sandstone		
7.30	7.90	0.60	Clay		
7.90	8.80	0.90	Shale Yellow		
8.80	61.00	52.20	Granite Porphyry		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW050004

Works Details (top)

GROUNDWATER NUMBER	GW050004
LIC-NUM	40BL110018
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1979-02-01
FINAL-DEPTH (metres)	57.50
DRILLED-DEPTH (metres)	57.50
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6080747.00
EASTING	703238.00
LATITUDE	35 23' 45"
LONGITUDE	149 14' 16"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	L23 DP226218 (95)

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	23 226218

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	57.50	130			Seated on Bottom
1	1	Opening	Perforations	51.60	57.20	130		1	Slotted In Hole; SL: 0mm; A: 3mm
1	1	Annulus	(Unknown)	0.00	57.50	160			Graded; GS: 3-6mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
51.70	57.20	5.50	(Unknown)	14.20		0.15			Fresh

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil		
0.30	2.50	2.20	Clay Sandy		
2.50	4.60	2.10	Shale Decomposed		
4.60	30.10	25.50	Shale		
30.10	57.50	27.40	Shale Water Supply		
30.10	57.50	27.40	Siltstone Bands		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW050980

Works Details (top)

GROUNDWATER NUMBER	GW050980
LIC-NUM	40BL110586
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore open thru rock
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1979-07-01
FINAL-DEPTH (metres)	35.40
DRILLED-DEPTH (metres)	35.40
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6081034.00
EASTING	702815.00
LATITUDE	35 23' 36"
LONGITUDE	149 13' 59"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	120

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	120

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	17.20	130			Seated

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
32.90	33.50	0.60	Fractured	11.60		1.10			Fresh

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil		
0.30	3.40	3.10	Clay Sandy		
3.40	16.00	12.60	Granite Decomposed		
16.00	32.90	16.90	Granite Green		
32.90	33.50	0.60	Granite Porphyry Water Supply		
33.50	35.40	1.90	Granite Green		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW061449

Works Details (top)

GROUNDWATER NUMBER	GW061449
LIC-NUM	40BL191516
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore open thru rock
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1985-11-01
FINAL-DEPTH (metres)	80.00
DRILLED-DEPTH (metres)	80.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	TALPA COUNTRY ESTATE P/L
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6080507.00
EASTING	702980.00
LATITUDE	35 23' 53"
LONGITUDE	149 14' 6"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1 285358

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1 285358

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Threaded Steel	-1.00	10.00	152			(Unknown)

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
21.00	40.00	19.00	Fractured			0.56			Hard
41.00	56.00	15.00	Fractured			0.44			Hard
57.00	64.00	7.00	Fractured			0.33			Hard
65.00	70.00	5.00	Fractured			0.67			Hard

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.31	0.31	Topsoil		
0.31	10.06	9.75	Shale Some Broken Bands		
10.06	70.10	60.04	Granite Water Supply		
10.06	70.10	60.04	Shale Bands		
70.10	80.00	9.90	Granite		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW061599

Works Details (top)

GROUNDWATER NUMBER	GW061599
LIC-NUM	40BL133089
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1985-07-01
FINAL-DEPTH (metres)	56.10
DRILLED-DEPTH (metres)	56.10
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6081167.00
EASTING	703752.00
LATITUDE	35 23' 31"
LONGITUDE	149 14' 36"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	L12 DP226218 (46)

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	12 226218

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Welded Steel	-0.30	30.50	165			Driven into Hole
1	1	Opening	Slots - Vertical	27.40	30.50	165		1	Oxy-Acetylene Slotted; SL: 0mm; A: 2mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
29.20	29.50	0.30	Fractured	11.60		0.12			Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil		
0.30	4.90	4.60	Granite Decomposed		
4.90	30.50	25.60	Granite Some Soft Bands Water Supply		
30.50	56.10	25.60	Granite		

should be sought in interpreting and using this data.

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW063668

Works Details (top)

GROUNDWATER NUMBER	GW063668
LIC-NUM	40BL135255
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1986-09-01
FINAL-DEPTH (metres)	22.90
DRILLED-DEPTH (metres)	22.90
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6076579.00
EASTING	700772.00
LATITUDE	35 26' 2"
LONGITUDE	149 12' 42"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	106

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	106

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Backfill	Backfill	15.20	22.80	0			
1	1	Casing	P.V.C.	-0.30	15.20	152			(Unknown)
1	1	Opening	Slots	11.30	15.30	152		1	SL: 0mm; A: 0mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
11.90	14.90	3.00	Fractured			1.26			(Unknown)
16.80	18.30	1.50	Fractured	4.90		3.28			(Unknown)

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.91	0.91	Topsoil Clay		
0.91	15.24	14.33	Granite Soft Bands Water Supply		
15.24	22.86	7.62	Granite Water Supply		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW064429

Works Details (top)

GROUNDWATER NUMBER	GW064429
LIC-NUM	40BL136581
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1919-01-01
FINAL-DEPTH (metres)	45.70
DRILLED-DEPTH (metres)	45.70
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6076944.00
EASTING	700982.00
LATITUDE	35 25' 50"
LONGITUDE	149 12' 50"
GS-MAP	0077A2

AMG-ZONE	55
COORD-SOURCE	PR.,ACC.MAP
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	L5 DP260066 (106)

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	PT LT6 DP260066

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Steel	0.00	7.30	152			(Unknown)

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
18.30	27.40	9.10	Fractured			1.26			(Unknown)

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	2.44	2.44	Overburden Weathered		
2.44	30.48	28.04	Rock Volcanic Water Supply		
30.48	45.72	15.24	Rock Solid		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW067501

Works Details (top)

GROUNDWATER NUMBER	GW067501
LIC-NUM	40BL139815
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	1989-10-08
COMPLETION-DATE	1989-10-12
FINAL-DEPTH (metres)	42.00
DRILLED-DEPTH (metres)	42.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	30.00
SALINITY	
YIELD	0.69

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6076145.00
EASTING	700342.00
LATITUDE	35 26' 17"
LONGITUDE	149 12' 26"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT31 DP747879

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	31 747879

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	42.00	150			Rotary Air
1	1	Casing	PVC Class 9	0.00	2.50	150			Driven into Hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
33.00	37.00	4.00	Fractured	30.00		0.69			Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	2.50	2.50	Decomposed Shale		
2.50	20.00	17.50	Hard Black Shale		
20.00	42.00	22.00	Black Granite		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW069070

Works Details (top)

GROUNDWATER NUMBER	GW069070
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1991-02-07
FINAL-DEPTH (metres)	57.00
DRILLED-DEPTH (metres)	57.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6081462.00
EASTING	703227.00
LATITUDE	35 23' 22"
LONGITUDE	149 14' 15"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	PR.,ACC.GIS
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	L5 DP218719

Licensed (top)

no details

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	12.00	152			Driven into Hole

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	18.00	18.00	Decomposed Granite		
18.00	57.00	39.00			

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW400206

Works Details (top)

GROUNDWATER NUMBER	GW400206
LIC-NUM	40BL186435
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1997-04-28
FINAL-DEPTH (metres)	39.60
DRILLED-DEPTH (metres)	39.60
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	4.60
SALINITY	
YIELD	0.76

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6076761.00
EASTING	700927.00
LATITUDE	35 25' 56"
LONGITUDE	149 12' 48"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT 3 DP 747879

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	3 747879

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	39.60	165			Rotary
1	1	Casing	P.V.C.	-0.30	24.40	150			Glued; Driven into Hole
1	1	Opening	Slots - Vertical	22.80	24.40	150			PVC; Sawn; SL: 457mm; A: 2mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
22.80	24.40	1.60		4.60		0.76	24.40		Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil.		
0.30	3.00	2.70	Clay.		
3.00	24.40	21.40	Soft shale.		
24.40	39.60	15.20	Hard shale.		

should be sought in interpreting and using this data.

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW400504

Works Details (top)

GROUNDWATER NUMBER	GW400504
LIC-NUM	40BL186066
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rot. Rev. Circ. Air
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1994-12-05
FINAL-DEPTH (metres)	60.80
DRILLED-DEPTH (metres)	60.80
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	3.00
SALINITY	
YIELD	0.38

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6076034.00
EASTING	699388.00
LATITUDE	35 26' 21"
LONGITUDE	149 11' 48"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	TUGGERANONG
PORTION-LOT-DP	LT 93 DP 775098

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	93 775098

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	3.80	200			Rotary Air
1		Hole	Hole	3.80	60.80	168			Down Hole Hammer
1	1	Casing	Steel	-0.40	4.00	168	159		

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
10.60	10.90	0.30		3.00	15.00	0.38	15.00	0.60	

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.10	0.10	TOP SOIL		
0.10	3.50	3.40	CLAYS		
3.50	4.00	0.50	WEATHERED DACITE		
4.00	60.80	56.80	DACITE		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW400530

Works Details (top)

GROUNDWATER NUMBER	GW400530
LIC-NUM	40BL143313
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1994-08-27
FINAL-DEPTH (metres)	
DRILLED-DEPTH (metres)	
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	13.00
SALINITY	
YIELD	0.38

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6081020.00
EASTING	703471.00
LATITUDE	35 23' 36"
LONGITUDE	149 14' 25"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT30 DP226218

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT30 DP226218

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	0.00	150			

Water Bearing Zones (top)

no details

Drillers Log (top)

no details

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW400534

Works Details (top)

GROUNDWATER NUMBER	GW400534
LIC-NUM	40BL143442
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1991-12-10
FINAL-DEPTH (metres)	30.00
DRILLED-DEPTH (metres)	30.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6080372.00
EASTING	702094.00
LATITUDE	35 23' 58"
LONGITUDE	149 13' 31"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	QUEANBEYAN
PORTION-LOT-DP	LT1 DP747879

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1 747879

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	30.00	150			Seated on Bottom

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
13.50	14.00	0.50		2.00		0.75	14.30	0.50	Good
25.00	25.20	0.20		1.00		1.50	30.00	0.50	Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	10.00	10.00	CLAY & WEATHERED SLATE		
10.00	30.00	20.00	HARD GREY SLATE		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW400714

Works Details (top)

GROUNDWATER NUMBER	GW400714
LIC-NUM	40BL186909
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1998-05-07
FINAL-DEPTH (metres)	72.00
DRILLED-DEPTH (metres)	72.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6080996.00
EASTING	703412.00
LATITUDE	35 23' 37"
LONGITUDE	149 14' 23"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT 15 DP 226218

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	15 226218

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	16.50	181			Rotary Air
1		Hole	Hole	16.50	72.00	152			Rotary Air
1	1	Casing	PVC Class 9	-5.00	16.50	150			Glued; Driven into Hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
48.00	49.00	1.00		16.00		0.12	49.00		

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	1.00	1.00	Clay		
1.00	15.00	14.00	Soft shale		
15.00	72.00	57.00	Granite		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW400813

Works Details (top)

GROUNDWATER NUMBER	GW400813
LIC-NUM	40BL187230
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1998-04-22
FINAL-DEPTH (metres)	54.00
DRILLED-DEPTH (metres)	54.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	22.00
SALINITY	
YIELD	0.20

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6076187.00
EASTING	699672.00
LATITUDE	35 26' 16"
LONGITUDE	149 11' 59"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT 70 DP 775098

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	70 775098

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	54.00	203			Down Hole Hammer
1	1	Casing	PVC Class 9	33.00	54.00	160			Screwed and Glued
1	1	Opening	Slots - Vertical	33.00	54.00	160			PVC Class 9; Oxy-Acetylene Slotted; SL: 220mm; A: 3mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
30.00	32.00	2.00		22.00	32.00	0.25	35.00	0.50	Fresh
46.00	48.00	2.00		22.00	32.00	0.13	54.00	1.00	

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.50	0.50	Brown clay		
0.50	12.00	11.50	Yellow brown soft granite		
12.00	54.00	42.00	Hard grey black granite		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW401001

Works Details (top)

GROUNDWATER NUMBER	GW401001
LIC-NUM	40BL187648
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1999-07-30
FINAL-DEPTH (metres)	80.00
DRILLED-DEPTH (metres)	80.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	LOT 5
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6081109.00
EASTING	704013.00
LATITUDE	35 23' 33"
LONGITUDE	149 14' 47"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT 5 IN DP 218720

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	5 218720

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	42.00	165			Rotary Air
1		Hole	Hole	42.00	80.00	140			Rotary Air
1	1	Casing	PVC Class 9	-0.40	42.00	125			Glued; Driven into Hole
1	1	Opening	Slots - Vertical	30.00	42.00	125			PVC Class 9; SL: .3mm; A: 2mm
1		Annulus	Waterworn/Rounded	0.00	42.00				Graded; GS: 5mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
30.00	42.00	12.00		12.00		0.08	80.00		Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	20.00	20.00	Weathered granite		

20.00	80.00	60.00	Pink granite

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW401068

Works Details (top)

GROUNDWATER NUMBER	GW401068
LIC-NUM	40BL187721
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1999-10-21
FINAL-DEPTH (metres)	36.00
DRILLED-DEPTH (metres)	36.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	10.00
SALINITY	
YIELD	1.00

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6073854.00
EASTING	699493.00
LATITUDE	35 27' 32"
LONGITUDE	149 11' 54"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LOT 17 DP 587961

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	17 587961

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	36.00	162			Rotary Air
1	1	Casing	PVC Class 9	-0.50	36.00	130			Glued; Seated on Bottom
1	1	Opening	Slots	24.00	36.00	130			PVC Class 9

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
27.00	34.00	7.00		10.00		1.00	36.00	1.00	

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.50	0.50	Top soil		
0.50	2.00	1.50	Soft shale		
2.00	12.00	10.00	Brown shale		
12.00	19.00	7.00	Broken brown shale		
19.00	36.00	17.00	Grey shale		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW401428

Works Details (top)

GROUNDWATER NUMBER	GW401428
LIC-NUM	40BL143274
AUTHORISED-PURPOSES	STOCK
INTENDED-PURPOSES	STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	(Unknown)
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1991-04-19
FINAL-DEPTH (metres)	53.00
DRILLED-DEPTH (metres)	
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	9.00
SALINITY	0.10
YIELD	0.19

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6077941.00
EASTING	699724.00
LATITUDE	35 25' 19"
LONGITUDE	149 11' 60"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT2O DP747879

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT2O DP747879

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	53.00	150			(Unknown)
1	1	Casing	P.V.C.	0.00	7.50	150			

Water Bearing Zones (top)

no details

Drillers Log (top)

no details

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW401683

Works Details (top)

GROUNDWATER NUMBER	GW401683
LIC-NUM	40BL188131
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2001-05-23
FINAL-DEPTH (metres)	121.00
DRILLED-DEPTH (metres)	121.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	0.13

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6075584.00
EASTING	699913.00
LATITUDE	35 26' 35"
LONGITUDE	149 12' 9"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	CARWOOLA
PORTION-LOT-DP	LOT101 DP775098

Licensed (top)

COUNTY	MURRAY
PARISH	CARWOOLA
PORTION-LOT-DP	101 775098

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	30.00	187.3			Rotary Air
1		Hole	Hole	30.00	121.00	133.3			Rotary Air
1	1	Casing	PVC Class 9	0.00	30.00	150	132		Glued; Driven into Hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
75.00	75.50	0.50		30.00		0.06	73.00	0.50	Good
115.00	115.50	0.50				0.06	121.00	0.50	Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	1.00	1.00	TOPSOIL		
1.00	12.00	11.00	GRANITE, DECOMPOSED		
12.00	29.00	17.00	GRANITE, BROKEN		
29.00	121.00	92.00	GRANITE, GREY		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW401763

Works Details (top)

GROUNDWATER NUMBER	GW401763
LIC-NUM	40BL186454
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1997-05-07
FINAL-DEPTH (metres)	99.10
DRILLED-DEPTH (metres)	99.10
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	30.50
SALINITY	
YIELD	0.05

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6081384.00
EASTING	704113.00
LATITUDE	35 23' 24"
LONGITUDE	149 14' 50"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT 15 DP 218720

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	15 218720

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	99.10	165			Rotary Air
1	1	Casing	PVC Class 9	-0.30	24.40	165			Glued; Driven into Hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
54.80	55.20	0.40		30.50		0.05	55.20		Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	TOPSOIL		
0.30	9.10	8.80	CLAY, RED		
9.10	24.40	15.30	GRANITE, SOFT		
24.40	99.10	74.70	GRANITE, HARD		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW401991

Works Details (top)

GROUNDWATER NUMBER	GW401991
LIC-NUM	40BL145336
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	STOCK
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1992-02-05
FINAL-DEPTH (metres)	48.00
DRILLED-DEPTH (metres)	48.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	15.00
SALINITY	
YIELD	1.10

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6075948.00
EASTING	699676.00
LATITUDE	35 26' 24"
LONGITUDE	149 11' 59"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT104 DP775098

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	104 775098

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	48.00	180			Rotary Air
1	1	Casing	P.V.C.	0.00	6.00	160			Driven into Hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
42.00	44.00	2.00		15.00	42.00	1.10	48.00	1.00	Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	6.00	6.00	Granite, decomposed		
6.00	40.00	34.00	Dacite		
40.00	48.00	8.00	Granite		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW402109

Works Details (top)

GROUNDWATER NUMBER	GW402109
LIC-NUM	40BL188916
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	Down Hole Hammer
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2002-12-02
FINAL-DEPTH (metres)	23.00
DRILLED-DEPTH (metres)	23.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	11.00
SALINITY	370.00
YIELD	12.50

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6076288.00
EASTING	701108.00
LATITUDE	35 26' 12"
LONGITUDE	149 12' 56"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GPS - Global Positioning System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT1 DP260066

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	2 1088510

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	23.00	200			Down Hole Hammer
1	1	Casing	PVC Class 9	-0.40	23.00	160			Screwed; Seated on Bottom
1	1	Opening	Slots - Vertical	17.00	23.00	160			PVC Class 9; SL: 120mm; A: 2mm
1		Annulus	Waterworn/Rounded	0.00	23.00				(Unknown) GS: 7-10mm; Q: 1.5m³

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
18.00	23.00	5.00		11.00		12.50	23.00	1.00	370.00

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	4.00	4.00	Clay, loamy		
4.00	18.00	14.00	Shale, weathered soft yellow		
18.00	23.00	5.00	Volcanic, large cavity		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW402157

Works Details (top)

GROUNDWATER NUMBER	GW402157
LIC-NUM	40BL188998
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	Down Hole Hammer
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2003-01-25
FINAL-DEPTH (metres)	66.00
DRILLED-DEPTH (metres)	66.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	20.00
SALINITY	
YIELD	0.50

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6078475.00
EASTING	701815.00
LATITUDE	35 25' 0"
LONGITUDE	149 13' 22"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT147 DP41994

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	147 41994

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	66.00	175			Down Hole Hammer
1	1	Casing	PVC Class 9	-0.50	66.00	139	125		Glued; Driven into Hole; Cap
1	1	Opening	Slots - Vertical	21.00	30.00	139			PVC Class 9; Sawn; SL: 200mm; A: 2mm
1	1	Opening	Slots - Vertical	48.00	66.00	139			PVC Class 9; Sawn; SL: 200mm; A: 2mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
25.00	31.00	6.00		20.00		0.13		0.50	
48.00	54.00	6.00		20.00		0.13		0.50	
55.00	58.00	3.00		20.00		0.13		0.50	
60.00	63.00	3.00		20.00		0.13		0.50	

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	23.00	23.00	Shale, soft		
23.00	66.00	43.00	Granite		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW402298

Works Details (top)

GROUNDWATER NUMBER	GW402298
LIC-NUM	40BL189226
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	Down Hole Hammer
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2003-03-24
FINAL-DEPTH (metres)	85.00
DRILLED-DEPTH (metres)	85.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	51.00
SALINITY	
YIELD	0.38

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6076116.00
EASTING	699627.00
LATITUDE	35 26' 18"
LONGITUDE	149 11' 57"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT71 DP775098

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	71 775098

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	85.00	175			Down Hole Hammer
1	1	Casing	PVC Class 9	-0.30	85.00	139	125		Riveted; Driven into Hole
1	1	Opening	Slots - Vertical	50.00	60.00	139			PVC Class 9; Casing - Hand Sawn Slot; SL: 200mm; A: 2mm
1	1	Opening	Slots - Vertical	62.00	68.00	139			PVC Class 9; Casing - Hand Sawn Slot; SL: 200mm; A: 2mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
54.00	55.00	1.00		51.00		0.19		0.50	
66.00	67.00	1.00		51.00		0.19		0.50	

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	9.00	9.00	Shale, soft yellow		
9.00	55.00	46.00	Shale, grey		
55.00	85.00	30.00	Granite, soft		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW402348

Works Details (top)

GROUNDWATER NUMBER	GW402348
LIC-NUM	40BL188945
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	(Unknown)
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2003-01-14
FINAL-DEPTH (metres)	45.00
DRILLED-DEPTH (metres)	45.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	0.44

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6076830.00
EASTING	700407.00
LATITUDE	35 25' 55"
LONGITUDE	149 12' 28"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT11 DP747879

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	11 747879

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	30.00	200			(Unknown)
1		Hole	Hole	30.00	45.00	133			(Unknown)
1	1	Casing	PVC Class 9	-0.30	30.00	155			Glued; Driven into Hole; Driven into small hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
32.00	33.00	1.00				0.44			

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil		
0.30	3.00	2.70	Clay		
3.00	31.00	28.00	Shale, soft		
31.00	45.00	14.00	Shale, hard		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW402383

Works Details (top)

GROUNDWATER NUMBER	GW402383
LIC-NUM	40BL187889
AUTHORISED-PURPOSES	TEST BORE
INTENDED-PURPOSES	TEST BORE
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2000-03-20
FINAL-DEPTH (metres)	122.00
DRILLED-DEPTH (metres)	122.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	LOT 6
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	0.33

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-2S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6079776.00
EASTING	704602.00
LATITUDE	35 24' 16"
LONGITUDE	149 15' 11"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT2 DP826105

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	6 270025

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	36.00	181			Rotary Air
1		Hole	Hole	36.00	122.00	125			Rotary Air
1	1	Casing	PVC Class 9	-0.30	36.00	125			Glued; Driven into Hole

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
88.00	96.00	8.00				0.33	96.00		Good

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil		
0.30	2.80	2.50	Clay		
2.80	36.00	33.20	Shale, soft		
36.00	122.00	86.00	Shale, hard blue		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW402859

Works Details (top)

GROUNDWATER NUMBER	GW402859
LIC-NUM	40BL190102
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2005-01-19
FINAL-DEPTH (metres)	
DRILLED-DEPTH (metres)	78.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6081520.00
EASTING	703026.00
LATITUDE	35 23' 20"
LONGITUDE	149 14' 7"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1 218719

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	79.00	150	120		
1	1	Opening	Slots	54.00	79.00				
1		Annulus	(Unknown)	0.00	79.00				(Unknown)

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
54.00	55.00	1.00				0.21			
68.00	70.00	2.00				1.89			

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	5.00	5.00	TOPSOIL, SOFT YELLOW GRANITE		
5.00	24.00	19.00	GRANITE, DECOMPOSED, PINK YELLOW		
24.00	78.00	54.00	GRANITE, PINK BLACK HIGHLY FRACTURED PINK BLACK GRANITE WITH QUARTZ BANDS		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW402872

Works Details (top)

GROUNDWATER NUMBER	GW402872
LIC-NUM	40BL188643
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2004-09-16
FINAL-DEPTH (metres)	102.00
DRILLED-DEPTH (metres)	102.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	LOT 4
GWMA	013 - MID MURRUMBIDGEE (U/S NARRANDERA)
GW-ZONE	-
STANDING-WATER-LEVEL	14.00
SALINITY	
YIELD	0.38

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6079839.00
EASTING	702668.00
LATITUDE	35 24' 15"
LONGITUDE	149 13' 55"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GPS - Global Positioning System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT4 DP219695

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	4 219695

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	102.00	200			Rotary - Air/Foam
1	1	Casing	PVC Class 9	0.00	102.00	160	152		Glued
1	1	Opening	Slots - Vertical	72.00	96.00	160			PVC Class 9; SL: 120mm; A: 2mm

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	2.00	2.00	Clay, loamy		
2.00	8.00	6.00	Slate, weathered/brown		
8.00	102.00	94.00	Dacite, grey/black		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403097

Works Details (top)

GROUNDWATER NUMBER	GW403097
LIC-NUM	40BL188111
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2001-04-22
FINAL-DEPTH (metres)	100.00
DRILLED-DEPTH (metres)	100.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	8.00
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6075451.00
EASTING	700986.00
LATITUDE	35 26' 39"
LONGITUDE	149 12' 52"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT4 DP867223

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	4 867223

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL DETAIL
1		Hole	Hole	0.00	100.00	150		
1	1	Casing	P.V.C.	80.00	85.00	150		

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.30	0.30	Topsoil		
0.30	2.50	2.20	Clay, brown		
2.50	8.30	5.80	Shale, weathered		
8.30	100.00	91.70	Porphry with intermittent quartz fractures		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403149

Works Details (top)

GROUNDWATER NUMBER	GW403149
LIC-NUM	40BL190318
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2005-07-01
FINAL-DEPTH (metres)	42.00
DRILLED-DEPTH (metres)	42.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	10.00
SALINITY	
YIELD	9.00

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6076489.00
EASTING	700090.00
LATITUDE	35 26' 6"
LONGITUDE	149 12' 15"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT27 DP747879

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	27 747879

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	42.00	200			Rotary - Percussion (Down Hole Hammer)
1	1	Casing	PVC Class 9	0.40	42.00	164	150		Glued
1	1	Opening	Slots - Vertical	28.00	30.00	164			PVC Class 9; SL: 200mm; A: 2mm

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.40	6.00	5.60	Granite, grey		
6.00	24.00	18.00	Shale, brown		
24.00	42.00	18.00	Shale, black		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403206

Works Details (top)

GROUNDWATER NUMBER	GW403206
LIC-NUM	40BL190661
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2004-01-13
FINAL-DEPTH (metres)	156.00
DRILLED-DEPTH (metres)	156.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6075397.00
EASTING	700366.00
LATITUDE	35 26' 41"
LONGITUDE	149 12' 27"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT2 DP838299

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	2 838299

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	PVC Class 9	-0.30	156.00	125			
1	1	Opening	Slots	135.00	142.00	125			PVC Class 9

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	1.00	1.00	Clay		
1.00	16.00	15.00	Shale, brown		
16.00	156.00	140.00	Shale, black		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403273

Works Details (top)

GROUNDWATER NUMBER	GW403273
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2001-04-24
FINAL-DEPTH (metres)	83.00
DRILLED-DEPTH (metres)	83.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6081430.00
EASTING	703751.00
LATITUDE	35 23' 23"
LONGITUDE	149 14' 36"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	Map Interpretation
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT9 DP220189

Licensed (top)

no details

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	83.00	150			

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.50	0.50	Topsoil		
0.50	8.30	7.80	Granite, yellow weathered		
8.30	83.00	74.70	Granite, red and white		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403321

Works Details (top)

GROUNDWATER NUMBER	GW403321
LIC-NUM	40BL189648
AUTHORISED-PURPOSES	INDUSTRIAL - SAND & GRAVEL
INTENDED-PURPOSES	COMMERCIAL INDUSTRIAL
WORK-TYPE	Bore
WORK-STATUS	
CONSTRUCTION-METHOD	
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	2003-09-30
FINAL-DEPTH (metres)	108.00
DRILLED-DEPTH (metres)	104.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	COOMA ROAD QUARRY
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	1.55
SALINITY	
YIELD	1.40

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6080996.00
EASTING	702151.00
LATITUDE	35 23' 38"
LONGITUDE	149 13' 33"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GPS - Global Positioning System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	LT111 DP754881

Licensed (top)

COUNTY	MURRAY
PARISH	CARWOOLA
PORTION-LOT-DP	111 754881

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	10.00	300			Rotary - Percussion (Down Hole Hammer)
1		Hole	Hole	10.00	108.00	200			Rotary - Percussion (Down Hole Hammer)
1	1	Casing	Steel - ERW	-0.50	10.00	219	209		Welded - Butt
1	1	Casing	PVC Class 9	-0.50	94.00	160	150		Glued
1	1	Opening	Slots - Vertical	20.00	90.00	160			PVC Class 9; SL: 200mm; A: 3mm
1		Annulus	Waterworn/Rounded	0.00	94.00				Graded; GS: 5-10mm; Q: 2m³

Water Bearing Zones (top)

no details

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT

0.00	4.00	4.00	Fill, broken ground
4.00	104.00	100.00	Drictic, fractured

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403582

Works Details (top)

GROUNDWATER NUMBER	GW403582
LIC-NUM	40BL188373
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	
WORK-TYPE	Bore
WORK-STATUS	New Bore
CONSTRUCTION-METHOD	
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	2002-10-30
FINAL-DEPTH (metres)	42.00
DRILLED-DEPTH (metres)	42.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	MT CAMPBELL
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	8.00
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6074863.00
EASTING	699070.00
LATITUDE	35 26' 59"
LONGITUDE	149 11' 36"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1//270301

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1 270301

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	42.00	200			Down Hole Hammer
1	1	Casing	PVC Class 9	0.00	42.00	160			Screwed; Seated on Bottom
1	1	Opening	Slots - Vertical	18.00	42.00	160			PVC Class 9; Slotted In Hole; SL: 120mm; A: 2mm
1		Annulus	Waterworn/Rounded	0.00	42.00				Graded; GS: 6-8mm; Q: 1.2m³

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
16.50	17.00	0.50		8.00		0.06	18.00	0.25	
22.00	23.00	1.00		8.00		0.25	24.00	0.25	
32.00	34.00	2.00		8.00		1.25	42.00	1.50	

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	3.00	3.00	Soil Brown Clay		
3.00	13.00	10.00	Soft Volcanics		
13.00	42.00	29.00	Weathered Pink Black Granites		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
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Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403879

Works Details (top)

GROUNDWATER NUMBER	GW403879
LIC-NUM	40BL190963
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	New Bore
CONSTRUCTION-METHOD	(Unknown)
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	2006-10-30
FINAL-DEPTH (metres)	71.00
DRILLED-DEPTH (metres)	71.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	20.00
SALINITY	
YIELD	

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6074090.00
EASTING	699058.00
LATITUDE	35 27' 24"
LONGITUDE	149 11' 37"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	2//880739

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	2 880739

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	71.00	150			(Unknown)
1	1	Casing	PVC Class 9	0.00	71.00	150			(Unknown)
1	1	Opening	Slots	53.00	71.00	150			PVC Class 9; (Unknown); (Unknown)

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
51.00	67.00	16.00		20.00					

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	6.00	6.00	CLAY/SHALE - FINE		
6.00	47.00	41.00	SHALE - BLUE		
47.00	71.00	24.00	SHALE - BROWN/BLUE		

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Wednesday, August 19, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW403897

Works Details (top)

GROUNDWATER NUMBER	GW403897
LIC-NUM	40BL189974
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	New Bore
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	2004-05-25
FINAL-DEPTH (metres)	128.00
DRILLED-DEPTH (metres)	128.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	0.44

Site Details (top)

REGION	40 - MURRUMBIDGEE
RIVER-BASIN	410 - MURRUMBIDGEE RIVER
AREA-DISTRICT	
CMA-MAP	8727-3S
GRID-ZONE	55/3
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6079047.00
EASTING	700172.00
LATITUDE	35 24' 43"
LONGITUDE	149 12' 16"
GS-MAP	

AMG-ZONE	55
COORD-SOURCE	GIS - Geographic Information System
REMARK	

Form-A (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1//1000529

Licensed (top)

COUNTY	MURRAY
PARISH	GOOGONG
PORTION-LOT-DP	1 1000529

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	16.00	190			Rotary Air
1		Hole	Hole	16.00	128.00	165			Rotary Air
1	1	Casing	PVC Class 9	-0.30	128.00	125			Glued; Seated on Bottom; Open End
1	1	Opening	Slots - Horizontal	57.00	59.00	125			PVC Class 9; Casing - Machine Slotted; SL: 60mm; A: 2mm; Glued
1	1	Opening	Slots - Horizontal	90.00	128.00	125			PVC Class 9; Casing - Machine Slotted; SL: 60mm; A: 2mm; Glued
1		Annulus	Waterworn/Rounded	57.00	128.00				Graded; GS: 4-7mm

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
57.00	59.00	2.00				0.13			
96.00	97.00	1.00				0.32			

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	14.00	14.00	GRANITE - DECOMPOSED		
14.00	57.00	43.00	GRANITE - BLUE - FRESH		
57.00	59.00	2.00	GRANITE - BROWN - FRACTURED		
59.00	128.00	69.00	GRANITE - BLUE - FRESH		