

Appendices



Appendix A

Submission summaries

Table A.1 Issue classification categories

Category code	Issue heading	Where addressed in this report (section number)
<i>Issues relating to project development, design and alternatives</i>		
3.2	Project justification	3.2
3.3	Support for the project	3.2
3.4	Objection to the project	3.3
3.5	Alternatives to the project	3.4, 4.3
3.6	Other issues	3, 4
3.7	Construction of the project	3-7
3.8	Design and features of the project	3.5
3.9	Operation of the project	3.6, 3.7
<i>Issues relating to potential impacts on hydrology and water security</i>		
4.2	Contextual information	4.2
4.3	Use of modelling in the impact assessment	4.3
4.4	Water access licences	4.4
4.5	Impacts on Macquarie River flows, heights, riffles etc	4.5
4.6	Impacts on existing water users	4.6
4.7	Impacts on future water security and use	4.7
4.8	Assessment concerns	4.8
<i>Issues relating to terrestrial ecology</i>		
5.2	Contextual information	5.2
5.3	Adequacy of assessment undertaken	5.3
5.4	Impacts on terrestrial ecology - general	5.4
5.5	Impacts on threatened species	5.5
5.6	Impacts on protected areas	5.6
5.7	Mitigation measures	5.7
5.8	Offsetting	5.8
<i>Issues relating to aquatic ecology</i>		
6.2	Contextual information	6.2
6.3	Adequacy of assessment undertaken	6.3
6.4	Impacts on threatened species, trout cod etc	6.4
6.5	Impacts on the ecology of the Macquarie River	6.5
6.6	Impacts on streams etc in the study area	6.6
6.7	Other impacts	6
6.8	Mitigation measures	6.7
<i>Issues relating to other potential environmental impacts</i>		
7.2	Surface water quality, groundwater and geomorphology	7.2
7.3	Air quality	-

Category code	Issue heading	Where addressed in this report (section number)
7.4	Noise and vibration	7.3
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7.6	Aboriginal heritage	7.5
7.7	Historic heritage	7.6
7.8	Landscape and visual	7.7
7.9	Contamination and soils	7.8
7.10	Traffic and transport	7.9
7.11	Infrastructure impacts	-
7.12	Spoil handling and waste	7.11
7.13	Socio-economic impacts	7.10
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8.2	Community involvement in the design process	8.2
8.3	Assessment of the application	8.3
8.4	Implementation of approval	8.4

Table A.2 Community submissions – key issues raised

Sub. no.	Key issues raised (category code)	Sub. no.	Key issues raised (category code)
41905	3.4	42702	6.3
41928	3.5, 4.5, 6.4, 7.8, 7.9	42704	3.4, 3.8
42119	3.4, 6.5, 8.3	42706	3.2, 3.4, 7.9
42194	3.4, 8.5	42710	3.4, 5.4, 7.9
42218	3.2, 4.6, 6.5	42712	4.7, 4.8, 7.2
42224	3.4	42714	3.4, 4.3, 6.5, 7.9
42229	3.5	42716	3.2, 3.4, 3.5, 3.8, 4.3, 4.5, 4.8, 6.3, 6.4, 6.5, 7.13, 7.2, 7.6, 8.2, 8.3
42233	3.4, 4.5	42718	3.2, 3.4, 3.5, 6.4
42235	3.4, 6.5	42720	3.2, 3.4, 3.5, 5.4, 6.4, 6.5, 7.9
42237	6.5	42726	3.4, 4.5, 6.3, 6.4, 6.5
42245	3.4, 3.5	42728	3.2, 3.5, 3.8, 5.4, 6.4, 6.5, 7.9
42284	3.2, 3.5, 3.8, 5.4, 6.3, 6.5, 7.9, 8.3	42738	3.2, 3.4, 3.5, 5.4, 6.4, 6.5, 7.9
42360	3.4	42741	3.2, 3.4, 3.5, 3.8, 4.7, 6.3, 6.5, 8.3
42366	3.4, 3.5, 5.4	42743	3.4, 3.5, 6.3, 6.4, 6.5
42368	3.4, 3.5, 6.4, 6.5, 7.8	42746	3.5, 6.3, 6.4, 6.5
42402	3.4, 3.5, 5.4, 6.4	42750	3.2, 3.5, 5.4, 6.3, 6.5, 7.13, 7.4, 7.5, 7.9, 8.2
42412	3.4, 3.5, 6.3, 6.4, 6.5	42752	3.5, 6.3, 6.4, 6.5
42418	3.4, 3.5, 6.3, 6.4, 6.5	42754	3.2, 3.4, 3.5, 5.4, 6.4, 6.5, 7.9

Sub. no.	Key issues raised (category code)	Sub. no.	Key issues raised (category code)
42421	3.4, 3.5, 6.3, 6.4, 6.5	42756	3.2, 3.4, 3.5, 4.6, 8.3
42429	3.4, 3.5, 6.3, 6.4, 6.5	42758	3.2, 3.4, 3.5, 5.4, 5.7, 6.3, 6.4, 6.5, 7.9, 8.3
42431	3.4, 3.5, 6.3, 6.4, 6.5	42760	3.2, 3.5, 3.8, 5.4, 6.3, 6.4, 6.5, 7.9, 8.2
42433	3.4, 3.5, 6.3, 6.4, 6.5	42762	3.2, 3.4, 3.5, 3.8, 5.5, 5.8, 7.9, 8.2, 8.3
42435	3.4	42764	3.5, 6.3, 6.4, 6.5
42499	4.6	42766	3.5, 6.3, 6.4, 6.5
42504	3.4, 3.5, 6.3, 6.4, 6.5	42769	3.5, 5.5, 6.3, 6.4, 8.3
42514	3.4, 3.5, 6.3, 6.4, 6.5	42778	3.4, 4.8, 6.3, 6.4, 6.5, 8.3
42516	3.4, 6.5	42780	3.2, 3.4, 3.5, 3.8, 5.8, 6.3, 6.5, 8.3
42522	3.2, 3.4, 3.5, 3.8, 5.4, 6.4, 7.13, 8.2, 8.3	42782	3.2, 3.4, 3.5, 5.4, 5.8, 6.4, 8.2, 8.3
42531	3.2, 4.3, 4.8, 6.3, 6.4, 6.5, 8.2	42784	3.2, 3.4, 3.5, 8.3
42546	3.4	42786	3.2, 3.4, 3.5, 3.8, 5.4, 5.8, 8.3
42548	3.2	42788	3.4, 3.5, 3.8, 5.5, 5.8, 8.3
42550	3.4	42790	3.4, 5.5, 6.3, 6.4, 6.5, 7.8, 7.9
42571	3.4, 6.4, 6.5, 7.13, 7.9	42796	3.2, 3.4, 3.5, 3.8, 5.3, 5.4, 5.5, 5.7, 5.8, 6.5, 8.2, 8.3
42580	3.2, 3.4, 6.4, 6.5	42800	3.5, 6.3, 6.4, 6.5
42582	3.4, 3.5, 6.3, 6.4, 6.5	42802	3.4, 3.5, 6.4
42584	3.4, 3.5, 6.3, 6.4, 6.5	42804	3.2, 3.4, 3.5, 4.6, 6.4
42588	3.2, 3.4, 3.5, 5.4, 6.4, 6.5, 7.9	42808	3.2, 3.5, 5.4, 5.5, 6.4, 6.5, 7.9
42591	3.2, 3.4, 3.5, 5.4, 6.4, 6.5, 7.9	42816	3.2, 3.4, 3.5, 3.8, 6.3, 6.4, 7.9
42595	3.4, 6.4, 6.5	42825	3.5, 6.3, 6.4, 6.5
42601	6.3, 8.3	42833	6.3, 6.4, 6.5
42606	3.4, 5.4, 6.4	42835	3.2, 3.4, 4.4, 5.3, 6.3, 6.5
42608	3.2, 3.5, 5.4, 6.4, 6.5, 7.9	42837	3.4, 6.4, 6.5
42610	3.4, 8.3	42839	3.4, 3.5, 4.8, 5.3, 6.3, 5.5, 6.4, 6.5
42612	3.4, 6.5	42843	5.4
42615	3.4, 3.8, 6.4, 6.5, 7.9	42845	3.2, 3.4, 3.5, 6.4, 7.9
42631	3.2, 3.5, 5.4, 6.4, 6.5, 7.9	42847	3.2, 3.4, 3.5, 4.4, 4.7, 6.3, 6.5
42634	3.2, 3.4, 3.5, 4.3, 4.4, 4.5, 6.3, 6.7, 7.4, 7.9	42849	3.5, 6.3, 6.4, 6.5
42642	3.4, 3.5, 6.3, 6.4, 6.5	42851	3.5, 6.3, 6.4, 6.5
42645	3.5, 5.4, 6.5, 7.9	42853	3.5, 6.3, 6.4, 6.5
42647	3.2, 3.4, 3.5, 6.5, 7.9	42855	3.2, 3.4, 3.5, 6.5
42649	3.4, 5.5, 5.7, 5.8, 7.7, 7.8	42857	3.2, 3.5, 5.5, 6.4, 6.5, 7.9
42651	3.2, 3.4, 6.4, 6.5, 7.9	42859	3.2, 3.4, 6.4
42653	3.4, 3.5, 4.5, 6.3, 6.4, 6.5	42861	3.2, 3.4, 3.5, 3.8, 5.4, 6.3, 6.4, 6.5, 7.9
42655	3.4, 5.4, 6.4, 6.5	42863	3.2, 3.5, 3.8, 5.5, 6.3, 6.4, 6.5, 7.9, 8.3

Sub. no.	Key issues raised (category code)	Sub. no.	Key issues raised (category code)
42657	3.4, 5.4, 6.4, 6.5	42865	3.4, 3.5, 6.4, 6.5
42659	3.4, 3.8, 6.3, 6.4	42871	3.4, 3.5, 6.4, 8.3
42662	6.5	42873	3.2, 4.3, 4.6, 5.3, 6.3, 5.6, 5.8, 6.3, 6.5, 6.4, 8.2, 8.3
42671	3.4, 4.3, 6.3, 6.4, 6.5	42875	3.2, 3.4, 3.5, 3.6, 6.3, 4.4, 4.6, 4.7, 4.8, 5.4, 6.3, 6.4, 6.5, 7.13, 7.2, 7.6, 7.7, 7.9, 8.3
42684	3.4, 6.4	42890	3.4, 3.5, 5.4, 5.8, 6.3, 6.4, 6.5, 6.7, 7.2, 7.9
42686	3.2, 3.4, 3.5, 5.4, 6.4, 6.5, 7.9	42892	3.2, 3.4, 3.5, 3.8, 6.3, 6.4, 6.7
42688	3.2, 3.4, 3.5, 5.5, 7.13, 7.9	42903	3.4, 3.5, 6.3, 6.4, 6.5
42690	3.4, 3.5, 4.5, 6.5, 7.2, 7.6	42919	3.2, 3.4, 3.5, 3.8, 5.4, 6.3, 6.4, 7.13, 7.9
42692	3.4, 5.4, 7.6	42940	6.3, 6.4
42694	3.4, 5.4, 7.6	42945	3.2, 3.4, 3.5
42696	3.4, 3.5, 6.4	43021	3.2, 3.5, 4.2, 4.4, 5.5, 5.8, 6.3, 6.5, 7.13, 7.2, 8.2
42700	3.4, 7.2, 7.9	43023	3.2, 3.4, 3.5, 7.13
		43160	3.2, 3.5, 3.7, 3.8, 4.6, 4.8, 7.5, 7.9

Table A.3 Government and agency submissions

Agency/submitter	Sub no.	Key issues raised (categories)
Bathurst Councillor	42736	3.2 (fit with overall plan), 3.5 (other options), 3.5 (Suma Park Dam), 3.5 (Browns Creek or Lake Rowlands), 4.6 (downstream impacts)
Bathurst MP	42798	3.2 (timeframes and cost), 3.5 (Suma Park Dam), 4.7 (impacts on other users) 6.3 (adequacy) 6.4 (impacts on threatened species)
Orange Councillor	42811	4.8 (adequacy), 5.7 (mitigation measures)
Bathurst Councillors	42818/20	3.5 (alternatives – other options)
Orange MP	42830	4.7 (no impacts on other users)
Dubbo MP	42898	3.2 (overall justification, current supply levels), 3.5 (Lake Rowlands), 4.7 (impacts on other users)
DPI (Crown Lands)	43104	5.7 (mitigation measures), 7.2 (creek crossings), 7.2 (monitoring) 7.4 (impacts on Crown land)
DPI (Fisheries)	43104	6.3 (adequacy) 6.5 (impacts on river ecology) 6.6 (impacts on streams) 6.7 (mitigation measures)
DPI (Office of Water)	43104	4.4 (water access licences) 8.4 (consultation) 3.7 (Operation – flow data, low flow regimes)
EPA	42841	7.3 (noise impacts) 7.11 (other issues)
OEH	43025	3.2 (overall justification), 3.5 (other options – groundwater resources), 3.5 (other options), 4.3 (modelling), 4.4 (water access licences), 4.5 (impacts on flows), 4.8 (adequacy), 5.3 (adequacy), 5.4 (hollow trees), 5.6 (impacts on protected areas), 5.7 (mitigation measures), 5.8 (offsetting)

Agency/submitter	Sub no.	Key issues raised (categories)
RMS	42561	7.9 (school buses)

Appendix B

Groundwater review

Assessment of Groundwater Resources

Orange Basalt Groundwater Source

for Orange City Council
December 2012

J1595.1R-rev1

CMJA

C. M. Jewell & Associates Pty Ltd

Assessment of Groundwater Resources –Orange Basalt Groundwater Source
December 2012

J1595.1R-rev1

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Important Information About Your Environmental Site Assessment

FIGURES

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Figure 3.4	Browns Creek Gold Mine Open Cut, 1994

1.0 INTRODUCTION

1.1 Background

This report provides an assessment of the groundwater resources that are likely to be available from the Orange Basalt groundwater source south of Orange, and the Lachlan Fold Belt MDB groundwater source at Browns Creek, also south of Orange.

C.M. Jewell & Associates Pty Ltd has previously carried out a number of desk studies and a field assessment into the availability of groundwater resources from the Orange Basalt and rocks of the Lachlan Fold Belt to augment the Orange town water supply.

The report was commissioned by Mr Martin Haege of Geolyse Pty Ltd of behalf of Orange City Council (Council).

1.2 Project Objectives

The objectives of this report are to review existing data and provide an assessment of the feasibility of obtaining new supplies of groundwater to supplement the Orange town water supply from the Orange Basalt Groundwater Source south-west of Orange, and the rocks of the Lachlan Fold Belt at and adjacent to the former gold mine at Browns Creek.

1.3 Scope of Work

CMJA has carried out a review of existing data available from previous investigations into the Orange Basalt, and publicly-available information about the aquifers at Browns Creek.

1.4 Report Format

Section 2 of this report deals with the Orange Basalts, and Section 3 with Browns Creek. Conclusions are provided at the end of each of those sections.

1.5 Limitations and Intellectual Property Matters

This report has been prepared by C. M. Jewell & Associates Pty Limited for the use of the client identified in Section 1.1, for the specific purpose described in that section. The project objectives and scope of work outlined in Sections 1.2 and 1.3 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.

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2.0 ORANGE BASALTS

2.1 Background

The Orange Basalts are a significant local source of groundwater. However, their hydrogeology is complex; yields are very variable and controlled by factors that, although well understood are not well mapped, and the available storage is difficult to estimate. There are many existing groundwater users. These factors combine to make development of additional groundwater resources in the basalts a difficult proposition.

2.2 Location and Setting

The Orange basalts occur over a considerable area that extends past Cudal in the west and as far as Molong in the north. However, this report is concerned only with the area south and south-west of Orange where the basalts form a thick and essentially contiguous cover. This triangular area is roughly bounded by Orange, Millthorpe and the Canobolas State Forest.

2.3 Geology

The Tertiary basalts and trachytes of the Orange Province include the Canobolas Volcanic Complex (CVC). The basalts and trachytes of the CVC cover an extensive area, with outcrops centred on Mount Canobolas and extending to Molong, Orange, Cowra and Blayney. Mount Canobolas is an extinct shield volcano; it last erupted around 11 to 13 million years ago, from around 30 vents within about 30 kilometres of the current summit. It is thought that the main vent continued to erupt for the entire life of the volcano, whilst most of the other vents were only active for short periods.

To the south of Orange, as shown on Figure 2.1, the basalts form an extensive series of lava plains resulting from the outpouring of several eruptions from Mount Canobolas during the Tertiary Period. The basalts, which radiate outwards from the now dissected volcanic centre, consist mostly of trachyte and alkali rhyolite, with common occurrences of olivine basalt and porphyritic andesine basalt layers throughout the unit. The olivine basalt is more widespread than the trachyte and rhyolite units. Its mineralogy is consistent throughout the district, and it is commonly used as a marker unit for the identification of basalt units in the Orange Province. Scoriaceous and vesicular horizons have also been noted within the basalts, although they are rare.

Beneath the Orange basalts are much older rocks of the Lachlan Fold Belt. These rocks have undergone multiple deformation events including folding, faulting, jointing and associated fracturing. Regional jointing and structural patterns have been adopted into the overlying basalts, contributing to the fractured nature of the unit. Most of the fractures within the basalt have alignments consistent with those of the major regional structural orientations.

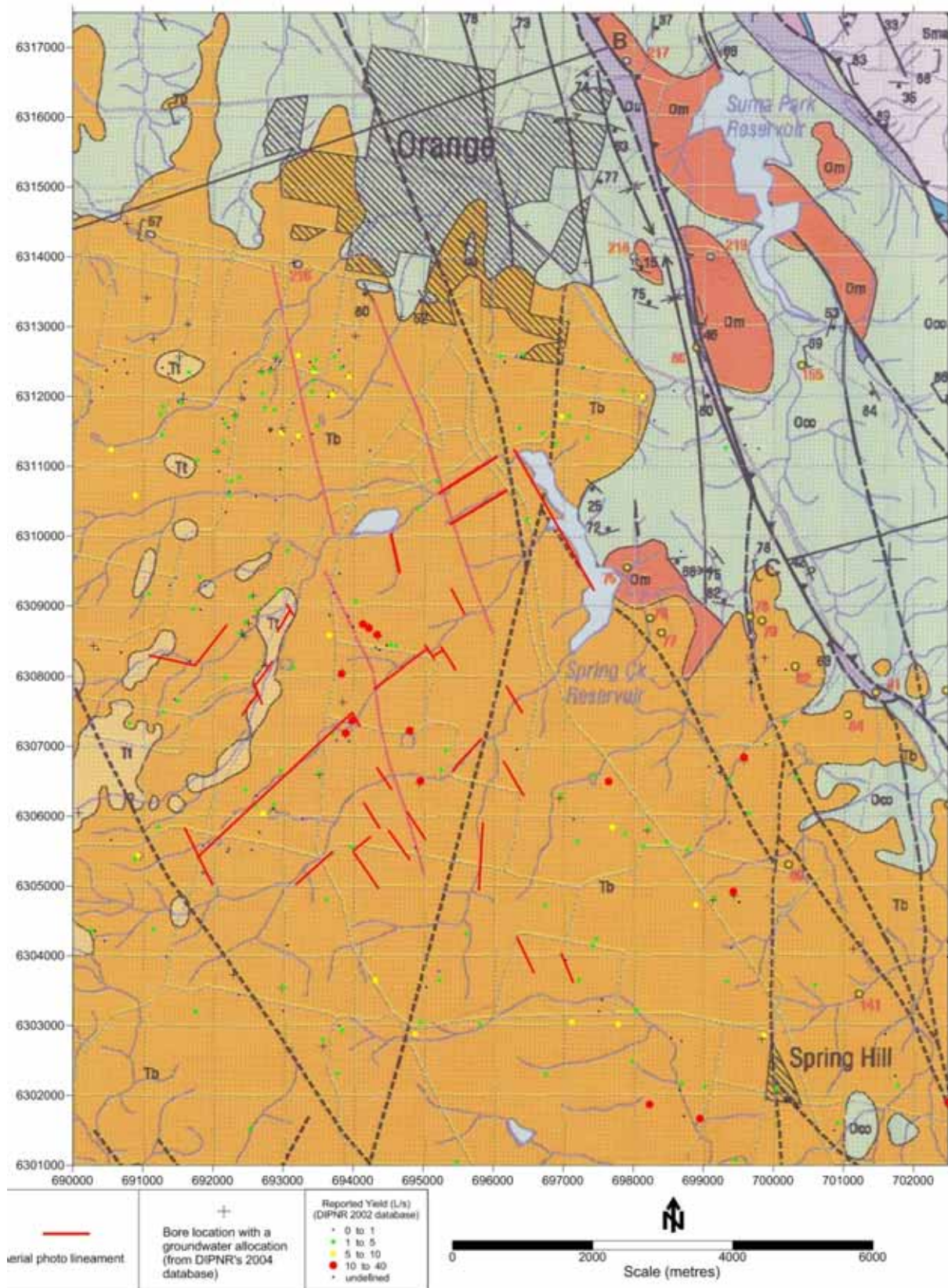


Figure 2.1: Orange Basalt Outcrop South of Orange, showing major lineaments and groundwater abstractions

2.4 Hydrogeology

The geological evolution described above has resulted in a groundwater flow pattern that is controlled by the Lachlan Fold Belt palaeodrainage patterns, the Orange basalt flow patterns, and the regional and local fracture and discontinuity orientations.

Groundwater resources are predominantly associated with the numerous basalt units that comprise the Orange basalts, hosted by secondary porosity features such as joints, voids, gravel units and fractures, whilst minor flows associated with weathered horizons and lithological contrasts are thought to contribute to the movement of groundwater within perched horizons, particularly within the weathered profile of the rock mass.

The primary source of groundwater recharge in the area is the infiltration of soil-water (derived from excess precipitation) through the subsoil and unsaturated country rock to the water table. Within the fractured rock aquifer, the water table is not as precisely defined as for granular aquifer materials, and is generally defined as the depth to which interconnecting joints, voids and fractures are water-filled; hence features such as the connectivity of a series of fractures both within and between differing geological units will greatly influence the characteristics of the aquifer.

The interconnected fractures act as an equivalent porous medium in distributing water pressure throughout the aquifer. Thus, the depth of saturation measured in a set of fractures will reflect the prevailing water pressure in the vicinity of the measurement, and cannot be assumed for the entire aquifer.

The Orange basalts provide variable, although sometimes very good yields to boreholes, and are also known for their association with useful springs, both within the unit and at its margins. The low storage and higher relief of the basalts renders these boreholes more prone to climatic events, and particularly to prolonged dry periods. They are therefore susceptible to declining water levels and yields during drought, but also can experience much faster recharge and recovery rates during wet climatic events.

Borehole depths within the basalts vary considerably, from 10 to 140 metres, depending on the area and the topography. Yields up to 30 litres per second (L/s) have been noted in the vicinity of Mount Canobolas, although these boreholes have shown diminishing yields and water tables during long-term pumping.

2.5 Available Resource and its Sustainability

The Orange basalt aquifer is used extensively for irrigation and stock and domestic purposes, and groundwater is also used for municipal water supplies.

Groundwater in the Orange basalt aquifers is not static, but flows radially away from 'recharge centres' and, usually, discharges to the surface drainage system at the edge of the basalt aquifers. The lateral flow rate within individual aquifers depends on their horizontal permeability and on the local hydraulic gradient, which is the average difference in pressure per unit distance, often expressed in metres (of water head) per metre. It is thus a dimensionless quantity.

There are also vertical flows within and between aquifers, and, in a similar manner, the direction and quantity of vertical flow depends upon the vertical hydraulic gradient and average vertical permeability.

The natural inflows by which aquifers are replenished are known as recharge. Recharge to the aquifers occurs by infiltration of rainfall and to a lesser extent by seepage of surface water through the beds of stream channels, and leakage and deep drainage of irrigation water.

Discharge from the aquifers may occur by pumping, by evapotranspiration, and by natural outflows to creeks/ rivers, lakes, springs and swamps.

In the long term, there must be a balance between the recharge to an aquifer system and the discharge from it. In the short term, however, imbalances between recharge and discharge are buffered by the storage capacity of the aquifer. In other words, an excess of discharge over recharge is met by water released from storage in the aquifer, while excess recharge is accommodated in increased aquifer storage. Changes in the volume of water stored are evidenced by changes in aquifer pressure, or the water level measured in boreholes that are open to the aquifer. The relative volume of water stored or released in response to a change in water level is a fundamental property of a particular aquifer, and depends upon the aquifer's effective porosity and elasticity, as well as the extent to which the aquifer is confined by overlying low-permeability layers.

This ability to store water (without evaporation loss) and thus to some extent 'even out' year-to-year fluctuations in recharge – in turn related to fluctuations in rainfall – is one of the great advantages of groundwater over surface water as a source for water supply.

Thus, groundwater supplies are intrinsically less volatile and more dependable than surface water supplies.

The period over which aquifer storage can act as a buffer must clearly depend upon the volume of water in storage relative to the average excess pumping rate. Although the volume of groundwater in storage cannot be calculated with accuracy – there are too many variables affecting aquifer thickness, composition and porosity – total storage in an aquifer system such as the Orange Basalts is likely to be equivalent to several years of use. One issue that must be recognised in relation to the Orange Basalts is that because much of the groundwater is transmitted through fracture systems and relatively thin scoriaceous zones and interflow horizons, the effective porosity is low in comparison with granular aquifer systems.

The National Land and Water Resources Audit (2000) estimated the sustainable yield of the Orange Basalts at 17,000 megalitres per year (ML/year). It also estimated the groundwater use at 6,400 ML/year (over an undefined period), and groundwater entitlements at 7,684 ML/year (over a similarly undefined period). The Audit ranked the recharge estimate as Category 'D', signifying data that is 'derived without investigation data'. The figures are estimated 'from data in nearby catchments, or extrapolated/interpolated from any available data'. The estimated accuracy is ± 50 per cent.

These figures are notably consistent with the long-term extraction limit (16,208 ML/year) and total of share components (7,920 ML/year) for the Orange Basalt groundwater source set out in the 2011 *Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources* (Section 2.7 of this report). The long-term average annual extraction limit specified in the plan is not necessarily the same as the sustainable yield, and is defined as being equal to "the long-term average annual rainfall recharge minus the amount of recharge reserved as planned environmental water". The latter includes maintenance of baseflow in surface watercourses.

No reliable estimate of groundwater storage in the Orange Basalts is available.

On the basis of a surface area of 250 km², an average saturated thickness of 50 metres and a specific yield of 0.01, the volume of water in storage would be 125,000 ML.

It must be emphasised that, at this time, the detailed regional hydrogeological studies and modelling that would be required to reliably estimate the groundwater storage, and a sustainable yield or long-term average annual extraction limit, for the Orange Basalt Groundwater Source have not been carried out. Furthermore, although a number of irrigation bores with high groundwater yields do exist, yields

are controlled by structural features and lithological variations that cannot be directly observed at the surface and must be inferred from indirect and sometimes ambiguous secondary indications.

In 2008, following on from a desk study that used the available regional data including a structural interpretation and an analysis of the yield pattern of existing groundwater bores, CMJA began a program of investigation drilling, supplemented by surface geophysics, to try to locate groundwater to supplement the Orange water supply during a period of drought. The investigation was constrained by the requirement of remaining on public land, and maintaining proximity to existing water supply infrastructure. No viable sources were located.

In consequence of the matters discussed in this section, in CMA's opinion:

- It will be difficult to find locations for high yielding boreholes suitable for town water supply.
- Access to private land is likely to be required to explore for, and construct such boreholes, which may be located distant from existing water supply infrastructure.
- Because high yielding bores will be associated with fracturing, thin scoria ceous zones or other features that have relatively high and directional transmissivity and low storage, the effect of pumping on water levels (drawdown) will extend further along the principal directions of transmissivity than would be the case in an isotropic aquifer. Therefore, the impact on existing users is likely to be amplified.
- The long-term performance of the aquifer, particularly during periods of prolonged drought when a reliable supply is most critical, cannot be predicted with confidence.

2.6 Water Quality

Water quality in the Orange Basalt Groundwater Source is generally good. The available information, derived principally from NSW Office of Water works summary reports, indicates consistently low salinity. However, in some areas there is risk of pollution derived from agricultural activities (principally the use of nitrate fertilisers) and mineralisation in underlying Lachlan Fold Belt rocks.

2.7 Licencing Requirements

The Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources (2011) is now in force and applies to groundwater in the Orange Basalts. The Groundwater would be drawn from the Orange Basalt Groundwater Source, which lies within the Lachlan Fold Belt MDB (Other) Management zone.

The long-term extraction limit for the groundwater source is 16,208 ML/ year. Currently share components for the source (aquifer access licences and local water utility access licences) total 7,920 ML/year.

As discussed in this report, groundwater is not uniformly available across the aquifer, and current abstractions are also very unevenly distributed. The constraints of local aquifer yield and interference with existing users and stream baseflow are likely to be more significant than the apparent overall surplus of extraction limit over existing share components.

However, it is likely that subject to adequate local hydrogeological appraisal and local impact assessment, additional local water utility access licences could be granted for the Orange Basalt.

Water supply works approvals would also be required for bores and associated infrastructure.

2.8 Conclusions

It is concluded that while the Orange Basalt aquifer is an established, and locally very important source of generally good-quality groundwater, the hydrogeology of the aquifer is complex and not fully understood, or mapped in detail. Yields are very variable and controlled by factors that are difficult to map or predict at a local scale. There is no reliable estimate of the available groundwater storage.

On a source-wide basis, the long-term extraction limit nominated in the Water-Sharing Plan exceeds current and share components by a factor of more than two, but these estimates have not been based upon a groundwater flow model or other hydrogeological investigation. At a local level, due to hydrogeological constraints, establishment of significant new supplies from the aquifer is likely to prove difficult.

Unless sited with great care, and at a substantial distance from existing bores, new bores are likely to have an impact on existing users.

3.0 BROWNS CREEK

3.1 Background

It has been suggested that water to supplement the Orange water supply could be obtained from a former gold mine at Browns Creek.

In 2008 Council engaged the NSW Department of Commerce (DOC) to carry out a desktop study on the feasibility of transferring water from the abandoned Browns Creek Mine Pit at Blayney for Orange City drinking water needs. That report, and other available information, in particular reports available on the NSW Department of Primary Industries (DPI) DIGS database, have been reviewed to allow an assessment of the available resource to be made.

The DOC study had the following Scope of Work.

1. Determine the available storage volume of water and potential annual yield of the mine using the available data from NSW Department of Water and Energy (DWE), Australian Native Landscapes (ANL), Department of Mineral Resources and Central Tablelands Water Supply;
2. Collect surface water samples from the mine pit or neighbouring bores and test them for the full spectrum of heavy metals and other toxic substances and then determine water treatment requirements of this water;
3. Identify routes for the transfer system from Browns Creek Mine to Orange using topographical maps;
4. Carry out hydraulic analysis to establish pipe sizes, balance tanks and pumping requirements;
5. Undertake a desktop study on power supply requirements;
6. Provide cost estimates of the pipeline route options;
7. Provide an overview of the possible land issues;
8. Provide a commentary on approvals and licence requirements for the construction of the pipeline in each of the routes; and
9. Provide an evaluation of the pipeline routes.

However, this review focusses on the geological and hydrogeological aspects of the proposal (essentially the issues covered by Items 1 and 2 of the DOC scope of work). It addresses these items in rather more detail, and includes an update on water-resource regulatory matters. CMJA cannot add usefully to the discussion of potential routes, infrastructure and other engineering aspects provided by DPI, and has not attempted to do so.

3.2 Site Location and Setting

Browns Creek Gold Mine is located 8 kilometres west of Blayney, approximately 35 kilometres south of Orange, as shown on Figure 3.1.

The now-flooded open pit has dimensions of approximately 440 metres NW-SE by 220 metres NE-SW, with an area of about 8.5 hectares.

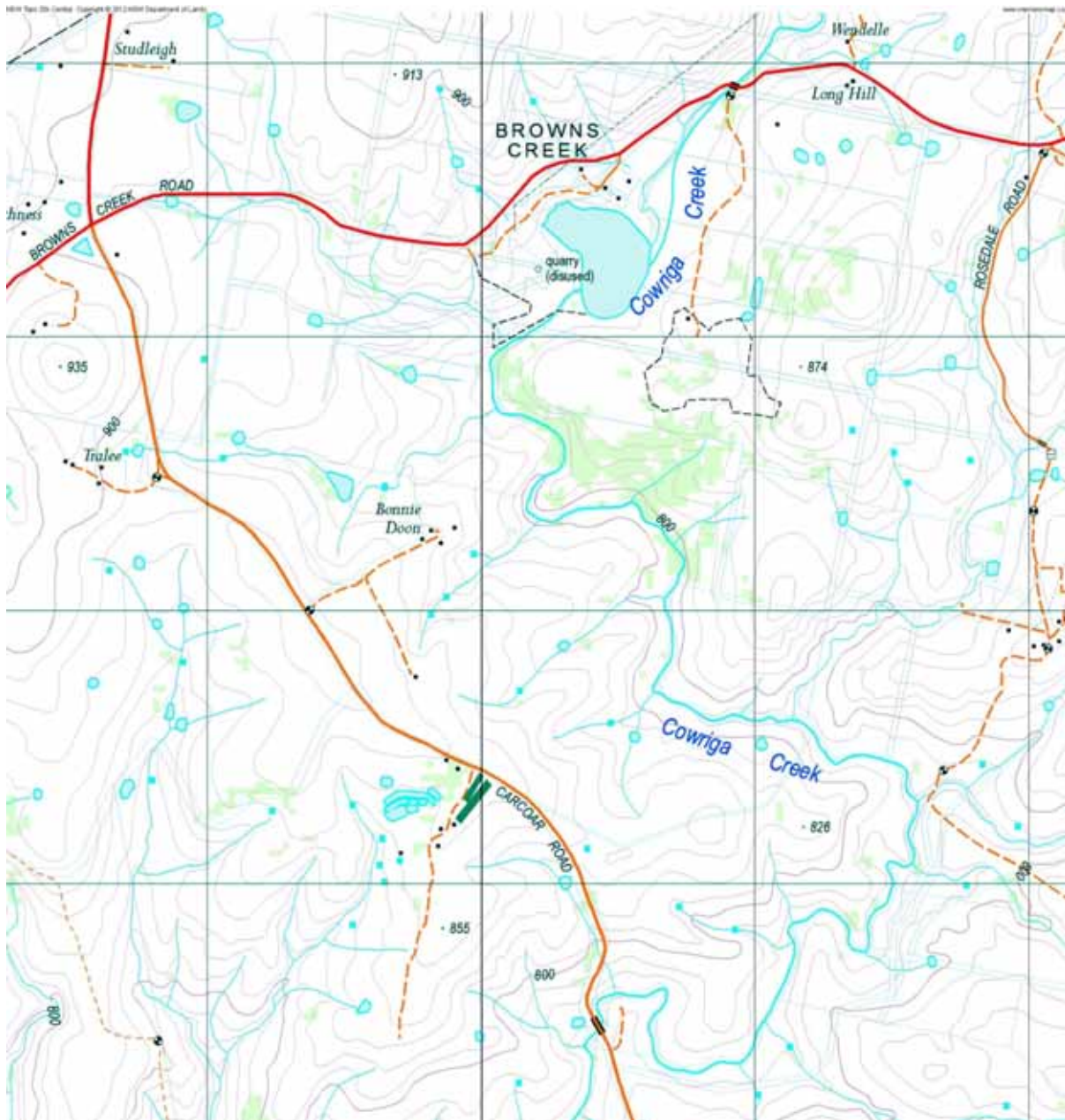


Figure 3.1: Mine Location and Topographic Setting

The area around the former mine is currently used by ANL as a soil processing facility. This can be seen in the image shown in Figure 3.2.



Figure 3.2: Image of Site

3.3 Mining History

Gold was discovered at Browns Creek in the 1870s. Underground mining began in about 1876, with the records indicating that about 55,000 ounces of gold were recovered from 300,000 tonnes of ‘clay’ ore (5.7 grams/tonne) before the water table was reached in 1887. Subsequent efforts at dewatering were not successful, but a further 4500 ounces was recovered by open pit mining between 1904 and 1910 (Egan 1995).

The mine was not worked again for 70 years, until it was reopened by Mr Michael Hickey in 1979. A treatment plant was constructed and ore was won from a new shaft and from open pit operations.

BHP Minerals Limited acquired the mine in September 1986 and commenced a major redevelopment of both mining and treatment operations, to establish a large open pit mine. The Browns Creek operation formed part of the merger between BHP Gold Mines Limited and Newmont Australia Limited which led to the formation of Newcrest Mining Limited.

The open pit at Browns Creek produced 132,521 ounces of gold from September 1986 to September 1992. In addition, a total of 2708 tonnes of copper in concentrates was produced from the auriferous skarn ore. Operations ceased in the open pit in early 1993 when it reached a depth of 140 metres, at which open pit mining was no longer viable because of thinning of the ore body and the increasing costs at depth (Egan 1995).

Underground mining commenced in 1995 and continued until late 1999. The underground mine was about 600 metres deep.

The mine was closed after a major water ingress incident occurred on 23 December 1999. This was triggered by a production blast causing a collapse in a stoped area, which intersected a major water-bearing system in karstic limestone rocks in the hanging wall of the mine (Cube 2006). This incident remains something of a mystery, not only because the previous water inflow problems at the mine were well known, as was the presence of karstified and brecciated limestone adjacent to the mine, but also because it happened immediately before Christmas when most of the mine workforce had left for the Christmas holidays. Hargraves Resources (and the mine) had just been sold to a South African

company, Durban Rooderpoort Deep, which ultimately went into administration and was sold under a deed of arrangement.

The mine has not been operated since 1999 and the open pit is now full of water. Water from the pit discharges to Cowriga Creek.

The 2008 DOC report indicated that mine pit was overflowing and that the water level was expected to be around RL 814 metres. Based on this estimate and the pit contours, the volume of water in the pit was calculated to be approximately 4,700 ML.

3.4 Geology

The geology of the area around the mine is shown on Figure 3.3, which is to approximately the same scale as Figure 3.1 and covers the same area, but with approximately 200 metres north and 80 metres west offsets in the grid.

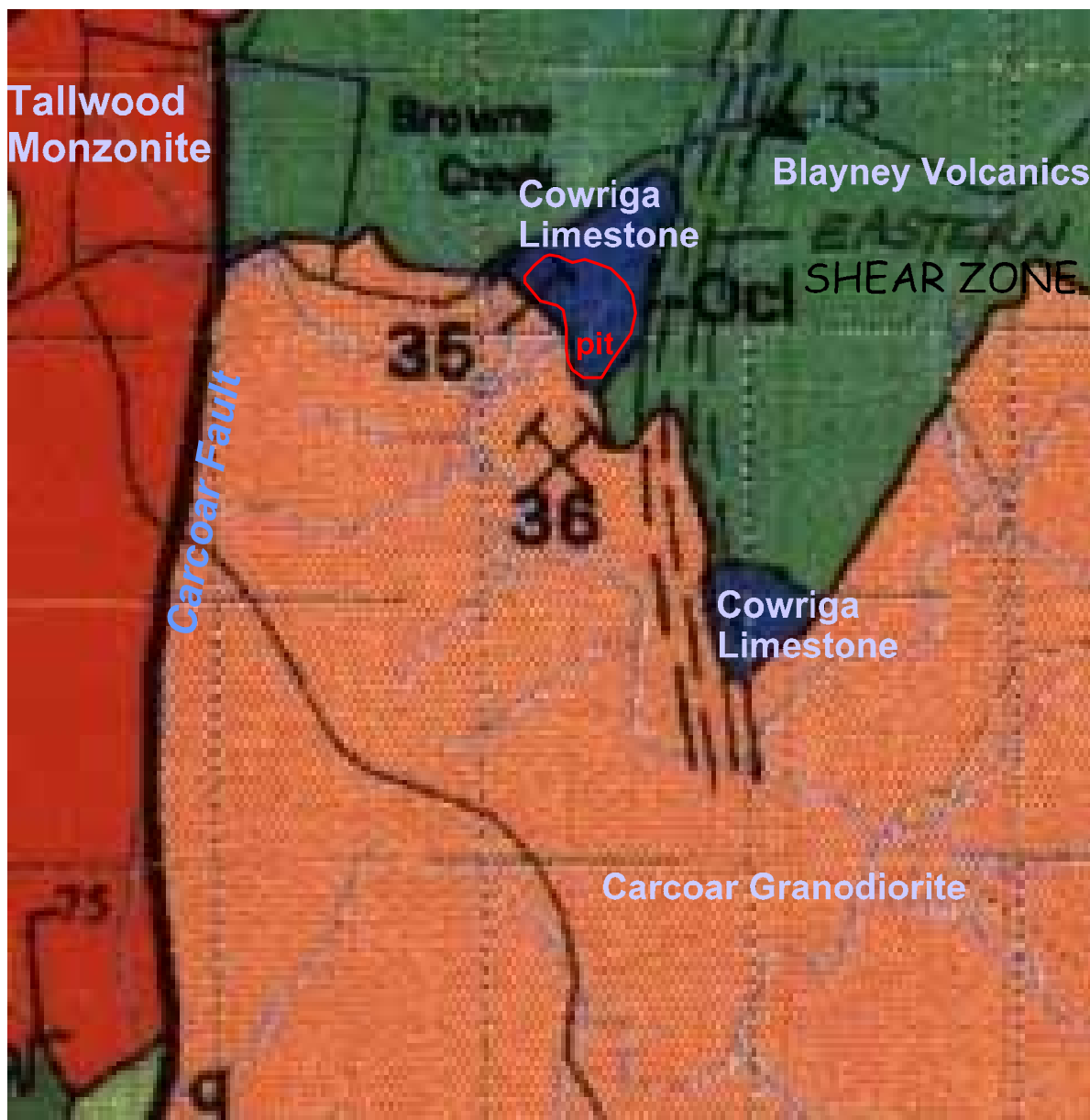


Figure 3.3: Geology around Browns Creek

As shown on Figure 3.3, the Browns Creek gold-copper deposit lies within the Late Ordovician Blayney Volcanics, a sequence of porphyritic basaltic, trachybasaltic and trachyandesitic volcanic conglomerates, volcaniclastics and lavas. The volcanic sequence encloses a number of large lenses or blocks of the Ordovician Cowriga Limestone member, and the metamorphosed contact with one of these is coincident with the mineralisation. The Blayney Volcanics and the Cowriga Limestone have been folded, faulted and subsequently intruded by the Late Silurian Carcoar Granodiorite batholith. The economic mineralisation is developed within garnet, wollastonite and pyroxene skarn rocks derived from the limestone and volcaniclastics adjacent to the sheared margin of the granodiorite.

Immediately to the east of the open cut, the Cowriga Limestone is bounded by an arcuate, north-trending zone of strong cleavage development, known as the Eastern Shear Zone.

The Carcoar Fault is located approximately 1 kilometre west of the mine area. This fault is a major north-south trending structure which separates the Blayney Volcanics and Carcoar Granodiorite to the east from the Forest Reef's caldera and intrusive complex, which is also of Late Ordovician age to the west. At this location the intrusive Tallwood Monzonite lies immediately west of the Carcoar Fault.

The major Palaeozoic rock units in the region are locally overlain by Tertiary basalt flows originating from the Mt Canobolas volcanic centre.

Egan (1995) indicated that within the Browns Creek open pit the Carcoar Granodiorite, on the south side of the pit, is separated from the marble of the Cowriga Limestone, on the northern and eastern sides of the pit, by a thin (10 to 30 metre wide) assemblage made up of basaltic volcaniclastics, metamorphosed limestone (marble) and high level intrusive rocks with developments of skarn. Several mafic dykes have intruded the marble along pre-existing structural planes and there is significant evidence to suggest that a large and possibly related basaltic dyke or stock has intruded both the marble and granodiorite in the north-western end of the pit. Late but genetically related monzonite, monzodiorite and aplite dykes of uncertain origin intrude all other lithologies and may be linked with a late hydrothermal alteration event, in part responsible for the development of the clay ore zone. A strong fault system is exposed in the eastern side of the open cut, the Mt David Fault, and it is believed to be a splay manifestation of the Eastern Shear Zone.

Subsurface erosion and weathering during Tertiary to recent times resulted in the development of caves and karstic collapse breccias.

Figure 3.4 shows the open cut in May 1994. The photograph was taken looking north-west. Granodiorite is visible on the western side of the pit, with marble on right and small microdiorite stock (under a waterfall) at western end of pit. Also visible are microdiorite dykes in marble, and caves developed in upper levels.



Figure 3.4: Browns Creek Gold Mine Open Cut, 1994

3.5 Hydrogeology

Generally the fractured plutonic, volcanic and meta-sedimentary rocks of the Lachlan Fold Belt do not usually provide high yields of groundwater. The area around the former Browns Creek mine is an exception to this general rule; a number of factors are responsible.

Firstly, both the Cowriga Limestone and the Blayney Volcanics have undergone thermal metamorphism at the contact with the Carcoar Granodiorite intrusion, and late-stage mafic intrusive rocks and skarn development are also associated with this contact. All of these processes are likely to result in a zone that is prone to brittle fracture development and localised deep weathering, enhancing the water-bearing characteristics of the rock.

Secondly, there is intense fracturing associated with the eastern shear zone and the Mt David Fault. The eastern shear zone may act as a conduit, draining groundwater towards the former mine pit from the Blayney Volcanics and the Carcoar Granodiorite.

Thirdly, there has been development of karst features such as solution channels and caves in the Cowriga Limestone. This karst development probably initiated along structural fractures weaknesses associated with the eastern shear zone and contact metamorphism.

Fracturing in the volcanic sequence and the granodiorite, and both open caves and breccia-filled collapse zones in the limestone are likely to have high groundwater transmissivity. Collapse breccias and zones of deep weathering may provide enhanced groundwater storage.

3.6 Available Resource

The DOC (2008) report estimated the outflow from the pit to be 0.75 ± 0.25 ML/d, and the pit storage to be 4700 ML. No estimate of groundwater storage or sustainable yield under pumping was made. The NSW DWE (quite rightly) indicated at that time that a large-scale (high rate, long duration) pumping test would be required to reliably estimate these quantities.

A minimum groundwater resource can be estimated from the outcrop area of the Cowriga Limestone (22 hectares), a specific yield of 0.05 and a saturated depth of 132 metres, with an adjustment for the volume of the existing pit. This minimum groundwater storage is about 1,200 ML. However, the Eastern Shear Zone may provide a conduit linking three areas of Cowriga Limestone, together with some storage in fractures in the Blayney Volcanics. Thus groundwater storage could be considerably higher.

However, at this time there is simply not enough information to assess whether or not a groundwater supply from Browns Creek could make a reliable contribution to the Orange Water Supply.

A detailed hydrogeological investigation involving drilling and pump testing in the Cowriga Limestone and along the Eastern Shear Zone would be required to establish whether or not this is the case.

It is likely that groundwater abstraction either from the pit or directly from the Cowriga Limestone would affect flows in Cowriga Creek.

3.7 Water Quality

The DOC (2008) report provided limited water quality data obtained from three samples taken from the mine pit. The water is of generally potable quality, but heavy metal concentrations are high. Arsenic in particular was reported at a concentration of 114 micrograms per litre ($\mu\text{g/L}$) against a drinking water guideline concentration of $7 \mu\text{g/L}$. Antimony concentrations were also above the guideline values, although by a small margin, while iron and manganese concentrations were within

guidelines. It is likely that arsenic has been released by oxidation of arsenic-bearing sulphides originally present in the mineralised zone.

As indicated by DOC, arsenic at these concentrations would need to be removed by water treatment. Neither the DOC study nor the routine sampling carried out by ANL have recently detected cyanide. Persistence of free or weak-acid dissociable cyanide from mining operations over 13 years ago is considered unlikely. It is possible that complex cyanides have persisted under reducing conditions in deeper parts of the mine.

DOC suggests that it may be possible to obtain water of better quality (i.e. with lower arsenic concentrations) by constructing bores in the aquifer away from the immediate vicinity of the mine. This may possibly be the case, but it should be recognised that the mineralised area extends beyond the mined area, and that there is hydraulic continuity between the open-cut and underground workings and the limestone aquifer, so that if the aquifer is pumped, water may be drained back into it from the mine workings. Thus while it may be possible to obtain water with lower arsenic concentrations in this way, it is unlikely that the need for treatment can be eliminated. Treatment to remove arsenic is feasible, but at an additional cost.

Logically, any drilling program would target the Cowriga Limestone north of the flooded mine pit. Although a structural / hydrogeological analysis would assist, intersecting karst features with boreholes would require a measure of luck as well. Drilling through karst collapse breccia may be challenging. Nevertheless, bore construction is probably feasible.

3.8 Licencing Requirements

The Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources (2011) is now in force and applies to groundwater associated with the Browns Creek mine. The Groundwater would be drawn from the Lachlan Fold Belt MDB Groundwater Source, and the site lies within the Lachlan Fold Belt MDB (Other) Management zone.

The long-term extraction limit for the groundwater source is 821,250 ML/year. Currently, share components for the source (aquifer access licences and local water utility access licences) total 73,599 ML/year. In such an extensive and heterogeneous groundwater source, local yield and sustainability is of much more significance than regional figures.

It is likely that subject to adequate local hydrogeological appraisal a local water utility access licence could be granted. The volume that would be licensed, is not known, and may initially be a small portion of the estimated sustainable yield.

A water supply works approval would also be required.

ANL has an aquifer access licence that currently allows an extraction of 80 ML/year from the pit.

3.9 Conclusions

It is concluded that although there is potentially a significant groundwater resource at Browns Creek, the sustainable yield of the local aquifer system, which may include the Cowriga Limestone and part of the Blayney Volcanics, has not been established. There are also significant water quality issues, but these are likely to be solvable, at a cost. A detailed local hydrogeological study would be required both to justify the costs of development, and as a prerequisite for obtaining an access licence and works approval.

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Appendix C

Decision support tool framework



ORANGE WATER SUPPLY SYSTEM

DEVELOPMENT OF A DECISION SUPPORT TOOL

SUGGESTED SCOPE & METHODOLOGY

PREPARED FOR

ORANGE CITY COUNCIL



JANUARY 2013

ORANGE WATER SUPPLY SYSTEM

DEVELOPMENT OF A DECISION SUPPORT TOOL

SUGGESTED SCOPE AND METHODOLOGY

PREPARED FOR:
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JANUARY 2013



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Report Title:	<i>Orange Water Supply System</i>
Project:	<i>Development of a Decision Support Tool</i>
Client:	<i>Orange City Council</i>
Report Ref.:	<i>211219_REP_004E.docx</i>
Status:	<i>Final</i>
Issued:	<i>18 January 2013</i>

Geolyse Pty Ltd and the authors responsible for the preparation and compilation of this report declare that we do not have, nor expect to have a beneficial interest in the study area of this project and will not benefit from any of the recommendations outlined in this report.

The preparation of this report has been in accordance with the project brief provided by the client and has relied upon the information, data and results provided or collected from the sources and under the conditions outlined in the report.

All information contained within this report is prepared for the exclusive use of Orange City Council to accompany this report for the land described herein and are not to be used for any other purpose or by any other person or entity. No reliance should be placed on the information contained in this report for any purposes apart from those stated therein.

Geolyse Pty Ltd accepts no responsibility for any loss, damage suffered or inconveniences arising from, any person or entity using the plans or information in this study for purposes other than those stated above.

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1.0 INTRODUCTION

1.1 BACKGROUND

Orange City Council has been expanding its water sources to include a range of independent supplies. This expansion has been driven by the need to increase the system secure yield. The Orange water supply currently includes surface water, stormwater and groundwater.

Despite this expansion, the secure yield of the existing system is less than the current estimated unrestricted demand. Further, Council has adopted a 50 year strategic planning period for water supply and over this period has the objective of having water supply infrastructure in place 10 years in front of the demand.

Council is currently seeking approval for the following works:

- Blackmans Swamp Creek stormwater harvesting Stage 1b;
- Raising Suma Park Dam; and
- The Macquarie River to Orange pipeline.

The Macquarie River to Orange pipeline was modelled for the environmental assessment adopting an operating rule of extracting 12 ML/day from the Macquarie River when flow in the river is greater than 38 ML/day and the volume in Suma Park Reservoir is less than 90% of full capacity. Under these operating rules, the pipeline project can deliver an additional secure yield of 2,700 ML/year.

Environmental and financial assessment of the Macquarie River pipeline was based on it operating as described above so that it provided a worse case basis for the assessment (in terms of river water extraction and cost). It was noted in the assessment that:

If the project obtains approval, Orange City Council would then have a variety of water supply options, each with different performance characteristics. Council therefore proposes to develop a decision support tool that would make use of operational and model data and consider elements such as seasonal variation and long term climate indicators (such as the southern oscillation index) to optimise the use of the various sources. It is considered that this tool would help reduce the required extraction from the Macquarie River such that the long term average annual extraction would be less than used in this impact assessment.

1.2 OBJECTIVES

The objective is to develop a decision support tool that:

- defines operating rules for the various water supply components;
- minimises the raw water costs;
- maximises the use of the existing surface water systems;
- allows sustainable management of the water drawn from the bores, Blackmans Swamp Creek, Ploughmans Creek, and the Macquarie River;
- provides flexibility in the operating rules through regular consideration of demand and supply indicators; and
- provides a means of accounting for environmental flow releases from Suma Park Dam.

The decision support tool would apply to the Orange city water supply system only (i.e. not the villages of Lucknow and Spring Hill which are supplied from groundwater).

2.0 WATER SUPPLY SYSTEM

2.1 EXISTING SUPPLY

The existing Orange water supply system consists of the following elements (**Figure 1**):

- Surface water catchments and the main reservoirs formed by Gosling Creek, Spring Creek and Suma Park Dams;
- The Blackmans Swamp Creek stormwater harvesting scheme – currently approved to operate whenever the level in Suma Park reservoir is below 50% (BSCSHS Stage 1a);
- The Ploughmans Creek stormwater harvesting scheme – currently approved to operate whenever the level in Suma Park reservoir is below 100%; and
- Groundwater bores at the Showground, Council works depot and Clifton Grove.

Modelling undertaken for the IWCM Evaluation Study determined that the secure yield of the current system is 4,750 ML/year (based on the 5/10/10 rule) made up of:

- | | |
|--|---------------|
| • Surface water catchments (Gosling, Spring Creek and Suma Park Dam) | 3,400 ML/year |
| • Harvesting schemes (Blackmans Swamp Creek and Ploughmans Creek) | 900 ML/year |
| • Bores (Licensed for 462 ML/year) | 450 ML/year |

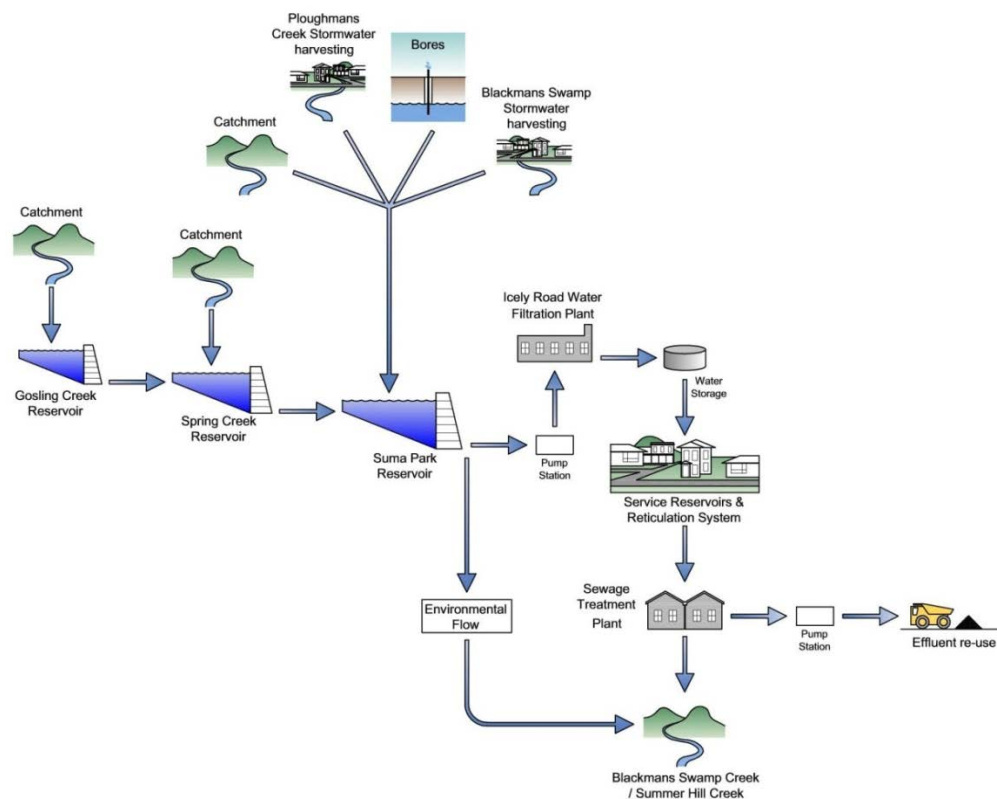


Figure 1: Orange existing water system schematic

2.2 FORECAST DEMAND

Forecast demand modelling was undertaken for the IWCN Evaluation Study and is shown in **Figure 2** through to 2060 for medium and high population growth. The existing secure yield of 4,750 ML/year (red line) is less than the current unrestricted demand of 5,400 ML/year. The impact of water demand management measures is predicted to keep the average annual water demand at around 5,400 ML/year for the next five years or so. Then population growth will start to increase the gap between demand and secure yield.

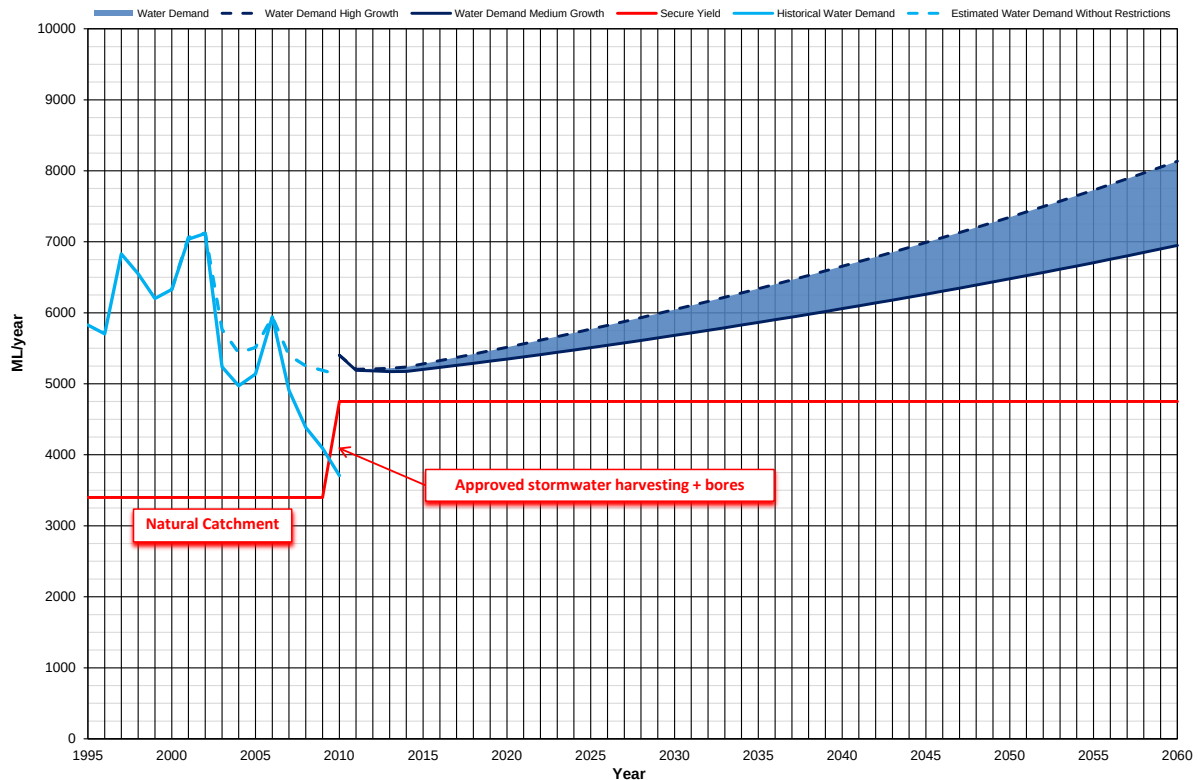


Figure 2: Orange city forecast water demand

2.3 PROPOSED SYSTEM SECURE YIELD

Council is currently seeking approval for the following works:

- Blackmans Swamp Creek stormwater harvesting Stage 1b (adds 200 ML/year secure yield);
- Raising Suma Park dam (adds 150 ML/year secure yield); and
- The Macquarie River to Orange pipeline (12/38 operating rule adds 2,700 ML/year secure yield).

These sources could increase the system secure yield to 7,800 ML/year which could provide water security for the next 39 to 58 years (without the potential impacts of climate change) based on high and medium population growth projections respectively.

2.4 SECURE YIELD, ACTUAL SUPPLY AND RISK MANAGEMENT

Secure yield is a strategic water supply assessment that demonstrates the proposed system (if approved) can be operated to provide water security for Orange for 39 to 58 years, subject to the restriction regime defined by the 5/10/10 rule. This water security is provided through drought periods. The secure yield does not represent a volume that will be/can be supplied each year.

The volume of water supplied by any of the sources will vary from year to year depending on demand (which is influenced by climate, demand management measures and population), climate and how each particular water source is performing. Operation of the water supply system will therefore be dynamic and will most likely vary from year to year depending on these factors.

Furthermore, predicting climate sequences into the future is uncertain, so operation of the system takes on a risk management approach. That is, as the system enters a drought period, it is not possible to predict with certainty how bad that drought sequence will be. Keeping the system storage fuller using external sources (bores, harvesting and the Macquarie River) reduces the risk of running out of water through an extended drought. The trade off with this risk management approach is that when drought breaking catchment inflows occur, less volume is required to fill the storage, resulting in a greater spill volume in that event. Less of the natural catchment runoff is captured.

The Macquarie River to Orange pipeline provides the greatest secure yield increase in the proposed system and contributes to long term water security for Orange. In the shorter term, it does not need to be operated as assessed to provide an adequate secure yield buffer above the demand. The pipeline project was developed for a 50 year planning period. It can be implemented in stages as demand grows with population growth. Operating the pipeline at a lower secure yield level would reduce the volume transferred from the river and provide more storage space to capture catchment runoff. Operating the pipeline in this manner will help meet several of the decision support tool objectives. The impact of different pipeline operating rules is described in the following section.

2.5 MACQUARIE RIVER TO ORANGE PIPELINE OPERATING RULES

The Macquarie River to Orange pipeline was based on a defined operating rule that allowed assessment of the project on what was considered to be a conservative basis. That is, it maximised the volume of water extracted from the river system and therefore maximised the impacts of the project (i.e. a worst case scenario approach).

The project was assessed on the 12/38 operating rule of extracting 12 ML/day from the river when:

- the flow in the Macquarie River is greater than 38 ML/day; and
- Suma Park Reservoir volume is less than 90%.

If approved, the pipeline project would be an additional supply source to the Orange water supply system. The potential secure yield from the Macquarie River pipeline shows that it can provide long term water security for Orange. Reduced yield from the project could be achieved by:

- lowering the trigger level in Suma Park Reservoir;
- increasing the river flow trigger;
- reducing the daily volume transferred from the river (by reducing the pump time);
- adopting a percentage of river extraction to limit the extraction around the river trigger flow; and/or
- a combination of all of the above.

Figure 3 shows the estimated secure yield from the pipeline system for various Suma Park Reservoir and river flow triggers. As expected, this shows decreasing secure yield from the system with lower Suma Park Reservoir trigger levels and higher river flow triggers. It does indicate that the transfer system could be operated on different rules to satisfy lower initial secure yield targets.

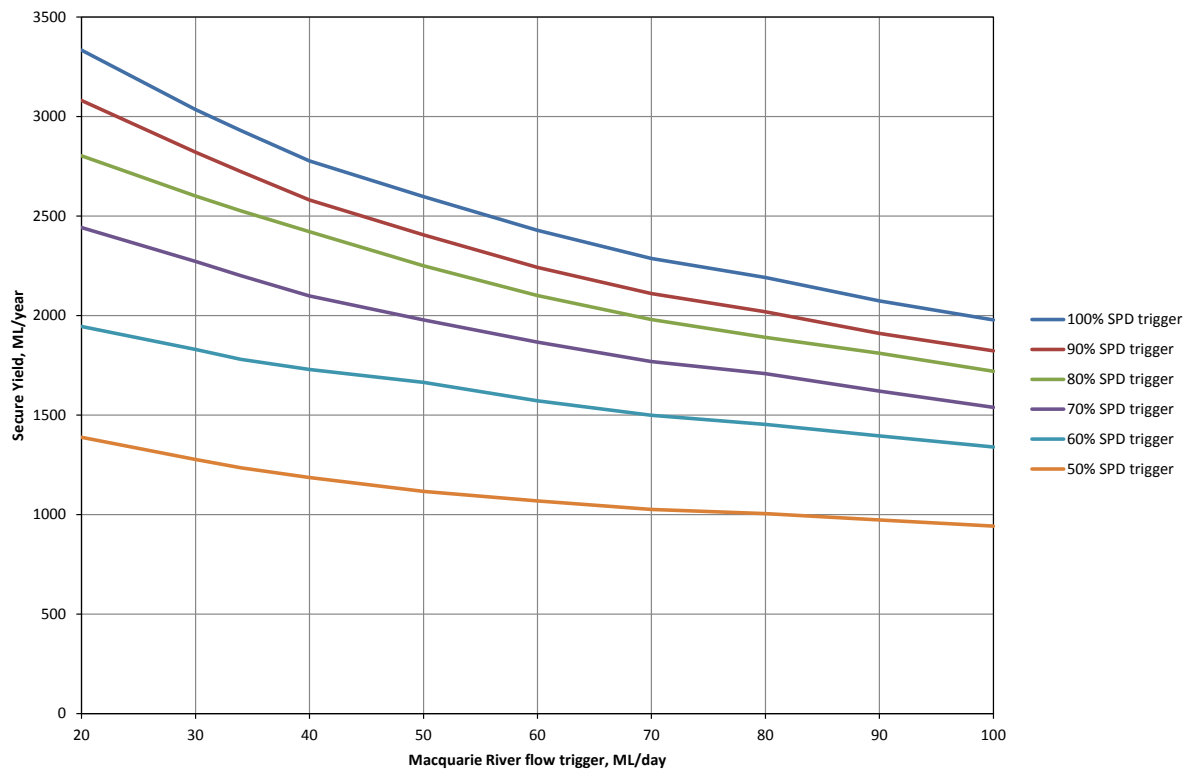


Figure 3: Secure yield estimates for various dam and river flow triggers

Another way to vary the transfer scheme operation is to change the volume pumped in a day (by controlling pump hours). **Figure 4** shows the relationship between the daily pump volume and the secure yield and average annual extraction for a range of daily extractions increasing to 12 ML/day and river flow trigger of 38 ML/day.

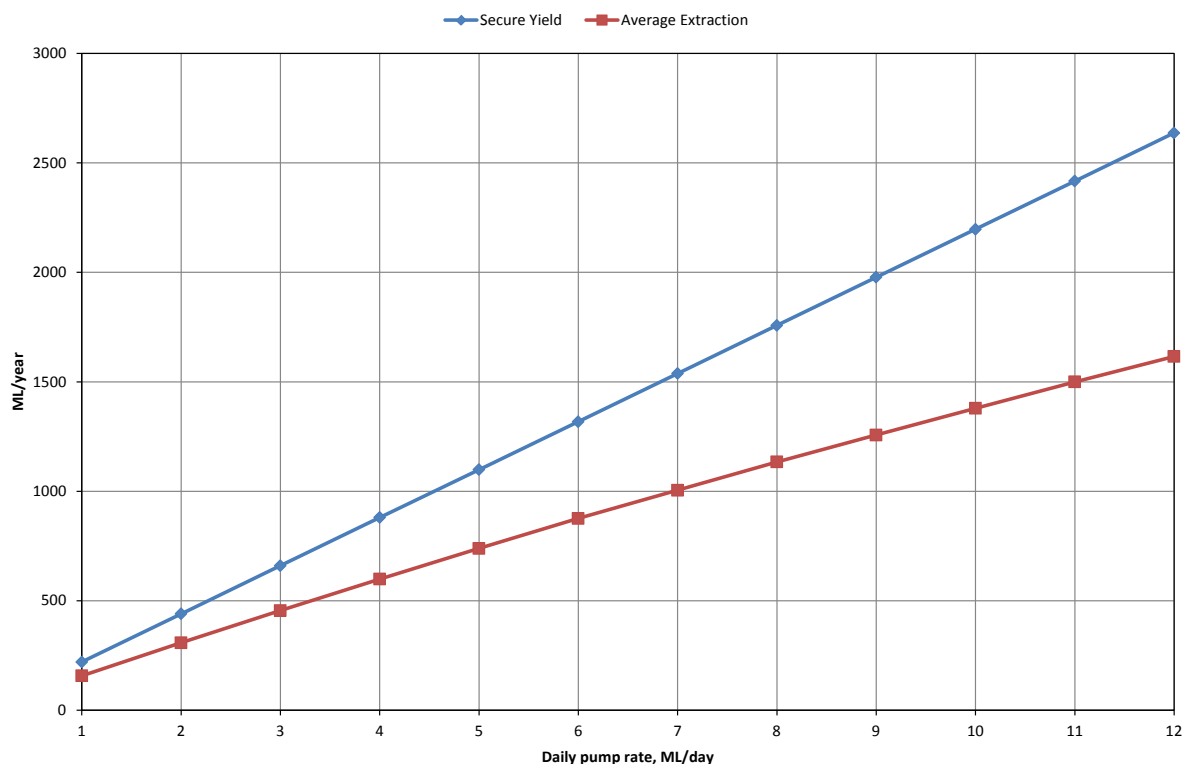


Figure 4: Secure yield and average annual extraction for different daily pumping rates

Another rule variation could be limiting the extraction to a set proportion of the daily flow once it is above a set river flow. This would limit the proportion of extraction at the adopted river trigger flow. For example the operating rule could be:

- No transfer if Suma Park Reservoir is above 90%;
- No transfer if the river is less than 38 ML/day; or
- Transfer a set percentage of the river flow once the flow goes above 38 ML/day (and Suma Park Reservoir less than 90%) up to a maximum of 12 ML/day. For example, for a set 10% extraction, if the river flow is 40 ML/day, the transfer would be 4 ML/day; if the river flow is 60 ML/day, the transfer would be 6 ML/day; and the full 12 ML/day transfer would not happen until the river reached 120 ML/day (and Suma Park Reservoir less than 90%).

Figure 5 shows the relationship between the set extraction percentage and the secure yield and average annual extraction for a range of extraction percentages increasing to 50%. Above 31.5% there is no change in secure yield or average annual extraction as this is extracting 12 ML from a flow of 38 ML/day.

A 10% extraction would arguably be immeasurable in terms of changes in the river flow conditions at the 38 ML/day trigger (i.e. taking 3.8 ML from a flow of 38 ML/day). The gauging station alone is expected to have errors of 10-15%. This mode of operation still provides a reasonable secure yield of 2,200 ML/year which is more than sufficient for the short term. Operation of the scheme to gain a higher secure yield (i.e. 2,700 ML/year) could then be based on river flow data obtained through the initial years of operation.

This mode of operation would limit the extraction at the adopted river trigger flow and indicates that the system has enough flexibility such that it can be operated to have negligible impact on the daily river flows.

Finally, this type of operating rule could be combined with various Suma Park Reservoir and river flow triggers (refer to **Figure 3**) as required to meet secure yield targets.

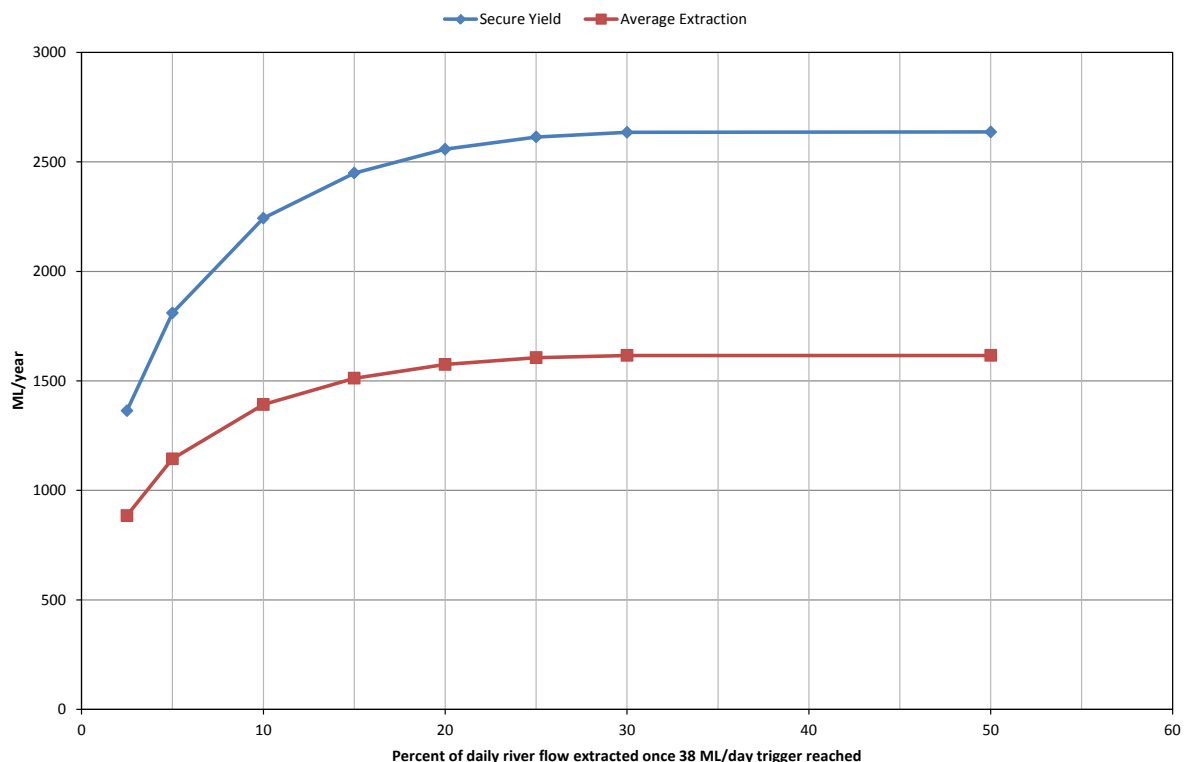


Figure 5: Secure yield and average annual extraction for set extraction percentages

3.0 TERMS OF REFERENCE

3.1 SCOPE AND OBJECTIVES

The decision support tool applies to the Orange city water supply system only (i.e. not the villages of Lucknow and Spring Hill).

The objective is to develop a decision support tool that:

- defines operating rules for the various water supply components;
- minimises the raw water costs;
- maximises the use of the existing surface water systems;
- allows sustainable management of the water drawn from the bores, Blackmans Swamp Creek, Ploughmans Creek, and the Macquarie River;
- provides flexibility in the operating rules through regular consideration of demand and supply indicators; and
- provides a means of accounting for environmental flow releases from Suma Park Dam.

The tool would consider the cost of raw water only (i.e. the cost of delivering water to the Icely Road water treatment plant).

3.2 WATER SUPPLY OPTIONS

The decision support tool would consider the following mix of water supply options:

- Existing surface water system;
- Existing bores;
- Blackmans Swamp Creek stormwater harvesting Stage 1a;
- Ploughmans Creek stormwater harvesting;
- Raising Suma Park Dam;
- Blackmans Swamp Creek stormwater harvesting Stage 1b; and
- Macquarie River to Orange pipeline.

3.3 ESTIMATED SECURE YIELD

The modelling of proposed operating rules would use the estimated secure yield approach and no external secure yield modelling would be undertaken.

4.0 DECISION SUPPORT TOOL

4.1 SUGGESTED STRUCTURE AND APPLICATION

It is suggested that the decision support tool has three elements:

- Element 1: defined operating rules that provide a system secure yield with adequate buffer above the forecast demand. These rules would be defined and optimised using a multi criteria methodology. It is suggested that the rules be defined and reviewed every five (5) years;
- Element 2: procedures for regular review each year (suggested quarterly) and adjustment of the operating rules based on consideration of demand and supply indicators; and
- Element 3: record keeping and reporting.

4.2 ELEMENT 1: DEFINED OPERATING RULES

4.2.1 Model Considerations

Optimisation of the operating rules should consider the following metrics for each water source:

- Water quantity/volume supplied;
- Water quality;
- Cost of supply water (\$/kL); and
- Environmental impacts.

A combination of operating rules could be used to deliver the minimum secure yield required and each set of operating rules would come at different cost. Therefore, rule set would be defined that would deliver the minimum secure yield required and these would be evaluated against criteria of water quality, cost and environment using a multi criteria analysis process (see **Section 4.2.2**).

The system operating rules would include the proposed environmental flow rules for Suma Park Dam. These rules would be subject to Council obtaining approval for raising the dam wall.

4.2.2 Analytical Hierarchy Process

The process called Analytical Hierarchy Process (AHP) would be used to assist with the development of the decision support tool and specifically the assessment of rule combinations. The weighting and scoring used in the AHP would be undertaken as a group using a cross-divisional team of Council staff.

The AHP is a systematic, formalised and accountable selection process used to weigh the relative merits of different options and to select the most optimal. The advantage with this approach is that the assessment criteria can be qualitative or quantitative and the final result can be a mixture (i.e. not everything needs to be expressed in the same units). This allows comparison of social, environmental and economic criteria. The process is robust, transparent and repeatable.

The process consists of four steps:

1. Decide upon the criteria against which the options will be assessed. As noted above the four suggested criteria are water quantity, quality, cost and environment. Others can be defined if considered appropriate.
2. Rate the relative importance of these criteria using pair-wise comparisons, assigning a value of between 1 and 9 (1 indicating equal importance, 9 indicating absolute greater importance) to the more important criterion, and assigning the reciprocal to the other criterion in the pair.
3. Rate each potential option (set of rules) relative to every other option on the basis of each selection criterion, by performing pair-wise comparisons of the options.
4. Combine the ratings derived in the second and third steps above to obtain an overall relative rating for each potential option.

The above process would be undertaken in an interactive group setting using a software program (Make it Rational) so that results can be determined and reviewed/discussed.

AHP Input Data

The following background data/information would be prepared to inform the AHP workshop:

- Three to four sets of operating rules for each five year block;
- Costs for these rules based on the cost of delivering raw water;
- An assessment of the relative volume of the water mix to inform the consideration of water quality impacts; and
- An assessment of the extraction volumes from each source to inform the consideration of water environmental impacts.

This information would be presented in a background paper.

AHP Workshop

A workshop would be used to discuss the rules developed and use the AHP process to identify the preferred rule set.

The preferred/adopted rules would be documented in the decision support tool following this workshop.

4.2.3 Reporting and Review

It is suggested that rules are defined for five year periods to provide a system secure yield with adequate buffer above the forecast demand.

Once the AHP process is defined it will provide a methodology to use in subsequent reviews. Results of the rule definition will be reported. The NSW Office of Water would be provided with the five year rules along with forecast of the likely licence transfer requirements.

The rules would be reviewed and re-defined as necessary every five (5) years.

4.3 ELEMENT 2: YEARLY REVIEW

The operating rules defined in Element 1 would provide the overarching rules for a five year period. However, in any one year, there will be indicators that may warrant temporary changes to the rules either to transfer more water into storage or to transfer less. These indicators include demand patterns, climate (current and forecast), current storage levels and catchment conditions.

It is suggested that the water supply position and operating rules are reviewed four times each year (say January, April, July and October) to correspond with seasonal changes. It is envisaged that the quarterly reviews would be undertaken by operational managers within the methodology defined in the five year rules.

Some factors that would be included in this review are:

- The seasonality of inflow to Suma Park Dam – historical data shows more spill in late winter/spring due to increased catchment runoff in these periods;
- Long term weather indicators (e.g. SOI) – this could be along the following lines: If a proportion of the climate models (suggested 5 of the 7 models) used by the Bureau of Meteorology predict a neutral/wet or wet forecast, and the Predictive Ocean Atmosphere Model for Australia for the NINO4 region predicts a greater than determined trigger percentage chance of an La Niña (50% chance is suggested) event during any one month of the approaching period then the operating rules would be reviewed as required;
- System performance – some elements of the supply system may be off-line, or scheduled to be off-line, for some reason relating to either maintenance or some other requirement; and
- Environmental consideration – there may be environmental reasons for not using some or all of the external water sources. An example could be extended periods of low flow in stream systems and a decision not to harvest until the system has been flushed. This may also be triggered by water quality concerns.

It is considered that the review would generally function as follows:

- The current storage level and demand profile would be reviewed and compared to forecasts;
- Weather forecasting indicators would be reviewed to determine the likelihood of wetter or drier conditions;
- Seasonality factors would be considered;
- Operational and environmental matters would be considered; and

- Rules would be reviewed as required:
 - If the system is tracking as forecast and indicators are for average conditions, rules would remain unchanged.
 - If the system is tracking below forecast and indicators are for drier conditions, rules would be modified to increase external transfers.
 - If the system is tracking above forecast and indicators are for average or wetter conditions, rules would be modified to decrease external transfers.

4.4 ELEMENT 3: RECORDS AND REPORTING

Council would maintain appropriate records to allow review and reporting on an annual basis. These records would include, but not necessarily be limited to, the following (it is noted that Council already maintains the majority of these records):

- Storage levels;
- Daily raw water demand;
- Daily inputs from external sources (bores, stormwater harvesting, Macquarie River pipeline);
- Daily stream flows – Summer Hill Creek, Blackmans Swamp Creek, Ploughmans Creek and Macquarie River;
- Environmental flow release from Suma Park Dam;
- Rainfall data; and
- Any operational matters that effect bulk water supply.

Data would be used to inform the quarterly review and would be collated into an annual report to correspond with July to June water years.

Annual reports would be provided to the NSW Office of Water.

Appendix D

Concept plans for the project

WORKING PLOT

ORIGINAL SIZE **A1**

GENERAL ARRANGEMENT
SECTION

NOT FOR CONSTRUCTION		
Status Stamp	WORKING PLOT	
Date Stamp		
Coordinate System		
Scales	AS SHOWN	Datum
Drawing No.	A1324400-04-001-C002	Rev
		A

