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COWAL GOLD MINE
E42 MODIFICATION
HYDROGEOLOGICAL AND TAILINGS SEEPAGE ASSESSMENT

Cowal Gold Mine, West Wyalong, NSW

GEOTLCOV21910AB-AE
7 July 2008

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Tables

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Attachments

EXECUTIVE SUMMARY

This Hydrogeological and Tailings Seepage Assessment was conducted for a proposed modification (herein referred to as the E42 Modification) to the approved Cowal Gold Mine (CGM).

The CGM is located approximately 38 kilometres north-east of West Wyalong, New South Wales.

The objectives of the Hydrogeological and Tailings Seepage Assessment were to assess the potential for the hydrogeological regime to change from that described in previous documentation by assessing:

- open pit dewatering;
- effects of pumping from the saline water supply;
- long-term inflows to the final void created by mining operations;
- short and long-term groundwater quality;
- seepage from tailings ponds; and
- the hydraulic relationship between Lake Cowal and groundwater and the short and long-term effects of mine closure on Lake Cowal.

Predicted Open Pit Inflows

For the modified CGM, groundwater inflows to the open pit are expected to be similar to, though slightly larger than, what would have occurred under the current mine plan. A small increase (of the order of 15%) in flow rate is anticipated as a result of the expanded open pit area. The increased depth of the open pit as a result of the E42 Modification is not considered a significant factor in relation to groundwater inflow as the rock permeability reduces substantially with depth.

Groundwater inflows are expected to gradually diminish with time as the surrounding groundwater levels draw down. The level of the open pit is well below the naturally occurring groundwater level and as a result the open pit would act as a groundwater sink for the duration of the mining operations. Consequently, groundwater flow direction would be inward towards the open pit during mining operations.

Following cessation of mining operations, groundwater inflow would diminish over time and stabilise when groundwater inflow balances net evaporative loss. The groundwater level within the open pit would stabilise well below the natural groundwater level and as a result the open pit would act as a groundwater sink in the long-term following completion of mining operations. Consequently, as is expected during mining, groundwater flow direction would be inward towards the open pit following completion of mining operations.

Potential Drawdown

The modified CGM is expected to experience flows to the open pit of the order of 1 megalitre per day (ML/day). Additionally, the small saline alluvial aquifer borefield proposed on Mining Lease 1535 would also extract approximately 1ML/day. Drawdowns resulting from the E42 Modification would be marginally greater than would have occurred under the current mine plan. Monitoring to date indicates that groundwater drawdown would be less than those predicted in the Cowal Gold Project Environmental Impact Statement (EIS) (North Limited, 1998).

Pumping at a rate of 1ML/day at the saline alluvial aquifer borefield to the south-east of the modified CGM open pit is not likely to impact groundwater levels in the Lachlan Formation, but may create localised drawdown in the upper reaches of the unconsolidated sediments at the location of that borefield. Potential drawdown effects are further discussed in Groundwater Consulting Services (2008) Saline Groundwater Assessment – Saline Alluvial Aquifer (Attachment AA).

Tailings Seepage

The E42 Modification would result in an increased height of tailings and hence an increased head of water. However, as the tailings consolidate, the thickness of low permeability consolidated tailings material would increase. This would increase the thickness of low permeability consolidated tailings at the base of the tailings storage facilities. Seepage from the tailings storage facilities to the underlying aquifers would be expected to continue as is the current case and ultimately slowly migrate toward the open pit via flows through the saline upper transported alluvial aquifer as predicted in the EIS. No other groundwater users of this aquifer have been identified, and hence no seepage impacts to other users would occur.

For the modified CGM, this process is expected to be essentially unchanged from that predicted in the EIS.

Predicted Impacts on Groundwater Quality

From the data supplied to date, Coffey Geotechnics Pty Ltd found no evidence to suggest that the natural groundwater chemistry would alter significantly as a result of the E42 Modification compared with the prediction set out in the EIS.

Hydraulic Relationship between Lake Cowal and the E42 Modification Open Pit

Whilst the E42 Modification would increase the size and depth of the final void, it would not alter the depth of relatively impermeable clay that separates the Lake Cowal bed from the aquifer system. Piezometric response in the Transported Alluvial Aquifers has been small and localised, consistent with low vertical and horizontal permeability, and inflows to the open pit have been small compared with the pre-development assessment. On this basis, the degree of hydraulic disconnection between Lake Cowal and the open pit described in the EIS would prevail for the modified CGM.

Effects of Mine Closure on Lake Cowal

The increased size and depth of the open pit for the modified CGM and the reduced (compared with the EIS) predicted groundwater inflow rates means that the final water level in the void may be different than predicted for the EIS. At the predicted long-term groundwater inflow rates to the open pit, the final void is expected to remain a permanent groundwater sink. Accordingly, the final void is assessed to remain hydraulically disconnected from Lake Cowal in the long-term.

A1 INTRODUCTION

Barrick Australia Limited (Barrick) proposes to modify a number of components of the approved Cowal Gold Mine (CGM), located within Mining Lease (ML) 1535 approximately 38 kilometres (km) north-east of West Wyalong in central New South Wales (NSW) (Figure A-1). Barrick's proposal to modify the approved CGM is herein referred to as the "E42 Modification".

Barrick commissioned Coffey Geotechnics Pty Ltd (Coffey[1]) to prepare a Hydrogeological and Tailings Seepage Assessment for inclusion in the Environmental Assessment (EA) for the E42 Modification.

Coffey has directed focus of the hydrogeological and tailings seepage assessment to address the following Director-General Requirement in relation to the EA for the E42 Modification.

"…*detailed modelling of potential…groundwater impacts of the revised mining operations, a geochemical assessment of the leachate impacts*…"

This requirement is addressed in this report through assessment of the potential for the hydrogeological regime to change from that described in previously approved documentation by assessing:

- open pit dewatering drawdown effects;
- effects of pumping from the saline water supply;
- long-term inflows to the final void created by mining operations;
- short and long-term groundwater quality;
- seepage from tailings ponds; and
- the hydraulic relationship between Lake Cowal and groundwater and the short and long-term effects of mine closure on Lake Cowal.

A1.1 E42 Modification

Figure A-2 shows the conceptual general arrangement of the modified CGM. The modified CGM is scheduled to commence in approximately Year 5 of CGM operations. The main changes to the approved CGM as a result of the E42 Modification would include those presented below:

- An increase to the operational mine life from 13 years to approximately 24 years.
- An increase in total production from approximately 76 million tonnes (Mt) of ore, to approximately 129Mt of ore.
- An increase in the maximum processing rate from approximately 6.9 million tonnes per annum (Mtpa) to approximately 7.5Mtpa.
- An increase in gold production from approximately 2.7 million ounces (Moz) of gold to approximately 3.5Moz of gold.

[1] In this report, the abbreviation "Coffey" refers to Coffey Geotechnics Pty Ltd, Coffey Geosciences Pty Ltd or Coffey International Pty Ltd, which are the various trading entities that have existed during the life of the CGM.

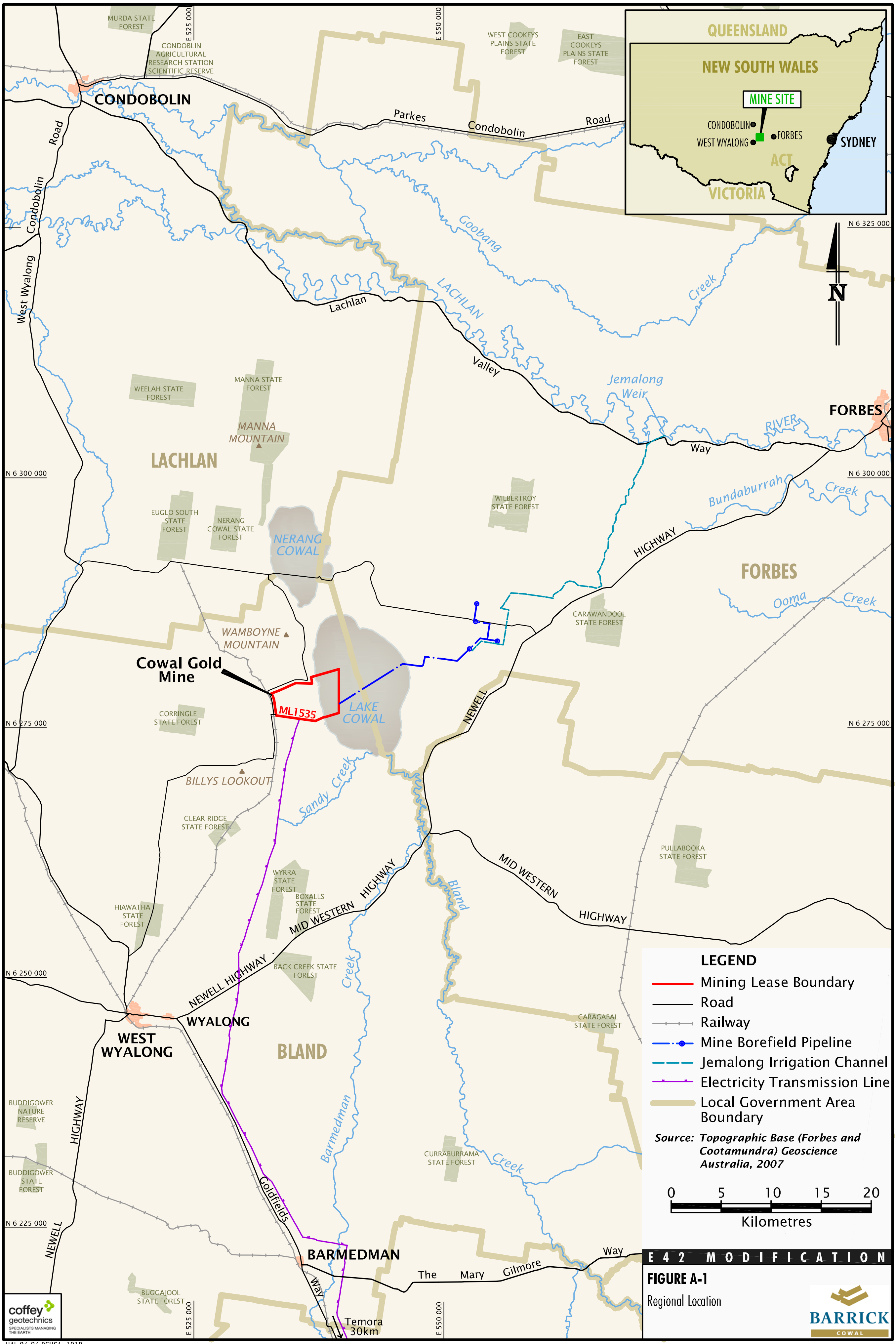
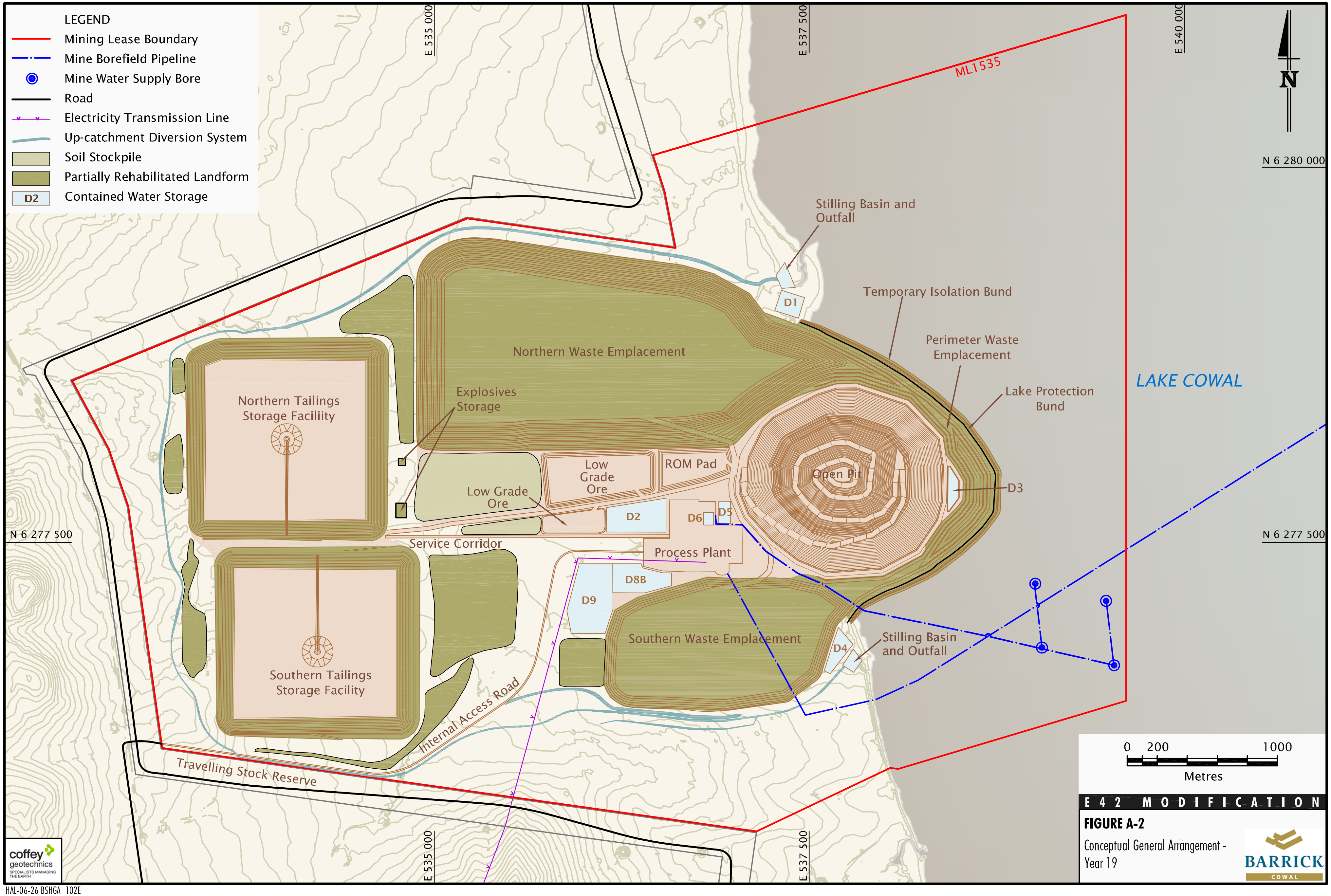


FIGURE A-1
Regional Location

HAL-06-26 BSHGA_101B



LEGEND
Mining Lease Boundary
Mine Borefield Pipeline
Mine Water Supply Bore
Road
Electricity Transmission Line
Up-catchment Diversion System
Soil Stockpile
Partially Rehabilitated Landform
D2 Contained Water Storage
E 535 000
E 537 500
E 540 000
N 6 280 000
N 6 277 500
N
ML1535
Stilling Basin and Outfall
Temporary Isolation Bund
Perimeter Waste Emplacement
Lake Protection Bund
LAKE COWAL
D1
D2
D3
D4
D5
D6
D8B
D9
Northern Waste Emplacement
Explosives Storage
Northern Tailings Storage Facility
Low Grade Ore
ROM Pad
Open Pit
Service Corridor
Process Plant
Southern Waste Emplacement
Stilling Basin and Outfall
Southern Tailings Storage Facility
Internal Access Road
Travelling Stock Reserve
0 200 1000
Metres
E 4 2 M O D I F I C A T I O N
FIGURE A-2
Conceptual General Arrangement - Year 19
BARRICK COWAL
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HAL-06-26 BSHGA_102E

- An increase in the total surface area of the open pit from approximately 70 hectares (ha) to approximately 130ha, with final pit dimensions increased from approximately 1,000 metres (m) long, 850m wide and 325m deep to approximately 1,250m long, 1,350m wide and 440m deep.
- An increase in the total volume of waste rock to be removed from the open pit from approximately 128Mt to approximately 184Mt.
- An increase the height and area of the northern waste emplacement to an approximate final height of relative level (RL) 275m Australian Height Datum (AHD) (increased from RL 243m AHD) and area of approximately 320ha (increased from approximately 160ha).
- An increase the height and area of the southern waste emplacement to an approximate final height of RL 255m AHD (increased from RL 223m AHD) and area of approximately 140ha (increased from approximately 120ha).
- A reduction in the height of the perimeter waste emplacement in places.
- An increase in the total surface area of low grade ore stockpiles from approximately 35ha to approximately 60ha.
- An increase in the total volume of tailings produced from approximately 76Mt to approximately 129Mt.
- An increase in the heights of the northern and southern tailings storage facilities to a final RL of 252m AHD (from approximately RL 233.5m AHD) and 256m (from approximately RL 241.5m AHD), respectively.
- Extraction of saline water from a saline groundwater supply borefield located within ML 1535.
- Other associated minor changes to infrastructure, plant, equipment and activities.

The E42 Modification would not result in changes to:

- Approved CGM open pit dewatering methods (although some open pit dewatering bores would be sacrificed as the final pit outline of the modified CGM extends beyond the ring of currently installed bores).
- Current approved limits on the extraction of water from the CGM Bland Creek Palaeochannel borefield, or the current system for managing groundwater levels around the CGM Bland Creek Palaeochannel borefield.

Consequently these matters are not discussed further in this report.

A2 INFORMATION SOURCES

Coffey has a long involvement with the CGM development and prepared documentation for the Cowal Gold Project Environmental Impact Statement (EIS) (North Limited, 1998). This hydrogeological assessment utilises the work previously conducted by Coffey and others that was documented or referred to in the EIS and subsequent information obtained during mining operations to date. Table A-1 summarises the technical reports that Coffey has used in this assessment.

Table A-1 Information Sources

Abbreviation	Document
EIS	North Limited (1998) Cowal Gold Project Environmental Impact Statement including: • Appendix N - Long Term Compatibility Assessment Studies (specifically Attachment N2-B Groundwater Studies – Hydrogeological Assessment); and • Appendix F - Water Management.
AEMR 2006	Barrick Australia Limited (2007) Cowal Gold Project Annual Environmental Management Report 2006 - Section 3.4 and Appendix B.
SWMP 2006	Barrick Gold of Australia (2003) Site Water Management Plan and 2004 and 2006 Addenda.
BHM 2007	Barrick Australia Limited (2007) Hydrogeology Monitoring Data for 2007.
SWGWBM 2005	Barrick Australia Limited (2005) Surface Water, Groundwater, Meteorological and Biological Monitoring Results 2005.
SWGWBM 2006	Barrick Australia Limited (2006) Surface Water, Groundwater, Meteorological and Biological Monitoring Results 2006.
PB – PHR 2007	Parsons Brinckerhoff Australia Pty Ltd (2007) Cowal Gold Project – Preliminary Hydrogeochemical Review of the Groundwater System.
URS–NTSF 2005	URS Australia Pty Limited (2005) Cowal Northern Tailings Storage Facility – Floor Permeability (ref 51755-005).
URS–STSF 2006	URS Australia Pty Limited (2006) Cowal Southern Tailings Storage Facility – Floor Permeability (ref 43167213).
COF-DEW 1995	Coffey Partners International Pty Ltd (1995) Lake Cowal Project – Hydrogeological Modelling and Dewatering Study. Report No. G255/28-AF April 1995.

A3 CHARACTERISATION OF THE HYDROGEOLOGICAL ENVIRONMENT

A3.1 Climate

The region is semi-arid with an average annual rainfall of 440 millimetres (mm) compared to average pan evaporation of 1,740mm. Rainfall is typically highest in winter. Since the mine operations commenced, the region has experienced consistently lower than average rainfall.

A3.2 Topography

The general landscape is flat to very gently undulating. Regionally, the mine is located in the Lachlan River Valley on the western margin of the Jemalong Plain, which is about 20 to 30km wide, bounded by the:

- Jemalong Range (Tullamore Syncline) to the east;
- Manna Anticline and its associated ridge, together with the regionally extensive Gilmore Suture, located to the west of Lake Cowal;
- Lachlan River to the north; and
- catchment of Bland Creek to the south.

A3.3 Regional Geology

The regional geological setting is dominated by the Gilmore Fault Zone, a structurally and lithographically complex feature that trends north–south through ML 1535 about 500m west of the modified CGM open pit. The fault separates a Late Ordovician volcaniclastic sequence (referred to as the Lake Cowal Volcanic Complex) from Siluro-Devonian sedimentary basement to the west. Siluro-Devonian sedimentary rocks also occur east of the Lake Cowal Volcanic Complex on the eastern side of Lake Cowal, where the basement has been deeply incised and lays host to palaeochannel deposits of the Bland Creek unit.

The region is covered by varying thicknesses of Tertiary and Quaternary regolith deposits. The Jemalong Plain was formed by the infilling of the Lachlan and Bland Creek palaeochannels, located to the north and east of Lake Cowal, respectively, with sediments of the Lachlan and Cowra Formations. The depth of these sediments is over 100m. Locally, Pleistocene Cowra alluvium overlies ML 1535 and thick Quaternary lacustrine sediments underlie Lake Cowal.

A3.4 Mine Geology

The E42 orebody is within the Lake Cowal Volcanics, which comprise massive stratified non-welded pyroclastic debris, overlying partly brecciated lava sequence, overlying volcanic conglomerate interbedded with siltstone and mudstone. The host rock has a consistent strike of 215 degrees (^{o}) and an approximate dip of 50^{o} to the north-west.

The Lake Cowal Volcanic Complex is intruded by several Late Ordovician diorite/gabbro stocks and mafic to intermediate dykes. Within the ore body there are several north/south oriented, near vertically dipping faults and fractured dykes.

Overlying the Ordovician host rock (Saprock and Primary) is a Tertiary age laterite (Saprolite), which averages about 20m thickness but is highly variable. Quaternary age sediments of predominantly lacustrine clay (Transported Alluvium) characteristically cover the Tertiary laterite. The depth is highly variable.

Figure A-3 shows a plan and cross-section of the modified CGM geology.

A3.5 Regional Hydrology

The Lachlan River is the major regional surface water system, forming part of the Murray-Darling Basin. The CGM is located on the western side of Lake Cowal, an ephemeral, fresh water lake within the Bland Creek valley. Lake Cowal receives inflow (in addition to direct rainfall and runoff) from:

- Bland Creek which drains into Lake Cowal at its southern end; and
- the Lachlan-Lake Cowal floodway to the north-east, when breakout flows from the Lachlan River directs floodwaters into the north-east section of Lake Cowal.

Lake Cowal covers an area of some 10,500ha and holds 150,000 megalitres (ML) of water when full. It has a maximum depth of about 4m. When full the lake overflows into Nerang Cowal to the north-west to eventually return to the Lachlan River.

Flow records for a gauging station on the mid-reaches of Bland Creek indicate that runoff is low and averages less than 5% of annual rainfall. Average runoff at the CGM as a proportion of rainfall is also expected to be small due to the flat, poorly drained nature of the terrain. Rainfall intensities for the area are also relatively low (compared to coastal areas) contributing to the low overall runoff potential (Gilbert and Sutherland, 1997).

A3.6 Hydrogeology

Regionally, groundwater resources within the region are associated with two geological formations:

- Lachlan Formation (Bland Creek Palaeochannel) which comprises an aquifer of quartz gravel with groundwater of generally low salinity; and
- Cowra Formation which comprises aquifers of isolated sand and gravel lenses in predominantly silt and clay alluvial deposits, with perched groundwater of generally higher salinity.

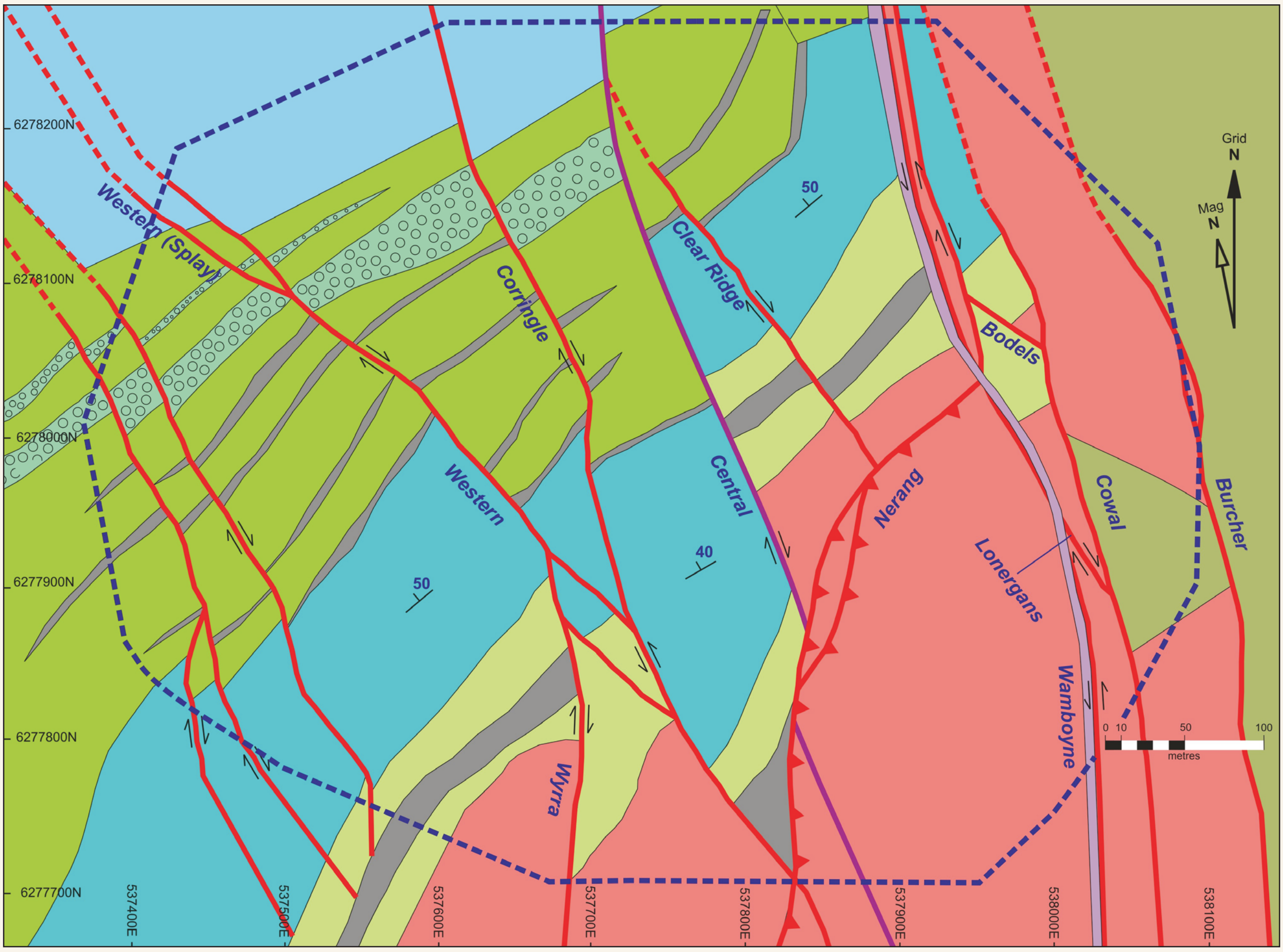
Locally, at the CGM, three saline aquifers have been identified. The Quaternary aged Cowra Formation sediments consist of thick clay sequences. These form aquitards to a gravel saline aquifer within the alluvium. A second saline aquifer occurs at the base of the Cowra Formation alluvium. Often these aquifers are termed collectively the Transported Alluvial Aquifers. Sometimes the lower aquifer is termed the Saprolite Aquifer (because of its position directly above the saprolite).

The saprolite underlying the alluvium forms another aquitard over a third saline aquifer that occurs in the weathered fractured surface of the Lake Cowal Volcanics before grading into more massive, less permeable rock. This is termed the Saprock Aquifer.

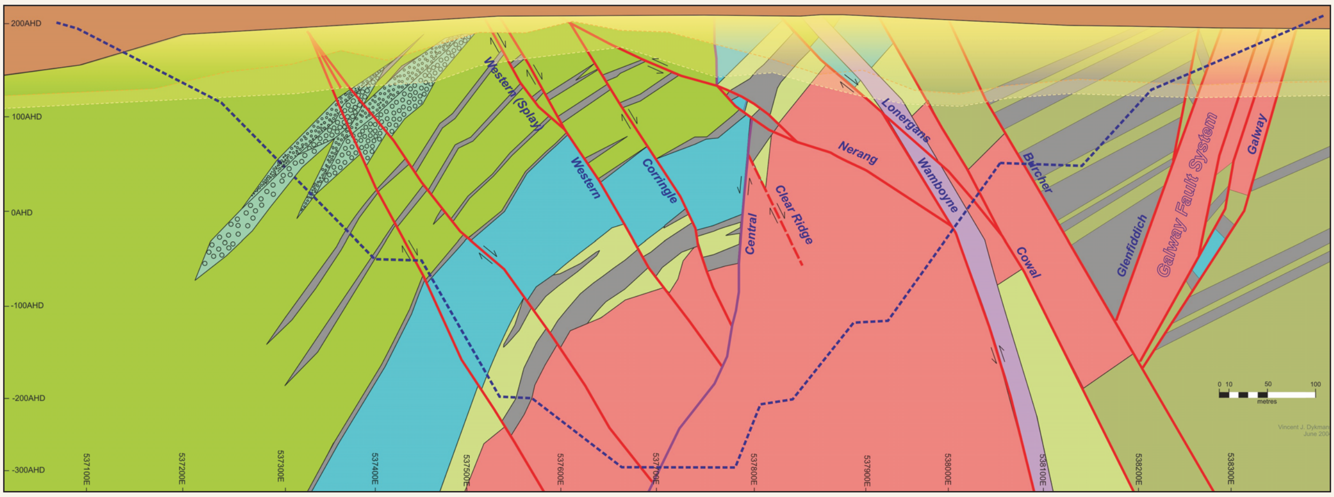
In the south-east of ML 1535 a fourth local saline alluvial aquifer has been investigated as a potential water source (Groundwater Consulting Services Pty Ltd [GCS], 2008 – see Attachment AA). Sands and gravels occurring in the upper part of the profile contain saline groundwater and appear to form a deposit oriented east-west, likely to be a part of the Cowra Formation discussed above.

The pre-mining groundwater flow was generally from east to west under a hydraulic gradient of about 0.1%, increasing to 0.3% further west.

FLITCH PLAN (1050 mRL)



CROSS SECTION (6278000 N)



Transported
Clay and Gravel (LACL/CCCL)

Upper Porphyritic Unit
Coherent / Autobrecciated Andesite (ANP/ANAI)

Upper Volcaniclastics
Sandstone/Conglomerate (VSG/VSC)
Interbedded Mudstone and Sanstone (VMS)
Graded Polymictic Deposit (VCCP)

Trachyandesite Lava
Coherent/Autobrecciaed /Resedimented Facies (TAP/TAAI/TAAR)

Lower Volcaniclastics
Sandstone/Conglomerate (VSG/VCCP)
Interbedded Mudstone and Sandstone (VMS)

Easter Volcaniclastics
Mudstone /Sandstone (VM/VSC)

Diorite Sill
Diorite/Monzodiorite (DI/MODI)

Diorite Dyke
Massive Porphyritic Dyke

Weathering
Saprolite
Top of Saprock
Saprock
Top of Fresh Rock

Structures
Fault Zone (FZ/SZ)
Central Fault Zone
Apparent Fault Movement
Thrust
Strike and Dip of Strata
Pit
Modified CGM Open Pit

Source: Barrick, 2008

E42 MODIFICATION

FIGURE A-3
Mine Geology

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A4 GROUNDWATER MONITORING

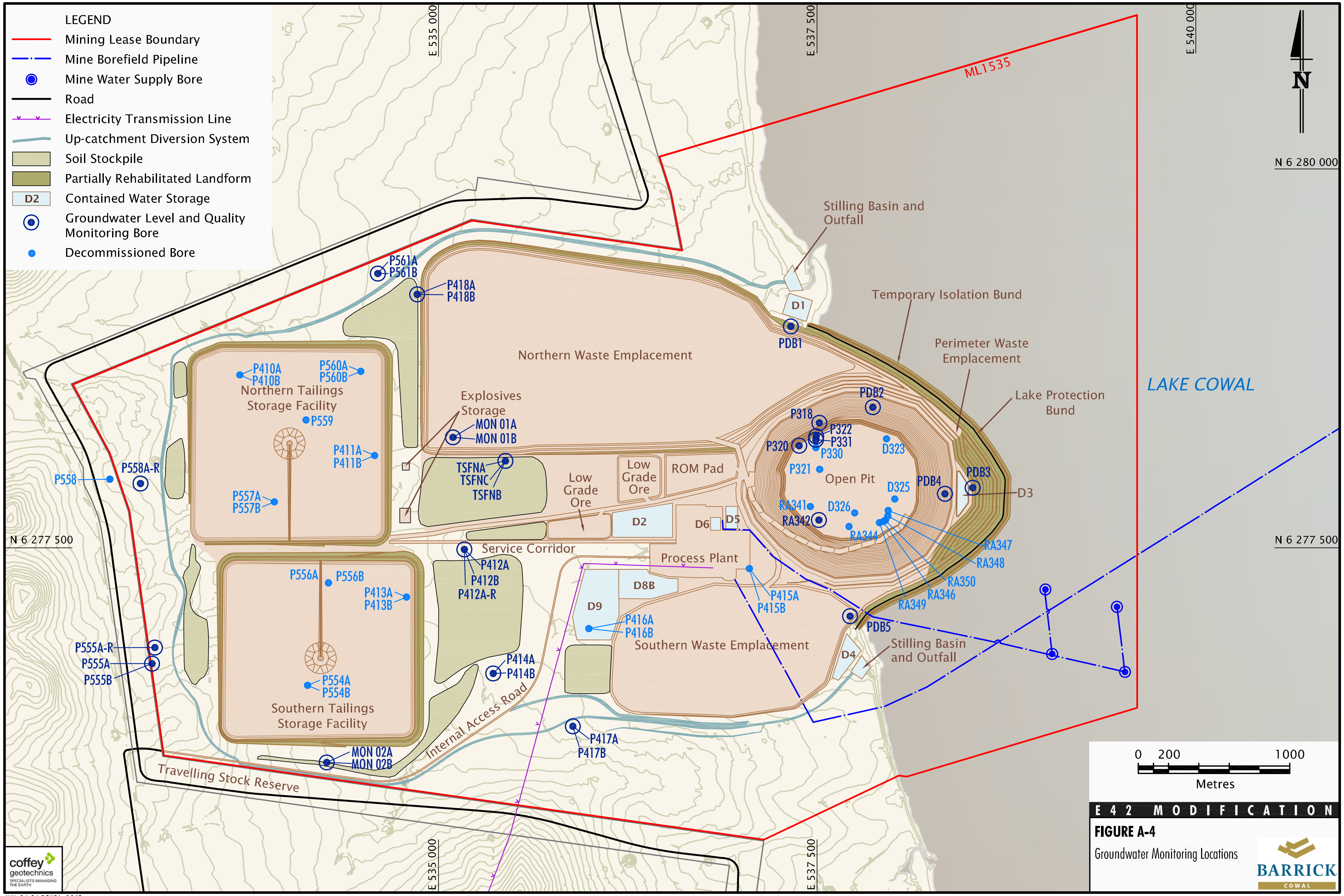
Groundwater monitoring boreholes installed within ML1535 are listed in Table A-2. During the period of mining operations some monitoring bores have been sacrificed as the open pit has increased in size, or as tailings storage facilities and waste emplacements have been constructed.

Table A-2 Groundwater Monitoring Sites within ML1535

Group	Groundwater Monitoring Bores	Function
A	D325[1], D326[1], RA341[1], RA342, RA344[1], RA347[1], RA348[1], RA349[1], RA350[1] D323[1], P321[1], RA346[1] P318, P322, P330[1], P320, P331, P415A[1] & B[1]	Open pit area – groundwater level monitoring bores. Open pit area – water quality monitoring bores. Groundwater level monitoring bores. Water quality monitoring bores.
B	PDB1, PDB2, PBD3, PDB4, PDB5	Pit dewatering water level monitoring bores located close to, but outside, the open pit void.
C	P412A & B, P412A-R, P414A & B, P416A[1] & B[1], P417A & B, P418A & B, P561A & B, MON01A, MON01B, MON02A, MON02B, P558[1], P558A-R, P555A & B, P555A-R, TSFNA, TSFNB, TSFNC	Long-term water quality monitoring bores located remote from the open pit mainly around the tailings storage facilities.
D	P410A[1] & B[1], P411A[1] & B[1], P557A[1] & B[1], P559[1], P560A[1] & B[1], P413A[1] & B[1], P554 A[1] & B[1], P556 A[1] & B[1]	Bores beneath the tailings storages (lost after development of the tailings storage facility).

[1] **Decommissioned bores**

Figure A-4 shows the locations of groundwater monitoring boreholes described above in Table A-2.



E 4 2 M O D I F I C A T I O N

FIGURE A-4

Groundwater Monitoring Locations

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A5 GROUNDWATER INFLOWS TO THE OPEN PIT

A5.1 Predicted Response in the EIS

Modelling by Coffey for the EIS indicated yields of 10 megalitres per day (ML/day) for the first 3 months with progressive decline over the subsequent 12 to18 months to about 5ML/day.

A5.2 Observed Response during Open Pit Dewatering to Date

Current operations utilise 19 dewatering bores located on the periphery and within the open pit. Each bore is screened in the Transported Alluvial and Saprock Aquifers.

In addition, in-pit horizontal drains have been installed on benches to drain saprock and underdrain less permeable clay and saprolite formations. The drains were installed progressively during excavation where monitoring indicated that enhancement of dewatering was required to promote pit slope stability.

Barrick records of dewatering volumes from boreholes PD1 to PD12, PD14, PD16 to PD27 and P322 for February 2005 to February 2008 indicate fairly consistent results after about August 2005. These are summarised below in Table A-3:

Table A-3 Water Extracted from Dewatering Bores

Period	Range (ML per month)	Average (ML per month)
Aug 05 to Dec 05	18.2 to 24.9	21.8
Jan 06 to Jun 06	13.4 to 30.5	24.1
Jul 06 to Dec 06	20.4 to 26.2	23.3
Jan 07 to Jun 07	16.9 to 20.1	19.1
Jul 07 to Feb 08	14.9 to 20.5	16.9

After reaching a peak in January 2006, the groundwater extraction rate appears to be gradually diminishing as groundwater levels drawdown around the open pit. This trend is indicated in Figure 29 of COF-DEW 1995. As a rough indication based on these previously modelled trends, average extraction rates may stabilise at 13 to 15ML per month within the next year.

The higher volumes of water collected in October 2006 to January 2007 in in-pit sumps (including rainfall) may indicate a period of higher rainfall. Volumes since February 2007 (converted to a monthly inflow rate) have been consistently within the range 10.2 to 13.8ML/month, except for a spike in inflows reaching 18.3ML/month in January 2008 (which may also reflect rainfall) (Table A-4).

Table A-4 Water Collected in In-Pit Sumps

Period	Range (ML per month)*	Average (ML per month)*
Oct 06 to Jan 07	25.9 to 29.7	28.2
Feb 07 to Feb 08	10.2 to 18.3	11.4

*** Includes rainfall.**

A5.3 Predicted Response for the Modified CGM

A5.3.1 Inflows during Mining Operations

Based on the above, the dewatering presently extracts about 1ML/day, comprising about 0.6ML/day from the dewatering bores and about 0.4ML/day (including rainfall) from sumps in the open pit.

For the modified CGM, groundwater inflows to the open pit are expected to be similar to, though slightly larger than what would have occurred under the current mine plan. A small increase (of the order of 15%) in flow rate is anticipated as a result of the expanded open pit area. The increased depth of the open pit as a result of the E42 Modification is not considered a significant factor in relation to groundwater inflow as the rock permeability reduces substantially with depth.

It is proposed that the potential saline alluvial aquifer assessed by GCS (2008) (Attachment AA) be pumped at a rate of 1ML/day total (from up to four pumping bores) to provide an additional mine water supply. The water source comprises the upper sands and gravels in a probable localised palaeochannel to the south-east of the mine open pit. Given the prevailing ground slope and the sources of inflow at the open pit (combined with the increased thickness of saprock and low permeability sediments at the open pit wall), drawdown from the pumping bores is not likely to significantly influence open pit inflows.

Groundwater inflows are expected to gradually diminish with time as the surrounding groundwater levels draw down. The level of the open pit is well below the naturally occurring groundwater level and as a result the open pit would act as a groundwater sink for the duration of the mining operations. Consequently, groundwater flow direction would be inward towards the open pit during mining operations.

On this basis, we recommend that the design for the modified open pit be based on an average total groundwater inflow into the open pit of 1ML/day during mining operations.

A5.3.2 Open Pit Inflows after Mining Operations

Following conclusion of mining operations, groundwater inflow would diminish over time and stabilise when groundwater inflow balances net evaporative loss. The groundwater level within the open pit would stabilise well below the natural groundwater level and as a result the open pit would act as a groundwater sink in the long-term following completion of mining operations. Consequently, as is expected during mining, groundwater flow direction would be inward towards the open pit following completion of mining operations.

A6 DRAWDOWN EFFECTS DUE TO OPEN PIT DEWATERING AND SALINE WATER SUPPLY

A6.1 Predicted Response in the EIS

The focus of the EIS was the potential regional effects of drawdown for groundwater users outside ML 1535.

The radius of influence of mine dewatering after 10 years (defined by the 1m drawdown contour) was not expected to exceed 10km from the mine periphery. The predicted drawdown distribution has irregular shape due to the presence of the Gilmour Suture to the west of the mine site, which acts as a low permeability boundary that restricts expansion of the cone of depression in a westerly direction. It should be noted that these effects were based on groundwater inflows to the open pit described in Section A5.1. Section A5.2 suggests that these inflows are substantially less. Coffey (1997) assessed the following drawdown effects at a distance 10km east of the open pit after several years of continuous pumping:

- less than 1m in the Upper Transported Alluvial Aquifer; and
- 3m in Saprock Aquifer.

A6.2 Observed Response during Operations to Date

A6.2.1 Local Response

Section 3.4 of the 2006 AEMR indicates a lowering of standing water level in bores around the open pit in response to mine dewatering and open pit development. Maximum drawdown due to open pit dewatering was 3.79m in the Transported Alluvial Units (PDB3B) and 12.34m in the Saprock Aquifer (PDB3A). Since then BHM 2007 indicates that standing water levels in bores immediately adjacent to the open pit have significantly deepened with levels in the Saprock Aquifer typically below 30m depth.

Drawdowns at monitoring bores around the open pit, including at Bores PDB1 and PDB5 which are located about 0.5km to the north and south of the open pit respectively, are provided in Table A-5.

Table A-5 Observed Drawdown in Group B Monitoring Bores

Distance from Open Pit	Location	Drawdown to December 2007	
		Saprock Aquifer	Transported Alluvium Aquifer
<50m	PDB4	28m	14m
<100m	PDB2	32m	Dry (>5m)
<200m	PDB3	20m	9m
500m	PDB5	9m	6m
700m	PDB1	4m	1m

Bores within ML 1535 further from the zone of influence of open pit dewatering generally displayed only minor standing water level changes (less than 0.2m) over the period July 2004 to December 2007. These variations are typical of barometric effects and a muted response to rainfall trends. Standing water level records for Group C (refer to Table A-2) monitoring boreholes around the tailings storage facilities (typically 2km distance from the open pit) indicate relatively consistent groundwater levels, with no evidence of being affected by drawdown due to water extraction from the open pit.

A6.2.2 Regional Response

Based on the above it would appear that there has not been any regional impact to date from open pit dewatering.

The Lachlan Formation (Bland Creek Palaeochannel) is a substantial regional aquifer containing water of good quality which is widely used for irrigation. This aquifer occurs some 10km east of the mine site and is hydraulically well separated from mine open pit dewatering operation and saline water supply. Due to this separation and the relatively small rate of dewatering (i.e. up to approximately 1ML/day), no regional groundwater impacts on the Lachlan Formation (Bland Creek Palaeochannel) are anticipated as a result of the E42 Modification open pit dewatering.

A6.3 Predicted Response for the Modified CGM

Pumping at a rate of 1ML/day at the saline alluvial aquifer borefield to the south-east of the open pit is not likely to impact groundwater levels in the Lachlan Formation, but may create localised drawdown in the upper reaches of the unconsolidated sediments at the location of that borefield. Potential drawdown effects are further discussed in Attachment AA.

Coffey's previous groundwater modelling was based on the inflows to the open pit predicted in Section A5.1. Section A5.3 indicates that the modified CGM is expected to experience flows to the open pit of the order of 1ML/day which are approximately 20% of the long-term flows previously assumed.

Table A-5 shows that there are significant drawdowns close to the open pit, but suggests that these diminish beyond a distance of 0.5km. This is supported by monitoring bores around the tailings storage facilities, which are within the zone predicted to experience drawdown in the EIS, yet show no evidence of drawdown due to mining operations.

Additional detailed modelling of the current open pit was carried out using the computer program "SEEP/W finite element groundwater modelling software". This analysis indicated groundwater inflow rates substantially lower than those predicted in the EIS and a reduced zone of drawdown. This analysis supports the assessment that inflow rates and drawdown effects associated with the modified CGM would be less than predicted for the EIS.

Based on the above, Coffey assess that the drawdowns resulting from the E42 Modification would be less than those predicted in the EIS.

A7 SEEPAGE FROM THE TAILINGS STORAGE FACILITIES

A7.1 Groundwater Levels and Seepage Rates

A7.1.1 Predicted Response in the EIS

Test drilling, geophysical studies and piezometer installation around the proposed tailings storage facilities indicated:

- The foundation comprises silty clay with some gravelly clay, and highly weathered rock occurring at shallow depth in the west. The thickness of unconsolidated sediments decreases from east to west.
- No groundwater or perched aquifers were detected within 17.9m of the natural ground surface, deepening to the south. The groundwater movement through the tailings areas is essentially from west to east. The hydraulic gradient is about 7×10^{-3}.
- Field permeability testing of the strata expected to be more permeable indicates low horizontal permeability of the order of 2 to 10×10^{-4} metres per day (m/day) for gravelly clay and 0.6 to 3.5 $\times 10^{-4}$ m/day for weathered rock.
- Laboratory infiltration tests indicate vertical permeability of the less permeable soils of the order of 0.9 to 1.3×10^{-6} m/day.

With the above seepage parameters assumed, the EIS predicted low rates of groundwater seepage from the tailings storage facilities. This seepage would flow toward the open pit due to the depressurisation at the open pit caused by dewatering.

These seepage parameters were used to assess solute transport from the tailings storage facilities. This provides an indication of the extent of expected seepage, although not an absolute extent because of retardation and decay factors associated with each solute parameter (i.e. seepage would be expected to extend further than the specific solute parameter assessed). Of the solute parameters Kalf and Associates (1997) assessed, cyanide was predicted to migrate the furthest from the tailings storages. A steady state condition (between cyanide decay and seepage rates) was predicted to extend up to 200m from the tailings storage facilities (Kalf and Associates, 1997). Solute transport within seepage is described further in Section A7.2.1 and potential effects from the E42 Modification are assessed in Section A7.2.3.

A7.1.2 Construction Stage Observations – Floor Permeability

Special Condition E3 of the approved CGM Environmental Protection Licence (EPL) required demonstration of compliance with the level of permeability specified in the EPL for the floors of the tailings storage facilities prior to their operational use. The specified requirement is for basal barrier or impermeable liner with equivalent permeability not greater than 10^{-9} metres per second (m/s) over a thickness of at least 1m.

URS Australia Pty Limited conducted field investigations and laboratory testing for both the northern and southern tailings storage facilities. In summary they concluded (URS-NTSF 2005 and URS-STSF 2006) that:

- investigations consistently showed the uppermost 5m of the tailings storage facilities footprints to be essentially clay soils of extremely low permeability;

- laboratory testing of typical samples from within 5m of floor level yielded permeabilities less than the target permeability of 10^{-9}m/s; and
- inspections of cut-off trench excavation[2] and storage floor did not reveal any significant extensive or continuous zones or lenses of high permeability soil that might provide a leakage path.

URS concluded that the floor of the approved CGM tailings storage facilities met the NSW Environmental Protection Agency's (EPA's) permeability requirements, and accordingly Special Condition E3 of the EPL was removed.

A7.1.3 Observed Groundwater Monitoring Response to Date

During the period July 2004 to December 2007, standing water level records for the 25 Group C monitoring boreholes (comprising 3 decommissioned and 22 active boreholes - see Table A-2), indicate relatively consistent groundwater levels (SWGWBM 2005 & 2006, BHM 2007). Minor fluctuations generally stabilised within a month. There is no evident trend of deepening or rising groundwater levels during this period except in the paired bores MON02A and MON02B closest to the tailings storage facilities (less than 100m south from the southern tailings storage facility - see Figure A-4). The standing water depth below ground reduced from an average of about 21.5m to 18.5m in MON02A and from an average of 21.6m to 19.9m in MON02B. Neither MON02A nor MON02B indicate significant variations in salinity or pH.

Stable water levels in all other monitoring bores indicate this to be either a local anomaly or commencement of the seepage predicted in the EIS. The EIS predicted a rise of up to 8m in groundwater level at a distance of 100m from the tailings storage facility after a period of 8 years. The measured response may reflect either a response due to pressurisation of the underlying saline aquifer (the Upper Transported Alluvial Aquifer) (Section A3.6) and potentially the commencement of the predicted seepage flows toward the open pit. Alternatively the measured response may be local mounding due to increased local recharge brought about by changes in surface water drainage patterns and increased local recharge to the upper saline aquifer. Notwithstanding, should the observed groundwater level response be associated with the southern tailings storage facility, it is a response which has occurred less than 100m from the facility and which is within the extent of seepage predicted in the EIS.

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[2] Coffey understands that a cut-off trench to provide security against shallow lateral migration of tailings water beneath the embankment was constructed beneath the starter embankment of the tailings storage facilities to a nominal 2.5m below original surface level. The floor of the cut-off trench was inspected to confirm that it consisted of low permeability clay (and further excavation of any areas where this was not the case), prior to backfilling of the cut-off trench with compacted and moisture-conditioned low permeability clay (URS Australia Pty Limited, pers. comm. 9 March 2007).

A7.1.4 Predicted Response for the Modified CGM

The E42 Modification would result in an increased height of tailings and hence increased head of water. Tailings permeability would tend to reduce following consolidation. As the tailings consolidate, the thickness of low permeability consolidated tailings material would increase. This would increase the thickness of low permeability consolidated tailings at the base of the tailings storage facilities.

Seepage from the tailings storage facilities to the underlying aquifers would be expected to continue as is the current case and ultimately slowly migrate toward the open pit via flows through the Upper Transported Alluvial Aquifer as predicted in the EIS. No other groundwater users of this aquifer have been identified, and hence no seepage impacts to other users would occur.

A7.2 Seepage Quality

This section deals with potential groundwater quality impacts down gradient of the tailings storage facilities through seepage of stored water. Comments on groundwater quality in relation to the hydrogeological regime are provided in Section A8.

A7.2.1 Predicted Response in the EIS

Section 6 of Attachment N2-A (Coffey, 1997) of the EIS presented the following assessment of the current locations of the tailings storage facilities. In summary the current locations were considered favourable because of the depth to water table, low permeability substrata and less defined aquifers.

Simulation of cyanide movement from the tailings storage facilities using a representative cross-section between the proposed location and the open pit indicated it would most probably reach a steady state concentration near the base of the tailings storage (i.e. no more than 200m from the facilities) (Kalf and Associates, 1997) equivalent to 0.1% concentration (below drinking water standards) compared to 100% within the tailings mass. Similar simulation of arsenic and zinc under the same conditions showed that they would become virtually immobilised even after a hundred years. It was further predicted that commencing about 10 years after mining ceases, cyanide would degrade in the tailings storage and surface of the underlying aquitard, after which cyanide would be effectively removed from the subsurface and arsenic and zinc would be adsorbed and effectively immobilised.

A7.2.2 Observed Response to Date

Water quality testing for Group C monitoring bores (refer to Table A-2) indicate that levels of arsenic and cyanide remain below detection limits.

Records for Group C monitoring boreholes indicate relatively consistent pH over the monitoring period. Occasional spikes occur but these fluctuations do not appear to reflect patterns of increasing or decreasing acidity and appear to be within the typical range of variation. Electrical conductivity is more variable, but the fluctuations do not show a specific trend, and do not appear more variable than other monitoring bores within ML 1535.

A7.2.3 Predicted Response for the Modified CGM

Observations to date together with the construction methodology implemented for the tailings storages and the predicted geochemistry of modified CGM tailings (i.e. similar to the predicted geochemistry described in the EIS)[3] indicate that the EIS predictions for solute transport in seepage from the tailings storages would remain the same for the modified CGM. These predicted outcomes are described in Section A7.2.1*.*

[3] The geochemical characteristics of E42 Modification tailings has been assessed by Geo-Environmental Management Pty Ltd (2008) to be similar to the characteristics described in the EIS.

A8 GROUNDWATER QUALITY

This section deals with the natural chemical characteristics of the groundwater and the potential for change as a result of the E42 Modification. The potential for groundwater quality impacts due to tailings storage facility seepage is discussed above in Section A7.2.

A8.1 Groundwater Quality before Mining

Attachment N2-A (Sections 2.2.1 and 6) (Coffey, 1997) of the EIS reported the following groundwater salinity levels prior to commencement of mining:

- Transported Alluvial Aquifers had very high salinity in the range 19,000 to 72,000 microSiemens per centimetre (µS/cm) measured beneath the proposed mine site and 6,000µS/cm to 44,400µS/cm beneath the proposed tailings area.
- In the volcanic rock, the salinity ranged from 50,900µS/cm in fresh volcanics to 63,700µS/cm in saprolite.

A8.2 Observed Groundwater Quality During Operations

Groundwater quality monitoring results reported in the 2006 AEMR provides information that correlates with Coffey's review of groundwater chemistry monitoring, which indicates that:

- Groundwater facies within ML 1535 are characterised by saline conditions. Total dissolved solids vary from 18,000 to 47,000 milligrams per litre attributed to heterogeneous aquifer material, geochemistry and depth in the profile.
- Electrical conductivities are within a similar range to those observed pre-mining. There are fluctuations from one monitoring episode to the next, but there does not appear to be a trend of increasing conductivity.
- Groundwater has a slightly alkaline to weakly acid pH range (6.0 to 7.5). The exception to date has been MON01B (a shallow bore screened in the Upper Transported Alluvial Aquifer) with more acidic pH readings of 4.3 to 5.3 since it was drilled in 2005.

The overall conclusion to date was that whilst open pit dewatering has a localised effect on groundwater levels, no changes in groundwater chemistry appear to be associated with this drawdown. The chemical groundwater data collected shows little variation for each bore and analysis has demonstrated good chemical correlation between data from the pre-mining and operational phases of the approved CGM. This indicates that there has not been any significant impact on the groundwater quality by mining activities.

A8.3 Predicted Impact for the Modified CGM

Excluding tailings related impacts discussed in Section A7, on the basis of information available for review, there is no evidence to suggest that the natural groundwater chemistry would alter significantly as a result of the E42 Modification compared with the prediction set out in the EIS.

A9 HYDRAULIC RELATIONSHIP BETWEEN LAKE COWAL & GROUNDWATER

A9.1 Predicted Relationship in the EIS

The EIS assessed the potential for seepage from Lake Cowal to the final void as a result of open pit dewatering and the resultant potential for Lake Cowal water balance changes and final void balance characteristics.

Coffey prepared a hydrogeological assessment (ref G255/41-AO dated 5 June 1997) that was included in the EIS (Coffey, 1997). The information presented was derived from:

- Coffey reports G255/16-AA May 1994 and G255/28-AF April 1995, which were qualitative studies undertaken prior to the EIS (Coffey, 1994; 1995).
- Field and laboratory permeability testing and mineralogy testing carried out for the EIS.

In summary:

- The clay underlying Lake Cowal is at least 6m thick, and on average 9m thick. The vertical and horizontal permeabilities of the clay measured in laboratory and/or field testing are several orders of magnitude less permeable than the permeability required by legislative authorities for landfill liners.
- The piezometric surface of the Upper Transported Alluvial Aquifer was lower than the lake surface level suggesting no direct hydraulic connection between surface and subsurface water.
- Test pumping (Bore RA350) in the Upper Transported Alluvial Aquifer did not indicate the presence of aquifer recharge boundaries.
- The salinity of the Upper Transported Alluvial Aquifer is about three orders of magnitude higher than the lake water.
- No salinity scalding has been observed by local landowners in the lake bed in dry conditions, nor has this been detected by satellite radiometric imaging.

These results indicate a very low potential for significant quantities of water to infiltrate from Lake Cowal into the underlying aquifers. The results were so low that Gilbert and Sutherland (1997) stated that the only way for low salinity water to mix with saline groundwater from the open pit would be by surface breaching of both the lake protection bund and perimeter waste emplacement.

Modelling conducted by Kalf and Associates (1997) for the EIS indicated that seepage from Lake Cowal to the final void would be an insignificant component of overall seepage because of the very low permeability of the clay pan deposits that form the lake bed and isolate Lake Cowal from the underlying aquifers.

A9.2 Observations during Operations

Lake Cowal has not filled during the period that the approved CGM has been operational. Accordingly, no relevant observations have been made to date.

A9.3 Predicted Effects for the Modified CGM

Whilst the E42 Modification would increase the size and depth of the final void, it would not alter the depth of relatively impermeable clay that separates the Lake Cowal bed from the aquifer system.

Opportunity to detect a potential hydraulic connection between Lake Cowal and the aquifer system has been very limited because the lake has been substantially dry since mining operations commenced. Piezometric response in the Transported Alluvial Aquifers has been small and localised, consistent with low vertical and horizontal permeability and inflows to the open pit have been small compared with pre-development assessment.

On this basis, the disconnectivity between Lake Cowal and the open pit described in the EIS would prevail for the modified CGM.

A10 EFFECTS OF MINE CLOSURE ON LAKE COWAL

A10.1 Predicted Effects in the EIS

In the EIS, Coffey modelled groundwater flow directions towards the open pit. These flow directions were described to be fundamentally maintained during and after mining but the gradients and flow rates would decrease over time. At the completion of mining (dewatering), the final void was described to be a permanent sink to local groundwater and would gradually fill with water from incident rainfall, runoff from adjacent mine areas and seepage from the intercepted aquifers. These inflows would be offset by evaporative losses and potentially by seepage out of the void if water levels rise above the neutral potentiometric groundwater level (Coffey, 1997).

A long-term water balance simulation showed that the final void is likely to refill to a steady state level that is significantly below the zero flow level and that it would oscillate above and below this level in response to climatic variability. The time to reach steady state level with oscillations was predicted to take 50 years (Coffey, 1995). This prediction was based on higher than subsequently observed open pit inflows.

A10.2 Predicted Effects for the Modified CGM

The increased size and depth of the modified CGM open pit and the reduced predicted groundwater inflow rates means that the final water level in the void may be different than predicted for the EIS. At the predicted long-term groundwater inflow rates to the open pit, the final void is expected to remain a permanent groundwater sink. Accordingly, the final void is assessed to remain hydraulically disconnected from Lake Cowal in the long-term. Predicted final void water levels and quality characteristics are assessed by Gilbert and Associates (2008).

A11 REFERENCES

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ATTACHMENTS

ATTACHMENT AA

SALINE GROUNDWATER ASSESSMENT – SALINE ALLUVIAL AQUIFER

E42 MODIFICATION, COWAL GOLD MINE

(Groundwater Consulting Services Pty Ltd, 2008)

Barrick Australia Limited

Saline Groundwater Assessment – Saline Alluvial Aquifer
E42 Modification, Cowal Gold Mine
West Wyalong, New South Wales

FINAL

Project Number: BARR010
Report Date: July 2008

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1. INTRODUCTION

Water resources for the Cowal Gold Mine are being assessed to augment the current water supply sources for the proposed E42 Modification. In summary, the E42 Modification includes increasing the life of the approved Cowal Gold Mine, size of the current open pit, tailings storage facilities and waste rock emplacements. Options to augment the use of low salinity groundwater from the off-site Bland Creek Palaeochannel borefield and demand from the Lachlan River are being investigated by various parties. Barrick Australia Limited (Barrick) geologists identified a prospective alluvial aquifer, located to the east and south of the approved Cowal Gold Mine open pit in Mining Lease (ML) 1535, through a review of mineral drilling records.

This report summarises the works that have been completed in the saline alluvial aquifer, to date, and these show the presence of a prospective local aquifer from which saline groundwater can be drawn to augment abstraction from other demands. Barrick propose to draw approximately 1 megalitres per day (ML/day) from this saline alluvial aquifer via a borefield located on the approved Cowal Gold Mine Mining Lease for the E42 Modification.

Recommendations for further work to contribute to the feasibility investigations are included.

2. INVESTIGATION PROGRAMME

2.1 PREVIOUS INVESTIGATIONS

Other previous investigations of potential saline water supply sources include preliminary airlift testing of a bedrock aquifer located south of the approved Cowal Gold Mine open pit reported in Groundwater Consulting Services Pty Ltd (2005), and open pit mine dewatering estimates for the approved Cowal Gold Mine by Coffey Partners International Pty Ltd (1997). The work found that initial flows of approximately 2-4 litres per second (L/s) were likely to be achieved from a single bore (multiple bores may be able to be installed), however, no further evaluation has been conducted. Saline aquifers beneath the approved Cowal Gold Mine Mining Lease have been previously identified during investigative work in the 1990s by Coffey Partners International Pty Ltd (1997).

2.2 DRILLING

Test drilling and bore construction in the saline alluvial aquifer was conducted by Boart Longyear, the mineral exploration drilling contractor on the site. Two main phases of drilling were conducted, one in November/December 2007 and one in May 2008.

The drilling was conducted using a UDR1000 track-mounted drilling rig, operating with either rotary air blast (November/December 2007) or air-core (May 2008) methods.

A total of two test bores and two piezometers were installed. One piezometer was destroyed by adjacent drilling (air short-circuited through the annulus) and was not reconstructed. A further 17 test holes were drilled but not completed. Some of the test holes are prospective for further development.

Figure 1 (Appendix A) shows the location of the drill holes and bores. A photograph showing the aquifer intersection is included as *Appendix B.*

Airlift flows were recorded periodically during drilling, and are reported in *Appendix C*. The airlift flows were measured at the sample cyclone, by recording the time taken to fill a container of known volume. The flows were recorded after a brief period to allow for stabilisation.

The lack of detailed lithological logging precludes reliable assessment of the contributions of the transported and underlying weathered materials to the airlift yields. Logs for holes WB013 and WB020 are provided in *Appendix D.*

Tables 1 and 2 summarise the drilling programme.

Table 1. Summary of Test Holes

Hole Numbers	Northing (MGA)	Easting (MGA)	Date Completed	Hole Status	Drilled Depth (metres [m])	Airlift Flow rate (L/s)
1535WB02	6276974	539380	1/12/2007	Piezo Aband	68	3.33
1535WB03	6276972	539280	1/12/2007	Abandoned	54	0.66
1535WB04	6276974	539480	1/12/2007	Abandoned	71	2.50
1535WB05	6276405	539424	4/12/2007	Abandoned	72	0.28
1535WB06	6276662	539351	3/12/2007	Abandoned	72	0.83
1535WB07	6276661	539231	3/12/2007	Abandoned	60	0.80
1535WB08	6277563	539229	29/11/2007	Abandoned	50	0.62
1535WB09	6277561	509142	29/11/2007	Abandoned	54	1.25
1535WB10	6277561	539331	29/11/2007	Abandoned	50	0.60
1535WB11	6277288	539206	4/12/2007	Piezo Aband	36	NR
1535WB13	6276967	539381	23/12/2007	Bore Aband	NR	NR
1535WB14	6277886	539210	24/05/2008	Abandoned	42	0.30
1535WB15	6277917	539202	24/05/2008	Abandoned	54	0.25
1535WB16	6277564	539104	24/05/2008	Abandoned	54	0.25
1535WB17	6277374	538656	25/05/2008	Abandoned	78	0.66
1535WB18	6276902	538287	25/05/2008	Abandoned	66	NR
1535WB19	6276635	538241	25/05/2008	Abandoned	54	0.16

Note: NR – not recorded

Table 2 Summary of Completed Monitoring and Test Bores

Hole Numbers	Licence #	Northing (MGA)	Easting (MGA)	Date Completed	Hole Status	Drilled Depth (m)	Airlift Flow rate (L/s)	Casing/Screen Material	Screen Interval (mBGL)
1535WB01	**70BL232442-TB8**	6277249	539223	28/11/2007	Test Production Bore	43	5	154mm ID Stainless Steel; 157mm ID PVC slotted	S/Steel 13-19m/31-37m; Slotted PVC 19-25m
1535WB12	**70BL232442 - TB9**	6277288	539257	5/12/2007	Monitoring Bore	72	n/a	*50mm PVC, slotted*	*0-50m*
1535WB20	**70BL232442 - TB10**	6276932	539362	29/05/2008	Test Production Bore	45.5	1.00	154mm ID Stainless Steel; 157mm ID PVC slotted	S/Steel 26-32m/35.5-45.5m; Slotted PVC 18-26m/32-35.50m

Note: construction details for WB12 uncertain

mBGL = metres below ground level

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2.3 PUMPING TESTS

Pumping tests in the saline alluvial aquifer were conducted by Barrick, under guidance from Groundwater Consulting Services, in early June 2008.

The tests were completed using a Grundfos SP14A-18 or SP14A -25 electric submersible pump fitted with a cooling shroud. A headworks comprising mechanical flowmeter, pressure gauge and flow control valve enabled measurement and control of the flow rate. Groundwater levels were recorded using a submerged micro-computer controlled datalogger reading from an integral pressure-sensor, programmed to record frequent water pressure readings. Manual water level measurements were also collected using an electrical probe on a calibrated tape. Water quality was recorded from a single sample by the site environmental technician using calibrated equipment.

The tests comprised a single-rate constant discharge test over a period of three days, followed by water level recovery, monitored over a period of approximately four days. The schedule of tests is provided in *Table 3.*

Table 3 Pumping Test Schedule

Pumping Bore	Monitoring Bores	Test Type	Test Start Time	Test End Time	Test Duration (minutes)	Average Pumping Rate (L/s)
WB01	WB01, WB12, WB20	Constant Discharge	3 June 2008 10:50am	6 June 2008 10:50am	4,320	3.4
WB01	WB01, WB12, WB20	Recovery	6 June 2008 10:50am	10 June 2008, 07:30am	5,560	nil

3. RESULTS

3.1 GEOLOGY

The test holes all penetrated transported sediments, which overlie saprolite and saprock (weathered bedrock materials). Some of the holes were extended to bedrock, although the aquifer in the transported materials was the main target.

The relatively clean sand/gravel aquifer intersected in WB01 is inferred to represent a local palaeochannel deposit filling a relict drainage channel likely to be oriented west to east, discharging from the higher ground towards the Bland Creek drainage. A west-east orientation is the most sensible interpretation, however other orientations are possible, as the aquifer may also represent a deltaic deposit (which may have a north-south orientation, sympathetic with the local shoreline). The most likely geometry would depend on the base level of the drainage system at the time of deposition – higher base levels would indicate deltaic style deposition, and more remote, deeper base levels would support a channel deposit.

The saline alluvial aquifer is laterally equivalent to, and represents, the Cowra Formation, which, as a geological formation, occurs beneath the approved Cowal Gold Mine Mining Lease, small areas west of Lake Cowal, Lake Cowal, and areas east of Lake Cowal. The Cowra Formation typically comprises sand and gravel lenses which host saline aquifers to varying extents. The sand and gravel lenses can be traced on a local scale, however their interconnection on a large scale is unknown. There is a potential hydraulic connection between the saline alluvial aquifer of the Cowra Formation near the mine and to other Cowra Formation aquifers beneath and to the east of Lake Cowal.

3.2 AIRLIFT YIELDS

Airlift yields from the test holes in the saline alluvial aquifer ranged from 0.16 to 5L/s. The resolution of the depth at which the yields were intersected was not considered reliable, however, the available records are provided in *Appendix B.* End of hole flows are considered to be reasonably reliable.

3.3 AQUIFER GEOMETRY

The data from the programme are not sufficient to assess the potential aquifer geometry or extent. A superficial assessment of the airlift yields from the test holes indicates a general alignment of higher yields in a north-west to south-east alignment, although further drilling would be required to increase the level of confidence in this assessment.

It is considered that the aquifer most likely represents a local palaeochannel which drained the elevated land to the west, in a generally easterly direction. The more permeable aquifer may grade laterally into other sandy/gravely lenses, or may be relatively isolated.

The diamond core records for hole E41D1229, on which test bore WB01 was targeted, indicate that a shallower sand/gravel aquifer occurs between 15.3 and 19m (and another, less prospective aquifer at 33-41m). It is considered that most of the water drawn during testing was from the upper aquifer, however the testing programme was not sufficient to enable the contribution from each part of the aquifer to be assessed. The upper and lower aquifers identified above are consistent with those reported by Coffey Geotechnics Pty Ltd (Coffey Geotechnics) (2008, and in previous assessments).

3.4 PUMPING TEST

Manual and logger-derived groundwater level measurements are presented on *Figure 2 (Appendix A)*. Extended drawdown responses to pumping are presented on *Figure 3 (Appendix A)* to enable consideration of the possible yield of the bore.

The drawdown induced by pumping at 3.4L/s was about 5m at the end of the constant discharge test. A large component of the drawdown was assessed to be due to well losses (indicated by the steep fall in water level in the early part of the pumping cycle), although a step-drawdown test has not yet been conducted. A step-drawdown test would provide resolution of the component of drawdown induced by the construction of the bore (materials and methods), as a percentage of the total drawdown.

The drawdown response shows a gently increasing drawdown per unit time on a semi-logarithmic chart, which probably reflects the limited extent of the higher permeability part of the aquifer. Extension of the drawdown trend for a period of several years (two years is approximately equal to 1,000,000 minutes) indicates a drawdown of around 10m, which is near the top of the upper aquifer.

The installed pump was not capable of drawing the groundwater level below the upper aquifer, which precluded assessment of the water level response to dewatering of the upper aquifer. Further tests with a higher capacity pump are planned (Section 6).

A drawdown of nearly 0.8m was induced in piezometer WB12, located 54m from the pumping bore. No drawdown was measurable in WB02, located 338m from the pumping bore. The monitoring bore records indicate a radius of influence of perhaps 100m (for a nominal 0.1m drawdown), although no analyses of the data were conducted.

Water level recovery in the pumping bores was within 0.2m of the initial water level after about four days of recovery. This observation, along with the observation of the gradual increase in the drawdown rate over time, indicates that bore yields are likely to gradually decline as the aquifer is dewatered. Thus prediction of future bore yields should be conducted with a conservative view.

The data available indicate that the bore can produce a flow rate of 3.3L/s for a period of one to two years on a continuous basis, assuming that most of the water is yielded by the upper aquifer. If significant contributions of water are provided by the lower aquifer, then more substantial flows could be drawn, perhaps up to 6 or 8L/s. If the well-losses are substantial (in which case much of the drawdown is induced across the gravel pack and screens) then the aquifer drawdown would be much smaller, and the potential bore yield would be higher.

A more intensive pumping test programme comprising a step-discharge test, and a constant discharge test, both of which induce drawdown in the aquifer to more than 15m (pumping water level of 20m or more below ground level), are required to improve the estimate of the achievable bore yield, and to assess the aquifer responses (Section 6).

3.5 WATER QUALITY

A single groundwater sample was collected during the pumping test and analysed by the site environmental technician using calibrated equipment. The results showed a pH of 4.5 and an electrical conductivity of 40,200 microSiemens per centimetre (uS/cm).

3.6 DWE CONSULTATION

Barrick discussed of the use of saline groundwater sources within and external to the approved Cowal Gold Mine Mining Lease with the Department of Water and Energy in March 2008, and the possibility of taking saline groundwater from the saline alluvial aquifer for the modified Cowal Gold Mine was raised. The Department of Water and Energy strongly supported any measures by Barrick to utilise saline groundwater in preference to low salinity groundwater, as this would reduce the impact on other groundwater users.

3.7 GROUNDWATER USERS

Barrick has maintained a very strong community consultation programme in relation to groundwater use from the Bland Creek Palaeochannel, and meets regularly with a community group representing both irrigators and stock/domestic groundwater users. Nearly all of the other groundwater users have installed bores into the Lachlan Aquifer of the Bland Creek Palaeochannel, which contains low salinity groundwater.

A test bore was installed into a shallow aquifer on the margin of the main Lachlan Aquifer (the Lachlan Aquifer was not present at the location of the test bore), and produced brackish groundwater (salinity about 4,000 milligrams per litre [mg/L] total dissolved solids [TDS]) from the shallower Cowra Formation. This bore is located to the north and east of Barrick’s Bland Creek Palaeochannel borefield, and is not in use due to the elevated salinity.

Therefore, there are no groundwater users that may be affected by utilisation of the saline groundwater for the modified Cowal Gold Mine. Development of this resource to its capacity has the potential to augment the current external water supply sources for the approved Cowal Gold Mine (ie the Lachlan River and the Bland Creek Palaeochannel borefield).

3.8 LAKE CONNECTIVITY

The available lithological logs confirm the presence of a clay layer underlying the lake bed. Coffey examined this layer in detail (Water Studies, 2003; Coffey Geotechnics, 2008, and prior studies) and confirmed that there is no upwards or downward flow through the lake floor. Groundwater pressures in the shallow aquifer do respond to the weight of water in the lake.

3.9 DRAWDOWN CONTEXT

The short-term pumping test showed a relatively local drawdown impact. Predictive modelling for the mine dewatering (Water Studies, 2003) provided estimates of drawdown after various pumping durations. The predicted drawdown in the saline alluvial aquifer after ten years of pumping at 6 ML/day showed about 1m of drawdown extending to about 4 kilometres (km) from the open pit. It is noted that this scenario included a component of pumping from the fractured bedrock and weathered bedrock (saprock) aquifers.

Coffey's more recent review (Coffey Geotechnics, 2008) notes much smaller dewatering pumping rates, and that drawdown has not yet extended to monitoring bores located about 2km from the pit after approximately four years of mine dewatering. Water Studies (2003) predicted drawdown impacts of about 1m at 3km radius from the open pit, after five years of operation, in the saline alluvial aquifer. The dewatering drawdown effectiveness is clearly less than predicted due to the low permeability and lower groundwater flows obtained from dewatering bores. Thus the 2003 predictions are considered to be conservative and the overall drawdown of the modified Cowal Gold Mine saline water supply proposal is likely to be less than the 2003 predictions.

Development of a revised local model would be required to provide quantitative predictions, however such work is not warranted because there are no known receptors sensitive to drawdown (in the saline alluvial aquifer) within 5km of the proposed borefield in the south-east of the Cowal Gold Mine Mining Lease.

4. FURTHER DEVELOPMENT

The test data indicate that bores, if they intersect the higher yielding aquifer, may produce between 2 and 5L/s. A borefield of three or four bores may be required to produce 1ML/day (11L/s). The spacing of the bores may be dictated by the geometry of the aquifer and infrastructure considerations, however bores should be spaced no closer than about 200m apart to minimise drawdown interference between individual bores, and subsequent reduced yields. Long-term interference drawdown may result in reduced yields over time even for greater bore spacings and on-going monitoring is required to enable reassessment of the resource from time to time.

The delineation of the aquifer has not been completed. The aquifer hosts saline groundwater, and significant variations in groundwater quality are not expected. It may be prudent to consider high-resolution electrical resistivity survey methods to evaluate the resistivity contrasts beneath the test bore, which may be used to map the aquifer. If the survey was able to discriminate the lithological variations, or any water quality variations, in the higher permeability aquifer, then extended survey transects could be conducted perpendicular to the possible and inferred aquifer orientation to identify anomalies on which additional drilling could be conducted.

Further pumping tests at higher discharge rates are warranted in the test bore WB01 to assess the response of the bore and aquifer. Preliminary testing at WB20 should be conducted.

The saline, deeper fractured bedrock aquifer identified in other Barrick drilling (Section 2.1), and reported in Groundwater Consulting Services (2005) should be evaluated by installing a test bore and conducting pumping tests. This aquifer is expected to be isolated from the saline alluvial aquifer and could be used to further augment water supply options.

5. CONCLUSIONS

- Two test bores and one monitoring bore were installed in a transported sand/gravel aquifer near the approved Cowal Gold Mine. A further 17 test holes were drilled but not completed.
- Preliminary testing of one of the bores indicates that it may yield between 3 and 6L/s in the long-term, and more testing is recommended.
- The groundwater produced from the tested bore was acidic and saline.
- There are no groundwater users within the vicinity of the Cowal Gold Mine using the saline water from the saline alluvial aquifers. Drawdown within the upper and/or lower saline alluvial aquifers would, therefore, not impact other groundwater users. The salinity of the groundwater precludes its use for stock, domestic or irrigation purposes.
- The Department of Water and Energy support the abstraction of saline water for mine water supply.
- Pumping water from the saline alluvial aquifer is not expected to have any influence on Lake Cowal.
- A borefield comprising three to four bores, spaced at least 200m apart, may be required to provide a long-term supply of 11L/s (1ML/day), and such a borefield is considered to be feasible.
- The geometry of the aquifer is not known, and geophysical methods may assist in mapping the aquifer to reduce the costs of further exploration and development drilling.
- Long-term interference drawdown may result in reduced yields over time and accordingly, water level monitoring would be required to guide the on-going management of the borefield.
- A saline deeper fractured bedrock aquifer has been identified and is recommended for further investigative drilling.

6. RECOMMENDATIONS

- Conduct a preliminary 24 to 48hr constant discharge test in the second test bore WB20 to assess its potential yield.
- Conduct step-discharge tests and a constant discharge test at higher flow rates (up to 10L/s) in WB01 to assess the response to higher pumping stresses.
- Install a test bore and conduct pumping tests in the saline, deeper fractured bedrock aquifer as recommended in Groundwater Consulting Services (2005).
- Assess the potential for geophysical methods to identify and map the aquifer.
- Install additional test bores approximately 200 to 300m apart (depending on the mapping exercise).

On behalf of Groundwater Consulting Services Pty Ltd,

Sam Burton
Director.

7. REFERENCES

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Modelling of Mine Dewatering, Cowal Gold Project". Consultants report to Barrick Gold of Australia, Project WSDJ/00360/01-ZD 30 April 2003.

8. LIMITATIONS

Groundwater Consulting Services Pty Ltd has prepared this report for Barrick, in accordance with generally accepted consulting practice. The specific conditions of the contract and subsequent communications have had a bearing on the depth and breadth of the Saline Groundwater Assessment and on the confidence in the findings. When client constraints, whether express or implied, have limited the scope of work, a lower than normal confidence may occur.

The confidence in the ability of a groundwater resource to support a nominated withdrawal of groundwater is subject to spatial and temporal variations in the aquifers, climate and landuse that may not be known or predictable. Conservative assumptions will have been used where-ever possible, however, estimates of bore yield or predicted impacts of pumping can be incorrect, especially where conditions on which predictions were made have been changed. Groundwater Consulting Services Pty Ltd's predictions are made on the basis that Groundwater Consulting Services Pty Ltd will be contracted to undertake regular reviews of operational data that may lead to groundwater availability or quality predictions being re-estimated.

Groundwater Consulting Services Pty Ltd does not provide advice on crop water requirements, irrigation schedules, irrigation system design and other non-groundwater related areas. Groundwater Consulting Services Pty Ltd's advice on bore placement and operation must be considered by the proponent with reference to expert advice from other disciplines.

The Saline Groundwater Assessment for which Groundwater Consulting Services Pty Ltd was contracted was undertaken for the client and its consulting advisors, and for review by regulatory agencies. The report should not be used by other parties without the consent of Groundwater Consulting Services Pty Ltd due to the potential for misunderstandings to occur.

9. APPENDICES

Appendix A – Figures

Appendix B – Aquifer Intersection Photograph

Appendix C – Airlift Yield Records

Appendix D – Lithological Logs

Appendix A

Figures

Figure 1 Bore Locations and Airlift Yields

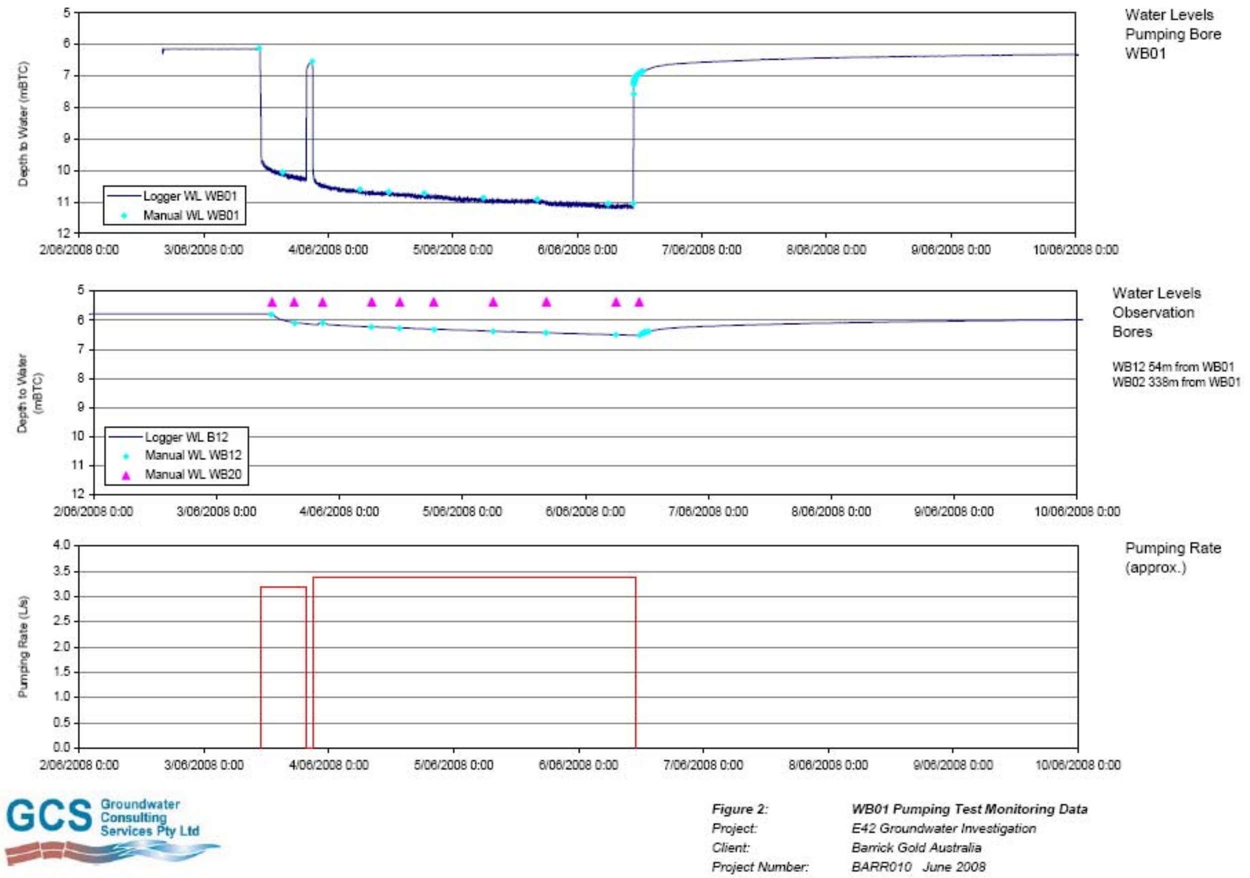
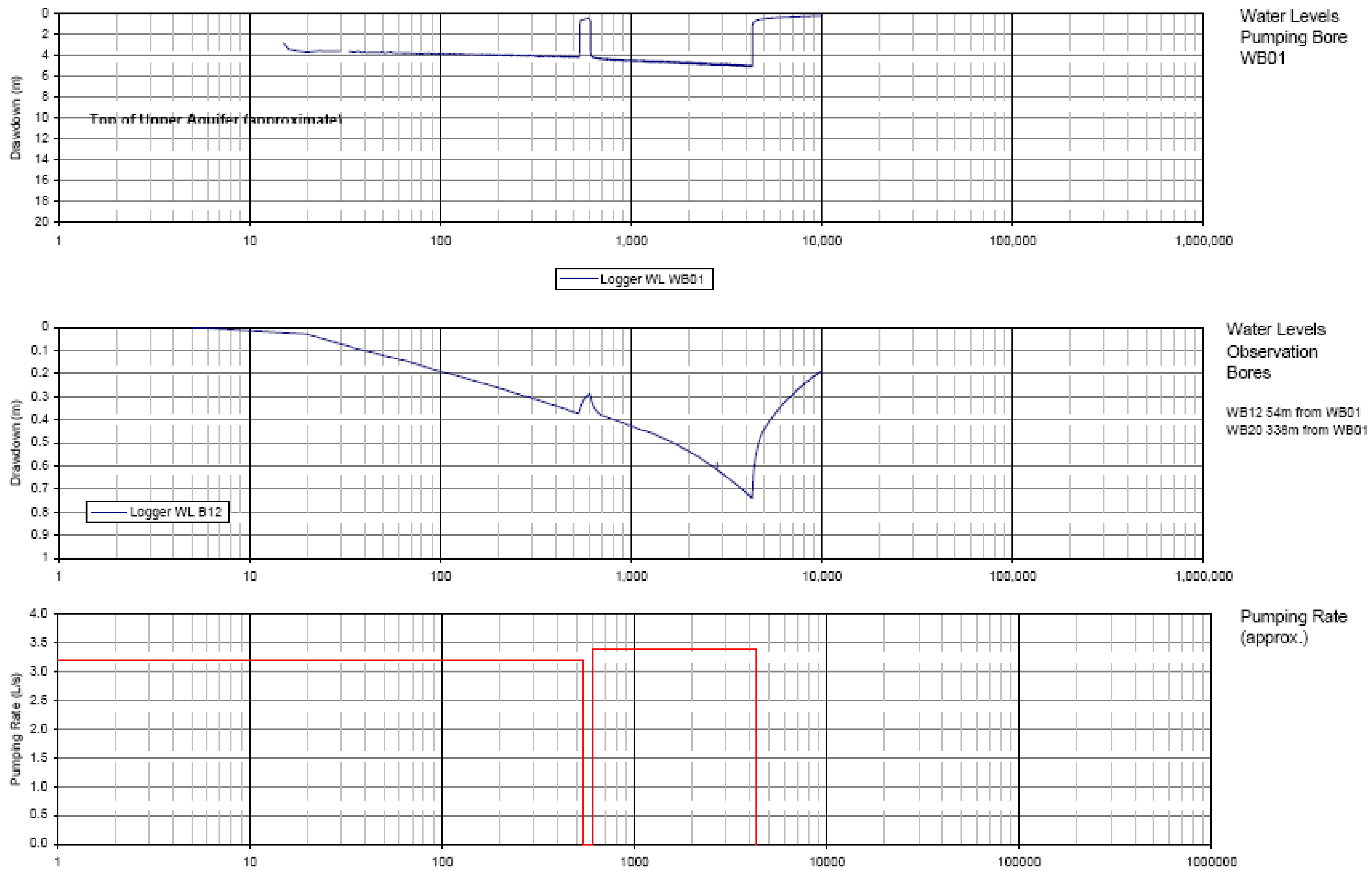


Figure 2 WB01 Pumping Test Monitoring Data – Manual and Logger-derived Groundwater Level Measurements



Groundwater Consulting Services Pty Ltd

Figure 3: ***WB01 Pumping Test Monitoring Data***
Project: *E42 Groundwater Investigation*
Client: *Barrick Gold Australia*
Project Number: *BARR010 June 2008*

Figure 3 WB01 Pumping Test Monitoring Data – Extended Drawdown Responses to Pumping

Appendix B

Aquifer Intersection Photograph


Hole
E41D
2249
From / To
12.50-
20.50
Tray
03

Appendix C

Airlift Yield Records

Hole Numbers	Hole Status	Licence #	Northing	Easting	Azi	Dip	EOH(m)	Depth of test	Time to fill 20litre	Flow rate l/sec	Comments
1535WB01	Water Bore		35566.4	87611.9	360	-90	51.5	41	4	5	Screened water bore
1535WB02	Piezo	70BL232442-TB8	35291	87768.8	360	-90	68	18	60	0.33	
								24	35	0.57	
								30	28	0.71	
								36	25	0.8	
								42	20	1	
								48	25	0.8	
								54	25	0.8	
								60	23	0.86	
								68	6	**3.33**	
1535WB03			35288.5	87668.1	360	-90	54	18	52	0.38	
								24	57	0.35	
								30	39	0.51	
								36	39	0.51	
								48	30	0.66	
								54	30	**0.66**	
1535WB04			35290.7	87868.5	360	-90	71	24	48	0.42	
								30	32	0.63	
								36	25	0.80	
								42	25	0.80	
								48	20	1.00	
								54	20	1.00	
								60	18	1.11	
								66	15	1.33	
								71	8	**2.50**	
1535WB05			34721.9	87812.4	360	-90	72	18			
								24	510	0.04	
								30	not enough water to test		
								36	not enough water to test		
								42	not enough water to test		
								48	not enough water to test		
								54	not enough water to test		
								60	100	0.20	
								66	75	0.27	
								72	72	**0.28**	
1535WB06			34978.6	87739.8	360	-90	72	18	130	0.15	
								24	58	0.34	
								30	50	0.40	
								36	33	0.61	
								42	30	0.67	
								48	31	0.65	
								54	20	1.00	
								60	25	0.80	
								66	31	0.65	
								72	24	**0.83**	
1535WB07			34977.8	87619.5	360	-90	60	18	45	0.44	
								24	55	0.36	
								30	37	0.54	
								36	20	1.00	
								42	21	1.00	
								48	19	1.00	
								54	25	**0.80**	
1535WB08			35879.8	87617.8	360	-90	50	18	60	0.33	
								20	40	0.50	
								30	40	0.50	
								36	40	0.50	
								42	27	0.74	
								48	32	**0.62**	
1535WB09			35877.7	57518.4	360	-90	54	36	15	1.33	
								48	16	1.25	
								54	16	**1.25**	
1535WB10			35877.7	87719.8	360	-90	50	18	120	0.16	
								24	70	0.28	
								30	50	0.40	
								36	42	0.47	
								42	38	0.52	
								48	33	**0.60**	
1535WB11			35604.8	87594	360	-90	36		No pump tests?		Abandoned Piezo hole due to caving sands
1535WB12	Piezo		35605.2	87645.4	360	-90	72		No pump tests?		
1535WB13		70BL232442 - TB9	35284	87770	360	-90					
1535WB14			36203	87598	360	-90	42	24		0.30	24m - 10liters in 30sec, same to eoh.
1535WB15			36234	87590	360	-90	54	30		0.25	10litres in 40sec
								54		0.25	10litres in 40sec
1535WB16			35881	87492	360	-90	54	24			dry
								30			minor water
								42		0.25	10litres in 40sec
								54		0.25	10litres in 40sec
1535WB17			35691	87044	360	-90	78	54		0.50	15litres in 30sec
								66		0.50	15litres in 30sec
								78	30	0.66	20litres in 30seconds
1535WB18			35219	86675	360	-90	66				dry hole
1535WB19			34952	86629	360	-90	54	12			dry
								18			dry
								24		0.13	4litres in 30sec
								30		0.16	5litres in 30seconds
1535WB20		70BL232442 - TB10	35249	87751	360	-90	45	45		1.00	

Appendix D

Lithological Logs

WB013 Lithology

From (m)	To (m)	Lithology
0	1	clay
1	2	clay
2	3	clay
3	4	clay
4	5	sandy clay
5	6	clay
6	7	clay
7	8	clay
8	9	moist clay
9	10	moist clay
10	11	moist clay
11	12	moist clay
12	13	moist clay
13	14	moist clay
14	15	moist clay
15	16	moist clay
16	17	moist clay
17	18	moist clay
18	19	moist clay
19	20	silt
20	21	clay - water
21	22	clay - wet
22	23	clay - wet
23	24	clay - wet
24	25	clay - wet
25	26	clay - wet
26	27	clay - wet
27	28	clay
28	29	clay
29	30	clay, minor grit
30	31	clay (minor grit)
31	32	clay (minor grit)
32	33	clay, very weak grit
33	34	clay, very weak grit
34	35	clay, very weak grit
35	36	clay gravel, grit (clay 10% snd/gravel)
36	37	clay (minor sand)
37	38	clay (20% snd/grit) - gravel to 5mm
38	39	clay (20% snd/grit) - gravel to 10mm
39	40	clay (20% snd/grit) - gravel to 10mm
40	41	clay (20% snd/grit) - gravel to 10mm
41	42	clay , 10% gravel/sand
42	43	clay , 10% gravel/sand
43	44	clay , 10% gravel/sand
44	45	clay (tr sand) water/ Saprolite
45	46	clay (tr sand) wet // Saprolite
46	47	clay (tr sand) wet // Saprolite
47	48	clay (tr sand) wet // Saprolite
48	49	clay (tr sand) wet // Saprolite
49	50	clay (tr sand) wet // Saprolite
50	51	clay
51	52	clay
52	53	clay

WB020 Lithology

From (m)	To (m)	Lithology
0	1	
1	2	
2	3	
3	4	wet clay
4	5	gritty clay
5	6	clay (minor sand)
6	7	clay
7	8	moist clay
8	9	moist clay
9	10	moist clay
10	11	moist clay
11	12	moist clay
12	13	moist clay
13	14	clay (minor sand)
14	15	moist sticky clay
15	16	moist sticky clay
16	17	moist sticky clay
17	18	moist sticky clay
18	19	moist sticky clay
19	20	dry clay
20	21	gritty clay
21	22	fine sandy clay
22	23	fine sandy clay
23	24	fine sandy clay
24	25	fine sandy clay
25	26	minor fine grained sand/clay
26	27	minor fine grained sand/clay
27	28	clay, fine grained sand
28	29	30% medium-coarse grained sand
29	30	30% medium-coarse grained sand
30	31	30% medium-coarse grained sand
31	32	30% medium-coarse grained sand
32	33	minor sand/ dark orange yellow clay
33	34	minor sand/ dark orange yellow clay
34	35	minor sand/ dark orange yellow clay
35	36	sandy clay - 30% medium sand
36	37	sandy clay - 30% medium sand
37	38	clay/saprolite?
38	39	minor sand
39	40	sand/gravel 30%
40	41	sand/gravel 30%
41	42	minor sand/saprolite
42	43	saprolite
43	44	dry saprolite
44	45	dry saprolite
45	46	dry saprolite
		EOH

WB013 Lithology

From (m)	To (m)	Lithology
53	54	clay
54	55	clay
55	56	wet clay
56	57	saprolite
57	58	saprolite
58	59	saprolite
59	60	saprolite
60	61	saprolite
61	62	saprolite
62	63	saprolite
63	64	saprolite
64	65	saprolite
65	66	saprolite
66	67	saprolite
67	68	saprolite
68	69	saprolite
69	70	saprolite
70	71	saprolite
71	72	saprolite
72	73	saprolite
73	74	saprolite
74	75	saprolite
75	76	saprolite
76	77	saprolite
77	78	saprolite
78	79	saprolite
79	80	saprolite
80	81	saprolite
81	82	saprolite
82	83	saprolite
83	84	saprolite, minor chips EOH