



APPENDIX B
Hydrological Assessment

**COWAL GOLD OPERATIONS
MINE LIFE MODIFICATION**
Environmental Assessment
2016





Cowal Gold Operations Mine Life Modification Hydrological Assessment

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1.0 INTRODUCTION

1.1 EXISTING MINE AND MODIFICATION DESCRIPTION

Evolution Mining (Cowal) Pty Limited (Evolution) is the owner and operator of the Cowal Gold Operations (CGO) located approximately 38 kilometres (km) north-east of West Wyalong in New South Wales (NSW) (Figure 1).

Mining operations at the CGO are approved to 31 December 2024 and are carried out in accordance with Development Consent DA 14/98 (as modified).

Evolution proposes to modify Development Consent DA 14/98 under section 75W of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) to facilitate the continuation of open pit mining and processing operations at the CGO for an additional 8 years (i.e. to end 2032) (herein referred to as the Modification).

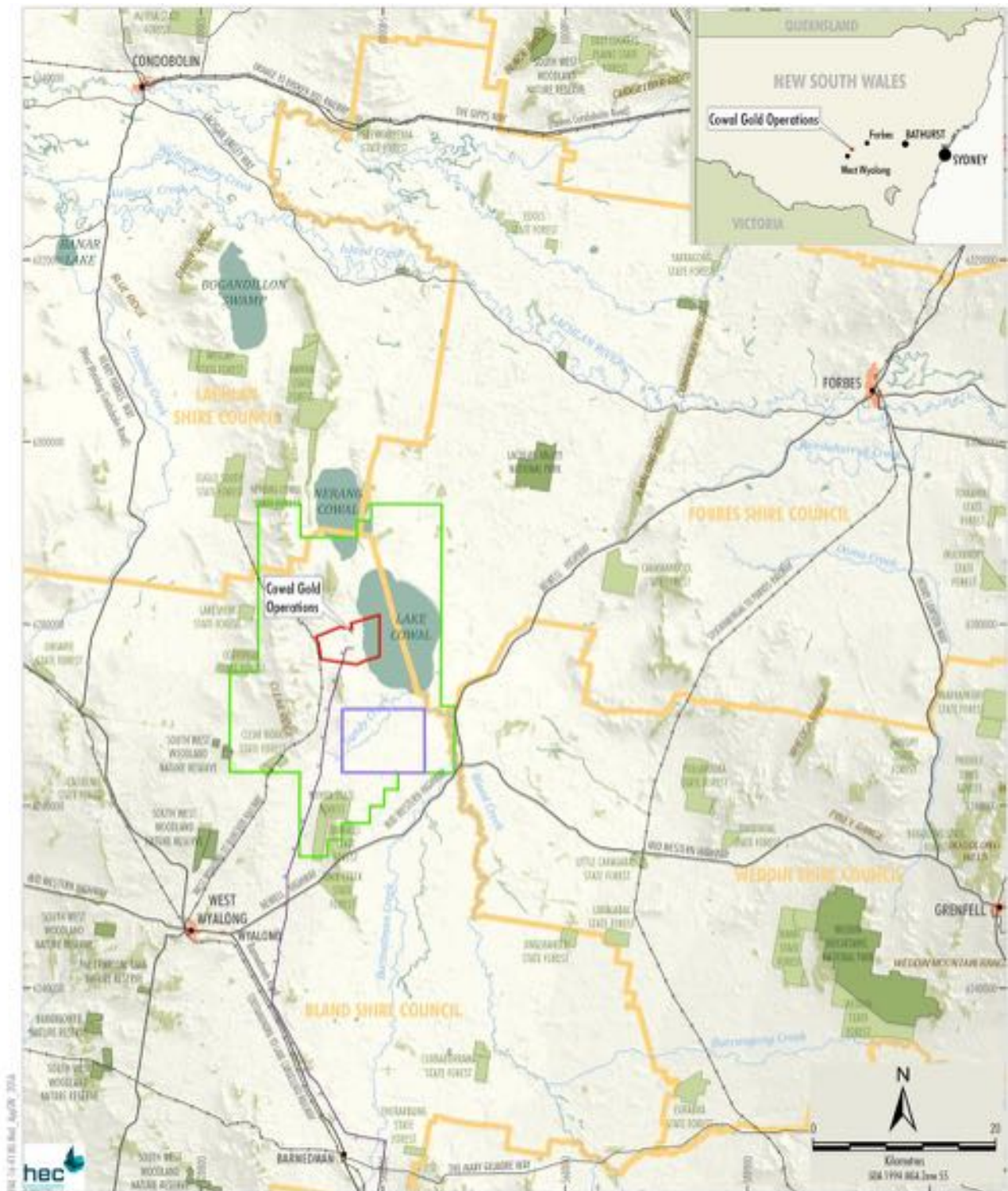
The main activities associated with development of the Modification would include:

- increasing the final depth of the open pit by 70 metres (m) to enable mining of additional ore and an increase in total gold production;
- extending the life of the approved CGO by up to 8 years, to 31 December 2032;
- upgrades to the existing leach circuit within the processing plant to improve gold recovery;
- increasing the total life of mine ore production/volume of tailings and mined waste rock;
- maximising tailings storage capacity of the existing tailings storage facilities (TSFs) via additional lifts and converting the area between the existing TSFs into a new storage area;
- incorporation of a rock fill buttress cover on the outer slopes of the TSF embankments to provide long-term stability; and
- an increase to the TSF embankment lift fleet.

The Modification would involve no change to the following key components of the existing CGO:

- mining tenement;
- lake isolation system;
- existing/approved surface development extent of the CGO;
- water management system and design objectives;
- mining methods;
- ore processing rate;
- waste rock emplacement disturbance areas;
- cyanide destruction method;
- approved cyanide concentration limits in the aqueous component of the tailings slurry;
- water supply sources;
- approved daily or annual extraction limits of the Bland Creek Palaeochannel Borefield;
- site access road;
- power supply;
- exploration activities;
- average or peak annual employment;
- hours of operation; or
- TSF embankment construction hours of 7 am to 6 pm.

This hydrological assessment report has been prepared by Hydro Engineering & Consulting Pty Ltd in support of the Modification Environmental Assessment (EA) and draws on results of groundwater modelling contained in the reports by Coffey Services Australia Pty Ltd (Coffey; 2016a and 2016b) (Appendix A of the EA).



- LEGEND**
- Mining Lease Boundary (ML 1535)
 - Exploration Licence (EL 1590)
 - Exploration Licence (EL 7750)
 - National Park & Nature Reserve
 - State Forest
 - Local Government Area Boundary
 - Electricity Transmission Line
 - Railway

Source: Geoscience Australia (2006); NSW Department of Industry (2016)



CGO MINE LIFE MODIFICATION
Regional Location

Figure 1 Regional Location

1.2 ASSESSMENT REQUIREMENTS

The guidelines used as a basis for assessing impacts in this report are shown below:

1	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a)	The surface water quality monitoring results from the existing CGO and surrounding areas have been compared to these guidelines where appropriate (Section 2.3).
2	National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000b)	Surface water quality monitoring would continue to be conducted in accordance with these guidelines (Section 2.3).
3	National Water Quality Management Strategy: Guidelines for Sewerage Systems – Effluent Management (ANZECC/ARMCANZ, 1997)	The existing sewerage systems at CGO (with upgrades as required) would continue to be operated in accordance with the <i>Environmental Guidelines: Use of Effluent by Irrigation</i> (DEC, 2004a).
4	National Water Quality Management Strategy: Guidelines for Sewerage System – Use of Reclaimed Water (ANZECC/ARMCANZ, 2000c)	The existing sewerage systems at CGO (with upgrades as required) would continue to be operated in accordance with the <i>Environmental Guidelines: Use of Effluent by Irrigation</i> (DEC, 2004a) which makes reference to ANZECC/ARMCANZ (2000c).
5	Using the ANZECC Guideline and Water Quality Objectives in NSW (DEC, 2006)	The Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a) has been applied in accordance with this guideline, including consideration of the NSW Government Water Quality and River Flow Objectives (NSW Government, 2016).
6	State Water Management Outcomes Plan (NSW Office of Water, 2013)	The assessment includes consideration of the policy developed under the State Water Management Outcomes Plan and the <i>Water Management Act 2000</i> , including the <i>Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012</i> and <i>Water Sharing Plan for the Lachlan Regulated River Water Source 2016</i> (refer this section).
7	Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC, 2004b)	Surface water quality monitoring would continue to be conducted in accordance with these guidelines (Section 2.3).
8	Managing Urban Stormwater: Soils & Construction (Landcom, 2004) and associated Volume 2E: Mines and Quarries (DECCW, 2008)	Existing and planned erosion and sediment controls would be designed in accordance with Landcom (2004) and DECCW (2008) to control suspended solids in runoff.
10	Managing Urban Stormwater: Treatment Techniques (EPA, 1997)	Would be considered and applied as relevant to drainage design/management around mine infrastructure area.
11	Managing Urban Stormwater: Source Control (EPA, 1998)	Would be considered and applied as relevant to drainage design/management in mine infrastructure areas.

12	Floodplain Development Manual (DIPNR, 2005)	Not considered relevant to this assessment as there are no properties other than those owned by the proponent that could be affected by mine infrastructure in any floodplain.
13	Floodplain Risk Management Guide (DECCW, 2010)	Not considered relevant to this assessment as the Modification is outside areas which could be affected by current sea level rise predictions and there are no properties outside those owned by the proponent that could be affected by mine infrastructure in any floodplain.
14	A Rehabilitation Manual for Australian Streams (CRCCH and LWRRDC, 2000)	This guideline would be considered upon approval of the Modification.
15	Technical Guidelines: Bunding & Spill Management	Would be used in design of containment systems for hazardous chemicals and would be incorporated into standard operating procedures for spill response.
16	Environmental Guidelines: Use of Effluent by Irrigation	The surface water quality monitoring results from the existing CGO and surrounding areas have been compared to guidelines set in ANZECC/ARMCANZ (2000a) for use of water as irrigation water where relevant (Section 2.3).
17	Guidelines for Practical Consideration of Climate Change (DECC, 2007)	Considered in the interpretations of post-mine impacts (Section 5.3 and Section 6.2.2).

DIPNR = NSW Department of Infrastructure, Planning and Natural Resources.

DECC = NSW Department of Environment and Climate Change.

ANZECC/ARMCANZ = Australian and New Zealand Environment and Conservation Council/ Agriculture and Resource Management Council of Australia and New Zealand.

DEC = NSW Department of Environment and Conservation.

OEH = NSW Office of Environment and Heritage.

DECCW = NSW Department of Environment, Climate Change and Water.

EPA = NSW Environment Protection Authority.

CRCCH and LWRRDC = Cooperative Research Centre for Catchment Hydrology and Land and Water Resources Research and Development Corporation.

The objects of the NSW *Water Management Act 2000* which is the principal statute governing management of water resources in NSW, were also considered during the assessment. *The Water Management Amendment Act 2014* was passed in 2014 and the provisions commenced on 1 January 2015. The objects of the *Water Management Act 2000* include:

...to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations and, in particular:

- (a) to apply the principles of ecologically sustainable development, and*
- (b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and*
- (c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including:*
 - (i) benefits to the environment, and*
 - (ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and*

- (iii) *benefits to culture and heritage, and*
- (iv) *benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water,*
- (d) *to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources,*
- (e) *to provide for the orderly, efficient and equitable sharing of water from water sources,*
- (f) *to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna,*
- (g) *to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users,*
- (h) *to encourage best practice in the management and use of water.*

The groundwater-related components of the assessment are provided separately in the Hydrogeological Assessment prepared by Coffey (2016a) (Appendix A of the EA). These include a discussion on the *NSW Aquifer Interference Policy 2012* and its implications for the Modification.

Under the *Water Management Act 2000*, the *Water Sharing Plan for the Lachlan Regulated River Water Source 2003* commenced on 1 July 2004 and was replaced on 1 July 2016. The *Water Sharing Plan for the Lachlan Regulated River Water Source 2016* covers licensed surface water accessed from the Lachlan River.

The external make-up of water supply at CGO is provided to the site via the mine borefield pipeline which draws water from the eastern saline borefield, the Bland Creek Palaeochannel Borefield and water extracted from the Lachlan River via the Jemalong Irrigation Channel. Water is currently extracted from the Lachlan River using regulated flow licences purchased by Evolution on the open market under the *Water Sharing Plan for the Lachlan Regulated River Water Source 2016*. Between approximately 4,000 and 274,000 megalitres (ML) of temporary water has been traded annually since records began in the 2004 to 2005 season.

Under the *Water Management Act 2000*, the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012* commenced on 14 September 2012.

The *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012* applies to all unregulated water sources in the Lachlan catchment which occurs naturally on the surface of the ground, and in rivers, lakes and wetlands.

Within the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012*, CGO is located within the Western Bland Creek Water Source, which has a total surface water entitlement of 2,275 megalitres per year (ML/year) divided between 33 surface water licences (Department of Primary Industries [DPI] Water, 2016).

Specific consideration of the objects of the *Water Management Act 2000* are provided in Attachment 2 (Aquifer Interference Policy Considerations and Water Licensing Addendum) in the Main Report of the EA.

1.3 SUMMARY OF RELEVANT FINDINGS OF PREVIOUS ENVIRONMENTAL APPROVALS DOCUMENTATION

Cowal Gold Project Environmental Impact Statement (EIS) (North Limited, 1998).

- Surface water on the mine site was to be permanently isolated from Lake Cowal by the Up Catchment Diversion System (UCDS), directing runoff from areas unaffected by mining around the perimeter of the site, and an Internal Catchment Drainage System (ICDS), capturing all site runoff and seepage for re-use in the processing plant. In the longer term the ICDS would direct site runoff to the final void which would become a permanent sink for groundwater and surface runoff.
- The long term final void water balance was such that the final void was predicted to not spill under any conceivable climate conditions.
- The operational water balance prediction was for a moderately negative site water balance. External water supply would be required from the Bland Creek Palaeochannel Borefield.
- Mine waste rock material was predicted to have the potential to generate moderately saline seepage, particularly during the active mining phase. During the active mining phase, all runoff and seepage from the waste rock emplacements would be contained within the ICDS.
- The tailings storages were designed to be able to contain runoff from a 0.1 percent (%) annual exceedance probability (AEP) rainfall event. Any spill or seepage would be contained within the ICDS, ultimately reporting to the open cut.
- In the longer term, it was predicted there would be little potential for movement of surface water or groundwater from the waste rock emplacements or of seepage from the tailings storages.

Use of suitable soils and vegetation in rehabilitation of waste rock emplacements and the tailings storages was predicted to result in low salt fluxes in surface waters consistent with regional runoff water quality.

Cowal Gold Mine Extension Modification (Gilbert & Associates, 2013) – Modification 11.

- There was no change proposed to the UCDS, directing runoff from areas unaffected by mining around the perimeter of the site, with the ICDS continuing to capture all site runoff and seepage for re-use in the processing plant.
- In order to effectively manage water within the ICDS and maintain water supply, some minor changes were proposed, including some re-direction of internal drainage from constructed mine landforms and construction of an additional raw water storage – D10.
- Augmentation of the external water supply pipeline (across Lake Cowal) was proposed increasing its capacity from 11 ML/day to 14 ML/day. This would also involve construction of another pump station which would be located outside the bounds of the Lake Cowal inundation limits and away from drainage paths. Any potential impacts of the pump station construction would be mitigated by appropriate design.
- Water balance modelling indicated that there were no external water supply shortfalls simulated, with the median peak annual water supply requirement from licensed Lachlan River extraction peaking at 2,924 ML. No spills were predicted in the water balance model from either of the contained water storages (D1 and D4) that could spill to Lake Cowal.
- Final void water balance modelling indicated that final void equilibrium water levels would be lower than those predicted in North (1998) and would be approximately 80 m below spill level.
- It was concluded that there would be a low risk of more than a negligible hydrological impact on Lake Cowal due to the Modification.

2.0 HYDROMETEOROLOGICAL SETTING

2.1 REGIONAL HYDROLOGY

CGO is located on the western side of Lake Cowal (refer Figure 2) and extends into the natural extent of Lake Cowal. Lake Cowal is an ephemeral, fresh water lake that forms part of the Wilbertroy-Cowal Wetlands which are located on the Jemalong Plain. Lake Cowal is in the lower reaches of the Bland Creek catchment. It also receives periodic inflows from the Lachlan River during periods of high flow¹ when flood waters enter Lake Cowal via two main breakout channels from the north-east. Breakout from the Lachlan River to Lake Cowal occurred in late 2010, in the first half of 2012 and again in 2016, but had not occurred prior to this since 1998.

Lake Cowal is a large oval shaped lake which, when full, occupies an area of some 105 square kilometres (km²), holds some 150 gigalitres of water and has a depth of approximately 4 m when full. It overflows to Nerang Cowal, a smaller lake to the north. When flows are sufficient, the lakes ultimately overflow and drain into the Lachlan River via Bogandillon Creek. The Lachlan River is the major regional surface drainage, forming part of the Murray-Darling Basin. Flows in the Lachlan River near Lake Cowal are regulated by releases from Wyangala Dam.

The area surrounding the CGO site is drained by ephemeral drainage lines which flow to Lake Cowal. Bland Creek and all other tributaries of Lake Cowal are also ephemeral. Bland Creek drains a catchment of approximately 9,500 km² which ultimately reports to Lake Cowal at its southern end. Flow records from a gauging station² on Bland Creek indicate that runoff is low, averaging about 5% of rainfall.

2.2 METEOROLOGY

The region experiences a semi-arid climate which is dominated by cool, wetter conditions in winter and hot and relatively dry conditions in summer. Table 1 summarises regional monthly and annual rainfall totals from Bureau of Meteorology (BoM) stations (Wyalong, Ungarie and Burcher Post Offices [PO]), as well as rainfall recorded at CGO since 2002.

Long-term regional rainfall averages some 470 millimetres (mm) per annum. Average annual rainfall recorded at the CGO from 2002 to mid 2016 averages 430 mm, which compares with an annual average of 438.1 mm recorded at Wyalong PO and 481.0 mm at Burcher PO for the same period.

Table 2 summarises regional monthly and annual pan evaporation totals from the nearest BoM pan evaporation stations. The nearest BoM pan evaporation station is located at the Condobolin Agricultural Research Station, approximately 65 km north of CGO.

¹ Inflows from the Lachlan River occur when flows at Jemalong Weir exceed 15,000 to 20,000 megalitres per day (ML/day) – North (1998).

² GS 412171 (Bland Creek at Marsden), which operated from 1998 to 2004.

Table 1 Rainfall Data Summary

	Wyalong PO (073054*)		Ungarie PO** (050040)		Burcher PO (050010)		CGO	
	Jun-1895 – Aug-2016		Oct-1895 – Aug-2016		Jun-1937 – Aug-2016		Jan-2002 – Aug-2016 [†]	
	Mean Total (mm)	Mean No. Raindays	Mean Total (mm)	Mean No. Raindays	Mean Total (mm)	Mean No. Raindays	Mean Total (mm)	Mean No. Raindays
Jan	41.9	4.8	42.1	3.7	42.6	4.0	28.2	5.4
Feb	38.7	4.6	39.3	3.7	44.0	3.9	58.8	6.5
Mar	36.7	4.7	38.7	3.7	40.6	3.9	31.7	5.1
Apr	34.3	4.8	32.9	3.8	33.3	4.1	20.3	4.6
May	39.1	6.6	38.3	5.5	37.7	5.8	24.3	5.8
Jun	44.1	8.8	43.3	6.7	36.9	6.6	49.6	11.3
Jul	42.9	9.8	38.5	7.1	39.3	7.4	40.7	10.4
Aug	38.8	9.0	35.6	6.9	37.9	6.5	31.2	8.4
Sep	35.3	7.3	33.3	5.7	34.6	5.2	30.5	6.0
Oct	45.1	6.9	40.8	5.5	45.7	5.5	29.1	6.1
Nov	36.3	5.5	36.6	4.2	37.1	4.7	34.4	5.9
Dec	44.5	5.5	43.5	4.3	42.3	4.1	49.9	7.3
Annual	477.7	78.4	463.1	60.9	471.7	61.9	428.7	82.6

* BoM Station Number.

** Data contains numerous gaps in recent years and early in the 20th century.

[†] Manual gauge to December 2006, automatic weather station thereafter.

mm = millimetres.

Note: Statistically, the sum of monthly means does not necessarily equal the annual mean.

Table 2 Evaporation Data Summary

	Pan evaporation Condobolin Agricultural Research Station (050052*)	Pan evaporation Condobolin Soil Conservation (050102*)	Pan evaporation Cowra Research Station (063023*)
	1973 – 2016	1971 – 1985	1965 – 2011
	Mean Total (mm)	Mean Total (mm)	Mean Total (mm)
Jan	310.0	235.6	229.4
Feb	245.8	200.6	180.8
Mar	210.8	161.2	148.8
Apr	129.0	102.0	90.0
May	74.4	58.9	49.6
Jun	48.0	36.0	30.0
Jul	49.6	43.4	34.1
Aug	77.5	68.2	49.6
Sep	117.0	96.0	78.0
Oct	182.9	142.6	124.0
Nov	234.0	189.0	165.0
Dec	297.6	235.6	217.0
Annual	1,972	1,569	1,388

* BoM Station Number.

Note: Statistically, the sum of monthly means does not necessarily equal the annual mean.

2.3 WATER QUALITY

2.3.1 Lake Cowal

Baseline water quality reported in the Cowal Gold Project EIS was based on results of an intensive sampling programme conducted between 1991 and 1995 and included 34 monitoring locations along four transects across Lake Cowal. This has been supplemented by an additional monitoring campaign undertaken from November 2010 through to July 2014³ which included sampling of lake inflow from Sandy and Bland Creeks. The results of additional monitoring were reported in the *Surface Water and Sediment Sampling and Analysis – Lake Cowal NSW* (DM McMahon Pty Ltd, 2011) and have been summarised in Table 3 and Table 4. The following assessment has been conducted using water quality data results obtained from sampling in Lake Cowal over this period (November 2010 to July 2014). Results from this assessment period are compared to relevant guideline values published in ANZECC/ARMCANZ (2000a) and with values obtained from sampling programs conducted in the baseline period prior to commencement of mining operations. Lake water quality monitoring locations are shown on Figure 2.

Average total nitrogen measured at the lake transect sites was 546 micrograms per litre ($\mu\text{g/L}$), which was higher than the maximum level recorded during the baseline period (257 $\mu\text{g/L}$) and the ANZECC/ARMCANZ (2000a) default trigger value for fresh water lakes (350 $\mu\text{g/L}$). It was, however, lower than the average concentration in lake inflows from Bland Creek and Sandy Creek over the assessment period (1200 $\mu\text{g/L}$).

Average total phosphorous measured at the lake transect sites was 385 $\mu\text{g/L}$, which was lower than the baseline data (range 970 to 2,640 $\mu\text{g/L}$) and lower than the average at the lake inflow sites (Bland Creek and Sandy Creek – 546 $\mu\text{g/L}$). It was however higher than the ANZECC/ARMCANZ (2000a) default trigger value for fresh water lakes (10 $\mu\text{g/L}$).

Average pH measured at the lake transect sites was 8.1, which was slightly lower than the average over the baseline period (8.48), but slightly higher than the average at the lake inflow sites (7.5). The range of pH levels recorded at the lake transect sites (5.56 to 11.42)⁴ was greater than that recorded at the lake inflow sample locations (5.78 to 9.39) and outside the trigger value range (6.5 to 8.0) published in ANZECC/ARMCANZ (2000a). The range measured at the lake transects during the baseline period was 7.72 to 9.8 (which is noted to also be outside the upper trigger level published in ANZECC/ARMCANZ [2000a]).

Average EC (a measure of salinity) in lake water over the assessment period was 417 microSiemens per centimetre ($\mu\text{S/cm}$). This is lower than the average EC measured at the lake transect sites during the baseline period (881 $\mu\text{S/cm}$). The average EC readings in the lake during the assessment period were consistent with the average at the lake inflow sample locations (221 $\mu\text{S/cm}$) over the assessment period. Both the average lake inflows and lake transect readings during the baseline and assessment periods were however well above the ANZECC/ARMCANZ (2000a) default trigger value for fresh water lakes (20 - 30 $\mu\text{S/cm}$).

Average turbidity levels recorded at lake transect sites during the assessment period was 278 nephelometric turbidity units (NTU) compared to 111 NTU recorded during the baseline period. Average turbidity recorded at lake transects was lower than the average recorded at the lake inflow sample locations (370 NTU) during the assessment period. The levels recorded during the baseline and assessed period were well above the ANZECC/ARMCANZ (2000a) default trigger level for protection of slightly disturbed ecosystems (1 to 20 NTU).

³ Evolution advise that between 2014 and late 2016, lake water levels were too low (or the Lake dry) for effective sampling to occur.

⁴ Two field pH values greater than 10 were recorded in late February 2011. 90% of recorded pH values were less than 8.7.

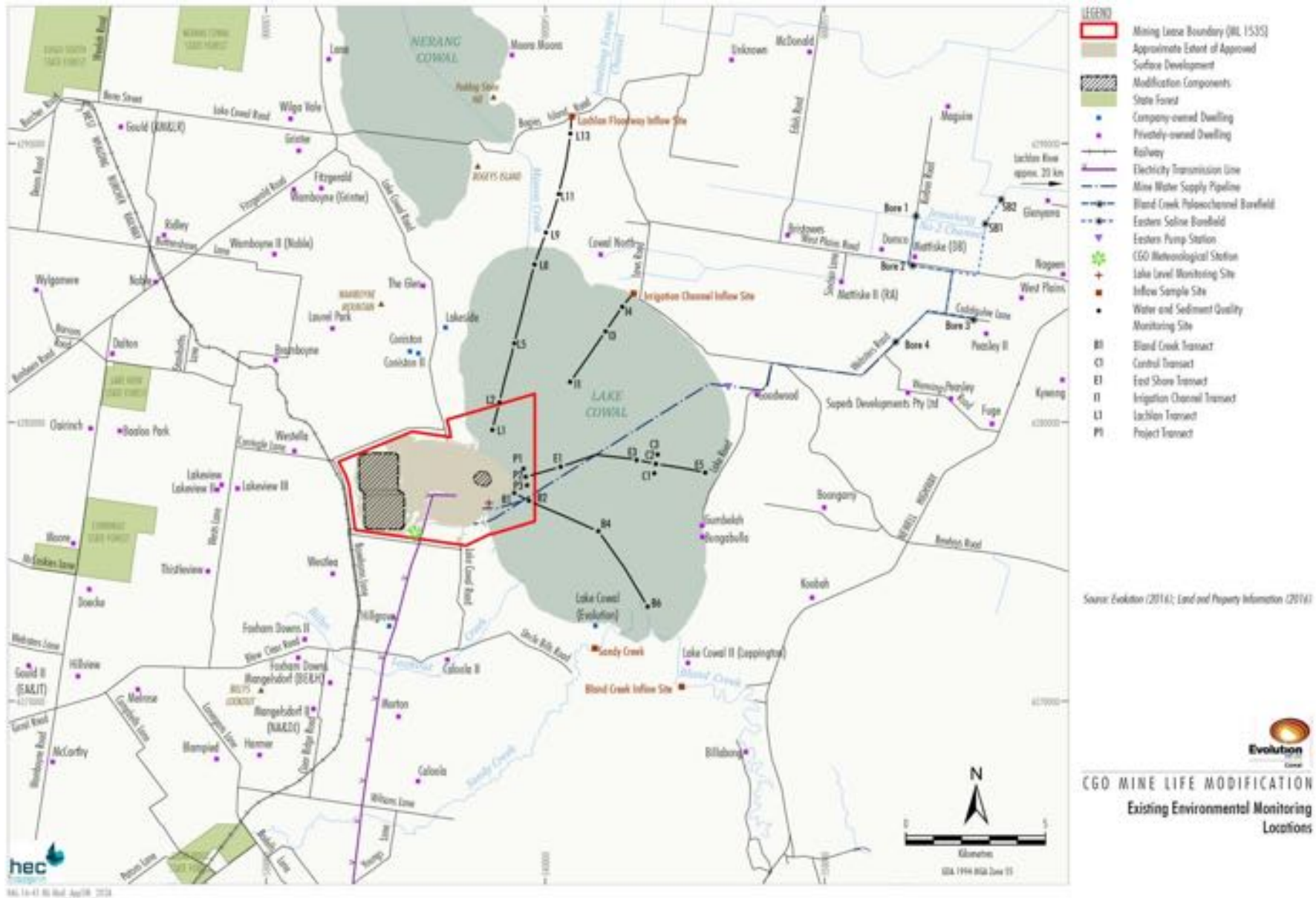


Figure 2 Existing Environmental Monitoring Locations

Table 3 Summary of Lake Cowal Water Quality – Generic Parameters

Parameter (Units as stated)	Default Trigger Values ¹		Lake Cowal Baseline Water Quality (1991-1995)	Baseline Data Inflow Sites Only (1991- 1992, Dec 93)	Baseline Data Lake Transects (1991- 1995)	Lake Cowal Transect Monitoring (Nov 2010 - August 2016)	Lake Cowal Inflow Sites (Nov 2010 - August 2016)
	Protection of Aquatic Ecosystems	Stock Water Protection Low Risk Trigger Value					
Total N (µg/L)	350 µg/L for SE Aust. Freshwater Lakes and Reservoirs	No trigger values given	Not available	660 to 2,610 (1,200**)	61 to 257 (136**)	10 to 5,620 (546**)	10 to 2,700 (844**)
Total P (µg/L)	10 µg/L for SE Aust. Freshwater Lakes and Reservoirs	No trigger values given	Not available	29 to 216 (79**)	970 to 2,640 (1,667**)	10 to 1,980 (385**)	170 to 1,860 (546*)
pH (pH units) - field	6.5 to 8.0 pH for SE Aust. Freshwater Lakes and Reservoirs	No trigger values given	8.27 to 8.67	7.6 to 8.2	7.72 to 9.80 (8.48**)	5.56 to 11.42 (8.1**)	5.78 to 9.39 (7.5**)
EC (measured in field)/TDS	EC 20-30 µS/cm for SE Aust. Freshwater Lakes and Reservoirs	TDS triggers 2,500 mg/L dairy cattle, 5,000 mg/L sheep	222 to 1,557 µS/cm	382 to 1,260 µS/cm (726**)	160 to 3,130 µS/cm (881**)	2.09 to 1,801 µS/cm (417**)	34 to 871 µS/cm (221**)
Turbidity (NTU – measured in field)/TSS (mg/L) [^]	1 to 20 NTU Turbidity Triggers for slightly disturbed ecosystems - lakes	No triggers given	22 to 224 mg/L	0.62 to 234 (70.5**) NTU [^] TSS 0.54 to 150 mg/L (37.9**)	7 to 566 (111**) NTU [^] TSS 13 to 271 mg/L (103.4**)	7.8 to 2,562 (278**) NTU [^] TSS 2 to 1,210 mg/L (132**)	13.4 to 2,819 (370**) NTU [^] TSS 6 to 640 mg/L (131.7**)

µg/L = micrograms per litre; µS/cm = microSiemens per centimetre; mg/L = milligrams per litre.

EC = electrical conductivity.

TDS = total dissolved solids.

TSS = total suspended solids.

NTU = nephelometric turbidity unit.

N = nitrogen

P = phosphorous

SE = south-east

[^] Catchments with highly dispersive soils will have high turbidity (ANZECC/ARMCANZ, 2000a).

** Average Value.

¹ Trigger values were taken from ANZECC/ARMCANZ (2000a). The NSW Water Quality Objectives do not differ from the ANZECC/ARMCANZ (2000a) guidelines.

Note: pH, turbidity, and EC data was derived from field samples, all other parameters were derived from laboratory analysis.

Conductivity in lakes and reservoirs is generally low, but will vary depending on catchment geology (ANZECC/ARMCANZ, 2000a).

Table 4 Summary of Lake Cowal Water Quality – Metals

Parameter (Units as stated)	Default Trigger Values ¹					Lake Cowal Baseline Water Quality (1991-1995)	Baseline Data Inflow Sites Only (1991-1992, Dec 93)	Baseline Data Lake Transects (1991 - 1995)	Lake Cowal Transect Monitoring (Nov 2010 - August 2016)	Lake Cowal Inflow Sites (Nov 2010 - August 2016)
	Protection Levels for Aquatic Ecosystems				Stock Water Protection Level					
	99%	95%	90%	80%	Low Risk Trigger Value					
As (Total) (µg/L)	0.8	13	42	140	500	2.6**	<0.1 to 3.5 (1.2**)	<0.5 to 3.98 (2.6**)	2 to 27 (6.7**)	2 to 26 (5.4**)
Cd (Total) (µg/L)	0.06	0.2	0.4	0.8	10	0.055**	<0.05 to 0.5 (0.1**)	<0.05 to 0.5 (0.06**)	0.1 to 1 (0.11**)	All samples less than or equal to the Level of Detection Limit (0.1)
Cu (Total) (µg/L)	1.0	1.4	1.8	2.5	1,000 µg/L cattle, 400 µg/L sheep	6**	1.6 to 7.5 (3.5**)	2.2 to 15.9 (5.8**)	1 to 31 (8**)	2 to 70 (12.8**)
Fe (Total) (µg/L)	No trigger values given				Not sufficiently toxic	-	-	-	360 to 33,600 (10,473**)	900 to 180,000 (22,318**)
Pb (Total) (µg/L)	1	3.4	5.6	9.4	100	2.9**	<0.5 to 7.2 (2.3**)	<0.5 to 6.5 (2.7**)	1 to 15 (4.8**)	1 to 97 (12.8**)
Mn (Total) (µg/L)	1,200	1,900	2,500	3,600	Not sufficiently toxic	-	-	-	55 to 470 (166**)	137 to 296 (217**)
Hg (Total) (µg/L) (inorganic)	0.06	0.6	1.9	5.4	2	>50% of samples less than the Level of Detection Limit (0.1)	<0.1 to 0.4 (0.2**)	<0.1 to 0.4 (0.13**)	All samples less than or equal to the Level of Detection Limit (0.1)	All samples less than or equal to the Level of Detection Limit (0.1)
Zn (Total) (µg/L)	2.4	8	15	31	20,000	12**	<3 to 22 (9.0**)	<3 to 30 (11.7**)	5 to 79 (18.9**)	5 to 234 (35**)
Ni (Total) (µg/L)	8	11	13	17	1,000	-	-	-	2 to 26 (10.3**)	3 to 77 (14.1**)

As = arsenic.

Cd = cadmium.

Cu = copper.

** Average Value.

Fe = iron.

Pb = lead.

Mn = manganese.

Hg = mercury.

Zn = zinc.

Ni = nickel.

> = greater than.

< = less than.

¹ Trigger values were taken from ANZECC/ARMCANZ (2000a). The NSW Water Quality Objectives do not differ from the ANZECC/ARMCANZ (2000a) guidelines.

Laboratory analysis of lake and inflow water quality samples included metals analyses for nine metals (arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel and zinc). Mercury concentrations were at or below laboratory detection level at both lake transect and lake inflow sites during the assessment period. Cadmium concentrations were at or below laboratory detection level at lake inflow sites and one sample returned a concentration above the laboratory detection in the lake transect sites.

Average arsenic, manganese and nickel concentrations at the lake transect sites were below ANZECC/ARMCANZ (2000a) default trigger levels for protection of slightly modified aquatic ecosystems (95% protection level). Average lead, copper and zinc concentrations at the lake transect sites were lower than the respective average concentrations measured at the lake inflow sites but above the ANZECC/ARMCANZ (2000a) default triggers (at 95% the protection level). The average lake copper (8 µg/L), lead (4.8 µg/L) and zinc (18.9 µg/L) concentrations were greater than the baseline values of 5.8, 2.7 and 11.7 µg/L respectively.

In summary, notable results are:

- the range of pH was high relative to ANZECC/ARMCANZ (2000a) default triggers and baseline ranges, however, as discussed further below has been similarly elevated at sites near and distant to the CGO;
- average copper, lead and zinc concentrations were high relative to both ANZECC/ARMCANZ (2000a) default triggers and baseline however as discussed further below has been similarly elevated at sites on the opposite side of Lake Cowal;
- average turbidity was significantly higher than the ANZECC/ARMCANZ (2000a) default trigger value and higher than baseline levels, however as discussed further below turbidity levels have occurred uniformly at sites close to and distant from the CGO; and
- total phosphorous concentrations were significantly higher than the ANZECC/ARMCANZ (2000a) default trigger value for fresh water lakes however as discussed further below concentrations have been similar at sites both close to the CGO and on the other side of Lake Cowal (it is also noted measured total phosphorus is less than the baseline average).

Because runoff and water within the CGO area is fully contained within the ICDS, there is no obvious causal link between the mining operations and the water quality in the lake. Given that groundwater, including any seepage from on-site storages, would flow toward the mine pit (Coffey, 2016a), the only plausible links between mining activity at CGO and lake water quality would be overflow from dams D1 and/or D4 (which are outside the ICDS), mine site dust fall-out onto the lake or runoff/wash-off from the outside batters of the perimeter waste emplacement when the Lake Temporary Isolation Bund is inundated. Both D1 and D4 storages are fitted with pump back systems and Evolution has advised⁵ that they have never overflowed to date. The data supports that there is no evidence that the existing CGO has resulted in changes to water quality in Lake Cowal.

Samples taken at transect sites P1, P2 and P3 are physically close to the Lake Temporary Isolation Bund and therefore more likely to reflect mine-related effects, whilst sites E3 and E4 are on the opposite side of the lake – refer Figure 2. A comparison of the monitored results from these sites for pH, copper, lead, zinc, turbidity and total phosphorous is shown in Figure 3 to Figure 8.

⁵ Pers comm., Evolution.

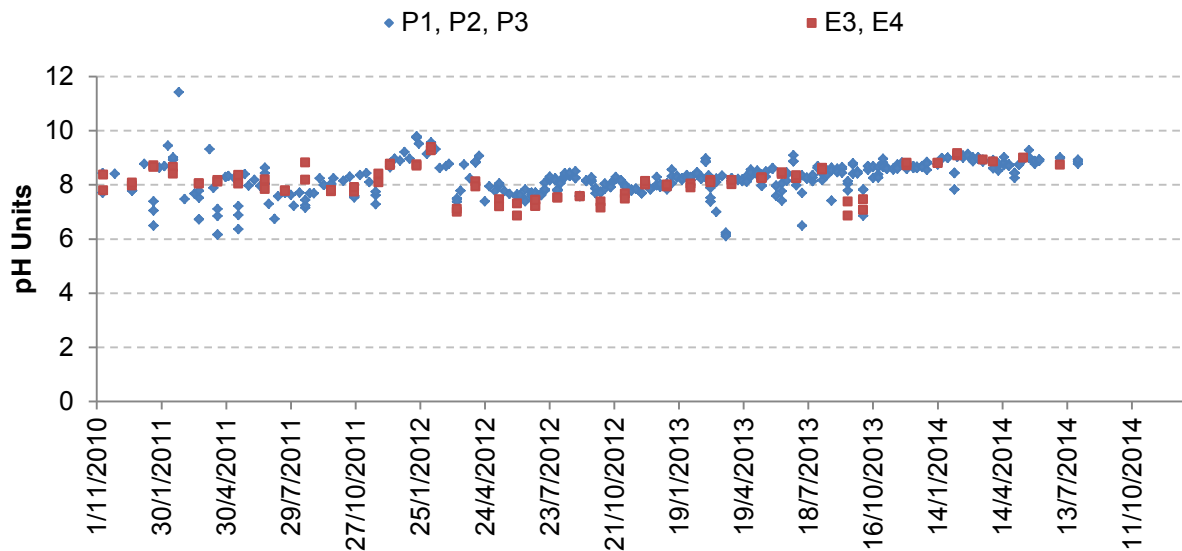


Figure 3 Field Measurement of pH at Selected Sites – Lake Cowal

The pH values were relatively elevated at lake sites close to CGO (P1, P2, and P3) in February 2011 compared to sites on the opposite side of the lake. Elevated pH levels were also recorded near the CGO in February 2012 although similar levels were also measured on the opposite side of the lake at that time.

To further assess whether there was a link between the elevated pH levels measured in February 2011 and proximity to CGO, an assessment was conducted on pH levels recorded at all sites considered to be relatively close to the Lake Temporary Isolation Bund (E1, L1, P1, P2, P3, B1 and B2 – refer Figure 2) and all other sites in the lake from 2011 to 2014 – refer Figure 4. This assessment indicates that pH levels were similar at sites close to CGO and at other (more distant) sites. In particular there was a relatively elevated pH value recorded at site C1 (11.05) in February 2011 which suggests that pH has been similarly elevated at sites near and distant from the CGO.

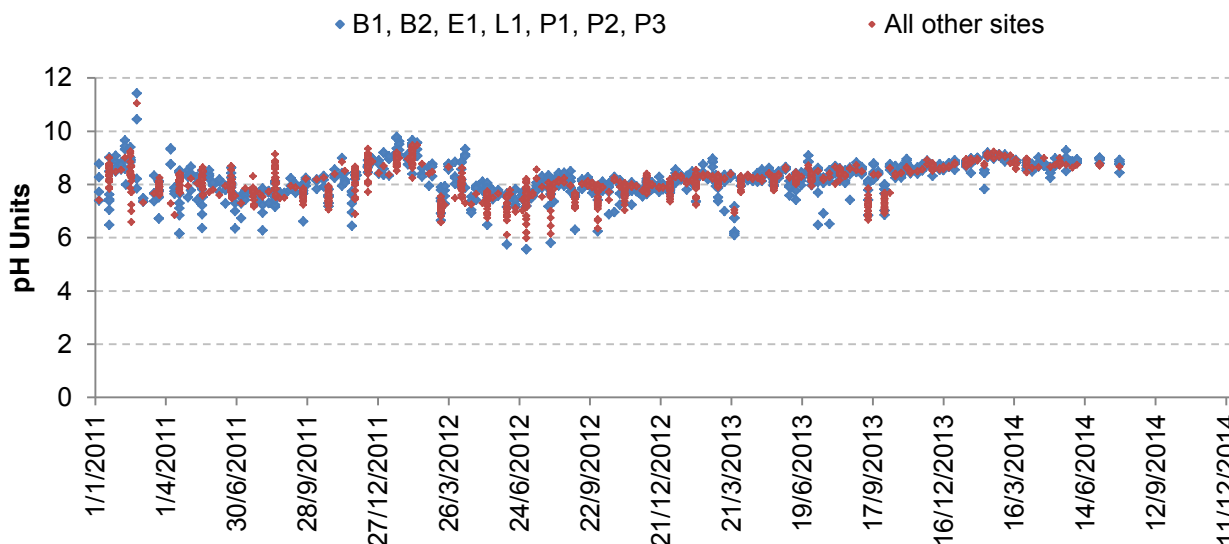


Figure 4 Field Measurements of pH – Lake Cowal

The assessment of copper concentrations at sites close to CGO and sites on the opposite side of the lake is presented in Figure 5. Results of this assessment indicate that copper concentrations have been similar at sites close to CGO and at sites on the opposite side of the lake.

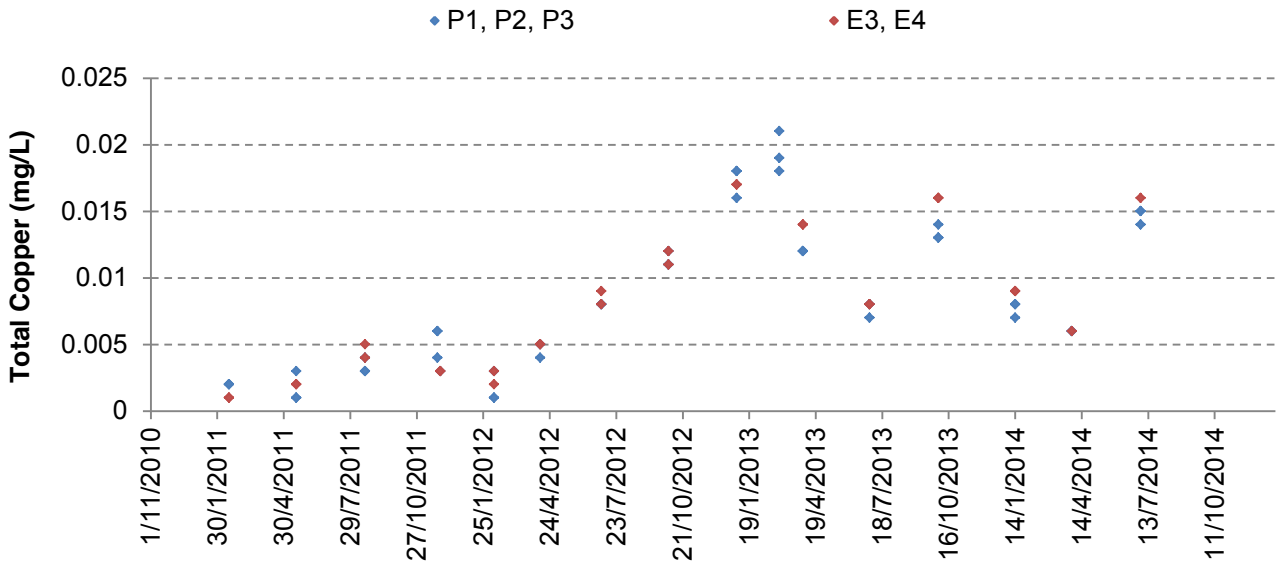


Figure 5 Recorded Copper Concentrations at Selected Sites – Lake Cowal

The assessment of lead concentrations at sites close to CGO and sites on the opposite side of the lake is presented in Figure 6. Results of this assessment indicate that lead concentrations have also been similar at sites close to CGO and at sites on the opposite side of the lake.

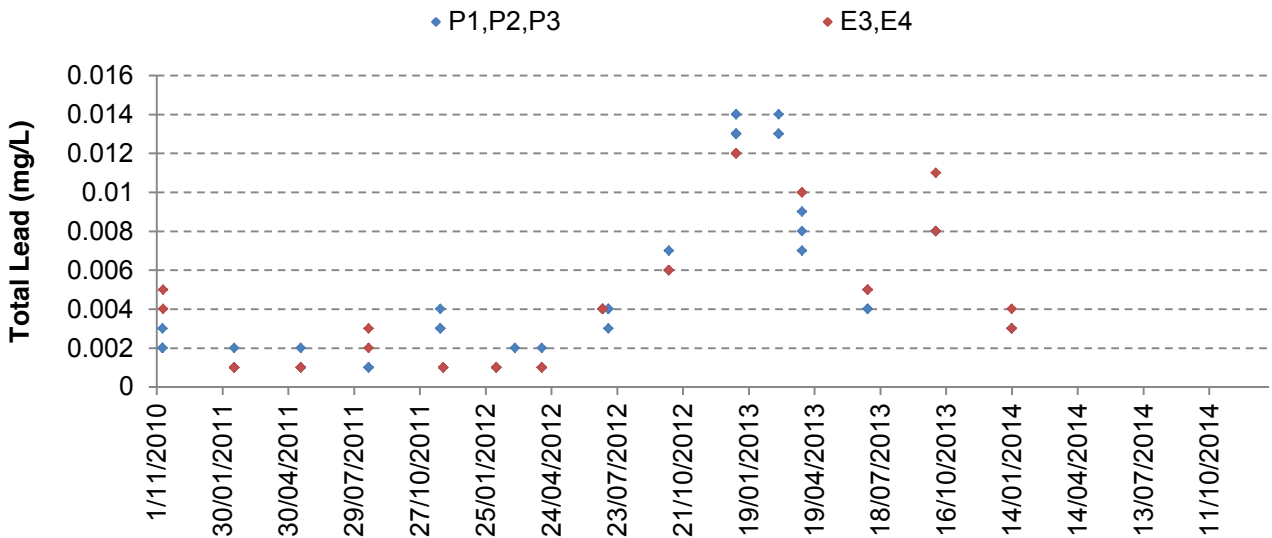


Figure 6 Recorded Lead Concentrations at Selected Sites – Lake Cowal

The assessment of zinc concentrations at sites close to CGO and sites on the opposite side of the lake is presented in Figure 7. Results of this assessment indicate that zinc concentrations have also been similar at sites close to CGO and at sites on the opposite side of the lake.

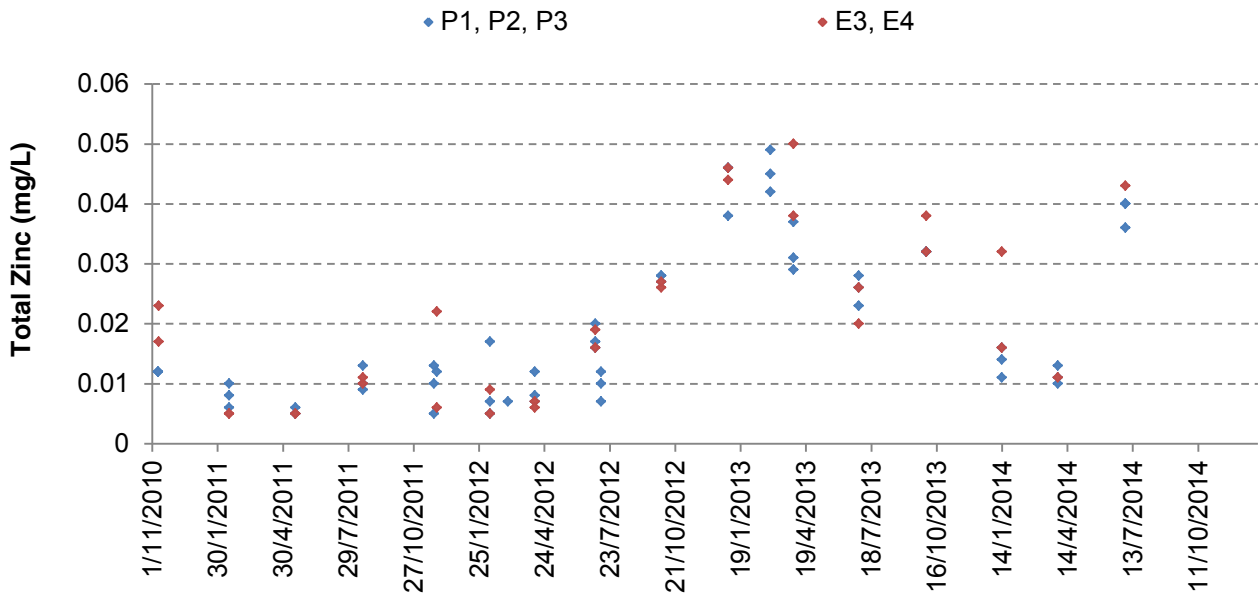


Figure 7 Recorded Zinc Concentrations at Selected Sites – Lake Cowal

The assessment of lake turbidity levels indicates a consistent trend of increasing turbidity from March to December 2012 at sites both close to CGO and sites on the other side of the lake – refer Figure 8. It is noted that flood water entered Lake Cowal in March 2012.

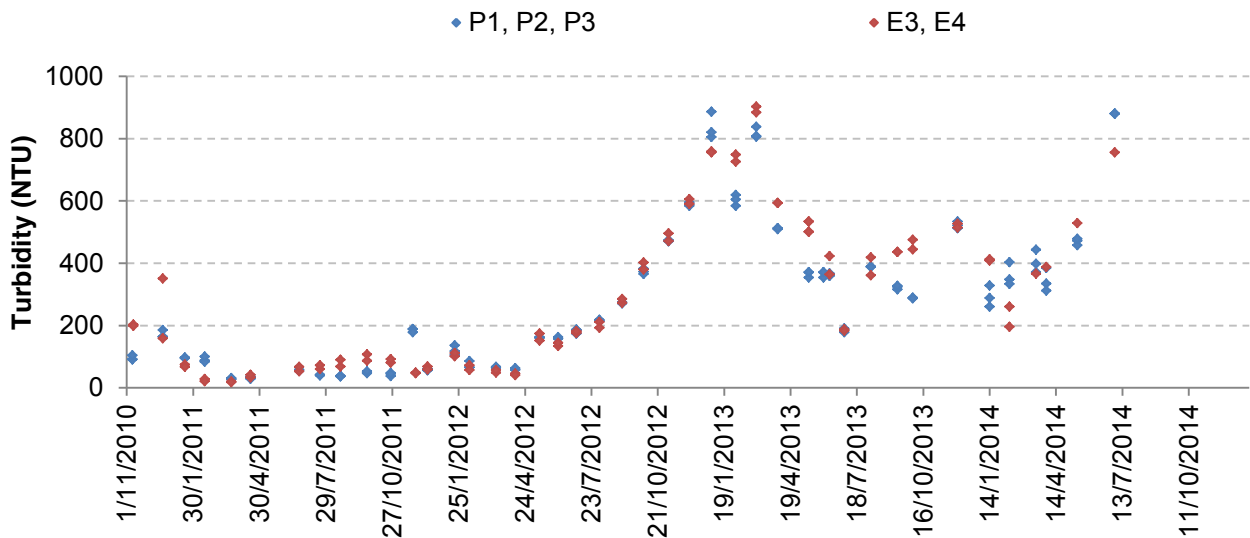


Figure 8 Field Measurements of Turbidity at Selected Sites – Lake Cowal

An assessment of the concurrent trends in lake turbidity and lake water level indicates the period of increasing turbidity followed by a gradual decline. This has occurred uniformly at sites close to and distant from the CGO.

Assessment of total phosphorous concentrations indicates that concentrations have been similar at sites both close to the CGO and on the other side of the lake (refer Figure 9).

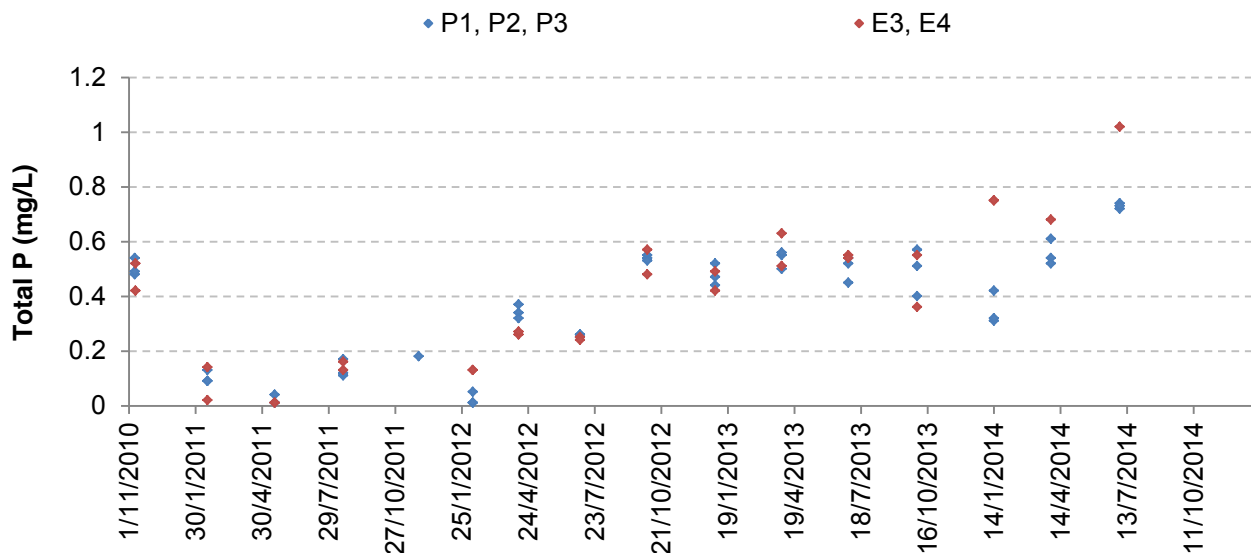


Figure 9 Recorded Total Phosphorous Concentrations at Selected Lake Sites and Lake Water Level

2.3.2 Other Water Quality Monitoring

CGO has monitored pH, EC and TSS concentrations in the UCDS from 2007 to late 2016. Recorded pH ranged from 5.9 to 9.7, EC between 61 and 2,916 $\mu\text{S}/\text{cm}$ and TSS from 4 to 2,140 mg/L.

CGO has also monitored pH, EC and TSS in site contained water storages and the open pit over a similar period. Ranges of pH in these site storages have been recorded from 4.4 to 10.3, EC between 300 and 142,700 $\mu\text{S}/\text{cm}$ and TSS from 1 to 3,300 mg/L. High recorded EC values reflect, at least in part, the use of water supplied from saline groundwater bores and saline groundwater inflow to the open pit.

2.4 HARVESTABLE RIGHT

Landholders in most NSW rural areas are allowed to collect a proportion of the rainfall runoff on their property and store it in one or more dams up to a certain size. This is known as a 'harvestable right'. Maximum harvestable right dam capacity is the total dam capacity allowed under the harvestable right for a given property. It is based on 10% of the average regional rainfall runoff and takes into account local evaporation rates and rainfall periods.

The regulations (made under the *NSW Water Management Amendment Act 2014*) relating to harvestable right exclude capture of drainage and/or effluent in accordance with best management practice, and dams constructed to control or prevent soil erosion. None of the storages on-site are used to harvest runoff from land and all storages are used to contain contaminated drainage, mine water or effluent in accordance with best management practice or are used to control soil erosion. It is concluded therefore that all of these storages should be excluded from consideration as a component of the harvestable right calculation.

2.5 GROUNDWATER

The groundwater levels and water quality in the CGO region are described separately in the Hydrogeological Assessment prepared by Coffey (2016a) and is provided in Appendix A of the EA.

3.0 CURRENT CGO WATER MANAGEMENT AND WATER SUPPLY

3.1 DESCRIPTION

CGO currently involves open cut mining and on-site ore processing. On-site ore processing involves crushing and grinding followed by a combined flotation and carbon-in-leach circuits. Tailings produced from the processing plant are deposited in TSFs. Mine waste rock is placed in waste rock emplacements located to the north, south and east of the open pit (refer Figure 10).

The CGO water management system has been designed such that the approved CGO does not impact on the integrity of Lake Cowal. Mine infrastructure and landforms have been constructed within a contained catchment (i.e. the ICDS). The ICDS combines with the UCDS and the lake isolation system to protect Lake Cowal from CGO development activities. The lake isolation system comprises a Temporary Isolation Bund and a permanent isolation bund (i.e. Lake Protection Bund). The Lake Protection Bund comprises a large engineered embankment that provides a permanent barrier between the lake and the open pit. Runoff from areas upslope of the ICDS (i.e. areas undisturbed by mining) is diverted via the UCDS, around the CGO to Lake Cowal.

The main water demand for the approved CGO is for supply to the process plant. Since the commencement of primary ore processing in mid-2007, the CGO processing rate has averaged 7.2 million tonnes per annum (Mtpa) and the water demand⁶ (total) has averaged 16.7 ML/day (of which up to approximately 7.5 ML/day was supplied by on-site recycling of return water and incident rainfall from the TSF decant ponds). Prior to mid-2007, during the initial oxide ore processing phase⁷, the ore processing rate averaged 6.4 Mtpa and the water demand (total) averaged 33.7 ML/day. A higher water demand is required for oxide ore due to the finer, clayey nature of the ore.

The only other significant water demand is for haul road dust suppression. Monitoring data (to end of March 2016) indicates that this demand averages 0.64 ML/day.

Water supply for the approved CGO involves re-use of mine process water (tailings water reclaim), capture and re-use of runoff from areas within the ICDS, groundwater seepage to the open pit and groundwater sourced from the saline groundwater supply bores within Mining Lease 1535 when Lake Cowal is dry. Other external make-up water supply is provided to the site via the mine borefield pipeline and is drawn from three sources (in order of priority):

1. The eastern saline borefield.
2. The Bland Creek Palaeochannel Borefield.
3. Water extracted from the Lachlan River via the Jemalong Irrigation Channel (Figure 11) using regulated flow licences purchased by or temporarily transferred to Evolution on the open market.

The various CGO water management system components and their linkages (via system transfers) are shown in schematic form in Figure 11.

⁶ Based on data provided by Evolution to end of May 2016.

⁷ Based on data provided as part of the Modification 11 Surface Water Assessment for period from August 2006 to April 2007 (refer Gilbert & Associates, 2013).

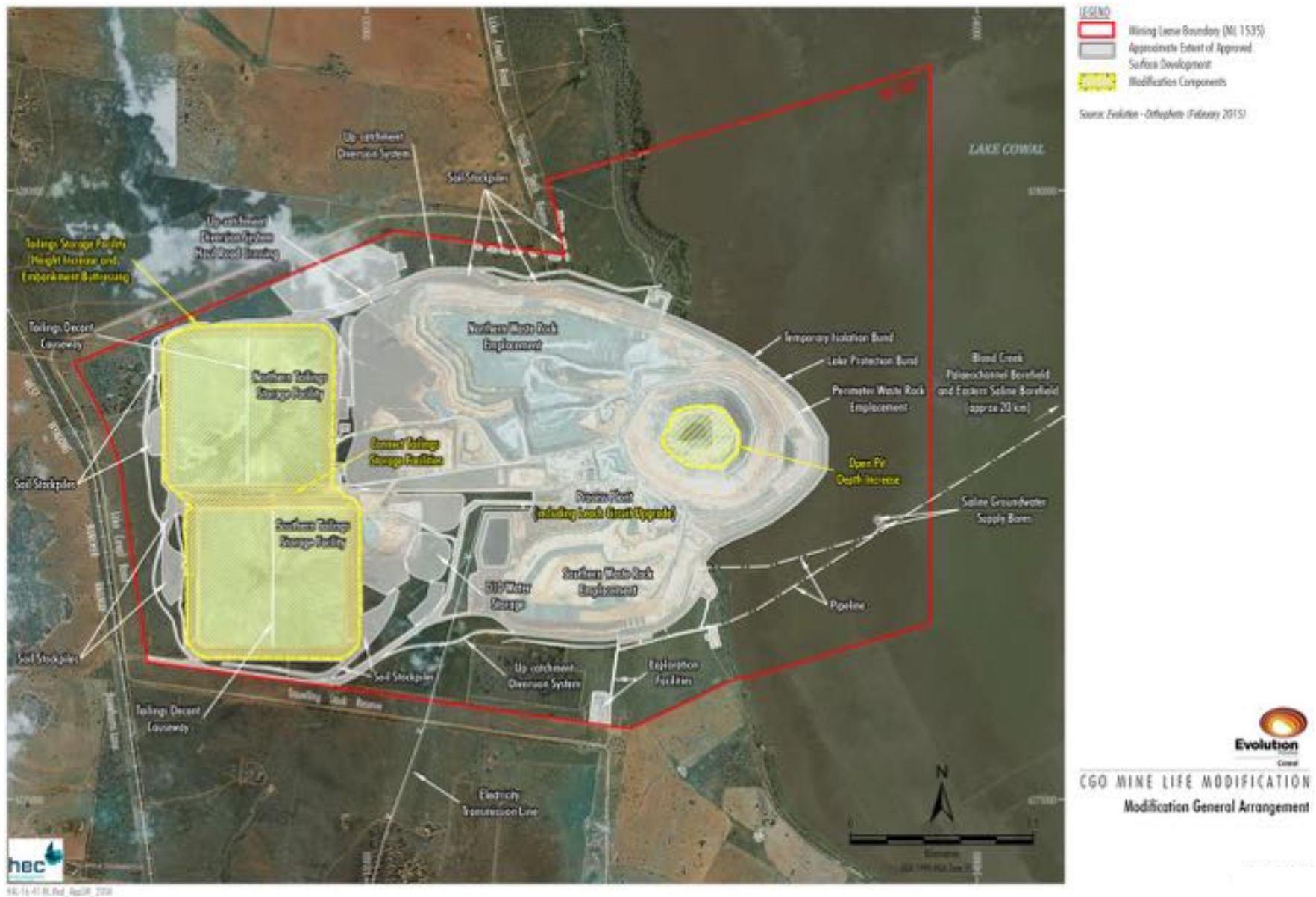


Figure 10 Modification General Arrangement

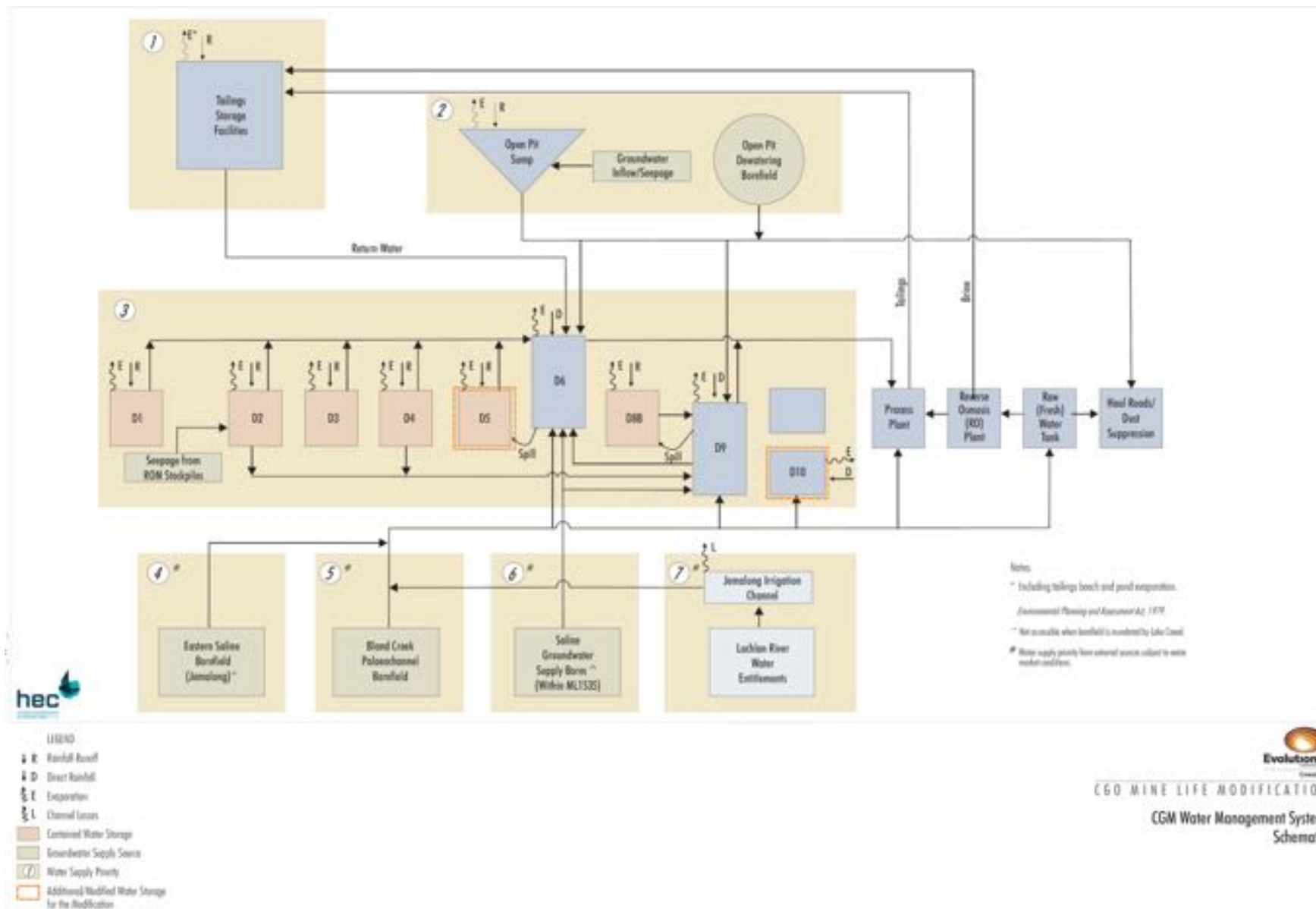


Figure 11 CGO Water Management System Schematic

3.2 CONTAINED WATER STORAGES

The ICDS comprises a series of six internal drainage catchments (each served by a contained water storage for runoff collection) and two water supply storages. Details of the catchment areas and the capacities of the contained water storages are summarised in Table 5. With the exception of D5, the contained water storages are designed to collect runoff generated from their contributing catchment during a 1% AEP rainfall event of 48 hours duration. Contained water storage D5 and water supply storages D6 and D9 are designed to contain runoff and/or incident rainfall from a 0.1% AEP rainfall event of 48 hours duration. With the exception of storages D1 and D4, all storages would (in the unlikely event) ultimately spill to the open pit. Storages D1 and D4 are equipped with pumps which facilitate dewatering of these storages such that they can be emptied in between rainfall events, as required. Runoff from the outer batters of the perimeter waste rock emplacement ponds against the Temporary Isolation Bund, which has a capacity for at least a 1% AEP rainfall event of 48 hours duration. Water that ponds in this area would be pumped to D6 (via D1 or D4) between rainfall events as required.

Table 5 Summary of Existing/Approved Internal Catchments and Contained Water Storages

Storage	Catchment/Function	Catchment Area (ha)*	Storage Capacity (ML)**
D1	Runoff from northern perimeter of the northern waste rock emplacement.	117	57
D2	Runoff/seepage from ROM pad, low grade ore stockpile and from the northern waste rock emplacement area.	335	195
D3	Runoff from perimeter catchment surrounding the open pit and the perimeter waste rock emplacement areas.	115	39
D4	Runoff from the southern perimeter of the southern waste rock emplacement.	51	69
D5	Process plant area runoff collection.	90	92
D6	Process water storage. Main source of process plant make-up.	11	10
D8B	Runoff from southern waste rock emplacement and area between southern tailings storage facility and D9.	200	43
D9	Process water storage and storage for raw water.	Incident area	726
D10 [†]	Process water storage and storage for raw water.	Incident area	1,637

ha = hectares

* Estimated from 2016 contour plans provided by Evolution.

** Calculated from as-built plans and confirmed by Evolution.

[†] Approved storage D10 is yet to be constructed.

3.3 PIT DEWATERING

Pit inflows occur via groundwater seepage and rainfall runoff from areas surrounding the open pit. The catchment area draining to the open pit varies from approximately 110 ha in 2016 up to 240 ha at the end of processing. The open pit would also be the final water containment point in the event of overflow from any of the contained water storages (except D1 and D4 which are emptied by pumping) or in the highly unlikely event of a spill from the TSFs.

A network of dewatering bores has been developed around the open pit. Pumping from these bores is directed to D3 and then to storage D6 and reduces groundwater inflows to the open pit. Inflows to the open pit accumulate in a sump in the pit floor and are pumped to storage D6.

Groundwater inflow predictions made as part of the Cowal Gold Project EIS (North Limited, 1998) were for quite high groundwater inflow rates. Significantly lower groundwater inflow rates have been encountered in practice as described in the Hydrogeological Assessment prepared by Coffey (2016a), provided in Appendix A of the EA.

3.4 WASTE ROCK EMPLACEMENT WATER MANAGEMENT

Mine waste rock from open cut mining operations is placed in three waste rock emplacement areas: the northern, southern and perimeter waste rock emplacements. The northern and southern waste rock emplacements are integral with the perimeter waste rock emplacement which is a component of the permanent lake isolation system. The outside faces of the northern and southern waste rock emplacements form part of the perimeter catchment limits of the approved CGO. The northern waste rock emplacement is the largest of the emplacement areas.

Runoff from the external face of the northern waste rock emplacement reports to the external contained water storage D1 which has been constructed below the external (north-eastern) toe of the northern waste rock emplacement area and is dewatered by pumping to storage D6.

Runoff from the external face of the southern waste rock emplacement reports to the external contained water storage D4 which has been constructed below the external (south-eastern) toe of the southern waste rock emplacement area and is dewatered by pumping to storage D6 or D9.

Runoff from the perimeter waste rock emplacement area would report to the storage which forms between the toe of the perimeter waste rock emplacement and the Temporary Isolation Bund. Water that accumulates in this storage would be returned to D6 as required.

3.5 TAILINGS STORAGE FACILITY WATER MANAGEMENT

Tailings material is deposited into the two TSFs (i.e. northern tailings storage facility and southern tailings storage facility) as a slurry, normally under sub-aerial conditions. The TSFs comprise confining embankments raised above the surrounding natural surface and, as such, their catchment area comprises only the area inside the confining embankments – estimated to be approximately 148 ha for the northern tailings storage facility and 139 ha for the southern tailings storage facility⁸. Tailings are discharged to only one TSF at any one time. Once the tailings level has risen to its design level, discharge is switched to the other TSF while the confining embankment of the first TSF is raised.

In general, tailings are deposited through a 400 mm nominal diameter polyethylene pipeline which runs from the process plant to the TSFs and around their perimeter embankments. There are spigots (smaller pipe sections) exiting from the deposition pipeline around the circumference of each TSF which deposit tailings around the perimeter of the inside of the TSF. Within each spigot is a gate valve which is used to alternate the locations of the deposition, allowing for intermittent drying times of the deposited tailings and for a consistent tailings beach height around the perimeter of the operational TSF. Tailings are discharged around the perimeter of the TSF and solids settle as they flow towards each TSF. Rainfall runoff and free water liberated during settling and consolidation of the tailings (termed 'bleed' water) accumulate in an internal (central) decant pond within each TSF. Water from the decant pond of the inactive TSF may be pumped to the active TSF. Water from the decant pond of the active TSF is pumped to storage D6 for re-use in the process plant. The TSFs have been designed to maintain a minimum freeboard sufficient to store at least the contingency 0.1% AEP rainfall event at all times⁹.

⁸ Estimated from 2016 contour plan provided by Evolution.

⁹ 1:1,000 AEP rainfall is calculated using procedures described in Institution of Engineers Australia (1998) by interpolation in between the 1:100 AEP rainfall and the probable maximum precipitation (PMP). The 1:100 AEP rainfall is obtained from the BoM. The PMP is calculated using methods published by BoM (2003).

4.0 FUTURE CGO WATER MANAGEMENT AND WATER SUPPLY

4.1 WATER MANAGEMENT

4.1.1 Staged Future Development

The future development of the CGO surface facilities is shown in a series of stage plans (Figure 12 to Figure 14) showing the layout of surface facilities and drainage at 2018, 2022 and the end of mining. As there is no change to the UCDS and ICDS, there is no change to catchment excised by the Modification that would otherwise report to Lake Cowal.

By 2018 (Figure 12) the northern waste rock emplacement would have expanded westwards towards the northern tailings storage facility. Topsoil recovered from the foundation of the northern waste rock emplacement would have already been placed in stockpiles west of the northern waste rock emplacement within the ICDS and in a stockpile located in the north of Mining Lease 1535 (Figure 12). Prior to placement of this topsoil material in the stockpile in the north of Mining Lease 1535, upslope runoff would be directed around the stockpile area via a system of diversion drains/bunds. Runoff from the topsoil stockpile area itself would be directed to a sediment basin constructed at the eastern boundary of the stockpile area. The upslope stockpile diversions and the sediment basin would be constructed and maintained in accordance with the guidelines in Landcom (2004) and DECCW (2008). A haul road would be constructed from the foundation of the northern waste rock emplacement to the topsoil stockpile across the UCDS. The UCDS crossing would be constructed to maintain the existing capacity of the UCDS.

During 2018 the southern waste rock emplacement would have expanded slightly with both waste rock emplacements increasing in elevation (to 298 m Australian Height Datum [AHD] [north] and 283 m AHD [south]). Drainage would be constructed between the northern tailings storage facility and the northern waste rock emplacement to direct runoff to contained water storage D2, limiting the catchment reporting to D1. The low grade ore stockpile north-east of D2 would have been developed further. Rehabilitation would have advanced around the perimeters of the waste rock emplacements. The open pit extent would have increased slightly and, as a result, D5 would have been relocated to D5a, which would be constructed with adequate capacity to capture all runoff generated from its contributing catchment during a 0.1% AEP rainfall event of 48 hours duration.

By 2022 (Figure 13) the northern waste rock emplacement would have changed in elevation (to 278 m AHD) and reached its full plan extent. Rehabilitation would have progressed further around the batters of the waste rock emplacements. The low grade ore stockpile would be developed to its full height (288 m AHD). Finally storage D10 (new raw water storage) would be constructed east of the southern tailings storage facility (refer Section 3.2) with topsoil recovered from its foundation stockpiled in two areas adjacent.

Toward the end of the mine life (Figure 14) the waste rock emplacements would have been completed to their maximum elevation and rehabilitation works would have been well advanced (refer also Section 6.0).

Runoff from waste rock emplacements would continue to be directed to contained water storages. A geochemical assessment has been prepared for the Modification by Geo-Environmental Management (2016) (Appendix C of the EA). The assessment report states that:

Because the waste rock, pit wall rock, low grade ore, ROM ore and tailings are expected to be relatively geochemically similar to those from the current pit configuration no changes to the site water quality monitoring programs for the pit, waste rock emplacements, low grade ore stockpile, ROM ore stockpile, and tailings storage facilities are expected to be necessary.

However, it is recommended that these programs be reviewed on an annual basis, and modified as necessary, in order to maintain and rationalise these programs.

4.1.2 Tailings Storage Facilities

Development of the TSFs would continue through the remaining mine life. Tailings discharge would be cycled with discharge planned to occur to one TSF for approximately one year and then to the other TSF for approximately one year and so on. Embankment raising (lifts) would occur on each TSF while it was inactive. Water for use in embankment construction (for earthfill conditioning and dust suppression) would be sourced from storage D9 or D10. Water reclaim from the decant pond of the active TSF to storage D6 would continue to occur, with any accumulated rainfall runoff water in the inactive TSF pumped to the active TSF.

In general the TSF embankment lifts will be constructed in conjunction with the required buttressing on the lift being constructed, although TSF buttressing is generally begun just prior to lift construction. The sequencing of buttress construction and size of buttressing requirements are consistently under review for the life of mine design. In approximately 2020 the centre area between the two TSFs will be joined by an embankment linking the eastern and western embankments in order to utilise the centre area for storage of tailings (refer Figure 13). It is expected that the deposition of the tailings within the centre area will occur in a similar fashion to the deposition along the embankments of the current facilities, utilising spigots spread along the linking embankment depositing tailings approximately every 60 m. Detailed designs are developed every year for the construction of the TSF lifts and designs are monitored and closely adhered to.

For each lift, drainage pipelines are constructed around the perimeter of the embankments connecting into the working layer of previous lifts. This aids in the dewatering of the tailings against the TSF embankments and increases stability. The water from these drains is collected and pumped to the centre decant well of the operational TSF for return to the processing plant. This design is also constantly under review and improvement throughout the life of the TSFs.

Evolution have indicated that it is expected that there will be approximately a 10% reduction in the rate of recovery of water from settling and consolidation of tailings within the TSFs during the period of initial deposition into the centre area between the two TSFs. This is scheduled for the period between August 2021 and approximately March 2023.

4.2 WATER SUPPLY

4.2.1 General

The main water demand for CGO would continue to be the requirements of the process plant as well as dust suppression (e.g. haul roads) and other potable and non-potable uses. Proposed future ore processing at CGO is summarised as follows:

- The primary ore processing rate would be maintained between 7.2 to 7.5 Mtpa from 2016 to 2019.
- In January 2020, a campaign of oxide ore processing would commence for approximately 6 months (to early July 2020) with approximately 3.8 million tonnes (Mt) of oxide ore planned to be processed.

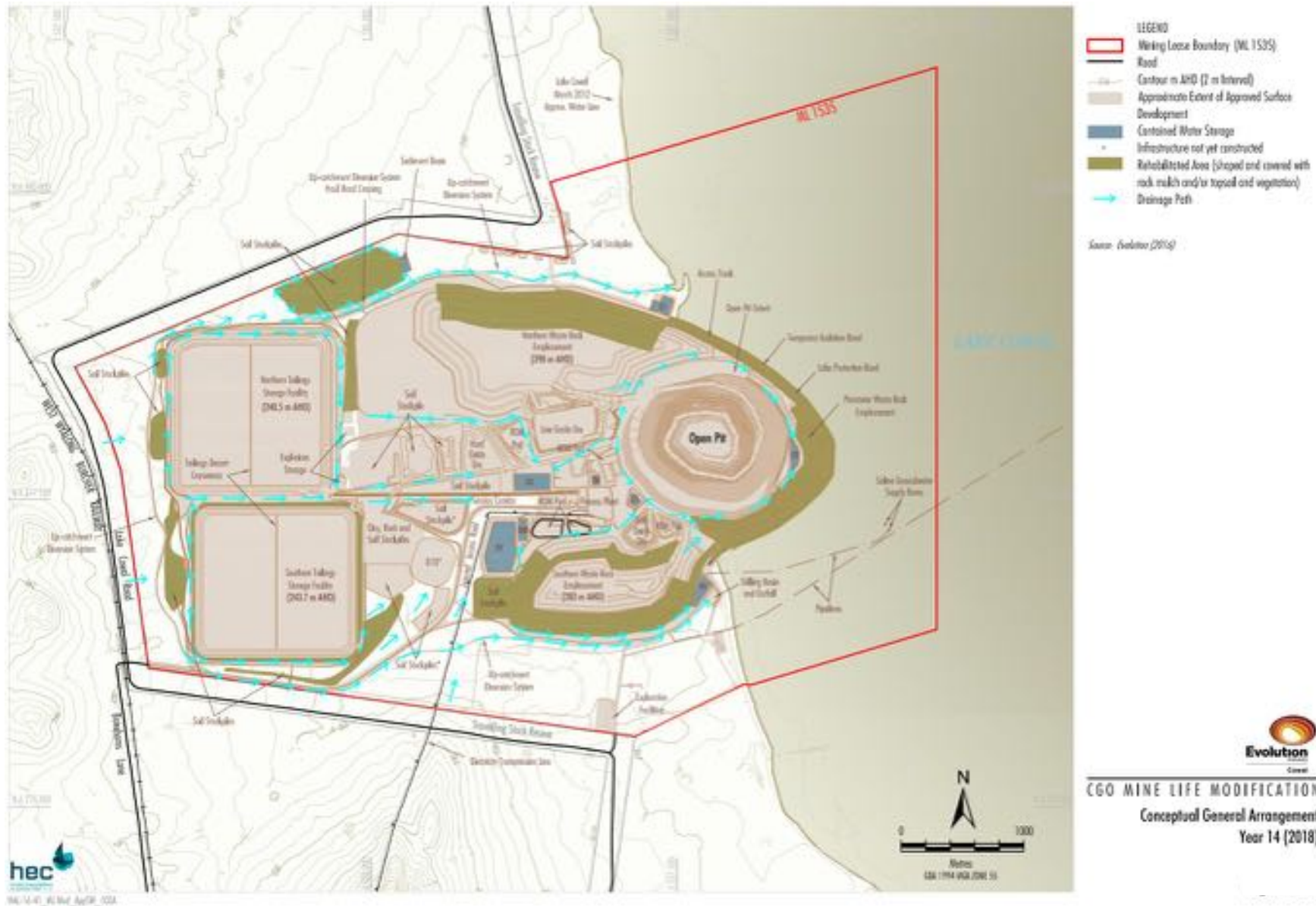


Figure 12 Conceptual General Arrangement Year 14 (2018)

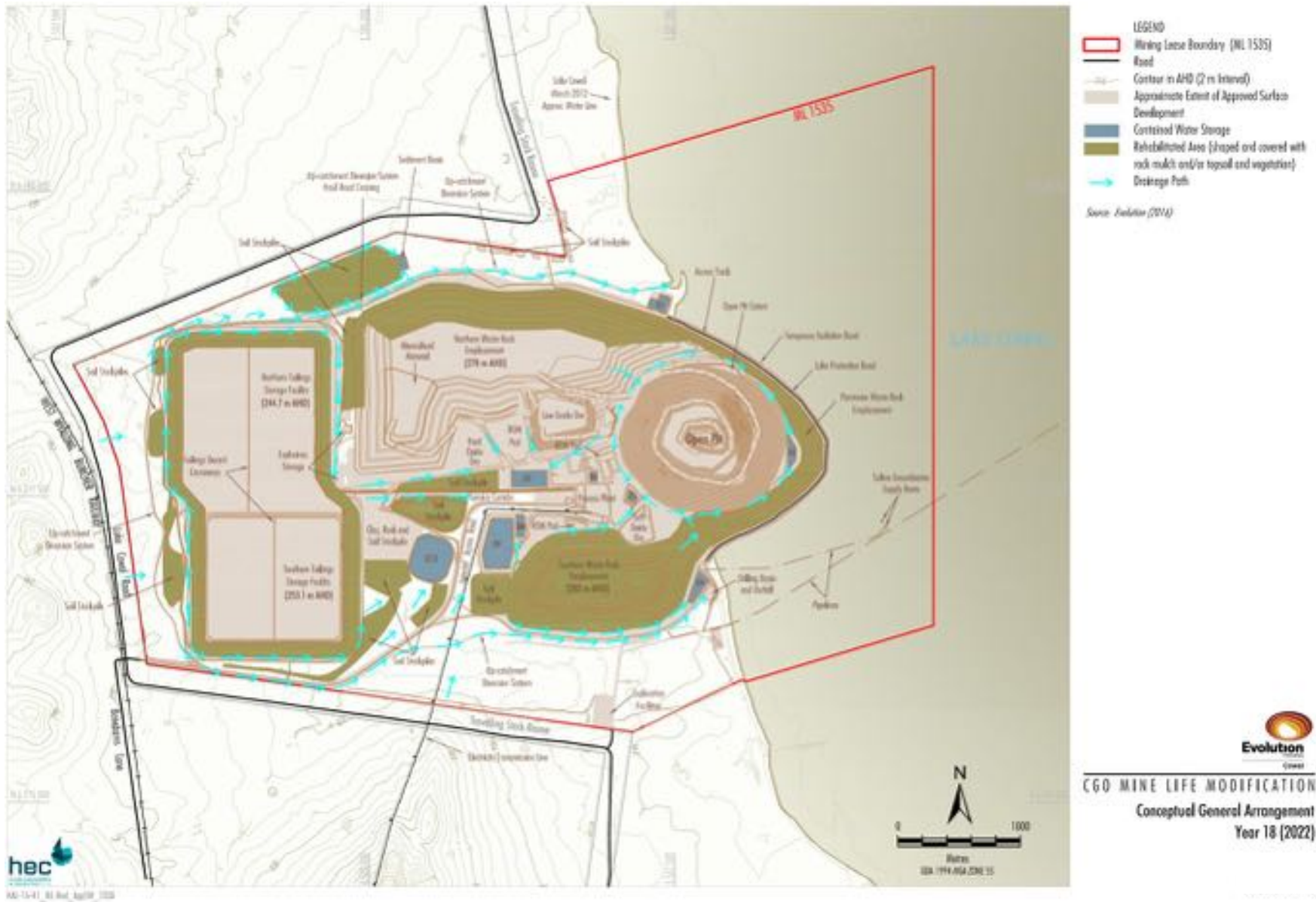


Figure 13 Conceptual General Arrangement Year 18 (2022)

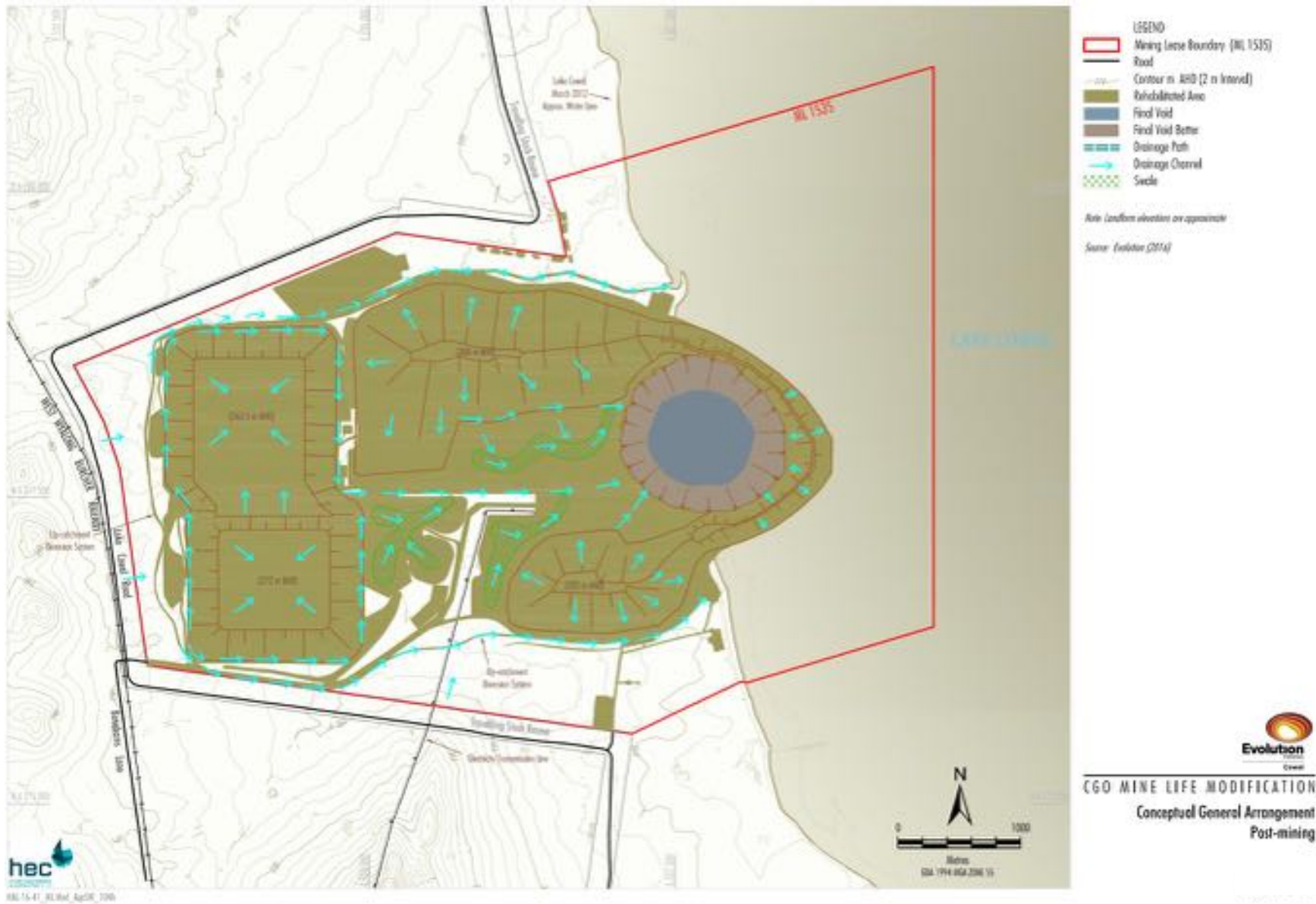


Figure 14 Conceptual General Arrangement Post-Mining

- Processing of primary ore would then resume in July 2020 until September 2030 at a rate between 7.3 Mtpa and 7.5 Mtpa.
- A second campaign of oxide ore processing would then occur for approximately 20 months starting in September 2030 and ending in April 2032, with 12.1 Mt planned to be processed.

It is estimated that the average process plant demand (total) at the above processing rates would be 18.8 ML/day for primary ore processing, while the average water demand (total) for oxide ore processing would be 35.5 ML/day (refer Section 5.0).

Water supply would continue to be sourced primarily from on-site sources, with make-up from external water supply sources. The order of priority of water supply sources would be:

1. Reclaim from the TSF decant ponds.
2. Pumping from the open pit dewatering bores and sump.
3. Water from contained water storages (transferred to either storage D6 or D9 as indicated on Figure 12).
4. Groundwater from the eastern saline borefield via the mine borefield pipeline.
5. Groundwater from the Bland Creek Palaeochannel borefield via the mine borefield pipeline (consistent with existing licensed limits – refer Section 4.2.4).
6. Groundwater from the saline groundwater bores located with Mining Lease 1535 when lake conditions allow.
7. Water accessed from the Lachlan River via the Jemalong Irrigation Channel using regulated flow licences purchased by Evolution on the open market.

In order to maintain a secure water supply during the oxide ore (higher water demand) processing campaigns, Evolution will augment the CGO water supply system by:

- A. Construction of the approved process water storage D10 with a design capacity of 1,637 ML.
- B. Increasing the capacity of the external water supply pipeline (across Lake Cowal, supplying water from sources 4, 5 and 7 above) from 11 ML/day to 14 ML/day (as previously approved).

The increased water supply pipeline capacity and storage D10 construction would be commissioned by 1 October 2019 (i.e. three months ahead of the first planned oxide ore processing campaign). Note that both these works were approved as part of Modification 11 (refer Section 1.3) – only the timing of their implementation has changed as part of the current Modification.

Storage D10 would effectively act as an enlarged storage D9, with water shared between the storages and used to provide make-up supply to the process plant. The proposed system would be managed such that storages D9 and D10 were as full as possible at the start of the oxide ore processing campaigns (supplied by on-site sources and the increased capacity of the external water supply pipeline). Water balance modelling of the proposed system (Section 5.0) indicates that storages D9 and D10 may draw down during the oxide ore processing campaigns but would be replenished upon resumption of primary ore processing.

The increased capacity of the external pipeline will include construction of the approved eastern pump station located outside the bounds of the Lake Cowal inundation limits and away from drainage paths. The approved pumping station will be located in a secure fenced area served by a graded road on the eastern side of Lake Cowal (Figure 15). The approved access road will be designed to provide “all weather” access to the pumping station.

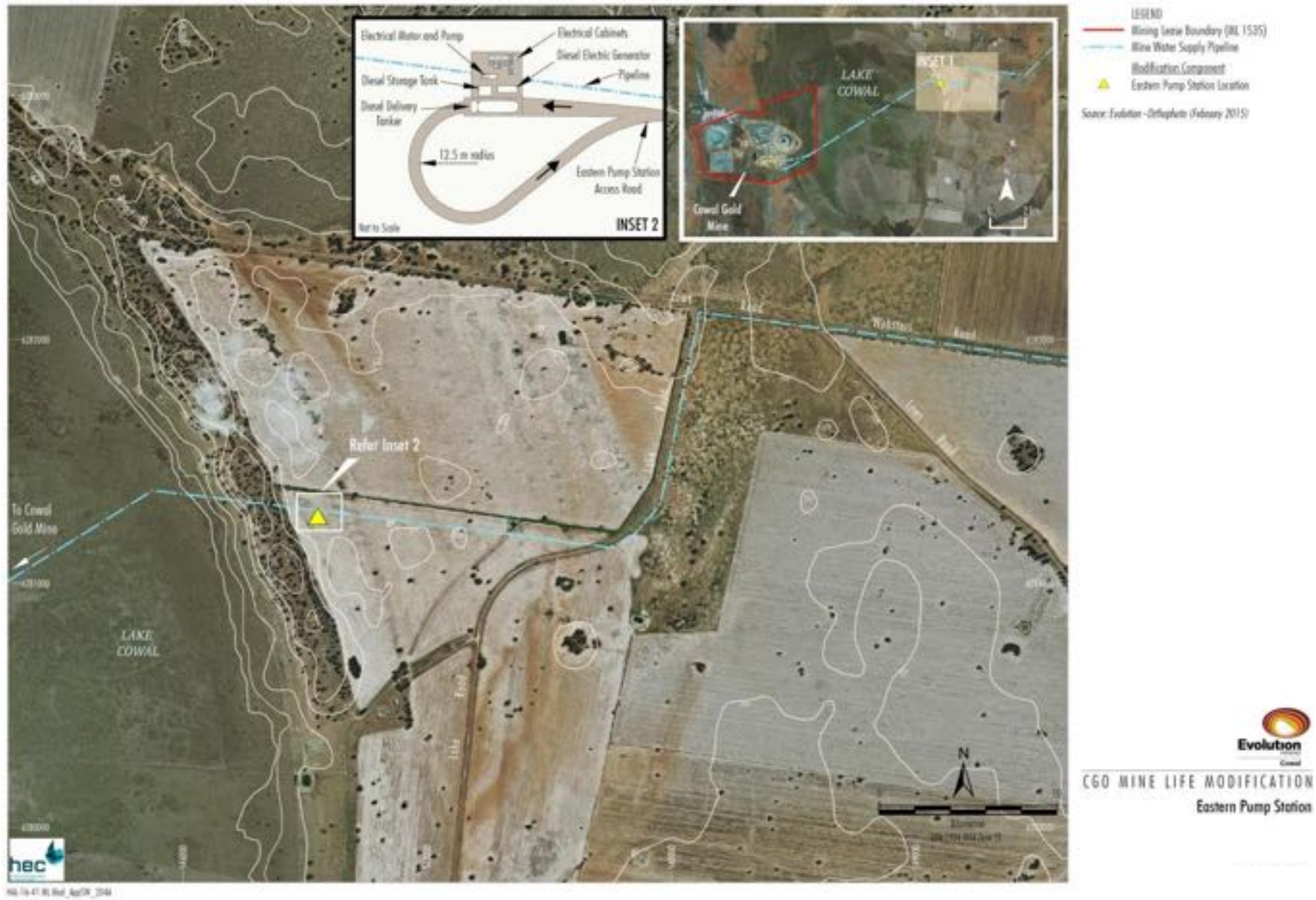


Figure 15 Eastern Pump Station

4.2.2 Saline Groundwater Supply Bores

The saline groundwater supply bores are located within Mining Lease 1535 to the south-east of the open pit (Figure 10). Continued operation of the existing saline groundwater supply bores is proposed for the mine life, although the planned priority of sourcing from these bores has been lowered – refer Section 4.2.1.

Pumping tests (Coffey, 2009) indicate that a borefield of approximately four bores could supply up to 1 ML/day of saline water (with an EC of approximately 40,000 $\mu\text{S}/\text{cm}$) from the saline groundwater supply bores for use in the process plant. During periods when Lake Cowal is inundated, the bores would be shut-down and capped. Therefore the bores would operate in drier times and be rested in wetter times. At various times during the mine life, the saline groundwater supply bores would continue to reduce demand on the other external water supply sources.

4.2.3 Eastern Saline Borefield

The eastern saline borefield is located approximately 10 km east of Lake Cowal's eastern shoreline (Figure 2). Pump tests (Groundwater Consulting Services, 2010) indicated that two bores could supply approximately 1.5 ML/day of saline water (with an EC of approximately 12,000 $\mu\text{S}/\text{cm}$). Average extraction since commissioning of the borefield has been approximately 0.4 ML/day (Coffey, 2016b). The borefield is currently approved for the life of the mine.

4.2.4 Bland Creek Palaeochannel Borefield

Extraction from the Bland Creek Palaeochannel Borefield (Bores 1 to 4) would continue for the mine life.

Groundwater extraction from the Bland Creek Palaeochannel borefield is limited by daily and annual licensed volumetric limits, as follows:

- maximum daily rate: 15 ML/day; and
- maximum annual extraction: 3,650 ML.

Extraction would be managed to maintain groundwater levels above established DPI Water trigger levels.

Although Coffey (2016b) have modelled continuous extraction of 5.1 ML/day (note: combined between the eastern saline borefield and the Bland Creek Palaeochannel Borefield) as being sustainable with respect to maintaining groundwater levels above the DPI Water trigger levels, it is intended that sourcing water from this borefield would continue in a similar manner as occurs currently, by alternating between this source and the Lachlan River to manage groundwater levels and provide flexibility with respect to extraction rates and the availability of temporary water in the Lachlan River during “good” years.

4.2.5 Lachlan River

The proposed external water supply arrangements for the remaining mine life involve continued purchase of temporary water from the Lachlan River regulated source. CGO's high security and general security zero allocation water access licences enable trade of temporary water.

This supply source has proven to be reliable throughout the operating history of the approved CGO – Table 6 summarises annual extraction volumes, from records supplied by Evolution. In 2016, up to 31 July, 135 ML had been extracted.

Table 6 Annual CGO Lachlan River Extraction Volumes

Year	Approximate Volume (ML)
2007	2,400
2008	1,980
2009	1,600
2010	0
2011	857
2012	438
2013	1,113
2014	1,841
2015	1,661
2016	135*

ML = megalitres

* To 31 July 2016.

DPI Water trading records show that between approximately 4,000 ML and 274,000 ML of temporary water has been traded annually in the Lachlan River Regulated Water Source since records began in the 2004 to 2005 season. All general security accounts were reset on 8 March 2012 to 136 per cent following the first spill of Wyangala Dam since December 2000. From 1 July 2011 to 1 July 2015, the available water determinations (AWDs) were zero but since then has ranged from 4% on 7 August 2015, 16% on 2 September 2015, 5% on 2 October 2015, 18% on 1 July 2016, and 25% on 15 July 2016. As at 5 September 2016¹⁰, AWDs for general security accounts were 9%, with high security accounts at 100%. DPI Water will continue to closely monitor rainfall and river inflows as well as usage in the valley to determine when subsequent changes to AWDs are made. As at 3rd October 2016, Wyangala Dam reservoir was at 98% of capacity¹¹.

Future water supply requirements (from external water sources and ultimately licensed extraction from the Lachlan River) have been estimated using a water balance model (refer Section 5.0). The median predicted annual demand from the Lachlan River during the primary ore processing phase peaks at approximately 1,909 ML in 2021 following the planned 2020 oxide ore processing campaign, while the median predicted annual demand overall peaks in 2020 at 2,854 ML as a result of the oxide ore processing. In relation to the projected CGO requirements during the Modification, it appears that there has in previous years been adequate temporary water available on the market from this source (Table 6).

¹⁰ NSW Water Register (DPI Water, 2016) <http://www.water.nsw.gov.au/water-licensing/registers>

¹¹ Refer <http://realtimedata.water.nsw.gov.au/water.stm>

5.0 SIMULATED PERFORMANCE OF WATER MANAGEMENT SYSTEM

The ability of the water management system to achieve its operational objectives was assessed by simulating the dynamic behaviour of its water balance over the remaining mine life (from the start of August 2016) under a range of different climatic conditions that may be encountered. A water balance model of the CGO water management system has been developed to simulate its behaviour. The model structure is generally as per the schematic in Figure 11, with planned new process water storage D10 modelled as an expansion to D9 from October 2019 onwards (refer Section 4.2.1).

The structure of this section is as follows:

- A description of the model structure, set-up data and assumptions (Section 5.1).
- Details of model predictions for the remaining mine life (Section 5.2).
- A qualitative assessment of the possible effects of climate change on model results (Section 5.3).

5.1 MODEL DESCRIPTION

5.1.1 General

The water balance model developed for CGO simulates all the inflows, outflows, transfers and changes in storage of water on-site at each model time step (i.e. 4-hourly basis). The model simulates changes in stored volumes of water in all site storages (contained water storages, TSFs and open pit) in response to inflows (rainfall runoff, groundwater inflow, tailings water, groundwater bore extraction and licensed extraction from the Lachlan River) and outflows (evaporation, process plant use and dust suppression use).

For each storage, the model simulates:

$$\text{Change in Storage} = \text{Inflow} - \text{Outflow}$$

Where:

Inflow includes rainfall runoff, groundwater inflows to the open pit, water liberated from settling tailings (termed 'bleed' water – for the northern tailings storage facility and southern tailings storage facility) and all pumped inflows from other storages, groundwater bores or the Lachlan River (via the Jemalong irrigation channel).

Outflow includes evaporation and all pumped outflows to other storages or to a water use¹².

Runoff from all mine areas is modelled as reporting to one of the contained water storages or the open pit. Pumping rates between model storages were set based on information consistent with that provided for the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013).

The main water use at CGO is for supply to the Process Plant. As indicated in Section 4.2.1, a priority system is in use (and was modelled) for supply to contained water storage D6 (the main supply source for the Process Plant). Supply is first drawn from the TSFs (return water), the open pit (including the dewatering bores) and contained water storages. Make-up supply is then sourced (to top-up storages D6 and D9/D10) from the three water supply borefields (refer Section 4.2.1). Ultimate make-up supply is then drawn from Lachlan River water entitlements. Lachlan River water is sourced via the Jemalong Irrigation channel – a channel loss rate of 1.3 ML/day was assumed based on information provided as part of the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013). The model was used to assess the future make up water supply requirements under the range of model conditions simulated.

¹² The model also provides for spill if the simulated storage capacity of a water storage is ever exceeded.

Contained water storages D1 and D4 (which capture runoff from waste rock emplacement areas) are reliant upon pumping to transfer accumulated water to the remainder of the ICDS. Pump extraction rates assumed in the model are summarised in Table 7.

Table 7 Modelled Pump Rates

From	To	Modelled Pump Rate (L/s)
D1	D6	100
D4	D6	85
D4	D9	20
D5	D6	83
D2	D6	93
D2	D9	93
D3	D6	50
D8B	D9	93
TSF Reclaim	D6	180*
Open Cut Sump	D6 or D9/D10	23

L/s = litres per second

* Rate assumed doubled during oxide ore processing periods.

Whilst not simulated in the model, runoff from the outer batter of the perimeter waste rock emplacement (which collects between the Lake Protection Bund and Temporary Isolation Bund) would be pumped back to D6 (via D1 or D4). In the model this was dewatered by pumping to either storages D6 or D9 as a priority, even if this led to spill of storages D6 or D9 (which spill internally within the ICDS – ultimately reporting to the open pit).

5.1.2 Climatic Data

A total of 127 years of daily rainfall and pan evaporation data (from 1889 to 2015) used in the model was sourced from the SILO Data Drill¹³. The Data Drill rainfall data was compared with the CGO rainfall data record (for the period from 2002 to July 2016) and found to be well correlated – refer Figure 16 which shows a plot of monthly rainfall totals from the CGO record versus monthly rainfall totals from Data Drill.

¹³ The Data Drill is a system which provides synthetic data sets for a specified point by interpolation between surrounding point records held by the BoM. Refer <https://www.longpaddock.qld.gov.au/silo/datadrill/>.

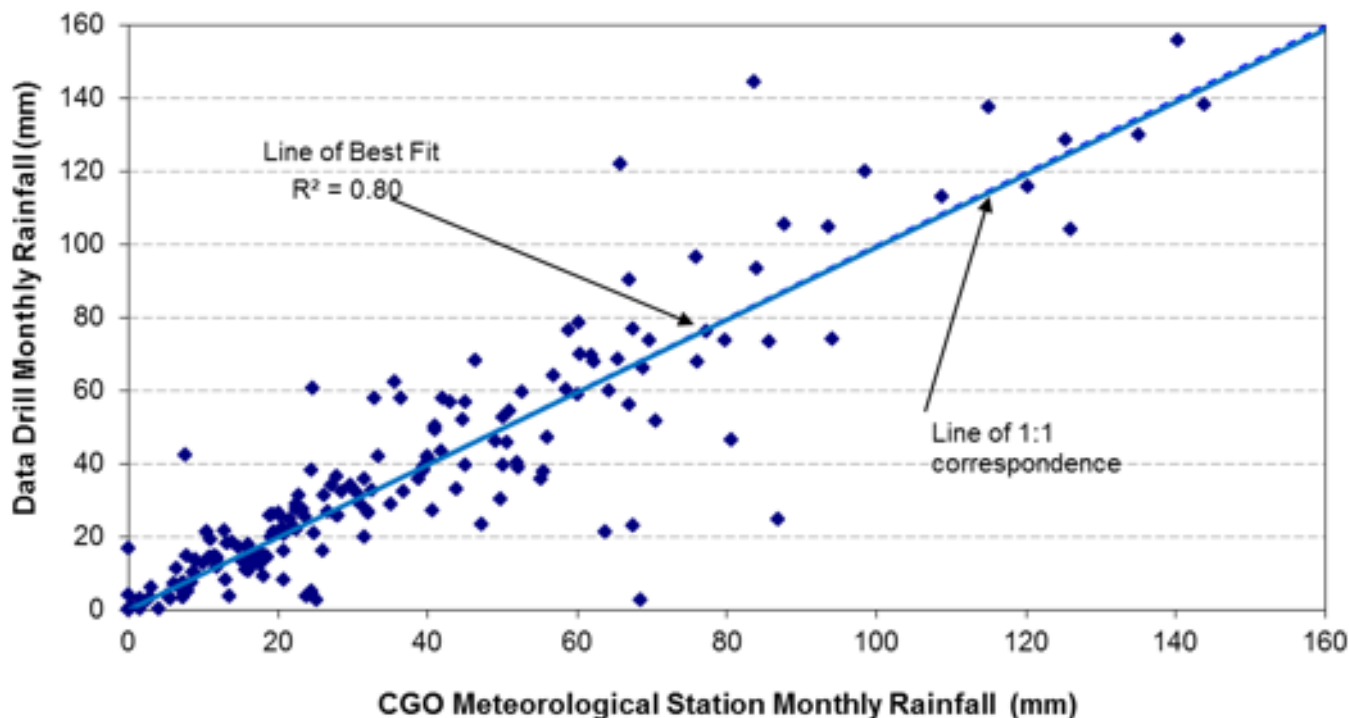


Figure 16 Monthly Rainfall Comparison – CGO Meteorological Station and Data Drill

Monthly pan evaporation factors (to convert pan evaporation to estimates of open water evaporation) were obtained from pan factors given in McMahon *et al.* (2013) for the nearest available location (Table 8).

Table 8 Seasonal Evaporation Pan Factors

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wagga Wagga AMO Pan Factor*	0.81	0.81	0.81	0.86	0.94	0.98	1.07	1.10	1.05	0.99	0.89	0.84

* From McMahon *et al.* (2013), located approximately 160 km south of CGO.

The model was run repeatedly, simulating 127 possible mine life “sequences”, each approximately 16 years in length (corresponding to the remaining mine life). The sequences were formed by moving along the Data Drill record one year at a time with the first sequence comprising the first 16 years in the record, the second sequence years 2 to 17 in the record while the third sequence comprised years 3 to 18 and so on. The start and end of the Data Drill record was ‘linked’ so that additional sequences, which included years from both the beginning and end of the historical record, were combined to generate additional climatic sequences. Using this methodology 127, 16-year sequences of daily rainfall and evaporation were formulated for use in the model simulations. CGO recorded daily rainfall data was used from November 2006 onwards¹⁴ instead of the Data Drill.

5.1.3 Runoff Simulation

The Australian Water Balance Model (AWBM) (Boughton, 2004) was used to simulate runoff from rainfall on the various catchments and landforms across the CGO area. The AWBM is a nationally-recognised catchment-scale water balance model that estimates streamflow from rainfall and evaporation. Modelling of the following six different sub-catchment types was undertaken:

- natural surface/undisturbed;

¹⁴Date of commencement of automatic weather station operation.

- waste rock emplacements;
- rehabilitated areas;
- hardstand;
- open pit; and
- tailings.

AWBM parameters for undisturbed areas were taken from model calibrations undertaken for a regional stream¹⁵. The rainfall-runoff model was calibrated as part of the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013). Table 9 gives the AWBM parameters used in the model.

Table 9 Water Balance Model AWBM Parameters

Parameter	Natural Surface	Waste Rock	Rehabilitated Areas	Hardstand	Open Pit	Tailings
C ₁ (mm)	10	5	21	2	5	0
C ₂ (mm)	101.3	75	56	6	15	50
C ₃ (mm)	202.7	-	120	-	-	-
A ₁	0.234	0.4	0.13	0.5	0.34	0.07
A ₂	0.333	0.6	0.43	0.5	0.66	0.93
A ₃	0.433	-	0.44	-	-	-
BFI	0.21	0.4	0.2	0.0	0.1	0.0
K _{base} (day ⁻¹)	0.806	0.97	0.92	-	0.9	-
K _{surf} (day ⁻¹)	0.5	0.2	0.2	0.1	0.1	0.2

Note: An evapotranspiration factor of 0.85 was used in the model as recommended by Boughton (2006).

5.1.4 Groundwater Inflow and Borefield Supplies

Groundwater inflow to the open pit was set to a time-varying rate as predicted by groundwater modelling (Appendix A of the EA). Figure 17 summarises the predicted inflow rate. Dewatering bore extraction was set to zero on the basis that the predicted groundwater inflows are understood to represent total groundwater inflows to the open pit.

The maximum pumped rate from the saline groundwater supply bores within Mining Lease 1535 was set to 0.7 ML/day (equivalent to 1 ML/day for 5 days/week). These bores are only available as a water source when the water level in Lake Cowal is low enough to allow access. Rather than simulating the water level in Lake Cowal as part of the water balance model, the availability of these bores was approximated by comparing the annual rainfall total for the given model year against long term median annual rainfall – if the annual rainfall in any simulated year was above the long term median, the bores were assumed unavailable.

The maximum pumped rate from the eastern saline borefield was set to 1.5 ML/day and these bores were assumed available for the duration of the mine life (refer Section 4.2.3).

Extraction from the Bland Creek Palaeochannel bores was controlled according to the following approved limits (refer Section 4.2.4):

- A maximum daily extraction rate of 15 ML/day.
- A maximum annual extraction rate of 3,650 ML.

¹⁵GS410048 - Kyeamba Creek at Ladysmith.

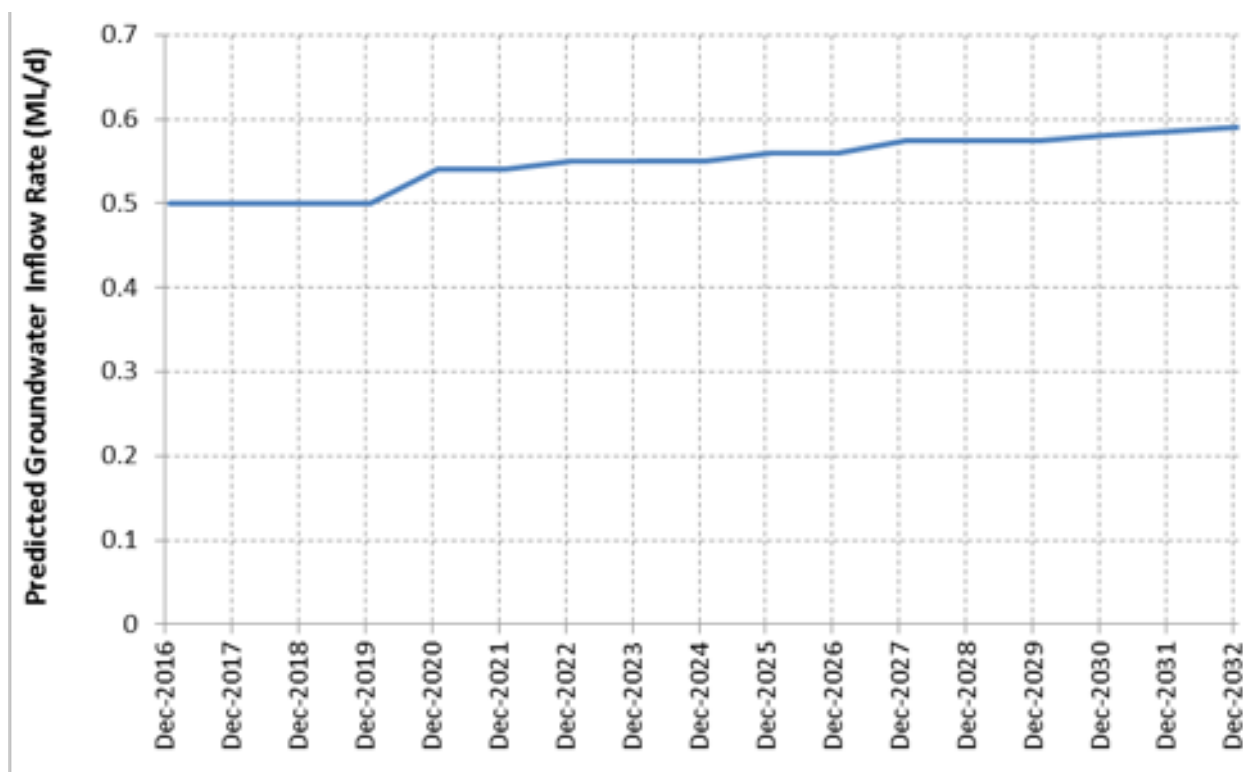


Figure 17 Predicted Open Pit Groundwater Inflow Rate

For modelling purposes, the latter annual volume was converted to a daily rate of 10 ML/day and used as the maximum daily extraction rate.

Supply via the mine borefield pipeline (i.e. Bland Creek Palaeochannel Borefield, eastern saline borefield and Lachlan River water entitlements) to storages D9/D10 is limited to 14 ML/day maximum rate (refer Section 4.2.1).

5.1.5 CGO Water Demands

The process plant make-up water demand (total) is required to replace water pumped to the TSFs with process tailings. Process plant water demand (total) was based on projected future processing tonnages (refer Section 4.2.1) and an assumed tailings solids concentration of 52% (based on the average tailings solids concentration monitored for the 2 years to December 2010¹⁶) for primary ore (note recent data provided by Evolution is consistent with this assumed tailings solids concentration). For oxide ore (planned to be processed in two campaigns – refer Section 4.2.1), the tailings solids concentration was set at 37% (based on monitored data from the initial oxide ore processing phase undertaken in 2006/2007). The calculated average process plant water demands (total) were 18.8 ML/day for primary ore and 35.5 ML/day for oxide ore.

A portion of process plant make-up water is required to be of high quality (low salinity water). This water is used in areas such as the semi-autogenous grinding mill and ball mill cooling towers, carbon elution circuit and scientific instrumentation. This water is produced from a reverse osmosis (RO) plant at CGO. The RO plant is fed by water from external water supplies only (Bland Creek Palaeochannel borefield, eastern saline borefield and Lachlan River water entitlements) and brine from the RO plant is discharged to the TSFs. The modelled RO plant demand was set at 0.15 ML/day consistent with data supplied for the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013).

¹⁶Data provided for the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013).

Demand for haul road dust suppression water was set to an average 0.63 ML/day, varying seasonally from 0.20 ML/day up to 1.06 ML/day, based on monitored data provided by Evolution. Dust suppression demand was set to zero on days with 10 mm of rain or more.

Water is also required for TSF embankment construction works which would be on-going throughout the mine life. A constant demand rate of 0.25 ML/day was set in the model for this purpose (drawn from contained water storage D9/D10).

5.2 SIMULATED FUTURE PERFORMANCE

The calibrated model was used to simulate the likely performance of the water management system over the simulated 127 climatic sequences. The model was run commencing at 1 August 2016 with storage volumes and mine conditions as they were at that date (based on data supplied by Evolution). The simulation was run until 20 April 2032 (simulated end of processing operations), with the following parameters set (refer Section 4.2.1):

- Borefield pipeline capacity 14 ML/day at 100% availability from 1 October 2019 (11 ML/day prior to this date).
- Oxide tailings bleed reduction = 2% (per model calibration – refer Modification 11 Surface Water Assessment – Gilbert & Associates [2013]).
- Bland Creek Palaeochannel Borefield daily extraction rate limited to 10 ML/day¹⁷.
- No limit on extraction from Lachlan River entitlements. If borefield supplies are inadequate to meet the demands for water importation to CGO, water is sourced from the Lachlan River and is limited only by the capacity of the borefield pipeline (i.e. 14 ML/day).

Model results are presented in the sub-sections below.

5.2.1 Overall Water Balance

Figure 18 summarises model predicted system inflows and outflows for the remaining mine life averaged over all climatic sequences.

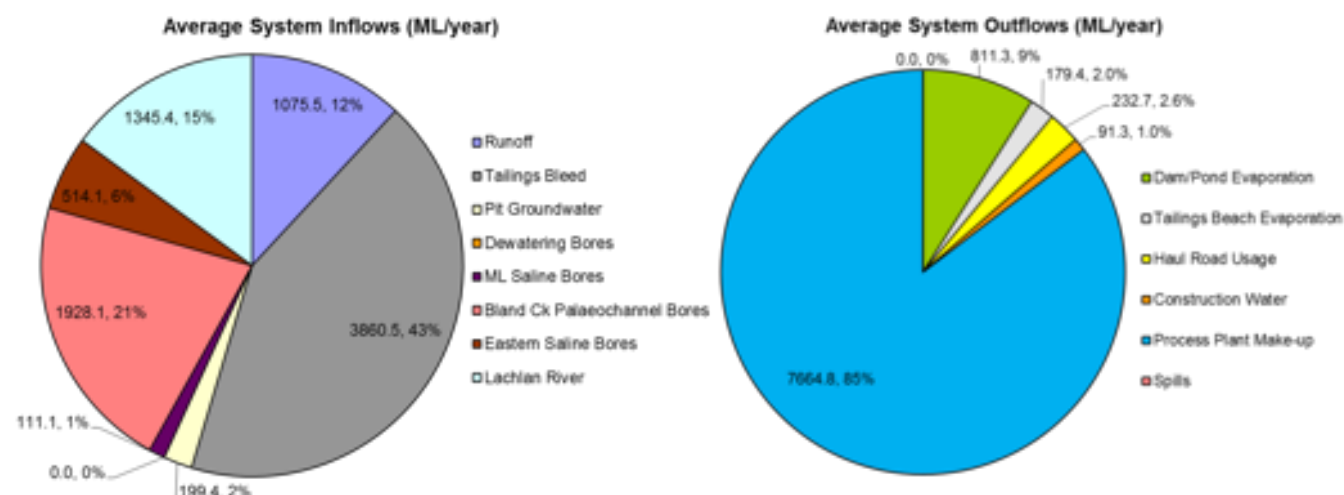


Figure 18 Average Modelled System Inflows and Outflows

¹⁷ Long-term average remained below the 5.1 ML/day modelled in the Hydrogeological Assessment (Coffey, 2016b).

Predicted total inflows average 9,043 ML/year while outflows average 8,979 ML/year.

Note that model results show an average of 1,928 ML/year would be sourced from the Bland Creek Palaeochannel Bores which is equivalent to 5.28 ML/day. This is above the long-term average of 5.1 ML/d predicted in the Hydrogeological Assessment (Coffey, 2016b) however if restrictions were placed on this value, the result would be an increase in the simulated volume of water sourced from the Lachlan River.

Table 10 summarises water balance model results in terms of system inflows and outflows for median, 10th percentile (dry) and 90th percentile (wet) 12-year total rainfall scenarios.

Table 10 Water Balance Model Results (Averaged over Remaining Mine Life ML/year)

	10 th percentile Rainfall Sequence (Dry)	Median Rainfall Sequence	90 th percentile Rainfall Sequence (Wet)
Inflows* (ML/year)			
Catchment Runoff	837	1,084	1,285
Tailings Bleed	3,861	3,861	3,861
Open Pit Groundwater	199	199	199
Saline Groundwater Supply Bores (within Mining Lease 1535)	137	94	86
Bland Creek Palaeochannel Bores	1,998	1,917	1,871
Eastern Saline Bores	522	516	507
Lachlan River Licensed Extraction**	1,445	1,329	1,268
Total Inflow	8,999	9,000	9,077
Outflows (ML/year)			
Evaporation	973	961	987
Haul Road Dust Suppression	234	233	231
TSF Embankment Construction Water	91	91	91
Process Plant Supply	7,665	7,665	7,665
Spills	0	0	0
Total Outflow	8,963	8,950	8,974

ML/year = megalitres per year

* Runoff recovered from the outside batters of the perimeter waste rock emplacement has not been simulated. Recovery would increase catchment runoff and would reduce by a corresponding amount the demand for water from external sources.

** Modelled volume of water actually reaching CGO – excludes irrigation channel losses (refer Section 5.1.1).

5.2.2 CGO External Water Demand

The demand from external sources (the eastern saline borefield, the Bland Creek Palaeochannel borefield and licensed extraction from Lachlan River water entitlements) in Table 10 for the median rainfall sequence averages 3,768 ML/year. This compares with 3,596 ML/year predicted as part of the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013). Therefore modelling indicates that reliance on external sources is likely to slightly increase as a result of the Modification.

Figure 19 to Figure 21 show predicted annual water demands from external sources. Figure 19 to Figure 21 plot the median annual water demands, the 90th percentile demand (i.e. the demand that was predicted not to be exceeded in 90% of the simulated 127 climatic sequences) and the 10th percentile demand (i.e. the demand that was predicted not to be exceeded in 10% of the simulated 127 climatic sequences). These percentile plots indicate predicted annual volume ranges within which the predicted annual volumes could vary, within these risk or confidence limits/levels.

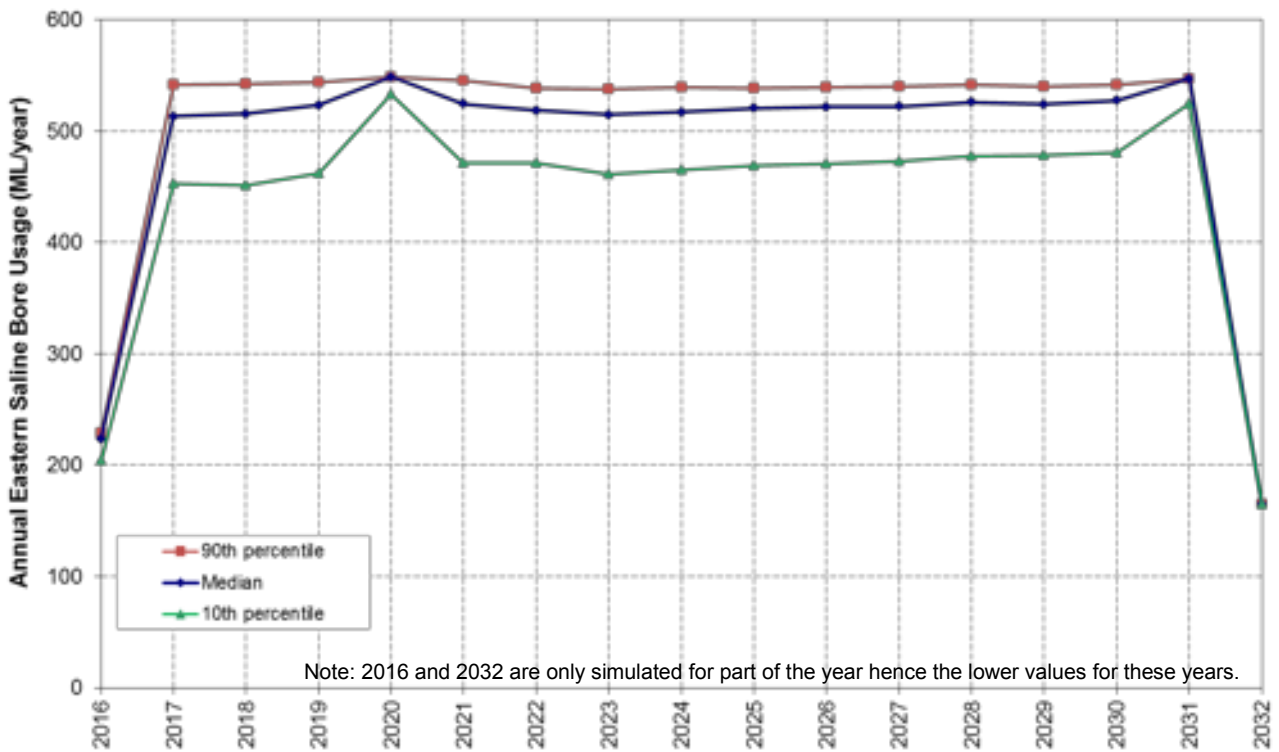


Figure 19 Predicted Annual Eastern Saline Borefield Usage

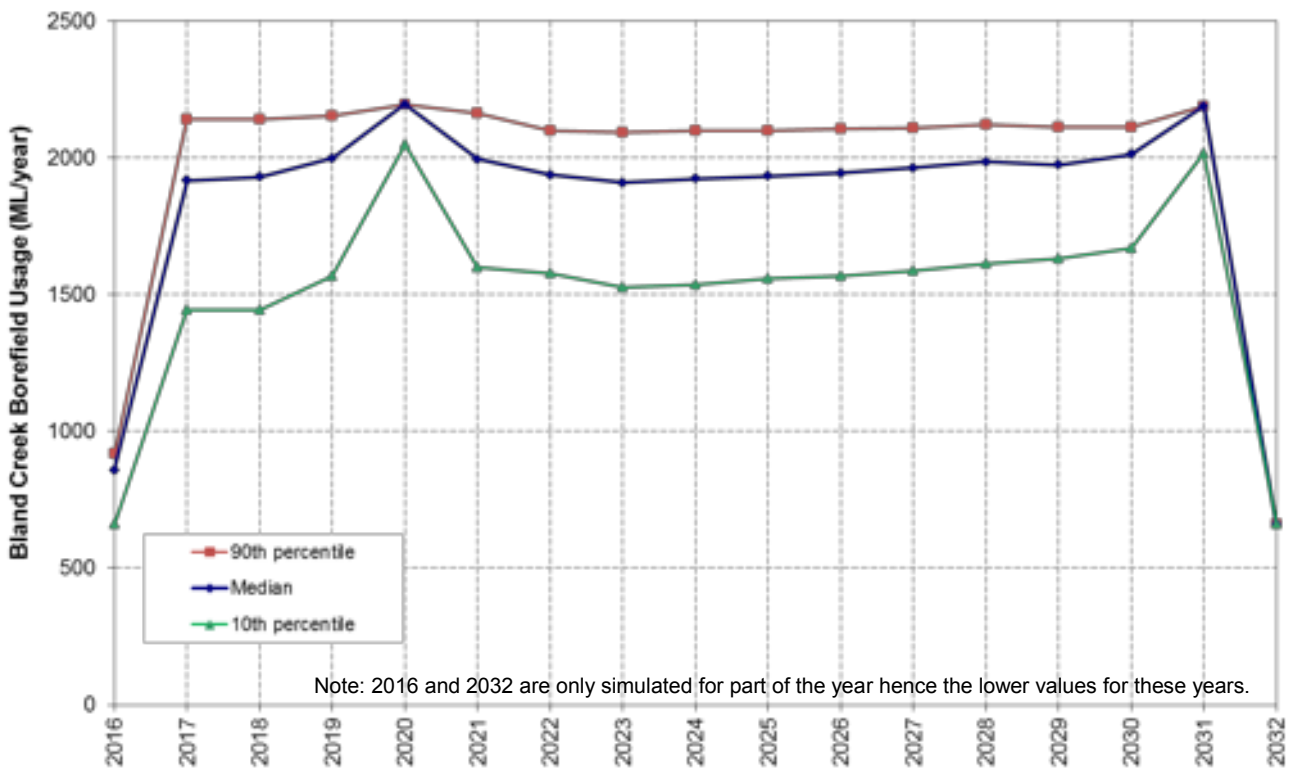


Figure 20 Predicted Annual Bland Creek Palaeochannel Borefield Usage

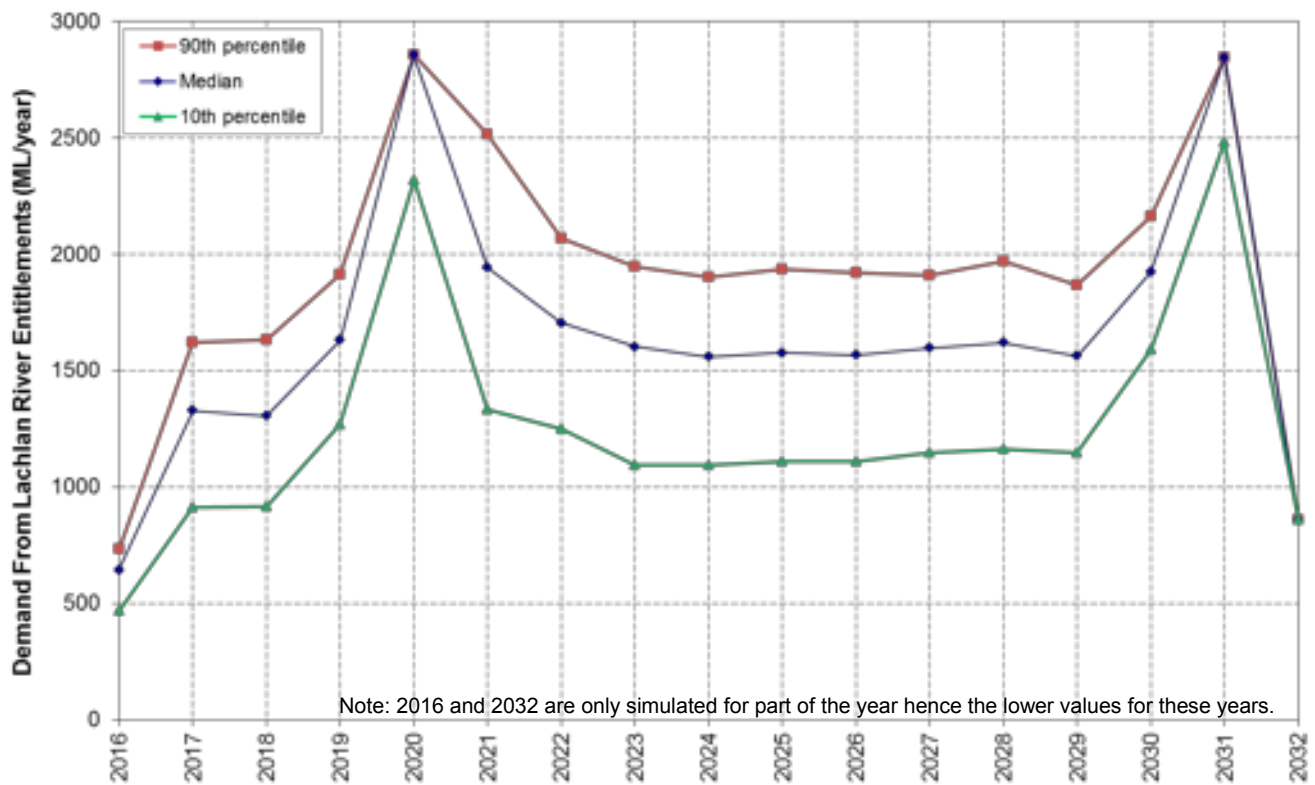


Figure 21 Predicted Annual Demand from Lachlan River Entitlements

Figure 21 shows that the predicted annual demand from licensed extraction from the Lachlan River is higher during and following the planned oxide ore processing campaigns. The predicted annual demands are lower than those forecast as part of the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013). This is likely due to the higher total volume modelled sourced from the eastern saline borefield, which would be available for the entire mine life (assumed to cease after 2015 for Modification 11).

No supply shortfalls were simulated in any of the 127 climatic sequences simulated.

5.2.3 Maximum Pit Water Volume

The maximum water volume held in the open pit in all 127 simulated climatic sequences was 1,293 ML. However, the risk of such a large water volume is low. Model results indicate that there is only a 5% risk of exceeding a pit water volume of 574 ML, and a 50% chance that a pit water volume of 16 ML will be exceeded at any time during the remaining mine life.

5.3 CLIMATE CHANGE EFFECTS AND WATER BALANCE IMPLICATIONS

Recent (post 1950) changes to temperature are evident in many parts of the world including Australia. The Intergovernmental Panel on Climate Change (IPCC) has, in its most recent (fifth) assessment (2013), concluded that:

Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, and in global mean sea level rise; and it is extremely likely to have been the dominant cause of the observed warming since the mid-20th century.

Predicting future climate using global climate models (GCMs) is now undertaken by a large number of research organizations around the world. In Australia much of this effort has been conducted and co-ordinated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). CSIRO and BoM have recently published a comprehensive assessment of future climate change

effects on Australia and future projections (CSIRO and BoM, 2015a). This is based on an understanding of the climate system, historical trends and model simulations of climate response to future global scenarios. Simulations have been drawn from an archive of more than 40 GCMs developed by groups around the world. Modelling has been undertaken for four Representative Concentration Pathways (RCPs) used by the latest IPCC assessment, which represent different future scenarios of greenhouse gas and aerosol emission changes and land-use change.

Predictions of future climate from these various models and RCPs have been used to formulate probability distributions for a range of climate variables including temperature, mean and extreme rainfall and potential evapotranspiration. Predictions are made relative to the IPCC reference period 1986 to 2005 for up to 13 future time periods between 2030 and 2090. Predictions for 2030 are relatively insensitive to future emission scenarios because they largely reflect greenhouse gases that have already been emitted. Longer term predictions become increasingly more sensitive to future emission scenarios.

Assessments of likely future concurrent rainfall and evapotranspiration changes have been undertaken using the online Climate Futures Tool (CSIRO and BoM, 2015b). Projected changes from all available climate models are classified into broad categories of future change defined by these two variables, which are the most relevant available parameters affecting rainfall runoff. The Climate Futures Tool excludes GCMs which were not found to perform satisfactorily over the Australian region. The assessments assumed a conservatively high emissions scenario – RCP 8.5 (representing a future with little curbing of emissions, with a carbon dioxide level continuing to rapidly rise to the end of the century). An assessment was performed for 2035 (i.e. close to the planned end of CGO life) for the Murray Basin region of the continent which showed the mean annual change from the reference period to be -3.2% change (i.e. a reduction) in rainfall and 4.1% change (i.e. an increase) in evapotranspiration.

These effects are likely to, in the longer term, lead to reductions in rainfall runoff in the project area. However, the implications of climate change predictions on water management are unlikely to be significant over the remaining mine life because they are small compared to the natural climatic variability.

5.4 SPILL RISK TO LAKE COWAL

No spills were predicted in the water balance model from either of the contained water storages (D1 and D4) that could spill to Lake Cowal in any of the 127 possible climate sequences modelled. This outcome is contingent upon pumped dewatering of these storages in between rainfall events. Pump extraction rates of 100 L/s and 105 L/s for storages D1 and D4 were assumed respectively (refer Table 7).

6.0 POST-CLOSURE WATER MANAGEMENT SYSTEM

6.1 EIS POST-CLOSURE MANAGEMENT CONCEPTS

The post-closure water management strategy described in the EIS (North Limited, 1998) included concepts for runoff minimisation from waste rock emplacements and TSFs, and the provision of stable drainage channels to drain site surface water to the final void. These concepts are described below.

6.1.1 Waste Rock Emplacements

At the completion of mining, the top surface of the northern and southern waste rock emplacement areas were to be graded such that any surface runoff would flow toward the final void. A cover layer comprising low salinity sub-soil and topsoil was to be laid over the graded top surface of the waste rock emplacements. The cover material and thicknesses were to be selected consistent with the overall objective of minimising runoff from the emplacement surface by encouraging infiltration and storage of rainfall in a relatively thick cover layer where it would be available for surface vegetation.

Deep rooting, high transpiration capacity vegetation species were to be utilised as cover vegetation to take-up and use the available moisture in the cover layer. The final surface of the waste rock emplacement areas was to be purposely left with a high degree of irregularity to provide surface retention of excess rainfall for longer term infiltration and take-up in the surface cover and plant system. A network of low energy drainage swales were to be provided on both waste rock emplacement areas for drainage of any net runoff to the final void. The external faces of the waste rock emplacements were to be constructed in a regular series of batters and berms. The berms were to be constructed with reverse grades to prevent overflow of berm runoff over the batters. Runoff retention areas and deep vegetated soil cover layers were proposed as concepts to minimise net runoff.

6.1.2 Tailings Storage Facilities

Concepts developed for rehabilitation of the external batters and berms of the tailings storages involved a similar approach as those developed for the outer faces of the waste rock emplacements. The concepts developed for the top surface of the tailings storages included retention of the final inverted cone shape of the final beach surface which would, by virtue of the planned peripheral tailings discharge regime, slope downward from the embankment perimeters toward the central decant areas. The final surface was to be covered with a relatively thick layer of low salinity sub-soil and topsoil to support a deep rooting plant cover. A capillary break layer between the final tailings surface and the cover was also identified as a requirement of the surface rehabilitation to prevent salt rise into the overlying soil cover layer. Planned surface irregularities, mounds and swale-like channels were also proposed for transient retention of surface runoff, to enhance moisture retention within the cover system and to provide a formal pathway for any net runoff under extreme conditions to be diverted to the final void.

6.1.3 Final Void

The final open pit was to be left as a void. The UCDS and the ICDS were to be retained. Surface drainage from the CGO area was to be diverted to the final void via a series of low energy swales. Drainage from areas upslope of the CGO area would flow to Lake Cowal via the UCDS and pre-mine creek lines.

At the completion of mining and processing, pit dewatering operations would cease and groundwater and inflows from rainfall runoff from the CGO area would accumulate in the open pit. Final void water and solute balance model simulations conducted as part of the EIS showed that, in the long-term, the

void would fill over a considerable period of time to a level some 22 to 24 m below the original ground level at the low point in the perimeter of the open pit. Modelling also indicated that water levels would fluctuate seasonally by a few metres above and below this level. The quality of final void water was predicted to be dominated by the naturally high salinity of the surrounding groundwater which had reported salinity in the range of 31,000 to 38,000 mg/L – predominantly sodium chloride. The final void water levels were such that it was predicted to act as a permanent sink for the surrounding groundwater system. Because the void had no outflow - other than direct evaporation, the salinity of void waters was predicted to continue to increase in the longer term due to evapo-concentration. The quality of void water was also predicted to vary with depth due to stratification which would occur due to temperature and salinity differentials.

6.2 PROJECT POST-CLOSURE WATER MANAGEMENT

The concepts developed for the EIS are considered to remain valid for the post-closure situation for the Modification. The changes occasioned by the Modification in relation to post-closure relate principally to the final void depth. The shaping, surface covering and surface treatments proposed in the EIS for the waste rock emplacement areas and the tailings storages are equally applicable. Evolution is undertaking on-going waste rock emplacement rehabilitation trials (using a number of different combinations of rock mulch, topsoil and gypsum) as well as rehabilitation trials on the TSFs. Results of these trials will inform the final design of the waste rock emplacement and TSF rehabilitation. Consistent with the 2014 Independent Monitoring Panel Report recommendations (Bell & Miller, 2014), Evolution would continue to monitor rehabilitation trials with a view to continually refine its approach to achieving large-scale sustainable rehabilitation.

The implications of changes associated with the Modification on the final void water balance are described in the following sub-sections.

6.2.1 Final Void Water Balance

The final void would, as a result of the Modification, be larger in surface area and deeper than the original (EIS) void and also larger in surface area and deeper than the void proposed as part of Modification 11 (Gilbert & Associates, 2013). The catchment area reporting to the final void would, in total, be unchanged from that proposed as part of Modification 11, with small increases in rehabilitated sub-catchments and a corresponding decrease in undisturbed areas. Groundwater inflows to the final void have been re-estimated (Coffey, 2016a). The inflows are predicted to be significantly lower than those that were originally predicted (in the EIS [North Limited, 1998]) and similar to those predicted for Modification 11.

A final void water balance model was set up as part of the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013) to simulate the behaviour of the final void water body. The model results indicated that the final void would fill slowly reaching an equilibrium water level between approximately relative level (RL) 125 m and RL 135 m (approximately 80 m below spill level) over several hundred years. This is lower than the original predictions (North Limited, 1998) due to lower groundwater inflows and higher evaporation rates from the larger water surface area in the void.

Given an increase in depth of the final void of approximately 70 m proposed as part of the Modification (compared with Modification 11), the time for the final void water level to reach equilibrium would be longer. At a final void level of RL 130m (approximate equilibrium median water level identified from Modification 11 water balance modelling), the water surface area of the final void proposed as part of the Modification is approximately 3% greater. For an equivalent final void water level, it is therefore expected that evaporation rates would be slightly higher and therefore the final

void water level would be slightly lower than that predicted as part of the Modification 11 Surface Water Assessment (Gilbert & Associates, 2013).

The void water quality would reflect the influence of the high salinity in the groundwater. Given that the only outflow from the final void would be evaporation, salinity is predicted to increase trending to hyper-salinity. Due to the slightly higher evaporation rates, it is expected that this trend to hyper-salinity would be faster for the Modification than for Modification 11. Water quality in the final void at any given point in time will vary with depth as a result of mixing and stratification processes that will occur as a result of temperature and salinity differentials.

6.2.2 Implications of Climate Change on Final Void Water Balance

Longer term climate change predictions have potential implications for post mine water management and specifically the water balance of the final void. In this regard the currently most accepted scenarios (refer Section 5.3) would see a reduction in overall rainfall, an increase in evaporation and a corresponding decrease in rainfall excess. This would translate to reduced surface water runoff inflow to the void and reduced incident rainfall over the surface of the void. There would also be increased evaporation loss for the void surfaces and as a consequence lower average water levels in the mine void.

7.0 POTENTIAL SURFACE WATER IMPACTS AND MITIGATION MEASURES

The following recommendations are made in consideration of the surface water management issues assessed for this Modification:

- The changes to water management outlined in this report be implemented in accordance with accepted and best practice management.
- The monitoring program and associated annual water management system performance reviews continue to be undertaken over the remaining CGO life.
- The soil and erosion control plan be reviewed and revised to incorporate changes necessitated by the Modification.

7.1 OPERATIONAL PHASE

Due to the increased CGO water demand there are potential impacts on Lachlan River flows. Future water demand would be met (in part) by sourcing water from Lachlan River regulated flows (licensed extraction purchased on the open market). Given the provisions inherent in the *Water Management Act 2000* regarding environmental flows, the impact of sourcing additional regulated flow from the Lachlan River would be neutral because if not extracted by Evolution for use at CGO the licenses could be either purchased and the same water extracted by others or the water could be used by the existing licence holders if they were unable to sell the water on the open market. It is also noted that forecast future demand from Lachlan River entitlements are lower than predicted for the approved Modification 11.

Overall there has been no apparent causal link between the mining operations and water quality changes in Lake Cowal and it is concluded that there would be a low risk of more than a negligible hydrological impact on Lake Cowal due to the Modification.

7.2 POST-CLOSURE

Post-closure surface water impacts would include possible risks of structural instability of final mine landforms affecting Lake Cowal water quality (salinity and turbidity/sedimentation). There is also the risk of discharge from the final void water body to Lake Cowal.

Previous final void water balance modelling (Gilbert & Associates, 2013) has indicated that the final void water level should stabilise well below spill level and below the local water table level and it is likely that this water level would be even lower as a result of the Modification (refer Section 6.1.3). The majority of the CGO site post-closure would continue to drain to the final void and would therefore have no impact on the water quality of Lake Cowal. The final profiles of the waste rock emplacements, TSFs and lake isolation system have been designed to effectively preclude instability which could cause impact on the Lake (North Limited, 1998). Stabilisation of the outer batters of the mine waste rock emplacements (using rock mulch and vegetation) would be undertaken well ahead of mine closure, allowing time for “proving” the stability of these batters.

Evolution is undertaking batter rehabilitation trials (using a number of different combinations of rock mulch, soil and vegetation). Results of these trials will inform the final design of the waste rock emplacement rehabilitation and will also allow prediction of sediment generation rates likely to be generated from the final landform to the Lake. North (1998) predicted final landform sediment generation rates that were of the same magnitude as (albeit somewhat greater than) those predicted from the site under pre-mine conditions. However given the direction of most of the site runoff to the final void, the area reporting to Lake Cowal would be reduced and therefore so would the net

sediment yield to Lake Cowal. Likewise the majority of salt generated from the final landform would be directed to the final void which is predicted to trend towards hyper-saline conditions in the long term (regardless of salt influx).

The salt concentration from the rehabilitated outer waste rock emplacement to Lake Cowal would be expected to reduce with time as salts present in the near surface layers were removed by natural leaching. In the longer term the predicted steady state TDS concentration in runoff from the waste rock dump is not likely to exceed 100 mg/L (North Limited, 1998) or an EC of approximately 150 $\mu\text{S/cm}$. This is less than the minimum value in the baseline data for Lake Cowal of 222 $\mu\text{S/cm}$ (refer Table 3). Salt fluxes were predicted to be extremely small compared with inflows to the Lake from Bland Creek and the Lachlan River.

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