# APPENDIX M
## Lake protection bund water balance modelling memorandum

Evolution MINING

EMM creating opportunities

Level 3 175 Scott Street
Newcastle NSW 2300
02 4907 4800
www.emmconsulting.com.au

# Memorandum

12 December 2023

To: Pierre Miquel

From: Tess Davies

**Subject: Open Pit Continuation Project - Lake protection bund water balance modelling**

This document summarises the approach and results of water balance modelling of the lake protection bund (LPB) expansion as part of the Cowal Gold Operations (CGO) Open Pit Continuation Project (the project) undertaken by EMM Consulting Pty Ltd (EMM). Water balance modelling has been undertaken to understand the water licensing implications for the project associated with dewatering any water trapped behind the bund following construction.

# 1 Summary

Water balance modelling has been undertaken to understand the water licensing implications for the project associated with dewatering any water trapped behind the north and south bunds following construction. The following key observations are made from the results:

- Dewatering of the northern bunded area had a low probability (less than 10%) of being restricted by the water access licence (WAL) accounting rules, with the volume of water modelled to be trapped behind the north LPB was less than 1,458 ML (i.e. two times the full WAL entitlement of 729 ML) over 90% of the time.
- Pumping option A (800 L/s pumping rate) resulted in less days to empty the northern bunded area compared to pumping option B (150 L/s pumping rate).
- The northern bunded area was modelled to be empty within six months (i.e. by September 2025) 98% of the time for both pumping options.
- Dewatering of the combined north and south bunded areas was modelled to take a similar total duration for both pumping options, with results more likely to be limited by the licensing restrictions than by the pump rate.
- Both bunded areas were modelled to be empty within 12 months (i.e. by April 2026) 70% of the time for both pumping options. However, for 30% of the time they would take between approximately 12 and 36 months to empty.

# 2 Modelling approach

A water balance model of Lake Cowal was developed by ATC Williams Pty Ltd (ATCW) for the surface water assessment (SWA) for the project (ATCW 2023) using GoldSim, which was provided to EMM on 25 October 2023. The model was then updated to include the LPB northern and southern extension and dewatering of any water trapped behind the bund.

## 2.1 Model description

The water balance model was developed in GoldSim (version 14). The model applies a continuous simulation methodology that assesses the Lake Cowal water level under a range of climatic sequences. The model simulates the volume of water within the lake as well as the north and south areas behind the LPB, based on the following balance equation:

*Change in volume over time = inflows – outflows*

where:

- model inflows consisted of direct rainfall onto the water surface area, catchment runoff and flood inflows from the Lachlan River
- model outflows consisted of evaporation from the water surface area, dewatering of the north and south areas behind the LPB and spills to Nerang Cowal and the downstream Lachlan River.

## 2.2 Probabilistic modelling

The model simulates the water cycle of Lake Cowal using daily time steps. To assess the influence of climate variability on the lake level, the modelling was completed by applying 128 different climate patterns over the simulation timeline, based on the historical climate record and Lachlan River flows between 1895 and 2022. To complete this, the simulation timeline was modelled for 128 'realisations', where each realisation represents a single model run. Each realisation began with a different year of the historical climate record and Lachlan River flow record, proceeding consecutively through the historical record (and looped to the start of the record where required). The results from all realisations were used to generate relevant statistical results. This method effectively includes all recorded historical climatic events in the water balance model, including high, average and low rainfall periods. Climate change has not been considered in this assessment.

## 2.3 Modelling data and assumptions

A summary of the input data and modelling assumptions for the Lake Cowal water balance model provided by ATCW is presented in Table 2.1. Further details on the model are provided in the SWA for the project (ATCW 2023).

**Table 2.1 Lake Cowal water balance model – input data and assumptions**

| Model aspect | Assumptions | Data source |
|---|---|---|
| Rainfall | Rainfall on water surface area | Daily rainfall record from 1895 to 2022 sourced from SILO database for location near catchment centroid of Bland Creek (coordinates -34.05, 147.75) |
| Catchment runoff | Runoff from rainfall modelled using an Australian Water Balance Model (AWBM) | Model parameters calibrated using Lake Cowal water level data between October 2010 and June 2022 |

**Table 2.1 Lake Cowal water balance model – input data and assumptions**

| Model aspect | Assumptions | Data source |
|---|---|---|
| Lachlan River flood inflows | Overflows from Lachlan River at locations near Jemalong Weir during high flow events | Daily Lachlan River flows at Jemalong Weir sourced from river gauging station data, supplemented with Lachlan River system modelling results provided by DPE<br>Flow routing parameter calibrated using Lake Cowal water level data between October 2010 and June 2022 |
| Evaporation | Evaporation from water surface area | Daily pan evaporation record from 1895 to 2022 sourced from SILO database and factored to convert pan evaporation to estimates of open water evaporation |
| Spills to Nerang Cowal and downstream Lachlan River | Overflows from Lake Cowal to Nerang Cowal during high flow events | Relationship between lake water level and downstream spill flow rate estimated from the results of flood modelling<br>Flow routing parameter calibrated using Lake Cowal water level data between October 2010 and June 2022 |
| Water surface area | Water level-volume-surface area relationship used by the model to calculate water surface area and level from modelled volumes | Relationship derived from bathymetric survey of Lake Cowal and aerial site survey information |

A summary of the additional model input data and assumptions used to update the model for the LPB is provided in Table 2.2.

**Table 2.2 Lake protection bund water balance model – additional input data and assumptions**

| Model aspect | Assumptions | Data source |
|---|---|---|
| Construction dates | North LPB complete on 1 April 2025<br>South LPB complete on 1 August 2025 | Evolution |
| Lake Cowal initial water level | Level of 205.478 m AHD on 20 November 2023 | Lake Cowal water level data |
| Water surface area | Water level-volume-surface area relationship used by the model to calculate water surface area and level from modelled volumes | Relationship derived from bathymetric survey of Lake Cowal and LPB design information<br>Refer Table A.1 |
| Maximum pump rate | Operation 24 hours/day, 7 days/week<br>Utilisation rate of 90%<br>Option A – maximum dewatering rate of 800 L/s (two 400 L/s pumps)<br>Option B – maximum dewatering rate of 150 L/s (five treatment plants with peak flow rate of 30 L/s) | Pump rate limited by dewatering treatment rate |
| Water licensing and accounting rules | Available water determination of 1 ML/unit share<br>Maximum annual licensed volume of 729 ML/unit share<br>Maximum carryover of 729 ML/unit share of unused allocation<br>Maximum of 2,187 ML/unit share of water taken over three consecutive water years<br>Licensed entitlement not used in year prior to dewatering | Water accounting rules specified by water sharing plan (refer Section 2.4) |

## 2.4 Water licensing

The *Water Sharing Plan for the Lachlan Unregulated River Water Sources 2012* (the WSP) applies to unregulated surface water sources in the Lachlan River catchment. The project is located in the Bogandillon and Manna Creeks Water Source. Evolution currently holds one WAL within the water source with a total entitlement of 729 unit shares.

The following water accounting rules are specified by the WSP:

- carryover – a maximum of 1 ML per unit share (i.e. 729 ML) of unused allocation is carried over from one water year to the next

- three-year average – water taken must not exceed a maximum of 3 ML per unit share (i.e. 2,187 ML) of allocation over a period of any three consecutive water years.

Appendix B provides an example of the water accounting rules in practice. Note a water year is the 12-month period from 1 July to 30 June.

## 2.5 Modelling scenarios

To assess the impact of licensing requirements on the dewatering timeframe, the following scenarios were modelled:

- Scenario 1 – considers no active dewatering (i.e. allowing the bunded area to empty via evaporative processes only)

- Scenario 2 – considers no licensing restrictions on dewatering rate (i.e. water licensing entitlement and accounting rules specified in Table 2.2 were not applied in the model):

  - Scenario 2A considers the option A dewatering rate of 800 L/s

  - Scenario 2B considers the option B dewatering rate of 150 L/s

- Scenario 3 – considers the licensing and accounting rules associated with the WAL (i.e. water licensing entitlement and accounting rules specified in Table 2.2 were applied in the model):

  - Scenario 3A considers the option A dewatering rate of 800 L/s

  - Scenario 3B considers the option B dewatering rate of 150 L/s.

# 3 Results

## 3.1 Interpretation of results

Results have been presented as percentiles, which give a ranking, in percentage terms, of all results from lowest to highest for the 128 model realisations based on the historical climate record from 1895 to 2022. For a given percentile, the corresponding result is the threshold below which that percentage of all recorded years falls. For example, a 10th percentile result marks the threshold for the lowest 10% of results. This means that 10% of results are less than this value, and 90% of results are above this value. Similarly, a 90th percentile result marks the threshold for the lowest 90% of results, equivalent to the highest 10%. This means that 10% of the results are greater than the 90th percentile result.

## 3.2 Climate

The SILO rainfall data has been used to summarise historical annual rainfall trends in Figure 3.1. The deviation (10 year moving average) from the average annual rainfall total of 510 mm/year is also shown to identify extended wet and dry periods. The data presented in Figure 3.1 indicates the first half of the record up to around 1950 was typically drier with below average rainfall compared to the 50 years to 2000, when above average rainfall was typically recorded.

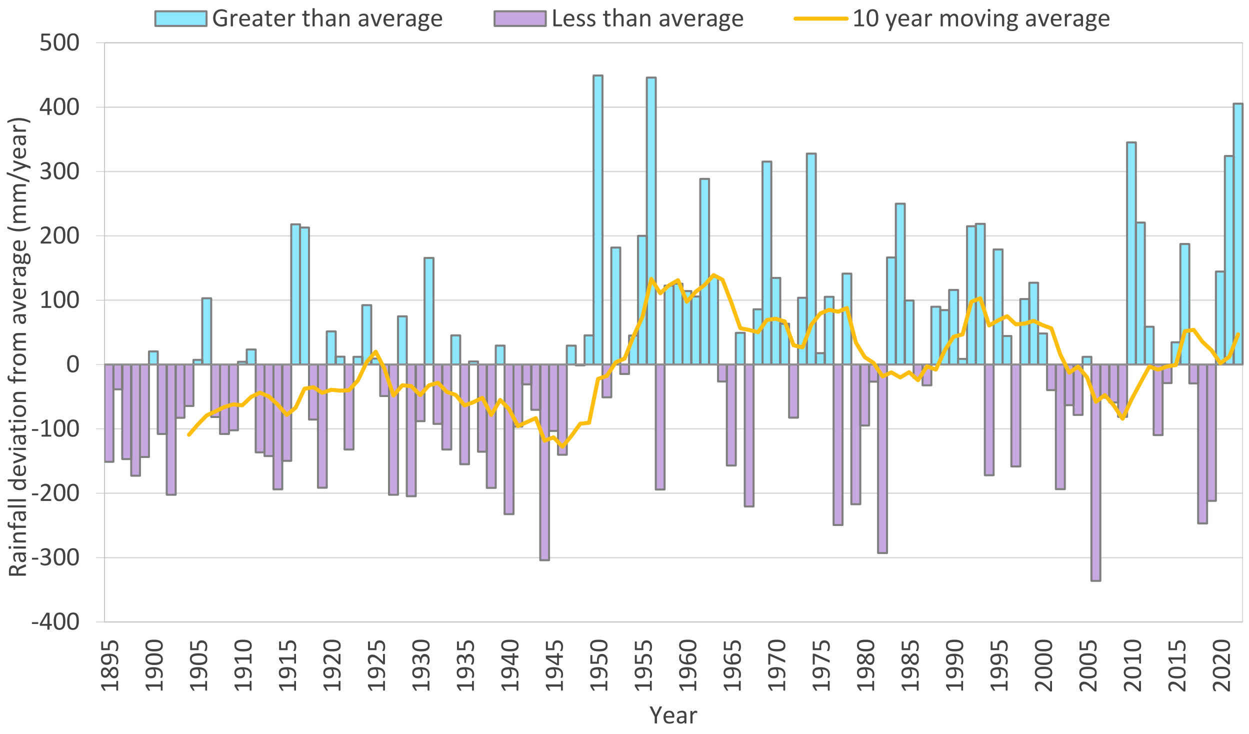


**Figure 3.1 Historical rainfall trend**

Figure 3.2 presents the ranked annual rainfall percentiles calculated from the SILO rainfall data over the 128 year period between 1895 and 2022.

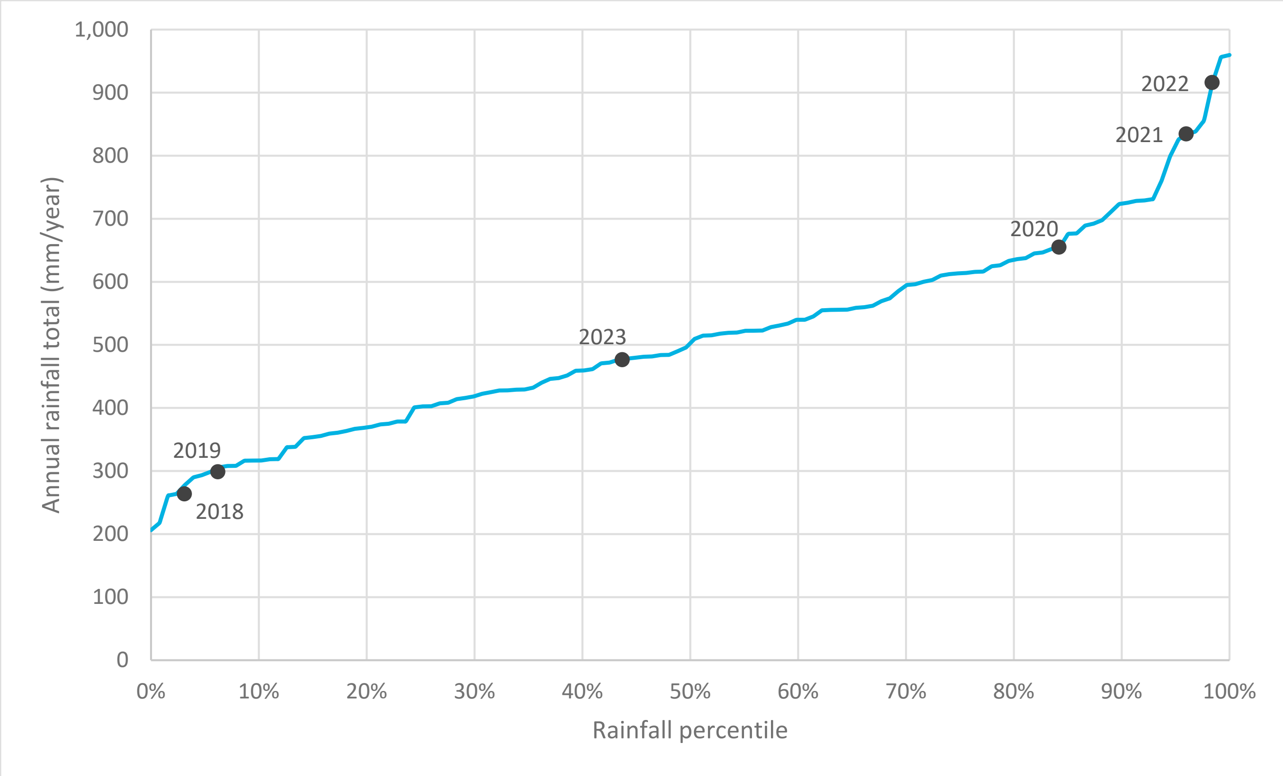


**Figure 3.2 Rainfall percentiles**

Figure 3.2 shows that 2018 and 2019 were third percentile and sixth percentile rainfall years respectively, representing some of the driest conditions observed in the historical rainfall record. This was followed by above average rainfall in 2020, 2021 and 2022, which are 84th percentile, 96th percentile and 98th percentile rainfall years respectively. Rainfall in 2023 has been slightly below average, representing a 44th percentile rainfall year (note that the rainfall total for 2023 includes recorded rainfall up to 6 December 2023).

## 3.3 Lake Cowal

The water balance model was used to simulate the water level of Lake Cowal over the next five years, as shown in Figure 3.3. Modelling commenced with a lake water level of 205.478 m AHD on 20 November 2023. Results are presented as the range of probabilities between the minimum and 10th percentile value, 10th percentile and 25th percentile, 25th percentile and 50th percentile (median), 50th percentile and 75th percentile, 75th percentile and 90th percentile, and 90th percentile and maximum.

The results in Figure 3.3 indicate that at the completion of construction of the north LPB on 1 April 2025, the median water level is predicted to decrease to 204.5 m AHD. The level was modelled to range between 205.6 m AHD under very wet (90th percentile) conditions and 203.7 m AHD under very dry (10th percentile) conditions.

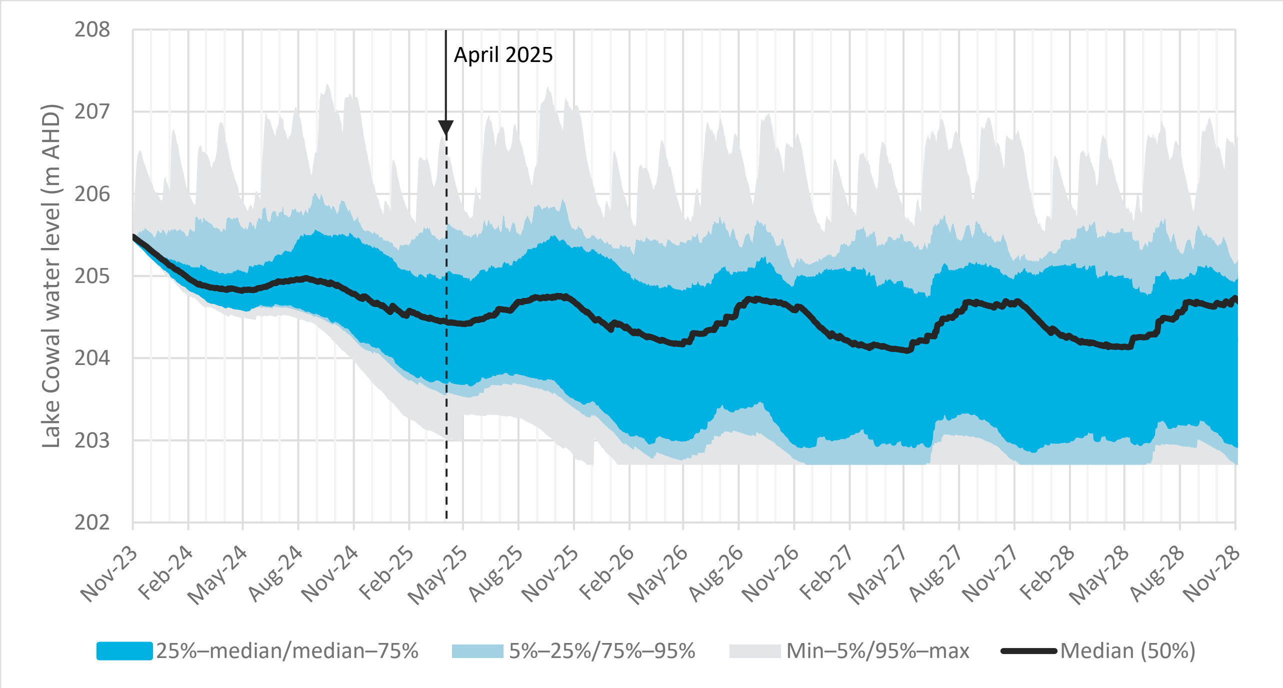


**Figure 3.3 Modelled Lake Cowal water level**

## 3.4 Dewatering of Lake Protection Bund

### 3.4.1 Volume of water trapped

Figure 3.4 presents the modelled volume of water trapped behind the bund following the completion of the north LPB, modelled to occur on 1 April 2025, and the south LBP, modelled to occur on 1 August 2025. Table 3.1 presents the estimated volumes for very dry, neutral and very wet climate conditions.

If Lake Cowal was to remain at the current water level of approximately 205.5 m AHD, the volume of water trapped behind the north LPB would be 1,316 ML. This equates to an 87th percentile result considering the full range of results based on the 128 year historical climate record.

The results for the very wet climate conditions indicate that 90% of the time, the volume of water modelled to be trapped behind the north LPB was less than 1,458 ML (i.e. two times the full WAL entitlement of 729 ML) and could be fully dewatered without being restricted by licence accounting rules. In 10% of modelled realisations, the volume of water trapped behind the north LPB was greater than 1,458 ML.

**Table 3.1 Volume of water modelled to be trapped behind LPB under very dry, neutral and very wet conditions**

| Climate conditions | Statistic | North LPB<br>1 April 2025 | South LPB<br>1 August 2025 |
|---|---|---|---|
| Very dry | 10th percentile | 26 ML | 190 ML |
| Neutral | 50th percentile | 341 ML | 877 ML |
| Very wet | 90th percentile | 1,446 ML | 2,928 ML |

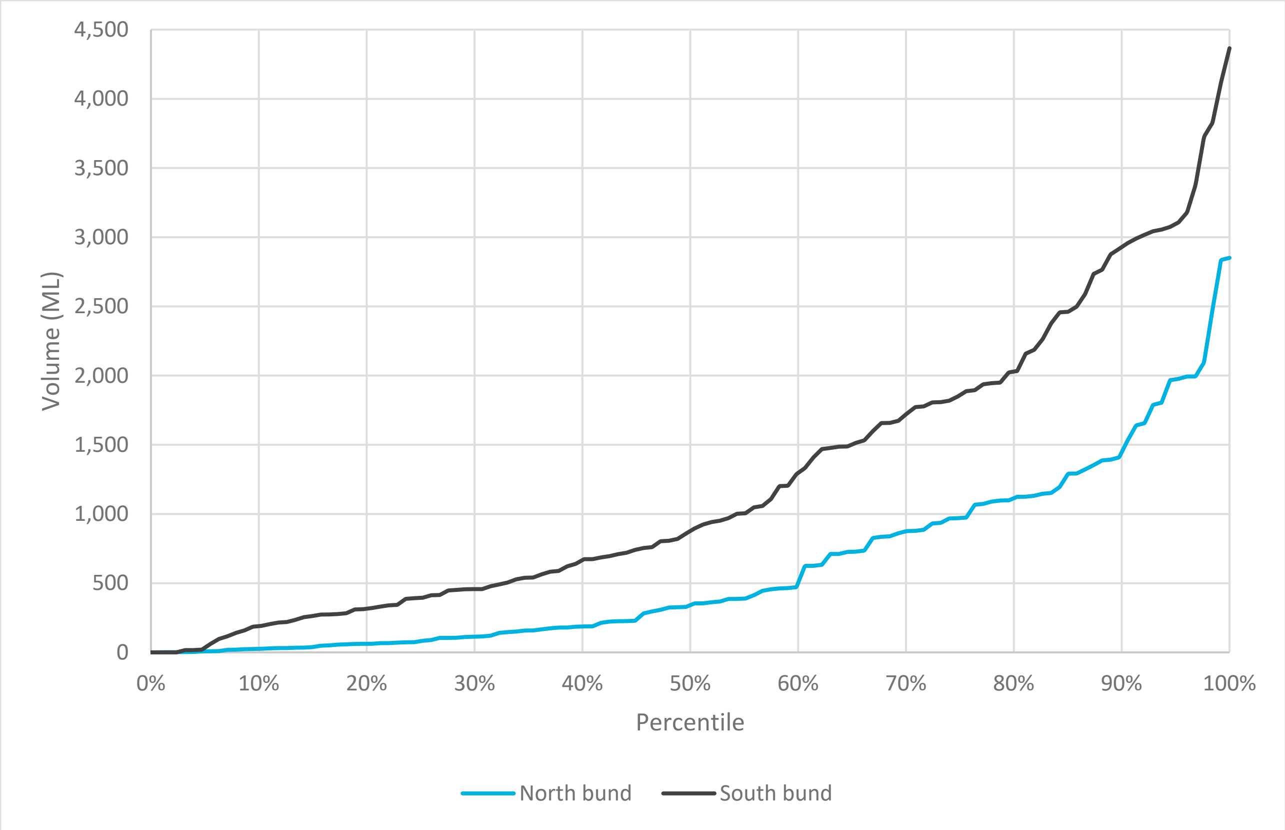


**Figure 3.4 Volume of water modelled to be trapped behind the LPB**

### 3.4.2 North LPB

The modelled percentiles of time taken to empty the water trapped behind the north LPB is presented in Figure 3.5 for Scenario 1 (no active dewatering), Scenario 2 (dewatering unrestricted by licensing) and Scenario 3 (dewatering restricted by licensing). Key metrics relating to the time taken to empty the north LPB are presented in Table 3.2 and Table 3.3.

The following observations can be made from the modelled results:

- Scenario 1 was estimated to take the longest to empty, with only evaporation from the water surface modelled (i.e. no active dewatering modelled). Under very dry (10th percentile) conditions, the north area was modelled to take 224 days to empty (i.e. up to November 2025). Under very wet (90th percentile) conditions, the area was modelled to take up to 990 days to empty (i.e. up to December 2027).
- The time taken to empty the bunded area for scenarios 2A and 3A were equal for up to 91% of results. Similarly, the time taken to empty for scenarios 2B and 3B were equal for up to 98% of results. This indicates that the licensing entitlement and water accounting rules associated with the WAL impacted less than 10% of results, generally during consecutive wet years when the three-year average rule restricted the modelled dewatering rate.
- Pumping option A (800 L/s pumping rate) resulted in less days to empty the bunded area compared to pumping option B (150 L/s pumping rate), with 24 days taken to empty under the higher pumping rate compared to 125 days taken for the lower pumping rate for very wet (90th percentile) conditions.
- The northern bunded area was modelled to be empty within six months (i.e. by September 2025) 98% of the time for both pumping options.

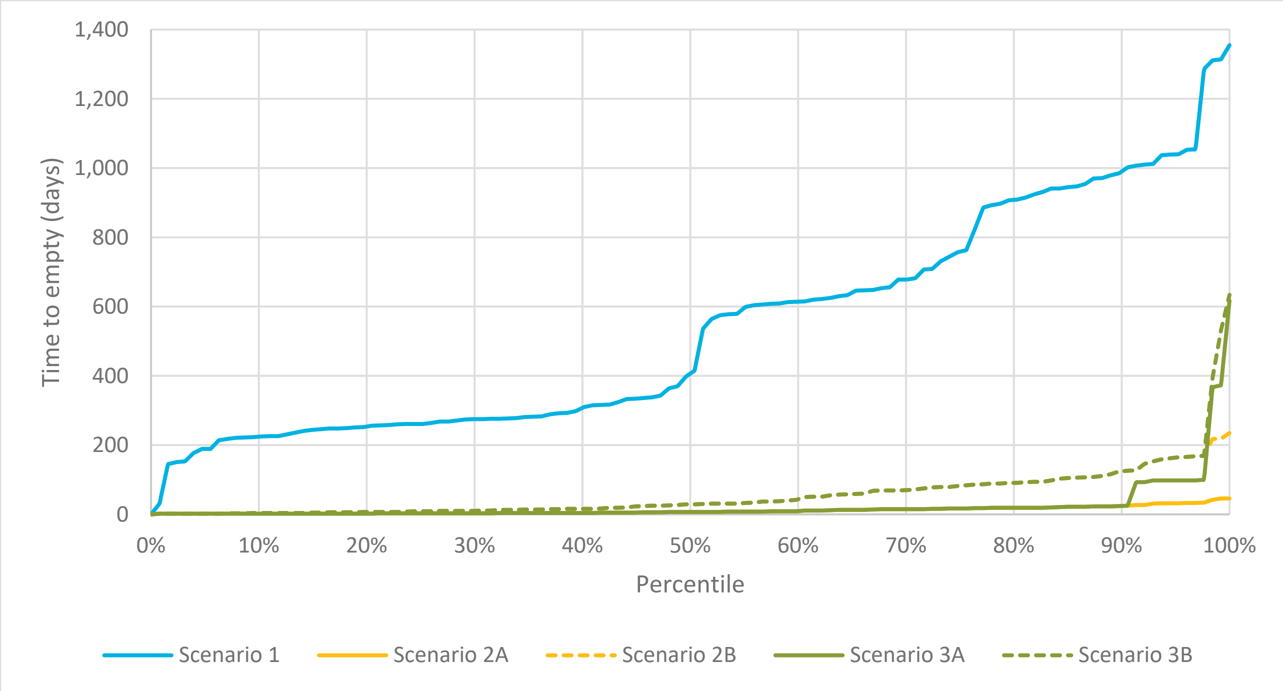


**Figure 3.5 Percentile results for the time taken to empty the north LPB**

**Table 3.2 Time taken to empty the north LPB**

| Rainfall conditions | Statistic | Time to empty (days) | | | | |
|---|---|---|---|---|---|---|
| | | Scenario 1 | Scenario 2A | Scenario 2B | Scenario 3A | Scenario 3B |
| Very dry | 10th percentile | 224 | 2 | 4 | 2 | 4 |
| Neutral | 50th percentile | 407 | 7 | 29 | 7 | 29 |
| Very wet | 90th percentile | 990 | 24 | 125 | 24 | 125 |

**Table 3.3 Percentage chance of emptying north LPB for Scenario 3**

| Time to empty | Pumping option A | Pumping option B |
|---|---|---|
| <1 month | 91% | 51% |
| <2 months | 91% | 66% |
| <3 months | 91% | 79% |
| <6 months | 98% | 98% |
| <12 months | 98% | 98% |

### 3.4.3 North and south LPB

The modelled percentiles of time taken to empty the water trapped behind both the north and south LPB is presented in Figure 3.6 for Scenario 1 (no active dewatering), Scenario 2 (dewatering unrestricted by licensing) and Scenario 3 (dewatering restricted by licensing). Key metrics relating to the time taken to empty both the north and south LPB are presented in Table 3.4 and Table 3.5.

The following observations can be made from the modelled results:

- The minimum time taken to empty both the north and south bunded areas was 122 days, i.e. 1 August 2025 when the south LPB was modelled to be completed.

- Scenario 1 was estimated to take the longest to empty, with only evaporation from the water surface modelled (i.e. no active dewatering modelled). Under very dry (10th percentile) conditions, the north and south areas were modelled to take 267 days to empty (i.e. up to December 2025). Under very wet (90th percentile) conditions, the area was modelled to take up to 1,742 days to empty (i.e. up to January 2030).

- The time taken to empty the bunded area for scenarios 2A and 3A were similar for around 30% of results. Likewise, the time taken to empty for scenarios 2B and 3B were similar for around 60% of results. Beyond these values, the licensing entitlement and water accounting rules associated with the WAL was found to restrict the modelled dewatering rate.

- Results were generally similar for both pumping options modelled, with results more likely to be limited by the licensing restrictions than by the pump rate.

- The bunded areas were modelled to be empty within 12 months (i.e. by April 2026) 70% of the time for both pumping options.

- Conversely, for 30% of the modelled outcomes, the bunded areas would take between approximately 12 and 36 months to empty.

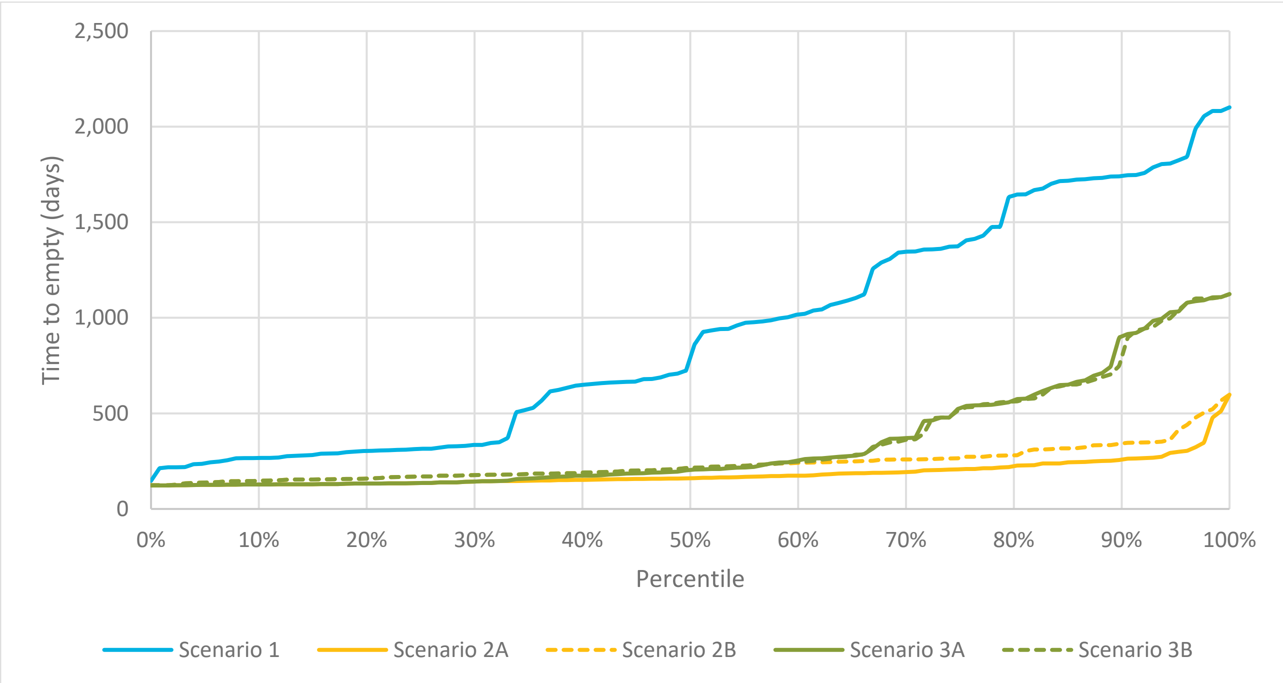

**Figure 3.6 Percentile results for the time taken to empty the north and south LPB**

**Table 3.4 Time taken to empty the north and south LPB**

| Rainfall conditions | Statistic | Time to empty (days) | | | | |
|---|---|---|---|---|---|---|
| | | Scenario 1 | Scenario 2A | Scenario 2B | Scenario 3A | Scenario 3B |
| Very dry | 10th percentile | 267 | 128 | 147 | 128 | 147 |
| Neutral | 50th percentile | 792 | 161 | 215 | 204 | 215 |
| Very wet | 90th percentile | 1,742 | 258 | 343 | 902 | 792 |

**Table 3.5 Percentage chance of emptying north and south LPB for Scenario 3**

| Time to empty | Pumping option A | Pumping option B |
|---|---|---|
| <5 months | 33% | 12% |
| <6 months | 44% | 35% |
| <9 months | 63% | 63% |
| <12 months | 70% | 70% |

# 4 Limitations

There are a range of limitations associated with the water balance model which should be acknowledged when interpreting the model results:

- The water balance modelling approach has been based on the Lake Cowal water balance model developed by ATCW for the SWA to support the project (ATCW 2023). No verification of the input data and assumptions (refer Table 2.1) or validation of this model's ability to predict the Lake Cowal water level has been undertaken.
- The model relies on the historical climate record between 1895 and 2022, which may not be sufficiently representative of the future climate. The potential impacts of climate change have not been taken into account.
- The model uses a daily timestep and pre-set rules/conditions and therefore operational decision making on a day-to-day basis are not captured.

# 5 Closing

We hope that this memorandum on the LPB water balance modelling adequately address your requirements. If you have any questions of require any additional information, please do not hesitate to contact Tess Davies.

Yours sincerely

**Tess Davies**
Senior Water Resources Engineer
tdavies@emmconsulting.com.au

# References

ATCW 2023, *Cowal Gold Operations Open Pit Continuation Environmental Impact Statement – Surface Water Assessment*, ATC Williams Pty Ltd, report 121155-14R001, May 2023.

# Appendix A

## Water level-surface area-volume data

**Table A.1 Water level-surface area-volume relationship for LPB extension areas**

| Water level (m AHD) | North LPB area | | South LPB area | |
|---|---|---|---|---|
| | Surface area (ha) | Volume (ML) | Surface area (ha) | Volume (ML) |
| 203.2 | 0 | 0 | 0.0 | 0 |
| 203.3 | 0 | 0 | 0.0 | 0 |
| 203.4 | 0 | 0 | 4.9 | 2 |
| 203.5 | 2 | 1 | 29.1 | 19 |
| 203.6 | 8 | 6 | 55.9 | 62 |
| 203.7 | 15 | 18 | 72.5 | 126 |
| 203.8 | 25 | 38 | 79.3 | 202 |
| 203.9 | 32 | 66 | 83.1 | 283 |
| 204.0 | 38 | 101 | 86.9 | 368 |
| 204.1 | 43 | 141 | 90.7 | 457 |
| 204.2 | 49 | 187 | 94.8 | 550 |
| 204.3 | 54 | 239 | 99.0 | 647 |
| 204.4 | 60 | 296 | 103.3 | 748 |
| 204.5 | 66 | 359 | 107.5 | 853 |
| 204.6 | 72 | 428 | 111.7 | 963 |
| 204.7 | 78 | 503 | 116.0 | 1,077 |
| 204.8 | 85 | 585 | 120.2 | 1,195 |
| 204.9 | 91 | 673 | 124.3 | 1,317 |
| 205.0 | 98 | 767 | 128.4 | 1,443 |
| 205.1 | 105 | 868 | 132.5 | 1,574 |
| 205.2 | 112 | 977 | 136.5 | 1,708 |
| 205.3 | 119 | 1,092 | 140.6 | 1,847 |
| 205.4 | 127 | 1,215 | 144.7 | 1,990 |
| 205.5 | 134 | 1,346 | 148.7 | 2,136 |
| 205.6 | 141 | 1,484 | 154.5 | 2,288 |
| 205.7 | 142 | 1,625 | 154.7 | 2,442 |
| 205.8 | 143 | 1,768 | 155.0 | 2,597 |
| 205.9 | 145 | 1,912 | 155.2 | 2,752 |
| 206.0 | 146 | 2,058 | 155.4 | 2,908 |
| 206.1 | 147 | 2,204 | 155.5 | 3,063 |

**Table A.1 Water level-surface area-volume relationship for LPB extension areas**

| Water level (m AHD) | North LPB area | | South LPB area | |
|---|---|---|---|---|
| | Surface area (ha) | Volume (ML) | Surface area (ha) | Volume (ML) |
| 206.2 | 148 | 2,352 | 155.7 | 3,219 |
| 206.3 | 149 | 2,501 | 155.8 | 3,374 |
| 206.4 | 150 | 2,650 | 156.0 | 3,530 |
| 206.5 | 150 | 2,800 | 156.3 | 3,686 |
| 206.6 | 151 | 2,951 | 156.4 | 3,843 |
| 206.7 | 151 | 3,102 | 156.4 | 3,999 |
| 206.8 | 152 | 3,254 | 156.4 | 4,156 |
| 206.9 | 152 | 3,406 | 156.4 | 4,312 |
| 207.0 | 152 | 3,558 | 156.4 | 4,469 |
| 207.1 | 152 | 3,710 | 156.4 | 4,625 |
| 207.2 | 152 | 3,863 | 156.4 | 4,782 |

# Appendix B
## Water accounting rules example

creating opportunities

The following water accounting rules are specified by the water sharing plan:

- carryover – a maximum of 1 ML per unit share of unused allocation is carried over from one water year to the next
- three-year average – water taken must not exceed a maximum of 3 ML per unit share of allocation over a period of any three consecutive water years.

An example of the water accounting rules for a water access licence with 50 shares is provided in Table B.1.

## Table B.1 Example of water accounting rules

| Year | Available water determination (ML/unit share) | Account balance (ML at start of water year) | Usage (ML) | Account balance (ML at end of water year) | Carryover (ML) 50 ML max | Forfeited (ML) | Rolling three-year use (ML) |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 50 | 0 | 50 | 50 | 0 | 0 |
| 2 | 1 | 100 | 25 | 75 | 50[1] | 25 | 25 |
| 3 | 1 | 100 | 100 | 0 | 0 | 0 | 125 |
| 4 | 1 | 50 | 25[2] | 25 | 25 | 0 | 150 |

1. Only 50 ML can be carried over as carryover is limited to 1 ML/unit share. The remaining 25 ML is forfeited.
2. Although there is 50 ML in the account, only 25 ML is available for extraction as the maximum extraction over three years is limited to 3 ML/unit share or 150 ML over years 2, 3 and 4.