Lake Vermont Meadowbrook Project EIS

Rehabilitated Pit Water Balance

Bowen Basin Coal Pty Ltd

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1 Introduction

1.1 BACKGROUND

The ‘Lake Vermont Meadowbrook Project’ (the Project) is a proposed extension of the existing Lake Vermont Coal Mine, proposed by Bowen Basin Coal Pty Ltd. The Project is located approximately 25 kilometres northeast of Dysart and approximately 160 kilometres southwest of Mackay, within central Queensland. It involves the construction and operation of an underground multiseam longwall coal mine and an open-cut pit and supporting infrastructure to produce pulverised coal injection (PCI) and coking coal, primarily for export. The proposed project layout is shown in Figure 1.1. The open-cut operation would commence operations in Project Year 20 (indicatively 2045) with a partially backfilled pit (to provide a post mining land use) at the conclusion of mining.

Bowen Basin Coal commissioned WRM Water & Environment to undertake the surface water impact assessment for the Meadowbrook Coal Mine to support the Environmental Impact Statement. This report outlines the long-term water balance of the rehabilitated pit.

1.2 SCOPE OF THIS STUDY

This report outlines the methodology and findings of the final void (rehabilitated pit landform) water balance investigations, including:

- description of the rehabilitated landform’s post-closure flood risk;
- description of the catchment of the rehabilitated depression;
- assessment of the expected behaviour of water captured in the rehabilitated depression (water and salt balances to determine the temporal variation in stored water volume, quality and equilibrium water level (including fill time and likelihood of overflow)); and
- assessment of the long-term contribution of groundwater and the potential for seepage from the rehabilitated pit to alluvial aquifers based on inputs from the groundwater assessment (JBT Consulting).

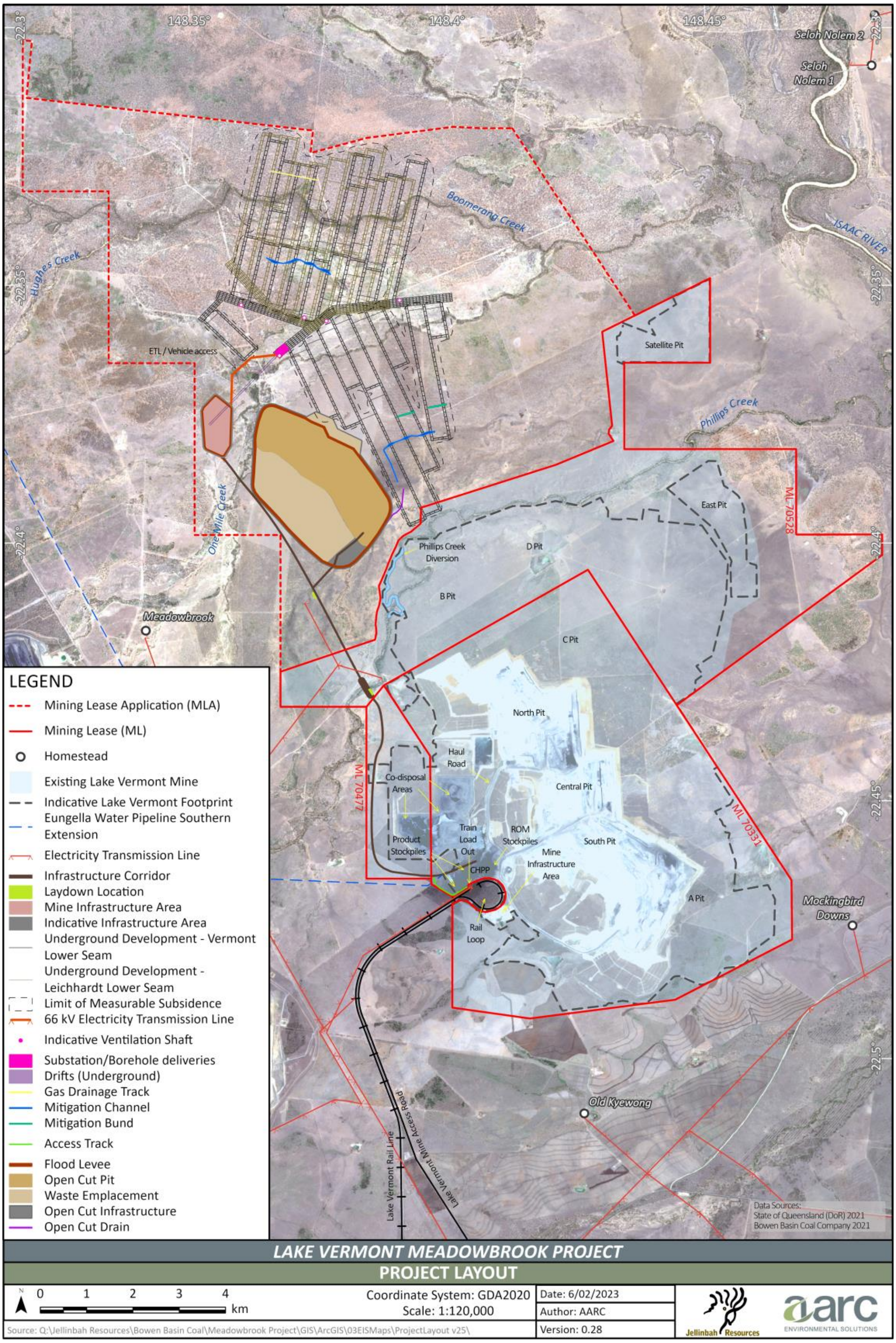

Figure 1.1 – Project layout

2 Rehabilitated landform configuration

2.1 PROPOSED LANDFORM

The proposed open cut mining method would involve initially developing a pit in the southeastern corner of the mining area on the northern Phillips Creek floodplain. Initially, waste-rock would be placed in an out-of-pit stockpile to the southwest of the pit. Mining would then proceed in a northwesterly direction, with waste rock then being placed in-pit to re-establish pre-mining ground levels in the Phillips Creek floodplain. Mining would later commence at the northwestern end of the mining area on the edge of the One Mile Creek floodplain and proceed southeast so that the final mine pit would be located in the high ground between the two floodplains.

The proposed rehabilitated final landform in Figure 2.1 shows the pit shell would be partially backfilled, leaving a surface depression at the final location of the open cut pit. The floor of the backfilled depression is designed at approximately 160 mAHD – which is above the regional groundwater level.

The waste rock placed in the pit shell will be relatively pervious and provide a preferential source of groundwater recharge. After mining, rainfall and runoff would seep into the in-pit spoil within the pit shell.

Following prolonged rainfall, water would occasionally accumulate in the lowest parts of the landform before seeping through the spoil forming the floor of the depression. The seepage water would fill the interstitial pore space in the underlying waste rock and recharge the regional groundwater.

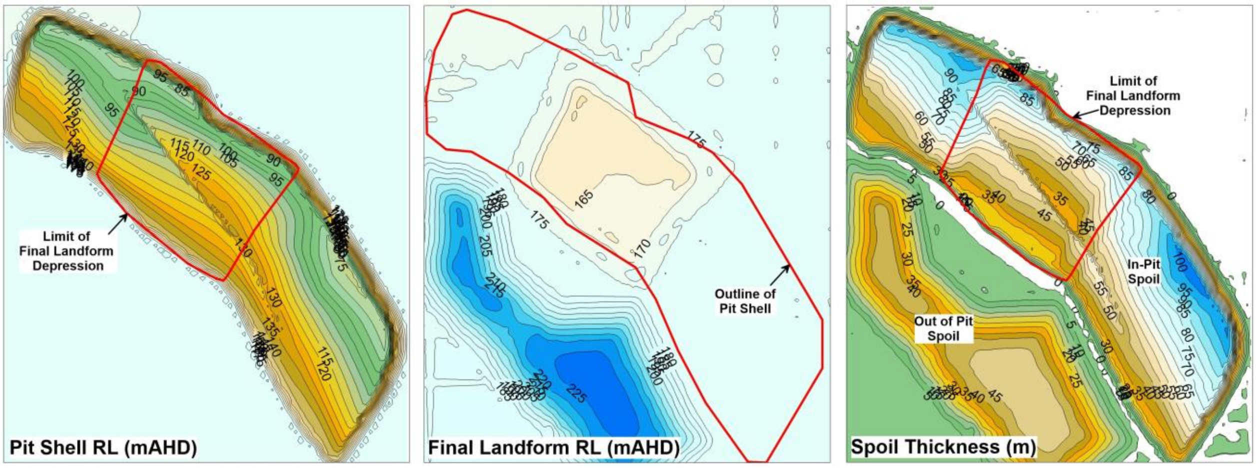

Figure 2.1 – Final landform depression catchments and land use (source: JBT, 2022)

2.2 WATER STORAGE CHARACTERISTICS

Table 2.1 shows key characteristics of the proposed final pit landform. After backfilling, the landform would have a floor level at approximately 160 mAHD, and a total depth of approximately 15 m to the overflow point at around 175 mAHD near the eastern corner. The total potential water storage capacity is significant, with up to approximately 9 GL of surface water storage (excluding the interstitial pore space in the adjoining waste rock) available above the backfilled surface to the overflow level.

Table 2.1 – Final landform water storage capacities

Depth (m)	Spill level (mAHD)	Potential surface water storage capacity (ML)
15	175	9,000

Stage-storage characteristics were derived from the preliminary landform design. The adopted level-storage and level-area characteristics presented in Figure 2.2 were used in the water balance model to estimate water level and surface area from stored water volume.

The rehabilitated pit shell storage vs elevation curve was modified to include additional spoil storage based on a spoil storage vs elevation relationship for the pit shell provided by JBT consulting, assuming the porosity of the adjacent spoil would be 25%.

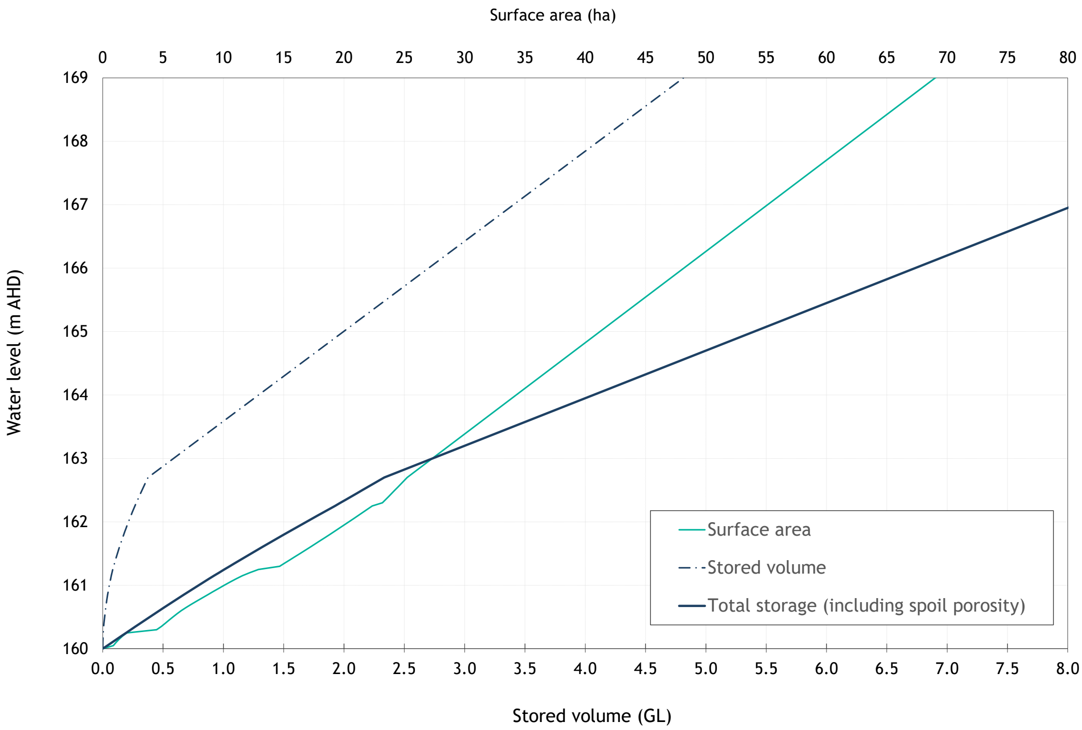

Figure 2.2 – Rehabilitated depression water storage curves

2.3 GROUNDWATER ENVIRONMENT

Groundwater modelling undertaken for the groundwater impact assessment (JBT, 2022) predicts that groundwater levels will be temporarily reduced in the project areas during underground and open cut operations. The modelling predicts it will take over one hundred years for the local groundwater levels within the final pit landform to return to regional groundwater levels. The relevant findings of the groundwater impact assessment are as follows:

- Above the northern longwall panels the groundwater level recovers to ~80% of the final equilibrium level after approximately 200 years, and to ~95% of the final equilibrium level after approximately 270 years. The final predicted equilibrium groundwater elevation in this area is ~161 mAHD, i.e., approximately 1.5 m above the pre-mining water level for both the Leichhardt and Vermont Seams in the central area of the northern longwall panels.

- Above the southern longwall panels the groundwater level recovers to ~80% of the final equilibrium level after approximately 120 years and to ~95% of the final equilibrium level after approximately 135 years. The final predicted equilibrium groundwater elevation in this area is ~160.5 mAHD, i.e., approximately 2.5 m lower than the predicted elevation of water in the base of the final landform depression and approximately 2.3 m above the pre-mining water level for both the Leichhardt and Vermont Seams in the central area of the southern longwall panels.

The final landform design was developed to ensure that even after the underlying groundwater level recovers to the maximum predicted level, the depression would remain a source of groundwater recharge, and would not receive seepage from the regional groundwater. This ensures the accumulating volumes of water and concentrations of salts are minimised.

2.4 CATCHMENT CHARACTERISTICS

Runoff from highwall areas would drain naturally away, so that (as illustrated in Figure 2.3) catchment areas flowing to the final pit landform would be limited to areas of the depression itself and the rehabilitated overburden in its immediate vicinity. The rehabilitated out-of-pit spoil would be shaped to minimise the size of the out-of-pit catchment draining to the base of the depression.

For runoff modelling purposes, the entire catchment draining to the final pit landform (175 ha) was assumed to be rehabilitated spoil material. Details of the runoff modelling approach are provided in section 3.4.1.

Infiltration through the waste rock would seep vertically until it reaches the underlying groundwater surface. Groundwater inflows to the backfilled pit and residual depression were assessed separately as part of the groundwater impact assessment studies which included allowance for enhanced infiltration through the waste rock.

2.5 GEOCHEMICAL CHARACTERISTICS OF SPOIL RUNOFF

Weathering processes result in the dissolution of soluble minerals, partial dissolution of lower solubility minerals (mineral weathering), cation exchange, and reaction. Mining activities increase the hydraulic conductivity and surface area of naturally occurring materials, resulting in a body of waste rock more prone to leaching.

Previous waste characterisation assessments (AARC, 2013 and AARC, 2014) described the Lake Vermont overburden as being typical of that overlying the Rangal coal measures. The waste rock predominantly comprises weathered and unweathered Permo-Triassic sediments, containing approximately equal proportions of greyish-green sandstones, siltstones and mudstones. The Rewan Formation was deposited in an upper fluvial environment, with no marine influence. Sulphide is rarely detected, and while the coal seams do contain minor pyrite nodules, this material is not associated with the mine waste, so the risk of acid forming has been assessed as low, and no such issues have been reported during operations so far.

The Geochemical Assessment of Mining Waste Materials Project (RGS, 2021) indicates waste rock at the Meadowbrook project would have similar characteristics at the existing operation, with:

- low sulfur content, excess acid neutralising capacity, negligible risk of acid generation and a high factor of safety with respect to potential for the generation of acidity;
- no significant metal/metalloid enrichment compared to median crustal abundance in unmineralised soils;
- slightly alkaline to alkaline surface runoff and seepage with relatively low salinity; and
- low dissolved metal/metalloid concentrations in surface runoff and leachate.

The water extract solutions were generally dominated by ions of sodium, chloride and sulfate with lesser concentrations of other major ions.

2.6 FLOOD RISK

The site is located to the west of the Isaac River between the floodplains of Phillips Creek (to the south) and One Mile Creek (to the north). The flood study prepared for the project (WRM, 2022), shows that under existing conditions, a portion of the proposed rehabilitated pit footprint would be crossed by shallow floodplain flows from the northern Phillips Creek floodplain to One Mile Creek (refer Figure 2.3 which shows the depth of inundation in the 0.1% AEP design flood). The final landform would be shaped to ensure floodwaters are excluded from the residual depression of the rehabilitated pit.

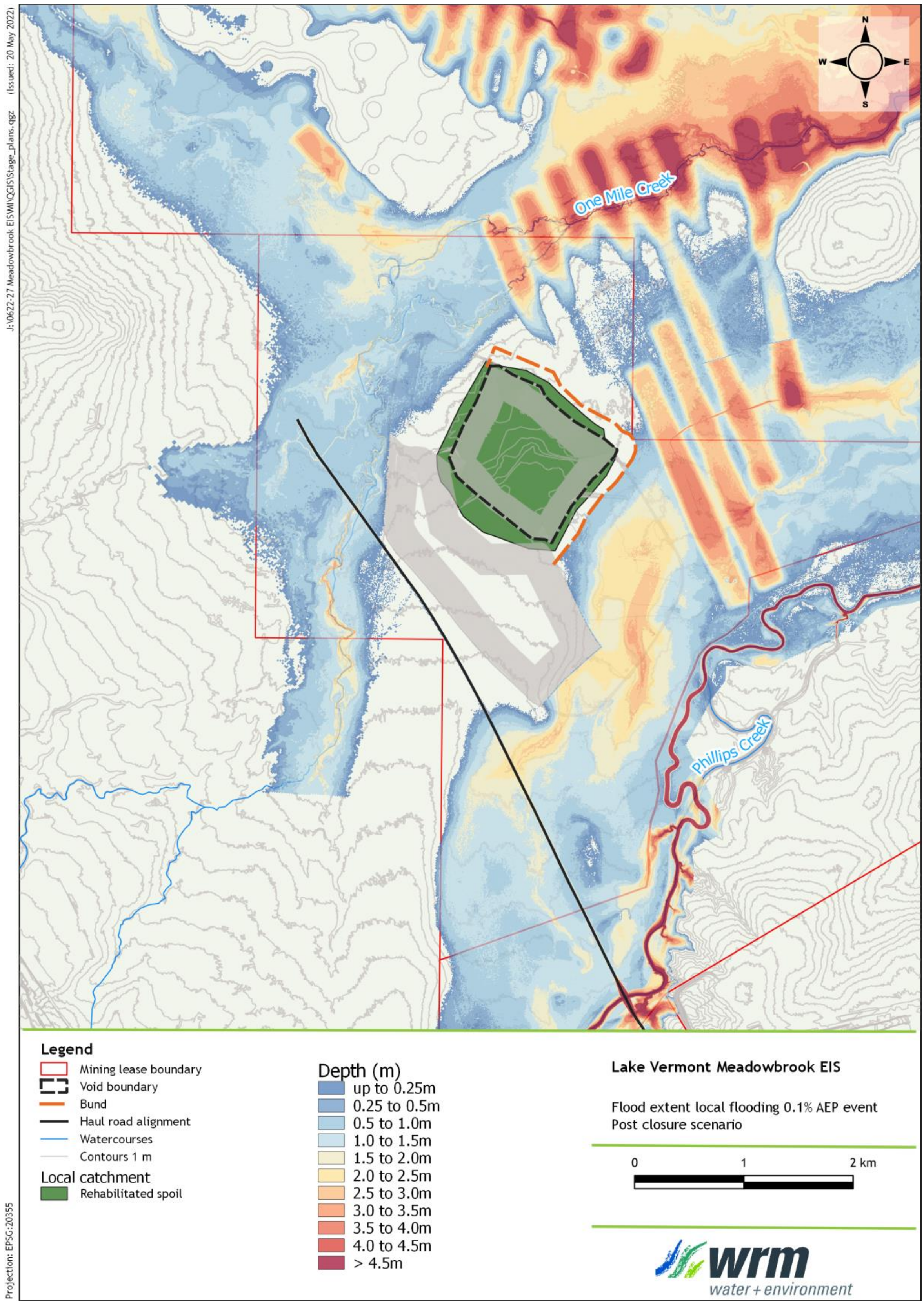

Figure 2.3 – Flood extent – 0.1% AEP event

3 Methodology

3.1 CONCEPTUAL MODEL

The water levels in the residual depression following pit rehabilitation will vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff, and groundwater.

Figure 3.1 shows the conceptual model developed for the analysis. The key components are:

- rainfall, including direct rainfall to the rehabilitated pit depression;
- evaporation from the rehabilitated pit depression;
- evapotranspiration and runoff generation from the catchments;
- outflows to the regional groundwater level; and
- salt fluxes in each component of flow – and a simple conservative solute balance.

The figure shows that key water inputs include rainfall on the rehabilitated pit depression, runoff from rehabilitated pit faces and rehabilitated upstream catchment areas. The landform would be configured to mostly shed water away from the depression, with some rainfall infiltrating through the in-pit waste rock. Infiltration through the waste rock would seep vertically until it reaches the underlying groundwater surface. Groundwater inflows to the backfilled pit were modelled separately as part of the groundwater impact assessment studies which included allowance for enhanced infiltration through the waste rock. The landform was designed on the basis of the groundwater modelling to ensure there would be no groundwater inflows to the residual depression after levels recover.

Outflows are limited to evaporation and seepage losses to the surrounding aquifer. Water accumulating in the pit depression would also infiltrate into the adjacent waste rock, creating additional water storage in this ‘spoil aquifer’. The rehabilitated pit shell storage vs elevation curve was modified to include additional spoil storage based on a spoil storage vs elevation relationship for the pit shell provided by JBT consulting, assuming the porosity of the adjacent spoil would be 25%.

The focus of the water quality assessment is the potential for salt accumulation within the residual depression (or final pit landform). Sources of salt include catchment runoff. It is anticipated that excess water and dissolved salt would seep from the proposed landform into the spoil under and adjacent to the pit landform. Seepage to the groundwater results in the removal of salt from the surface water system, and thus, if seepage outflow rates are sufficiently high, salts would not accumulate in surface water over time.

In principle, for an initially empty depression, water is expected to accumulate until evaporative losses from the wetted surface area balance the combined influence of catchment runoff, rainfall and groundwater interception. Where catchment inflows are limited, over a sufficiently long timescale, water levels are expected to reach a nominal steady state, with some variation about the steady state level during prolonged periods of wet or dry climate bias. This principle works in reverse for any depression that is filled (e.g. by pumping) above the steady state level prior to relinquishment; water levels will reduce due to evaporation until the wetted surface contracts to a point where evaporative losses balance inflows.

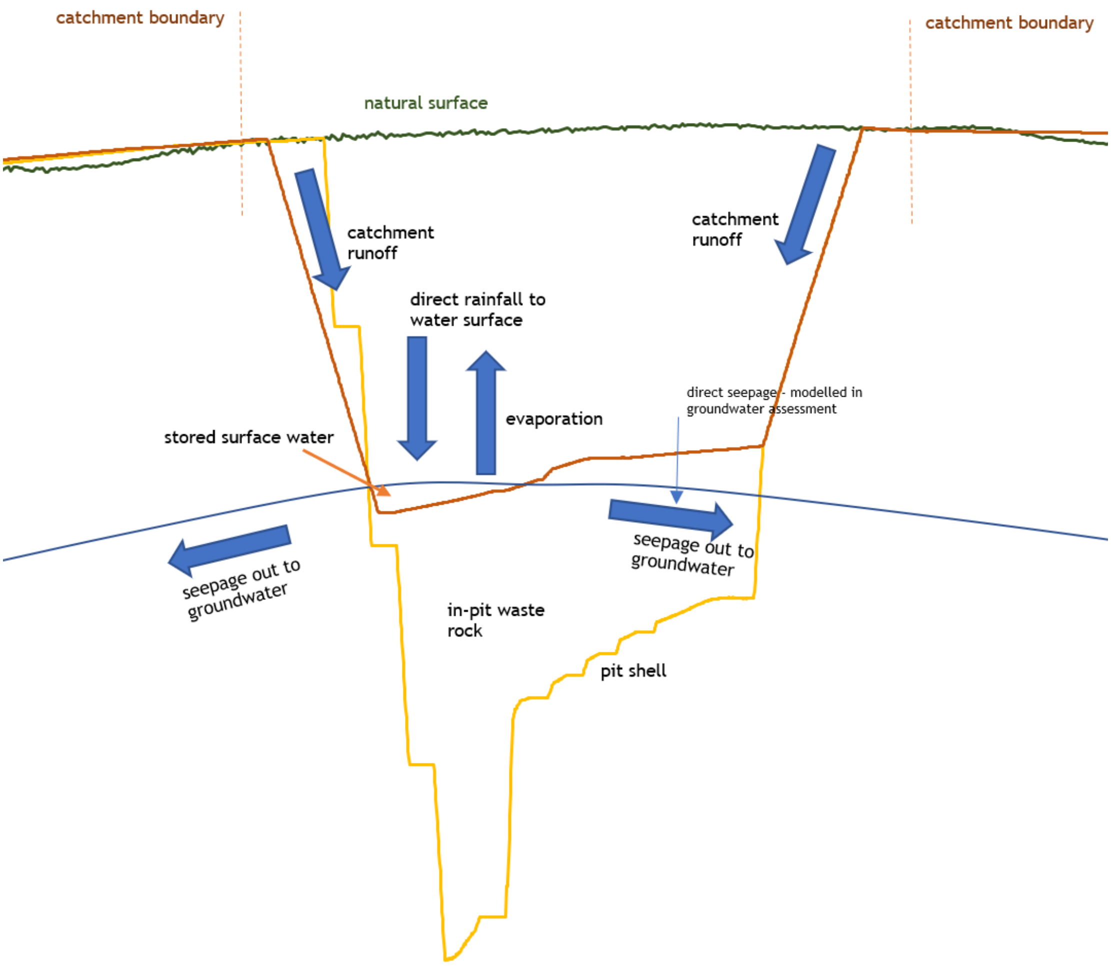

Figure 3.1 – Conceptual surface water model of rehabilitated pit landform (typical cross-section)

3.2 NUMERICAL MODELLING APPROACH

Final water levels in the rehabilitated pit depression have been simulated using a GoldSim water balance simulation model. The model runs on a daily timestep and uses historical climate data as input to generate daily surface water inflows and evaporative losses from the residual depression.

The potential effects of climate change were assessed using climate-change adjusted SILO climate data developed as part of the Consistent Climate Scenarios (CCS) project by the Queensland Government's Department of Environment and Science (DES).

The volume of water in the rehabilitated pit depression is calculated in each time step as the sum of direct rainfall, catchment runoff less evaporation and groundwater seepage losses.

To model changes over long timeframes, the simulation was run using an extended climate dataset created by extracting the first 700 years of a repeated 132-year sequence of SILO climate data (from 1889 to 2020).

3.3 CLIMATE DATA

Water levels in the final pit landform will vary depending on the prevailing climatic conditions, and the balance between evaporation and seepage losses and inflows from rainfall, and surface runoff.

3.3.1 Existing climate

Long term daily rainfall and evaporation data for the area from January 1889 to December 2020 (132 years) was obtained from SILO (latitude: -22.45 longitude: 148.40 https://www.longpaddock.qld.gov.au/silo/). This data set is corrected for accumulated daily rainfall totals and missing data and is well suited to use in water balance modelling.

Average annual rainfall is 583 mm/a and average annual (pan) evaporation is 2,061 mm/a. Annual rainfall is presented in Figure 3.2. Monthly average rainfall and evaporation are shown in Figure 3.3.

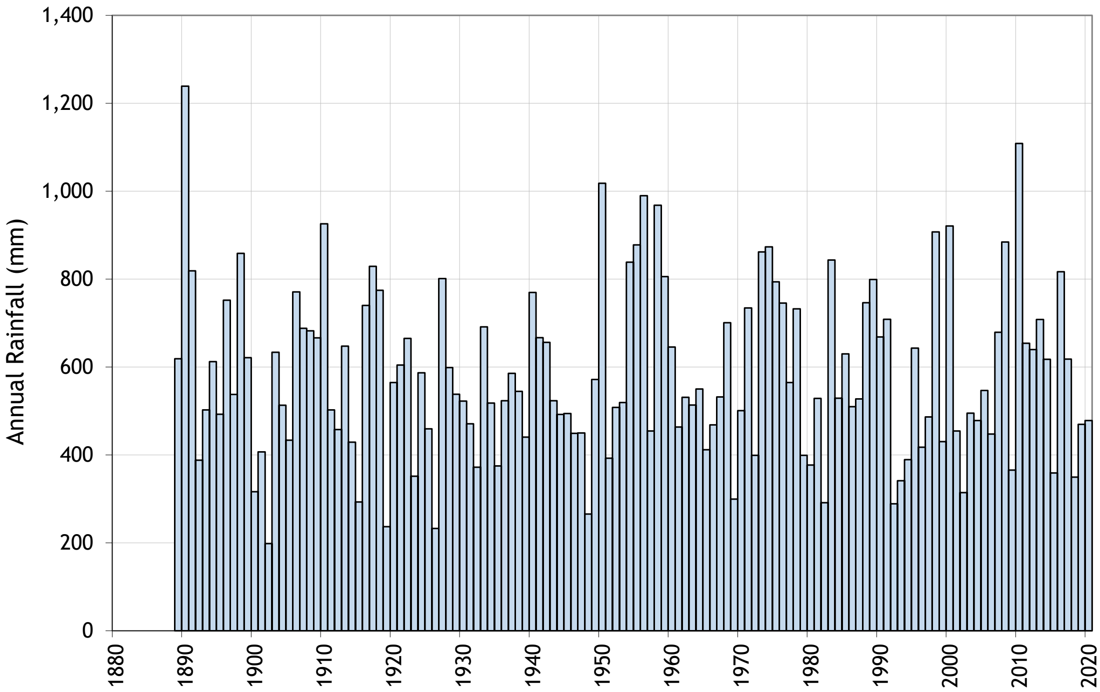

Figure 3.2 – Lake Vermont long-term annual rainfall (SILO)

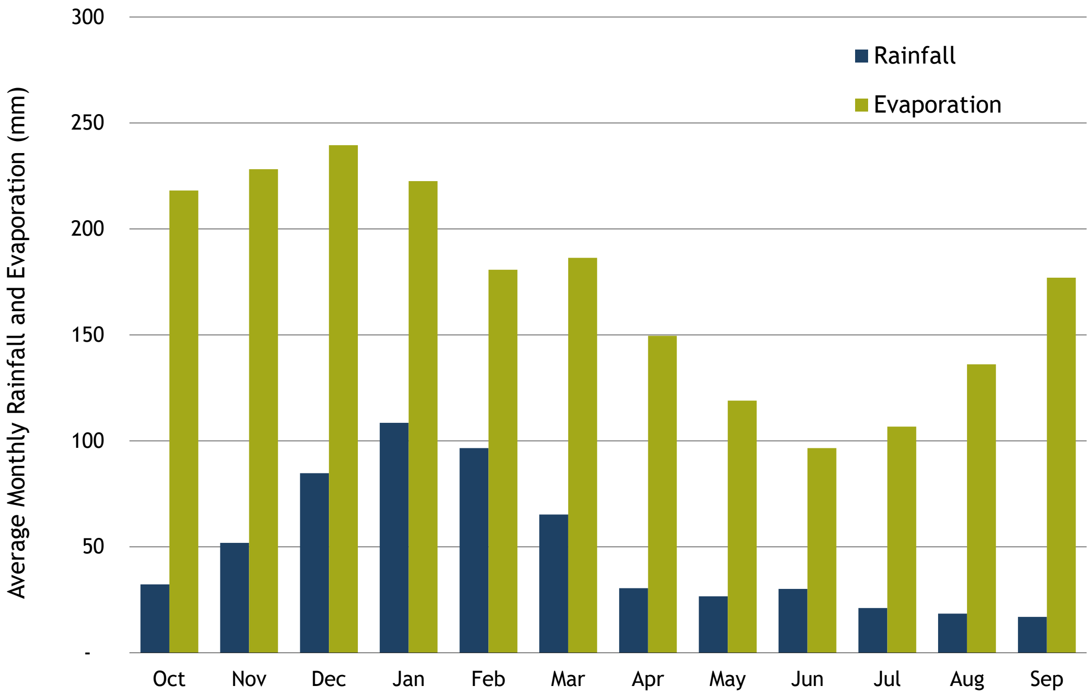

Figure 3.3 – Lake Vermont average monthly rainfall and evaporation (SILO Data)

3.3.2 Future climate

Climate-change adjusted SILO climate data are available from the Queensland Government Department of Environment and Science (DES) and were developed as part of the Consistent Climate Scenarios (CCS) project. The CCS project hosts data from 19 separate global climate models (GCMs), which explore four emissions scenarios, three timing horizons and three climate warming sensitivities. The nineteen separate models can be split into four Representative Future Climate (RFC) partitions, defined below:

- HI: a high level of global warming, where the Eastern Indian Ocean (EIO) warms faster than the Western Pacific Ocean (WPO);
- HP: a high level of global warming, where the WPO warms faster than the EIO;
- WI: a low level of global warming, where the EIO warms faster than the WPO; and
- WP: a low level of global warming, where the WPO warms faster than the EIO.

Figure 3.4 is an excerpt from the CCS project user guide (DSITIA, 2015) showing the four RFC quadrants, component models and indicative rainfall trends. The caption associated with the original version of this figure has been reproduced as a footnote[1].

Data based on the mean result of all models within each RFC quadrant is offered by the CCS for applications where considering the output of all 19 models is not feasible/practical. This approach has been followed for the purposes of assessing climate change sensitivity as part of current investigations. Table 3.1 and Table 3.2 list the percentage change in evaporation and rainfall respectively, based on mean output for the four RFC quadrants. Data is based on the most conservative carbon emission rate (RCP8.5) available in the CCS dataset, and expected climate as at 2070. Data has been listed for the low, medium and high sensitivities. Information is for the Lake Vermont Mine location.

The adjustments listed in Table 3.1 and Table 3.2 have been applied to the long-term SILO daily climate time-series and passed through the AWBM rainfall runoff sub-model to produce daily estimates of runoff (rehabilitated land use AWBM parameter set used). Annual average runoff depths have been plotted against average annual net evaporation depths (evaporation minus rainfall) in Figure 3.5 to illustrate the potential to impact on long-term water levels in the rehabilitated pit landform for the Project. Note the naming convention used in the figure, and henceforth in this document, is XX.Y where XX is the scenario (e.g. HI) and Y is the sensitivity (medium).

Figure 3.5 shows that all scenarios predict increases in net evaporation, and that all scenarios except the WP scenarios predict reductions in runoff. It is evident that all scenarios will result in lower final water levels than the base case scenario. The sensitivity of water levels to changes in the future climate have been assessed by modelling all the above scenarios.

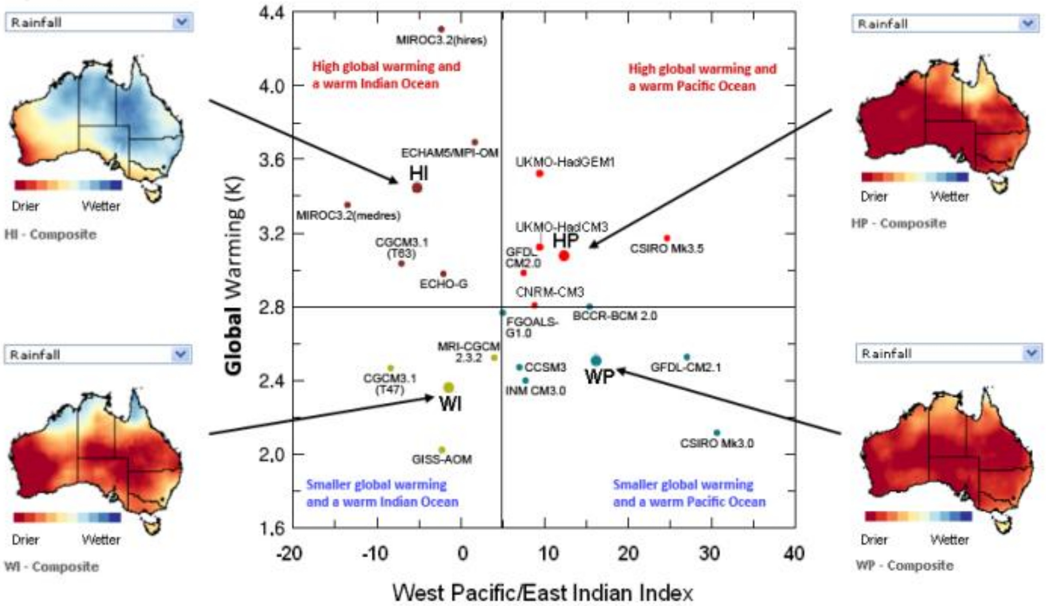

Figure 3.4 – A partition of Global Climate Models for future climate using global warming sensitivity and ocean warming indices (source: DSITIA, 2015)

[1] From DSITIA, 2015 – Figure 8.1 (verbatim): A partition of CMIP3 Global Climate Models (GCMs) for future climate using global warming sensitivity and ocean warming indices (adapted from Watterson, 2011). Values for nineteen individual GCMs (forced by the SRES A1B emissions scenario) are represented by the small dots and labelled by their GCM model code (Table 8.2). The central horizontal and vertical lines separate the four Representative Future Climate (RFC) partitions. The larger dots indicate the CCS composite means for GCMs within each of the four RFC responses: (HI) high global warming and a warmer Indian Ocean; (HP) high global warming and a warmer Pacific Ocean; (WI) lower global warming and a warmer Indian Ocean and (WP) lower global warming and a warmer Pacific Ocean. The maps show projected 21st Century changes in rainfall for the GCMs clustered in each of the four (HI, HP, WI and WP) RFC partitions.

Table 3.1 – Percentage change in evaporation by model and sensitivity

Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	17.3	18.1	20.9	12.8	12.2	10.2	8.3	6.7	11.2	11.6	17.0	11.8	12.9
HI (med)	10.7	11.2	12.9	8.0	7.5	6.0	5.0	4.0	7.0	7.3	10.7	7.3	7.6
HI (low)	5.8	6.1	6.9	4.3	4.0	3.1	2.6	2.1	3.8	4.0	5.9	4.0	3.7
HP (high)	18.9	19.0	19.8	15.9	16.2	17.3	13.4	14.2	14.3	15.7	15.4	14.8	15.4
HP (med)	11.9	11.9	12.4	10.0	10.2	10.8	8.3	8.9	9.0	10.0	9.8	9.4	9.4
HP (low)	6.6	6.5	6.8	5.4	5.6	5.9	4.5	4.9	5.0	5.5	5.4	5.2	4.8
WI (high)	16.7	16.1	12.7	8.8	7.8	10.3	10.8	7.6	10.2	8.0	9.9	11.8	10.3
WI (med)	10.5	10.1	7.9	5.4	4.7	6.2	6.6	4.6	6.4	4.9	6.2	7.4	6.1
WI (low)	5.8	5.5	4.2	2.9	2.4	3.3	3.5	2.4	3.5	2.7	3.4	4.1	2.9
WP (high)	30.4	16.7	23.0	21.0	25.0	18.5	14.5	10.5	10.2	15.0	20.9	14.0	17.5
WP (med)	19.1	10.3	14.4	13.3	15.7	11.3	8.8	6.4	6.3	9.4	13.2	8.7	10.6
WP (low)	10.5	5.6	7.9	7.3	8.6	6.0	4.7	3.4	3.4	5.2	7.3	4.7	5.4

Note: * model is RFC partition, text in brackets is the sensitivity

Table 3.2 – Percentage change in rainfall by model and sensitivity

Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	-20.9	16.6	-6.8	-51.5	49.0	-39.7	2.4	8.6	-6.6	-10.6	-46.4	0.7	-8.3
HI (med)	-14.0	11.1	-4.6	-34.5	32.9	-26.6	1.6	5.8	-4.4	-7.1	-31.1	0.5	-5.6
HI (low)	-8.1	6.5	-2.6	-20.0	19.1	-15.5	0.9	3.3	-2.5	-4.1	-18.0	0.3	-3.2
HP (high)	-11.9	-14.5	3.5	-15.9	-35.1	-34.8	-20.3	-34.3	-46.2	-61.4	-46.7	-30.3	-24.6
HP (med)	-8.0	-9.8	2.4	-10.6	-23.5	-23.3	-13.6	-23.0	-31.0	-41.2	-31.3	-20.3	-16.5
HP (low)	-4.6	-5.7	1.4	-6.2	-13.6	-13.5	-7.9	-13.3	-18.0	-23.9	-18.2	-11.8	-9.6
WI (high)	-13.8	-3.5	6.4	-3.8	-2.2	-14.8	-3.0	-1.9	-12.4	-9.9	-22.8	-20.3	-9.8
WI (med)	-9.3	-2.4	4.3	-2.5	-1.5	-10.0	-2.0	-1.3	-8.3	-6.6	-15.3	-13.6	-6.6
WI (low)	-5.4	-1.4	2.5	-1.5	-0.9	-5.8	-1.2	-0.7	-4.8	-3.8	-8.9	-7.9	-3.8
WP (high)	-9.3	16.3	-0.6	-15.0	-72.0	21.4	-5.1	54.8	8.9	-26.0	-39.1	13.3	-4.5
WP (med)	-6.2	10.9	-0.4	-10.0	-48.3	14.4	-3.4	36.7	6.0	-17.4	-26.2	8.9	-3.0
WP (low)	-3.6	6.3	-0.2	-5.8	-28.0	8.3	-2.0	21.3	3.5	-10.1	-15.2	5.2	-1.7

Note: * model is RFC partition, text in brackets is the sensitivity

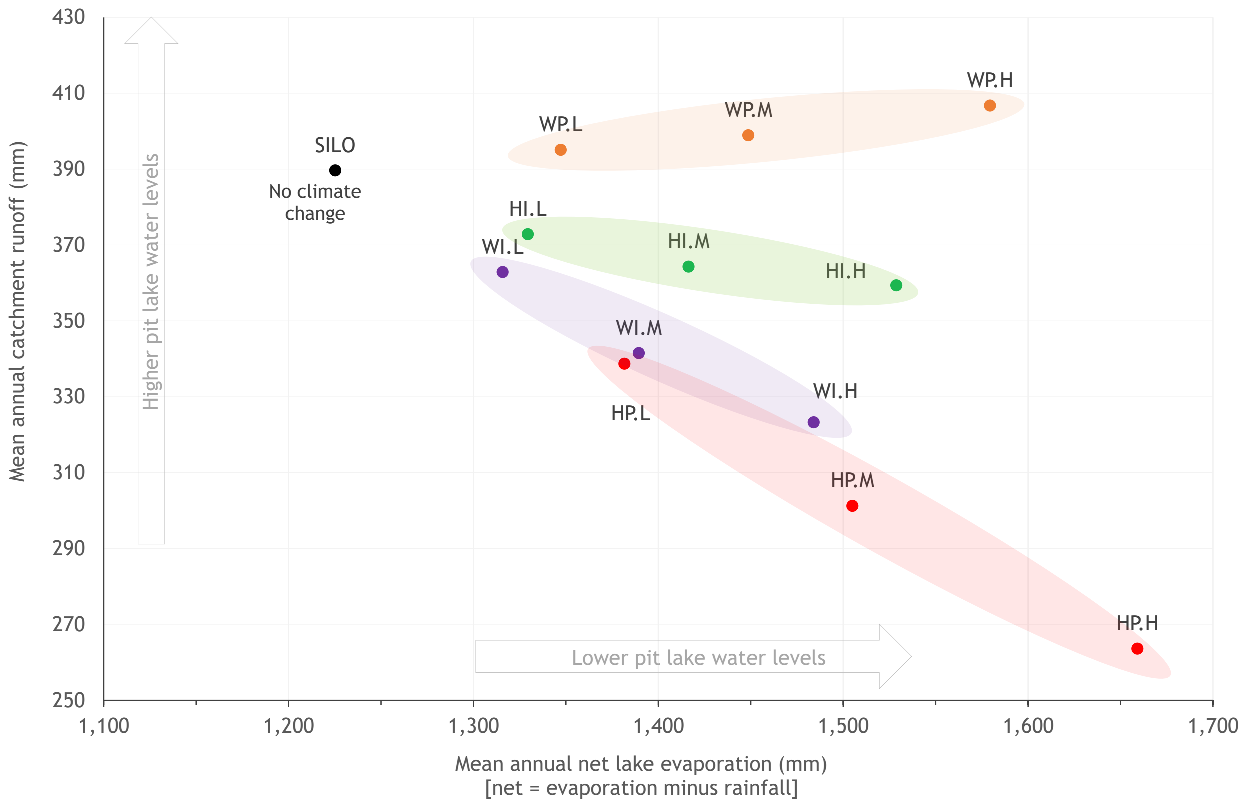

Figure 3.5 – Plot of net evaporation versus runoff for HI, HP, WI and WP GCM groupings

3.4 MODEL DETAILS

3.4.1 Catchment runoff model

The GoldSim model of the residual depression post rehabilitation incorporates the Australian Water Balance Model (AWBM) (Boughton and Chiew, 2003) to estimate daily runoff from daily rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff.

The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evapotranspiration. Simulated surface runoff occurs when the storages fill and overflow. Figure 3.6 shows the conceptual configuration of the AWBM model.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying the contributing catchment area.

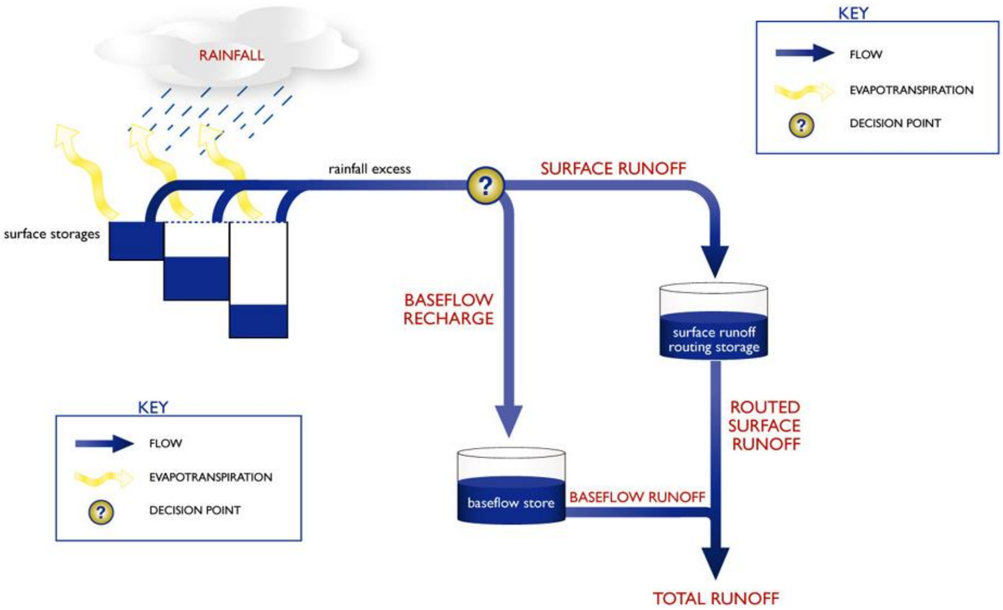

Figure 3.6 – AWBM model configuration

At each time step, the AWBM performs the following calculations:

Rainfall is added to each of the 3 surface moisture stores and evapotranspiration is subtracted from each store. The water balance equation is:

$$store_n = store_n + rain - evap \ (n = 1 \text{ to } 3).$$

If the value of moisture in the store becomes negative, it is reset to zero. If the value of moisture in the store exceeds the capacity of the store, the moisture in excess of capacity becomes runoff and the store is reset to the capacity.

When runoff occurs from any store, part of the runoff becomes recharge of the baseflow store. The fraction of the runoff used to recharge the baseflow store is BFI*runoff, where BFI is the baseflow index.

The remainder of the runoff, i.e. (1.0 - BFI)*runoff, is surface runoff.

The baseflow store is depleted at the rate of (1.0 - K)*BS where BS is the current moisture in the baseflow store and K is the baseflow recession constant of the time step being used (daily).

The surface runoff can be routed through a store if required to simulate the delay of surface runoff reaching the outlet of a medium to large catchment. The surface store acts in the same way as the baseflow store and is depleted at the rate of (1.0 - KS)*SS, where SS is the current moisture in the surface runoff store and KS is the surface runoff recession constant of the time step being used.

The model parameters define the storage depths, the proportion of the catchment represented by each of the storages, and the rate of flux between them (Boughton and Chiew, 2003).

The AWBM model parameters were selected for consistency with a model prepared for the existing operation. The model has been calibrated to observed stored water volumes in the Mine Water and Stormwater Management Systems.

The model divides the different land use types into separate model runoff sources. The adopted parameters and long-term runoff coefficients for each of the catchment land use types are presented in Table 3.3.

The surface runoff catchment area draining to the rehabilitated pit landform was determined based on the preliminary final landform design. The following land use assumptions were adopted:

- All overburden dumps and cleared areas within the catchment of the rehabilitated pit landform will be rehabilitated and revegetated after cessation of mining.
- All rehabilitated catchments will naturally revert toward pre-disturbed conditions over time (as vegetation matures and topsoil weathering and consolidation takes place).
- Waste rock emplacements adjacent to the rehabilitated pit depression will be constructed to drain runoff and seepage away from the depression.
- Direct rainfall onto the pond surface was modelled with no losses and zero salinity.

Table 3.3 – Adopted pit depression catchment AWBM parameters

Parameter	Rehabilitated Spoil
A1	0.134
A2	0.433
C1 (mm)	6
C2 (mm)	58
C3 (mm)	116
BFI	0.39
K_b	0.993
K_s	0
Average Annual Volumetric Runoff Co-efficient	**11.8%**

3.4.2 Evaporation and evapotranspiration

Evaporation from the water surface of the pit depression was modelled using estimates of Morton's Lake evaporation.

The reduced evaporation resulting from shading and wind shielding provided by the pit walls was modelled using an adjustment factor referred to herein as the 'pit factor'. A linearly varying depth-dependent storage evaporation factor has been applied the pit depression to simulate the change in evaporation as water levels increase. The storage evaporation factors are as follows:

- Pit factors are supported by the findings of ACARP Project No. C7007 (2001) which entailed development of a practical methodology for predicting the hydrology and water quality of final spoil-pit shell systems. The study proposed adopting typical pit factors of 0.56 for near-empty pits and 0.78 for near-full pits based on modelling undertaken at several mines in Queensland and NSW.
- As the proposed landform depression is relatively shallow with gentle slopes, the level of shading and sheltering will be less than for typical coal mine final voids. The adopted pit factor was 0.85. Daily estimates of Morton's Lake evaporation (obtained from SILO) were used for estimating evaporation from open water surfaces. The following factors, where applicable, were applied to evaporation rates for different surfaces.

Table 3.4 – Other evaporation factors

Factor	Value	Basis
Storage Factor	0.85	Reduction in evaporation in open cut pits due to lower wind effects and shading from pit walls.
Salinity Factor	$1/(1+Sx10^{-6})$	Reduction in evaporation due to salinity - using Morton's relationship* – i.e. $E'=E/(1+Sx10^{-6})$ – where S is salinity in parts per million

*Morton et al, 1985

3.4.3 Groundwater inflows and seepage outflows

The results of groundwater modelling undertaken for the project groundwater impact assessment (JBT, 2022) concluded that (including allowance for seepage from the catchment and water ponded in the final landform depression) post-mining recovery of groundwater to equilibrium levels (approximately 161 m AHD and 160.5 mAHD above the northern and southern longwall panels respectively, i.e. just above the adopted base level of the final landform depression) would take about 135 years to 270 years.

During this period, water would seep from the landform to the rising groundwater table. The equilibrium groundwater flow potential would be towards the final landform at very shallow gradients. Once the groundwater reaches an equilibrium level, seepage from the final landform depression would result in mounding of groundwater below the landform, with the groundwater flow potential being away from the depression.

The final landform design is such that the floor of the depression would be above 160 mAHD. As a result, there would be no groundwater inflows to the final landform depression and water can be assumed to always seep away into the underlying spoil and regional groundwater.

In the period prior to recovery of groundwater levels (assumed as 150 years for modelling purposes), water was assumed to seep into the underlying spoil at a rate of 100 mm/d over the daily pond surface area. Based on the groundwater modelling results, a maximum seepage rate of 1.8 L/s was applied to the above seepage rate post-groundwater recovery.

3.4.4 Runoff salinity

Runoff water salinities measured as Total Dissolved Salts (TDS) have been simulated to estimate water salinity within the final pit landform.

The salinity of water extracts from water quality static tests conducted for the waste characterisation studies (RGS, 2021) was typically low (from 107 to 1,040 µS/cm (median 529 µS/cm)). Observations of salinity in the north spoil dam and south spoil dam, which receive runoff from fresh waste rock, have been as low as 820 µScm following rainfall. This suggests (after allowing for the contribution of seepage, and the effect of evaporation) the median salinity of the water extracts (529 µS/cm) is reasonably representative of runoff salinity.

Prior to mine closure, the surface of the waste rock emplacement will be regraded, topsoiled and revegetated. These changes should result in improved surface runoff quality. In the long-term, leaching of salts from the root zone, should result in runoff salinities reducing to background levels. Water quality in Clean Water Dam South and the various sediment dams at the existing Lake Vermont Mine has been monitored for several years. Water stored in these dams immediately following rainfall is representative of the quality of runoff from areas not disturbed by mining activities. Typical values of EC at these times have been around 225 µS/cm, which is equivalent to TDS of approximately 145 mg/L.

To account for the uncertainty in long-term runoff salinity to the rehabilitated pit landform, the model was run under two (high and low) salinity scenarios, as described in Figure 3.7. The figure shows that for the high salinity case, the inflow salinity is initially 700 mg/L (1,075 µS/cm) and reduces at an exponential rate to 250 mg/L (385 µS/cm). For the low salinity case, the inflow salinity is initially 360 mg/L (550 µS/cm) and reduces at an exponential rate to 145 mg/L (223 µS/cm). The base case salinity curve is the average of the curves for the high and low scenarios.

The adopted rate of decay is similar to the rate of root zone salinity reduction recorded at monitored rehabilitation plots at the nearby Saraji Mine and reported in ACARP research (Grigg et al (Report C12043), 2005).

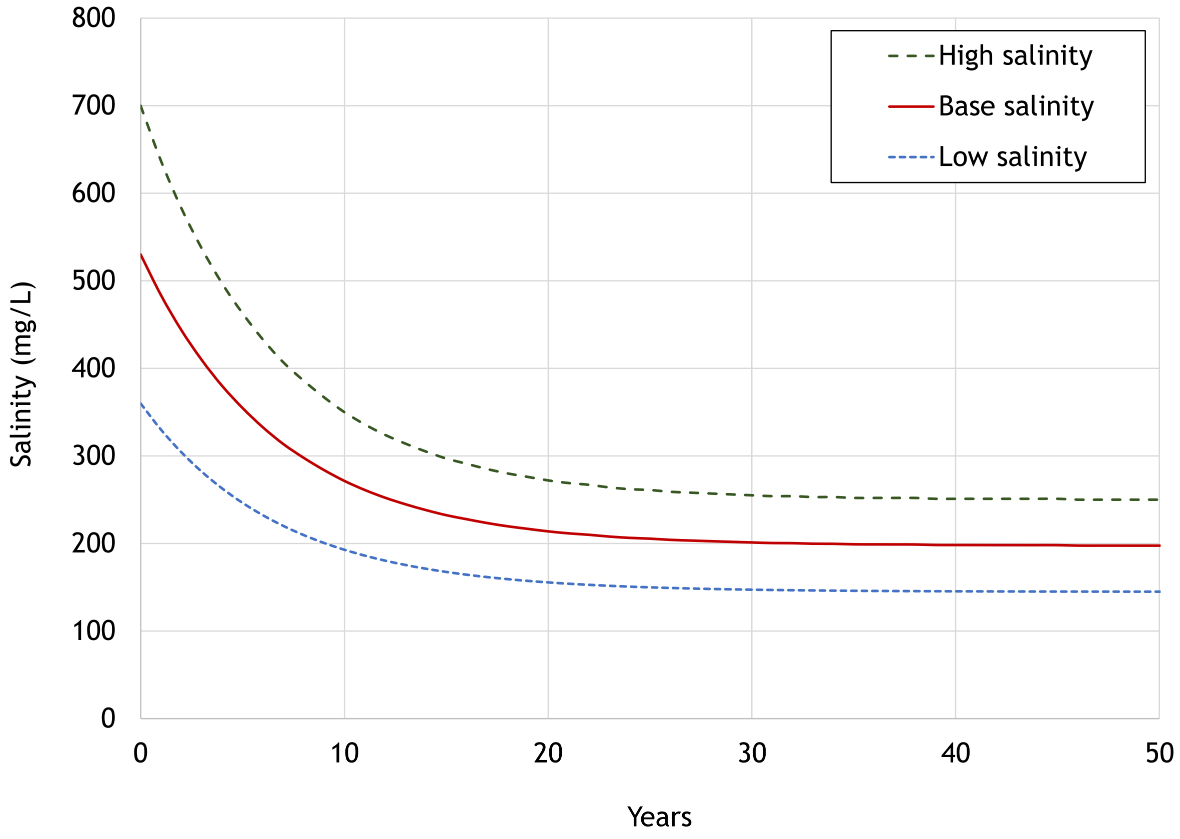

Figure 3.7 – Adopted inflow salinity scenarios

4 Results

4.1 LONG TERM WATER LEVEL BEHAVIOUR

The modelled long-term behaviour in the Meadowbrook rehabilitated pit landform is illustrated in Figure 4.1, which shows the simulated long-term water levels under all climate change scenarios.

Due to the relatively large surface of the rehabilitated pit floor, water levels in the depression are expected to rapidly reach equilibrium level and fluctuate within a 1.2 m range above the floor level, well below the overflow level of the rehabilitated pit landform. The WI.M scenario levels are closest to the average of all modelled climate scenarios, however, all climate scenarios yield very similar water levels.

Table 4.1 compares the simulated long term equilibrium water levels with the floor level and spill level of each residual depression. The results of the modelling show the modelled water levels were not sensitive to the seepage rate.

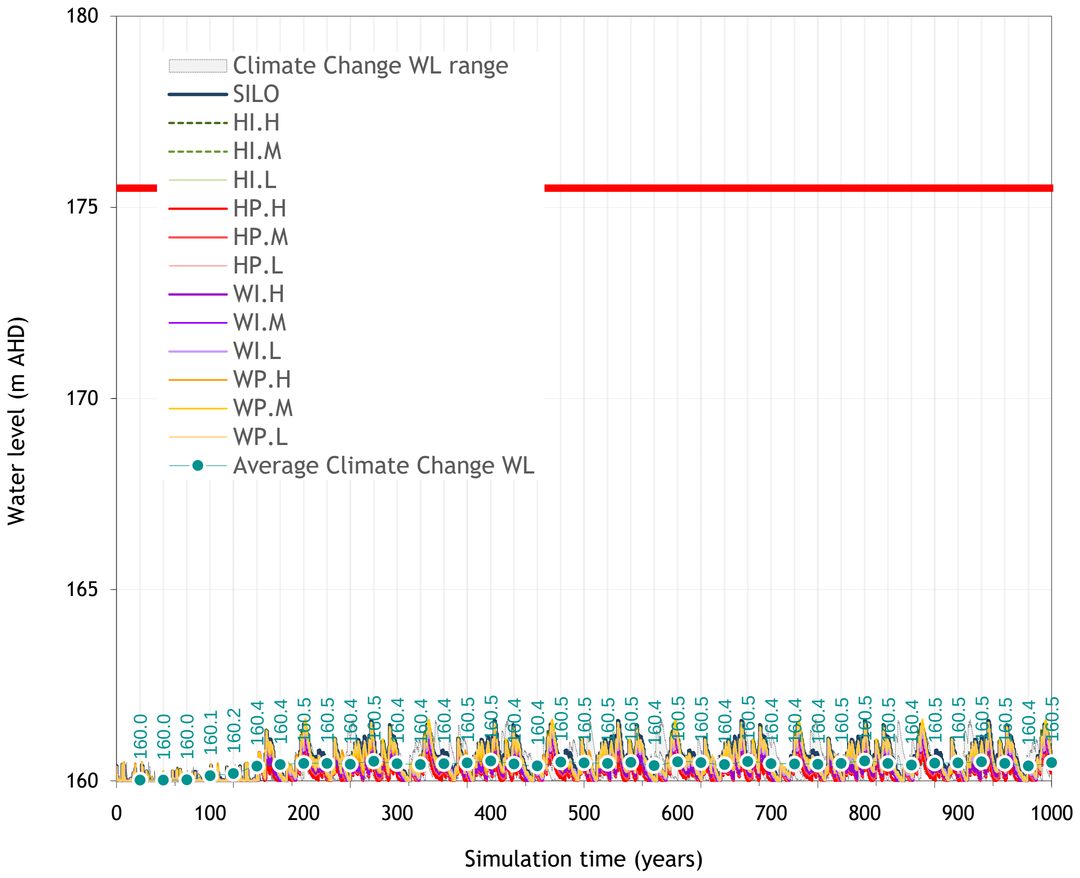

Figure 4.1 – Results of pit depression modelling

Table 4.1 – Final landform depression water storage behaviour

Scenario	Floor level (mAHD)	Spill level (mAHD)	Modelled pre GW recovery water level (min-average -max) (mAHD)	Modelled long-term water level range (all climate scenarios) (mAHD)
Low long-term seepage	160	175.5	160.0 -160.4-161.2	160.0 -160.6-161.5
Base long-term seepage	160	175.5	160.0 -160.4-161.2	160.0 -160.3-161.2
High long-term seepage	160	175.5	160.0 -160.4-161.2	160.0 -160.2-161.0

Table 4.2 summarises the simulated long-term water balance of the rehabilitated pit landform.

Table 4.2 – Overall rehabilitated pit landform water balance (under WI.M scenario - closest to average climate scenario)

Item	Flow (ML/a)		
	Low seepage (0.9 L/s max)	Base (1.8 L/s max)	High seepage (3.6 L/s max)
Inflows			
Direct Rainfall	31.7	21.3	10.2
Runoff	106.4	107.2	108.2
GW inflow	0	0	0
Outflows			
Pit waterbody evaporation	97.0	65.4	30.7
Seepage	41.2	65.7	96.4

4.2 SALINITY OF THE WATER PONDING IN THE REHABILITATED PIT LANDFORM

The modelled salinity is summarised in Table 4.3. As the rehabilitated pit landform water body would be relatively shallow, the salinity would fluctuate due to concentration with evaporation.

Catchment runoff inflows provide sources of dissolved salts but these are balanced by seepage outflows into the groundwater – resulting in relatively moderate salinities.

Table 4.3 – Modelled salinity TDS (mg/L)

Low salinity (min - median - max)	Base salinity (min - median - max)	High salinity (min - median - max)
144 – 270 – 552	197 – 362 – 751	249 – 465 – 950

5 Conclusions

The results of the rehabilitated landform water balance show that due to the limited surface catchment and seepage through the base of the depression, accumulated water volumes would be relatively small. The mean modelled surface water volume was 8 ML, ranging up to 80 ML following periods of the highest recorded rainfall. Significantly more water would be stored in the interstitial pore space in the adjacent waste rock.

With the proposed landform design, the stored water depth would be very shallow (of the order of up to 1.2 m above the floor level). Under all climate change scenarios modelled, the long-term water levels would remain around 15 m below the spill level and would not overflow.

Catchment runoff is likely to provide a diminishing source of dissolved salts, and as there will be no groundwater inflows, seepage to the underlying spoil would prevent the accumulation of dissolved salts in the final landform depression.

The salinity of surface water within the rehabilitated landform depression will fluctuate over a relatively moderate range, such that the modelled median TDS under low and high runoff salinity scenarios was 270 mg/L and 465 mg/L respectively (ranging up to 553 mg/L and 950 mg/L).

6 References

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