ROY HILL IRON ORE

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S3	**Not Reviewed, Information Only.**	☐
S4	**Not suitable for Review,** **Revise & Resubmit Within 15 Working Days.**	☐

Review of the document does not relieve the Contractor/Supplier of its responsibility for the due and proper performance of the Works in accordance with the Contract.

ADDITIONAL COMMENTS

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Next Issue at Revision: ______________

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Name: ______________________

Position: ______________________

Roy Hill Iron Ore Pty Ltd

McPhee Creek Iron Ore Project - Water Management Studies

Water Balance Assessment

October 2021

Executive summary

GHD Pty Ltd was commissioned by Roy Hill Iron Ore Pty Ltd to undertake a water balance assessment for the proposed McPhee Creek Iron Ore mine site. The purpose the site water balance was to estimate the size of major components of the site water management system (such as drains, dams, pumps, pipes) required to achieve adequate performance in terms of water security, availability of pit for mining and post closure recovery.

A lumped mass balance model was developed for the Project which considered rainfall, evaporation, catchment runoff, dewatering, ore crushing, dust suppression, camp water use and off-site discharge. The modelling undertaken was consistent with outputs from the surface water and groundwater assessments undertaken by GHD (2020).

The modelling results indicate that the site is expected to be in water excess during most of the project life, except for the initial period when mining occurs above the water table and groundwater abstraction will be required to supply site operational demands. During the latter part of the project life, the expected dewatering requirements to maintain all pits in a dry state is roughly equal to the operational site demands, and therefore the site may be close to water neutral during dry years.

The project is expected to require off-site discharge of excess water throughout the project life and will have high water security. A proposed pit dewatering system with a nominal capacity of 100 L/s is expected to enable mining in the pits to resume quickly following significant rainfall events. The pit lake system is expected to remain as a long term groundwater sink post closure.

While the modelling indicates that the site will have high water security throughout its' life, there remains inherent uncertainty particularly in relation to the dust suppression demands and dewatering yield that have the potential to result in a water deficit in the later part of project life. This deficit may be sourced from groundwater abstraction associated with the existing dewatering bores.

The dust suppression demand should be reviewed as part of further studies in the event that layout or design changes alter the expected haul road length and area and other assumptions made in this assessment. Future updates of the groundwater drawdown and pit lake recovery prediction should include consideration of this anticipated demand during the later part of the mine life.

It is recommended that a comprehensive record keeping of the number, frequency, volume of dust suppression, and the area it is applied to is maintained during the early part of the mine operations. All meters, including those fitted to standpipes, should be fitted and linked to a telemetry system. Water carts should manually record meter readings at start and stop of each fill up. Further individual water carts should designated to serve specific areas of the mine. Records once the site moves to extreme water excess are unlikely to be a reliable indicator of the minimum dust suppression requirement that may be required during the latter part of the mine life.

The groundwater monitoring network proposed as part of the H3 groundwater assessment (GHD 2020), is expected to provide adequate data for recalibration of the groundwater drawdown and pit lake recovery modelling as required.

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1. Introduction

GHD Pty Ltd (GHD) was commissioned by Roy Hill Iron Ore Pty Ltd (Roy Hill) to undertake a water balance assessment for the proposed McPhee Creek Iron Ore mine site (the Project). The assessment has estimated the size of major components of the site water management system required to achieve adequate performance in terms of water security, availability of pit for mining and assess recovery post closure. The assessment was coordinated with the surface water and groundwater assessments undertaken by GHD (2020).

Generally, a site water balance is a quantification of inflows, outflows and internal flows of water in a particular catchment. When applied to a mine site, the catchment is generally limited to the disturbance footprint of the mine and considers water fluxes including rainfall, evaporation, catchment runoff, dewatering, ore crushing, dust suppression, camp water use and off-site discharge.

The site water balance was determined using a spatially lumped mass balance model (a spatially lumped model simplifies a spatially distributed system a topology of discrete entities). The model was implemented using a software package called GoldSim. This report documents the data inputs, methodology and interprets the results of the model.

1.1 Background

Atlas Iron Pty Limited (Atlas Iron), now part of Redstone Pty Ltd, a subsidiary of Hancock Prospecting Pty Ltd, is proposing to develop an iron ore mine (the Proposal), located at McPhee Creek in the northern Pilbara of Western Australia. The Proposal comprises five open pits situated along northeast to southwest trending ridgeline. Mining will occur above and below water table and the mining rate is expected to be up to 14 Million tonne per annum (Mtpa). Atlas Iron plans to transport processed ore via truck to the Roy Hill mine site or other third parties.

1.2 Purpose of this report

The purpose of this report is to estimate the site water balance of the proposed McPhee Creek Iron Ore mine, estimate the size of major components of the site water management system (such as drains, dams, pumps, pipes) required to achieve adequate performance in terms of water security, availability of pit for mining and post closure recovery.

1.3 Scope of work

The scope of work included:

1. Data review and identification of data gaps
2. Construction of Goldsim model
3. Predictive simulations, uncertainty analysis and risk analysis
4. Preparation of water balance report

Following completion of the water balance modelling, the mine layout and schedule were further refined. These slight changes have not been included in the water balance modelling, however they are considered in this assessment.

1.4 Limitations

This report: has been prepared by GHD for Roy Hill Iron Ore Pty Ltd and may only be used and relied on by Roy Hill Iron Ore Pty Ltd for the purpose agreed between GHD and the Roy Hill Iron Ore Pty Ltd as set out this report.

GHD otherwise disclaims responsibility to any person other than Roy Hill Iron Ore Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Roy Hill Iron Ore Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Project description

2.1 Background

Atlas Iron is an iron ore company, mining and exporting ore from its operations in the Pilbara region of Western Australia. Atlas Iron is proposing to develop the McPhee Creek iron ore project (the Proposal), which is located approximately 30 km north of the Nullagine townsite in Mining Lease 45/1243-I. The McPhee Creek Proposal involves developing a green field mine and crushing operation, to export up to 14 Mtpa of McPhee Creek iron ore to market via trucks.

The McPhee Creek project area can be accessed via public road approximately 266 km drive southwest from the town of Port Hedland, or by public road approximately 220 km drive north from Newman. The location of the site is shown in Figure 2-1.

2.2 Key Project Characteristics

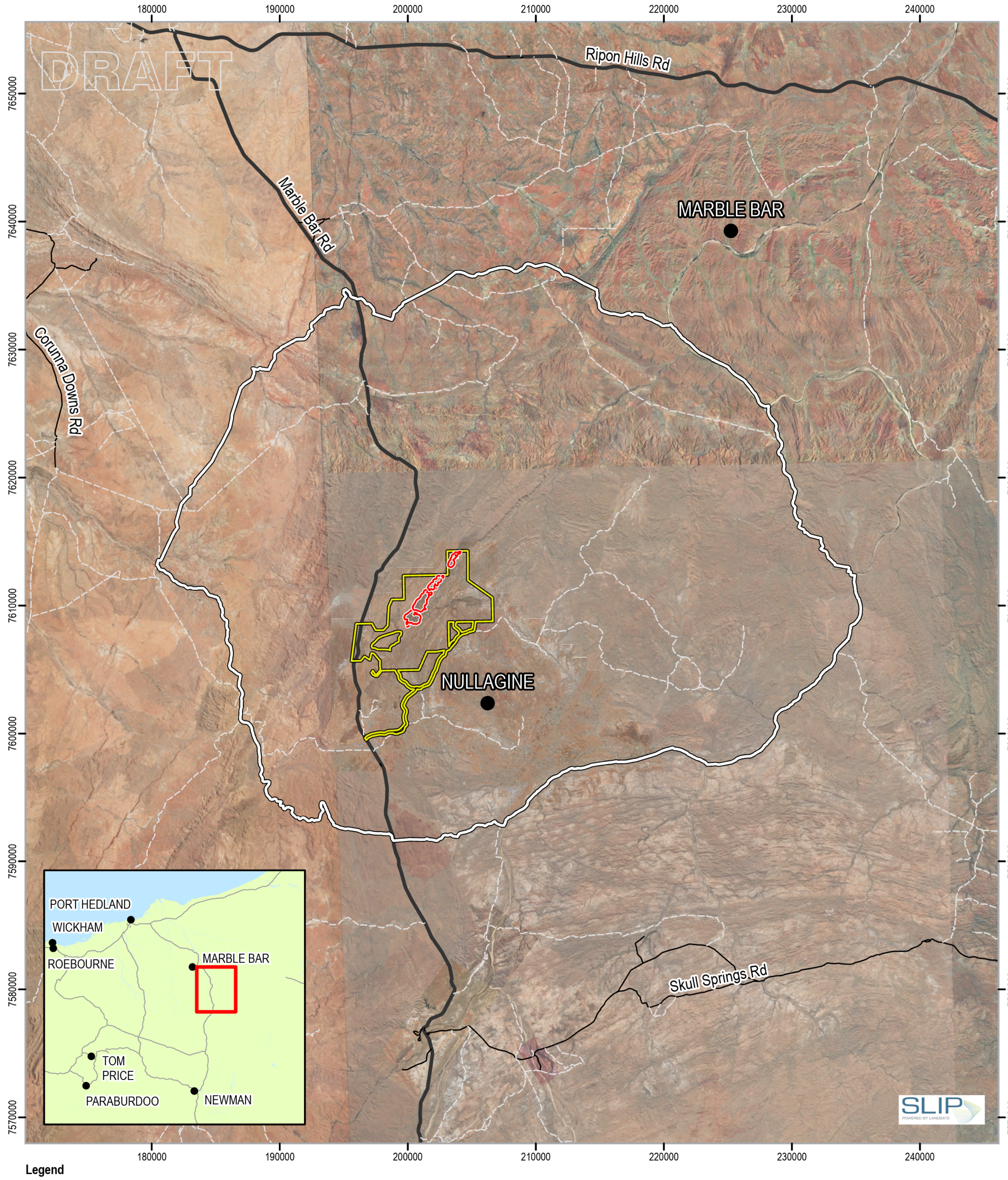
Within the 4,465 ha Development Envelope, the McPhee Creek mine will consist of conventional iron ore mining infrastructure and associated activities that includes:

- Above and below water table mining of five open pits
- Ore crushing infrastructure and truck loading infrastructure
- Waste rock dumps, ore stockpiles, topsoil stockpiles and sub-soil stockpiles
- Support facilities: including small scale power generation at each of the mine facilities (including but not limited to workshops and crusher), telecommunications tower, solar field, workshops, hydrocarbon storage, explosive mixing and storage facilities, laydown areas and offices
- Linear infrastructure: including heavy and light vehicle access roads, conveyors, pipelines, power and communications distribution
- Infrastructure for surface water management: including diversion drains, levees and culverts
- Infrastructure for dewatering and groundwater abstraction for water supply
- Dewatering water management and associated infrastructure for discharge to surface water systems.
- Construction and operation workforce accommodation camp/s
- Transport of the ore to the existing Roy Hill project or other third parties

2.3 Mining

Mining will be conventional drill and blast, load, and haul methods, with a maximum production capacity of 14 Mtpa. Mining will be undertaken on a 24 hour basis, seven days a week

A portion of the ore is located below the water table and as such dewatering will be required. It is anticipated that up to a maximum of 16 GL/yr of dewatering will initially be required, which will decrease over the life of the mine. Estimate groundwater inflows are presented in Section 4.5 and the production schedule adopted for the purpose of this assessment is presented in Section 4.6.



Legend

- Main road
- Minor
- Track
- Assessment domain
- Project Development Envelope
- Pit footprint

Paper Size ISO A4

0 2 4 6 8 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

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GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Site Location

Project No. **12520160**
Revision No. **A**
Date **22/10/2020**

FIGURE 2-1

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Data source: GHD: Pit Footprint, Assessment Domain - 20201016, Landgate: Roads - 20171106, Locality - 20180319 WA Now Imagery LGATE MS: Landgate / SLIP. Created by: pjhernandez

2.4 Processing

Once blasted, broken ore and waste rock will be loaded separately into haul trucks. Ore will be transported via the haul road network from the ROM pad. Crushing may be undertaken using a small mobile dry crushing and screening facility. If required, a plant may consist of primary and secondary crushing stages and dry screening facilities, samples station and product stacker(s). Stockpiling of marginal ore material will also be undertaken to ensure maximum resource recovery. No tailings or wet waste product will be produced.

Following mining, the McPhee ore will be stockpiled for transport via trucks for third-party processing or sale off the McPhee site.

2.5 Waste rock management

Approximately 126 Mt of waste rock will be mined throughout the life of the mine, in addition to 50Mt of lower grade material (LG), which will be stockpiled for future processing should a feasible solution become viable. The LG material will be stockpile assuming it can be reclaimed but also such that it can be rehabilitated should no future solution become viable.

Waste rock will initially be used to construct infrastructure (e.g. access roads and ramps, ROM and stockpile bases, drainage structures and safety bunds) with the remainder stored in above ground waste rock dumps.

Runoff from the waste rock emplacements will be directed to sediment ponds for primary treatment by settlement prior to off-site discharge.

2.6 Additional infrastructure and support facilities

Bulk explosive materials will be located in a secure compound accessible from the main access route to provide safe and efficient access for bulk supplies. Initiating explosive will be stored in separate secure magazine compound located in excess of 1.5 km from mine workings and operations services, utilizing bunding and the natural topography to assist in security and isolation.

To support the mine operation, offices, workshops, power generation, communication infrastructure and parking areas will also be constructed.

A 200 person accommodation village will be constructed within the Development Envelope prior to implementation of the current proposal.

2.7 Water management

The Project's water supply will be sourced from local groundwater. All groundwater bores will be licensed under the *Rights in Water and Irrigation Act 1914* (RIWI Act), as administered by the Department of Water and Environmental Regulation (DWER). The dewatering strategy requires initial (first five years) dewatering up to a maximum up to 16 GL per annum, which will decrease over the life of the mine to around 2 GL per annum. Other water use (camp, dust suppression etc.) will total less than 2 GL per annum and will mostly be sourced from the dewatering supply. The dewatering schedule is shown in Chart 1

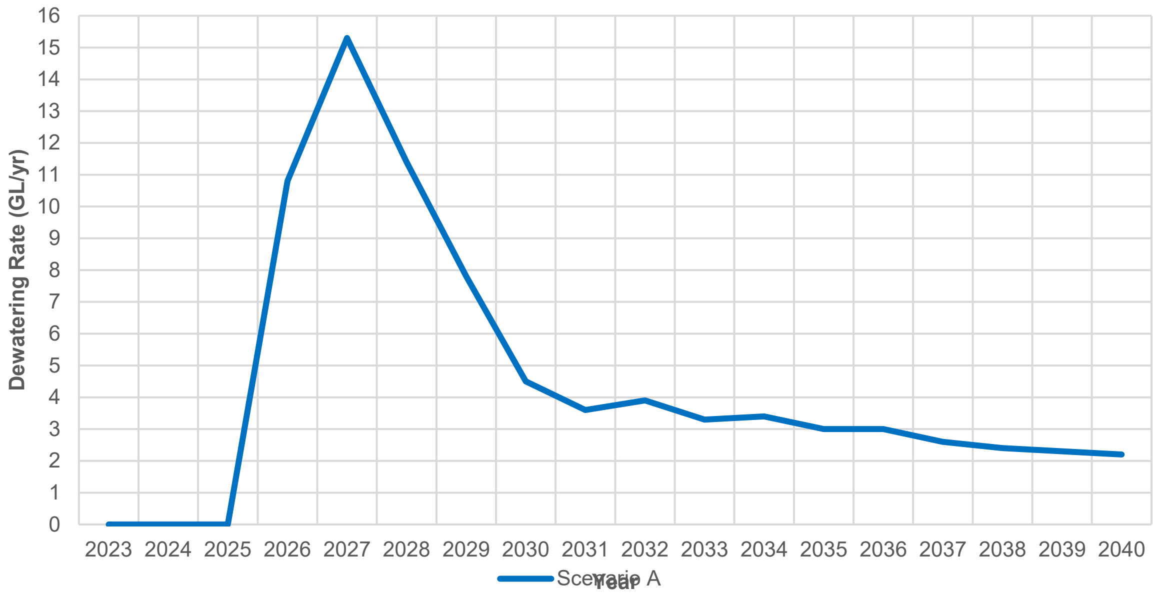


Chart 1 Dewatering Schedule

The excess dewatering volume (i.e. that not utilized by the mine operations) will be discharged to nearby creeks in a controlled manner. Discharge volumes will be up to approximately 15 GL per annum initially, significantly decreasing over the life of the mine. The discharge locations will be constructed with scour and erosion protection measures to minimize impact on the creek line.

Refer to Section 4.5 for a detailed description on the forecast groundwater flows adopted for the purpose of the modelling.

3. Water management features

The water management system at McPhee Creek was conceptualised as a network of water management features representing surface water storages, operational processes and discharges to receiving waters. Each water management feature was defined by its connection to other water management features by inflows and outflows of water. The water management system was conceptualised based on mine layout information provided by Roy Hill.

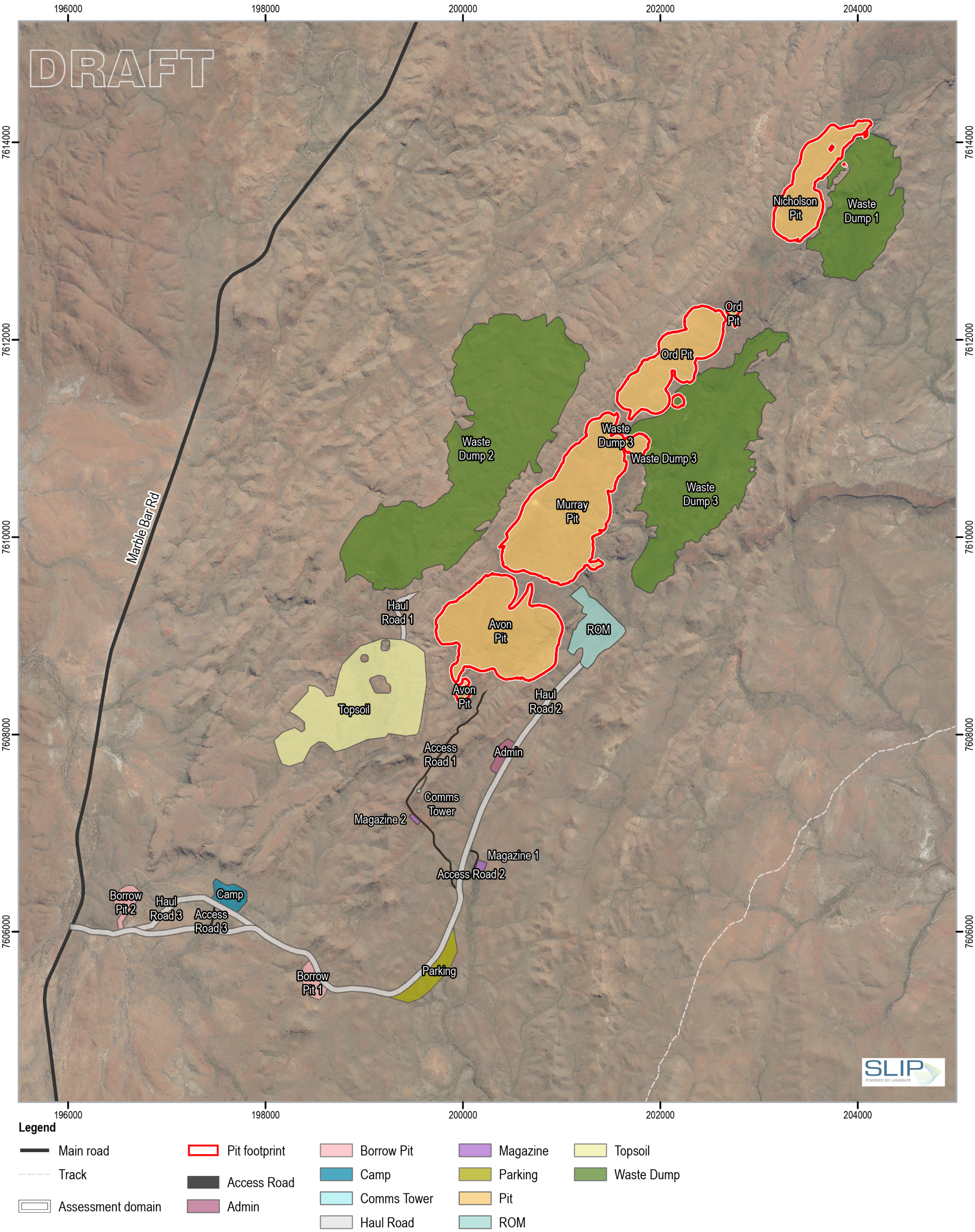
The major water management features considered in this assessment are summarised in Table 3-1. All surface water storages receive inputs from direct rainfall and catchment runoff and losses to evaporation, which are omitted from Table 3-1 for brevity. The site water features are schematically shown in Figure 3-2.

No reticulation of rainfall runoff on waste rock dumps (WRD) is proposed because WRD is designed to promote direct infiltration of rainfall. These were not included in the site water balance model. The raw water dam is a turkey's nest style dam and therefore has no external catchment.

Table 3-1 Water management features

Feature	Surface water storage	Inflows	Outflows
Avon Pit	Yes	Groundwater inflows (post closure)	Pump to Raw Water Dam Overflow to McPhee Creek
Murray Pit	Yes	Groundwater inflows (post closure)	Pump to Raw Water Dam Overflow to McPhee Creek
Nicholson Pit	Yes	Groundwater inflows (post closure)	Pump to Raw Water Dam Overflow to WRE1 sediment ponds
Ord Pit	Yes	Groundwater inflows (post closure)	Pump to Raw Water Dam Overflow to McPhee Creek Overflow to WRE3 sediment ponds
Crushing plant	No	Supplied from Raw Water Dam	Lost to ore moisture and evaporation
Raw Water Dam	Yes	Dewatering bores	Supply to crushing plant Supply to dust suppression Supply to camp Discharge to creek

The Crescent Moon Pit has not been assessed as part of the water management system. The Crescent Moon Pit is located atop a ridge and the catchment is limited to the disturbance footprint of 20 ha that is minor (less than 5%) compared to the total catchment area of all pits estimated to be approximately 621 ha. Crescent Moon Pit does not intercept groundwater. Therefore, Crescent Moon Pit is expected to have a minor influence on the site water balance which is within the uncertainty of the modelling outputs.



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

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GHD

Roy Hill Ltd
McPhee Iron Ore Project
Water Management Studies

Site Layout

Project No. **12520160**
Revision No. **A**
Date **21/10/2020**

FIGURE 3-1

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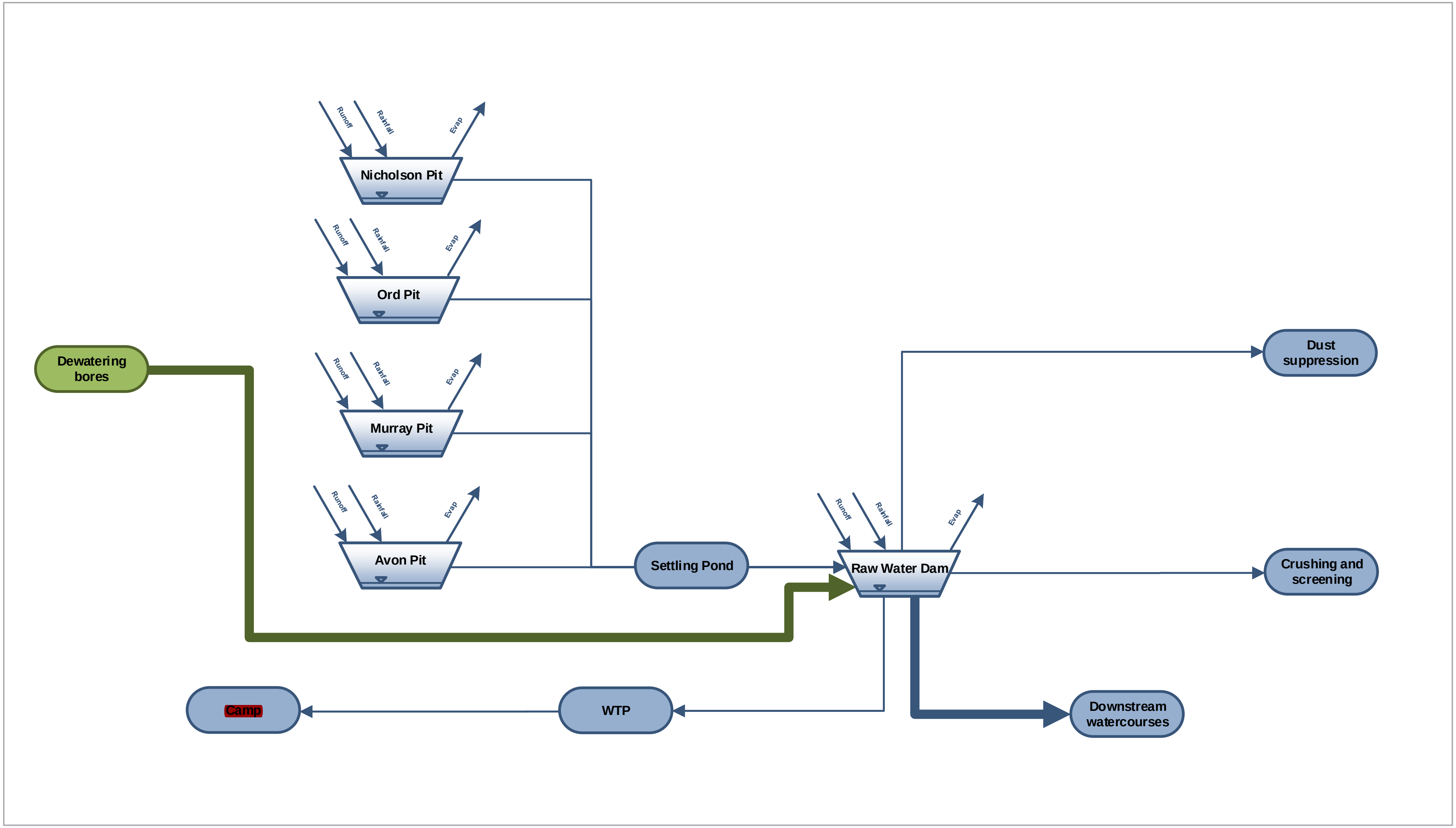
Data source: GHD: Drainage Lines, Pit Footprint, Assessment Domain, Ground Elevation - 20201016, Landgate: Roads - 20171106 WA Now Imagery LGATE MS: Landgate / SLIP. Created by: pjhernandez



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Surface water flow
- Groundwater flow

Atlas Iron Limited
McPhee Creek Iron Ore Project
Water Management Studies

Water management schematic

Project No. **12520160**
Revision No. **A**
Date **23/10/2020**

FIGURE 3-2

Created by: Tyler Tinkler

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4. Data sources

The development of the water balance for the Project involved the collation, review and interpretation of data from various sources. The sources of data used are shown in Table 4-1.

Table 4-1 Summary of data sources

Data	Source
Historical rainfall and evaporation records	SILO (DSITI, 2020)
Catchment areas, land use	Developed from aerial imagery, site contours and mine layout provided by Roy Hill (1m contours)
Storages geometry of pits	Data provided by Roy Hill
Dewatering requirements	From groundwater modelling (GHD 2020a)
Operational water demand	Data provided by Roy Hill

4.1 Rainfall

A historical rainfall record of point rainfall data was obtained from the Scientific Information for Land Owners (SILO) database hosted by the Science Division of the Queensland Government's Department of Environment and Science. SILO point data consists of interpolated estimates based on historically observed data from Bureau of Meteorology (BOM) gauging stations. Point rainfall data has the advantage of capturing a range of temporal patterns from observations, while being adjusted for geographic location. It is intended to characterise the potential rainfall patterns over the scale of weeks, months and years that can be reasonably be expected at the site based on the historical record. For this assessment, SILO data was obtained for the grid point located at -21.55N, 120.2E, which is located within the Project area.

Figure 4-1 presents the historical annual SILO point rainfall data between 1889 and 2019. The annual statistics associated with the SILO data are:

- Minimum rainfall total – 27 mm in 1924
- Median rainfall total – 320
- Average rainfall total - 341
- Maximum rainfall total – 892 mm in 2000

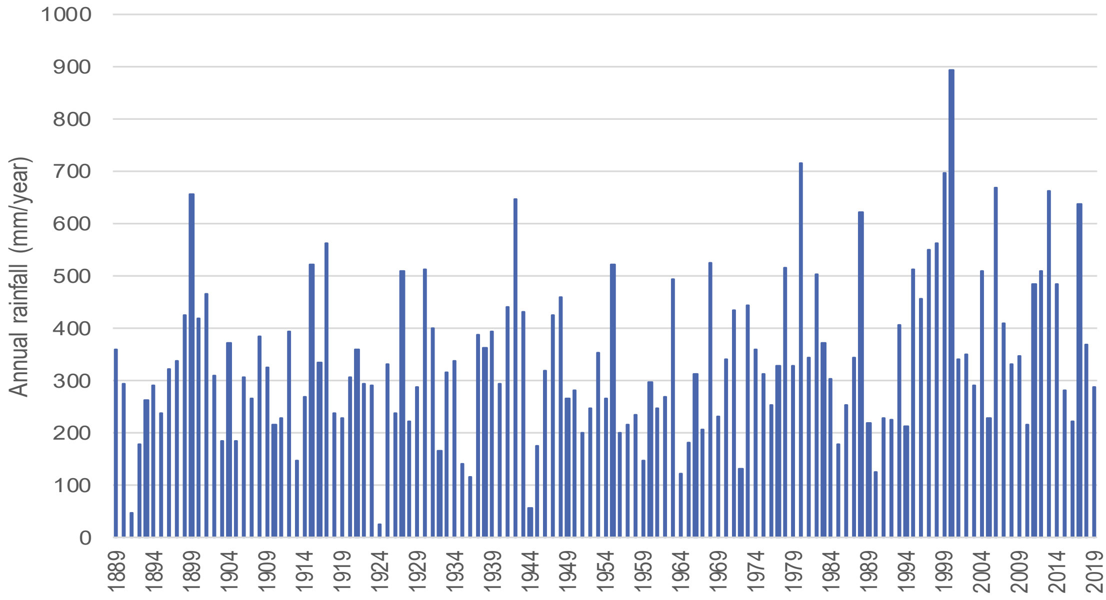


Figure 4-1 Historical annual rainfall record

4.2 Evaporation and evapotranspiration

Point evaporation (synthetic estimate) and Morton's wet-environment areal evapotranspiration over land (mm) data were also obtained from SILO at the same grid point location at -21.55 S, 120.2 E as rainfall data. Average monthly rainfall, evaporation, and evapotranspiration rates were determined from the historical SILO point data between 1889 and 2020 are presented in Figure 4-2.

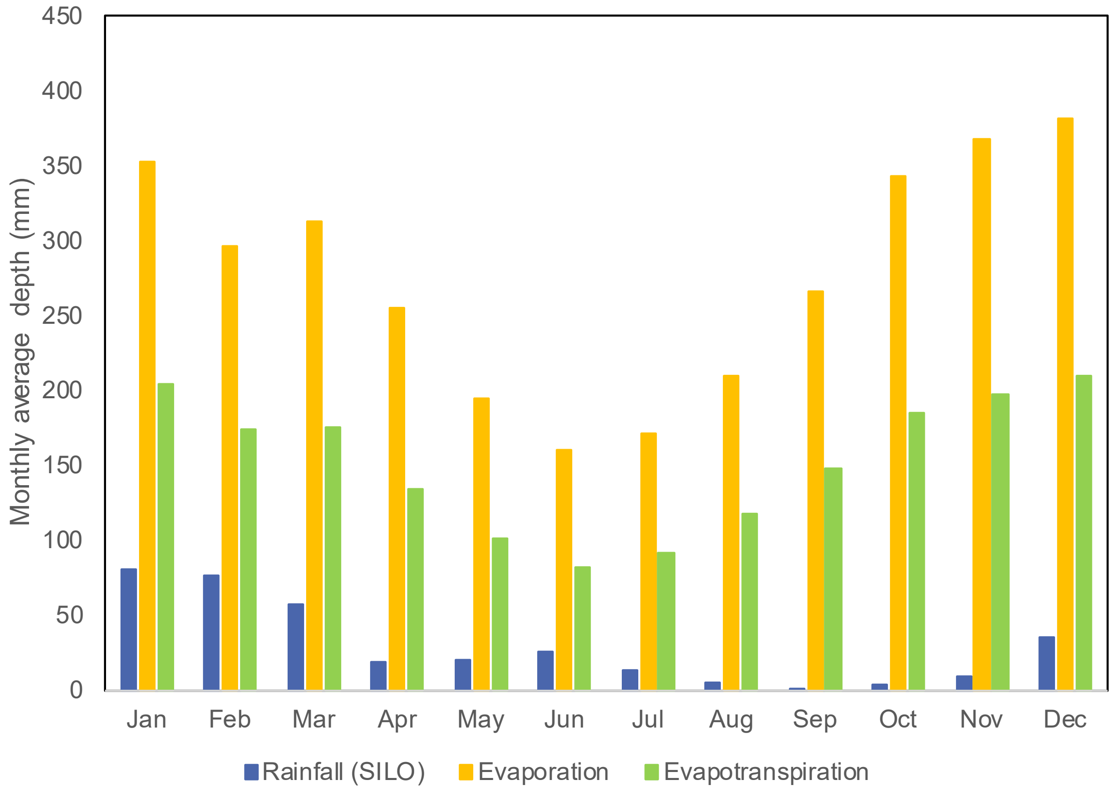


Figure 4-2 Average monthly rainfall, evaporation and evapotranspiration rates (SILO)

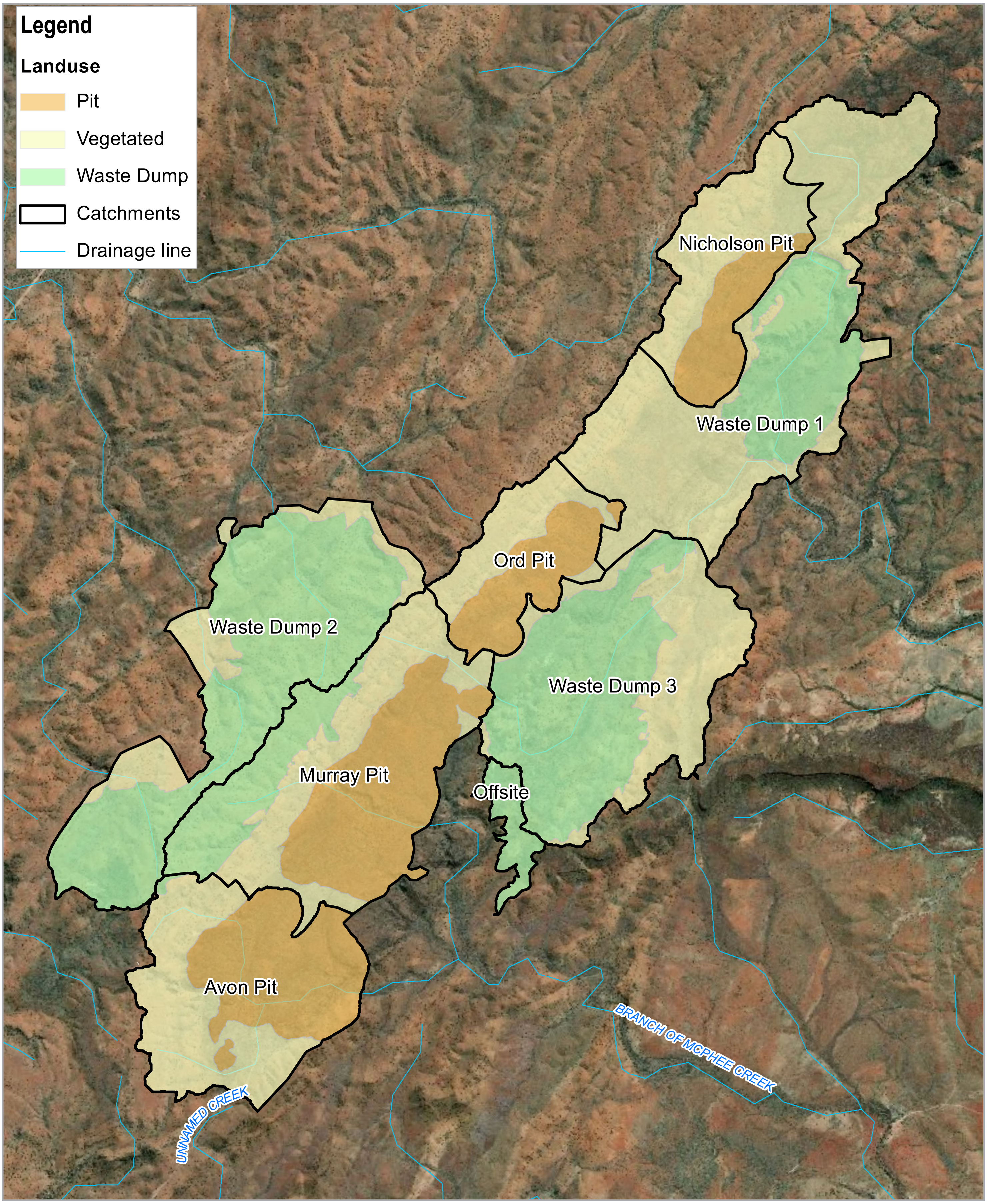
4.3 Catchments and landuse

The catchment areas of each water management feature (the pits) were delineated based on topographic information using the GIS toolkit ArcHydro. The land use of the catchment areas of each pit was delineated using aerial imagery and based on the mine plans provided. The catchment area and land use for each water management feature are summarised in Table 4-2 and presented in Figure 4-3.

Table 4-2 Catchment areas

Catchment	Vegetated (%)	Hardstand (%)	WRD (%)	Pit (%)	Total (ha)
Avon Pit	49%	0%	1%	50%	197
Murray Pit	33%	0%	22%	46%	268
Nicholson Pit	62%	0%	0%	38%	118
Ord Pit	56%	0%	0%	44%	97
Crescent Moon Pit					0

The total catchment area for the purpose of site water balance model adopted for Murray Pit (268 ha), was larger than adopted in GHD (2021) for the purpose of the surface water assessment due to refinements to the diversion of clean water following completion of site water balance model. This difference is minor (less than 10%) of the total catchment area is partially offset by the absence of consideration of Crescent Moon Pit (refer to Section 3) The Crescent Moon Pit is located atop a ridge and therefore has no catchment area other than the pit area itself (20ha).



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Map Projection: Transverse Mercator
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Grid: GDA 1994 MGA Zone 51

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Roy Hill Iron Ore Pty Ltd
McPhee Creek Iron Ore Project - Water Management Studies
Water Balance Modelling

Project No. 12520160
Revision No. -
Date 07/10/2020

Catchment and landuse

FIGURE 4-3

Data source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: jmmacatanong

4.4 Storages

The stage storage relationship of the final void of Avon and Murray Pit, which will be deeper and where pit lakes are expected to form, are shown in Figure 4-4.

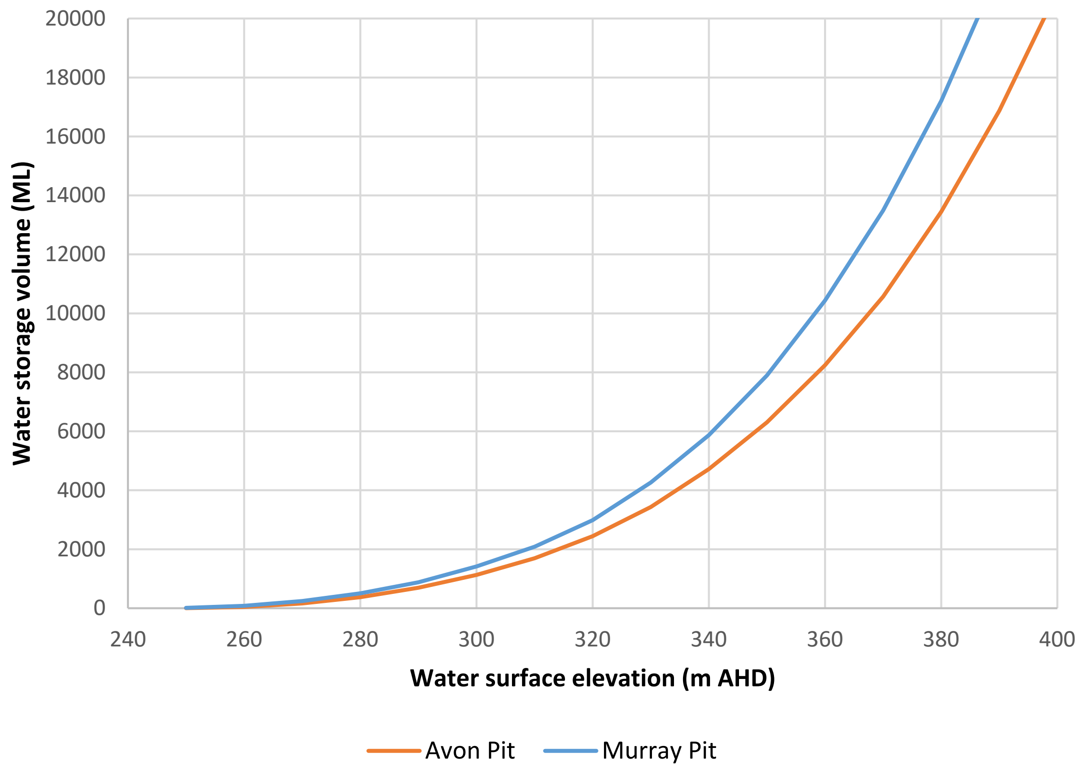

Figure 4-4 Pit lake void geometry

4.5 Dewatering requirements

The dewatering requirements were based on outputs from the groundwater modelling undertaken as part of the H3 groundwater assessment report (GHD 2021). The expected dewatering requirements are shown in Figure 4-5 and two scenarios were considered:

- Scenario 1 “minimum dewatering requirements” - where groundwater is allowed back into the pits and groundwater levels are only dewatered to the level that is required based on the depth of active mining at that time.
- Scenario 2 “additional dewatering potential” - Where all pits remain dry during operations. The additional dewatering requirements above the “minimum dewatering requirements” represents “additional dewatering potential” during the latter stages of the mine life. This “additional dewatering potential” represents water that is expected to be available to supply operations using the same dewatering infrastructure even if it is not essential for mining to continue.

Figure 4-5 shows that the total inflow is expected to peak at about 16 GL/year early in the mine life. To sustain a secure water supply for operations, a minimum of about 2 GL/year is expected to be available throughout the mine life.

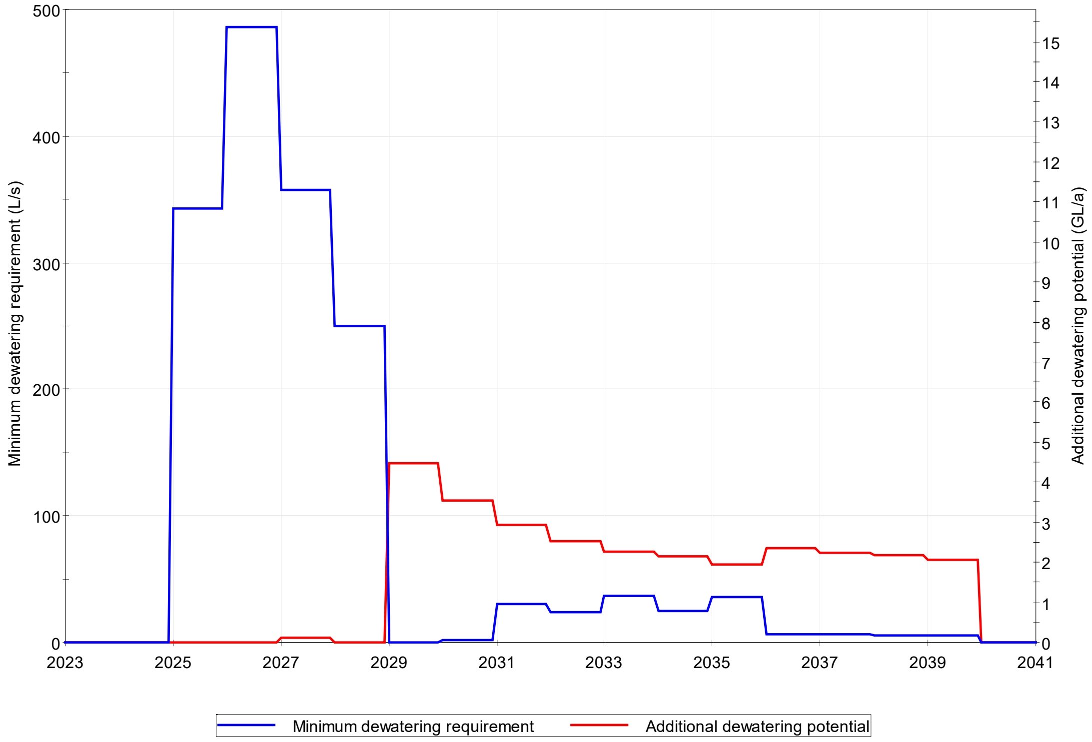

Figure 4-5 Annualised groundwater inflows

4.6 Mining schedule

Roy Hill provided an indicative mining and production schedule for production rate of 10 Mtpa as shown in Figure 4-6. The production rate was used to estimate the operational water demand (discussed in Section 4.7). Cumulative production rate is presented in Figure 4-7, conservatively (for water security) assuming that the low grade ore is also crushed but stockpiled on site.

The production schedule used for the purpose of water balance assessment is presented in this section. Minor changes to the production schedule are expected to be reflected proportionally in the overall water demand.

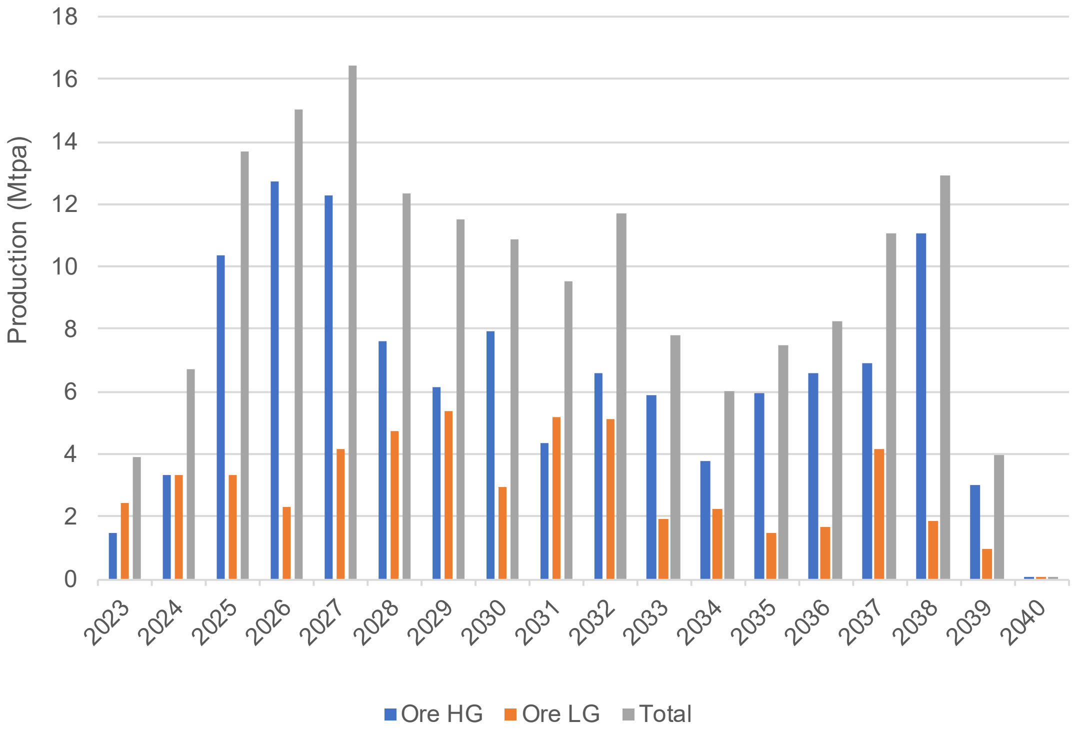

Figure 4-6 Production schedule

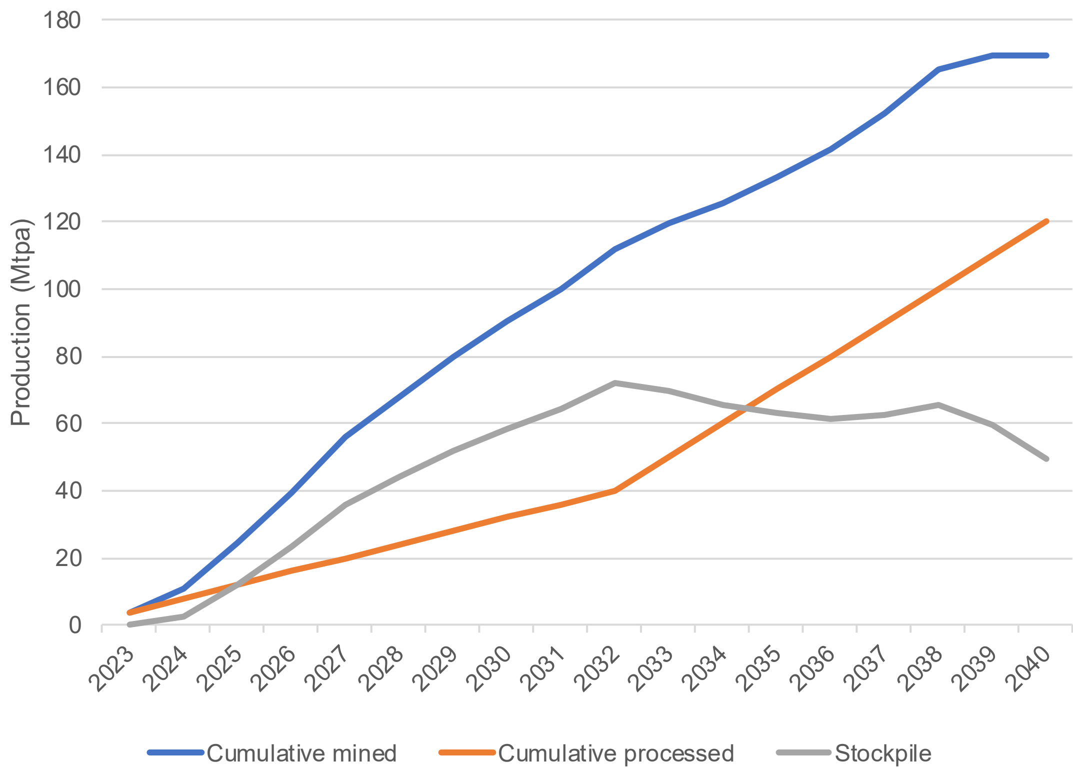

Figure 4-7 Cumulative production rates

4.7 Water demands

The operational water demands have been estimated based on a combination of theoretical basis (such as mass balance based on surface area and net evaporation) and benchmarking against Atlas Iron's operations at Mt Webber as summarised in Table 4-3. Without on-site processing, the dominant water demand during operations is expected to be dust suppression.

Table 4-3 Operational water demand estimates

Water demand	Input	Unit demand rate
Ore crushing		
Crusher	5,920 kL/month	33 L/ROM tonne
ROM stockpile (finger)	7,930 kL/month	
Wash down	2,872 kL/month	
Benchmark: 6.14 Mtpa production at Mt Webber	16,722 kL/month	
Dust suppression		
Benchmark: 6.14 Mtpa production at Mt Webber	58,054 kL/month	113 L/ROM tonne (average throughput assuming similar strip ratios)
Theoretical	2,953 mm net evaporation x 30 m road width x 20 km haul road based on mine layout	Minimum 1,772 ML/year
Camp		
Benchmark: 150 man camp at Mt Webber	2,306 kL/month	504 L/person/day

4.8 Pit dewatering

Dewatering of water (runoff, rainfall) that collects in the pit sumps was assumed to be dewatered by mobile diesel pumps at a nominal pump rate of 100 L/s. The actual dewatering rate will depend on the stage of mining progression, depth of the pits and the active working areas.

5. Modelling methodology

5.1 Mass balance

The site water balance for the Project was modelled as a semi-distributed mass balance, considering the water management features described in Section 3. A site-specific water balance equation was derived from the catchment scale water balance equation described by Ladson (2008). The water balance equation applies conservation of mass to derive an ordinary differential equation that describes how the volume of water V changes over time t:

$$\frac{dV}{dt} = R + C + G_{in} + P_{in} + Q_{in} - E - P_{out} - Q_{out}$$

The water balance considered the inflows into each storage:

- Direct rainfall R, estimated from the simulated water surface area of the storage and the simulated rainfall intensity.
- Catchment runoff C, using the Australian Water Balance model (AWBM) (Boughton & Chiew, 2003) and accounting for the change in simulated water surface area.
- Dewatering inflow G_{in}, estimated from the groundwater modelling (GHD 2020).

The water balance considered the outflows from each storage:

- Evaporation E, estimated from the simulated water surface area of the storage.

The water balance considered transfers between storages:

- Pumped transfers P_{in} and P_{out}, according to site-specific operating rules and pump rates.
- Overland channel and gravity pipe flow Q_{in} and Q_{out}, according to site-specific operating rules and flow rates and due to overflows from one storage to another.

5.2 Hydrological model

The Australian Water Balance Model (AWBM), as described in Boughton (1993), was used to estimate catchment runoff. The AWBM is a partial area saturation overland flow model. The use of partial areas divides the catchment into regions (contributing areas) that produce runoff during a rainfall-runoff event and those that do not.

These contributing areas vary within a catchment according to antecedent catchment conditions, allowing for the spatial variability of surface soil moisture storage in a catchment. The use of the partial area saturation overland flow approach is simple, and provides a good representation of the physical processes occurring in most Australian catchments (Boughton, 1993). This is because daily infiltration capacity is rarely exceeded, and the major source of runoff is from saturated areas. A schematic layout of the AWBM is shown in Figure 5-1.

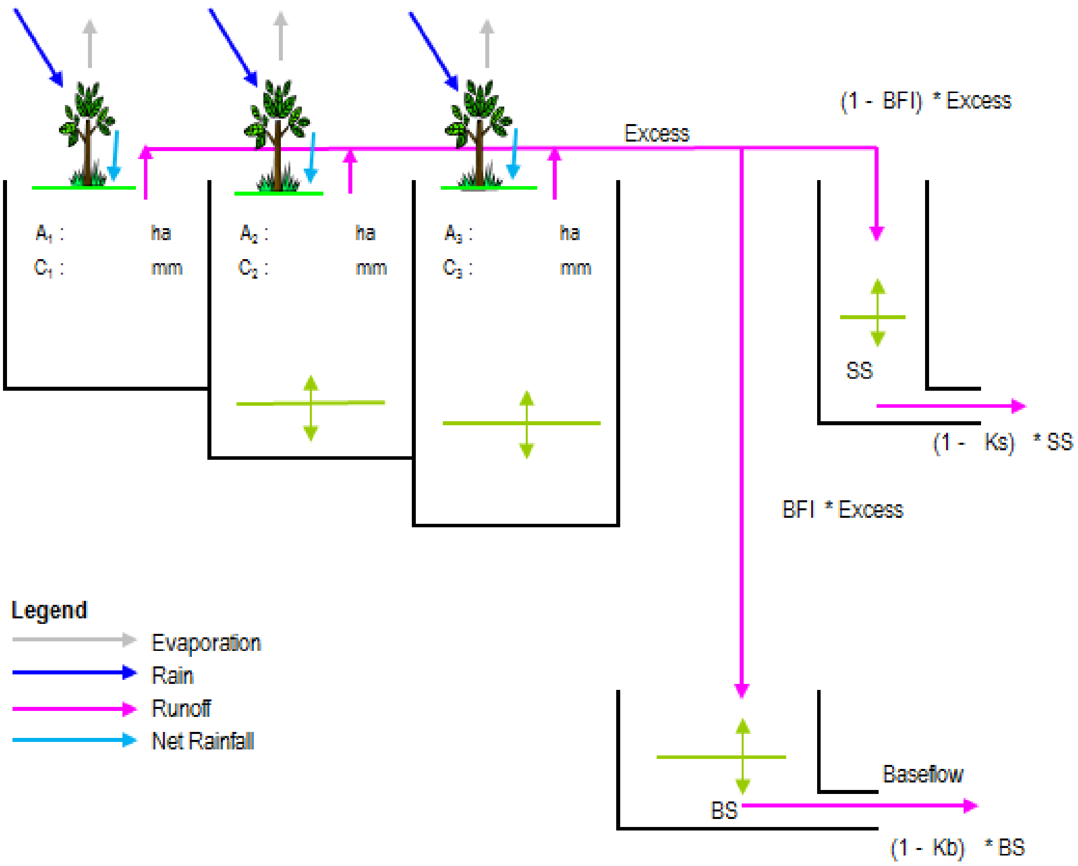

Figure 5-1 AWBM model schematic

Figure 5-1 shows that for an individual catchment, the model consists of three soil moisture stores (with surface areas A_1, A_2 and A_3). Rainfall enters these storages and once a storage element is full, any additional rainfall is considered excess rainfall. Of this excess rainfall a proportion is routed to the baseflow storage (BS) while the remainder is routed to the surface storage (SS). The discharge from the baseflow storage and surface storage is calculated using the respective recession constants. The total runoff is the sum of the outflow from these two storages. The definition of the parameters used in the AWBM is provided in Table 5-1.

Table 5-1 AWBM parameters

Parameter	Description
A_1, A_2, A_3	The partial areas of the overall catchment contributing to storages 1, 2 and 3 respectively.
C_1, C_2, C_3	The capacity of storages 1, 2 and 3 respectively.
BFI	The proportion of excess rainfall contributing to the baseflow.
K_b	The proportion of the volume of the baseflow storage remaining in the storage at the end of each day.
K_s	The proportion of the surface storage remaining in the storage at the end of each day.

The site-specific land uses (refer to Section 4.3) were characterised with different sets of AWBM parameters. The AWBM parameters adopted for the water balance model are summarised in Table 5-1.

Table 5-2 Site parameterisation of AWBM

Parameter	Vegetated	Hardstand	WRE	Pit
A1, A2, A3	0.134,0.433,0.433 respectively			
Cave	200	20	40	40
C1, C2, C3	0.01,0.33,0.66 respectively			
BFI	0	0	0	0
Kb	0.98	0	0.98	
Ks	0	0	0	0

5.3 Climatic variability

In order to assess the variability of the results due to the key climatic variables of precipitation and potential evapotranspiration, the historical record was used to simulate a series of 130 climatic sequences, or realisations. Each realisation began with a different year of the historical record, to maintain seasonality. The historical record was looped where required due to the start date of the sample from the historical record plus the duration of simulation being greater than the end of historical record. This series of realisations collectively constituted the "probabilistic" climatic conditions and therefore the results were interpreted statistically.

5.4 Geometric approximations

For the pit sumps that have a small volume and vary as mining progresses the geometry of the surface water storages was estimated using a power law approximation after Brooks (2002), where the depth *d* of a solid of revolution was related to its volume *V* as:

$$d = d_{max}\left(V\frac{1+{}^{2}/_{p}}{A_{max}d_{max}}\right)^{\frac{p}{p+2}}$$

where *d_max* was the maximum depth, *V_max* was the capacity of the storage, *A_max* was the maximum surface area of the storage and *p* was dimensionless shape parameter.

5.5 Numerical implementation

The water balance model was implemented using GoldSim 12.1. GoldSim is a computer simulation software widely used for mine site water balance studies. GoldSim uses the forward Euler method to solve the ordinary differential equations derived from the mass balance model described in Section 5.1. A basic timestep of 1 day was used, consistent with the daily rainfall data used in the model.

6. Modelling results

The model was used to estimate the site water balance for the Project for a range of potential rainfall sequences starting from a nominal project start date of 1 January 2023 and the operational model was simulated from 1 January 2023 to 1 January 2040, assuming that the first month of the mine schedule corresponded to January 2023. The model was initialised with all water storages empty. The adopted modelling years are for the purpose of presentation of results only. If the actual project start date differs, the results are expected to be similar but offset by a difference corresponding to the difference in project start date.

A post closure model was simulated from 1 January 2041 until 1 January 2200 to simulate the recovery of levels in the pit voids that will remain at the completion of mining.

6.1 Uncertainty analysis

To consider potential rainfall variability, a total of 131 different rainfall patterns were simulated (as described Section 5.3). The results presented show the average, 10th percentile and 90th percentile values. The purpose of displaying the three results is to indicate both the average value and the likely possible range. The 10th percentile represents the value at which 10% of the modelled outputs were less than this value. Similarly, the 90th percentile represents the value at which 90% of the modelled outputs were less than this value.

The 10th and 90th percentile values have been used rather than minimum and maximum values to characterise likely very wet and very dry conditions that may be experienced. The set of 10th or 90th percentile values do not necessarily all correspond to the same rainfall series, that is, they do not correspond to a 10th percentile “dry” or 90th percentile “wet” year.

The mass balance has been developed for the purpose of quantitatively comparing the relative risk of acidity in different surface water storages on site and the absolute quantities should be considered order of magnitude estimates only. The model provides a framework for further refinement as the additional site observations and design details become available and, if appropriately validated, may ultimately serve as an operational management tool.

6.2 Annual water balance

The predicted average annual water balance for McPhee Creek are summarised in Table 6-1 for two selected years that characterise the peak dewatering requirements (2026) and the latter part of the mine life (2038) for scenario 2 (refer to Section 4.5).

Table 6-1 shows that in the first five years of mine life, peaking in 2026, the water balance is dominated by the requirement to dewater to enable extraction of the ore body below the predevelopment water table. This water is proposed to be discharged off site via creek lines as discussed in Section 2.7 and assessed in the Groundwater H3 Report (GHD, 2021) and Surface Water Assessment Report (GHD, 2021).

In the last three years of mine life after 2038, the groundwater expected to be dewatered in order to keep the pits dry is approximately equal to the total operational demands. Therefore, only runoff reporting to the pits is expected to be required to be managed and discharged off-site. This balance between the available groundwater supply (from abstraction for pit dewatering) and the operational site demands are shown in Figure 6-1. This shows that the site is expected to remain in water surplus throughout the project life.

Table 6-1 Annual average water balance – selected years

Water management element	Year 2026 (ML/year)	Year 2038 (ML/year)
Direct rainfall onto storages	465	580
Catchment runoff	289	573
Groundwater abstraction for dewatering	15,344	2,274
TOTAL INPUTS	**16,097**	**3,427**
Evaporation	377	516
Discharge to creeks	13,282	540
Use at camp	36	36
Ore moisture loss	463	395
Dust suppression use	1,939	1,940
TOTAL OUTPUTS	**16,097**	**3,426**
Surface water storages	0	0
TOTAL CHANGE IN STORAGE	**0**	**0**
Balance = Inputs – outputs – change in storage	0	0

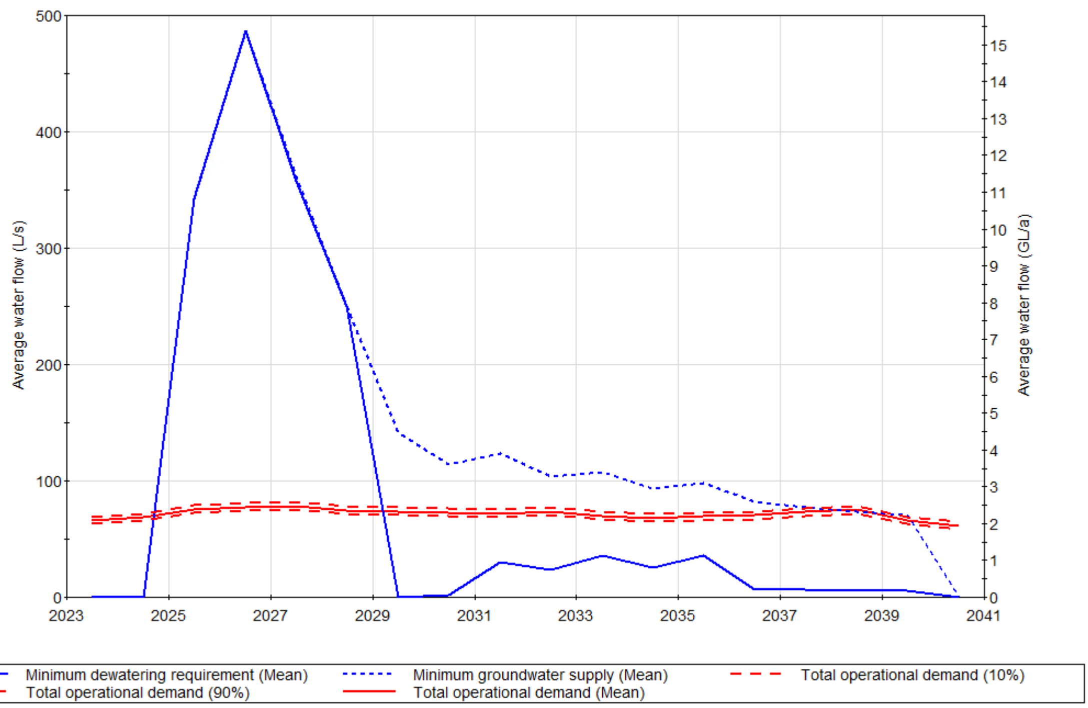

Figure 6-1 Available groundwater supply and total operational demand

6.3 Off site discharges

The expected pit dewatering requirements, will require off-site discharge throughout the life of the project. As no ore processing is proposed on site, there is limited potential for reuse and the site is expected to remain in water surplus. Excess water disposal is proposed to be discharged off-site via a three creek lines and is discussed in the excess water disposal assessment reported in the Groundwater H3 Report (GHD, 2021) and Surface Water Assessment Report (GHD, 2021).

6.4 Water security

The water supply available from dewatering is expected to be sufficient to supply the operational demands throughout the mine life.

6.5 Pit availability

Periods of above average rainfall and the accumulation of water in the base of the pits have the potential to reduce the ability to mine in the pits. While wet weather delays are inherently accounted for in the mining schedule, the dewatering system must be designed so that delays are minimised.

Based on a nominal sump volume of 30 ML and a dewatering pump rate of 100 L/s (refer to Section 4.8), the cumulative mean wet weather delay (days) expected based on the water balance modelling is shown in Figure 6-2.

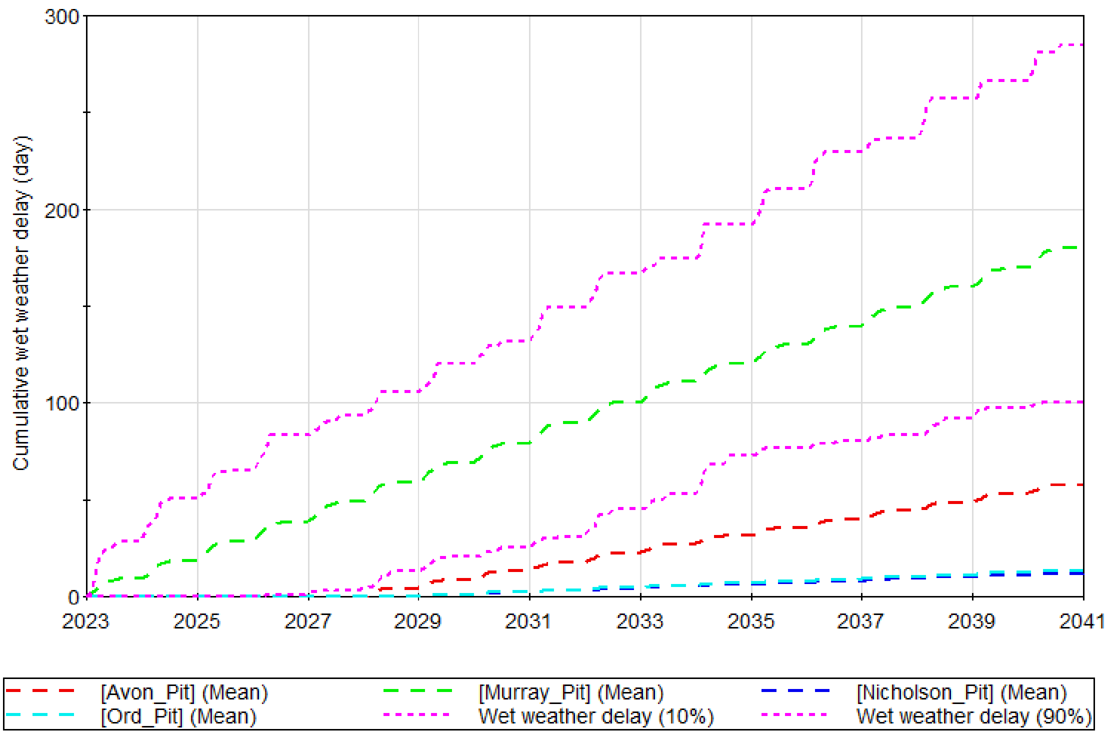

Figure 6-2 Cumulative wet weather delay

Figure 6-2 shows that Murray Pit, with the largest catchment area and longest operational period of all the pits has a mean cumulative expected wet weather delay of about 3% of the mine life period. To reduce this delay a larger than nominal sump volume would need to be applied combined with additional pump capacity.

6.6 Pit lake recovery

Long-term pit lake recovery modelling is described in the H3 groundwater assessment report (GHD 2021). The recovery modelling showed that the pit lakes are expected to remain long-term evaporative sinks with predicted steady state pit lake levels well below the existing ground levels. While some flow through Nicholson and Ord Pit to Murray and Avon Pit is expected, the pit lake system as a whole is expected to remain a sink.

The evaporation and runoff estimates in the pit lake recovery modelling (GHD 2021) were consistent with those adopted in the water balance modelling approach. The water balance of the entire pit lake system is shown in Figure 6-3 and shows that the system is expected to recover to equilibrium within about 40 years post closure and remain a long term groundwater sink with a net groundwater inflow. The estimated water levels in the pit lakes formed in Murray Pit and Avon Pit are shown in Figure 6-4.

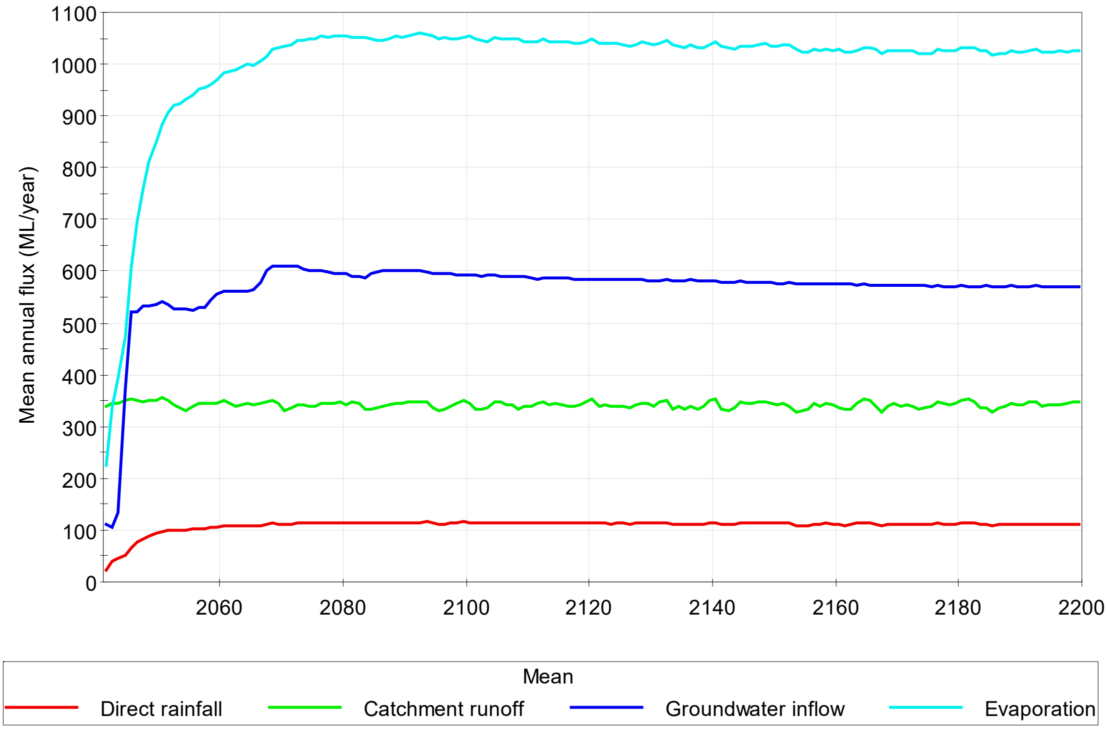

Figure 6-3 Pit lake recovery water fluxes

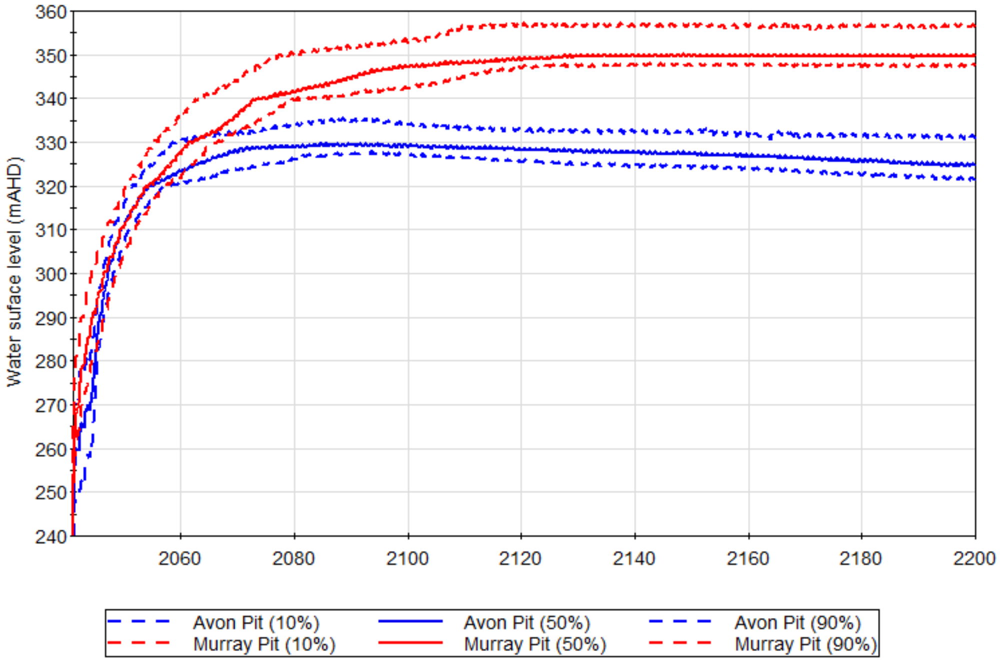

Figure 6-4 Estimated water levels in the pit lakes

Figure 6-4 shows the expected equilibrium water levels in Avon and Murray pit lakes are about 340 m AHD, consistent with the pit lake recovery modelling, and the expected variability under different rainfall conditions is relatively small. There is evidence of a slight decreasing trend in water levels, which is consistent with the regional groundwater recovery trends.

7. Conclusion and recommendations

A lumped mass balance model was developed for the McPhee Iron Ore project. The water balance modelling considered rainfall, evaporation, catchment runoff, water management storages, dewatering, ore crushing, dust suppression, camp water use, intermediate storages, off-site discharge and post-closure recovery of water in open pits. The modelling undertaken was consistent with outputs from the surface water and groundwater assessments undertaken by GHD (2020).

The modelling results indicate that the site is expected to be in water excess during most of the project life, except for the initial period when mining occurs above the water table and groundwater abstraction will be required to supply site operational demands. This could be supplied by advance dewatering.

During the latter part of the project life, the expected dewatering requirements to maintain all pits in a dry state (scenario 2 and base case) is roughly equal to the operational site demands, and therefore the site may be close to water neutral during dry years.

The project is expected to require off-site discharge of excess water throughout the project life and will have high water security.

A proposed pit surface water dewatering system with a nominal sump and pump capacity of 30ML and 100 L/s respectively in each pit is expected to enable mining in the pits to resume quickly following significant rainfall events with a mean modelled delay of approximately 3% of time due to wet weather. Murray Pit operations will benefit from installing additional dewatering capacity to reduce potential delays.

While the modelling indicates that the site will have high water security throughout its' life, there remains inherent uncertainty particularly in relation to the dust suppression demands and dewatering yield that have the potential to result in a water deficit in the later part of project life. This deficit may be sourced from groundwater abstraction associated with the existing dewatering bores.

The dust suppression demand should be reviewed as part of further studies in the event that layout or design changes alter the expected haul road length and area and other assumptions made in this assessment. Future updates of the groundwater drawdown and pit lake recovery prediction should include consideration of this anticipated demand during the later part of the mine life.

It is recommended that a comprehensive record keeping of the number, frequency, volume of dust suppression, and the area it is applied to is maintained throughout the mine operations. Records, once the site moves to extreme water excess, are unlikely to be a reliable indicator of the minimum dust suppression requirement that may be required during the latter part of the mine life. The groundwater monitoring network proposed as part of the H3 groundwater assessment (GHD 2020), is expected to provide adequate data for recalibration of the groundwater drawdown and pit lake recovery modelling as required.

Post closure the pit lake system is expected to remain as a long term groundwater sink

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GHD

Level 10
999 Hay Street
T: 61 8 6222 8222   F: 61 8 9463 6012   E: permail@ghd.com

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