Toms Gully Underground Project EIS Supplement

Appendix K– Site Water Balance

Primary Gold Ltd

Toms Gully Gold Project
Site water balance

July 2018

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1. Introduction

1.1 Background

Toms Gully mine, located near Mount Bundey in the Northern Territory, has been in operation since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery the project area has been operating intermittently under the ownership of several different operators, most recently Crocodile Gold, until 2010. Then, after a period of care and maintenance, it was divested to Primary Gold Ltd (Primary Gold). Operating conditions at Toms Gully Mine have been subject to obligations outlined in the Public Environmental Review (PER) and associated documents that were released in 1988 and a series of waste discharge licences (WDLs). Primary Gold Limited, the new lease owner, proposes to recommence underground mining and ore processing at the Toms Gully Mine. This will include:

- construction of a new water dam (New WSD)
- dewatering and refurbishment of the existing workings
- potential upgrade of Tailings Storage Facility 1 ("old") (TSF1) and Tailings Storage Facility 2 ("new") (TSF2)
- if required as a contingency measure, the construction of a new Tailings Storage Facility (TSF)
- refurbishment and upgrade of the processing circuit
- establish a water treatment plant

The NT EPA determined that the Project required assessment under the Environmental Assessment Act at the level of an Environmental Impact Statement (EIS). A draft EIS document was lodged with the NT EPA in 2015.

Primary Gold engaged GHD Pty Ltd (GHD) to prepare a site water balance for the purpose of updating the 2015 water balance to support the EIS Supplement and associated changes. Additionally the work provides a framework to develop an operational water management tool for ongoing use.

The water balance has been updated to reflect more recent data and studies (including the groundwater modelling and geochemical baseline and conceptual site model (GHD 2018). Where there is an absence of detailed site information, the site water balance draws on the previously prepared *Toms Gully Underground Project: Water Balance Model* (Coffey 2015).

1.2 Purpose of this report

The purpose of this report is to describe the site water balance of Toms Gully mine. The site water balance has been analysed using a site water balance model. This report describes input data, the model methodology and presents and interprets the results of the model.

1.3 Scope

The scope of the site water balance includes the rainfall, runoff, evaporation and seepage of surface storages on site; gravity and pumped flows of water; and water usage for operational processes. The site water balance also includes a coupled acid mass balance, for the purpose of estimating the relative risk of acid mine drainage in the surface water storages.

2. Water management

Toms Gully mine is located within the Mount Bundey creek catchment. The land surface comprises a series of small ridges and dissected hills drained by small stream channels which flow north into Mount Bundey creek. Mount Bundey creek flows through the northern portion of the project site from west to east, about 300 m north of Toms Gully open pit, before discharging into Hardies creek, approximately 7 km east of the project area. Coulter creek is a tributary of Mount Bundey creek and flows through the south-eastern corner of the of the project area discharging to Mount Bundey creek about 5 km downstream of the project area. All the creeks and drainage lines are ephemeral and only flow during the wet season after rainfall events. The surface elevation reaches 51 m Australian Height Datum (AHD) in the south-west corner of the mining lease and falls to 16 m AHD in the low-lying areas.

The inflows to Toms Gully mine are:

- Direct rainfall and catchment runoff
- Groundwater inflows.
- ROM ore moisture

The outflows from Toms Gully mine are:

- Evaporation and seepage losses from surface storages.
- Off-site discharges or supply of treated water to third party.
- Losses from dust suppression.
- Moisture retained in tailings.

Toms Gully mine includes an open pit, a processing plant, waste rock dumps (WRD) and tailings storage facilities (TSF). The open pit (Toms Gully Open Pit) is currently filling with water and Primary Gold proposes to dewater the pit to access the underground mining area. As part of the management of the water that would need to be removed from Toms Gully Open Pit, Primary Gold propose to construct an offline new water storage dam (New WSD) on the west of the site and a water treatment plant. Primary Gold proposes to upgrade both of the existing TSF1 and TSF2 for use during the operation of the mine but also has contingency plans to construct a new TSF to the west of the site.

The processing plant can be supplied by the turkeys nest style Process Water Pond. Runoff from processing plant area and ROM pad reports to the Stormwater Pond. The sulphide WRD to the north west encloses a pair of cascading storages known as Evaporation Pond 1 (EP1) and Evaporation Pond 2 (EP2). The oxide WRD to the south east is skirted by a drainage bund.

Overflow from the Stormwater Pond and drainage bund report to an area known as the wetland oxbow before entering Mount Bundey Creek. As no active management (by pumping) of the wetland oxbow is proposed at this stage, it is not considered within the site water balance. For the same reason, a natural depression to the east, Lake Bazzamundi is not considered in the site water balance.

2.1 Water management features

The water management system at Toms Gully mine was conceptualised as a network of water management *features* representing surface water storages, operational processes and 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 features considered are summarised in Table 2-1. The site water features are shown spatially in # indicates that, although considered hydrologically possible for the purpose of completeness, such overflows are unlikely given the inherent geometry and hydrology of these water storages.

Figure 2-1 and site water management is summarised schematically in Figure 2-2.

Table 2-1 Water management features

Feature	Inflows	Outflows
Evaporation Pond 1 (EP1)	Direct rainfall and catchment runoff Pump from Oxide WRD drainage bund Pump from Stormwater Pond	Evaporation and seepage losses Pump to Process Water Pond Dewater to New WSD via WTP *Overflow to EP2#*
Evaporation Pond 2 (EP2)	Direct rainfall and catchment runoff *Overflow from EP1#*	Evaporation and seepage losses Pump to Process Water Pond Dewater to New WSD via WTP *Overflow to Mount Bundey Creek#*
Oxide WRD drainage bund	Direct rainfall and catchment runoff	Evaporation and seepage losses Dewater to EP1 Overflow to wetland Oxbow
Process Water Pond (PWP)	Direct rainfall and catchment runoff Pump from EP1 Pump from EP2 Pump from New TSF Pump from New WSD	Evaporation and seepage losses Use in processing plant *Overflow to Mount Bundey Creek#*
Processing plant	Supply from PWP ROM ore moisture	Tailings moisture (bleed water and retained in tailings)
TSF1 (“old”)	Direct rainfall and catchment runoff Bleed water from tailings	Evaporation and seepage losses Decant to TSF1 decant pond Dewater to New WSD via WTP *Overflow to Mount Bundey Creek#*
TSF1 (“old”) decant pond	Direct rainfall and catchment runoff Decant from TSF1	Decant to PWP *Overflow to Mount Bundey Creek#*
TSF2 (“new”)	Direct rainfall and catchment runoff Bleed water from tailings	Evaporation and seepage losses Decant to PWP Dewater to New WSD via WTP *Overflow to Mount Bundey Creek#*
New Tailings Storage Facility (New TSF) (if constructed)	Direct rainfall and catchment runoff Bleed water from tailings	Evaporation and seepage losses Decant to PWP Dewater to New WSD via WTP *Overflow to Mount Bundey Creek#*
New Water Storage Dam (New WSD) (once constructed)	Direct rainfall and catchment runoff Pump from Toms Gully Open Pit (via WTP)	Evaporation and seepage losses Pump to PWP Discharge to Mount Bundey Creek Dust suppression *Overflow to Mount Bundey Creek#*
Stormwater pond	Direct rainfall and catchment runoff	Evaporation and seepage losses Dewater to EP1 Overflow to wetland Oxbow
Toms Gully Open Pit	Direct rainfall and catchment runoff Groundwater inflows	Evaporation Dewater to New WSD (via WTP) *Overflow to Mount Bundey Creek#*

# indicates that, although considered hydrologically possible for the purpose of completeness, such overflows are unlikely given the inherent geometry and hydrology of these water storages.

Figure 2-1 Water management system layout

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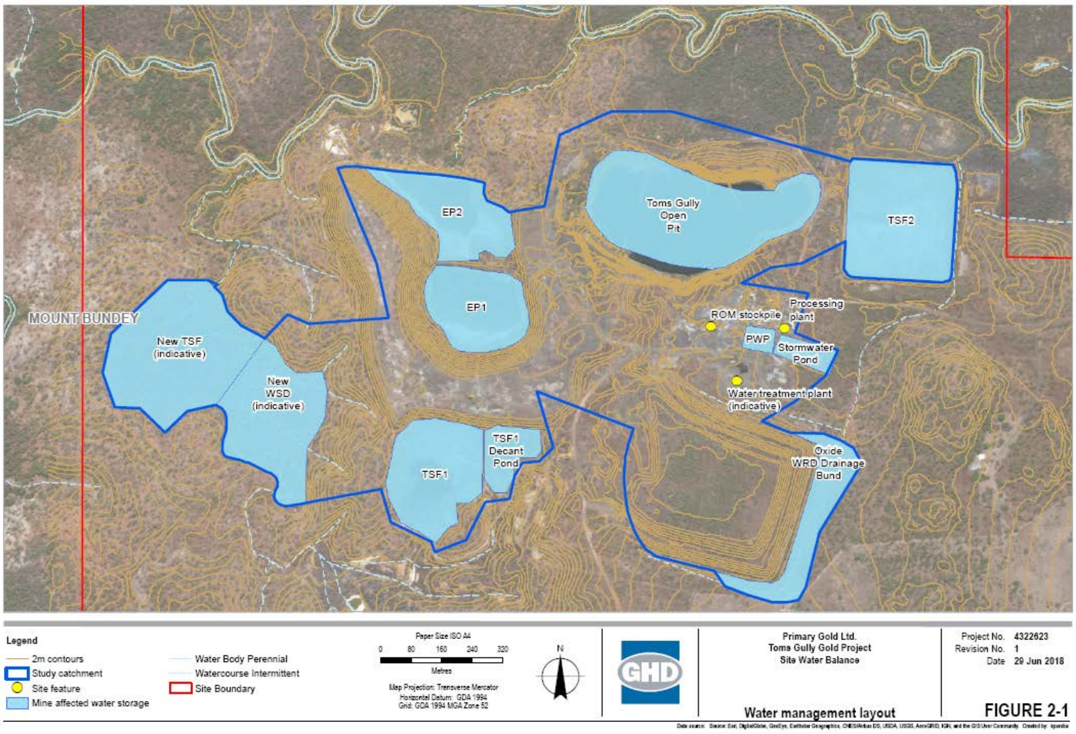

Figure 2-2 Water management schematic

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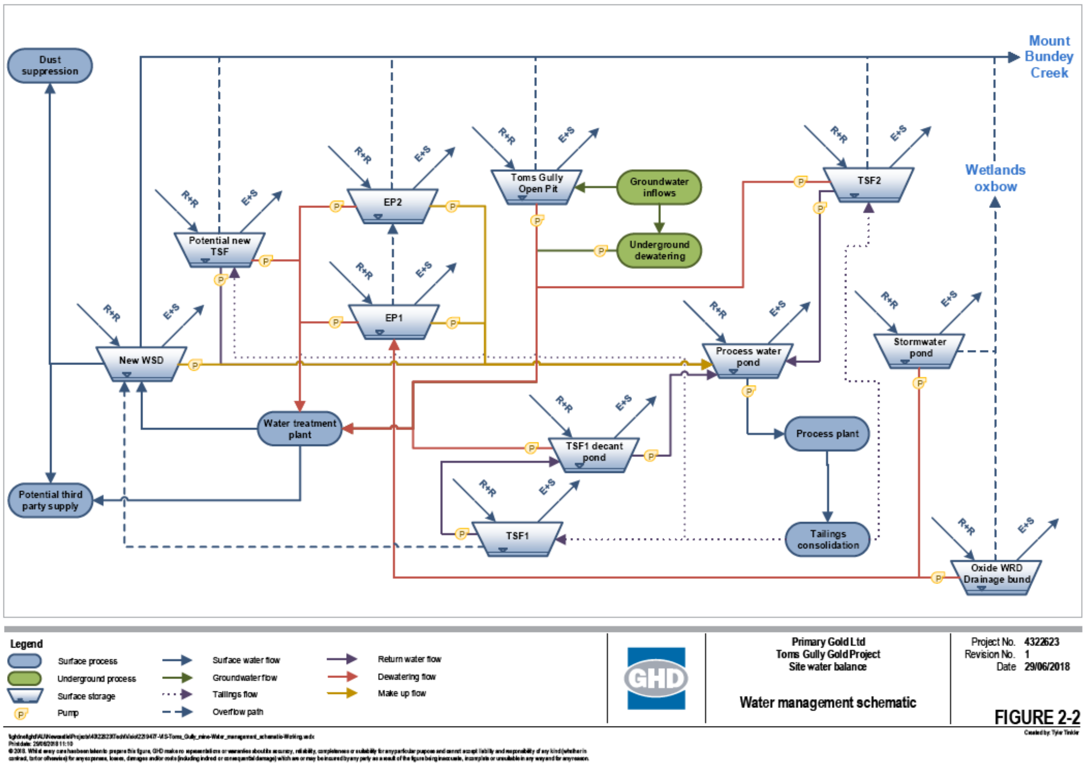

3. Data

The development of the water balance for Toms Gully mine involved the collation and interpretation of data from various sources. The purpose of this section is to summarise the data used. The sources of data used are shown in Table 3-1.

Table 3-1 Summary of data sources

Data	Source
Historical rainfall and evaporation record	SILO (DSITI, 2017)
Catchment areas and landuse	Develop from aerial imagery and site contours provided by Primary Gold
Storages	Coffey (2014)
Groundwater	Coffey (2014)
Operations	Conceptualised in consultation with Primary Gold
Geochemistry	Derived from GHD (2018)

3.1 Rainfall and evaporation

A historical record of daily rainfall, evaporation and evapotranspiration depths was obtained in the form of a patched point data set from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Science, Information Technology and Innovation (DSITI). SILO patched point data is based on observed historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolating with data from nearby stations (DSITI 2017).

For this assessment, SILO data was obtained for the Middle Point Rangers station (station number 014090), which is located approximately 39 km north-east of the site. This station was chosen based on proximity to the site and similarity of elevation. The period of rainfall data used for this assessment extended from 1 January 1957 to 1 January 2018 (a total of 61 years).

Figure 3-1 shows the distribution of annual rainfall and evaporation totals near Toms Gully mine. Annual rainfall totals vary between from about 1000 mm to about 2200 mm, with an average of about 1430 mm. Annual pan evaporation totals are about 2100 mm, resulting in annual potential evaporation of about 1500 mm.

Figure 3-2 shows the average monthly rainfall and evaporation totals near Toms Gully mine. The climate of the Darwin-Katherine region is tropical and experiences two distinct seasons. The monsoonal wet season occurs from November to April and is typified by high humidity, temperature and evaporation. The cooler, less humid dry season occurs from May to October.

Figure 3-3 shows the average distribution of daily rainfall totals near Toms Gully mine. On average, daily rainfall totals exceeding 0.1 mm occur on about 30 % of days, while daily rainfall totals exceeding 50 mm occur on less than 1 % of days.

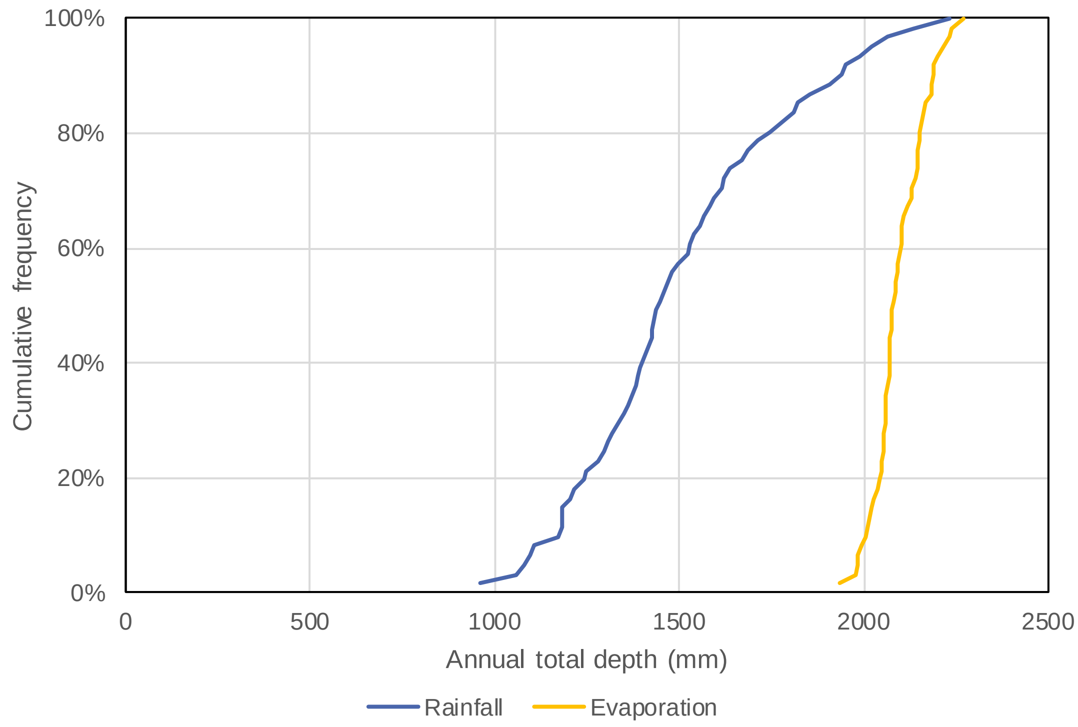

Figure 3-1 Annual rainfall and evaporation totals

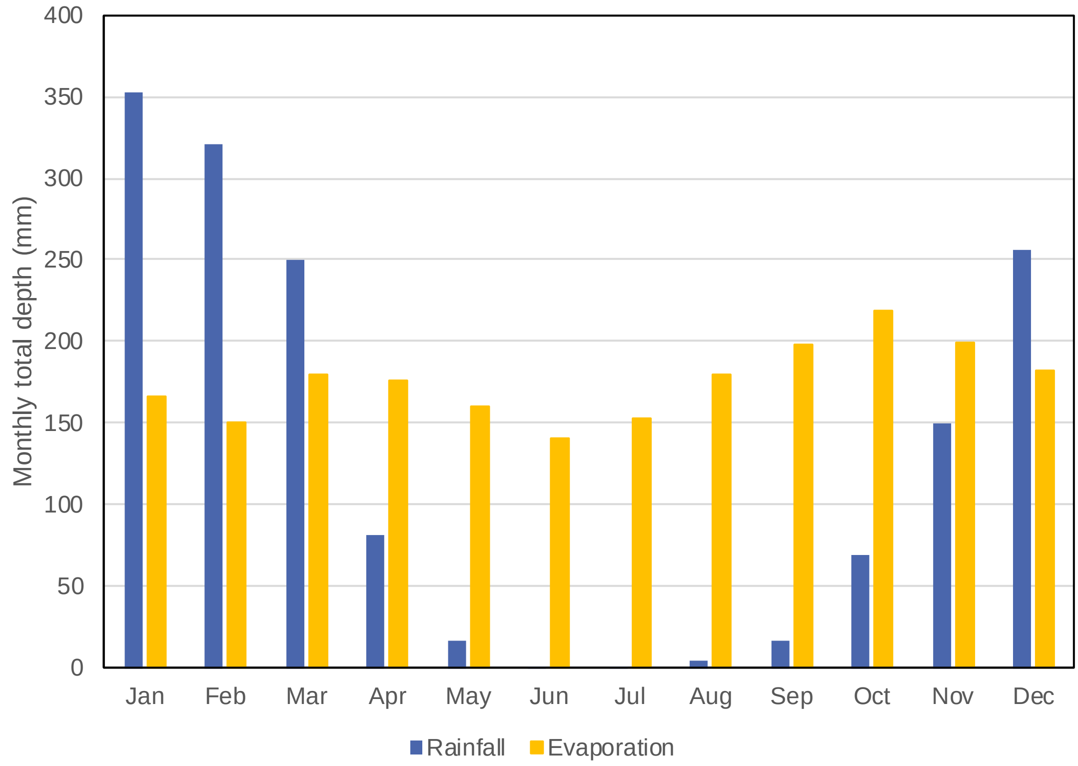

Figure 3-2 Monthly rainfall and evaporation totals

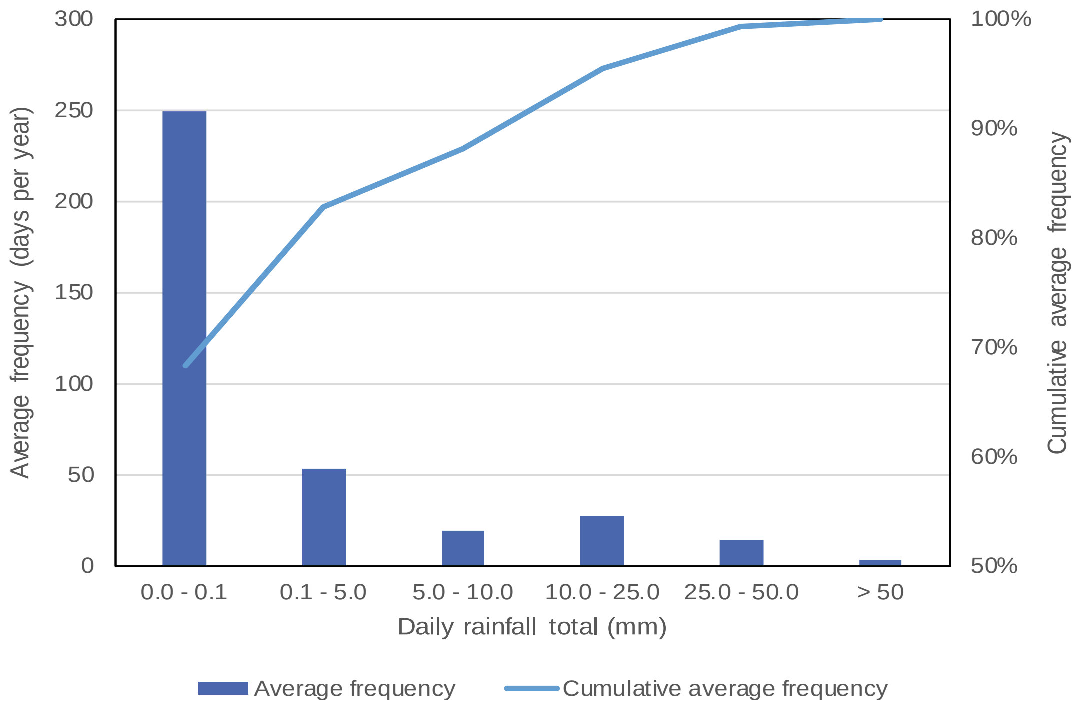

Figure 3-3 Daily rainfall totals

3.2 Catchments

The catchment areas of each water management feature were delineated based on topographic information. The land use of site, for the purpose of the site water balance, was delineated based on aerial imagery and site observations. The catchment area and land use distributions for each water management feature are summarised in Table 3-2.

Table 3-2 Catchment areas

Catchment	Hardstand (ha)	Oxide WRD (ha)	Pit (ha)	Sulphide WRD (ha)	TSF (ha)	Undisturbed (ha)
EP1	-	-	-	15.0	-	-
EP2	-	-	-	10.6	-	-
New WSD	-	-	-	-	10.5	-
Drainage Bund	-	-	-	2.4	-	15.7
PWP	-	22.5	-	-	-	-
Stormwater Pond	0.5	-	-	-	-	-
Toms Gully Open Pit	10.4	-	-	-	-	6.7
TSF1	-	-	32.3	1.6	-	-
TSF1 decant pond	-	-	-	1.1	6.7	1.4
TSF2	-	-	-	1.1	2.1	0.1
New TSF	-	-	-	-	8.7	-

Catchments and land uses are shown in Figure 3-4.

Figure 3-4 Catchments and land use

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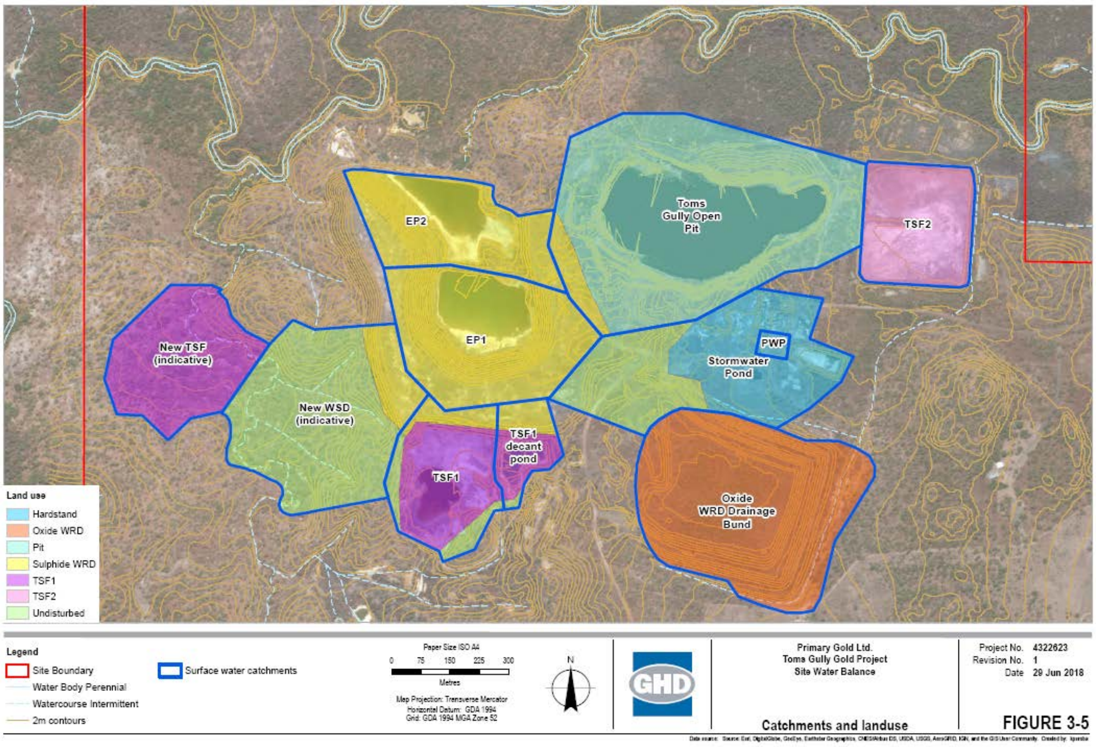

3.3 Storages

The capacity of surface water storages and the maximum surface areas were provided by Primary Gold. Compared to the previous water balance report (Coffey 2015), the design of the New WSD has been reduced to suit the revised water management system and its offline configuration. The geometric properties of the surface water storages are summarised in Table 3-3. In the absence of detailed survey, a shape factor was used to characterise a power law relationship, as discussed in Section 4.5.

Table 3-3 Water storages

Water management feature	Capacity (ML)	Spill level (m RL)	Maximum inundated area	Shape factor
EP1	346	1029.35	4.67	5
EP2	354	1025.76	4.79	5
New WSD	1000 (once constructed)	Unknown	16.0	2
Drainage bund	5.0	Unknown	7.4	2
PWP	1.4	Unknown	0.03	3
Stormwater pond	12.5	Unknown	0.6	2
Toms Gully Open Pit	4660	1019.0	9.0	3
TSF1 (including decant pond)	135.2	Unknown	7.4	5
TSF2	408.9 (once upgraded)	1026.5	8.7 (once upgraded)	5
New TSF	Unknown	Unknown	9.0	5

3.4 Groundwater

Groundwater inflows and potential seepage losses, as included in the previous water balance modelling (Coffey 2015) are summarised in Table 3-4. The most significant groundwater inflow is to the pit and underground, which was observed to be about 32 L/s in 2010 at the end of operations (GHD 2018). More recent groundwater modelling (GHD 2018) did not provide any quantitative predictions of groundwater flows.

Table 3-4 Groundwater flows

Water management feature	Groundwater inflows (kL/day)	Potential seepage losses (kL/day)
EP1	0	10
EP2	0	10
New WSD	0	398
Drainage bund	0	10
PWP	0	0
Stormwater pond	0	0
Toms Gully Open Pit	Up to 2765 (scaled linearly based on depth of water in pit)	0
TSF1	0	10
TSF2	0	15
New TSF	0	0

Part of the rainfall that falls on the sulphide WRD and oxide WRD is likely to infiltrate into the WRDs and seep through the WRD. Most of this water is collected by the adjacent surface water storages: the sulphide WRD reports to EP1, EP2, open pit and New WSD (once constructed) while the oxide WRD reports to the drainage bund. This seepage is accounted for in the site water balance as part of the catchment runoff to the surface water storages. A relatively minor portion of seepage is likely to report offsite, especially in the north west corner of the sulphide WRD. The quantity of this off site seepage has not been estimated in the site water balance, but it is considered minor, relative to the surface water flows. Any potential off site seepage is likely to be reduced once the open pit is dewatered due to increase the hydraulic gradient towards the pit.

3.5 Operations

Operational rules were developed to approximate the operations and pumping at Toms Gully mine. The operational processes and pumping rules adopted for the purpose of the site water balance model are summarised in Table 3-5. It is expected that the operational rules will be refined as the design of water management infrastructure is further developed.

Table 3-5 Operational pumping

Pumped transfer	Pump rate	Pump trigger on	Pump trigger off
Dewater Toms Gully Open Cut to New WSD (via WTP)	Discharge up to 30 ML/day when New WSD is greater than 500 ML. Maintain at least 500 ML for drought security.		
Discharge outlet from WSD	1 % of simulated flow in Mount Bundey Creek	New WSD greater than 510 ML	New WSD less than 490 ML
Dust suppression	30 kL/day	At all times from New WSD	
Process water makeup from EP1, EP2 or New WSD	1 ML/day	PWP less than 0.2 ML	PWP greater than 0.6 ML
		Pump from whichever of EP1 or EP2 is higher until both below 10 ML. Then pump from New WSD	
Processing demand (less ore moisture of 0.05 ML/day = 5 % @ 0.35 Mtpa)	1044 kL/ROM tonne (1000 kL/day @ 0.35 Mtpa)	Whenever water volume in Toms Gully Open Pit is less than 20 ML (ie when mining is occuring)	
Dewater EP1, EP2, TSF1 and TSF2 to New WSD (via WTP)	100 L/s	Maintain freeboard for the 1000 year ARI design flood event	
Tailings consolidation	80 % of tailings moisture retained or lost	Whenever processing plant is operating	
Tailings decant to PWP	1 ML/day	PWP is less than 0.6 ML	PWP is greater than 0.8 ML
Dewater Drainage bund to EP1	50 L/s	Drainage bund is not empty	Drainage bund is empty
Dewater Stormwater Pond to EP1	50 L/s	Stormwater pond is not empty	Stormwater pond is empty

4. Model methodology

4.1 Water balance

The site water balance for Toms Gully mine was modelled as a semi-distributed mass balance, considering the water management features described in Section 2.1. 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.
- Groundwater inflow G_{in}, estimated from the separate groundwater modelling.

The water balance considered the outflows from each storage:

- Evaporation E, estimated from the simulated water surface area of the storage. A pan factor of 0.9 was adopted to the pan evaporation to estimate both potential evaporation and potential evapotranspiration from simulated pan evaporation.

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.

4.2 Rainfall variability

Rainfall variability was considered in the site water balance by sampling simulated rainfall from the historical rainfall record (refer to Section 3.1). A series of simulations were performed, each beginning in a different year of the historical rainfall record and proceeding consecutively through the record (and looped where required).

4.3 Hydrologic model

The Australian Water Balance Model (AWBM) (Boughton & Chiew, 2003) was used to estimate the runoff contributing to the surface water storages. The AWBM was adopted as it:

- Is widely used throughout Australia, especially for mining applications.
- Has been verified through comparison with large amounts of recorded streamflow data.
- Has literature available to assist in estimating input parameters.
- Considers soil moisture retention state when determining runoff.

The AWBM is a soil moisture water balance model that calculates runoff from rainfall after allowing for losses and storage. A schematic of the model is included in Figure 4-1, which shows that the model consists of three storage elements (with surface areas A_1, A_2 and A_3) representing soil moisture.

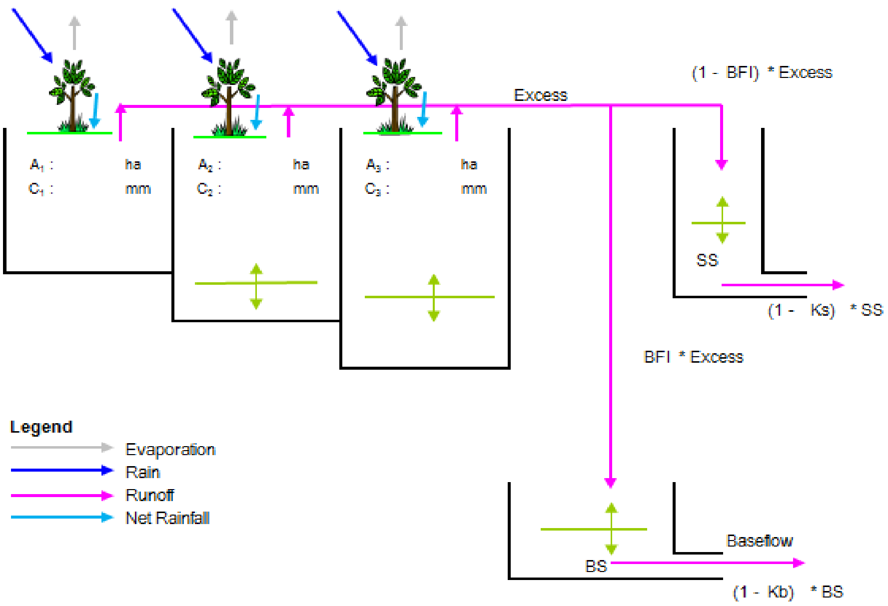

Figure 4-1 Australian water balance model schematic

Rainfall enters these storages and when a storage element is full, any additional rainfall is considered to be 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 estimated as a proportion of the volume of the storages at the end of each day. The total runoff is the combined volume of water discharged from these two storages. The parameters of the AWBM are summarised in Table 4-1.

Table 4-1 Australia water balance model parameters

Parameter	Description
A1, A2, A3	The partial areas of the overall catchment contributing to each storage.
C1, C2, C3	The capacity of storages 1, 2 and 3 respectively.
BFI	The proportion of excess rainfall flowing to the baseflow.
Kb	The proportion of the volume of the baseflow storage remaining in the storage.
Ks	The proportion of the surface storage remaining in the storage.

The site-specific land uses (refer to Section 3.2) were characterised with different sets of AWBM parameters. The AWBM parameters adopted for the water balance model are summarised in Table 4-2.

Table 4-2 Site parameterisation of Australian water balance model

Parameter	Hardstand	Oxide WRD	Pit	Sulphide WRD	TSF	Undisturbed
A1, A2, A3	0.134, 0.433, 0.433					
Cave	35.4	100.2	35.4	100.2	14.3	120
C1, C2, C3	0.01, 0.33, 0.66					
BFI	0	0	0	0	0.01	0.3
Kb	0	0	0	0	0.81	0.98
Ks	0	0	0	0	0	0

The parameters used to characterise the land uses are typical hydrologic parameters for such areas.

4.4 Acid mine drainage model

A key risk for the future operations at Toms Gully is acid mine drainage (AMD). The conceptual site model of sources, pathways and receptors of acid mine drainage was developed by GHD (2018). This conceptual site model was used to develop a mass balance of acid, expressed in mass of $CaCO_3$ that may be used to treat the water to neutralise the acidity. The acid mass balance was coupled with the water balance model for the purpose of quantitatively comparing the relative risk of acid mine drainage.

GHD (2018) identified the significant sources of potential acid generation as the sulphide waste rock dump, oxide waste rock dump, TSF1 and TSF2 and estimated net acid generation. The ROM stockpile, metallurgical tailings and waste rock were also identified as an acid and metalliferous drainage risk, but as the risk was deemed lower it was not quantified in terms of net acid generation. The undisturbed catchments and in situ rock were deemed as a neutral and not a significant source of acid generation. For the purpose of the acid mine drainage model, the neutralising potential of sediment in surface water storage was ignored.

The net acid generation of the different site land uses are summarised in Table 4-3. A nominal net acid generation rate of 0.1 kg $CaCO_3$/ tonne/year was adopted for the disturbed hardstand (predominately the ROM stockpile) and pit areas. It was assumed that any new tailings produced would be lower risk than the existing tailings.

Table 4-3 Net acid generation

Land use	Net acid generation (kg $CaCO_3$/ tonne/year)
TSF1	34
TSF2	3.0
Sulphide WRD	0.4
Oxide WRD	0.1
Hardstand	0.1
Pit	0.1
Undisturbed	0.0

The net acid generation was estimated as a rate per unit catchment area by assuming that the top 1 m of material was exposed to sufficient oxygen for the acid generation to occur. A bulk density of 1.5 tonne/m^3 was assumed for tailings and 2.0 tonne/m^3 for other material. The generated acid was simulated to accumulate in the catchment and then be flushed out with rainfall at a concentration of up to 2000 mg $CaCO_3$/L, based on the approximate upper bound of observed acidity in surface water at the site.

The acid mine drainage model does not consider the any potential of seepage of water from WRDs and surface water storages that may report offsite. The actual flow rates of seepage are difficult to quantify at this stage, but are considered minor and of lower risk than any potential discharge of water directly from surface water storages.

4.5 Geometric approximation

In the absence of survey or design stage storage relationships, the geometry of the surface water storages was estimated using a power law approximation after Hayashi (2000), 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.

4.6 Numerical implementation

The water balance model was implemented in GoldSim (version 12.0). A basic time step of 0.5 day was used, with additional time steps dynamically inserted were required. GoldSim uses the forward Euler method to solve the mass conservation equations described in Section 4.1.

5. Model forecasts

The site water balance model for Toms Gully was used to estimate the site water balance for a range potential rainfall sequences starting from existing conditions at 1 July 2018. The initial conditions are summarised in Table 5-1, based on Coffey (2015) and GHD (2018).

Table 5-1 Initial conditions

Water management feature	Initial volume (ML)	Initial acidity (mg $CaCO_3$/L)
EP1	150	940
EP2	150	975
New WSD	0	0
Oxide WRD drainage bund	0	200
PWP	0.5	30
Stormwater pond	2	0
Toms Gully Open Pit	2600	190
TSF1 (including decant pond)	10	1190
TSF2	10	1600
New TSF	0	0

The following operations were assumed over the proposed mine life:

- Dewatering of Toms Gully Open Pit commenced 1 October 2019.
- Production started when Toms Gully Open Pit was fully dewatered (approximately January 2019).
- Production continued for 3.7 years (44 months) with a ROM rate of 0.35 Mtpa.

The model was simulated from 1 July 2018 to 1 July 2023.

5.1 Interpretation of results

To consider potential rainfall variability, a total of 61 different rainfall patterns were simulated (as described Section 4.2). 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 exclude infrequent extreme wet and dry conditions. 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 acid mine drainage mass balance has been developed for the purpose of quantitatively comparing the relative risk of acid mine drainage of 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.

5.2 Water balance

The forecast average annual water balance for Toms Gully mine is summarised in Table 5-2.

Table 5-2 Average annual site water balance

Water flux	Year ending June 2019 (ML)	Year ending June 2020 (ML)	Year ending June 2021 (ML)	Year ending June 2022 (ML)	Year ending June 2023 (ML)
INPUTS					
Direct rainfall onto storages	692	701	690	686	715
Catchment runoff	603	621	621	623	609
Groundwater inflows	673	971	969	969	969
ROM ore moisture	8	18	18	18	5
Total inputs	1976	2311	2298	2295	2298
OUTPUTS					
Evaporation	705	789	775	768	811
Uncontrolled off site discharge	29	28	28	28	31
Discharge from New WSD (or supply to third party)	2988	1080	1063	1048	1090
Seepage losses	127	164	164	164	164
Dust suppression losses	8	11	11	11	11
Tailings moisture losses	130	293	292	292	75
Total outputs	3986	2365	2334	2312	2181
CHANGE IN STORAGE					
Surface water storages	-2009	-54	-36	-16	117
Total change in storage	-2009	-54	-36	-16	117

Table 5-2 shows that on average, the model forecasts that Toms Gully mine will be in water excess, with no requirement for external water supply. The main inflows to Toms Gully mine are catchment runoff and groundwater inflows, while the main outflows are discharges from the New WSD and evaporation. The total volume of water stored at Toms Gully mine is forecast to decrease on average over the mine life, mainly due to the dewatering of the open pit.

5.3 Water inventory

The median (50th), 10th and 90th percentile daily water volumes in EP2, New WSD and Toms Gully Open Pit are shown in Figure 5-1, Figure 5-3 and Figure 5-2 respectively. The results shown for EP2 are very similar to EP1.

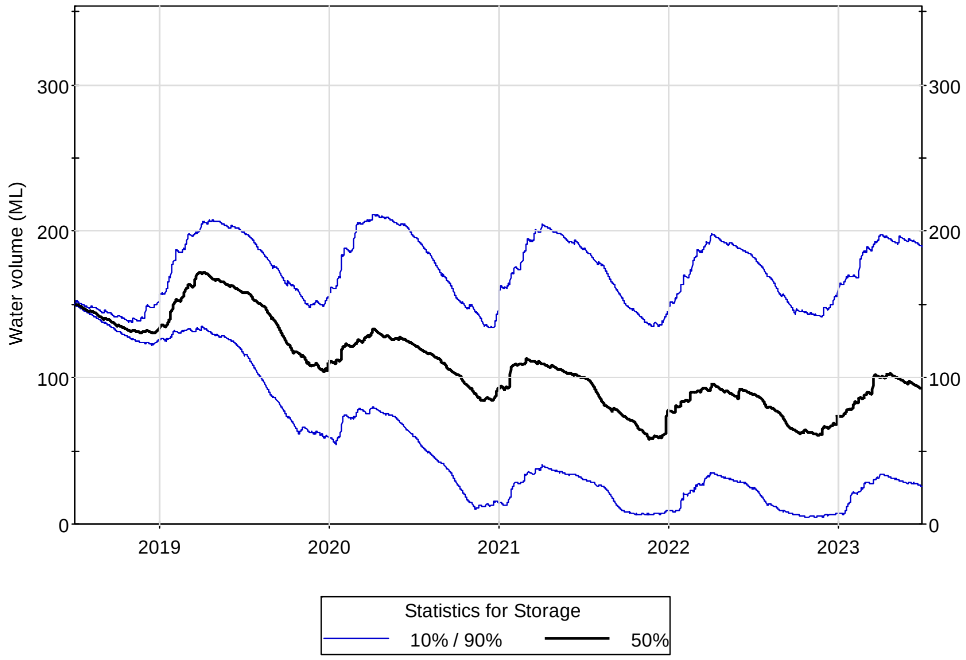

Figure 5-1 Forecast volume of water in EP2

Figure 5-1 shows that average volume of water in EP2 is likely to be about 100 ML over the mine life, varying seasonally and with above and below average rainfall. Using the water treatment plant to treat excess water in EP1 and EP2 allows the water volume to be managed with minimal risk of offsite discharge.

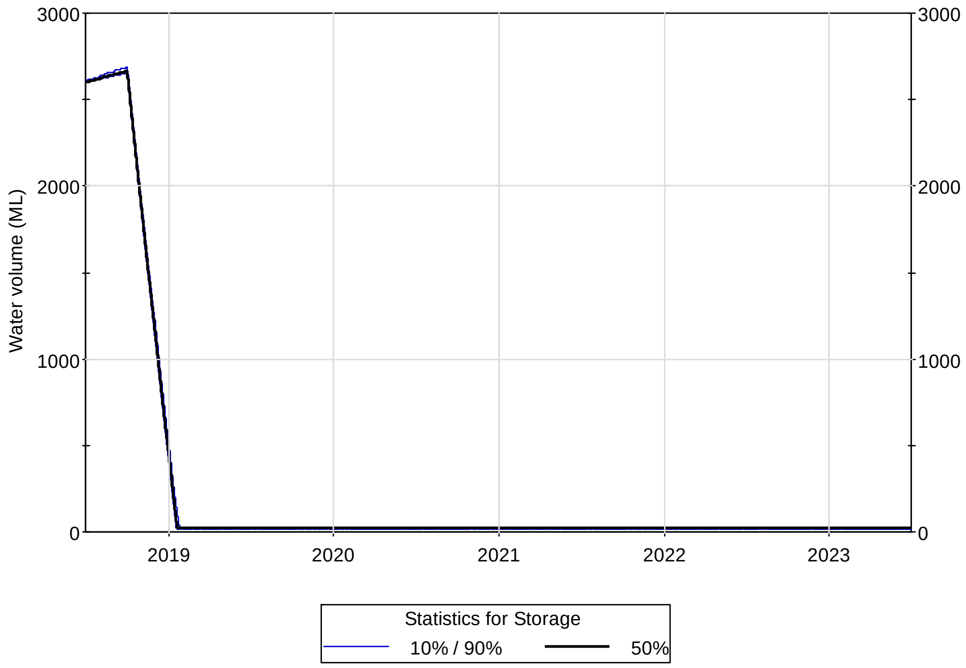

Figure 5-2 Forecast volume of water in Toms Gully Open Pit

Figure 5-2 shows that the volume of water in Toms Gully Open Pit is likely to continue to increase until dewatering commences. Once dewatered, the pit and underground area is maintained drawdown by continuous dewatering. The modelling has assumed that only a small sump (20 ML) can safely be stored below the underground portal.

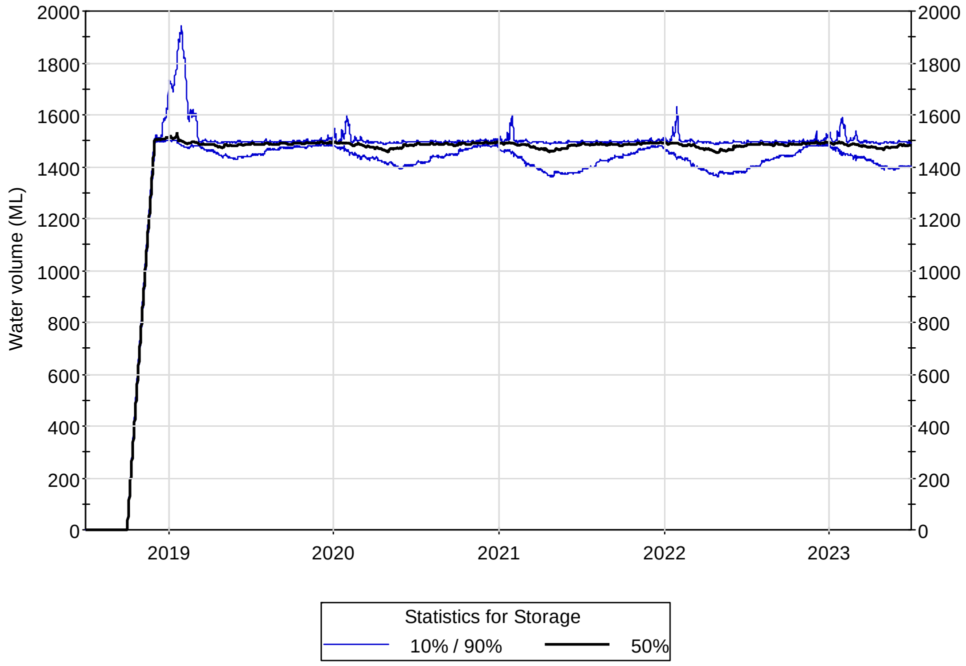

Figure 5-3 Forecast volume of water in New WSD

Figure 5-3 shows that the New WSD is likely comes close to filling in early 2019 April 2019, as the Toms Gully Open Pit is dewatered, combined with the catchment runoff. The volume of water in the New WSD is likely to remain at its high operating volume throughout the remained of the mine life.

5.4 Discharge risk

Figure 5-4 shows the modelled probability of uncontrolled discharge from Stormwater Pond and Oxide WRD drainage bund occurring in any given month over the mine life. No discharges from the other surface water storages were forecast by the model simulations.

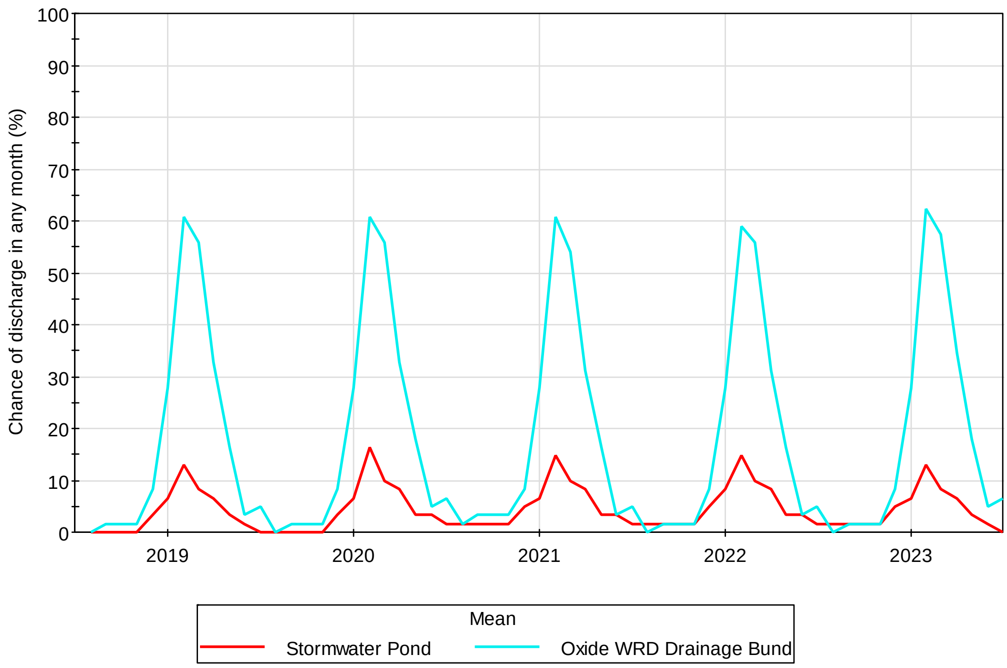

Figure 5-4 Forecast monthly probability of uncontrolled discharges

Figure 5-4 shows that the probability of discharge is, as expected, highest during the wet season. The likelihood of discharge from the Stormwater Pond and Drainage Bund is up to 15 % and 60 % respectively in any one month during the wet season, due to insufficient storage capacity to capture runoff from the surface water catchment.

The annual probability of discharge from Stormwater Pond and Drainage Bund are summarised in Table 5-3. These forecast probability of offsite discharge of mine affected water are significantly higher than 1 %, which is the generally accepted design criteria for new mining projects.

Table 5-3 Forecast annual probability of uncontrolled discharge

Water storage	Annual probability of discharge
Drainage bund	87%
Stormwater pond	32%

In order to achieve a particular design criteria, mine affected water storages are generally required to have at least the capacity to contain runoff from the design rainfall event and achieve timely dewatering of the storage. The design containment freeboard was estimated for the 1 % AEP and 1 in 1000 AEP (72 hour duration) design rainfall depth, using a volumetric runoff coefficient of 0.5 for undisturbed areas and 0.9 for disturbed areas. The design containment freeboard for each storage is summarised in Table 5-4.

Table 5-4 Design freeboard

Storage	Design containment freeboard for 72 hour duration design depth (ML)		Capacity (ML)
	1 in 100 AEP	1 in 1000 AEP	
EP1	62	92	346
EP2	44	65	354
New WSD	46	69	1000
Drainage bund	93	138	5
PWP	0.3	0.3	1.4
Stormwater Pond	59	86	12.5
TSF1 (including decant pond)	51	76	135.2
TSF2	36	53	409
New TSF	37	55	Unknown

Table 5-4 shows that most storages have sufficient capacity to include the design containment freeboard, except for Stormwater Pond and Oxide WRD drainage bund. The design containment freeboard required for Stormwater Pond could be reduced by diverting upslope catchment around the processing area if the upslope catchment was not mine affected.

5.5 Acid mine drainage balance

The forecast average annual acid balance for Toms Gully mine is summarised in Table 5-5 The potential acid mine drainage is expressed in terms of mass of $CaCO_3$ that may be used to treat the water to neutralise the acidity.

Table 5-5 Average annual acid mine drainage balance

Acid flux	Year ending June 2019 (tonne $CaCO_3$)	Year ending June 2020 (tonne $CaCO_3$)	Year ending June 2021 (tonne $CaCO_3$)	Year ending June 2022 (tonne $CaCO_3$)	Year ending June 2023 (tonne $CaCO_3$)
INPUTS					
Direct rainfall onto storages	0	0	0	0	0
Catchment runoff	419	499	507	512	487
Groundwater inflows	0	0	0	0	0
ROM ore moisture	0	0	0	0	0
Total inputs	419	499	507	512	487
OUTPUTS					
Evaporation	0	0	0	0	0
Uncontrolled off site discharge	1	1	1	1	2
Discharge from New WSD (or supply to third party)	5	9	11	12	13
Seepage losses	22	19	20	20	23
Dust suppression losses	0	0	0	0	0
Tailings moisture losses	152	297	291	277	61
Treated by WTP	693	208	200	198	218
Total outputs	873	534	524	509	317
CHANGE IN STORAGE					
Surface water storages	-454	-36	-17	3	169
Total change in storage	-454	-36	-17	3	169

Table 5-5 shows that on average, the model forecasts that the only influx of acid to Toms Gully mine is from catchment runoff, while the main outflux is treatment by the WTP. Based on modelling assumptions, a significant loss of acid is also the entrainment, along with water moisture, in the tailings. There is a small quantity that is forecast to be discharged from the New WSD, due to some of its catchment being made up of sulphide WRD. The modelling forecasts that the total acid on site will decrease over the mine life, mainly associated with the dewatering of the open pit.

The mean forecast total acid in the water stored in major water storages shown in Figure 5-6. Treating the water pumped out of the open pit will reduce the total acid in water storage on site. Following the initial dewatering, the total acid is forecast to remain relatively stable, with seasonal variation. The peak in total acid in water storages is forecast to occur in the middle of the wet season. This may represent the process where acid generated in dry season accumulates in the waste rock and tailings in the catchment, before being flushed out by rainfall. The total acid in water storages then generally decreases through the remainder of the year as water is treated and discharged.

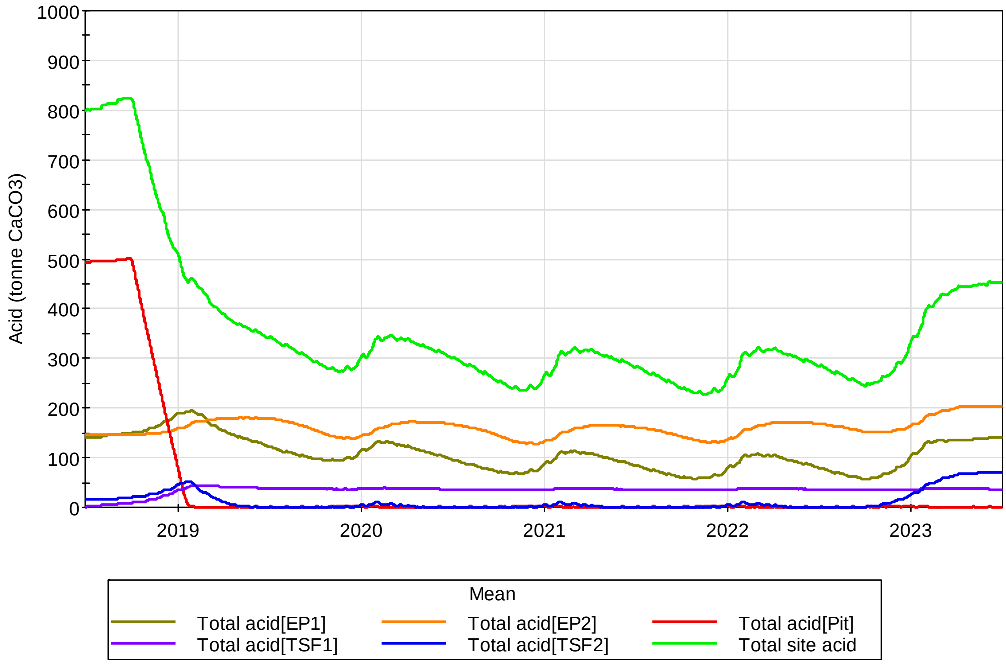

Figure 5-5 Forecast total acid in water storages

The mean forecast acidity of the water stored in major water storages shown in Figure 5-6. The acidity of EP1 is forecast to remain relatively stable, with seasonal variation as explained above. The acidity of EP2 is forecast to increase. Unlike EP1 that is flushed by dewatering of the Stormwater Pond and Drainage Bund, EP2 experiences evapoconcentration, although the model likely overestimates the effect, as the neutralising capacity of the sediment in EP2 is not considered. The acidity of TSF1 and TSF2 are forecast to remain relatively stable, and the actual acidity will depend on the actual tailings emplacement. There is some acidity in the New WSD due to its catchment including a small part of the sulphide WRD.

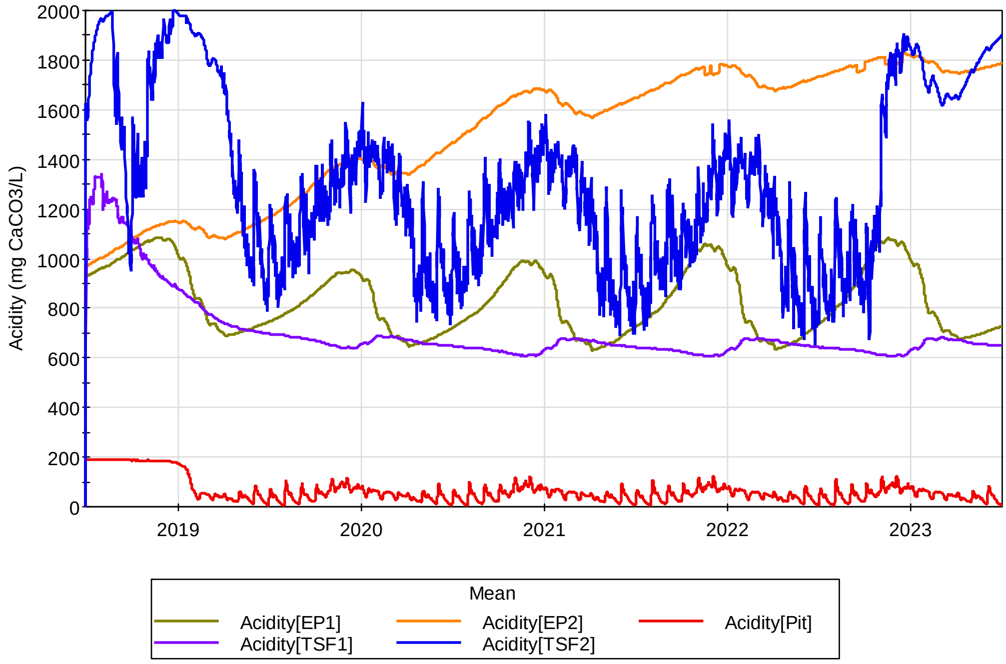

Figure 5-6 Forecast acidity in water storages

Figure 5-7 shows the forecast treatment rate of the WTP to neutralise the acidity in water before it is discharged. The treatment rate is forecast to peak at about 150 tonne $CaCO_3$/month during the dewatering of the open pit and thereafter vary seasonally, peaking in the wet season at about 30 tonne $CaCO_3$/month on average and 90 tonne $CaCO_3$/month in the 90th percentile case.

As the site water balance and design of the water treatment plant is refined, the actual treatment rate may be optimised by using the water storage capacity of EP1 and EP2 below the containment freeboard to smooth out seasonal fluctuations.

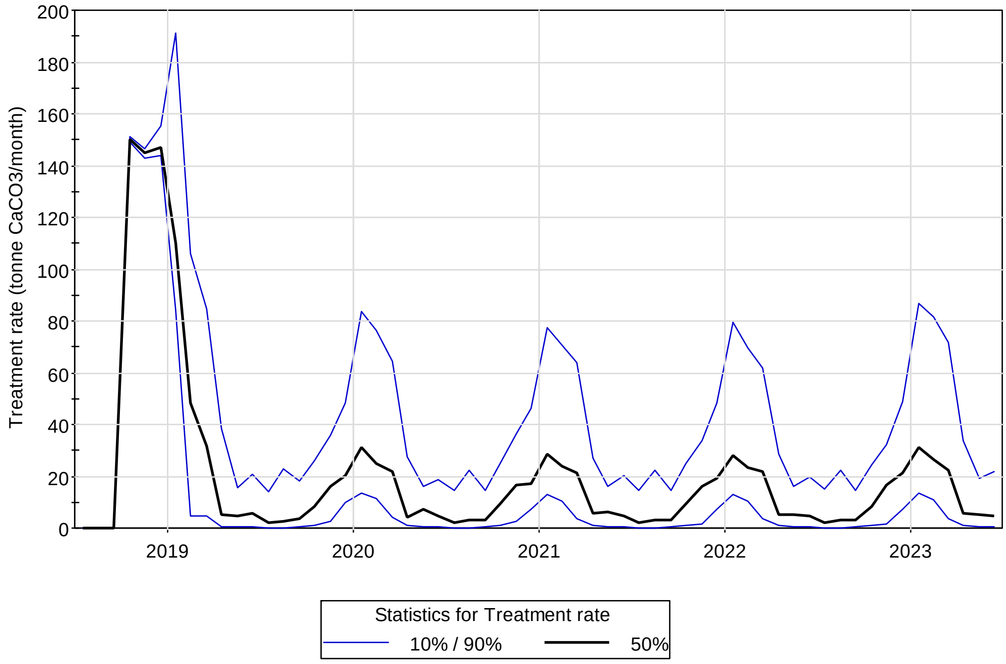

Figure 5-7 Forecast acidity treatment rate

6. Conclusion and recommendations

The site water balance for Toms Gully mine has been updated, building on the previous water balance report prepared by Coffey (2015) and more recent work by GHD (2018). Overall, the model forecasts the probability of offsite discharge of mine affected water of at least 87 % in any given year, which is significantly higher than is generally acceptable for new mining projects in Australia.

The water balance model was coupled with a mass balance to quantitatively compare relative risk of acid mine drainage, expressed in tonnes of $CaCO_3$ that may be used to treat the water. The models forecasts that in the order of 200 tonne $CaCO_3$/year may be required to manage acid mine drainage at the site or the water treatment plant needs to be sized and operated to manage peak water inputs/flows thus managing acid mine drainage at the site.

To enhance accuracy of the water balance in the future, the model may be improved by:

- Incorporating surveyed and design stage-storage relationships surface water storages, particularly for Toms Gully Open Pit and New WSD.
- Incorporating the level of the underground portal and any safe water storage capacity in the pit below it.
- Confirming current water levels in major storages.
- Validating the model against site observations over time. In particular, how the mineral processing and tailings emplacement affects acid generation in the TSFs.
- Considering any seepage from the WRDs or water storages that does not report to the site water management system.

The modelled performance of the site water management system may be improved by:

- Increasing the capacity of the drainage bund and Stormwater Pond.
- Using the water storage capacity of the EP1 and EP2 below the containment freeboard to optimise the required treatment rate by smoothing out seasonal fluctuations in treatment demand.
- Diverting any non mine affected catchment upslope of the ROM pad around the processing area to reduce discharges of mine affected water from the Stormwater Pond.

7. Limitations

This water balance considers the effect of rainfall variation on the results of the model, based on a historical rainfall record. This approach assumes that the historical rainfall record is characteristic of future rainfall variability and does not consider inter-annual climate patterns such as the El Niño Southern Oscillation, Indian Ocean Dipole, or long term trends such as climate change.

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