WATER BALANCE OF METAL MINING TAILINGS MANAGEMENT FACILITIES: INFLUENCE OF CLIMATE CONDITIONS AND TAILINGS MANAGEMENT OPTIONS

by

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Abstract

The objective of this research was done to review and compare available methods for Tailings Management Facilities (TMFs) water balance; to develop deterministic and probabilistic models; and to compare the impacts of different tailings management options and climate conditions.

The developed models were spreadsheet based. Mount Polley operational data were used. Water balance models were created for lined and unlined impoundments in both wet and dry climates. Wet condition climate data were extracted from ClimateBC (a University of British Columbia Software Program) using the location of the Kerr-Sulphurets-Mitchell (KSM) project in British Columbia. Climatic data from the Cerro Negro mine site in Argentina were used to simulate the dry condition.

After developing a deterministic model, Monte Carlo simulation computational algorithm was used to develop the probabilistic evaluations. Simulations were carried out using the Oracle Crystal Ball Excel add-in. Evaluations were done on four management options (slurry, thickened, paste, and filtered tailings) by changing the tailings solids content.

Results confirmed that entrainment and evaporation were the biggest water losses in TMF. For slurry tailings, entrainment loss was more than 80% of the total water loss in the wet condition and more than 50% of the total water loss in the dry condition.

The reported average mine water consumption for slurry tailings in arid climate is between 0.4 and 0.7 m^3/tonne. The estimated mean required make up water from the developed model in this reaserch was 0.70 m^3/tonne. Water withdrawal in dry climate conditions can decrease to 0.18m^3/tonne when a filtered tailings option is implemented.

The average water surplus in wet climate conditions for an unlined impoundment varied between 0.83 and 1.12 m^3/tonne for solids contents between 45% (slurry tailings) and 80% (filtered tailings). The corresponding values for a lined impoundment were 0.86 and 1.16 m^3/tonne.

Implementing dewatered tailings is not recommended in wet climates. In contrast, paste tailings and filtered tailings are good options in arid areas for proper-size operations.

TMFs are site-specific complex systems. Results presented here are only examples to outline how the mining industry can work toward reducing water losses by using dewatering and tailings management technologies.

Preface

As the author of this dissertation, I am fully responsible for the design, data gathering, statistical analyses, research outcomes, and printed results.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

AEP	Annual Exceedance Probability
ARD	Acid Rock Drainage
CDA	Canadian Dam Association
EDF	Environmental Design Flood
IDF	Inflow Design Flood
NOWL	Normal Operating Water Level
PDF	Probability Density Function
PMF	Probable Maximum Flood
RD	Relative Density
TMF	Tailings Management Facility

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To my Family…

Chapter 1: Introduction

1.1 Background

Water management at Tailings Management Facilities (TMF)[1] has always been a challenging issue for the mining industry. Insufficient and excessive water cause problems for operations and the environment. Insufficient free pond water could result in water withdrawal from the water resources. Although mine water consumption has been a small portion of overall global water use, mine water requirements are still considered very high. In 2006, water use for the copper mining industry alone accounted for 1.3 billion m^3 (Gunson et al., 2012).

Excess water in the pond can result in overtopping and uncontrolled release into the environment. The International Commission on Large Dams (ICOLD) and United Nations Environmental Programme (UNEP) (2001) listed 221 total historical tailings incidents and failures. Most reported failure cases were induced by, “overtopping, slope instability, seepage and erosion; all caused by a lack of control of the water balance within the impoundments” (ICOLD and UNEP, 2001, p. 31).

Water balance modeling should be used in the design stage of TMFs to evaluate the water inflows and outflows.

In a dry climate, zero surface discharge can be achieved. However, water conservation remains an issue. Conversely, in a wet climate the main challenge is to attain the most efficient containment in order to minimize environmental effects. Environmental impacts can be reduced by controlling the inflow from runoff, by expanding the ponds, by increasing exposure to

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[1] In much of literature, the term Tailings Storage Facility (TMF) is used. However, in this thesis, Tailings Management Facility (TMF) is used to signify the importance of managing the tailings versus storing the tailings.

evaporation, by decreasing the use of fresh make-up water through recycling water from the TMF, and by decreasing the tailings water retention through fines generation reduction during grinding. Another method is to thicken slurry before deposition to reduce water reporting to the tailings impoundment.

Table 1.1 shows the influence of practising different tailings management options on water use in a hypothetical mine studied by Gunson (2013). This mine could save water by reducing evaporation losses, by thickening the slurry, using ore pre-sorting, or by combining the above mentioned methods. Gunson's study only focuses on water losses.

Table 1.1 Water use reduction scenarios (after Gunson, 2013)

#	Scenario	Description	Water consumption	Water withdrawal m^3/t of ore processed (considering water with ROM of 1,020 m^3/d)
1	Base case	Conventional concentrator	100 % (38,955 m^3/d)	0.76
2	Base case with water conservation	Conventional concentrator and reduction in evaporation losses	87% (33,822 m^3/d)	0.66
3	Paste tailings case	Conventional concentrator and paste tailings disposal	79% (30,682 m^3/d)	0.59
4	Filtered tailings case	Conventional concentrator and filtered tailings disposal	42% (16,491 m^3/d)	0.31
5	Ore pre-sorting case	Conventional concentrator and 20% ore rejection	82% (32,096 m^3/d)	0.62
6	Combined water reduction case	Conventional concentrator and reduction in evaporation losses, as well as 20% ore rejection and filtered tailings disposal	28% (10,878 m^3/d)	0.20

Studies of the influence of different management practices on water balance are not conducted in a consistent way specifically for wet and dry climates. This research not only compares the influence of various tailings management options on water balance, but also studies the effects of two different climate conditions.

In the design stage, the initial water balance models are usually deterministic, meaning they are developed on the average values of input data. Although these models provide fairly good prediction of water balance, they do not include the uncertainty related to the stochastic parameters of water balance. To account for the uncertainties, probabilistic water balance models are introduced. This research implements probabilistic modelling by defining the variable parameters in the model.

Spreadsheet models for water balances made it is easy to vary the input data to evaluate the changes in the system. Transforming the deterministic spreadsheet models to stochastic models is possible by using add-in packages such as Oracle Crystal Ball or @Risk. The water balance models in this research was developed in Microsoft Excel spreadsheets with the Oracle Crystal Ball add-in. Multivariate stochastic systems programs such as GoldSim can also be utilized to develop dynamic probabilistic water balance models.

1.2 Thesis objectives

This research presents a probabilistic water balance model for metal mines incorporating the uncertainty of variables: climate data and tailings management options. It aims to answer the question: How do different tailings management options in different climates affect mine water requirements and surpluses?

The objectives of this research are as follows:

- Review and compare available methods for tailings water balance.

- Extract and analyze climate data for wet and dry conditions. Statistical analyses of climate data are used to reflect the uncertainty of the input data.
- Develop both a deterministic and probabilistic water balances.
- Conduct analyses on different tailings management options.

1.3 Thesis outline

The introduction in Chapter 1 included an overview of the study and the thesis objectives. Chapter2 is a literature review that includes water management options and different methods of water balance. Chapter 2 also discusses the associated advantages and disadvantages of different tailings management options. Chapter 3 describes the methodology of the research. The structure and components of water balance models with data input and climate parameters are addressed in this chapter. Results of deterministic and probabilistic water balance models are presented in Chapters 4 and 5 respectively. The *Discussion* in Chapter 6 compares the results of this research with previous works. Chapter 7 presents the conclusions. Chapter 8, provides suggestions for future research. Graphs and tables of the developed models are provided in the Appendices.

Chapter 2: Literature review

Davies (2001) categorizes tailings impoundments among the largest man-made structures which do not produce any income for the mining companies and only impose costs. How can the cost of tailings disposal be reduced while also environmental considerations are taken into account? In arid climates where water is scarce, water management is necessary to reduce fresh water removal. In wet climates, managing excess water can lower the cost of closure and reduce environmental risks.

The most critical component of water management is a mine water balance model which estimates the water quantity at each operational unit. A comprehensive water balance inspects all mining operations and develops flow diagrams of both impacted water and clean water. Mine site inflow networks include natural rainfall/runoff cycles and water contained in the ore (Meggyes et al., 2003).

Water balance models are developed on different spatial and temporal scales. These scales depend on the objectives of modeling. Periods of balance differ for each project, but it is usually annual, which can summarize one complete hydrological cycle (Naghibi, 2015; Welch, 2000). The focus of this research is around TMF. This chapter focuses on tailings water balance studies and modelling.

2.1 Tailings water balance

TMF water balance is used for design purposes, as well as operational considerations such as the capacity of the impoundment. To store high precipitation events, water balance calculations are used to evaluate the minimum freeboard required. It is also used to estimate mine water requirements. The required water is site specific and influenced by many factors such as the type of commodity being processed, processing method, climate, waste management option, etc. Over the years, multiple publications have provided various estimations of mine water requirements. Table 2.1 summarizes the water consumption statistics reported over time. The studies do not indicate whether the water consumption is the balance between water storage and water discharge or if it is only the water withdrawals (Gunson, 2013).

Table 2.1 Water consumption at different mines (after Gunson, 2013)

Year of publication	**Author**	**Water Consumption (m^3/tonne of ore)**	**Note**
1920	Callow	0.6-30 (including recycle water)	Survey from 25 major mining operations.
1932	Gaudin	1.8-4.8	With flotation pulp density of 18-30%.
1939	Gaudin	0.07-1.5	For mill water consumption.
1985	Yezzi	0.4-20 (of ore processed)	
2003	Brown	0.4-1.0 (of ore processed)	
2003	Atmaca and Kuyumcu	0.13-0.71 (of product for coal) 18.5-23.9 (for copper porphyry) 4-10 (for chrome) 2-29 (for Cu-Pb-Zn) 0.4-5 (for potash and boron salts).	

Welch (2000, p. 391) suggests water balances should have the following specifications:

- simple and easy to use with identifiable input data

- easy to understand and validate
- easy to vary the input data to apply the changes in the system and to conduct sensitivity analyses
- easy to be used by the mine personnel and regulators

Models can become complicated even when basic physics and hydrogeological equations are involved. Modeling is not only the use of equations, but it is a combination of skills, experience and knowledge to distinguish to what extent the model can become complex and if the complexity is necessary (Aydin et al., 2005). The simplest widely used traditional model is "merely a mathematical tool that adds inflows and subtracts losses in a system" based on average values of water cycle components over months or years (Nalecki and Gowan, 2008; Welch, 2000, p. 391; Wels and Caldwell, 2013). It simplifies or ignores complex and transient processes such as consolidation, settlement or evaporation (Wels and Caldwell, 2013). Equation [2.1] and Figure 2.1 show a typical diagram of water inflows and outflows of a TMF, and the mathematical presentation of the basic water balance model respectively.

$$Change\ in\ storage = \sum Water\ inflow - \sum Water\ outflow \qquad [2.1]$$

In this research, the terms "water out", "water outflow", and "water output" are equivalent. "Water in" refers to "water inflow", or also "water input".

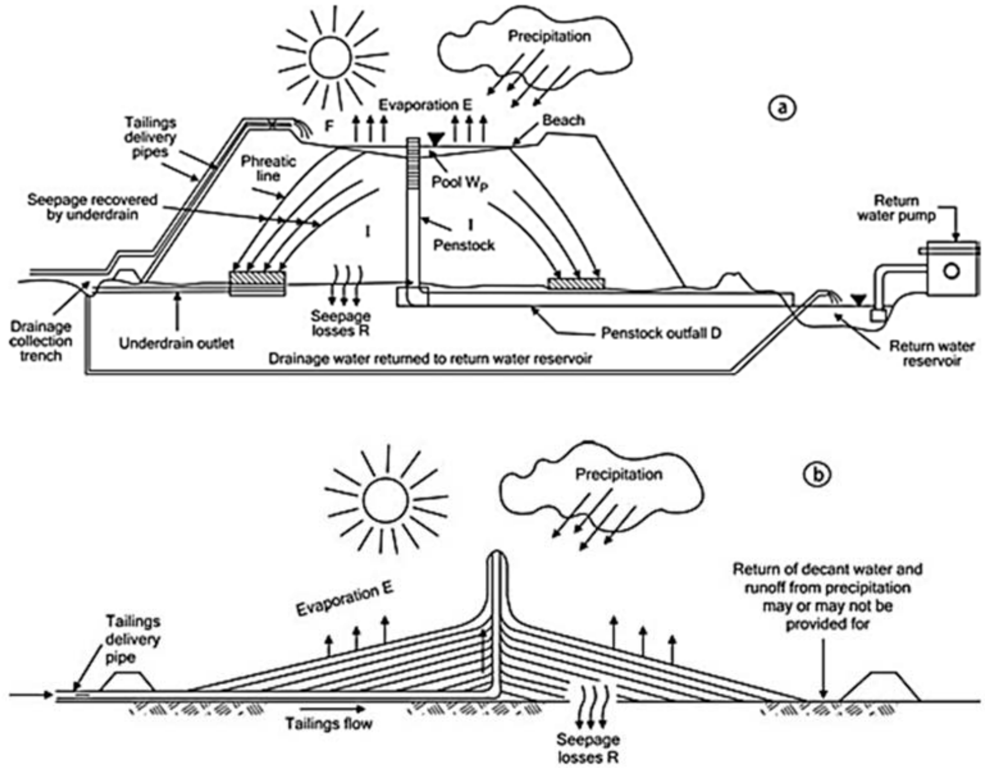


Figure 2.1 Inflow and outflow parameters in a water balance for: a) conventional TMF, b) dewatered tailings (Blight, 2010)

Table 2.2 shows the water inputs and outputs for a TMF water balance.

Table 2.2 Water inflows and outflows at a TMF (after Wade, 2014)

Water inflow	**Water outflow**
Precipitation	Evaporation
Runoff	Seepage
Water with tailings	Reclaim water
Other water streams	Entrainment

The amount of water inflow with the deposited tailings depends on the tonnage of the throughput and the tailings solids content. This water turns into the water trapped in the pores after tailings settles which usually cannot be recovered, and the supernatant water which is collected in the pool.

Precipitation can be in the form of rainfall or snowfall that falls directly on the free water at the TMF. Whereas runoff forms from the precipitation on the "undisturbed" regions above the TMF, inactive beaches and mine areas including pit, mine rock piles, stock piles, etc., if all impacted water is stored in TMF. Water with tailings is also a water inflow component.

Considering the components in Table 2.1, Equation [2.1] expands to Equation [2.2].

$$\begin{aligned} &Change\ in\ storage\ (water\ balance) \\ &= \sum[Water\ with\ tailings + Precipitation + Surface\ runoff] \\ &- \sum[Evaporation + Entrainment + Reclaim\ water + Seepage] \end{aligned} \quad [2.2]$$

According to Blight (2010), "The integral of the changes in the storage may be used to predict the water level at any time, both on the top of the tailings storage and in the return water reservoir" (Blight, 2010, p. 385). The details of water balance components and calculations methods are described in the following sections.

The extra simplification in the basic water balance approach can result in inaccurate outcomes. Therefore refinements are introduced to the basic water balance. Models of water recovery, consolidation/seepage and probabilistic water balance are developed based on the refinements.

The extent of water balance refinements depends on the project. Physical processes such as consolidation, dessication and desaturation are not usually studied or considered in water balance modelling. Therefore estimations of entrainment losses and the time-dependent discharges are usually not accurate (Lopes and van Zyl, 2006a).

2.1.1 Water inflow

The inflow parameters are described in this section.

2.1.1.1 Water with tailings

Water with tailings includes the water from the ore moisture content and the water which is added to the throughput in the process plant. The water addition to the process plant can be either fresh water or reclaimed water from the TMF. In theory, the required water for the mill is equal to the water with tailings minus the ore moisture water. However, in practise, the ore moisture water is not considred when the water is added to the process system.

The amount of water leaving the process plant with the tailings depends on the density of the tailings, S_t. The volume of water deposited with slurry is defined by the following equation

$$V_w = \left[\left(\frac{W_s}{S_t}\right) - W_s\right] \div \rho_w \; where, S_t = \left(\frac{W_s}{W_s + W_w}\right)100 \qquad [2.3]$$

Where:

W_s: weight of dry solids fed to the process plant (tonne/day)
W_w: weight of the water with tailings (tonne/day)
V_w: volume of water leaving the process plant (e.g. m^3/day)
S_t: solids content of tailings (%)
ρ_w: density of water (tonne/m^3) (it changes with temperature and altitude)

Moisture content in the ore

Assuming targeted dry throughput of W_s (tonne/day), with a moisture content of x, total throughput including the moisture content reported to the TMF equals to $\frac{W_s}{1-x}$ tonne per day. Therefore the amount of water (tonne/day) from the moisture content can be calculated from the following equations:

$$Water\ from\ moisture\ content = \frac{W_s}{1-x} - W_s \qquad [2.4]$$

$$Volume\ of\ water\ from\ moisture\ content = (\frac{W_s}{1-x} - W_s)/\rho_w \qquad [2.5]$$

2.1.1.2 Surface runoff

Surface runoff into a TMF can be from natural terrain and/or from the tailings surface. There are different methods to estimate surface runoff from natural terrain. A simple method to calculate the surface runoff is the "Rational Method" showed in the following equation.

$$Runoff = Runoff\ coefficient \times Rainfall\ intensity \times Drainage\ area \qquad [2.6]$$

In a large watershed, the runoff coefficient is assumed to be 50%. In smaller watersheds like tailings impoundments, it is considered to be larger, up to 75%, because no vegetation cover exists in TMFs. In dry conditions, this number decreases to 10 to 20% (or even to zero) depending on the amount of infiltration into the watershed (Welch, 2000).

Another method for calculating runoff is the NRCS (Natural Resources Conservation Services) method which uses a curve number to calculate surface runoff (See Equations [2.7] to [2.9]) (National Resources Conservation Service, 2004). This method was initially developed to calculate runoff on agricultural fields. It is now broadly used including estimating the peak runoff rates for urban hydrology.

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}\ , if\ P > I_a\ , or$$

$$Q = 0\ , if\ P \leq I_a \qquad [2.7]$$

Where,

Q: depth of runoff (inches)

P: depth of rainfall (inches)

I_a: initial abstraction (inches)

S: maximum potential retention (inches)

In Equation [2.7], S is determined by the curve number (CN) from the following equation. The curve number is site specific. It is critical to use the curve number that matches the hydrologic condition of the site and the type of the ground cover.

$$S = \frac{100}{CN} - 10 \qquad [2.8]$$

$$I_a = 0.2S \qquad [2.9]$$

In arid regions, "surface run-on and precipitation are negligible" (Wels and Robertson, 2003, p. 88).

2.1.2 Water outflow

What happens to water remaining after sedimentation depends on the water management plans. Any of the following might occur (Oliveira-Filho and van Zyl, 2006):

- Reclaimed
- Left to seep through the tailings into the TMF foundation or collected into the drainage system.
- Left to evaporate

2.1.2.1 Evaporation

Evaporation loss is calculated using the following formula.

$$L_{EVA} = PE \times f_{pan} \times Area \qquad [2.10]$$

L_{EVA}: evaporation losses from the area of study

PE: pan evaporation

f_{pan}: pan factor (%)

It is diffucult to measure the evaporation rate from a lake. Therefore, as an alternative, evaporation is commonly measured from a pan. Then pan evaporation is multiplied by a factor which is less than one. That implies that the evaporation form the small area of the pan is greater than the evaporation from a lake. Because the pan's side takes heat through. Pan factor is different for each part of the tailings embankment. Wels and Robertson (2003) used the same pan factor for pond areas, and for flooded areas.

Penman (1948 & 1963) develped equations for estimating the potential of evaporation or evapotranspiration. The classical form of Penman equation is as follows (Shuttleworth, 1993):

$$E_p = \frac{\Delta}{\Delta+\gamma} . \frac{(R_n)}{\lambda} . \frac{\gamma}{\Delta+\gamma} . \frac{6.43(f_u)\delta}{\lambda}, \text{ where } f_u = a_u + b_u u \text{ and } \delta = (e_s - e_a) \quad [2.11]$$

Where, E_p is potential open water evaporation from the open water, or evapotranspiration (kg m^{-2} d^{-1}≈ mm d^{-1}); R_n, net radiation (MJ m^{-2} d^{-1}); Δ, slope of saturated vapor pressure-temperature curve (kPa °C^{-1}); γ, psychrometric constant (kPa °C^{-1}); λ, latent heat of vaporization (MJ kg^{-1});. f_u, wind function; a_u and b_u, wind function coefficients; u, wind speed at 2m height (m s^{-1}); δ, vapor pressure deficit (kPa); e_s, saturation vapor pressure (kPa); e_a, actual vapor pressure (kPa).

Monteith (1965) modified Penman equation (refer to Equestion [2.12]. The Penman-Monteith equation can be used to evaluate the daily potential evaporation from soil using the following equation for zero surface resistance (Aydin et al., 2005):

$$E_p = \frac{\Delta(R_n - G_s) + 86.4\, \rho c_p \delta / r_a}{\lambda(\Delta + \gamma)} \quad [2.12]$$

“Where, G_s is soil heat flux (MJ m^{-2} d^{-1}); ρ, air density; c_p, specific heat of air (kJ kg^{-1} $^{\circ}C^{-1}$=1.013); r_a, aerodynamic resistance (s m^{-1}). In Equation [2.12], the factor of 86.4 is for converting kJ s^{-1} to MJ d^{-1}” (Aydin et al., 2005, p. 93).

Aydin et al. (2005) mentioned that a large proportion of total water loss is due to evaporation from the soil surface. Temperature, atmospheric condition of the region, and soil properties have an important influence on evaporation rates.

If there is no shallow water table, the “evaporation following wetting” happens in three stages. Table 2.3 lists these stages and the influencing factors on each stage.

Table 2.3 Evaporation phases following wetting (after Aydin et al., 2005)

Stage	**Influencing factors on the evaporation process**
Constant rate	Climate and atmospheric conditions
Falling rate	Hydraulic properties of the soil and time
Low rate	The movement of vapor through the dry soil

According to the study of Aydin et al. (2005), when water dries out from the top layer of the soil after the rainfall, the dried surface acts as a barrier. It does not allow the water or vapor to come to the surface. However, depending on the type of the soil and moisture content, there is still some upward liquid movement due to capillary forces. Surface water loss in the soil decreases the moisture content and the hydraulic conductivity of the soil, as well as the water potential. On the other hand, it increases the hydraulic gradient. Decrease in soil hydraulic conductivity and water potential causes a decrease in soil evaporation.

In normal field conditions, the values of moisture content at the surface of the soil, evaporative flux, and soil-water potential are unknown. Given that the water potential at the surface of the dry soil is at equilibrium with the atmosphere, the Kelvin equation (Equation [2.13]) can be used to evaluate the mininmum water potential.

$$\psi_{ad} = \frac{R_g T}{mg} \ln H_r \qquad [2.13]$$

Where:

ψ_{ad}: water potential for air-dry conditions (cm of water)
T: absolute temperature (K)
g: gravitational acceleration (981 cm s^{-2})
m: molecular weight of water (0.01802 kg mol^{-1})
H_r: relative humidity of the air (fraction)
R_g: univeral gas constant (8.3143×10^4 kg cm^2 s^{-2} mol^{-1} K^{-1})

Soil evaporates at a constant rate until it reaches the threshold of water potential. At the next stage, the evaporation drops progressively below the potential evaporation or so called threshold potential (φ_{tp}). This stage is called the falling rate. When the top layer of the soil dries out to the air-dry wetness, the water potential reaches the minimum value and the top layer acts as a barrier. This value of the water potential (matric suction) is called air-dryness (φ_{ad}). After this point, the evaporation and water loss are due to vapor diffusion. The loss is negligible. The model which Aydin et al. (2005) presented is showed in Figure 2.2. The ratio of actual evaporation to the potential evaporation can be calculated using the following equation.

$$f = \frac{E_a / E_p}{\log|\psi| - \log|\psi_{ad}|} = \frac{1}{\log|\psi_{tp}| - \log|\psi_{ad}|} \qquad [2.14]$$

Where:

f: slope of the solid line
E_a: actual evaporation rate

E_p: potential evaporation rate

ψ_{tp}: "absolute values of soil- water potential (matric potential) at which actual evaporation starts to drop below potential one"

ψ_{ad}: water potential for air-dry conditions

ψ: absolute value of soil- water potential (cm of water) to be determined in situe between ψ_{tp} and ψ_{ad}

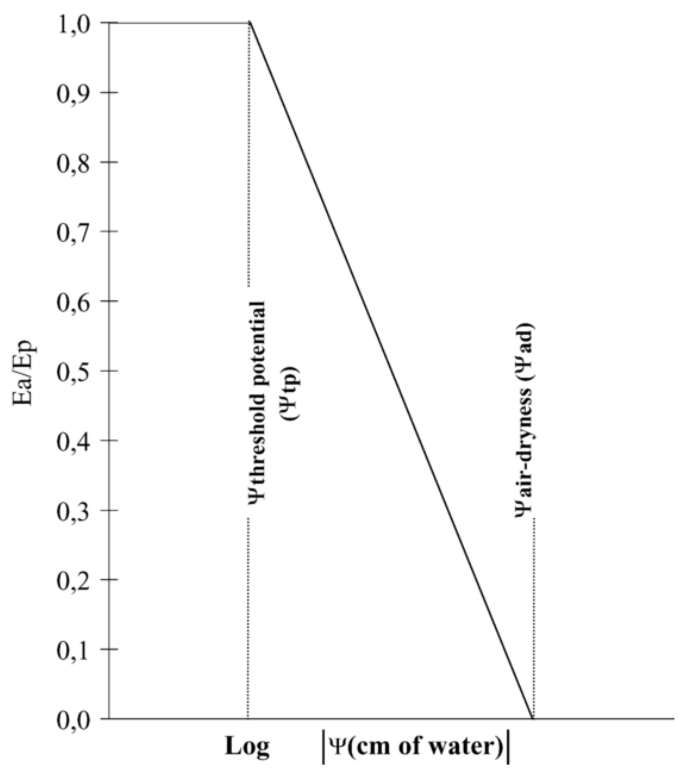


Figure 2.2 Relationship between the actual evaporation to potential evaporation (Aydin et al., 2005)

The Equation [2.13] estimates the actual evaporation using the water potential (φ) near the surface of the soil. Estimating the surface soil-water potential, also known as surface matric potential, is difficult. If it is not practical to measure the surface water potential, the observed water potential at a deeper section of the top layer can be used for calculations. If the potential of soil at the deeper part of the top layer is used, it leads to overestimation of the soil evaporation during the drying period, because the soil is wetter in subsurface. Use of water potential in deeper sections on the other hand, leads to underestimation of the soil evaporation in rewetting cycles (Aydin et al., 2005). Over a drying soil, some modifications such as "relative humidity" and "suction adjustment factor" are proposed to adjust the overestimation issue. The properties of the soil (e.g. swelling, cracking and shrinkage) can influence the ratio of the actual evaporation to the potential evaporation. There is a point in the soil evaporation process where the flow of water to the surface does not happen at a rate where the actual evaporation can reach the potential value. It is due to the decrease in hydraulic conductivity of the soil. At this point, the soil surface is desiccated and water is not exposed to the atmosphere.

Salt concentrations also affect the evpoartion rate. The rate of evaporation from a body of salty water is reduced according to salt concentration. This is because the saturation vapour pressure over salin water is less than that over fresh water. In saturated salt solutions, evaporation ceases.

2.1.2.2 Entrained water

Entrainment is the water remaining in the tailings pores of the saturated tailings remaining during sedimentation. This water can be released during the subsequent flow processes of consolidation, desiccation, and desaturation.

Although this water is not physically lost like evaporated water, it is not available for reclaiming to the mill. The proportion of water trapped in the pores of tails depends on their final dry density after sedimentation. Tailings grading affects entrainment, fines cause more entrainment losses. The mill circuit controls the grading and the percent of fines content (Blight, 2010; Wels et al., 2004). Therefore, "there is little, if any, opportunity to minimize entrainment losses as part of tailings management" (Wels et al., 2004, p. 5).

The equations used in the basic water balance to calculate the entrainment quantity for the fully saturated tailings is as follows:

Wels and Robertson (2003) used the following equation to estimate the entrainment losses:

$$L_{ENT} = e_0 \times (Tonnes\ of\ tailings)/G_S, \text{ where } e_0 = \left(\frac{G\gamma_w}{\gamma_d}\right) - 1 \quad [2.15]$$

Where:

L_{ENT}: entrainment losses during the initial sedimentation
e_0: void ratio after completion of initial sedimentation (dimensionless)
G: specific gravity of the solids (dimensionless)
γ_w: density of water (mass volume^{-1})
γ_d: density of solids (mass volume^{-1})

As noted before, the entrainment loss is controlled by void ratio. Accurate measurements of initial void ratio, hydraulic segregation and the required sedimentation time are important. Sedimentation studies in the laboratory and on the site can assist in estimating these properties (Wels and Caldwell, 2013, p. 15).

2.1.2.3 Seepage

Seepage is a complicated phenomenon and difficult to model. Useful seepage modelling requires a comprehensive study of tailings behaviour after deposition. Seepage loss represents a small portion of loss compared to evaporation and entrainment losses. Darcy's Law gives a good estimate of seepage through the tailings impoundment (Ausenco, 2014). If the foundation hydraulic condcuctivity is much higher than the hydraulic conductivity at the TMF underlying the reclaim pond, K_{pond}, the seepage loss from the pond can be estimated by the following equation.

$$Pond\ seepage = K_{pond} \times i \times Pond\ area \quad [2.16]$$

Where i is the vertical hydraulic conductivity at the TMF underlying the reclaim pond. Seepage depends on the hydraulic properties of the tailings, permeability specifications of the liner and the phreatic surface. As the embankment rises, the phreatic surface goes up and as a result the head on the liner increases. Seepage flow rate also depends on layering of the tailings. The process of liquid migration through tailings and liners can be very complicated (Wade, 2014). Giroud (1997) has developed “equations for calculating the rate of liquid migration through composite liners due to geomembrane defects”. He developed equations for different boundary conditions as well as shapes of liner defects including circular, square, rectangular and infinitely long defects. Although seepage flow models such as Darcy’s law and more complex models have been used to estimate the seepage loss. Seepage estimation is always a site specific issue. In this research, it is assumed that there is no seepage loss through the liners.

Rewetting

Active discharge points form a fan-shaped wet beach that continues to grow as the discharge happens. Rewetting is the beach seepage into “deeper, previously deposited tailings layers and ultimately into the foundation soils/bedrock” (Wels and Robertson, 2003, p. 3). Once the discharge point is inactive, the wetted area stops growing.

Rewetting losses from the pond and beaches are defined by the following equations (Wels and Robertson, 2003).

$$L_{REW} = Initial\ rewetting\ losses + Repeated\ wetting\ losses \quad [2.17]$$

$$Initial\ rewetting\ losses = DRW \times (1 - S_{dry}) \times \frac{e_f}{1 + e_f} \quad [2.18]$$

L_{REW}: rewetting losses from the flooded area
DRW: average effective depth of rewetting

S_{dry}: average degree of saturation of active beach

e_f: final void ratio after completion of stage 1 and stage 2

$$Repeated\ rewetting\ Loss = MD \times Flooded\ Area \quad [2.19]$$

MD: moisture deficit ("a function of the time the recently deposited tailings have been exposed to air-drying")

$$Return\ time = (R_f - 1) \times T_{Dep} \quad [2.20]$$

R_f: ratio of active beach to flooded area

T_{Dep}: average time of deposition of a single layer

$$T_{Dep} = D_{layer} \times Flooded\ area \times \frac{\delta_d}{Q_d} \quad [2.21]$$

D_{layer}: thickness of individual layer

δ_d: dry bulk density

The repeated rewetting losses (second term in Equation [2.17] above), are subtle and can be considered negligible (Wels et al., 2004). Rewetting loss is not considered in in this study in order to simplify the process of modelling.

2.1.2.4 Reclaimed water

Reclaimed water (also known as decanted, or water recovery) is the supernatant water that is taken from the pool on top of the TMF to be re-used, evaporated or treated and released. This is typically done using barge pump systems or penstocks. It can be stored in the return water reservoir to be reused in the processing plant.

2.1.3 Water recovery (RGC "Make-up" water model)

A water recovery model developed by Wels and Robertson (2003) was based on recovery of water which is deposited with tailings. Water recovery is a function of tailings sedimentation, evaporation, seepage and rewetting (Wels and Caldwell, 2013; Wels and Robertson, 2003). One of the advantages of this method over the tradition approach is that it “allows modeling of highly transient near-surface processes” (Wels and Caldwell, 2013, p. 15). Water Recovery is the difference between the total water from the tailings slurry feed delivery line and the total losses. Water losses include evaporation from the pond, active and inactive beaches, seepage and the water which is reclaimed back to the process plant.

The water recovery model only includes the active beach areas and water recovery right after the settlement begins. In other words, it does not take into account all components of water balance “(e.g. basal seepage, evaporation from dry beaches)”. It is not easy to determine the area of the wet beaches in a large TMF which is not contained by berms, as well as to estimate the size of flooded area involved in water recovery. Satellite images can be used to estimate sizes of active and flooded regions (Wels and Caldwell, 2013, p. 15).

When flooded area moves to another part of the TMF, the evaporation and seepage rates decline. In the pond, however, these rates remain almost constant if the water level does not vary remarkably. In the pond, the evaporation rate is close to the flooded area, but the seepage is less because of the low permeability of the tailings deposited which mainly consist of clays. Change in the discharge locations as well as movement of the flooded areas which happens naturally influence water losses.

Water recovery model was used for the Pampa de Pabellon TMF at Minea Doña Ines de Collahuasi in northeastern Chile to determine water losses and water recovery. The make-up water required for the processing plant was estimated to vary between 0.61 and 0.65m^3/ton of processed ore. The input parameters of the model were based on the collected data over 9 months (Wels et al., 2004).

2.1.4 Consolidation/seepage model

This approach focuses on estimating consolidation and seepage properties of TMF. It is used to estimate the capacity of the impoundment by implementing the consolidation theory (Wels et al., 2000). Typical one-dimensional models are used to delineate the consolidation and seepage development at TMF over time. This is an appropriate approach in the wet conditions or where the TMF is rising at a high rate (Wels and Caldwell, 2013, p. 15).

Oliveira-Filho and van Zyl (2006a) described the physical processes of tailings deposition in three stages to model the volume changes of tailings:

- Sedimentation: Separation of solids particles from water with no interparticle forces.
- Consolidation due to self-weight: Particles accumulation, creation of interparticle forces and deformation due to self weight.
- Dessication: Drying of the surface due to decrease in water level. Dessication happens at the upper layers of the tailings until the shrinkage limit is reached. During the desaturation phase the water is drained down until the moisture content of the tailings reaches the residual water content.

The timelines for the physical processes that happens in the tailings after deposition are showed in Figure 2.3. The most imporatant factor which affects these processes is the tailings particle sizes. In tailings with a high percentage of fine materials like clay, consolidation is the dominating phenomenon which takes longer and involves more volume change. However desatuartion is the dominant process of water discharge for coarser grained materials with a higher percentage of sands. In silt tailings, it seems that all three processes are evenly involved (Lopes and van Zyl, 2006a).

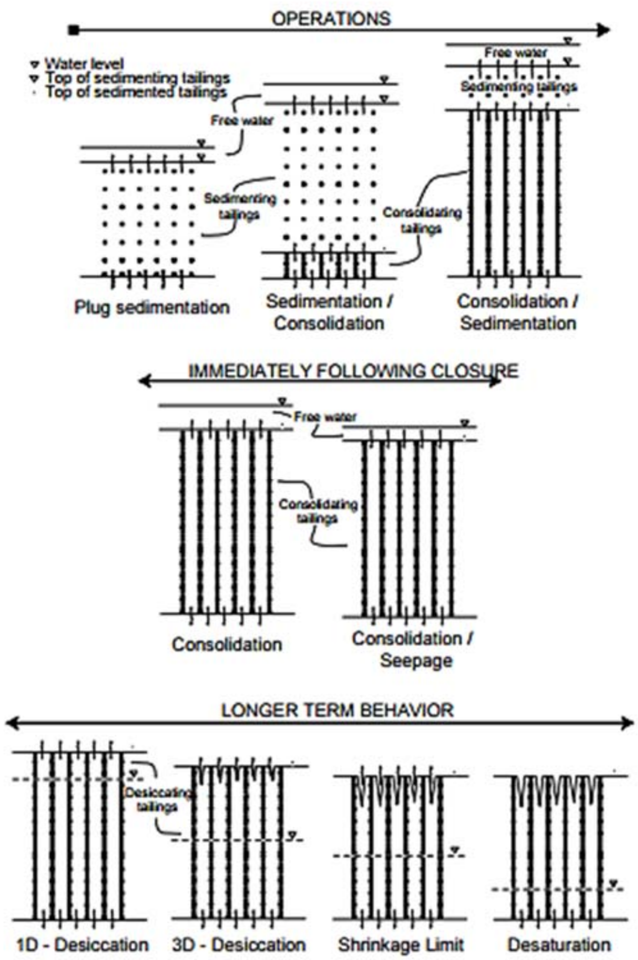


Figure 2.3 Physical processes occurring in the tailings during the life of a TMF (Lopes and van Zyl, 2006a).

In saturated tailings, during consolidation, mechanical forces such as tailings weight, "seepage forces, surcharge or the combination of those" reduces the void ratio. The total change in volume is equal to the volume of water discharged, therefore volume change can be calculated using void ratio. This may also apply to early stages of dessication (Lopes and van Zyl, 2006a).

In unsaturated tailings, complication happens during the residual shrinkage phase when the water removed is bigger than the total change in volume (Figure 2.4). In this case, change in void ratio cannot be used to calculate water entrainment which adds to variable parameters and uncertainity of the modelling for unsaturated tailings. In unsaturated soils, in addition to mechanical forces, negative pore water pressure in fine grained soil may cause volume change (Lopes and van Zyl, 2006a).

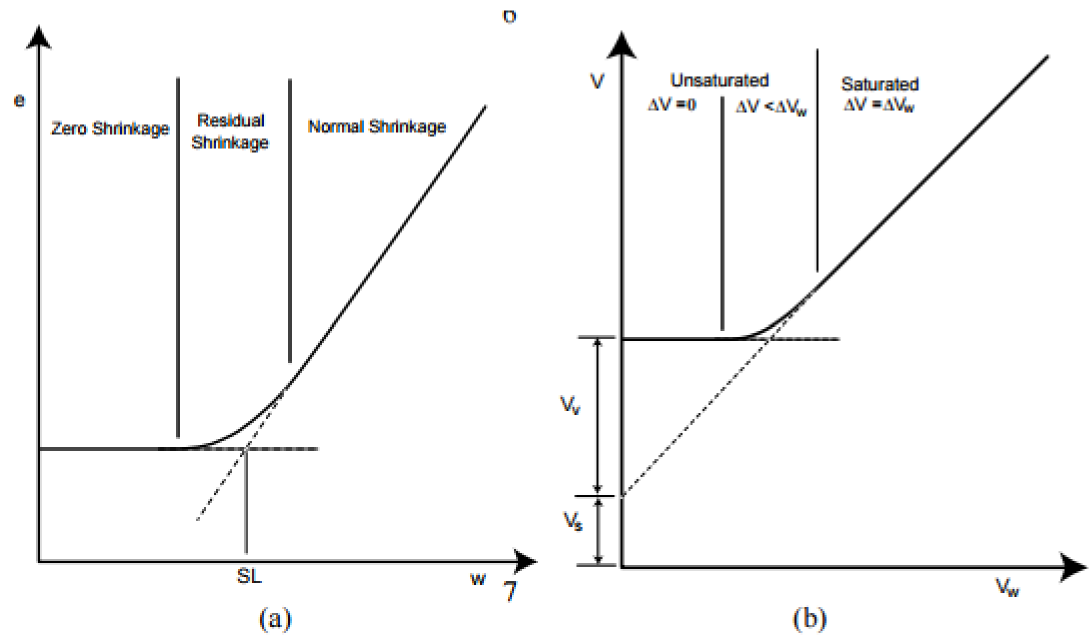


Figure 2.4 Soil shrinkage phases (Lopes and van Zyl, 2006a)

Negative pore water pressure and capillary forces cause volume changes in fine grained soils during the shrinkage stage. Net normal stress $(\sigma - u_a)$ and matric suction $(u_a - u_w)$ define the volume change in unsaturated soils. These stress state variables can also be used to define the volume changes in saturated soils. In unsaturated soils, the effective stress and pore pressure replace respectively the net normal stress and matric suction. For unsaturated soil, u_w is a negative value or is less than the atmospheric pressure.

It is difficult to separate sedimentation and consolidation processes during the operation, but “it is useful to separate them for modelling purposes” (Lopes and van Zyl, 2006a).

Tests such as “Constant Rate Deformation (CRD) and Seepage Induced Consolidation” can be used to study consolidation process and to model “self-weight, seepage forces, and surcharge” due to consolidation.

In the consolidation stage, saturated soil has positive pore water pressure which is equal to atmospheric pressure, therefore matric suction is equal to zero (Lopes and van Zyl, 2006a).

In the desiccation process, suction caused by negative pore pressure forces shrinkage. As soil starts to desiccate, it also desaturates while shrinking. Thus the void ratio changes are not good measures to estimate the changes in discharged water volume. A solution to this problem is using the gravimetric water content to track the changes in water volume. Another important factor to consider is the “net surface flows” which is influenced by actual evaporation rates. When tailings are wet, the evaporation is affected by meteorological consolidations. But when the tailings surface is dry due to desiccation, soil conditions become the influential factors on evaporation rate (Lopes and van Zyl, 2006a).

For unsaturated soil, relations between unsaturated hydraulic conductivity and suction is usually analyzed with a soil water characteristics curve (or water retention curve) (Lopes and van Zyl, 2006a). The model developed by Oliveira-Filho and van Zyl (2006) has limited application in describing the desaturation process. Desaturation analysis is complex because the water flow is influenced by both climate and soil condition. In addition, “the void ratio (or volumetric water content") profile is not uniform due to the desiccation and consolidation effects. Therefore using the average properties of soil is inevitable (Lopes and van Zyl, 2006b).

Sedimentation analysis is usually done through the sedimentation column. After the sedimentation is completed, for clay-like tailings the top layer void ratio is calculated, but for silt-like tailings, the average void ratio of the whole column is calculated (Lopes and van Zyl, 2006a).

Sedimentation is a process with zero effective stress. During the sedimentation, change in interstitial water volume (ΔV_w) is directly related to change in void ratio (Δe) (Lopes and van Zyl, 2006a).

$$\Delta V_w = H_s \Delta e = H_s (e_{slurry} - e_{00}) \qquad [2.22]$$

e_{slurry}: void ratio of slurry

e_{00}: void ratio after sedimentation at zero effective stress

H_s: height of solids

Height of solids can be estimated using the following equation:

$$H_s = \frac{H_{slurry}}{1 + e_{slurry}} = \frac{H_{sed}}{1 + e_{00}} \qquad [2.23]$$

H_{slurry}: "height of the whole tailings in the slurry state"

H_{sed}: "height of the sedimented tailings (nominal heights)"

Consolidation starts right after sedimentation and may continue after closure. A few meters of tailings deposited at the top show sharp transition in void ratio relative to the depth. But for the greater depths, void ratio remains almost constant. In desiccation process, the volume change only happens at the top of the tailings. Discharge from the top equals evaporation rate, and discharge from the bottom equals seepage rate (Lopes and van Zyl, 2006b).

During desaturation, evaporation decreases noticeably, thus no flow at the top boundary is considered in Oliveira-Filho and van Zyl's (2006b) analysis.

"In terms of water reclamation strategies, the sedimentation and consolidation events are far more important than the other phenomena" (Lopes and van Zyl, 2006a, p. 221). The desiccation process is short.

Wels et al. (2000) applied the consolidation model to Culmitzsch, a large uranium tailings impoundment. They estimated the consolidation properties of coarse, intermediate and fine materials settled in different regions of the impoundment in order to study the degree of settlement under the self weight and cover placement. The air photos were used to identify zones with different geotechnical properties. The model input included "filling rate, slurry density, and functions of "void ratios- effective stress", "permeability coefficients- void ratios". Wels et al. (2000) calibrated their model against "observed void ratio profiles, measured rates of settlement (after filling was completed) and observed pore pressures using a trial-and-error approach". These properties were collected through field characterization, in-situ monitoring and lab testing (Wels et al., 2000). They found out that during the first phase of discharge, sandy tailings deposited near the discharge points show less void ratio than the fine slimes which are "settled in the water covered pond area distant from discharge points". Good underdrainage and lateral drainage in the impoundment cause decrease in excess pore water pressure. However the results show that the fine tailings in this impoundment were not fully consolidated. The void ratios in highly plastic clay with low shear strength ranging from 1.5 to 4.8 in the shallow depth, while the coarser tailings with a low, if any, plasticity and higher shear strength had void ratios between 0.5 and 1.1. Different zones of the impoundment show different degree of consolidation and therefore different degrees of settlement due to self weight consolidation and cover placement. The degree of consolidation depends on the drainage system and segragation of the fine tailings, as well as the slurry discharge pattern. The sensitivity analysis that Wels et al. (2000) conducted indicated that the non-linear material functions (“void ratios- effective stress”, “permeability coefficients- void ratios”) have the most influences on the degree of consolidation.

Evaporation, tailings “anisotropy”, and “heterogeneity” may significantly change the consolidation and seepage rates because of their effects on permeability. As a result, this model is difficult to calibrate. Comprehensive detailed monitoring that consists of “depth profiling” is required for calibration (Wels and Caldwell, 2013, p. 15).

In this research, sedimented tailings densities are used to calculate the entrained water volume. The volume change due to consolidation and desiccation processes are not considered.

2.2 Tailings management options

New innovations in the dewatering systems have brought many advantages to mining industry including (Davis, 2001; Marques and Pérez, 2013):

- To enable companies to save energy and water by reducing the size of pond area and the amount of water loss through evaporation
- To reduce the expenses related to transportation, storage and management of tailings slurries and excess water.
- To reduce the Oxygen ingress in tailings with potential of Acid Rock Drainage (ARD).
- To decrease the seepage rate, and downsize the storage facility area.
- To increase the stability of the storage facility due to the reduction or elimination of erosion and seepage in the storage.

The most common technologies of waste management in mining industry are listed below (Davies and Rice, 2001; Salfate, 2011):

- Slurry tailings: Tailings with lower densities and solid contents of 35-55% which are pumpable and can become segregated.
- Thickened tailings: Tailings dewatered to 45-65% solids content which are still pumpable. Chemical additives can be used to increase the thickening rate. With this degree of dewatering, tailings exhibits a yield stress which allows tailings to deposit in a self-supporting trend with mild slopes.
- Paste tailings: When thickened tailings are mixed with chemical additive such as Portland cement, another tailings with higher density can be formed. Solids content of paste tailings ranges from 65% to 75%. Paste tailings are non-segregating and show small settlement after deposition.
- Filtered tailings or dry stack: When tailings become unsaturated to more than 70% solids content, a non-pumpable product is formed. These tailings are not completely dry but the moisture content is way below saturation making the deposited tailings trafficable. Transportation can be done by conveyors or trucks. Retention dams are not required because the filtered tailings are not saturated and are compacted after placement. This method requires an expensive technology, but the economic benefits of this water recovery can offset the capital and operating expenditures particularly in arid regions where the cost of water is high. It is also beneficial in areas where there is a high seismic risk, and in cold areas with freezing temperature, where water transportation and handling is difficult. Present experience indicates that filtered tailings limits of application are throughputs of less than 15,000 t/d and they are most suitable for operations under 2,000 t/d. This method is not attractive when the TMF has dual purpose (i.e. as a storage for tailings and also as a storage for annual snow melt run off for year round water supply to the operation) (Davies and Rice, 2001).

Table 2.4 summarizes the characteristics of different tailings management systems.

Table 2.4 Features of tailings management options
(after Davies and Rice, 2001 & Martin et al., 2002 & www.tailings.info, UBC MINE 480 Course Notes)

Tailings management option	**Tailings Slurry**	**Thickened Tailings**	**Paste Tailings**	**Filtered Tailings**
% Solid for typical hard rock tailings	35-55	45-65	65-70	>70
Saturation	>100%	Dewatered- >100% Sat.	Dewatered- additive to thickened tailings >100% Sat.	Unsaturated Typical tailings (i.e. Gs~2.7) can be dewatered to <20% moisture content
Particle Segregation during deposition	Segregating	Non- Segregating	Non- Segregating	Non- Segregating
Conveyance system	Pumpable Slurry pipeline and appropriate pumps can be used	Centrifugal Pumps	Positive displacement pumps	Non-pumpable- Conveyor or truck used for transport of tailings Placement by conveyor radial stacker system or trucks w_{opt}~ 60-80% saturation
Water Management	- Considerable water - Surface water management - Using diversions to limit inflow - Groundwater discharge must be collected in a drain	- Considerable water: - Bleeding water & surface water collected in a pond at the lowest point of the facility - Diversion channels if required	- Little to no water to manage - Minimal water bleeding	- The only available water is the water freed due to further consolidation - Groundwater and runoff should be diverted by perimeter ditches, bunds and/or drains; groundwater cut-off and drainage system (ditches and/or cut-off wall, depending on site conditions) - Precipitation on the dry stack should be collected (by armoured channels; slope lengths and gradients should be designed to prevent/reduce erosion) - Impacted groundwater and seepage from dry stack should be collected
Beach slope	0.5-1 %	Slightly steeper than conventional slurry	Slightly steeper than conventional slurry (2-10%)	No beaches Material can be treated as an earth fill
Containment of tailings	- Containment constructed using borrow materials or tailings - Three embankment configurations - Embankment construction using cyclones	- Self-supporting on very low slope angles - Minor retention structures may be required	- Self-supporting on low slope angles - Minor retention structures may be required - Possible desiccation and cracking after deposition, increase rate of evaporation and consolidation. - Improved stability through interlocking between new overlying flow and old cracked tailings surface	- Self- supporting at steep slopes - No dam for retention
Dewatering method	-	Compression thickeners or by combining thickeners and filter presses	High rate and deep cone thickeners.	Vacuum or pressure filtration Filtration configurations: horizontally or vertically stacked plates
Deposition		Self- supporting conical shape	Similar to thickened tailings (conical pile), with often steeper slopes.	
Operating Cost	Closure and reclamation	Higher operating cost than conventional slurry due to dewatering cost Closure and reclamation	High dewatering Cost Closure and reclamation	Affecting items on unit cost: Dewatering equipment Haul distance Placement strategy Compacting effort Closure and reclamation
Capital Cost		- Dewatering plants (thickeners) - Conveyance system (pumps and pipelines) - Tailings containment dams - Water management structures (e.g. diversion ditches, liners)	- Dewatering plants (thickeners, flocculants and additives included) - Conveyance system (pumps and pipelines), higher transportation costs compared to other methods - Tailings containment dams - Water management structures (e.g. diversion ditches, liners) - Booster stations may be required (increasing in capital costs)	Depends on: - Size of operation More attractive for operations <10,000 tpd - Costs related to closure, site development costs - Dewatering plant (filters) - Conveyance system (trucks/conveyors/spreaders/dozers) - Water management structures (e.g. diversion ditches, liners)
Closure and reclamation	Large footprint	Large footprint.	- Smaller footprint. - Reduced seepage - Reduced risk of tailings transport by water if embankment fails (less environmental problems)	- Reduced footprint - Less long-term risk and liability - Easier to reclaim and close

“One of the main issues in balancing power cost and associated water saving is the effect of the exponential increase in yield stress as solids concentration increases” (Paterson, 2015, p. 188). Paterson (2015) compared the pumping energy as a function of solids concentration. Figure 2.5 shows a graph of yield stress vs solids contents. Result of Paterson study showed that an increase in the solids content from 40 to 60% reduces the water consumption by 0.206 m^3/t, but it increses the energy requirement by 0.245 kW/t/km. Increasing the solids concentration to 70% reduces the water consumption by only 0.042 m^3/t less than the water consumption when implementing solids concentration of 60%. In this case, the additional energy of 0.673 kW/t/km is required. It is important to consider the energy consumption and the related costs when determining the most appropriate solids content for a dewatering system.

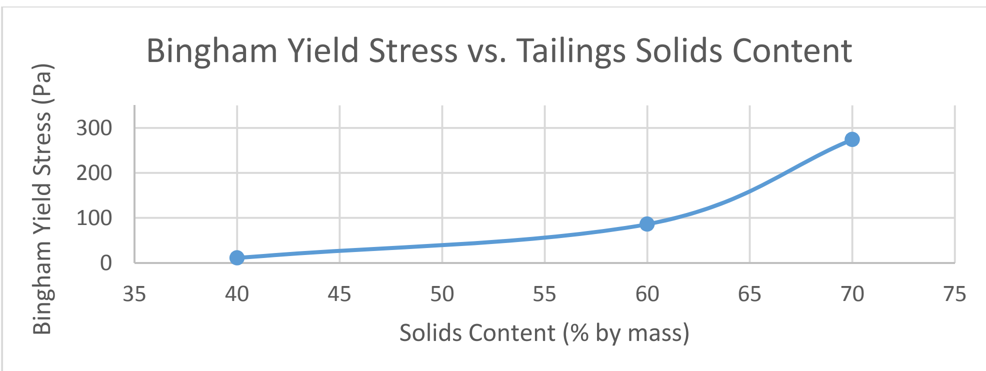


Figure 2.5 Relationship of Bingham yield stress versus solids content for a system transporting 300 dry tonnes per hour tailings (after Paterson, 2015)

Figure 2.6 shows a schematic of different tailings management technology and water content of the final products.

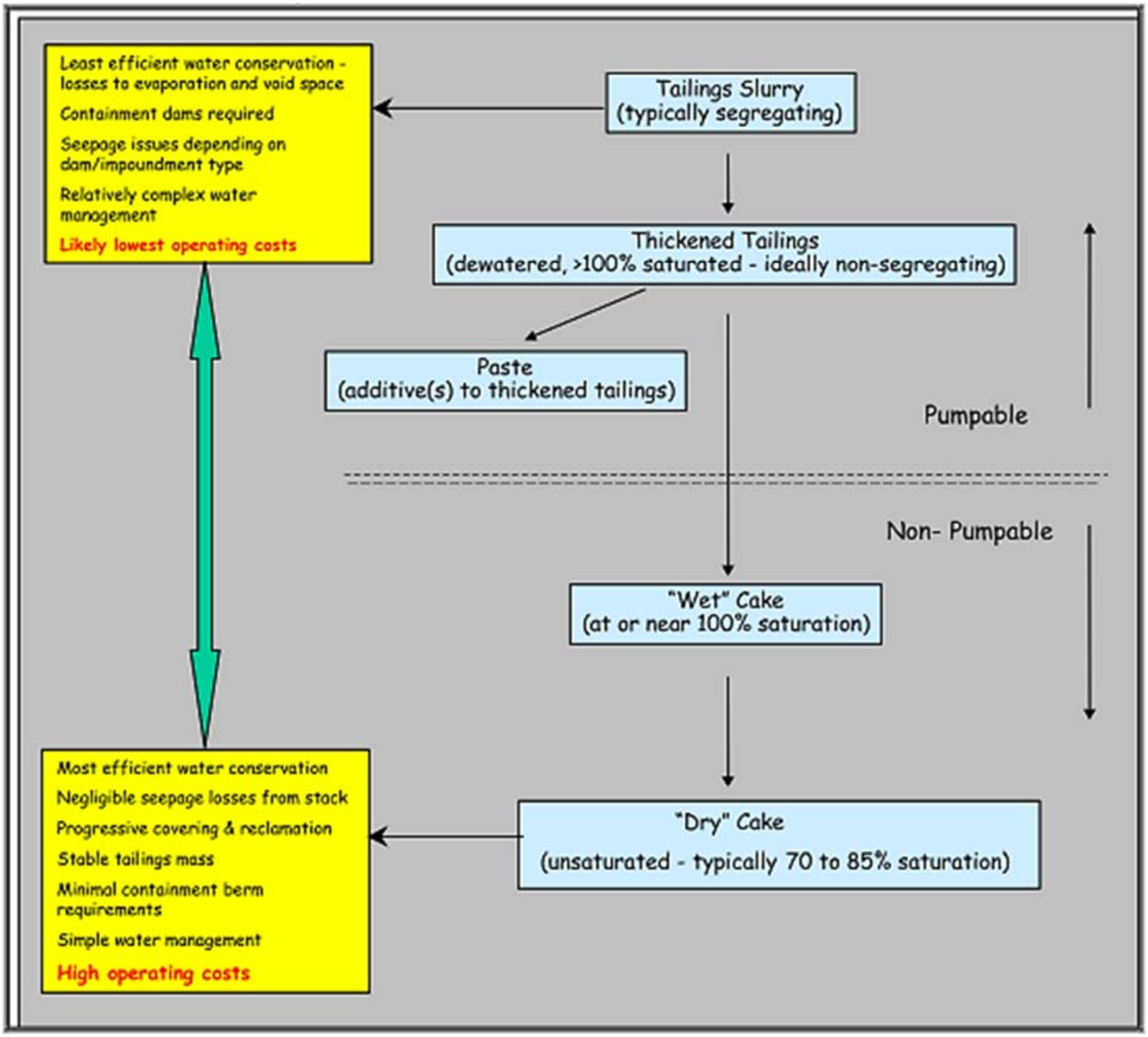


Figure 2.6 Tailings management options based on degree of dewatering (Davies and Rice, 2001)

Marques and Pérez (2013) reviewed the application of non-conventional tailings management in Brazil. They listed the studies performed in Brazil related to nine TMFs designed to use the non-conventional disposal methods from 2007 to 2013. The statistics show that eight of the cases use "non- segregating" method of disposal (thickened tailings) and one uses paste tailings.

2.3 TMF Water savings

In slurry TMFs, limited water saving methods are available. The following approaches can be practised (Blight, 2010; Gunson et al., 2012):

- Maintain the minimum size of the pool so that it is only enough to allow the solids to "settle out and the decant water to clarify".
- Reduce seepage and evaporation from the return water reservoir by having deep reservoirs with minimum surface areas. The reservoirs can be lined to reduce seepage and they can be covered to reduce evaporation.
- Increase the rate of embankment rise. It increases the ratio of water decanted to water evaporated. However, increasing the rising rate causes embankment instability due to the rise in phreatic surface and it causes the decline in the shear strength.
- Selective mining reduces the tonnage of tailings deposited at the TMF and also water consumption.
- To reduce clay generation during grinding.
- To select tailings size classification during tailings deposition.

Figure 2.7 shows the process of seepage and evaporation losses over time with duration of discharge. "Initially, seepage losses are high, because tailings are discharged onto older, desiccated tailings". Once tailings have been resaturated, rewetting losses decrease substantially. "While the flooded areas, where active deposition of tailings occurs, approach a maximum size, there is a continuous increase in the size of the total (wetted) deposition area, as more and more tailings are deposited. Over time, the active tailings stream will occupy a smaller and smaller percentage of the total deposition area, i.e. the ratio of flooded area to wetted area will decrease. This natural shift of flooded areas across an active deposition fan will incur additional seepage losses because the freshly deposited tailings will desaturate (mainly due to evaporation) during the time between the deposition of successive lifts of tailings. When the active tailings stream returns to this area, the recently deposited tailings will berewetted to saturation. Note that the magnitude of the variable water losses illustrated in Figure 2.5 will vary depending on the tailings properties. For example, a shift from active deposition in the coarse beach area to a fines area near the pond is likely to reduce seepage losses but increase evaporation losses. Such a shift may either increase or decrease the total water losses, depending on whether the variable system losses were seepage-controlled or evaporation-controlled at the time. While the time trends of water losses shown in Figure 2.5 are qualitative, they provide first clues on how to best manage tailings discharge. In general, both very short (days) and very long (months) periods of discharge from a single discharge point should be avoided. The best management practice is likely that of a regular rotation of discharge points to avoid the development of very large active deposition areas" (Wels and Robertson, 2003, pp. 23–24)

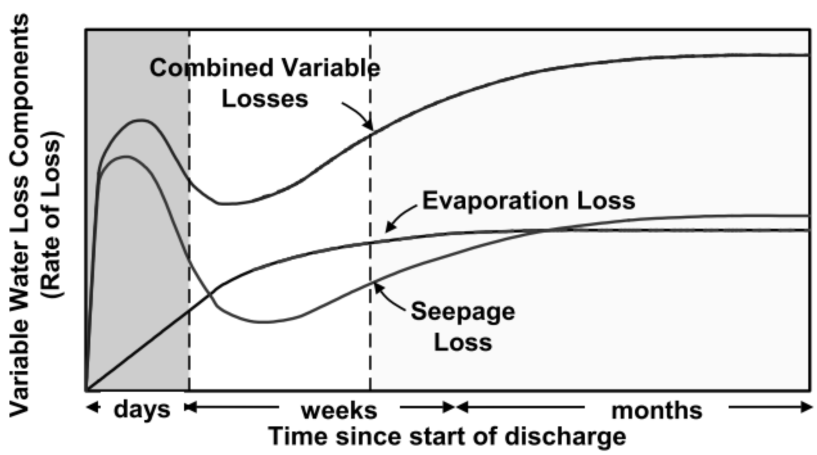


Figure 2.7 Changes in water loss components of water balance over time (excluding entrainment losses) (Wels and Robertson, 2003)

A way to reduce the water consumption is to use an alternative tailings management option by dewatering the slurry. "In the case of thickened tailings or paste storages, the intention is to save water by thickening and thus eliminating decant water" (Blight, 2010). However, water entrainment, seepage and evaporation losses still occur and the overall water consumption is not lower unless the void ratio or the moisture content of the deposited dewatered tailings is less than the corresponding values in deposited slurry tailings. The slurry is not thickened to a "non-draining RD" by drainage alone and has to be dewatered and thickened to reach this RD or beyond it (Blight, 2010). Change in relative density (RD) of slurry tailings after deposition at the TMF is difficult to estimate.

Gunson (2013) developed a model to study alternative ways to reduce water consumption based on Wels and Robertson's recovery model for a hypothetical mine in an arid region with the throughput of 50,000 tonnes per day. Gunson's study includes six scenarios as showed in Table2.5. The mine water consumption includes the water used in the processing plant, maintenance shop, office, and for dust suppression on the haul roads. The maintenance shop water use is considered to be negligible. Detail of water consumption in the mine for different scenarios is listed in Table2.6.

Reduction in water consumption in this model is the result of different water management plans:

The first scenario is the base case. The estimated water withdrawal in this scenario is 0.76 m^3/t of ore processed.

In the second scenario, the goal is: to reduce the water loss due to evaporation by covering the tanks and cells; to cut down the water required for dust suppression by applying "organic binders" to the roads; and to lower office water consumption by using low use shower heads and toilets. Water consumption for primary crusher dust suppression can decrease by installing a fog dust suppression system.

In the third scenario, the application of thickened tailings use (thickened to 70% solids content by mass) allows for reduction in water loss due to evaporation and rewetting. It is assumed that paste tailings do not change the water entrainment loss. There is no free water available to form a pond and to be reclaimed. Therefore the pond evaporation becomes zero. Although the thickener area is added to the open area which is subjected to evaporation, the total evaporation is smaller than evaporation in the first scenario.

Table 2.5 Water use reduction scenarios (after Gunson, 2013)

#	Scenario	Description	Water consumption	Water withdrawal m^3/t of ore processed (considering water with ROM of 1,020 m^3/d)
1	Base case	Conventional concentrator	100 % (38,955 m^3/d)	0.76
2	Base case with water conservation	Conventional concentrator and reduction in evaporation losses	87% (33,822 m^3/d))	0.66
3	Paste tailings case	Conventional concentrator and paste tailings disposal	79% (30,682 m^3/d)	0.59
4	Filtered tailings case	Conventional concentrator and filtered tailings disposal	42% (16,491 m^3/d)	0.31
5	Ore pre-sorting case	Conventional concentrator and 20% ore rejection	82% (32,096 m^3/d)	0.62
6	Combined water reduction case	Conventional concentrator and reduction in evaporation losses, as well as 20% ore rejection and filtered tailings disposal	28% (10,878 m^3/d)	0.20

In scenario 4, filtered tailings (thickened to 80% solids content by mass) eliminates rewetting loss, beach evaporation, as well as evaporation from the pond and the tailings. Water retained in the tailings also decreases.

In Scenario 5, rejecting low grade ore after the primary crusher by using a pre-sorting system happens. The decrease in the mill feed not only downsizes the equipment and as a result the total area exposed to evaporation, but also it reduces the tailings production and entrainment, rewetting and evaporation losses.

Scenario 6 is a combination of Scenarios 2, 4 and 5.

Table 2.6 Details of water consumption scenarios (after Gunson, 2013)

Water loss	Scenario 1 (m^3/day)	Scenario 2 (m^3/day)	Scenario 3 (m^3/day)	Scenario 4 (m^3/day)	Scenario 5 (m^3/day)	Scenario 6 (m^3/day)
Road-Dust Suppression	3,520	757	3,520	3,520	3,520	757
Human Consumption	58	3.3	58	58	58	3
Raw Water Tank- Evap.	2.2	0	2.2	2.2	2.2	0
Process Water Tank- Evap.	3.4	0	3.4	3.4	3.4	0
Primary Crusher-Dust Supp.	360	50	360	360	360	50
Stockpile-Dust Supp.	120	0	120	120	120	0
Flotation Cell- Evap.	6.7	0	6.7	6.7	6.7	0
Conc. Thickener- Evap.	1.2	0.0	1.2	1.2	1.2	0
Final Concentrate	89	60	89	89	88	59
Tailings Thickener- Evap.	0	0	30.9	30.9	0	1.5
Tailings Retained, L_{ENT}	20,792	20,792	20,792	12,299	16,573	9,803
Beach Evaporation, L_{EVAP}	9312	9312	5,698	9312	7,422	0
Pond Evaporation, L_{POND}	1,890	47	0	0	1,506	0
Beach Rewetting, L_{REW}	2,800	2,800	0	0	2,232	0
Pre-Sorting Rejects	0	0	0	0	204	204
Total	**38,955**	**33,822**	**30,682**	**16,491**	**32,096**	**10,878**

Gunson (2013) concluded that the major reduction in water consumption is related to the combined scenario which can reduce the water withdrawal from 0.76 m^3/t of ore processed to 0.20 m^3/t of ore processed. However, the high operating and capital cost of dry stack technology, limitation of pre-sorting to some ores, negative process impacts of high water reuse and recycle, and costly and high risk evaporation saving methods are the drawbacks and constraints of the proposed scenarios.

Gunson (2013) noted that hydrogeological properties, water flow in the mine, tailings impoundment, and climate data influence on the water balance. He emphasized that his developed model may not be realistic for mines and was an outline toward more water savings in the mining industry.

Similarly, Obermeyer et al. (2013) developed a water balance model for Cerro Verde Copper Mine in Peru at the design stage. The model was calibrated and updated during the operation phase of TMF. Although the mine is located in a very arid region with an evaporation to precipitation ratio of 60, the Enlozada centreline constructed TMF was recognized as the most water-efficient TMF in the world. The mine owes this title to its efficient water management plan. While the range of required make-up water of similar mines is between 0.4 and 0.7m^3/tonne, average make-up water at the Enlozada was less than 0.38m^3/tonne. The low water consumption was due to several water management design factors such as:

- the method of embankment construction allows to deposit the tailings more on the embankment with low impermeability. “The ratio of impoundment to embankment volume is relatively low (about 3.3). The high density and low moisture content of the embankment result in much higher water recovery from the embankment than from the impounded finer tailing which remain saturated and at a lower density”.
- the efficient drain network with a low permeable foundation for the impoundment; to collect the seeped water
- the decrease in size of the reclaim pond surface area
- the limiting of the location of the reclaim pond by practising an optimized deposition from outer perimeter of the embankment
- the thickening of the tailings from 27% to about 55% solids content by weight (because of the high rate of production, application of dry stack was not practical)
- the regular updating and calibrating of the water balance

2.4 Role of climate and water data

Climate data that are used in water balance are usually gathered from the national databases. The data for a certain location is extracted by interpolation of the climate data of nearby stations. The National Oceanic and Atmospheric Adminitration (NOAA)'s Climate Divisional Data Centre

(NCEI) is an Operating Unit of the U.S. Department of Commerce which "is responsible for preserving, monitoring, assessing, and providing public access to the Nation's treasure of climate and historical weather data and information". The National Weather Service has 122 Weather Forecast Offices in six regions in the USA. The official records of climate data for many climatological stations in Canada can be obtained at the National Climate Data and Information Archive.

In 2015, the Centre for Forest Conservation Genetics at UBC developed a series of programs (ClimateBC, ClimateWNA and ClimateNA) which are able to generate "high-resolution" climate data in British Columbia, Western North America, and North America as a whole. The programs (available from: http://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/) generate monthly data based on the historical weather station data. They predict the future climate data for a specific geological location using global circulation models. The baseline climate data is based on 1961-1990 normals. The ClimateBC database includes data from 1901 to 2013. This software program is used to generate wet climate data for this research. Figure 2.8 shows the graphical user interface of ClimateBC.

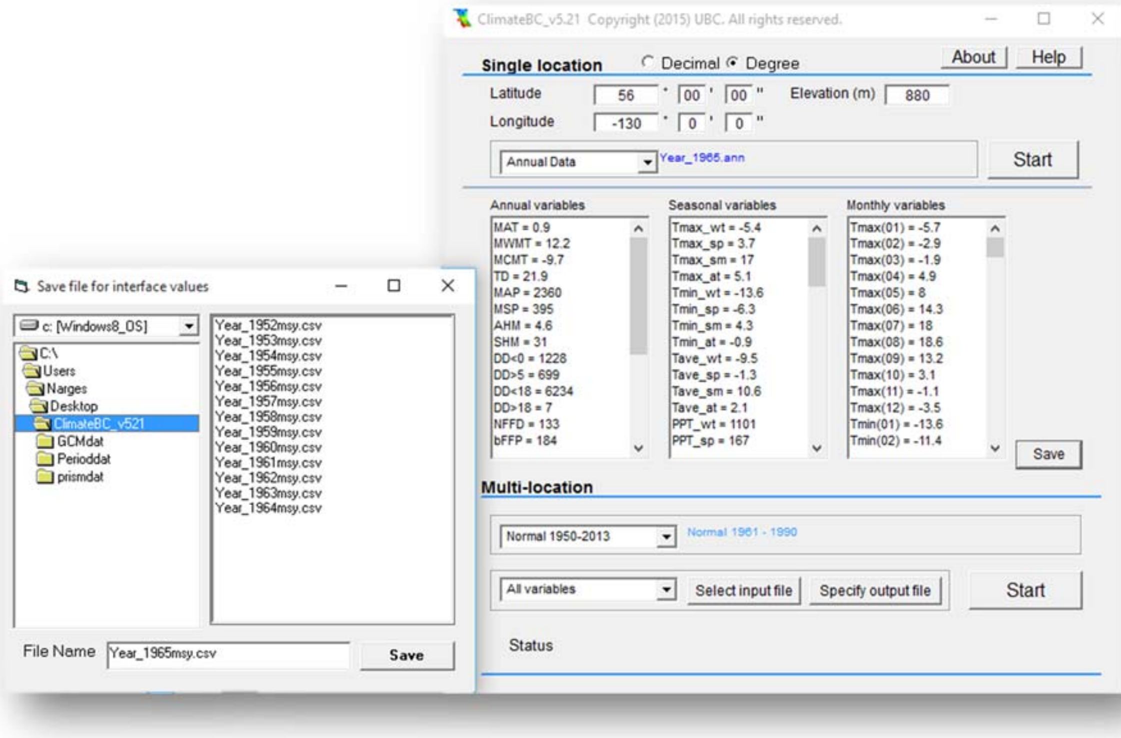


Figure 2.8 ClimateBC Desktop Version 5.21 interface

2.4.1 Water management in storm events

According to Canadian Dam Association (2014), mine water management requires to address the following "functions":

- "Temporary storage of seasonal flows and sufficient water to allow settling of fines
- Temporary storage of the Environmental Design Flood (EDF)
- Storage and/or safe passage of Inflow Design Flood (IDF) runoff to ensure the integrity of the containment dams"

EDF is the design limit to ensure that if storm events with return periods of 50 to 200 years happen, unscheduled discharge of water to the environment is preventable. The EDF level is between the Normal Operating Water Level (NOWL) and the emergency spillway level (refer to Figure 2.9) (CDA, 2014).

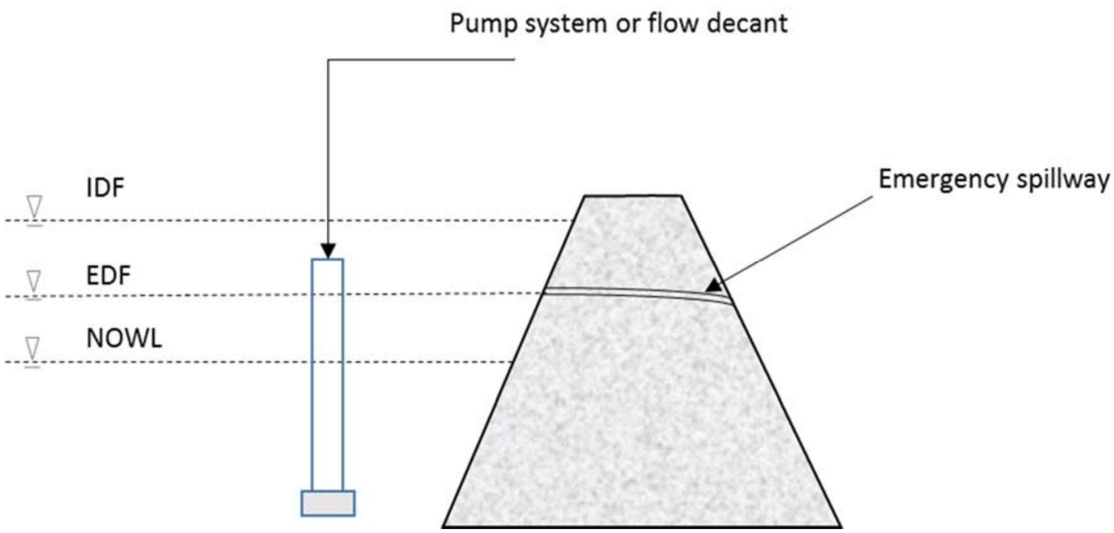


Figure 2.9 Water levels required to be considered in designing of a TMF

When the flood exceeds EDF, the excess water is allowed to be dischrged from the spillway. Since overtopping and release of tailings to the environment is not acceptable. Therefore TMF should have an emergency spillway. During unexpected events, water managemnt would rather release water to the environment through spillways than to let the dam overtop. If a TMF does not have spillways, the impoundment must have the capacity to store the Probable Maximum Flood (PMF). If an unscheduled release of water to the environment is not acceptable, EDF is at same level as IDF (Welch, 2000).

2.5 Probabilistic analyses

Water management is site specific and a lot of uncertainities are involved in defining and estimating of water balance components. Deterministic water balance models usually deal with inherent uncertainty through sensitivity analysis on parameters such as runoff coefficients, annual precipitation, hydraulic properties of tailings, etc. In contrast, probabilistic water balance models do not analyse single data points and simulate inherent uncertainties and variabilities through histograms of data points. Simulations determine probability and likelihood of the events. Stochastic scenarios are commonly used for risk-management purposes (Naghibi, 2015; Wade, 2014). Probability Density Function (PDF) of the outputs defines the uncertainty and confidence level, as well as variability of the outputs (McPhail, 2005)

Application of probabilistic modeling requires that the owners and operators have a good understanding of statistics and the mathematics of probability. Probabilistic water balance is usually performed and simplified by external consultants other than the onsite professionals. When changes in the water balance are required, the external specialists have to apply the associated changes to the model due to the high complexity of the logic of the model. External specialists submit a report consisting all the necessary evaluations to the owner (McPhail, 2005).

2.5.1 Water balance uncertainties

Plate and Duckstein (1987) lists two uncertainties for water resource issues; data uncertainty and parameter uncertainty. Data uncertainty is due to the errors in measuring and sampling hydrological variables which depend on the climate and/or runoff charactersitics. Parameter uncertainty is due to uncertain physical parameters in hydraulic phenomena ("such as, for a levee, roughness changes, wave and wind effects") (Plate and Duckstein, 1987, p. 43).

The most significant variabilities and uncertainties associated with the TMF water balance are related to components: rainfall, runoff factors, evaporation, and seepage into the foundation (McPhail, 2005).

To conduct a simple probabilistic water balance, required information for uncertainty analysis includes (Estergaard, 1999):

- average and standard deviation of monthly rainfall
- average and standard deviation of monthly snowfall

- average and standard deviation of monthly evaporation
- number of simulated periods (e.g. months) of operations
- periods and intervals of snowpack accumulation
- snow melt period and temporal distribution

2.5.2 Stochastic rainfall and evaporation

As previously noted, precipitation and evaporation have large influence on water balance. Therefore, using average climatic parameters can only provide a crude estimate of water balance of a tailings impoundment. Generation of stochastic rainfall and evaporation data enables development of “climate sequences” based on historical data. The same statistical parameters of historical data are utilized for climate sequences (i.e. the sequences have the same distribution as historical data: same mean, same coefficient of variation, same skewness, and same wet and dry months).

2.5.3 Oracle Crystal Ball and Monte Carlo simulation

For the purpose of conducting a probabilistic analysis in this research, Oracle Crystal Ball was implemented to develop the water balance model. Crystal Ball is an Excel add-in which performs Monte Carlo simulations. The default number of iterations is set to 100 runs, but this number can be customized. It varies according to the level of reliability that one can expect from the model. The Oracle Crystal Ball was used to run the simulations in this model, because the visual presentation of the results and the ability to extract the probabilities and distribution percentiles help analyse the risk of water deficit or water surplus in the mine for different climate conditions. One of the advantages of using spreadsheet and Oracle Crystal Ball for simulation is that the developed model can be reviewed and checked.

2.6 Water balance case studies

Nalecki and Gowan (2008) presented a probabilistic approach to mine water management using GoldSim. The variables of the proposed model are based on statistical distribution of possible values. A fictious example of application of their model was created based on a real-life problem. Figure 2.10 shows the forecast of changes in water level over time and proposed spillway changes. It shows the minimum volume of water required to be stored in order to provide the continuous supply of water during the operational life of the mine under different climate and operational conditions (Nalecki and Gowan, 2008). Using a classic water balance cannot predict a good estimation of the water level over time.

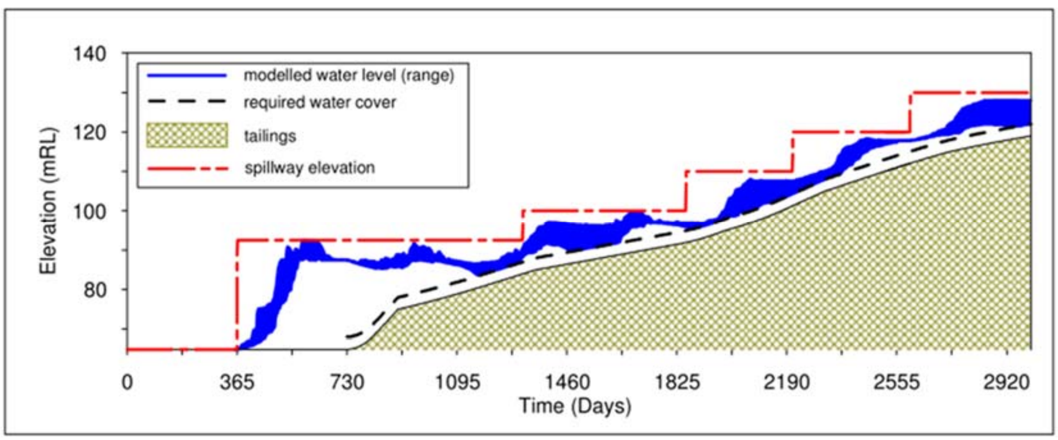


Figure 2.10 Ranges of water level at a TMF simulated with a water balance model and the spillway elevation proposed by the model (Nalecki and Gowan, 2008).

Wade (2014) carried out a probabilistic water balance to forecast the water budget of a mine in South America. The water budget depends on the size of TMF and the capacity of the reclaim pump. GoldSim was used to conduct 100-realization simulations. GoldSim runs "what if" scenarios and accordingly predicts the results using Monte Carlo simulations. Figure 2.11 shows an example of GoldSim interface used for tailings management facility water balance.

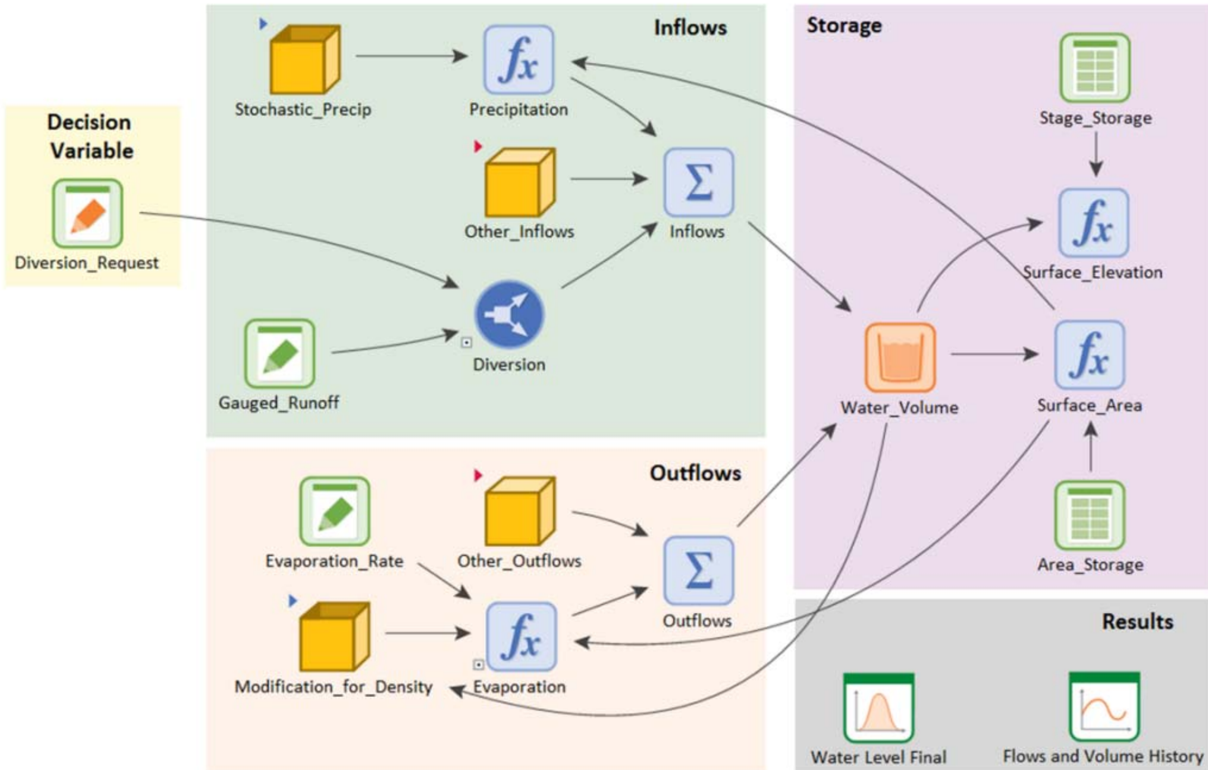


Figure 2.11 Graphical and object- oriented simulation environment of GoldSim (www.goldsim.com)

The precipitation data Wade (2014) used in her study were gathered from the closest meteorological stations to the mine site and one station on the site. The probabilistic model as a product of Wade's research showed that the water available at the TMF seasonally declines under the water level where the pumps can function. It means pumps cannot work constantly. She predicted a 1 in 100 year 24 hour storm event and showed that the designed water management did not account for the storm event. She showed that this event would cause water to exceed the embankment elevation.

2.7 Water balance calibration and validation

Coefficient of correlation between the simulated output and measured data can help calibrate the model (McPhail, 2005). Figure 2.12 shows the comparison between simulated results of a probabilistic water balance and measured data. Calibration of the probabilistic models can be done by calculating the correlation coefficient between two sets of simulated and measured data. Histograms of simulated and measured data can be compared and gaps can be analysed.

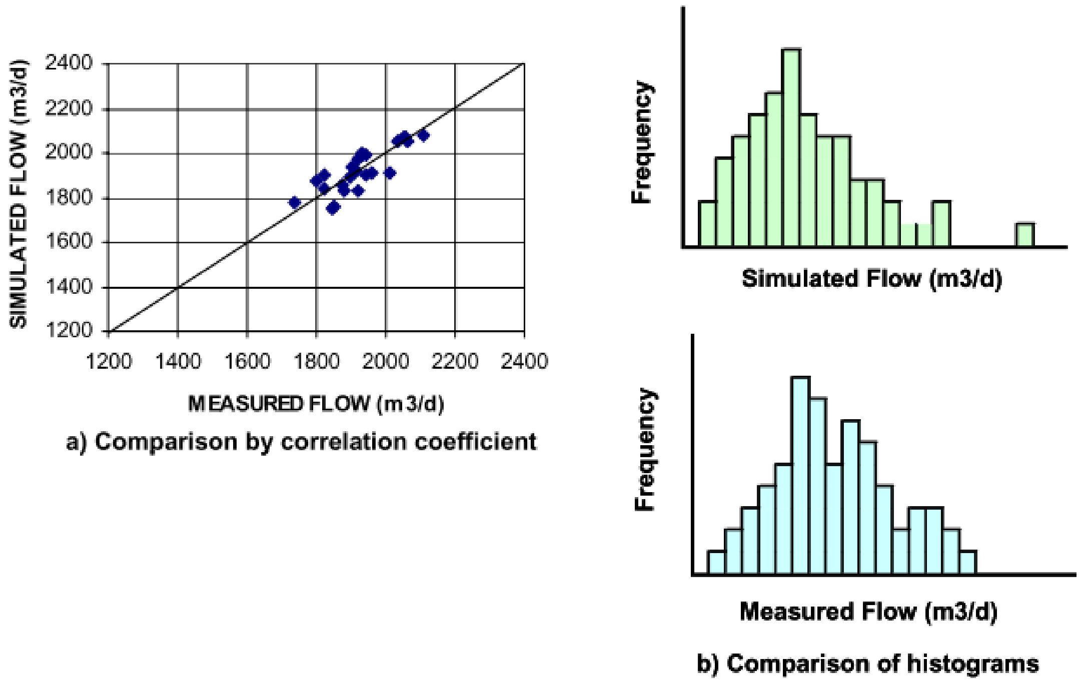


Figure 2.12 Comparison between simulated results of a probabilistic water balance and field measured data (McPhail, 2005)

Ongoing monitoring is required after water balance is modeled. Rainfall, streamflow, and groundwater data should continuely be updated.

Water balance models have to be calibrated and validated in accordance with the mine site. Naghibi (2015) performed a study to review different water balance models in British Columbia. He studied the water balance models of five mining projects and compared the temporal and spatial scales of the models, as well as the modelling tool and the uncertain parameters that were considered in each project.

The model in the Project A (Table 2.7) did not consider uncertainty in parameter values and was calibrated only for the runoff coefficient for average annual precipitation. This model was not validated.

Table 2.7 Modelling attributes of the projects studied by Naghibi (2015)

Project	Temporal scale	Spatial scale	Runoff modelling	Uncertain parameters considered	Modelling tool
A	Annual	Mine site	Empirical (average annual runoff coefficient); external numerical modelling for groundwater dewatering estimates	n/a	Spreadsheet
B	Monthly	Reginal watershed	Empirical (monthly effective precipitation and runoff coefficient); external numerical modelling for groundwater dewatering estimates	Precipitation, diversion efficiency	GoldSim™
C	Monthly	Mine site	Lumped conceptual; external numerical modelling for groundwater dewatering estimates	Precipitation, snowmelt, hydraulic conductivity	Spreadsheet
D	Monthly	Regional watershed	Semi-distributed conceptual	Precipitation	Spreadsheet

The pre-mined water balance of Project B was calibrated using the data of flows observed in the TMF and mine site. The results showed that the model was reliable. In contrast, calibration of the model in Project C against the on site collected data showed that the results were not reliable due to the unreliable precipitation data. Therefore the model was modified based on regional precipitation data. The calibration of the model in Project D compared the data of the model which were based on streamflow assessment points and the time series created based on the observed site and reginal flows. The calibration showed reliable monthly flows except for one streamflow assessment point. The dry and wet climate conditions were reviewed using sensitivity analysis scenarios.

2.8 Summary of literature review

From a review of the literature on water balance models, models can be devided into two major categories: simplified water balance models and the water balance models with refinements. Table 2.8 shows the simplified water balance vs the refinements to the model for lined and unlined facilities. Refinements on the water balance model are usually applied to seepage loss estimation. In simplified water balance, Darcy's law is used to estimate the seepage. Beach seepage loss (or rewetting losse), and consolidation related discharges are not considered. When the tailings consolidation begins the water is discharged through the top and bottom of the tailings. The discharge water through the top is subsequently evaporated. The water that is released from the bottom is either collected in the drainage system or seeped into the foundation.

Table 2.8 Modelling attributes of simplified water balance and models with refinements

Model/ Facilities	Lined	Unlined
Simplified	No seepage	Seepage
Refinements	Rewetting (beach seepage)	Rewetting (beach seepage)
	Consolidation related discharge through the top and subsequent evaporation of discharged water	Seepage loss through the bottom and consolidation related discharge through the top with subsequent evaporation of discharged water

Table 2.9 summerizes the refinements that Wels and Robertson (2003), Wels et al. (2000), and Oliveira-Filho and van Zyl (2006) have applied in their water balance models. More refinements are also suggested in this table that can take into account the unceratnities of evaporation.

Table 2.9 Modelling attributes suggested to be adopted to water models

	Parameter	Simplified	Suggested adoption
Water inflow	Surface runoff	Rational method (Eq. [2.6])	NRC Method (Eq. [2.7] to [2.9] (National Resources Conservation Service, 2004)
Water outflow	Seepage loss	Darcy's Law	Eq. [2.15] (Wels and Robertson, 2003)
			Eq. [2.22] & [2.23] (Lopes and van Zyl, 2006a)
	Evaporation	Eq. [2.25]	Penman-Monteith method (Eq. [2.12])
			Eq's. [2.13] & [2.14] (Aydin et al., 2005)

Chapter 3: Methodology- data input

Chapter 3 discusses the data selection and the methodology used in this research to develop the water balance models.

3.1 Water balance data selection

Reliable water balance evaluations require site specific information that is as accurate as possible, e.g. short monitoring intervals may not provide data that are sufficiently accurate. Assumed parameters and a generic understanding of the properties of tailings impoundments are not sufficient. The properties and characteristics of tailings may change hourly, daily or monthly. Good water management tracks the changes, makes adjustments to account for the changes, and updates the water balance. In this research, a generic model has been developed to study different scenarios using deterministic and stochastic approaches. Some values of the parameters are assumptions based on professional experience and based on reported data.

3.1.1 Climate data

This section includes the methodology used to select the data for modelling and the statistical analysis conducted on climate data.

3.1.1.1 Climate data selection

Wet climate and dry climate data that were used to develop the water balance models are described here.

Wet climate

Wet climate is defined as a climate in which extra annually accumulated water has to be released into the environment to maintain the annual water balance in the tailings impoundment (Welch, 2000).

To represent a mine in the wet condition, the location of Kerr-Sulphurets-Mitchell (KSM) project, of Seabridge Gold in North Western British Columbia on the Pacific Coast, was used. As shown in Figure 3.1, the KSM mine is located at latitude 56°30'00", longitude -130°00'00", and at an average elevation of 880m above sea level (Klohn Crippen Berger, 2013). The climate data were generated by ClimateBC program over the period of 1970-2013. Tables A.1, A.2, and A.3 in Appendix A show monthly rainfall, snowfall and evaporation respectively in this location. This information is not based on a weather station with a long history located at the site, it was effectively "estimated" on the basis of information from a database of weather stations in the vicinity.

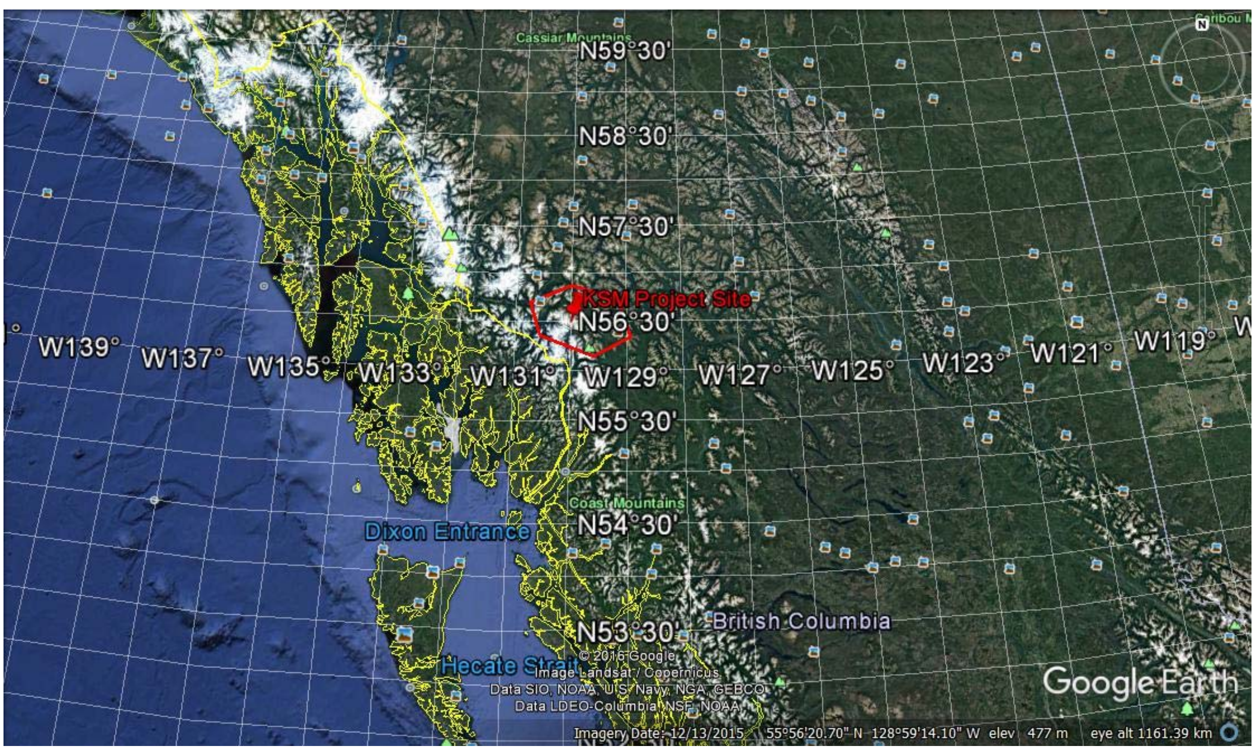


Figure 3.1 Approximate location of KSM Project used for the wet climate location (Google Earth, retrieved in Feb 2017)

The frost free days begin between the 120th and 175th days of the year. Some day between the 245th and 280th days of the year, the frost free days end. For simplification, the medians of these days were used as the start date and end date of freezing. It is assumed that the mine site is frost free between June 1st and October 1st. Snow accumulation and thaw follows the pattern shown in Table 3.1.

Table 3.1 Snowpack accumulation and melt times

	Snowpack	Proportion of total snowpack melts
Jan	Accumulates	0%
Feb	Accumulates	0%
Mar	Accumulates	0%
Apr	Melts	10%
May	Melts	30%
Jun	Melts	50%
Jul	Melts	10%
Aug	No snowpack	0%
Sep	No snowpack	0%
Oct	Accumulates	0%
Nov	Accumulates	0%
Dec	Accumulates	0%
Total		100%

Dry climate

To simulate the dry condition, the climate data at the Cerro Negro mine site were used. The Cerro Negro site is located in Argentina, province of Santa Cruz. Figure 3.2 shows the approximate location of the mine site. The climate data were extracted from Wade (2014), refer to Table A.4 in Appendix A. For simplification of water balance modelling, it is assumed that the hypothetical mine site does not receive any snowfall.

Figure 3.2 Approximate location of Cerro Negro Project used for the dry climate location (Google Earth, retrieved in Feb 2017)

3.1.1.2 Statistical analysis of climate data

Wet climate

The average annual rainfall for the selected site was approximately 2571 mm/year from1970 to 2013. Table 3.2 presents the mean and standard deviation of the monthly climate data from Tables A.1 to A.3 in Appendix A.

Table 3.2 Mean and standard deviation of monthly climate data over from 1970 to 2013

	Rainfall (mm)		Snowfall (mm)		Pan evaporation (mm)	
	Mean (μ)	Standard deviation (σ)	Mean (μ)	Standard deviation (σ)	Mean (μ)	Standard deviation (σ)
Jan	373.1	145.7	287.4	144.2	0	0
Feb	197.7	73.4	166.6	70.3	0	0
Mar	167.2	47.8	154.3	46.7	0	0
Apr	117.8	57.5	76.8	42.3	30.2	16.1
May	98.5	34.8	27.4	19.2	61.7	7.9
Jun	98.3	35.1	4.5	3.6	80.1	10.1
Jul	102.8	40.8	2.6	1.7	79.2	8.4
Aug	163.6	64.5	4.5	2.1	68.3	7
Sep	246.2	74.2	26.9	13.5	34.7	3
Oct	354.8	100.7	122.1	69.1	13.5	2.5
Nov	337.9	121.3	248.6	89.8	0	0
Dec	313	120	207.9	95.2	0	0
Annual	2570.8	276.1	1329.6	227.2	367.8	33.2

Analysis of the rainfal and evaporation data showed that no correlation existed between rainfall and evaporation (see Figure 3.3). The coefficient of correlation of 0.01 indicated that the two variables were independent.

Figure 3.3 Correlation between Rainfall and Evaporation data

Dry climate

"The average monthly evaporation [at the Cerro Negro mine] is 136.5mm and when compared to the average monthly precipitation of 16.3 mm […], it can be seen that evaporation is eight times higher than precipitation on a monthly average basis” (Wade, 2014, p. 34). The mean and standard deviation of annual dry climate rainfall data are respectively 198mm and 109.2mm. Hence, the annual evaporation is also considered to be 8 times greater than rainfall (1584mm). It is assumed that the standard deviation of evaporation is also 8 times greater than the rainfall standard deviation i.e. 873.6mm. Table 3.3 shows the mean and standard deviation of the monthly rainfall. The data of monthly evaporation for the dry climate was not available, therefore the temporal distribution of evaporation data in the wet cliamate condition was used to extract the mean and standard deviation of monthly pan evaporation using the mean and standard deviation of the annual evaporation the in the dry climate condition (Table 3.4).

Table 3.3 Rainfall (mm/month) from 1978 to 2012 recorded in Project Site Weather Station (EMA BN) (after Wade, 2014)

	Rainfall (mm)	
	Mean (μ)	**Standard deviation (σ)**
Jan	8.9	18.5
Feb	8	13.8
Mar	12.5	17
Apr	18.3	21.6
May	30.4	26.3
Jun	30.8	31.6
Jul	17.6	23
Aug	13.8	16
Sep	17.4	16.6
Oct	16.8	17.9
Nov	15.9	39.4
Dec	7.8	15.2
Annual	198	109.2

Table 3.4 Dry climate monthly pan evaporation based on the average evaporation in the dry condition and temporal distribution of evaporation in the wet condition

	Proportion of total evaporation (from wet climate data)	Mean Evaporation (mm)	Standard deviation (mm) $(8 \times annual\ std\ dev \times proportion\ of\ total\ evaporation)$
Jan	0%	0.0	0.0
Feb	0%	0.0	0.0
Mar	0%	0.0	0.0
Apr	8%	130.0	71.7
May	17%	265.9	146.6
Jun	22%	345.1	190.3
Jul	22%	341.2	188.2
Aug	19%	294.3	162.3
Sep	9%	149.6	82.5
Oct	4%	58.1	32.1
Nov	0%	0.0	0.0
Dec	0%	0.0	0.0
Annual	100%	1,584	874

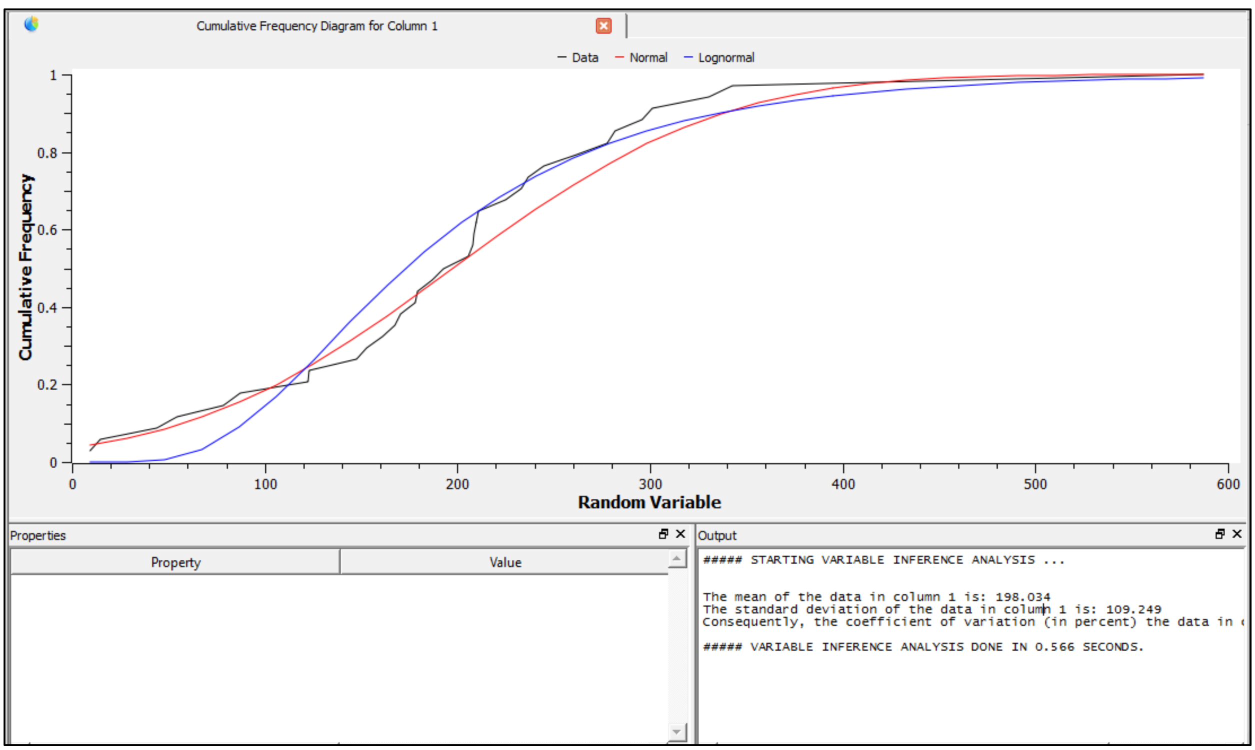


Figure 3.4 Cumulative Frequency Diagram of the rainfall data of table 3.3 (the red and blue lines show the best normal and log normal distributions fitted to the data)

It is assumed that the mine is located in the northern hemisphere to be able to compare the results of wet and dry climate water balance models. Therefore when applying in the model, the values of monthly rainfall and evaporation were shiftted so that the seasons (summer: winter) matched the northern hemispher seasons i.e. first of September in Argentina became equivalent to the first of March in the Northern Hemisphere (see Table 3.5).

Table 3.5 The pattern for switching the values of monthly rainfall in the model

Month in original data set	Switched to month
July	January
August	February
September	March
October	April
November	May
December	June
January	July
February	August
March	September
April	October
May	November
June	December

3.1.2 Operational data

Daily total throughput, open pit area and open pit run off coefficient, areas of tailings impoundment pond and beaches, and solids content of the tailings reporting to the TMF are derived from the technical reports of Mount Polley Tailings Facilities. Table 3.6 presents the required assumptions used in the water balance model.

The water balance models in this research are developed for metal mines tailings management facilities where the tonnage of mill throughput is almost same as the tonnage of ore being processed. For mines other than metal mines (such as industrial mineral mines), the amount of tailings discharge from the mill is dependent on the amount of economical product produced, which can be 20% or higher.

Table 3.6 Operating data inputs and assumptions

Parameter	Value	Data source	Nature of data
Density of water	1000 kg/m^3	Assumption	Constant
Daily ore throughput (dry solid)	13,425 tonne	Mount Polley Mine reports (Knight Piesold, 1995a)*	Constant
Solids content in mill circuit	35%	Assumption	Constant
Tailings solids content	45-80%	Assumption	Variable
Impoundment area	230 ha	Mount Polley Mine reports (Knight Piesold, 1995a)*	Constant
Pond, wet beach, drying beach, and dry beach areas	Proportion of impoundment area	Assumption	Constant
Pond evaporation pan factor	0.8	Assumption	Constant
Wet beach evaporation pan factor	0.8	Assumption	Constant
Drying beach evaporation pan factor	0.4	Assumption	Constant
Dry beach evaporation pan factor	0.1	Assumption	Constant
Pit area	18 ha	Mount Polley Mine reports (Knight Piesold, 1995b)*	Constant
Pit runoff coefficient	0.5	Mount Polley Mine reports (Knight Piesold, 1995b)*	Constant
Minimum storage required for wet climate and solids content less than 70%	1,000,000	Assumption	Constant
Snow density	310 kg/m^3	Assumption	Constant

*** Available from: https://www.mountpolleyreviewpanel.ca/**

For considering the evaporation surface area, the total area of the TMF is divided into four areas: pond, wet beach, drying beach and dry beach. These areas for different tailings solids contents are shown in Table 3.7. For simplification, the area of the tailings impoundment, open pit, and beaches are assumed to be constant. However, these areas are changing over time.

Table 3.7 Proportions of poond and beaches areas relative to the total TMF area

	Tailings solids content (%)	Pond area (% of TMF area)	Wet beach (% of TMF area)	Drying beach (% of TMF area)	Dry beach (% of TMF area)
Wet condition	45	25	50	25	0
	60	25	50	25	0
	70	0	50	50	0
	80	0	50	50	0
Dry condition	45	25	25	25	25
	60	15	25	30	30
	70	0	25	35	40
	80	0	0	40	60

3.1.3 Tailings material characteristics

Table 3.8 summarizes the characteristics of tailings material. The specific gravity and moisture content of tailings and seepage rate of the impoundment come from the Mount Polley Mine technical reports.

Table 3.8 Tailings material characteristics input data and assumptions

Parameter	Value	Data source	Nature of data
Tailings specific gravity	2.78	Mount Polley Mine reports*	Constant
Initial dry density of settled tailings	1.1 to 1.8 tonne/m^3	Assumption (refer to Table 3.10)	Variable
Moisture content of ore	0.04	Mount Polley Mine reports*	Constant
Average hydraulic conductivity of tailings	1×10^{-6} cm/s	Assumption	Constant

*** Available from:**
https://www.mountpolleyreviewpanel.ca/

3.2 Water balance models

The water balance developed in this study is only for the operating tailings management facilities. It does not include closure and post-closure water balances. The proposed water balance model is Excel spreadsheet based. It is possible to extend and use the model for more complex water managements by adding extra features to the model. Figure 3.5 shows the conditions that are considered in developing the water balance models in this research.

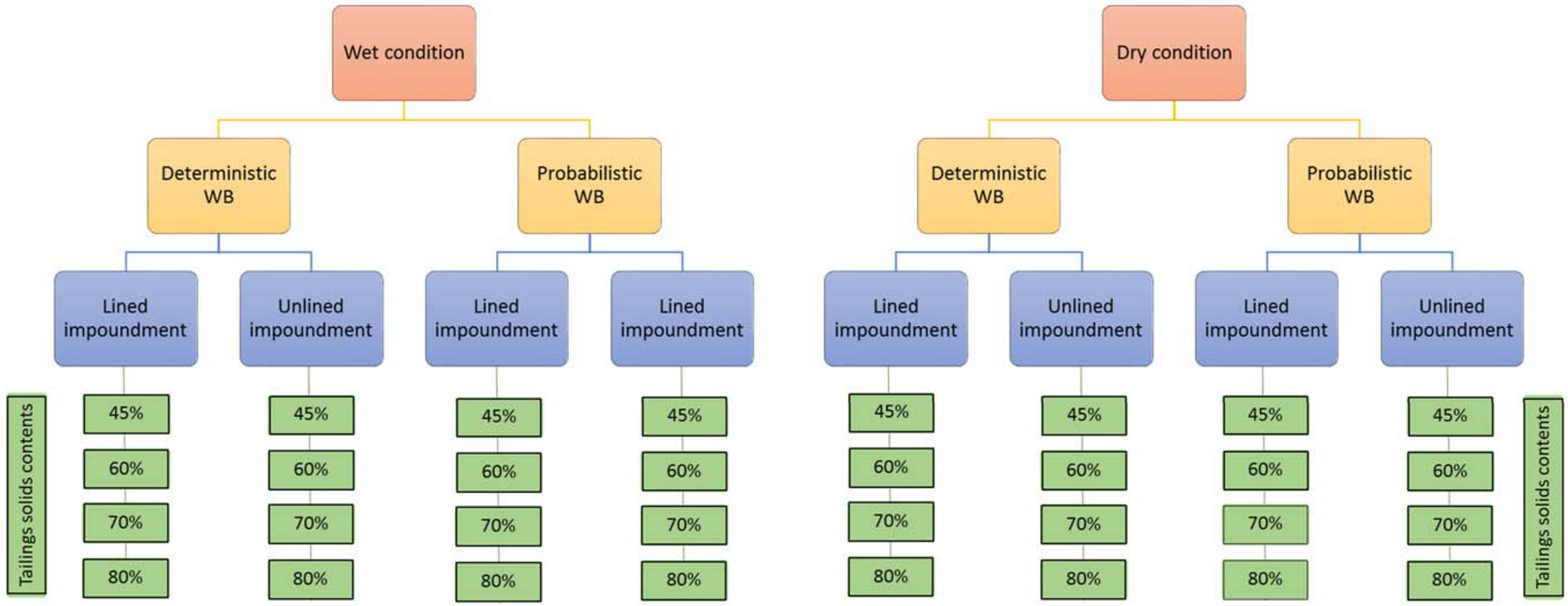


Figure 3.5 Conditions considered in developing the water balance models in this reserch

A simplified schematic of the water balance components, in Figure 3.6, summarizes the structure of the water balance model. The diagram is later quantified for different scenarios in Chapters 4 and 5.

Solids content of the mill circuit is 35% solids by mass. It is assumed that the tailings solids content changes in dewatering systems to reach 45% to 80% by mass. Solids contents of 45%, 60%, 70%, and 80% are used to develop the models for different tailings management options: respectively slurry tailings, thickened tailings, paste tailings, and filtered tailings. These solids contents are typical in hard rock tailings.

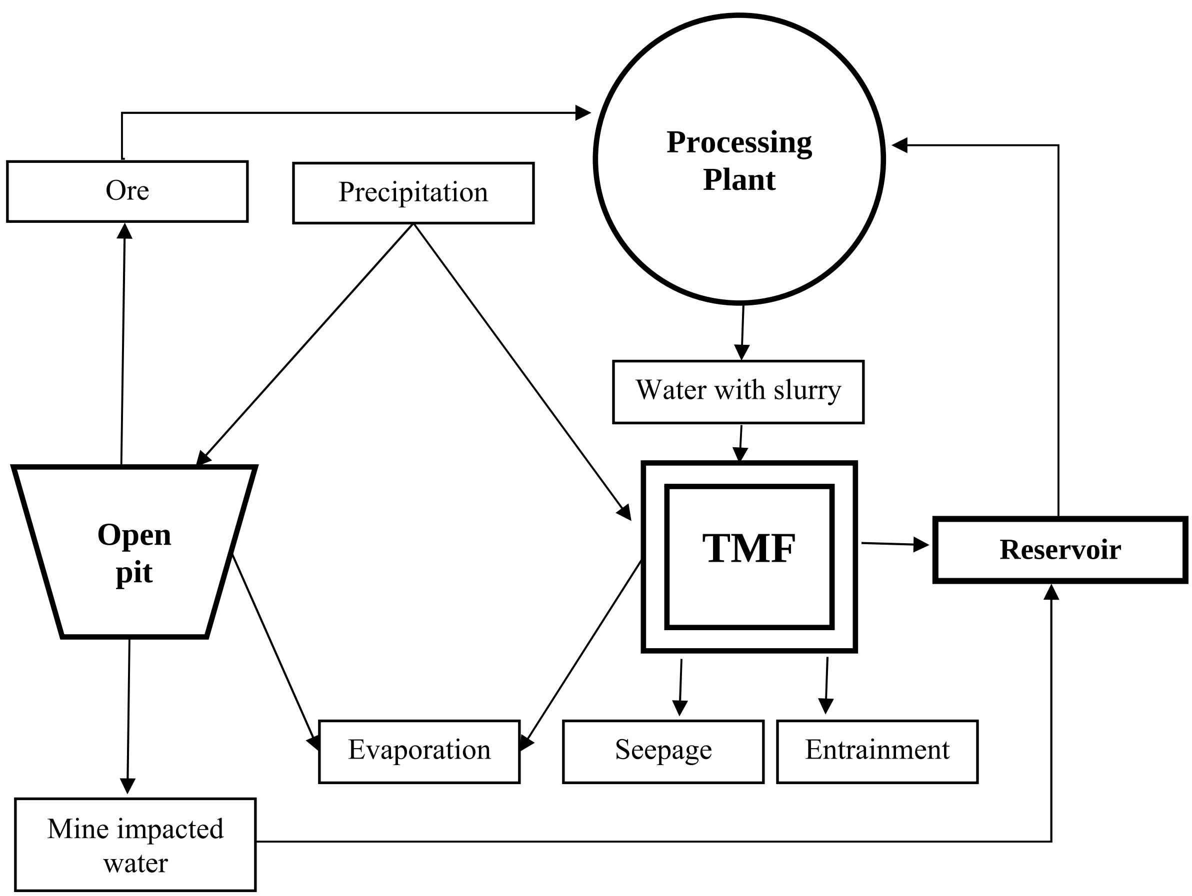


Figure 3.6 Simplified schematic of a TMF water balance used in the research

3.2.1 Deterministic water balance

A deterministic water balance is developed based on Equation [2.2] and the average values of the parameters are used in an Excel Spreadsheet (Table 3.9). The ore moisture water is usually negligible and is not considered in the water balance calculations.

Table 3.9 The Excel spreadsheet table used to develop the water balance model.

No.	Category	Parameter
1	**Time**	Month
2		Number of days in month
3	**Precipitation water (mm/month)**	Rainfall
4		Snow water equivalent from snow melt
5	**Water in (m^3)**	Water with tailings
6		Precipitation onto impoundment
7		**Total Water Input**
8	**Water out (m^3)**	Evaporation
9		Entrained water
10		Seepage
11		**Total Water Output**
12	**Mill required water (m^3)**	Water with tailings
13		**Total mill required water**
14	**Water on the pond (m^3)**	**Monthly change in storage**
15		**Water moved to reservoir**
16		**Cumulative change in storage**
17		**Water remained in TMF**
18	**Mine impacted water runoff**	
19	**Reservoir storage (m^3)**	**Monthly reservoir storage**
20		**Cumulative reservoir storage**
21		**Returned to TMF from reservoir**
22		**Water in TMF+ return to TMF from reservoir**
23	**Cumulative water deficit/ surplus (m^3/tonne)**	

This model is the water balance over the mine life (60 months). The equations used to calculate the parameters for different scenarios are presented in the following sections. Water balance is developed for lined and unlined impoundments.

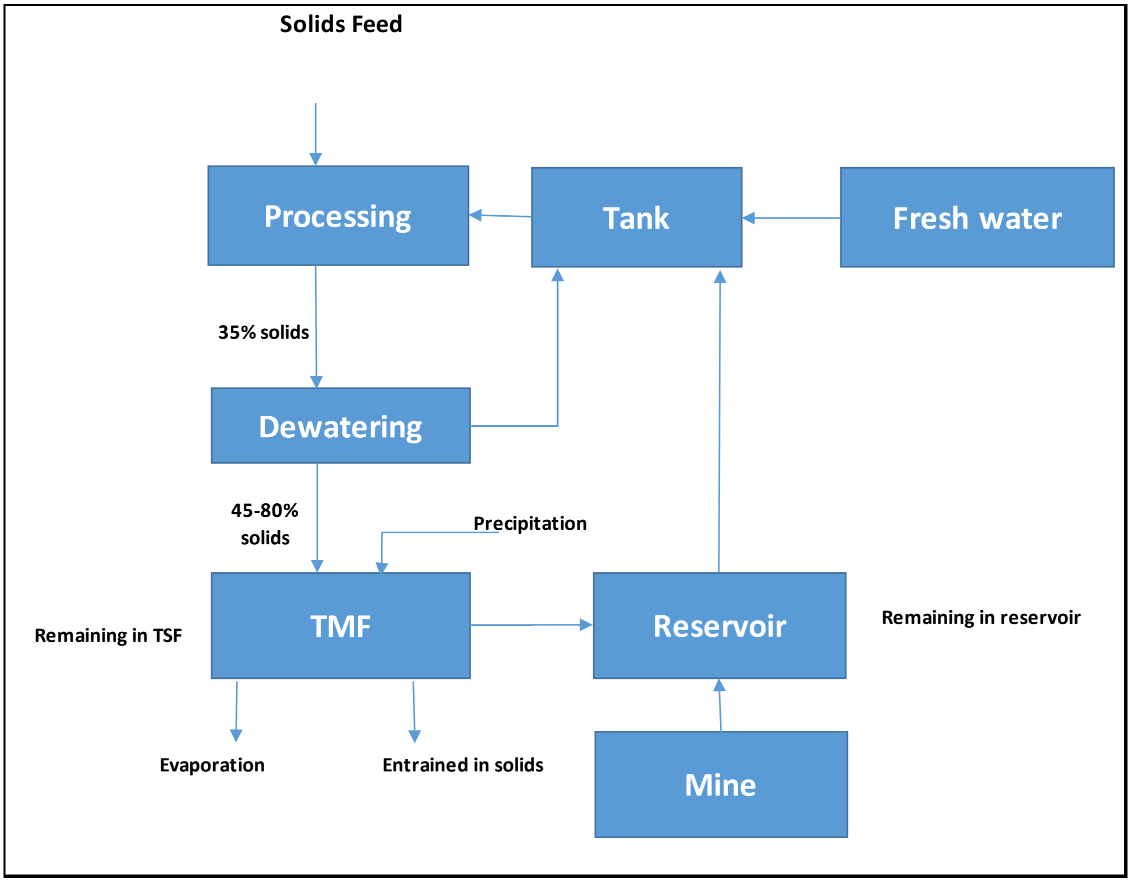
3.2.1.1 Lined impoundment

The model was compiled with the assumption that there is no seepage loss in the lined impoundment. However, it has to be noted that even with a complex liner systems, zero discharge of seepage from TMF is not possible (www.tailings.info).

Wet climate

Figure 3.7 shows the schematic flowchart of water circulation considered in the wet climate model. In wet climate, since there is a lot of water surpluses, It was assumed that the extra water is stored in the reservoir. The water balance was estimated based on the water that remained in the reservoir. So the water balance was done for the water remained in the TMF. Table 3.10 shows the calculation used to determine the parameters in Table 3.9 for a lined impoundment in the wet condition. The flow chart related to this model is provided in Appendix A, Figure A.5.

Wet Climate Assumptions



Parameter	Nature in this model	Value
Mean annual rainfall (mm)	Constant	2570.77
Standard deviation of annual rainfall (mm)	Constant	276.08
Mean annual snowfall water equivalent (mm)	Constant	412.16
Standard deviation of annual snowfall (mm)	Constant	70.42
Mean annual pan evaporation (mm)	Constant	367.82
Standard deviation of annual pan evaporation (mm)	Constant	33.15
Evaporation pan factor for pond	Constant	0.8
Evaporation pan factor for wet beach	Constant	0.8
Evaporation pan factor for drying beach	Constant	0.4
Evaporation pan factor for dry beach	Constant	0.1
Snow density (tonne/m^3)	Constant	0.31
Solids content in mill circuit (%)	Constant	35
Daily ore throughput (tonne)	Constant	13,425

Figure 3.7 Water circulation at TMF for wet climate condition

Table 3.10 Calculation methods and assumptions used to determine water balance parameters for wet condition lined impoundment

Description	Data Source	Note/Calculation Method
Rainfall (mm/month)	ClimateBC	Average monthly rainfall extracted from ClimateBC rainfall data over the period of $1970-2013$.
Snowpack accumulation water equivalent (mm/month)	Calculated	$=$ Monthly accumulated snow water equivalent
Snow water equivalent of snow melt (mm/month)	Calculated	$=$ Monthly snow water equivalent as the result of snowpack melting in the frost free period
Evaporation (mm/month)	ClimateBC	Average monthly evaporation extracted from ClimateBC rainfall data over the period of $1970-2013$.
WATER IN (m^3)		
Volume of water with tailings	Calculated	$= \text{Daily ore throughput} \times \text{Days in a month} \times \left(\frac{1-\text{tailings \% solid}}{\text{tailings \% solid}}\right)$
Precipitation onto impoundment	Calculated	$= \frac{\text{Rainfall(mm)} + \text{Snow water equivalent of snowmelt (mm)}}{1000\ \left(\frac{mm}{m}\right)} \times \text{Pond area(ha)} \times 10{,}000\left(\frac{m}{ha}\right)$
Total water input	Calculated	$=$ water with tailings $+$ Precipitation onto impoundment $+$ Mine impacted water runoff
WATER OUT (m^3)		
Evaporation	Calculated	$= (\text{Pond area(ha)} \times \text{Evaporation factor for pond} + \text{Area of wet beach(ha)} \times \text{Evaporation factor for wet beach} + \text{Drying beach(ha)} \times \text{Evaporation factor for drying beach} + \text{Dry beach(ha)} \times \text{Evaporation factor for dry beach}) * 10{,}000 \times \text{Evaporation(mm)}/1000\left(\frac{mm}{m}\right)$
Entrainment	Calculated	$= \text{Daily ore throughput} \times \text{Days in month} \times \left(\frac{\text{Tails S.G.}}{\text{Final dry density}} - 1\right)/\text{tails S.G.}$
Total water output	Calculated	$=$ Evaporation from pondand beaches $+$ Seepage losses $+$ Entrainment
Monthly change in storage	Calculated	$=$ Total Water Input $-$ Total Water Output
Total water required in the mill	Calculated	$=$ Water with tailings
Water moved to reservoir*	Calculated	$= \text{If (cumulative storage} < \textit{Minimum required storage}, 0, \text{Cumulative storage} - \text{Minimum required storage)}$
Mine impacted water runoff*	Calculated	$= \text{Total pit area(ha)} \times 10000 \times \text{Pit area runoff coefficient} \times \frac{\text{Rainfall(mm)} + \text{Snow water equivalent of snowmelt (mm)}}{1000\ \left(\frac{mm}{m}\right)}$
Water remained in TMF	Calculated	$= \text{IF(Cumulative storage} > \textit{Minimum required storage}, \textit{Minimum required storage}, \textit{Cumulative storage})$
Water return to TMF*	Calculated	If the water in the pond is less than the minimum required storage, the required water is returned to the pond from reservoir
Monthly reservoir storage*	Calculated	$=$ Water moved to reservoir $+$ Mine impacted water $-$ Water returned to the pond $-$ Water required in the mill
Water surplus/deficit**	Calculated	$= \frac{\text{Cumulative water remained in reservoir}}{\text{Cumulative ore throughput}}$

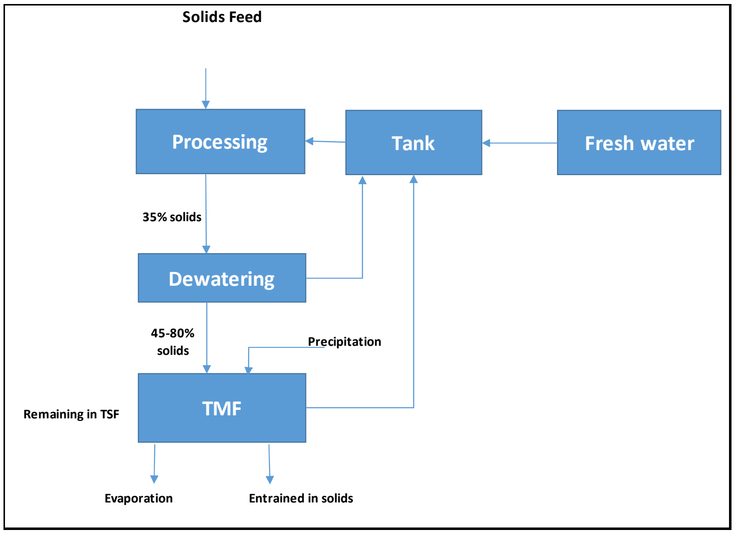
*** Reservoir is only needed in the wet condition**
**** Water surplus/deficit in the dry condition is the difference between the cumulative storage at the TMF and the water required in the mill**

Rainfall-runoff from the pit reports to the reservoir. A minimum of 1,000,000 m^3 water storage at the TMF is required. The minimum storage ensures that solids are not pumped as that can impact the quality of the water being returned to the mill for re-use. When the storage drops below the minimum storage volume the pumps must stop running. For solids contents greater than 65%, there is no need to maintain a minimum storage. It is assumed that for paste tailings and dry stack tailings, the precipitation and runoff water are diverted and collected.

Dry climate

Figure 3.8 provides a water cycle schematic and the monthly rainfall data at the hypothetical TMF located in an arid region. Because of the water deficit, having a reservoir was not required in the dry climate condition. The same Excel Spreadsheet which was used for the wet condition (Table 3.7) can be used to develop the model for the arid climate except that in the model for dry climate, no snow water input and no mine impacted water runoff exist. The calculations of water balance in the dry condition is same as the wet condition with a minor difference in precipitation water calculations. In the dry condition, precipitation water is only rainfall and the monthly value follows the temporal distribution from the historical data.

Dry Climate Assumptions



Parameter	Nature in this model	Value
Mean annual rainfall (mm)	Constant	198.03
Standard deviation of annual rainfall (mm)	Constant	109.25
Mean annual snowfall water equivalent (mm)	Constant	0
Standard deviation of annual snowfall (mm)	Constant	0
Mean annual evaporation (after applying pan factor)* (mm)	Constant	1584.2
Standard deviation of annual evaporation (after applying pan factor)* (mm)	Constant	874
Evaporation pan factor for pond	Constant	0.8
Evaporation pan factor for wet beach	Constant	0.8
Evaporation pan factor for drying beach	Constant	0.4
Evaporation pan factor for dry beach	Constant	0.1
Solids content in mill circuit (%)	Constant	35
Daily ore throughput (tonne)	Constant	13,425
Tails solids content (%)	Variable	35-80
Tailings Specific gravity	Constant	2.78
Water content of ore	Constant	0.04
Final dry density (tonne/m^3)	Variable	1.1-1.5
Pond area (ha)	Constant	230
Temporal Distribution	**Rainfall**	**Evaporation**
JAN	22%	0%
FEB	19%	0%
MAR	9%	0%
APR	4%	8%
MAY	0%	17%
JUN	0%	22%
JUL	0%	22%
AUG	0%	19%
SEP	0%	9%
OCT	8%	4%
NOV	17%	0%
DEC	22%	0%

*** Evaporation is 8 times greater than rainfall.**

Figure 3.8 Water circulation at TMF for dry climate condition

3.2.1.2 Unlined impoundment

Wet climate

Given the average hydraulic conductivity of 1×10^{-8} m/s, and the hydraulic gradient of 1, the average seepage rate according to the Equation [2.16] is equal to 59,616 (m^3/month) down through the 230-hectare area of the impoundment. It is assumed that 75% of the seepage is collected in a drainage system and returned to the reservoir. Therefore the seepage loss equals to 14,904m^3/month. The water outflow is the sum of seepage, evaporation, and entrained water. Figure 3.9 shows the schematic of the water circulation for the unlined impoundment in the wet condition.

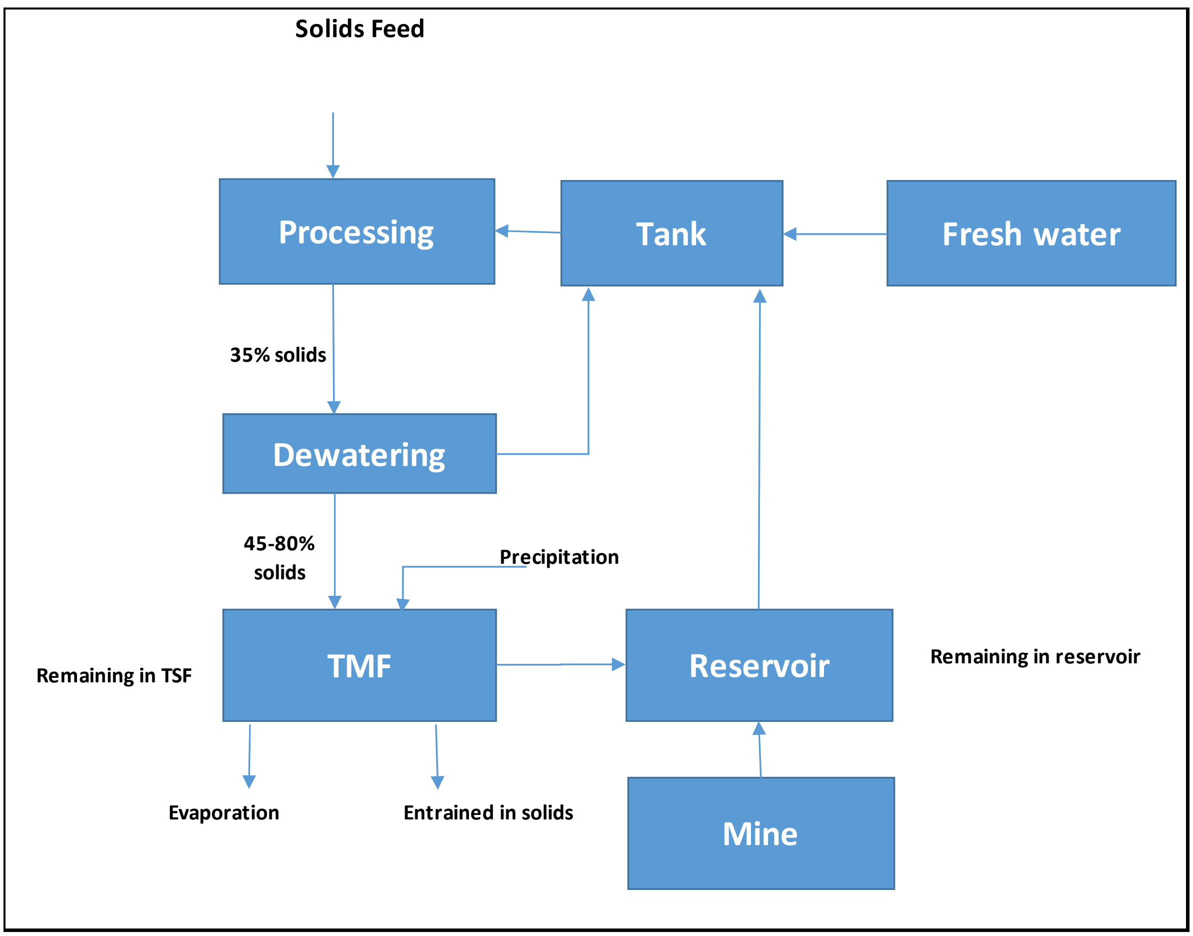


Figure 3.9 Schematic of water circulation for the unlined impoundment in the wet climate condition

Dry climate

It is assumed that the unsaturated seepage in the dry condition is only one-third of the seepage rate in the wet condition. It means the average seepage loss of 4,968 m^3/month has been considered for the dry condition. Figure 3.10 shows the schematic for water circulation in the unlined impoundment.

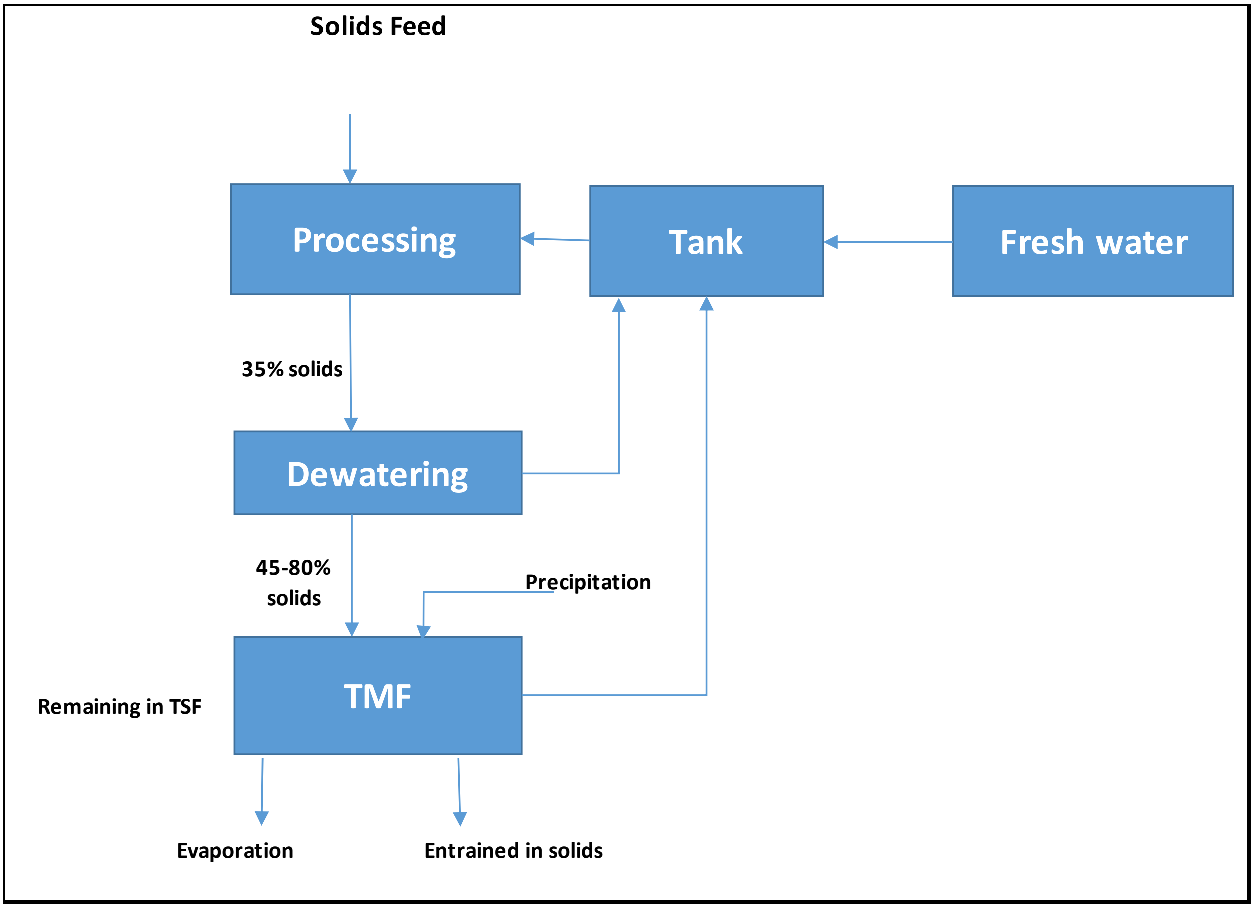


Figure 3.10 Schematic of water circulation for the unlined impoundment in the dry climate condition

3.2.2 Probabilistic water balance

The variable parameters of precipitation, evaporation and dry density have been changed using their distributions to reflect the uncertainity of the model. Precipitation and evaporation are variables with the highest degree of uncertainties.

The water entrainment depends on the dry density of the deposited tailings. One of the challenges to estimate the volume of the entrained water is that the dry density of deposited tailings is not readily available during the design phase. Dry density is a dynamic value during the operational life of the TMF. It is a function of tailings particle size. It is assumed that the relationship between tailings solids content and dry density follows an S-shape curve. Triangle distributions have been used to simulate dry densities during the initial depositions of tailings (van Zyl, 2015). The values of dry density for different solids contents vary according to Table 3.11 and Figure 3.11.

Table 3.11 The relationship between dry density and solids content of tailings

Solids content (%)	Most likely dry density (tonne/m^3)	Minimum dry density (tonne/m^3)	Maximum dry density (tonne/m^3)
35	1.1	0.90	1.3
40	1.14	0.94	1.34
45	1.2	1.00	1.4
50	1.29	1.09	1.49
55	1.42	1.22	1.62
60	1.55	1.35	1.75
65	1.64	1.44	1.84
70	1.7	1.50	1.9
75	1.74	1.54	1.94
80	1.8	1.60	2.0

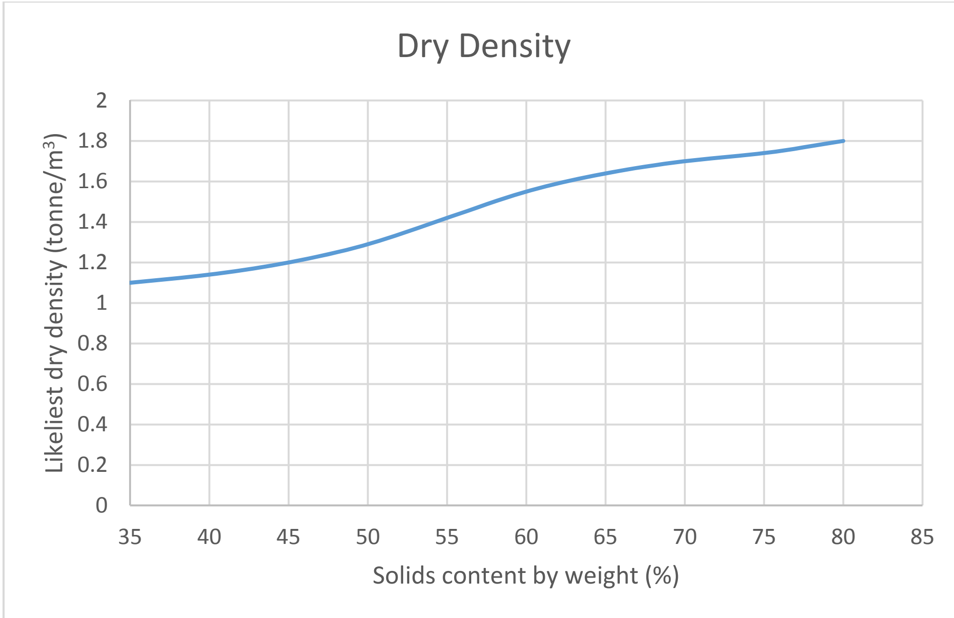


Figure 3.11 Most likely Dry density assumption for different solids contents

The distributions of climate parameters and dry density of the tailings after sedimentation are defined as inputs in Crystal Ball. Monte Carlo Simulation with previously defined realizations of 10000 is run to generate stochastic climate data over the 5-year (60 months) life of the mine which equals to 50000 years (600,000 months) of modelled mine life. Samples of precipitation, evaporation, and dry density are picked from their previously determined distributions. The model is run for these sampled values of the parameters and the output is saved in Oracle Crystal Ball. After completion of the simulation, histograms of outputs (in this case monthly water surpluses/deficits) are provided by Crystal Ball.

Histograms can be used to predict the probability of expected events, such as:

- the probability of exceeding a given critical threshold of water surplus which might result in the low freeboard and/or overtopping
- the probability of water level dropping to a critical point than the minimum required to maintain pumping and the full capacity of the reclaim pumps cannot be met

- the probability of water dropping to a certain critical value of water level that requires adding specific amount of make-up water to the system.

3.2.2.1 Lined impoundment

Wet climate

Different distributions were tested to the climate data but they did not pass the goodness of fitness test, therefore triangular distribution with the properties in Table 3.12 was used. This distribution truncates the outlined values of the Probability Density Function. The minimum value in the triangular distribution was the mean minus 3 standard deviations, the peak value was equal to the mean and the maximum value equaled mean plus 3 standard deviations. This assumption ensured that 99% of data were considered in simulations. There is no seepage loss considered for lined impoundments.

Table 3.12 Triangular distribution parameters for wet climate data from 1970 to 2013

	Rainfall (mm)			Snowfall (mm)			Pan evaporation (mm)		
	Minimum Value* $=\mu-3\sigma$	Peak Value $=(\mu)$	Maximum Value $=\mu+3\sigma$	Minimum Value* $=\mu-3\sigma$	Peak Value $=(\mu)$	Maximum Value $=\mu+3\sigma$	Minimum Value* $=\mu-3\sigma$	Peak Value $=(\mu)$	Maximum Value $=\mu+3\sigma$
Jan	0	373.1	810.2	0	287.4	720	0	0	0
Feb	0	197.7	417.9	0	166.6	377.5	0	0	0
Mar	23.8	167.2	310.6	14.2	154.3	294.4	0	0	0
Apr	0	117.8	290.3	0	76.8	203.7	0	30.2	78.5
May	0	98.5	202.9	0	27.4	85	38	61.7	85.4
Jun	0	98.3	203.6	0	4.5	15.3	49.8	80.1	110.4
Jul	0	102.8	225.2	0	2.6	7.7	54	79.2	104.4
Aug	0	163.6	357.1	0	4.5	10.8	47.3	68.3	89.3
Sep	23.6	246.2	468.8	0	26.9	67.4	25.7	34.7	43.7
Oct	52.7	354.8	656.9	0	122.1	329.4	6	13.5	21
Nov	0	337.9	701.8	0	248.6	518	0	0	0
Dec	0	313	673	0	207.9	493.5	0	0	0

***If the minimum value in the triangular distribution was negative value we would substitute the negative value with zero.**

Dry climate

The triangular distribution of rainfall for the dry climate is according to Table 3.13.

Table 3.13 The properties of triangular distribution for the dry climate

	Rainfall (mm)		
	Minimum Value* $=\mu-3\sigma$	Peak Value $=\mu$	Maximum Value $=\mu+3\sigma$
Jan	0	8.9	64.4
Feb	0	8	49.4
Mar	0	12.5	63.5
Apr	0	18.3	83.1
May	0	30.4	109.3
Jun	0	30.8	125.6
Jul	0	17.6	86.6
Aug	0	13.8	61.8
Sep	0	17.4	67.2
Oct	0	16.8	70.5
Nov	0	15.9	134.1
Dec	0	7.8	53.4

***If the minimum value in the triangular distribution was negative value we would substitute the negative value with zero.**

3.2.2.2 Unlined impoundment

Wet climate

The seepage rate of 14,904 m^3/month is applied to the wet condition water balance in the previous section to model the seepage loss.

Dry climate

The dry condition water balance in previous section has been re-run for unlined impoundment by adding the seepage loss rate of 4,968 m^3/month to the model.

Chapter 4: Deterministic water balance results

This chapter summarizes the results of deterministic water balance for lined and unlined impoundments for two climate conditions.

4.1 Lined impoundment

The water balance parameters are determined using the equations and input data presented in Chapter 3. It is assumed that there is no seepage loss.

4.1.1 Wet climate

Table 4.1 shows the model results for solids content of 45% for wet climate. This model is developed based on the average values of climate parameters and dry density of 1.2 tonne/m^3. The water balance models for solids contents of 60, 70, and 80 percent are provided in Appendix B, Tables B.1 to B.3.

The schematic flowchart of water circulations for the four tailings solids contents are illustrated in Figure 4.1. The volume of water flowing between each unit is calculated based on the average of water flows over 60 months of TMF operating life. Only some make up water is required for the first month of operation for 45 and 60 percent solids contents.

Table 4.1 Deterministic water balance for solids content of 45% in the wet condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)			Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Total Water Input	Evaporation	Entrainment	Total Water Output	Water with tailings	Total mill required water	Monthly change in storage	Water moved to reservoir	Cumulative change in storage	Water remained in TMF	Mine impacted water runoff	Monthly reservoir storage	Cumulative reservoir storage	Water returned to TMF from reservoir	Water remained in reservoir	Water remained in TMF+ Water returned to TMF from reservoir
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	1,169,656.0	169,656.0	1,169,656.0	1,000,000.0	33,578.1	203,234.1	203,234.1	0.0	0.0	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	178,034.2	459,433.3	459,433.3	736,017.1	736,017.1	1,736,017.1	1,000,000.0	17,789.4	753,806.5	753,806.5	0.0	294,373.2	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	696,017.0	696,017.0	1,696,017.0	1,000,000.0	15,044.4	711,061.4	1,005,434.6	0.0	496,776.3	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	239,372.9	492,250.0	492,250.0	663,174.1	663,174.1	1,663,174.1	1,000,000.0	16,055.1	679,229.2	1,176,005.5	0.0	683,755.5	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	296,494.6	508,658.3	508,658.3	712,068.7	712,068.7	1,712,068.7	1,000,000.0	19,561.5	731,630.2	1,415,385.7	0.0	906,727.4	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	319,728.0	492,250.0	492,250.0	824,848.0	824,848.0	1,824,848.0	1,000,000.0	25,525.8	850,373.8	1,757,101.2	0.0	1,264,851.2	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	324,669.6	508,658.3	508,658.3	506,931.7	506,931.7	1,506,931.7	1,000,000.0	12,636.9	519,568.6	1,784,419.8	0.0	1,275,761.5	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	307,104.5	508,658.3	508,658.3	580,938.8	580,938.8	1,580,938.8	1,000,000.0	14,845.5	595,784.3	1,871,545.8	0.0	1,362,887.5	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	246,666.2	492,250.0	492,250.0	830,887.8	830,887.8	1,830,887.8	1,000,000.0	22,903.2	853,791.0	2,216,678.5	0.0	1,724,428.5	1,000,000.0
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	218,844.3	508,658.3	508,658.3	1,105,946.0	1,105,946.0	2,105,946.0	1,000,000.0	31,935.6	1,137,881.6	2,862,310.1	0.0	2,353,651.8	1,000,000.0
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	1,269,489.0	0.0	190,750.9	190,750.9	492,250.0	492,250.0	1,078,738.1	1,078,738.1	2,078,738.1	1,000,000.0	30,413.7	1,109,151.8	3,462,803.6	0.0	2,970,553.6	1,000,000.0
Year 1	DEC	31.0	313.0	0.0	508,658.3	719,900.0	1,228,558.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	1,031,449.0	1,031,449.0	2,031,449.0	1,000,000.0	28,170.0	1,059,619.0	4,030,172.6	0.0	3,521,514.3	1,000,000.0
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	1,169,656.0	1,169,656.0	2,169,656.0	1,000,000.0	33,578.1	1,203,234.1	4,724,748.4	0.0	4,216,090.1	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	178,034.2	459,433.3	459,433.3	736,017.1	736,017.1	1,736,017.1	1,000,000.0	17,789.4	753,806.5	4,969,896.6	0.0	4,510,463.3	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	696,017.0	696,017.0	1,696,017.0	1,000,000.0	15,044.4	711,061.4	5,221,524.7	0.0	4,712,866.4	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	239,372.9	492,250.0	492,250.0	663,174.1	663,174.1	1,663,174.1	1,000,000.0	16,055.1	679,229.2	5,392,095.6	0.0	4,899,845.6	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	296,494.6	508,658.3	508,658.3	712,068.7	712,068.7	1,712,068.7	1,000,000.0	19,561.5	731,630.2	5,631,475.8	0.0	5,122,817.5	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	319,728.0	492,250.0	492,250.0	824,848.0	824,848.0	1,824,848.0	1,000,000.0	25,525.8	850,373.8	5,973,191.3	0.0	5,480,941.3	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	324,669.6	508,658.3	508,658.3	506,931.7	506,931.7	1,506,931.7	1,000,000.0	12,636.9	519,568.6	6,000,509.9	0.0	5,491,851.6	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	307,104.5	508,658.3	508,658.3	580,938.8	580,938.8	1,580,938.8	1,000,000.0	14,845.5	595,784.3	6,087,635.9	0.0	5,578,977.6	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	246,666.2	492,250.0	492,250.0	830,887.8	830,887.8	1,830,887.8	1,000,000.0	22,903.2	853,791.0	6,432,768.6	0.0	5,940,518.6	1,000,000.0
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	218,844.3	508,658.3	508,658.3	1,105,946.0	1,105,946.0	2,105,946.0	1,000,000.0	31,935.6	1,137,881.6	7,078,400.2	0.0	6,569,741.9	1,000,000.0
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	1,269,489.0	0.0	190,750.9	190,750.9	492,250.0	492,250.0	1,078,738.1	1,078,738.1	2,078,738.1	1,000,000.0	30,413.7	1,109,151.8	7,678,893.7	0.0	7,186,643.7	1,000,000.0
Year 2	DEC	31.0	313.0	0.0	508,658.3	719,900.0	1,228,558.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	1,031,449.0	1,031,449.0	2,031,449.0	1,000,000.0	28,170.0	1,059,619.0	8,246,262.7	0.0	7,737,604.4	1,000,000.0
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	1,169,656.0	1,169,656.0	2,169,656.0	1,000,000.0	33,578.1	1,203,234.1	8,940,838.5	0.0	8,432,180.2	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	178,034.2	459,433.3	459,433.3	736,017.1	736,017.1	1,736,017.1	1,000,000.0	17,789.4	753,806.5	9,185,986.7	0.0	8,726,553.4	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	197,109.3	508,658.3	508,658.3	696,017.0	696,017.0	1,696,017.0	1,000,000.0	15,044.4	711,061.4	9,437,614.8	0.0	8,928,956.5	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	239,372.9	492,250.0	492,250.0	663,174.1	663,174.1	1,663,174.1	1,000,000.0	16,055.1	679,229.2	9,608,185.7	0.0	9,115,935.7	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	296,494.6	508,658.3	508,658.3	712,068.7	712,068.7	1,712,068.7	1,000,000.0	19,561.5	731,630.2	9,847,565.9	0.0	9,338,907.6	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	319,728.0	492,250.0	492,250.0	824,848.0	824,848.0	1,824,848.0	1,000,000.0	25,525.8	850,373.8	10,189,281.4	0.0	9,697,031.4	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	324,669.6	508,658.3	508,658.3	506,931.7	506,931.7	1,506,931.7	1,000,000.0	12,636.9	519,568.6	10,216,600.0	0.0	9,707,941.7	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	307,104.5	508,658.3	508,658.3	580,938.8	580,938.8	1,580,938.8	1,000,000.0	14,845.5	595,784.3	10,303,726.0	0.0	9,795,067.7	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	246,666.2	492,250.0	492,250.0	830,887.8	830,887.8	1,830,887.8	1,000,000.0	22,903.2	853,791.0	10,648,858.7	0.0	10,156,608.7	1,000,000.0
Year 3	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	218,844.3	508,658.3	508,658.3	1,105,946.0	1,105,946.0	2,105,946.0	1,000,000.0	31,935.6	1,137,881.6	11,294,490.3	0.0	10,785,832.0	1,000,000.0

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)			Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water moved to reservoir**	**Cumulative change in storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Water returned to TMF from reservoir**	**Water remained in reservoir**	**Water remained in TMF+ Water returned to TMF from reservoir**
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	**1,269,489.0**	0.0	190,750.9	**190,750.9**	492,250.0	**492,250.0**	1,078,738.1	1,078,738.1	2,078,738.1	**1,000,000.0**	30,413.7	**1,109,151.8**	**11,894,983.8**	**0.0**	**11,402,733.8**	**1,000,000.0**
	DEC	31.0	313.0	0.0	508,658.3	719,900.0	**1,228,558.3**	0.0	197,109.3	**197,109.3**	508,658.3	**508,658.3**	1,031,449.0	1,031,449.0	2,031,449.0	**1,000,000.0**	28,170.0	**1,059,619.0**	**12,462,352.8**	**0.0**	**11,953,694.5**	**1,000,000.0**
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	**1,366,765.3**	0.0	197,109.3	**197,109.3**	508,658.3	**508,658.3**	1,169,656.0	1,169,656.0	2,169,656.0	**1,000,000.0**	33,578.1	**1,203,234.1**	**13,156,928.6**	**0.0**	**12,648,270.3**	**1,000,000.0**
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	**914,051.3**	0.0	178,034.2	**178,034.2**	459,433.3	**459,433.3**	736,017.1	736,017.1	1,736,017.1	**1,000,000.0**	17,789.4	**753,806.5**	**13,402,076.8**	**0.0**	**12,942,643.5**	**1,000,000.0**
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	**893,126.3**	0.0	197,109.3	**197,109.3**	508,658.3	**508,658.3**	696,017.0	696,017.0	1,696,017.0	**1,000,000.0**	15,044.4	**711,061.4**	**13,653,704.9**	**0.0**	**13,145,046.6**	**1,000,000.0**
	APR	30.0	117.8	60.6	492,250.0	410,297.0	**902,547.0**	48,622.0	190,750.9	**239,372.9**	492,250.0	**492,250.0**	663,174.1	663,174.1	1,663,174.1	**1,000,000.0**	16,055.1	**679,229.2**	**13,824,275.8**	**0.0**	**13,332,025.8**	**1,000,000.0**
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	**1,008,563.3**	99,385.3	197,109.3	**296,494.6**	508,658.3	**508,658.3**	712,068.7	712,068.7	1,712,068.7	**1,000,000.0**	19,561.5	**731,630.2**	**14,063,656.0**	**0.0**	**13,554,997.7**	**1,000,000.0**
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	**1,144,576.0**	128,977.1	190,750.9	**319,728.0**	492,250.0	**492,250.0**	824,848.0	824,848.0	1,824,848.0	**1,000,000.0**	25,525.8	**850,373.8**	**14,405,371.5**	**0.0**	**13,913,121.5**	**1,000,000.0**
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	**831,601.3**	127,560.3	197,109.3	**324,669.6**	508,658.3	**508,658.3**	506,931.7	506,931.7	1,506,931.7	**1,000,000.0**	12,636.9	**519,568.6**	**14,432,690.1**	**0.0**	**13,924,031.8**	**1,000,000.0**
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	**888,043.3**	109,995.2	197,109.3	**307,104.5**	508,658.3	**508,658.3**	580,938.8	580,938.8	1,580,938.8	**1,000,000.0**	14,845.5	**595,784.3**	**14,519,816.1**	**0.0**	**14,011,157.8**	**1,000,000.0**
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	**1,077,554.0**	55,915.3	190,750.9	**246,666.2**	492,250.0	**492,250.0**	830,887.8	830,887.8	1,830,887.8	**1,000,000.0**	22,903.2	**853,791.0**	**14,864,948.8**	**0.0**	**14,372,698.8**	**1,000,000.0**
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	**1,324,790.3**	21,735.0	197,109.3	**218,844.3**	508,658.3	**508,658.3**	1,105,946.0	1,105,946.0	2,105,946.0	**1,000,000.0**	31,935.6	**1,137,881.6**	**15,510,580.4**	**0.0**	**15,001,922.1**	**1,000,000.0**
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	**1,269,489.0**	0.0	190,750.9	**190,750.9**	492,250.0	**492,250.0**	1,078,738.1	1,078,738.1	2,078,738.1	**1,000,000.0**	30,413.7	**1,109,151.8**	**16,111,073.9**	**0.0**	**15,618,823.9**	**1,000,000.0**
Year 4	DEC	31.0	313.0	0.0	508,658.3	719,900.0	**1,228,558.3**	0.0	197,109.3	**197,109.3**	508,658.3	**508,658.3**	1,031,449.0	1,031,449.0	2,031,449.0	**1,000,000.0**	28,170.0	**1,059,619.0**	**16,678,442.9**	**0.0**	**16,169,784.6**	**1,000,000.0**
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	**1,366,765.3**	0.0	197,109.3	**197,109.3**	508,658.3	**508,658.3**	1,169,656.0	1,169,656.0	2,169,656.0	**1,000,000.0**	33,578.1	**1,203,234.1**	**17,373,018.7**	**0.0**	**16,864,360.4**	**1,000,000.0**
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	**914,051.3**	0.0	178,034.2	**178,034.2**	459,433.3	**459,433.3**	736,017.1	736,017.1	1,736,017.1	**1,000,000.0**	17,789.4	**753,806.5**	**17,618,166.9**	**0.0**	**17,158,733.6**	**1,000,000.0**
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	**893,126.3**	0.0	197,109.3	**197,109.3**	508,658.3	**508,658.3**	696,017.0	696,017.0	1,696,017.0	**1,000,000.0**	15,044.4	**711,061.4**	**17,869,795.0**	**0.0**	**17,361,136.7**	**1,000,000.0**
	APR	30.0	117.8	60.6	492,250.0	410,297.0	**902,547.0**	48,622.0	190,750.9	**239,372.9**	492,250.0	**492,250.0**	663,174.1	663,174.1	1,663,174.1	**1,000,000.0**	16,055.1	**679,229.2**	**18,040,365.9**	**0.0**	**17,548,115.9**	**1,000,000.0**
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	**1,008,563.3**	99,385.3	197,109.3	**296,494.6**	508,658.3	**508,658.3**	712,068.7	712,068.7	1,712,068.7	**1,000,000.0**	19,561.5	**731,630.2**	**18,279,746.1**	**0.0**	**17,771,087.8**	**1,000,000.0**
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	**1,144,576.0**	128,977.1	190,750.9	**319,728.0**	492,250.0	**492,250.0**	824,848.0	824,848.0	1,824,848.0	**1,000,000.0**	25,525.8	**850,373.8**	**18,621,461.6**	**0.0**	**18,129,211.6**	**1,000,000.0**
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	**831,601.3**	127,560.3	197,109.3	**324,669.6**	508,658.3	**508,658.3**	506,931.7	506,931.7	1,506,931.7	**1,000,000.0**	12,636.9	**519,568.6**	**18,648,780.2**	**0.0**	**18,140,121.9**	**1,000,000.0**
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	**888,043.3**	109,995.2	197,109.3	**307,104.5**	508,658.3	**508,658.3**	580,938.8	580,938.8	1,580,938.8	**1,000,000.0**	14,845.5	**595,784.3**	**18,735,906.2**	**0.0**	**18,227,247.9**	**1,000,000.0**
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	**1,077,554.0**	55,915.3	190,750.9	**246,666.2**	492,250.0	**492,250.0**	830,887.8	830,887.8	1,830,887.8	**1,000,000.0**	22,903.2	**853,791.0**	**19,081,038.9**	**0.0**	**18,588,788.9**	**1,000,000.0**
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	**1,324,790.3**	21,735.0	197,109.3	**218,844.3**	508,658.3	**508,658.3**	1,105,946.0	1,105,946.0	2,105,946.0	**1,000,000.0**	31,935.6	**1,137,881.6**	**19,726,670.5**	**0.0**	**19,218,012.2**	**1,000,000.0**
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	**1,269,489.0**	0.0	190,750.9	**190,750.9**	492,250.0	**492,250.0**	1,078,738.1	1,078,738.1	2,078,738.1	**1,000,000.0**	30,413.7	**1,109,151.8**	**20,327,164.0**	**0.0**	**19,834,914.0**	**1,000,000.0**
Year 5	DEC	31.0	313.0	0.0	508,658.3	719,900.0	**1,228,558.3**	0.0	197,109.3	**197,109.3**	508,658.3	**508,658.3**	1,031,449.0	1,031,449.0	2,031,449.0	**1,000,000.0**	28,170.0	**1,059,619.0**	**20,894,533.0**	**0.0**	**20,385,874.7**	**1,000,000.0**

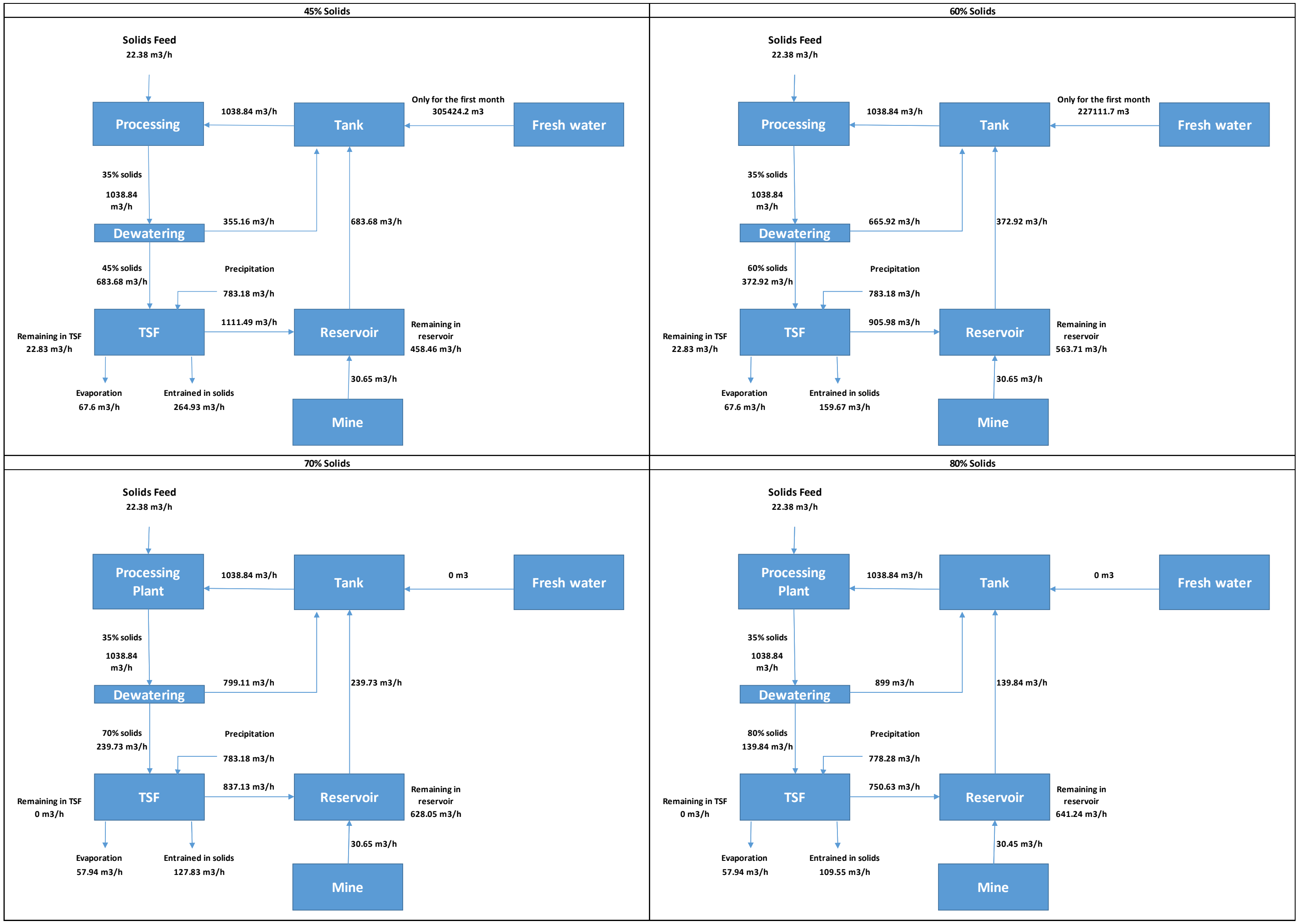


Figure 4.1 Schematics of water balance for different solids contents in the wet condition for a lined impoundment

The cumulative water surplus and cumulative water surplus per tonne of mill throughput for solids contents of 45, 60, 70 and 80% are compared in Figures 4.2 and 4.3 The water surplus per tonne of mill throughput using the average values of parameters varies between 0.8 and 1.1 m^3/tonne. Cumulative water surplus is the water retained in reservoir at the end of each month. Graphs in Figure 4.3 shows that water surplus reaches a relative steady state after end of the second year. Minimum storage in TMF was not required for 70 and 80% solids contents. This affected the water surplus graphs in Figure 4.3. The water surplus are significantly higher in the first 6 month of TMF operation.

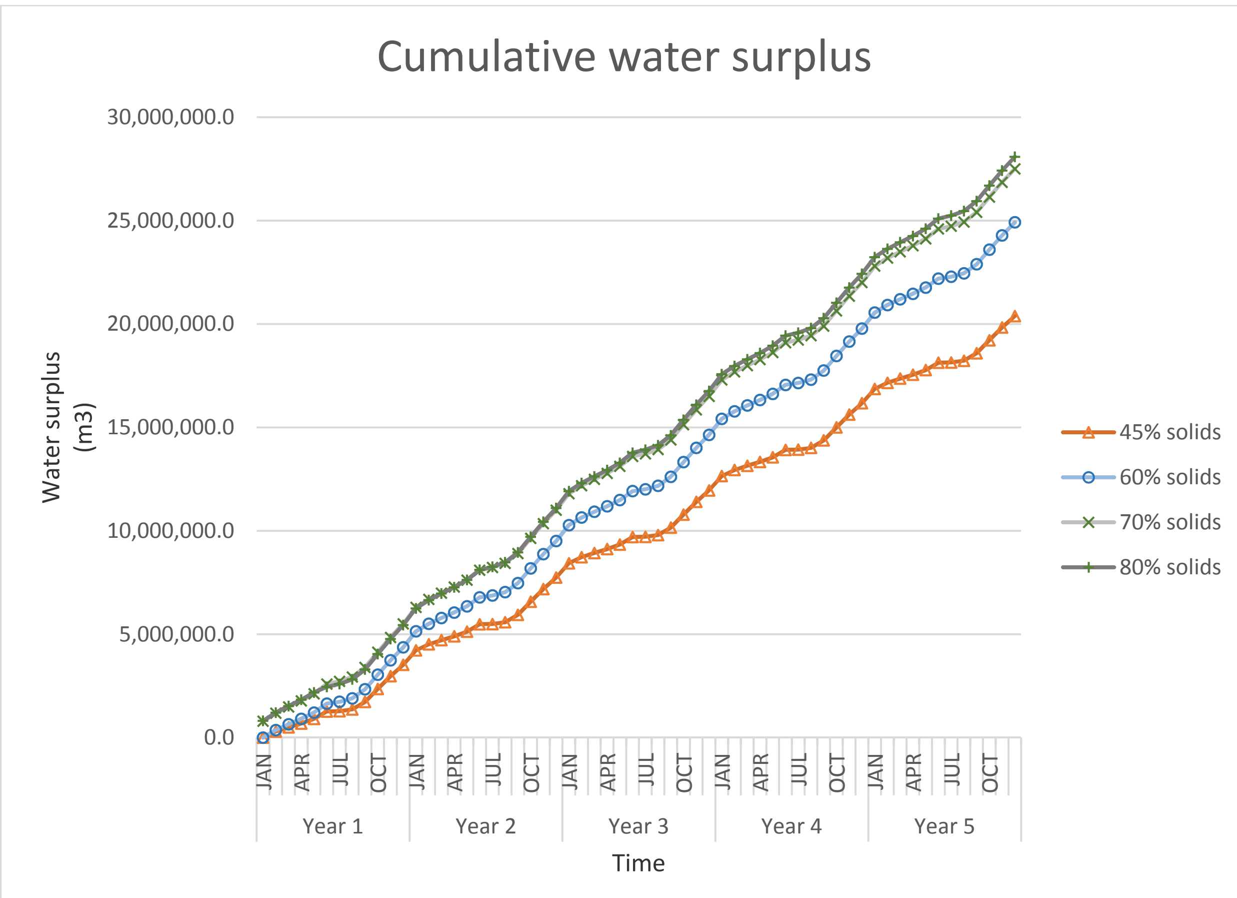


Figure 4.2 Cumulative water surplus for different solids contents in the wet condition for a lined impoundment

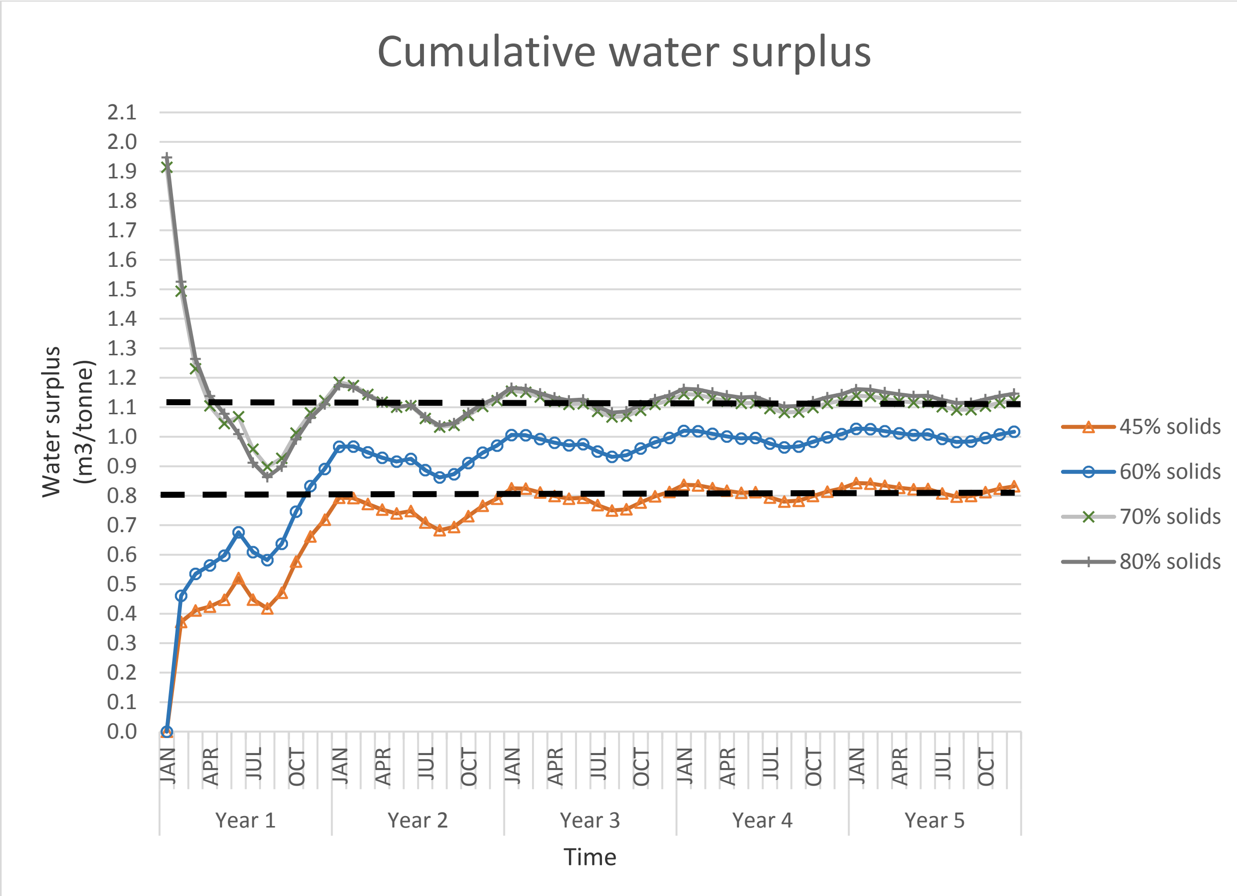


Figure 4.3 Cumulative water surplus per tonne of mill throughput for different solids contents in the wet condition for a lined impoundment

4.1.2 Dry climate

The model outputs for solids content of 45% for dry climate is showed in Table 4.2. This model is based on the average climate values and dry density of 1.2 tonne/m^3. The water balance models for solids contents of 60, 70, and 80 are provided in Appendix C, Tables C.1 to C.3.

Figure 4.4 presents a schematic flowchart of the water circulations for four solids contents. The volume of water flowing between each unit is calculated based on the average of water flows over 60 months of TMF operating life. To supply the required water for the mill, the make up water required to add to the system for solids contents of 45, 60, 70, and 80% equals 683.68, 372.92, 239.73, and 139.84 m^3/hour respectively.

Table 4.2 Deterministic water balance for solids content of 45% in the dry condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-47,631.0**	-0.1
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-95,475.2**	-0.1
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-143,566.3**	-0.1
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-244,253.8**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-348,297.5**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-448,985.0**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-553,028.8**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-657,072.5**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-757,760.0**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-833,179.7**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-848,528.4**	-0.2
Year 1	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-865,799.5**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-913,430.5**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-961,274.7**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-1,009,365.7**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,110,053.2**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,214,097.0**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,314,784.5**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,418,828.2**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,522,872.0**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,623,559.5**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-1,698,979.1**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-1,714,327.9**	-0.2
Year 2	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-1,731,598.9**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-1,779,230.0**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-1,827,074.2**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-1,875,165.2**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,975,852.7**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,079,896.5**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,180,584.0**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,284,627.7**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,388,671.5**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,489,359.0**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-2,564,778.6**	-0.2
Year 3	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-2,580,127.4**	-0.2

			Precipitation water (mm/month)		Water in (m^3)				Water out (m^3)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m^3)**	**Water deficit (m^3/tonne)**
	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-2,597,398.4**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-2,645,029.5**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-2,692,873.6**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-2,740,964.7**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,841,652.2**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,945,695.9**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,046,383.4**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-3,150,427.2**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-3,254,470.9**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,355,158.4**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-3,430,578.1**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-3,445,926.8**	-0.2
Year 4	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-3,463,197.9**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-3,510,828.9**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-3,558,673.1**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-3,606,764.2**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,707,451.7**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-3,811,495.4**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,912,182.9**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-4,016,226.7**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-4,120,270.4**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-4,220,957.9**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-4,296,377.6**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-4,311,726.3**	-0.2
Year 5	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-4,328,997.4**	-0.2

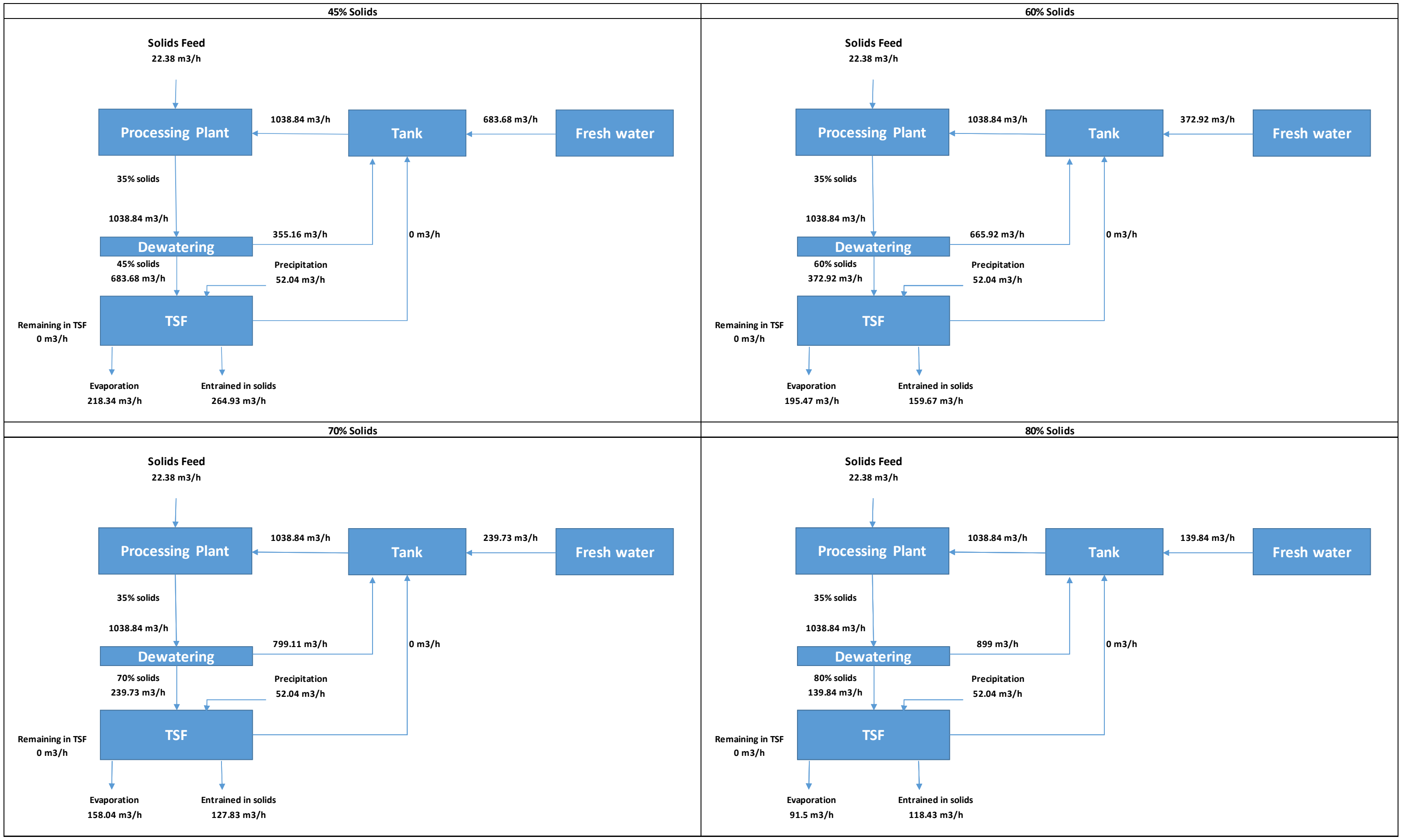


Figure 4.4 Schematics of water balance for different solids contents in the dry condition for a lined impoundment

The cumulative water deficit and cumulative water deficit per tonne of mill throughput for solids contents of 45, 60, 70 and 80% are compared in Figures 4.5 and 4.6. The water deficit per tonne of mill throughput using the average values of parameters varies between 0.17 and 0.72 m^3/month. The cumulative water deficit is the cumulative change in storage.

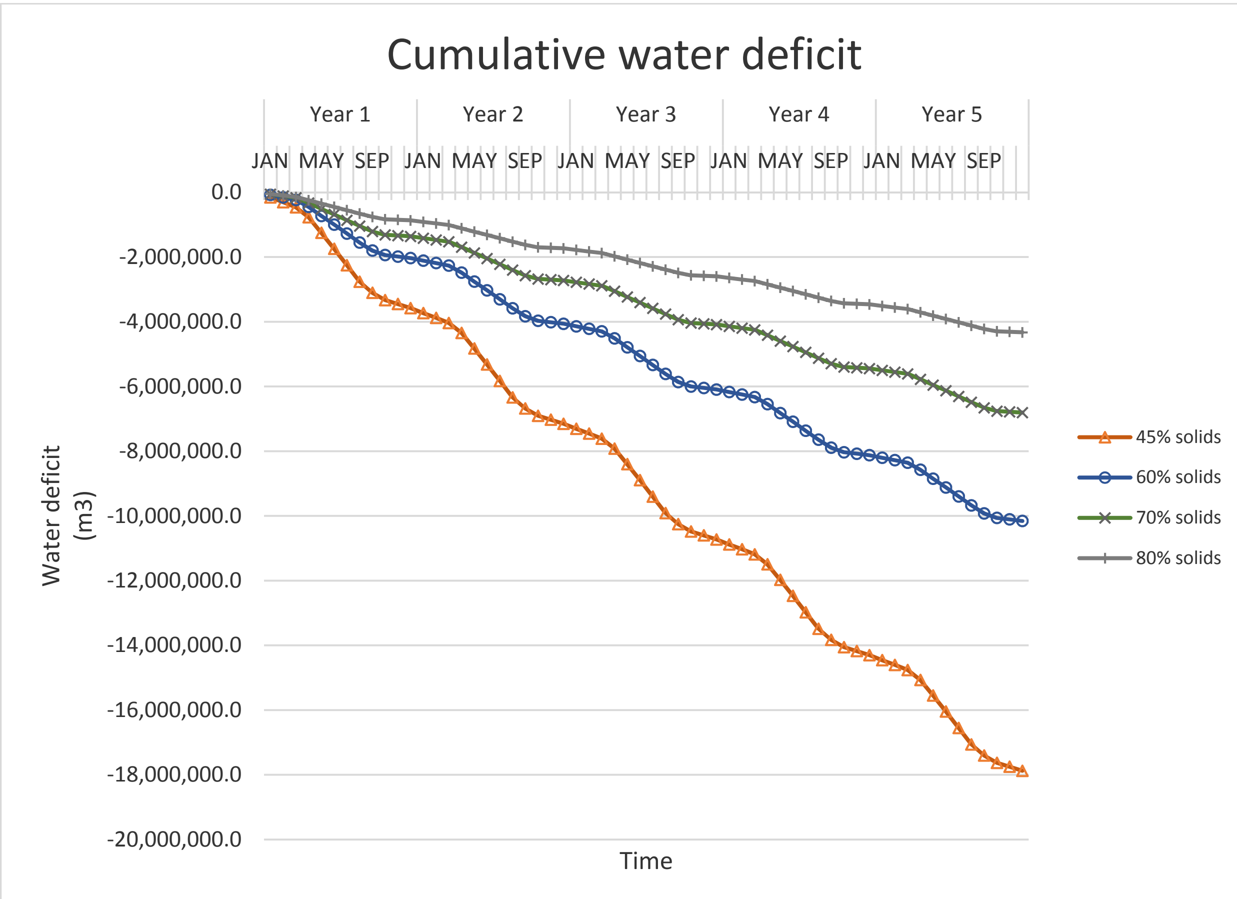


Figure 4.5 Cumulative water deficit for different solids contents in the dry condition for a lined impoundment

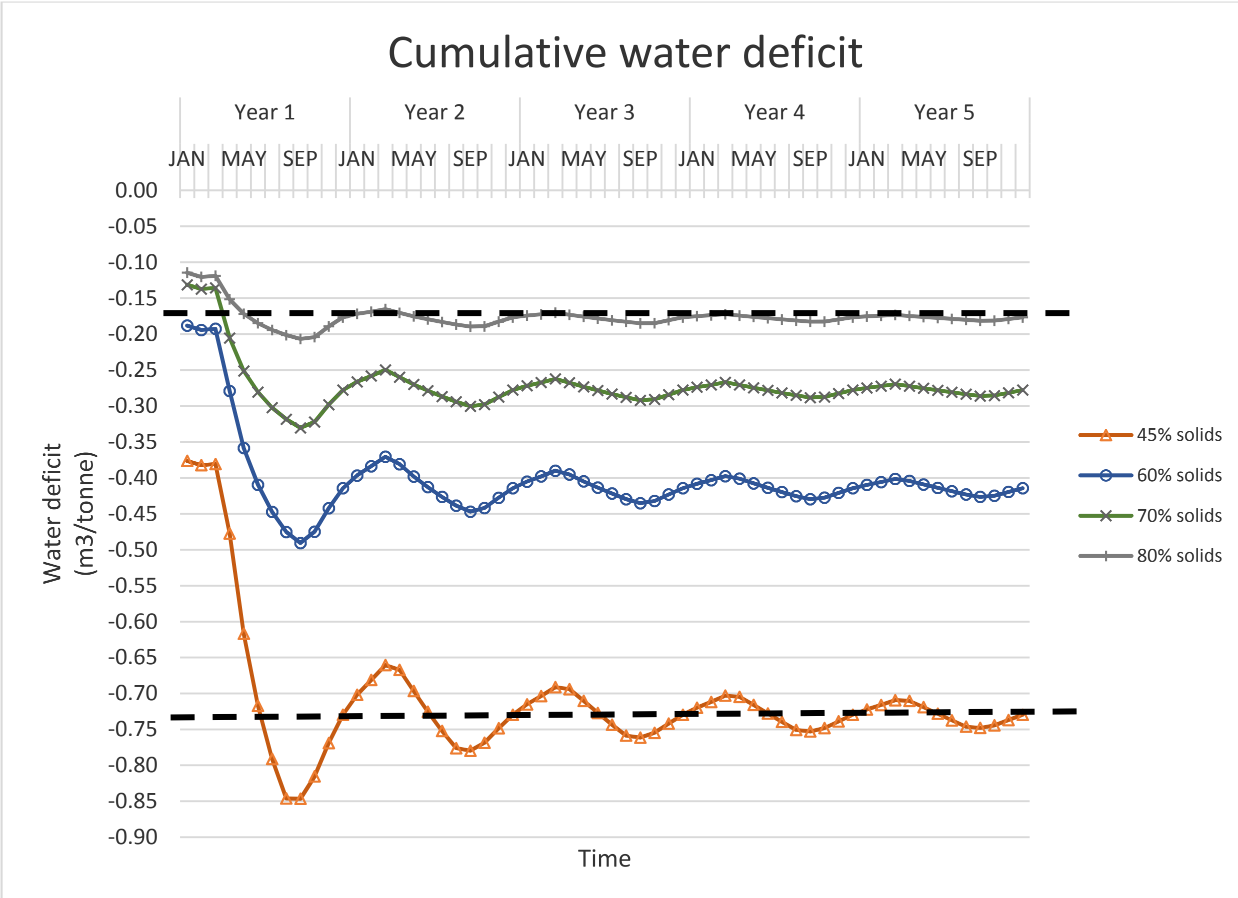


Figure 4.6 Cumulative water deficit per tonne of mill throughput for different solids contents in the dry condition for a lined impoundment

4.2 Unlined impoundment

In this section, results of water balances with consideration of the monthly seepage losses for wet and dry climates are provided.

4.2.1 Wet climate

Table 4.3 shows the model for solids content of 45% for wet climate. The model is adopted from the model illustrated in Table 4.1 with a monthly seepage loss of 14,904 m^3/month. The water balance models for solids contents of 60, 70, and 80 percent are provided in Appendix B, tables B.4 to B.6.

The schematic flowcharts of the water circulations for four scenarios of tailings solids contents are plotted in Figure 4.7. Similar to the model for unlined impoundment, make up water addition is only required for the fist month of operation for 45 and 60% solids contents. The difference of the water which was required to be added to the system for the first month of the mine operation for lined and unlined impoundments for solids contents of 45 and 60 % equals the monthly seepage loss (14,904 m^3/month).

Table 4.3 Deterministic water balance for solids content of 45% in the wet condition for an unlined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)				Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with slurry (m^3)	Precipitation onto impoundment	**Total Water Input**	Evaporation	Water retained in tailings	Seepage loss	**Total Water Output**	Water with slurry	**Total mill required water**	**Monthly storage**	**Water move to reservoir**	**Cumulative storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Returned to pond**	**Water remained in reservoir**	**Water remained on TMF+ return from reservoir**
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,154,752.0	154,752.0	1,154,752.0	1,000,000.0	33,578.1	188,330.1	188,330.1	0.0	0.0	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	14,904.0	192,938.2	459,433.3	459,433.3	721,113.1	721,113.1	1,721,113.1	1,000,000.0	17,789.4	738,902.5	738,902.5	0.0	279,469.2	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	681,113.0	681,113.0	1,681,113.0	1,000,000.0	15,044.4	696,157.4	975,626.6	0.0	466,968.3	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	14,904.0	254,276.9	492,250.0	492,250.0	648,270.1	648,270.1	1,648,270.1	1,000,000.0	16,055.1	664,325.2	1,131,293.5	0.0	639,043.5	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	14,904.0	311,398.6	508,658.3	508,658.3	697,164.7	697,164.7	1,697,164.7	1,000,000.0	19,561.5	716,726.2	1,355,769.7	0.0	847,111.4	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	14,904.0	334,632.0	492,250.0	492,250.0	809,944.0	809,944.0	1,809,944.0	1,000,000.0	25,525.8	835,469.8	1,682,581.2	0.0	1,190,331.2	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	14,904.0	339,573.6	508,658.3	508,658.3	492,027.7	492,027.7	1,492,027.7	1,000,000.0	12,636.9	504,664.6	1,694,995.8	0.0	1,186,337.5	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	14,904.0	322,008.5	508,658.3	508,658.3	566,034.8	566,034.8	1,566,034.8	1,000,000.0	14,845.5	580,880.3	1,767,217.8	0.0	1,258,559.5	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	14,904.0	261,570.2	492,250.0	492,250.0	815,983.8	815,983.8	1,815,983.8	1,000,000.0	22,903.2	838,887.0	2,097,446.5	0.0	1,605,196.5	1,000,000.0
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	14,904.0	233,748.3	508,658.3	508,658.3	1,091,042.0	1,091,042.0	2,091,042.0	1,000,000.0	31,935.6	1,122,977.6	2,728,174.1	0.0	2,219,515.8	1,000,000.0
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	1,269,489.0	0.0	190,750.9	14,904.0	205,654.9	492,250.0	492,250.0	1,063,834.1	1,063,834.1	2,063,834.1	1,000,000.0	30,413.7	1,094,247.8	3,313,763.6	0.0	2,821,513.6	1,000,000.0
Year 1	DEC	31.0	313.0	0.0	508,658.3	719,900.0	1,228,558.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,016,545.0	1,016,545.0	2,016,545.0	1,000,000.0	28,170.0	1,044,715.0	3,866,228.6	0.0	3,357,570.3	1,000,000.0
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,154,752.0	1,154,752.0	2,154,752.0	1,000,000.0	33,578.1	1,188,330.1	4,545,900.4	0.0	4,037,242.1	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	14,904.0	192,938.2	459,433.3	459,433.3	721,113.1	721,113.1	1,721,113.1	1,000,000.0	17,789.4	738,902.5	4,776,144.6	0.0	4,316,711.3	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	681,113.0	681,113.0	1,681,113.0	1,000,000.0	15,044.4	696,157.4	5,012,868.7	0.0	4,504,210.4	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	14,904.0	254,276.9	492,250.0	492,250.0	648,270.1	648,270.1	1,648,270.1	1,000,000.0	16,055.1	664,325.2	5,168,535.6	0.0	4,676,285.6	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	14,904.0	311,398.6	508,658.3	508,658.3	697,164.7	697,164.7	1,697,164.7	1,000,000.0	19,561.5	716,726.2	5,393,011.8	0.0	4,884,353.5	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	14,904.0	334,632.0	492,250.0	492,250.0	809,944.0	809,944.0	1,809,944.0	1,000,000.0	25,525.8	835,469.8	5,719,823.3	0.0	5,227,573.3	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	14,904.0	339,573.6	508,658.3	508,658.3	492,027.7	492,027.7	1,492,027.7	1,000,000.0	12,636.9	504,664.6	5,732,237.9	0.0	5,223,579.6	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	14,904.0	322,008.5	508,658.3	508,658.3	566,034.8	566,034.8	1,566,034.8	1,000,000.0	14,845.5	580,880.3	5,804,459.9	0.0	5,295,801.6	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	14,904.0	261,570.2	492,250.0	492,250.0	815,983.8	815,983.8	1,815,983.8	1,000,000.0	22,903.2	838,887.0	6,134,688.6	0.0	5,642,438.6	1,000,000.0
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	14,904.0	233,748.3	508,658.3	508,658.3	1,091,042.0	1,091,042.0	2,091,042.0	1,000,000.0	31,935.6	1,122,977.6	6,765,416.2	0.0	6,256,757.9	1,000,000.0
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	1,269,489.0	0.0	190,750.9	14,904.0	205,654.9	492,250.0	492,250.0	1,063,834.1	1,063,834.1	2,063,834.1	1,000,000.0	30,413.7	1,094,247.8	7,351,005.7	0.0	6,858,755.7	1,000,000.0
Year 2	DEC	31.0	313.0	0.0	508,658.3	719,900.0	1,228,558.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,016,545.0	1,016,545.0	2,016,545.0	1,000,000.0	28,170.0	1,044,715.0	7,903,470.7	0.0	7,394,812.4	1,000,000.0
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,154,752.0	1,154,752.0	2,154,752.0	1,000,000.0	33,578.1	1,188,330.1	8,583,142.5	0.0	8,074,484.2	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	14,904.0	192,938.2	459,433.3	459,433.3	721,113.1	721,113.1	1,721,113.1	1,000,000.0	17,789.4	738,902.5	8,813,386.7	0.0	8,353,953.4	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	681,113.0	681,113.0	1,681,113.0	1,000,000.0	15,044.4	696,157.4	9,050,110.8	0.0	8,541,452.5	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	14,904.0	254,276.9	492,250.0	492,250.0	648,270.1	648,270.1	1,648,270.1	1,000,000.0	16,055.1	664,325.2	9,205,777.7	0.0	8,713,527.7	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	14,904.0	311,398.6	508,658.3	508,658.3	697,164.7	697,164.7	1,697,164.7	1,000,000.0	19,561.5	716,726.2	9,430,253.9	0.0	8,921,595.6	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	14,904.0	334,632.0	492,250.0	492,250.0	809,944.0	809,944.0	1,809,944.0	1,000,000.0	25,525.8	835,469.8	9,757,065.4	0.0	9,264,815.4	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	14,904.0	339,573.6	508,658.3	508,658.3	492,027.7	492,027.7	1,492,027.7	1,000,000.0	12,636.9	504,664.6	9,769,480.0	0.0	9,260,821.7	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	14,904.0	322,008.5	508,658.3	508,658.3	566,034.8	566,034.8	1,566,034.8	1,000,000.0	14,845.5	580,880.3	9,841,702.0	0.0	9,333,043.7	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	14,904.0	261,570.2	492,250.0	492,250.0	815,983.8	815,983.8	1,815,983.8	1,000,000.0	22,903.2	838,887.0	10,171,930.7	0.0	9,679,680.7	1,000,000.0
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	14,904.0	233,748.3	508,658.3	508,658.3	1,091,042.0	1,091,042.0	2,091,042.0	1,000,000.0	31,935.6	1,122,977.6	10,802,658.3	0.0	10,294,000.0	1,000,000.0
Year 3	NOV	30.0	337.9	0.0	492,250.0	777,239.0	1,269,489.0	0.0	190,750.9	14,904.0	205,654.9	492,250.0	492,250.0	1,063,834.1	1,063,834.1	2,063,834.1	1,000,000.0	30,413.7	1,094,247.8	11,388,247.8	0.0	10,895,997.8	1,000,000.0

	Month	Number of days in month	Precipitation water (mm/month) Rainfall	Snow water equivalent from snow melt	Water in (m^3) Water with slurry (m^3)	Precipitation onto impoundment	Total Water Input	Water out (m^3) Evaporation	Water retained in tailings	Seepage loss	Total Water Output	Mill required water (m^3) Water with slurry	Total mill required water	Water in the TMF (m^3) Monthly storage	Water move to reservoir	Cumulative storage	Water remained in TMF	Mine impacted water runoff	Reservoir storage (m^3) Monthly reservoir storage	Cumulative reservoir storage	Returned to pond	Water remained in reservoir	Water remained on TMF+ return from reservoir
	DEC	31.0	313.0	0.0	508,658.3	719,900.0	1,228,558.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,016,545.0	1,016,545.0	2,016,545.0	1,000,000.0	28,170.0	1,044,715.0	11,940,712.8	0.0	11,432,054.5	1,000,000.0
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,154,752.0	1,154,752.0	2,154,752.0	1,000,000.0	33,578.1	1,188,330.1	12,620,384.6	0.0	12,111,726.3	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	14,904.0	192,938.2	459,433.3	459,433.3	721,113.1	721,113.1	1,721,113.1	1,000,000.0	17,789.4	738,902.5	12,850,628.8	0.0	12,391,195.5	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	681,113.0	681,113.0	1,681,113.0	1,000,000.0	15,044.4	696,157.4	13,087,352.9	0.0	12,578,694.6	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	14,904.0	254,276.9	492,250.0	492,250.0	648,270.1	648,270.1	1,648,270.1	1,000,000.0	16,055.1	664,325.2	13,243,019.8	0.0	12,750,769.8	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	14,904.0	311,398.6	508,658.3	508,658.3	697,164.7	697,164.7	1,697,164.7	1,000,000.0	19,561.5	716,726.2	13,467,496.0	0.0	12,958,837.7	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	14,904.0	334,632.0	492,250.0	492,250.0	809,944.0	809,944.0	1,809,944.0	1,000,000.0	25,525.8	835,469.8	13,794,307.5	0.0	13,302,057.5	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	14,904.0	339,573.6	508,658.3	508,658.3	492,027.7	492,027.7	1,492,027.7	1,000,000.0	12,636.9	504,664.6	13,806,722.1	0.0	13,298,063.8	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	14,904.0	322,008.5	508,658.3	508,658.3	566,034.8	566,034.8	1,566,034.8	1,000,000.0	14,845.5	580,880.3	13,878,944.1	0.0	13,370,285.8	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	14,904.0	261,570.2	492,250.0	492,250.0	815,983.8	815,983.8	1,815,983.8	1,000,000.0	22,903.2	838,887.0	14,209,172.8	0.0	13,716,922.8	1,000,000.0
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	14,904.0	233,748.3	508,658.3	508,658.3	1,091,042.0	1,091,042.0	2,091,042.0	1,000,000.0	31,935.6	1,122,977.6	14,839,900.4	0.0	14,331,242.1	1,000,000.0
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	1,269,489.0	0.0	190,750.9	14,904.0	205,654.9	492,250.0	492,250.0	1,063,834.1	1,063,834.1	2,063,834.1	1,000,000.0	30,413.7	1,094,247.8	15,425,489.9	0.0	14,933,239.9	1,000,000.0
Year 4	DEC	31.0	313.0	0.0	508,658.3	719,900.0	1,228,558.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,016,545.0	1,016,545.0	2,016,545.0	1,000,000.0	28,170.0	1,044,715.0	15,977,954.9	0.0	15,469,296.6	1,000,000.0
	JAN	31.0	373.1	0.0	508,658.3	858,107.0	1,366,765.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,154,752.0	1,154,752.0	2,154,752.0	1,000,000.0	33,578.1	1,188,330.1	16,657,626.7	0.0	16,148,968.4	1,000,000.0
	FEB	28.0	197.7	0.0	459,433.3	454,618.0	914,051.3	0.0	178,034.2	14,904.0	192,938.2	459,433.3	459,433.3	721,113.1	721,113.1	1,721,113.1	1,000,000.0	17,789.4	738,902.5	16,887,870.9	0.0	16,428,437.6	1,000,000.0
	MAR	31.0	167.2	0.0	508,658.3	384,468.0	893,126.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	681,113.0	681,113.0	1,681,113.0	1,000,000.0	15,044.4	696,157.4	17,124,595.0	0.0	16,615,936.7	1,000,000.0
	APR	30.0	117.8	60.6	492,250.0	410,297.0	902,547.0	48,622.0	190,750.9	14,904.0	254,276.9	492,250.0	492,250.0	648,270.1	648,270.1	1,648,270.1	1,000,000.0	16,055.1	664,325.2	17,280,261.9	0.0	16,788,011.9	1,000,000.0
	MAY	31.0	98.5	118.9	508,658.3	499,905.0	1,008,563.3	99,385.3	197,109.3	14,904.0	311,398.6	508,658.3	508,658.3	697,164.7	697,164.7	1,697,164.7	1,000,000.0	19,561.5	716,726.2	17,504,738.1	0.0	16,996,079.8	1,000,000.0
	JUN	30.0	98.3	185.4	492,250.0	652,326.0	1,144,576.0	128,977.1	190,750.9	14,904.0	334,632.0	492,250.0	492,250.0	809,944.0	809,944.0	1,809,944.0	1,000,000.0	25,525.8	835,469.8	17,831,549.6	0.0	17,339,299.6	1,000,000.0
	JUL	31.0	102.8	37.6	508,658.3	322,943.0	831,601.3	127,560.3	197,109.3	14,904.0	339,573.6	508,658.3	508,658.3	492,027.7	492,027.7	1,492,027.7	1,000,000.0	12,636.9	504,664.6	17,843,964.2	0.0	17,335,305.9	1,000,000.0
	AUG	31.0	163.6	1.4	508,658.3	379,385.0	888,043.3	109,995.2	197,109.3	14,904.0	322,008.5	508,658.3	508,658.3	566,034.8	566,034.8	1,566,034.8	1,000,000.0	14,845.5	580,880.3	17,916,186.2	0.0	17,407,527.9	1,000,000.0
	SEP	30.0	246.2	8.3	492,250.0	585,304.0	1,077,554.0	55,915.3	190,750.9	14,904.0	261,570.2	492,250.0	492,250.0	815,983.8	815,983.8	1,815,983.8	1,000,000.0	22,903.2	838,887.0	18,246,414.9	0.0	17,754,164.9	1,000,000.0
	OCT	31.0	354.8	0.0	508,658.3	816,132.0	1,324,790.3	21,735.0	197,109.3	14,904.0	233,748.3	508,658.3	508,658.3	1,091,042.0	1,091,042.0	2,091,042.0	1,000,000.0	31,935.6	1,122,977.6	18,877,142.5	0.0	18,368,484.2	1,000,000.0
	NOV	30.0	337.9	0.0	492,250.0	777,239.0	1,269,489.0	0.0	190,750.9	14,904.0	205,654.9	492,250.0	492,250.0	1,063,834.1	1,063,834.1	2,063,834.1	1,000,000.0	30,413.7	1,094,247.8	19,462,732.0	0.0	18,970,482.0	1,000,000.0
Year 5	DEC	31.0	313.0	0.0	508,658.3	719,900.0	1,228,558.3	0.0	197,109.3	14,904.0	212,013.3	508,658.3	508,658.3	1,016,545.0	1,016,545.0	2,016,545.0	1,000,000.0	28,170.0	1,044,715.0	20,015,197.0	0.0	19,506,538.7	1,000,000.0

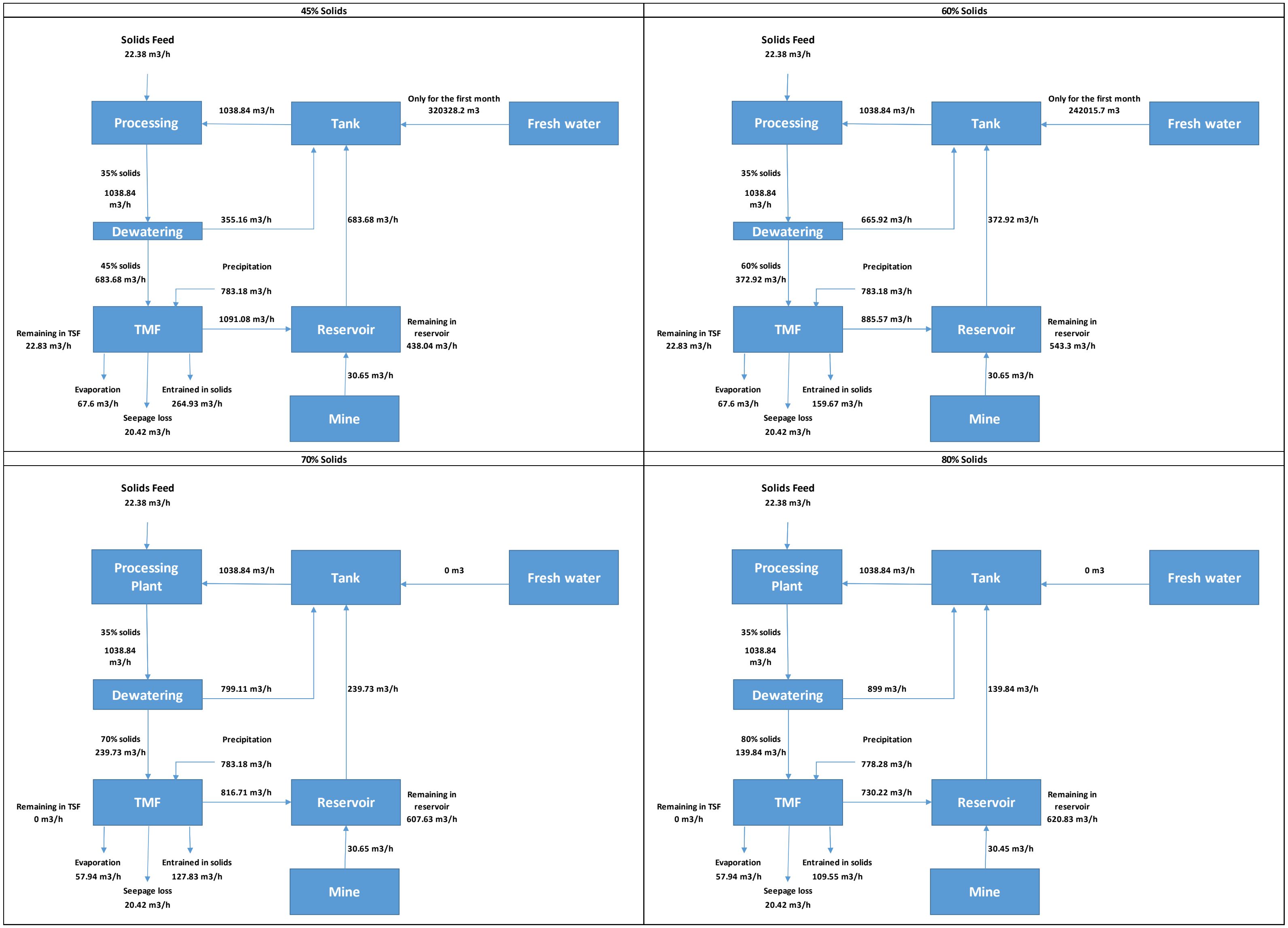


Figure 4.7 Schematics of water balance for different solids contents in the wet condition for an unlined impoundment

The cumulative water surplus and cumulative water surplus per tonne of mill throughput for solids contents of 45, 60, 70 and 80% are compared in Figures 4.8 and 4.9. The water surplus per tonne of mill throughput using the average values of parameters in an unlined impoundment is 4% less than the corresponding values in a lined impoundment due to the seepage losses.

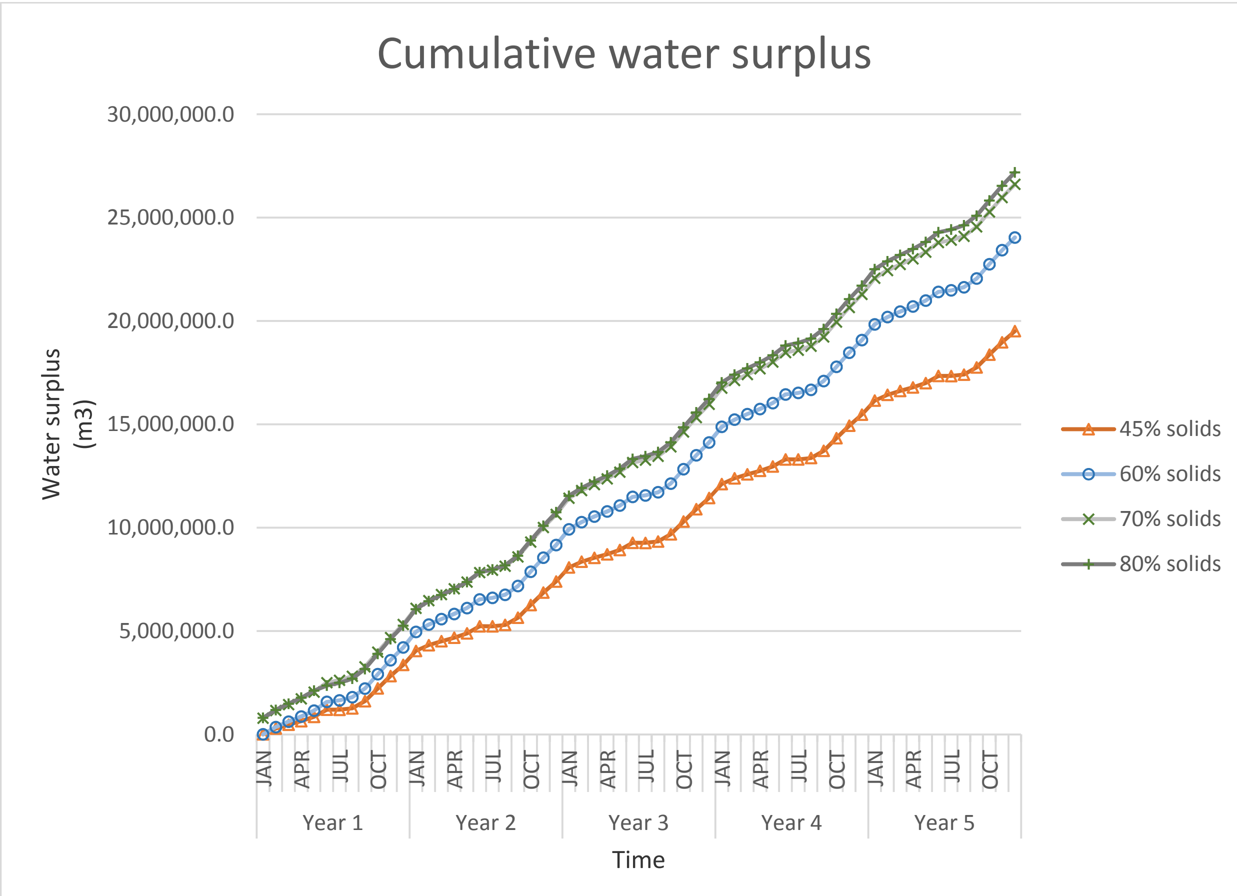


Figure 4.8 Cumulative water surplus for different solids contents in the wet condition for an unlined impoundment

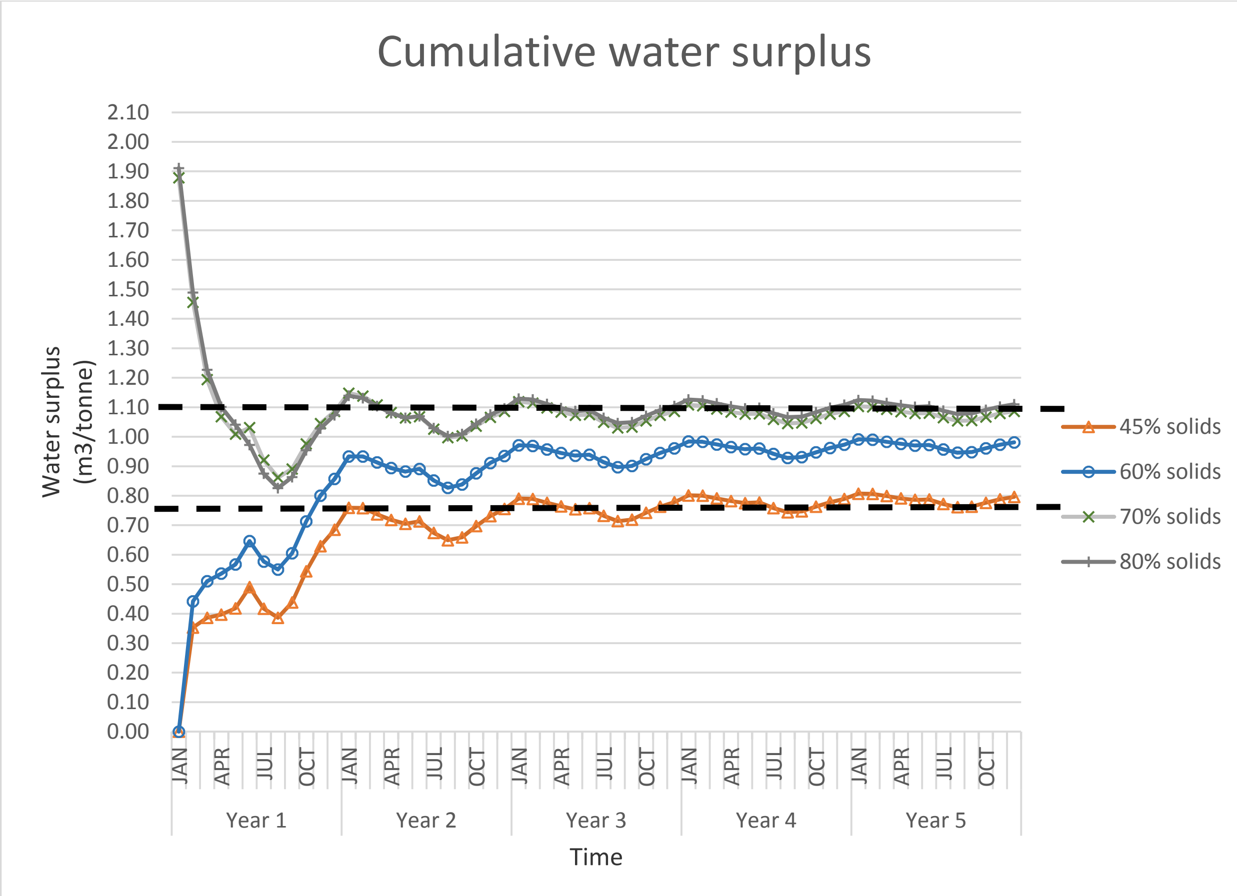


Figure 4.9 Cumulative water surplus per tonne of mill throughput for different solids contents in the wet condition for an unlined impoundment

4.2.2 Dry climate

The monthly seepage loss of 4,968 m^3/month has been considered for the unlined impoundment in dry conditions. The model results for solids content of 45% for dry climate is shown in Table 4.4. The water balance models for solids contents of 60, 70, and 80 percent are provided in Appendix C, Tables C.4 to C.6.

Figure 4.10 illustrates the schematic flowchart of the water circulations for four solids contents. The volume of water flowing between each unit is calculated based on the average of water flow over 60 months. The make up water required does not differ from the the make up water for the lined impoundment because there is almost no water left in the TMF to be reclaimed in both the lined and unlined cases.

Table 4.4 Deterministic water balance for solids content of 45% in the dry condition for an unlined impoundment

			Precipitation water (mm/month)		**Water in (m³)**			**Water out (m³)**				**Water required in the mill (m3)**		**Water in the TMF (m3)**		**Water deficit**	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation from pond	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	JAN	31.0	17.6	0.0	508,658.3	40,480.0	**549,138.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	347,061.1	508,658.3	-161,597.3	-0.4
	FEB	28.0	13.8	0.0	459,433.3	31,740.0	**491,173.3**	0.0	178,034.2	4,968.0	**183,002.2**	459,433.3	**459,433.3**	308,171.2	459,433.3	-312,859.4	-0.4
	MAR	31.0	17.4	0.0	508,658.3	40,020.0	**548,678.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	346,601.1	508,658.3	-474,916.7	-0.4
	APR	30.0	16.8	0.0	492,250.0	38,640.0	**530,890.0**	157,095.8	190,750.9	4,968.0	**352,814.6**	492,250.0	**492,250.0**	178,075.4	492,250.0	-789,091.3	-0.5
	MAY	31.0	15.9	0.0	508,658.3	36,570.0	**545,228.3**	320,953.5	197,109.3	4,968.0	**523,030.8**	508,658.3	**508,658.3**	22,197.6	508,658.3	-1,275,552.1	-0.6
	JUN	30.0	7.8	0.0	492,250.0	17,940.0	**510,190.0**	416,587.5	190,750.9	4,968.0	**612,306.4**	492,250.0	**492,250.0**	0.0	492,250.0	-1,767,802.1	-0.7
	JUL	31.0	8.9	0.0	508,658.3	20,470.0	**529,128.3**	411,999.0	197,109.3	4,968.0	**614,076.3**	508,658.3	**508,658.3**	0.0	508,658.3	-2,276,460.4	-0.8
	AUG	31.0	8.0	0.0	508,658.3	18,400.0	**527,058.3**	355,246.5	197,109.3	4,968.0	**557,323.8**	508,658.3	**508,658.3**	0.0	508,658.3	-2,785,118.8	-0.9
	SEP	30.0	12.5	0.0	492,250.0	28,750.0	**521,000.0**	180,642.0	190,750.9	4,968.0	**376,360.9**	492,250.0	**492,250.0**	144,639.1	492,250.0	-3,132,729.7	-0.9
	OCT	31.0	18.3	0.0	508,658.3	42,090.0	**550,748.3**	70,155.8	197,109.3	4,968.0	**272,233.0**	508,658.3	**508,658.3**	278,515.3	508,658.3	-3,362,872.7	-0.8
	NOV	30.0	30.4	0.0	492,250.0	69,920.0	**562,170.0**	0.0	190,750.9	4,968.0	**195,718.9**	492,250.0	**492,250.0**	366,451.1	492,250.0	-3,488,671.6	-0.8
Year 1	DEC	31.0	30.8	0.0	508,658.3	70,840.0	**579,498.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	377,421.1	508,658.3	-3,619,908.9	-0.7
	JAN	31.0	17.6	0.0	508,658.3	40,480.0	**549,138.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	347,061.1	508,658.3	-3,781,506.1	-0.7
	FEB	28.0	13.8	0.0	459,433.3	31,740.0	**491,173.3**	0.0	178,034.2	4,968.0	**183,002.2**	459,433.3	**459,433.3**	308,171.2	459,433.3	-3,932,768.3	-0.7
	MAR	31.0	17.4	0.0	508,658.3	40,020.0	**548,678.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	346,601.1	508,658.3	-4,094,825.5	-0.7
	APR	30.0	16.8	0.0	492,250.0	38,640.0	**530,890.0**	157,095.8	190,750.9	4,968.0	**352,814.6**	492,250.0	**492,250.0**	178,075.4	492,250.0	-4,409,000.2	-0.7
	MAY	31.0	15.9	0.0	508,658.3	36,570.0	**545,228.3**	320,953.5	197,109.3	4,968.0	**523,030.8**	508,658.3	**508,658.3**	22,197.6	508,658.3	-4,895,461.0	-0.7
	JUN	30.0	7.8	0.0	492,250.0	17,940.0	**510,190.0**	416,587.5	190,750.9	4,968.0	**612,306.4**	492,250.0	**492,250.0**	0.0	492,250.0	-5,387,711.0	-0.7
	JUL	31.0	8.9	0.0	508,658.3	20,470.0	**529,128.3**	411,999.0	197,109.3	4,968.0	**614,076.3**	508,658.3	**508,658.3**	0.0	508,658.3	-5,896,369.3	-0.8
	AUG	31.0	8.0	0.0	508,658.3	18,400.0	**527,058.3**	355,246.5	197,109.3	4,968.0	**557,323.8**	508,658.3	**508,658.3**	0.0	508,658.3	-6,405,027.6	-0.8
	SEP	30.0	12.5	0.0	492,250.0	28,750.0	**521,000.0**	180,642.0	190,750.9	4,968.0	**376,360.9**	492,250.0	**492,250.0**	144,639.1	492,250.0	-6,752,638.5	-0.8
	OCT	31.0	18.3	0.0	508,658.3	42,090.0	**550,748.3**	70,155.8	197,109.3	4,968.0	**272,233.0**	508,658.3	**508,658.3**	278,515.3	508,658.3	-6,982,781.5	-0.8
	NOV	30.0	30.4	0.0	492,250.0	69,920.0	**562,170.0**	0.0	190,750.9	4,968.0	**195,718.9**	492,250.0	**492,250.0**	366,451.1	492,250.0	-7,108,580.4	-0.8
Year 2	DEC	31.0	30.8	0.0	508,658.3	70,840.0	**579,498.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	377,421.1	508,658.3	-7,239,817.7	-0.7
	JAN	31.0	17.6	0.0	508,658.3	40,480.0	**549,138.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	347,061.1	508,658.3	-7,401,415.0	-0.7
	FEB	28.0	13.8	0.0	459,433.3	31,740.0	**491,173.3**	0.0	178,034.2	4,968.0	**183,002.2**	459,433.3	**459,433.3**	308,171.2	459,433.3	-7,552,677.1	-0.7
	MAR	31.0	17.4	0.0	508,658.3	40,020.0	**548,678.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	346,601.1	508,658.3	-7,714,734.4	-0.7
	APR	30.0	16.8	0.0	492,250.0	38,640.0	**530,890.0**	157,095.8	190,750.9	4,968.0	**352,814.6**	492,250.0	**492,250.0**	178,075.4	492,250.0	-8,028,909.0	-0.7
	MAY	31.0	15.9	0.0	508,658.3	36,570.0	**545,228.3**	320,953.5	197,109.3	4,968.0	**523,030.8**	508,658.3	**508,658.3**	22,197.6	508,658.3	-8,515,369.8	-0.7
	JUN	30.0	7.8	0.0	492,250.0	17,940.0	**510,190.0**	416,587.5	190,750.9	4,968.0	**612,306.4**	492,250.0	**492,250.0**	0.0	492,250.0	-9,007,619.8	-0.7
	JUL	31.0	8.9	0.0	508,658.3	20,470.0	**529,128.3**	411,999.0	197,109.3	4,968.0	**614,076.3**	508,658.3	**508,658.3**	0.0	508,658.3	-9,516,278.1	-0.8
	AUG	31.0	8.0	0.0	508,658.3	18,400.0	**527,058.3**	355,246.5	197,109.3	4,968.0	**557,323.8**	508,658.3	**508,658.3**	0.0	508,658.3	-10,024,936.5	-0.8
	SEP	30.0	12.5	0.0	492,250.0	28,750.0	**521,000.0**	180,642.0	190,750.9	4,968.0	**376,360.9**	492,250.0	**492,250.0**	144,639.1	492,250.0	-10,372,547.4	-0.8
Year 3	OCT	31.0	18.3	0.0	508,658.3	42,090.0	**550,748.3**	70,155.8	197,109.3	4,968.0	**272,233.0**	508,658.3	**508,658.3**	278,515.3	508,658.3	-10,602,690.4	-0.8

			Precipitation water (mm/month)		Water in (m³)			Water out (m³)				Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation from pond	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	NOV	30.0	30.4	0.0	492,250.0	69,920.0	**562,170.0**	0.0	190,750.9	4,968.0	**195,718.9**	492,250.0	**492,250.0**	366,451.1	492,250.0	-10,728,489.3	-0.8
	DEC	31.0	30.8	0.0	508,658.3	70,840.0	**579,498.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	377,421.1	508,658.3	-10,859,726.6	-0.7
	JAN	31.0	17.6	0.0	508,658.3	40,480.0	**549,138.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	347,061.1	508,658.3	-11,021,323.8	-0.7
	FEB	28.0	13.8	0.0	459,433.3	31,740.0	**491,173.3**	0.0	178,034.2	4,968.0	**183,002.2**	459,433.3	**459,433.3**	308,171.2	459,433.3	-11,172,586.0	-0.7
	MAR	31.0	17.4	0.0	508,658.3	40,020.0	**548,678.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	346,601.1	508,658.3	-11,334,643.2	-0.7
	APR	30.0	16.8	0.0	492,250.0	38,640.0	**530,890.0**	157,095.8	190,750.9	4,968.0	**352,814.6**	492,250.0	**492,250.0**	178,075.4	492,250.0	-11,648,817.9	-0.7
	MAY	31.0	15.9	0.0	508,658.3	36,570.0	**545,228.3**	320,953.5	197,109.3	4,968.0	**523,030.8**	508,658.3	**508,658.3**	22,197.6	508,658.3	-12,135,278.7	-0.7
	JUN	30.0	7.8	0.0	492,250.0	17,940.0	**510,190.0**	416,587.5	190,750.9	4,968.0	**612,306.4**	492,250.0	**492,250.0**	0.0	492,250.0	-12,627,528.7	-0.7
	JUL	31.0	8.9	0.0	508,658.3	20,470.0	**529,128.3**	411,999.0	197,109.3	4,968.0	**614,076.3**	508,658.3	**508,658.3**	0.0	508,658.3	-13,136,187.0	-0.7
	AUG	31.0	8.0	0.0	508,658.3	18,400.0	**527,058.3**	355,246.5	197,109.3	4,968.0	**557,323.8**	508,658.3	**508,658.3**	0.0	508,658.3	-13,644,845.3	-0.8
	SEP	30.0	12.5	0.0	492,250.0	28,750.0	**521,000.0**	180,642.0	190,750.9	4,968.0	**376,360.9**	492,250.0	**492,250.0**	144,639.1	492,250.0	-13,992,456.2	-0.8
	OCT	31.0	18.3	0.0	508,658.3	42,090.0	**550,748.3**	70,155.8	197,109.3	4,968.0	**272,233.0**	508,658.3	**508,658.3**	278,515.3	508,658.3	-14,222,599.2	-0.8
	NOV	30.0	30.4	0.0	492,250.0	69,920.0	**562,170.0**	0.0	190,750.9	4,968.0	**195,718.9**	492,250.0	**492,250.0**	366,451.1	492,250.0	-14,348,398.1	-0.7
Year 4	DEC	31.0	30.8	0.0	508,658.3	70,840.0	**579,498.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	377,421.1	508,658.3	-14,479,635.4	-0.7
	JAN	31.0	17.6	0.0	508,658.3	40,480.0	**549,138.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	347,061.1	508,658.3	-14,641,232.7	-0.7
	FEB	28.0	13.8	0.0	459,433.3	31,740.0	**491,173.3**	0.0	178,034.2	4,968.0	**183,002.2**	459,433.3	**459,433.3**	308,171.2	459,433.3	-14,792,494.8	-0.7
	MAR	31.0	17.4	0.0	508,658.3	40,020.0	**548,678.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	346,601.1	508,658.3	-14,954,552.1	-0.7
	APR	30.0	16.8	0.0	492,250.0	38,640.0	**530,890.0**	157,095.8	190,750.9	4,968.0	**352,814.6**	492,250.0	**492,250.0**	178,075.4	492,250.0	-15,268,726.7	-0.7
	MAY	31.0	15.9	0.0	508,658.3	36,570.0	**545,228.3**	320,953.5	197,109.3	4,968.0	**523,030.8**	508,658.3	**508,658.3**	22,197.6	508,658.3	-15,755,187.5	-0.7
	JUN	30.0	7.8	0.0	492,250.0	17,940.0	**510,190.0**	416,587.5	190,750.9	4,968.0	**612,306.4**	492,250.0	**492,250.0**	0.0	492,250.0	-16,247,437.5	-0.7
	JUL	31.0	8.9	0.0	508,658.3	20,470.0	**529,128.3**	411,999.0	197,109.3	4,968.0	**614,076.3**	508,658.3	**508,658.3**	0.0	508,658.3	-16,756,095.8	-0.7
	AUG	31.0	8.0	0.0	508,658.3	18,400.0	**527,058.3**	355,246.5	197,109.3	4,968.0	**557,323.8**	508,658.3	**508,658.3**	0.0	508,658.3	-17,264,754.2	-0.8
	SEP	30.0	12.5	0.0	492,250.0	28,750.0	**521,000.0**	180,642.0	190,750.9	4,968.0	**376,360.9**	492,250.0	**492,250.0**	144,639.1	492,250.0	-17,612,365.1	-0.8
	OCT	31.0	18.3	0.0	508,658.3	42,090.0	**550,748.3**	70,155.8	197,109.3	4,968.0	**272,233.0**	508,658.3	**508,658.3**	278,515.3	508,658.3	-17,842,508.1	-0.8
	NOV	30.0	30.4	0.0	492,250.0	69,920.0	**562,170.0**	0.0	190,750.9	4,968.0	**195,718.9**	492,250.0	**492,250.0**	366,451.1	492,250.0	-17,968,307.0	-0.7
Year 5	DEC	31.0	30.8	0.0	508,658.3	70,840.0	**579,498.3**	0.0	197,109.3	4,968.0	**202,077.3**	508,658.3	**508,658.3**	377,421.1	508,658.3	-18,099,544.3	-0.7

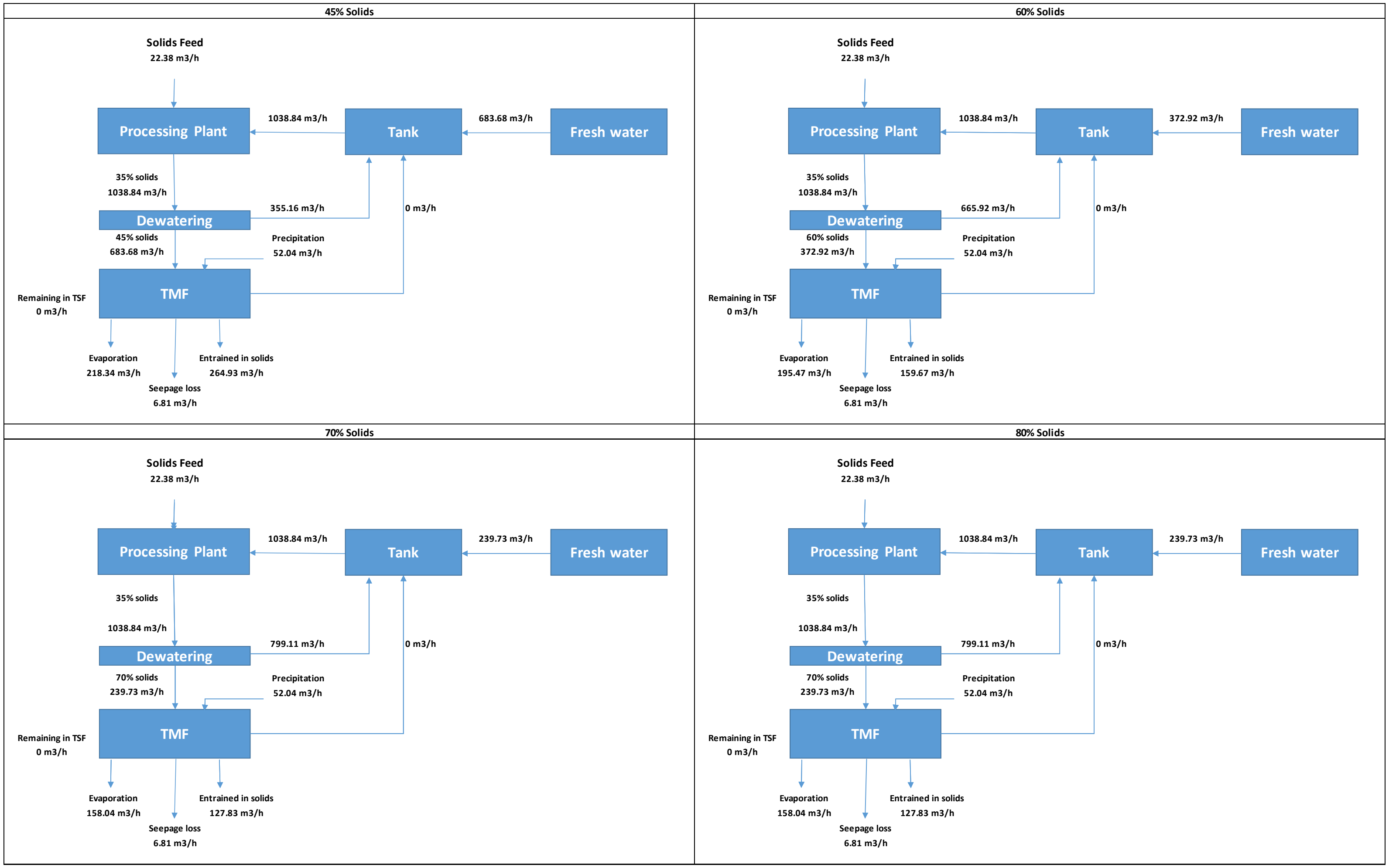


Figure 4.10 Schematics of water balance for different solids contents in the dry condition for an unlined impoundment

The cumulative water deficit and cumulative water deficit per tonne of mill throughput for solids contents of 45, 60, 70 and 80% are compared in Figures 4.11 and 4.12.

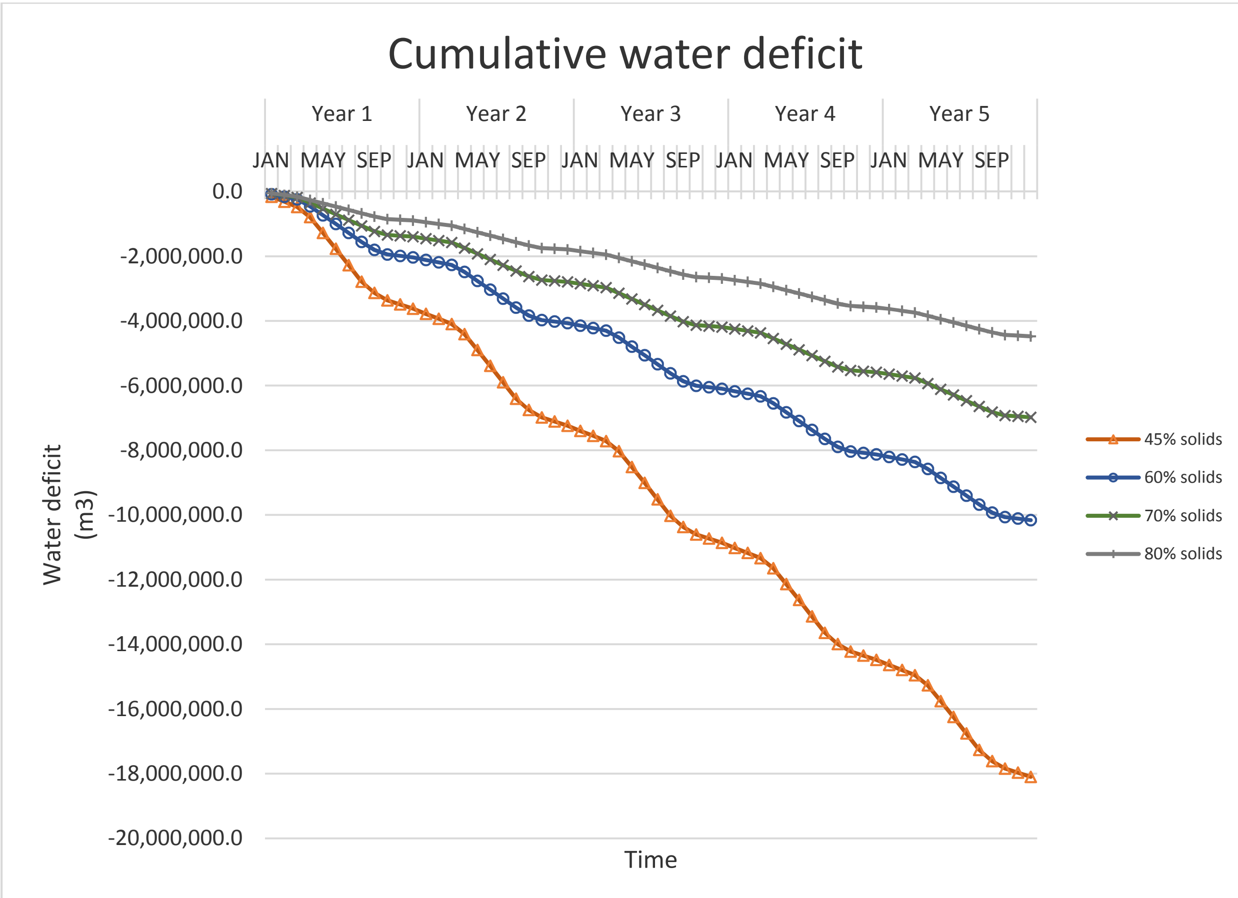


Figure 4.11 Cumulative water deficit for different solids contents in the dry condition for an unlined impoundment

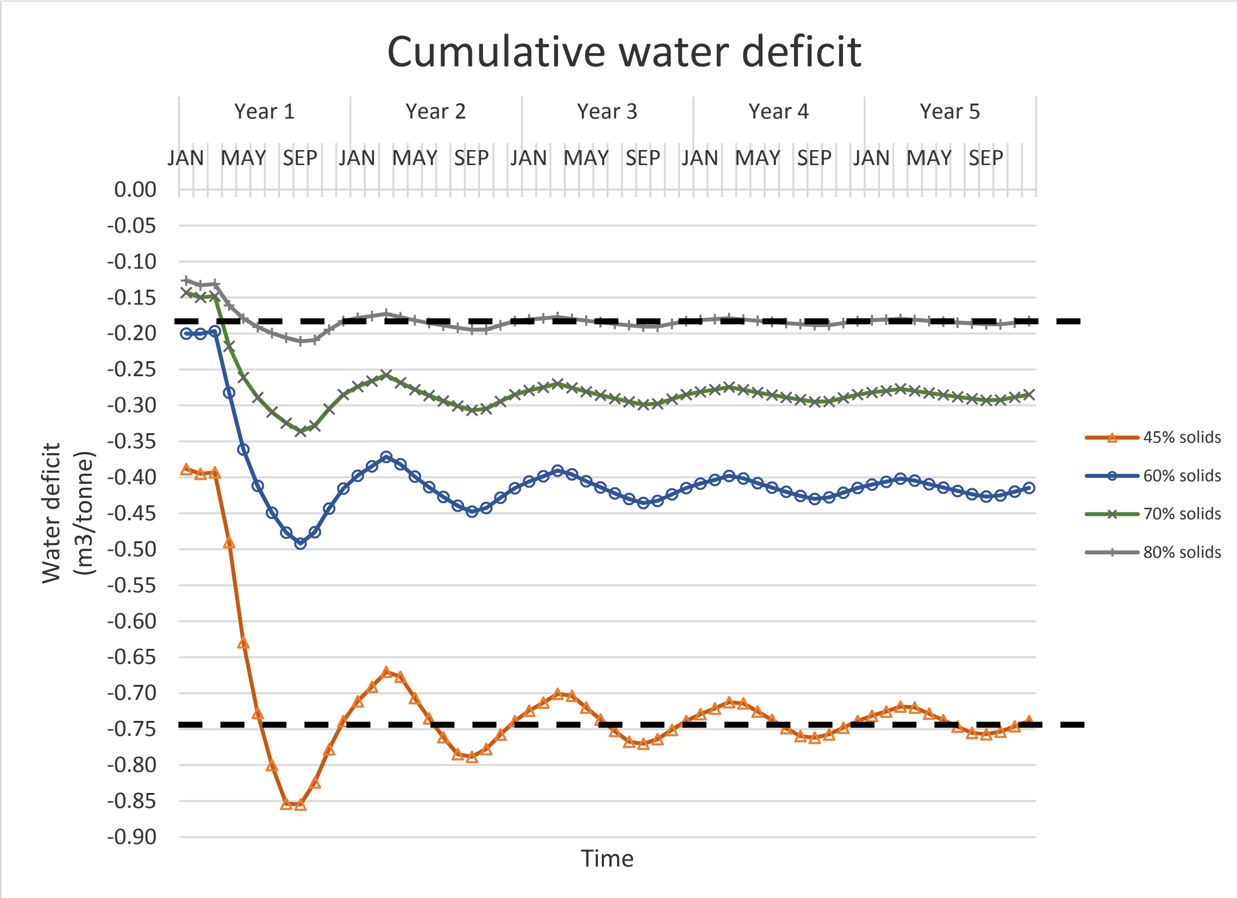


Figure 4.12 Cumulative water deficit per tonne of mill throughput for different solids contents in the dry condition for an unlined impoundment

Chapter 5: Probabilistic water balance results

This chapter summarizes the results of probabilistic water balance for lined and unlined impoundments. The Monte Carlo algorithm in Oracle Crystal Ball ran the models for 10000 trials for each month. The graphs that are presented here are based on data extracted from the histograms of monthly cumulative surplus and deficit.

5.1 Lined impoundment

5.1.1 Wet climate

Figures 5.1 to 5.3 respectively show the mean cumulative water surplus as well as the 5th and 95th percentiles of cumulative water surplus per tonne of mill throughput in the wet condition for a lined impoundment.

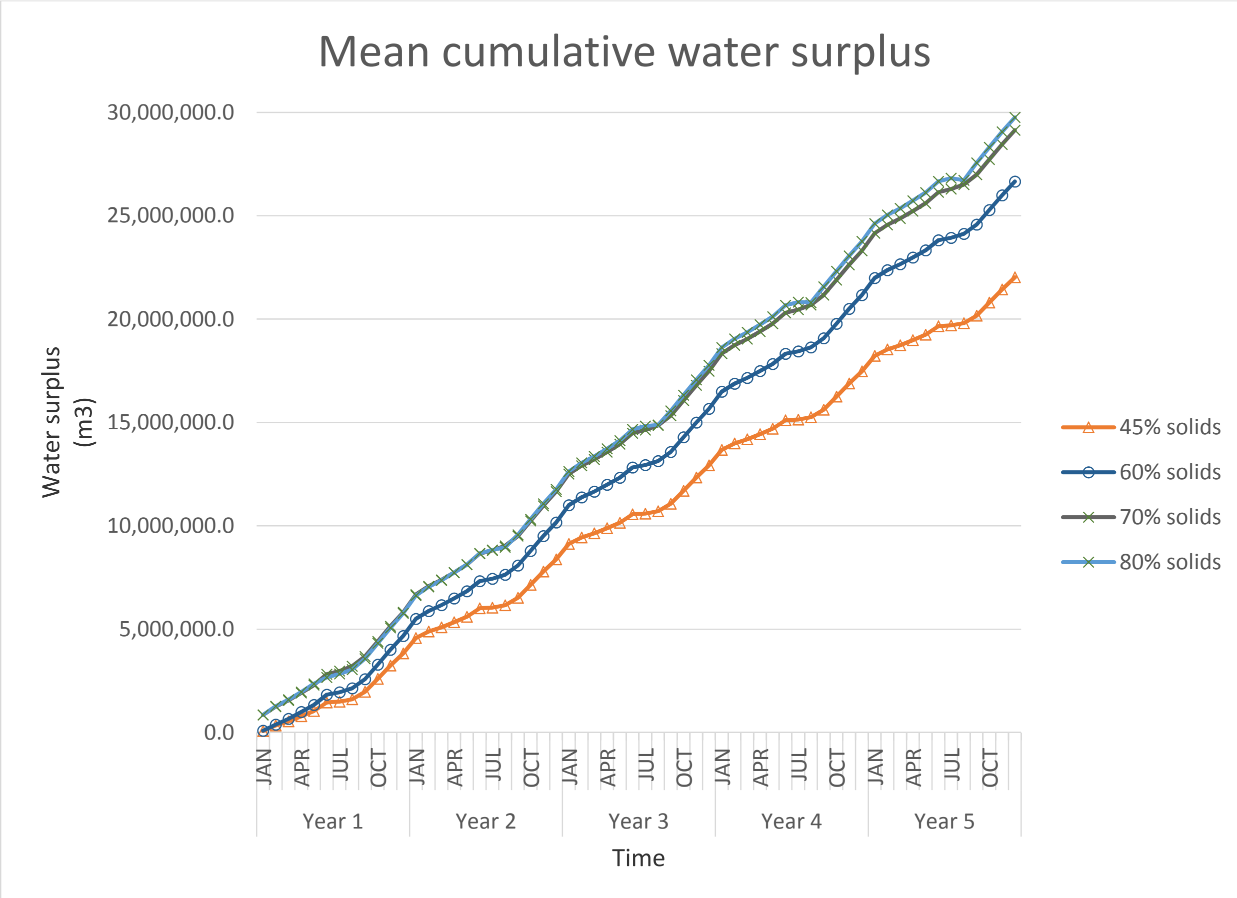


Figure 5.1 Mean cumulative water surplus for different solids contents in the wet climate condition for a lined impoundment

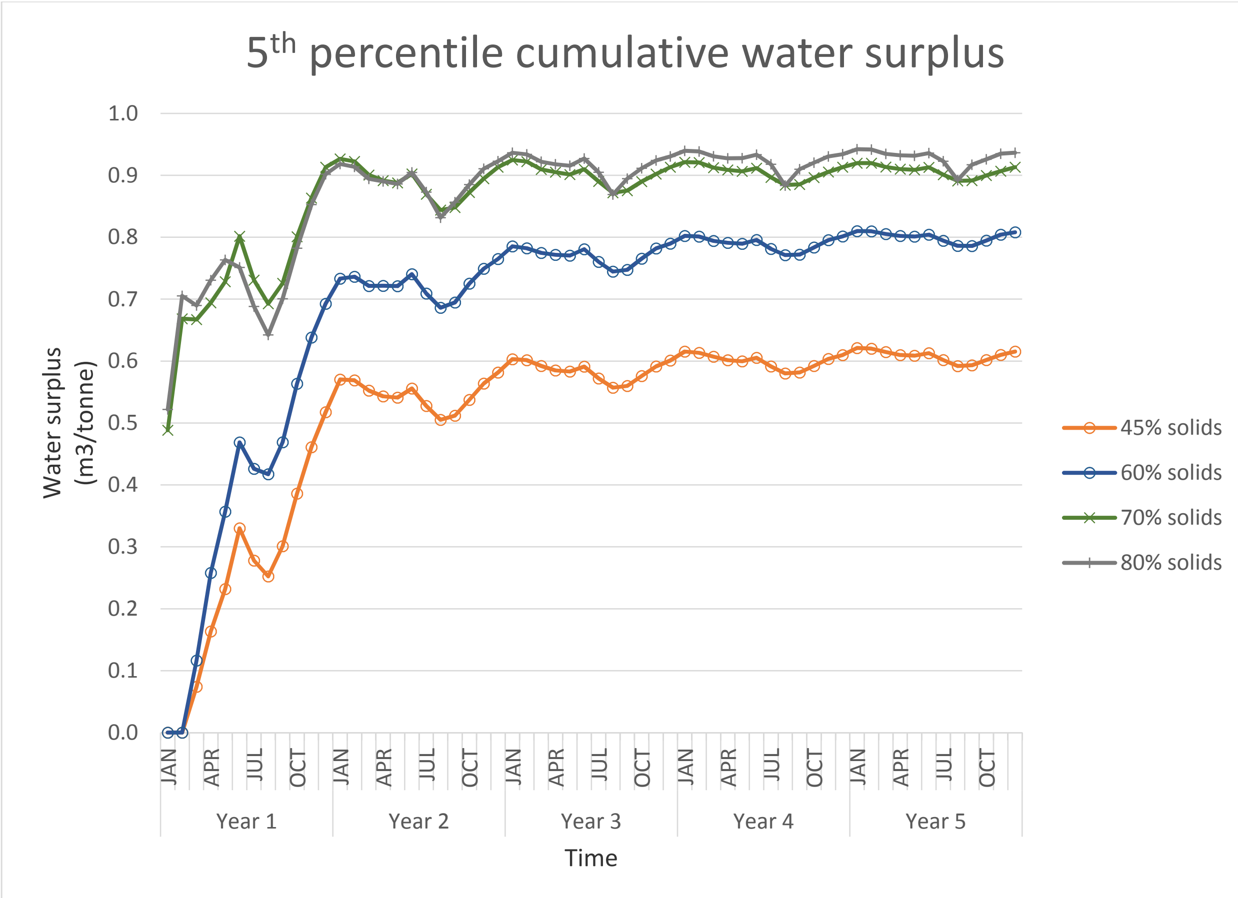


Figure 5.2 The 5th percentile of cumulative water surplus per tonne of mill throughput for different solids contents in the wet condition for a lined impoundment

Figure 5.2 shows that for 5% of the results, cumulative water surpluses for dry stack tailings in any given August are less than corresponding values for filtered tailings. This is from the random sample selections from the ranges of dry densities. As noted in Chapter 3, the dry density for paste tailings ranges from 1.7 to 1.9 tonne/m^3. For filtered tailings, dry density varies between 1.8 and 2.0 tonne/m^3. It means the samples for the solids content of 70% has been selected randomly from the range of [>1.8 tonne/m^3] for any given August. The graphs of 95th percentile show that the water surplus for 95% of the results, ranges from 1.2 to 1.5 m^3/tonne.

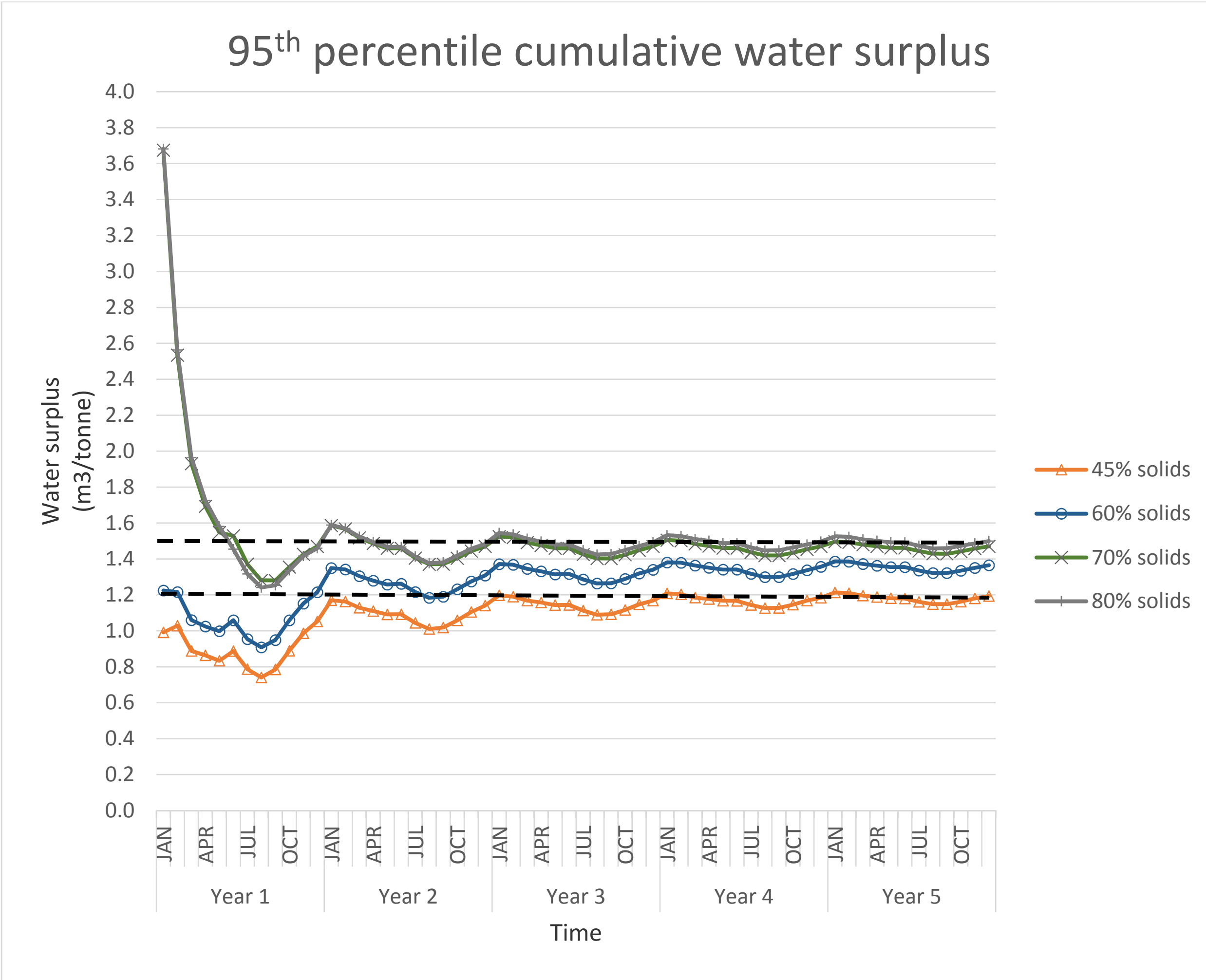


Figure 5.3 The 95th percentile of cumulative water surplus per tonne of mill throughput for different solids contents in the wet condition for a lined impoundment

5.1.2 Dry climate

Figures 5.4 to 5.6 respectively show the mean cumulative water surplus as well as the 5th and 95th percentiles of cumulative water surplus per tonne of mill throughput in the dry condition for a lined impoundment. Figure 5.5 shows that the water deficit for 5% of the results, ranges from 0.16 to 0.76m^3/tonne (because the values are negative, the 5th percentile represents the 95th percentiles of water deficits absolute values).

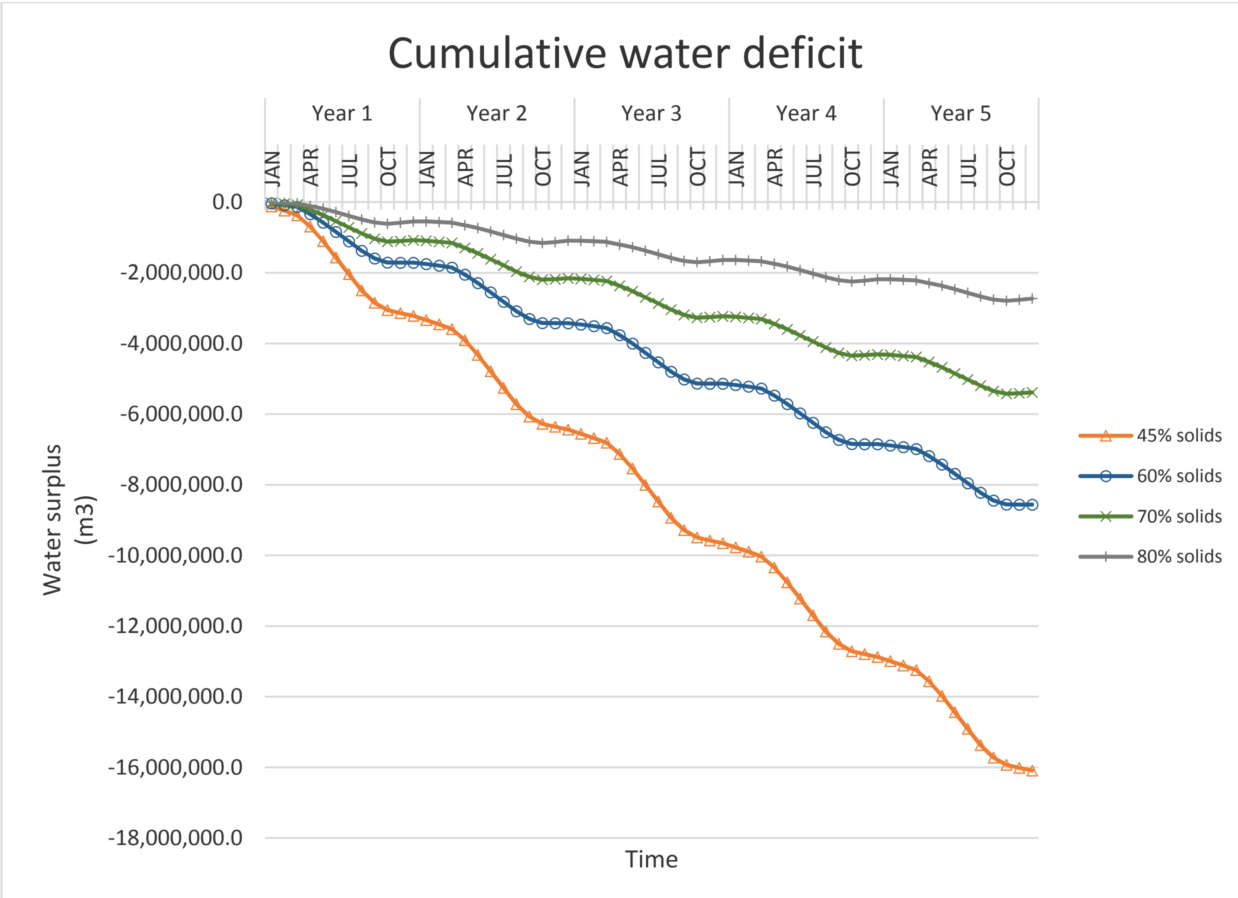


Figure 5.4 Mean cumulative water deficit for different solids contents in the dry climate condition for a lined impoundment

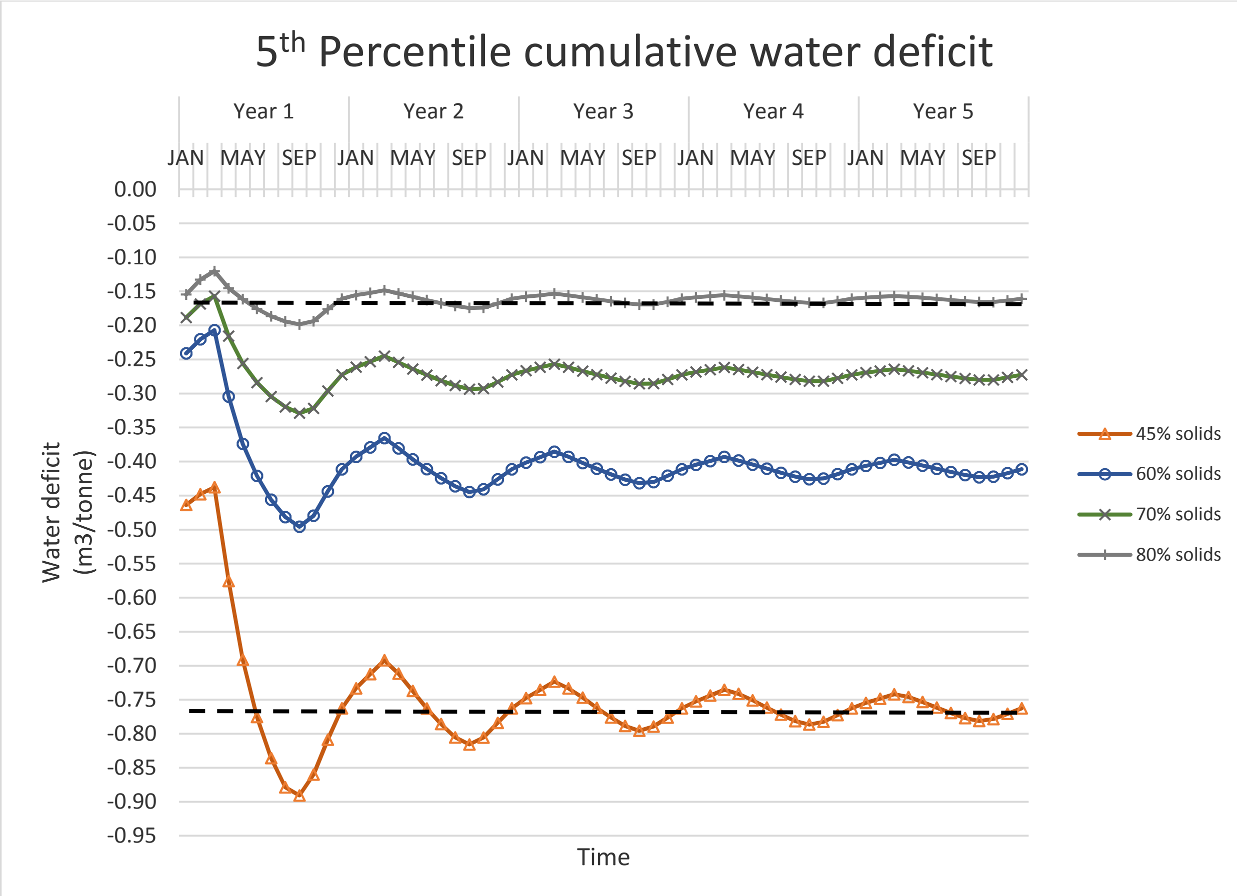


Figure 5.5 The 5th percentile of cumulative water deficit per tonne of mill throughput for different solids contents in the dry condition for a lined impoundment

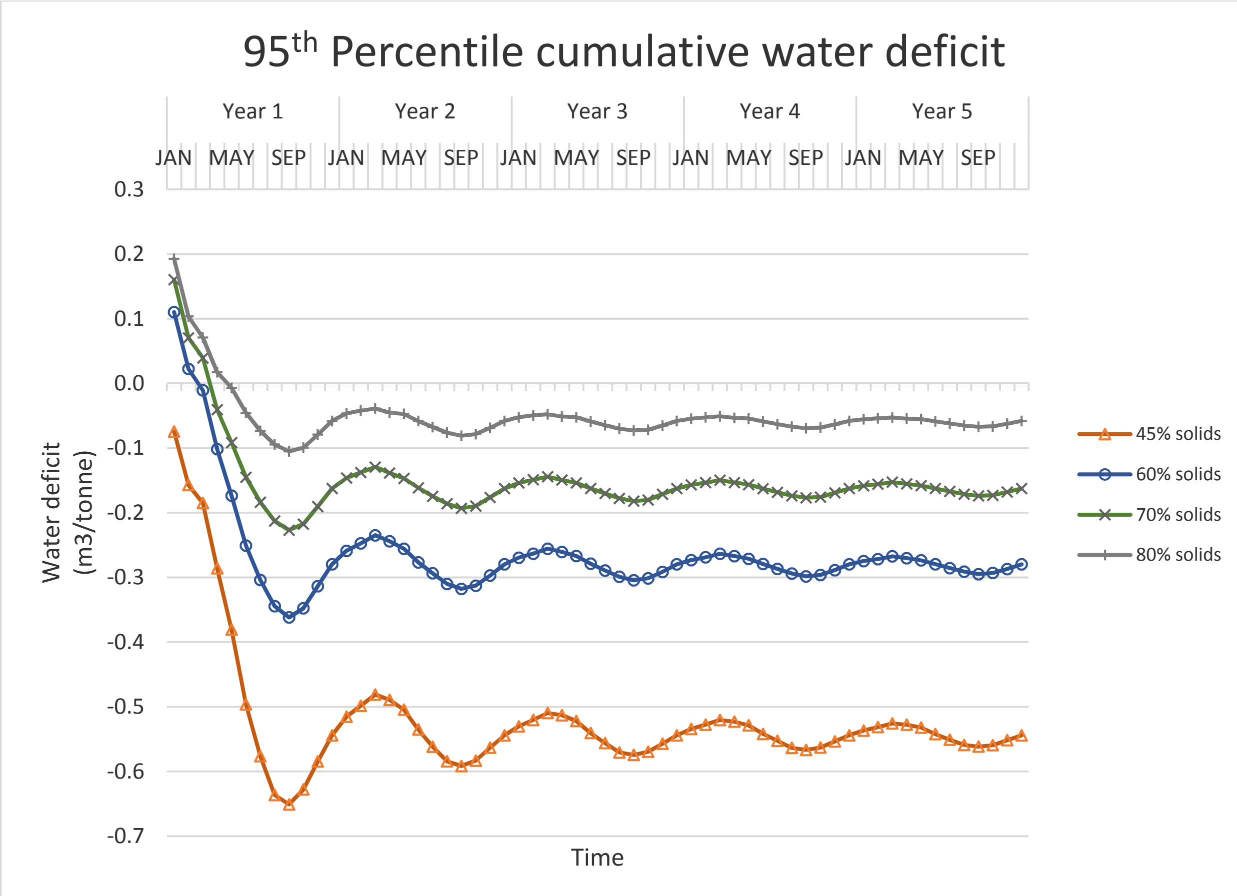


Figure 5.6 The 95th percentile of cumulative water surplus/deficit per tonne of mill throughput for different solids contents in the dry condition for a lined impoundment

5.2 Unlined impoundment

5.2.1 Wet climate

Figures 5.7 to 5.9 respectively show the mean cumulative water surplus, the 5th, and 95th percentiles of cumulative water surplus per tonne of mill throughput in the wet condition for an unlined impoundment.

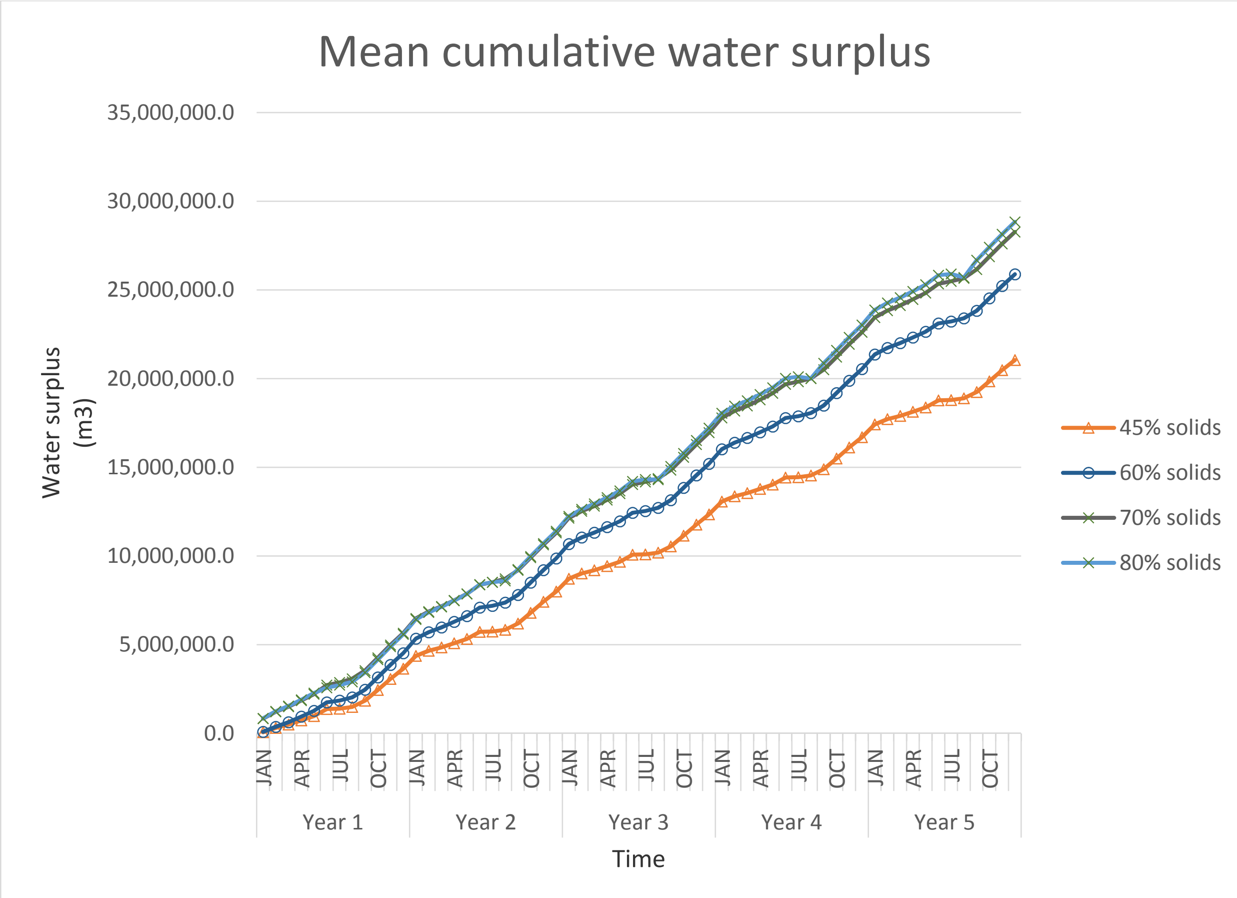


Figure 5.7 Mean cumulative water surplus for different solids contents in the wet climate condition for an unlined impoundment

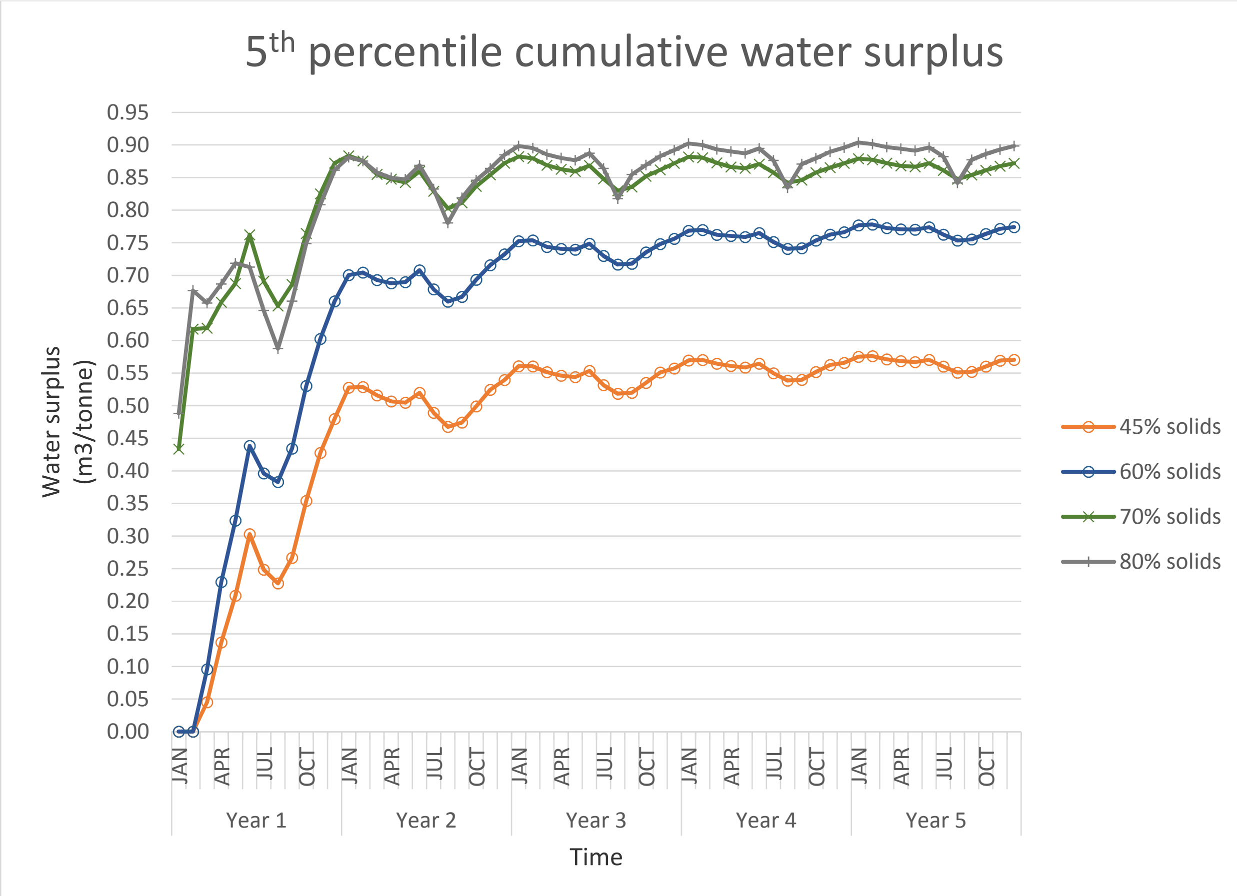


Figure 5.8 The 5th percentile of cumulative water surplus per tonne of mill throughput for different solids contents in the wet condition for an unlined impoundment

Similar to the results for the lined impoundment, Figure 5.2 shows that for 5% of the results in an unlined impoundment, cumulative water surpluses for 80% solids content tailings in any given August are less than corresponding values for 70% solids content tailings.

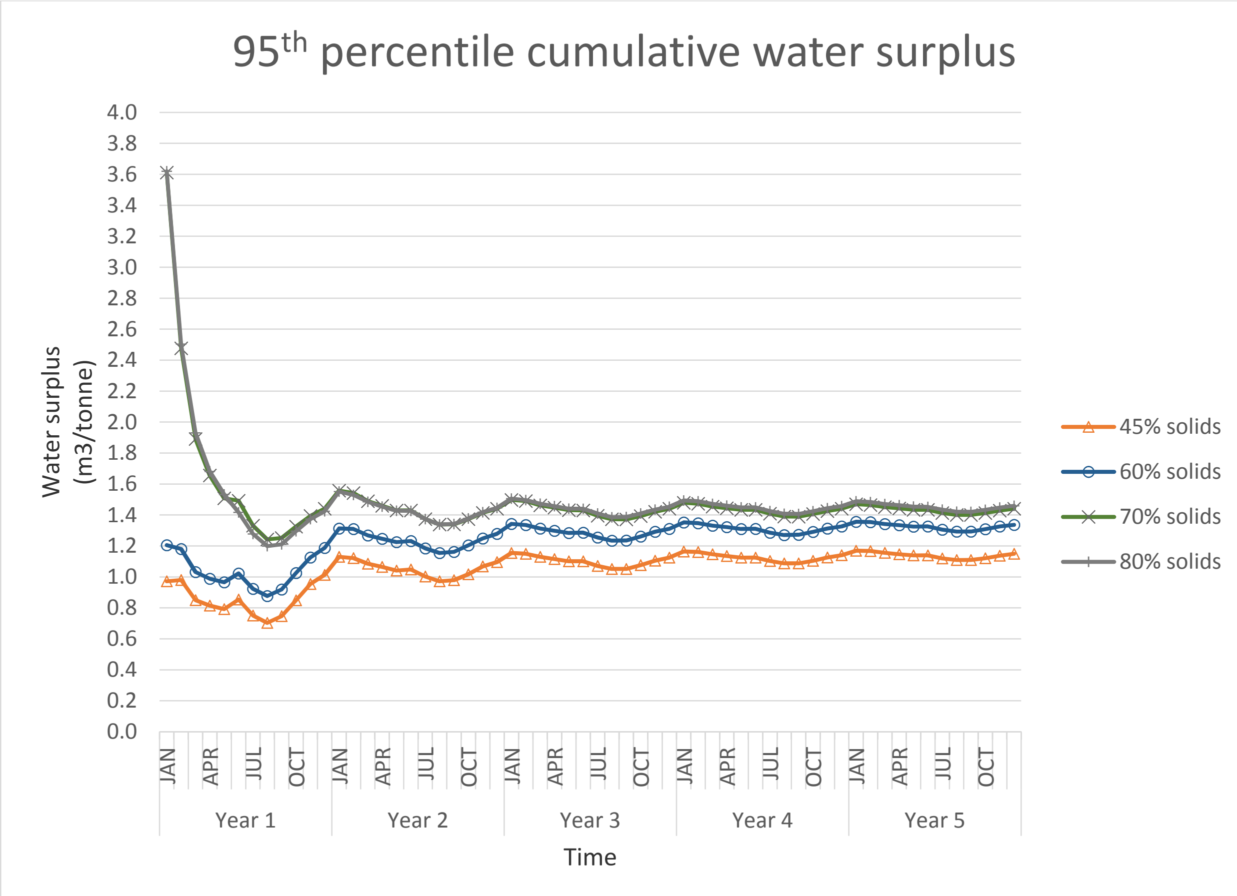


Figure 5.9 The 95th percentile of cumulative water surplus per tonne of mill throughput for different solids contents in the wet condition for an unlined impoundment

Figures 5.3 and 5.9 show that for both lined and unlined impoundments for 95 % of the results, the cumulative water surplus for paste tailings and filtered tailings are very close and based on this water balance model and the assumption made, there is no reason to use the filtered tailings method over the paste tailings method in the wet condition.

5.2.2 Dry climate

Mean cumulative water deficit, the 5th, and 95th percentiles of cumulative water deficit per tonne of mill throughput in the dry condition are plotted in Figures 5.10 to 5.12 respectively.

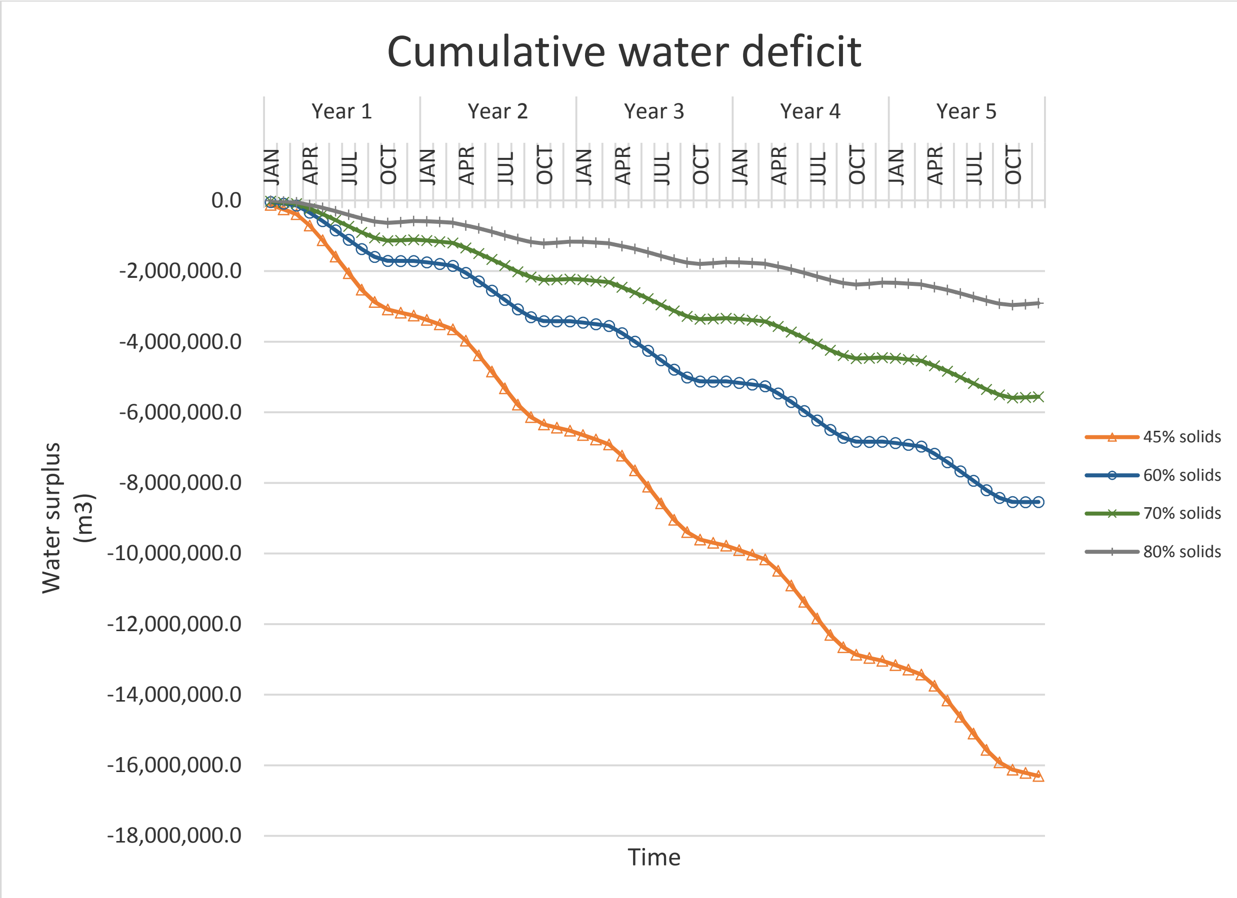


Figure 5.10 Mean cumulative water deficit for different solids contents in the dry climate condition for an unlined impoundment

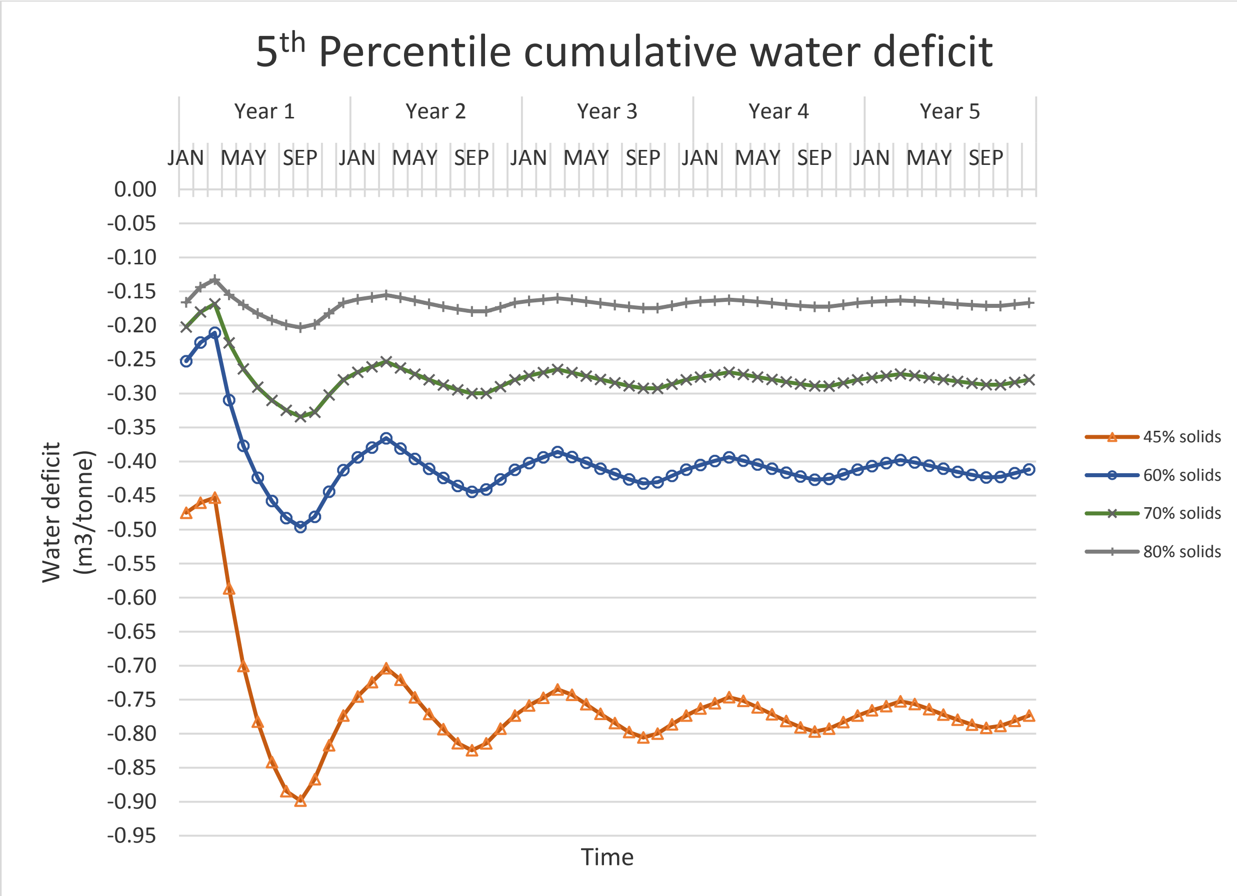


Figure 5.11 The 5th percentile of cumulative water deficit per tonne of mill throughput for different solids contents in the dry condition for an unlined impoundment

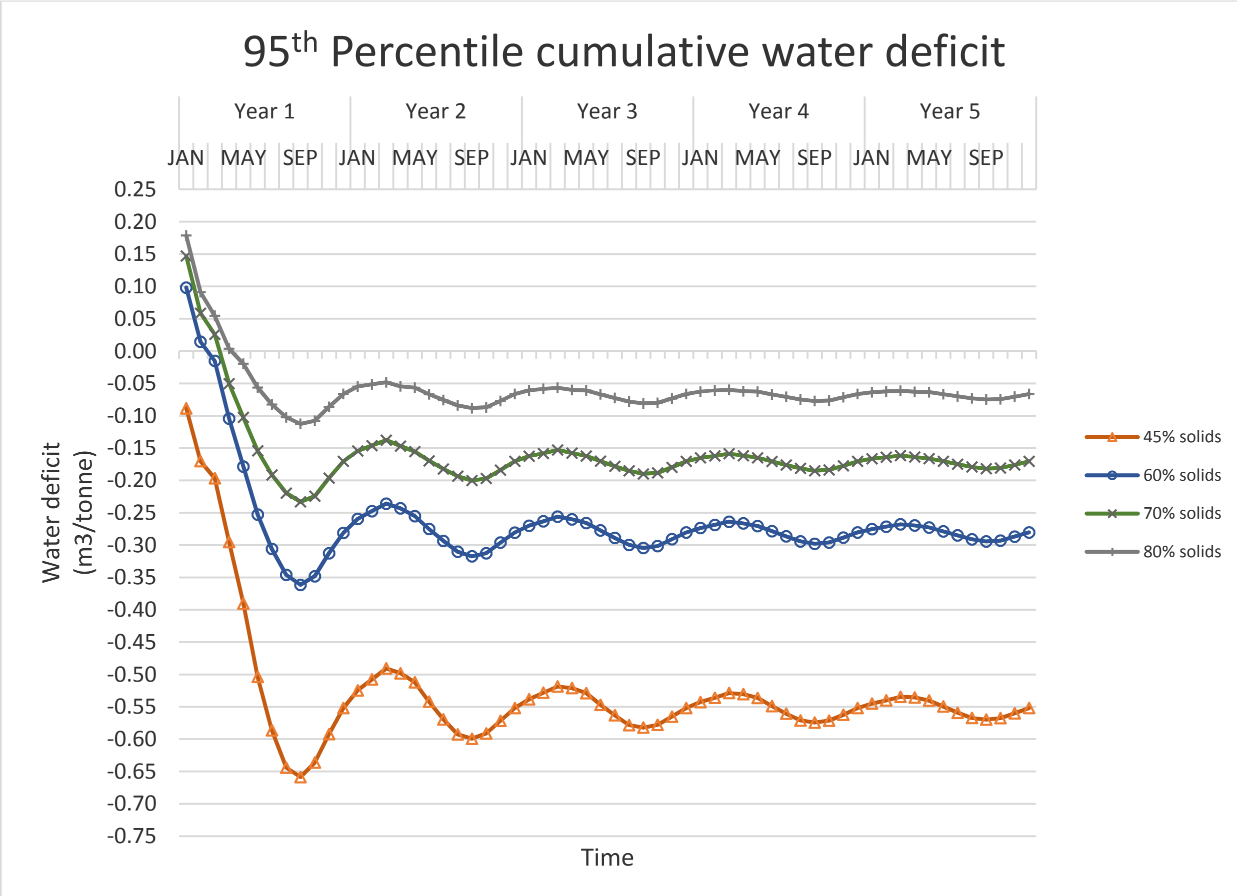


Figure 5.12 The 95th percentile of cumulative water deficit per tonne of mill throughput for different solids contents in the dry condition for an unlined impoundment

Chapter 6: Discussion

Results from a deterministic water balance model were presented in Chapter 4. Uncertainities and variabilities of water balance parameters were added to the model using Oracle Crystal Ball to obtain the results presented in Chapter 5.

Figures 6.1 and 6.2 show the water quantities of each water balance parameter in arid and wet climate conditions respectively for solids content of 45%. Figure 6.3 shows similar values for a hydraulic fill TMF water balance developed by Blight (2010).

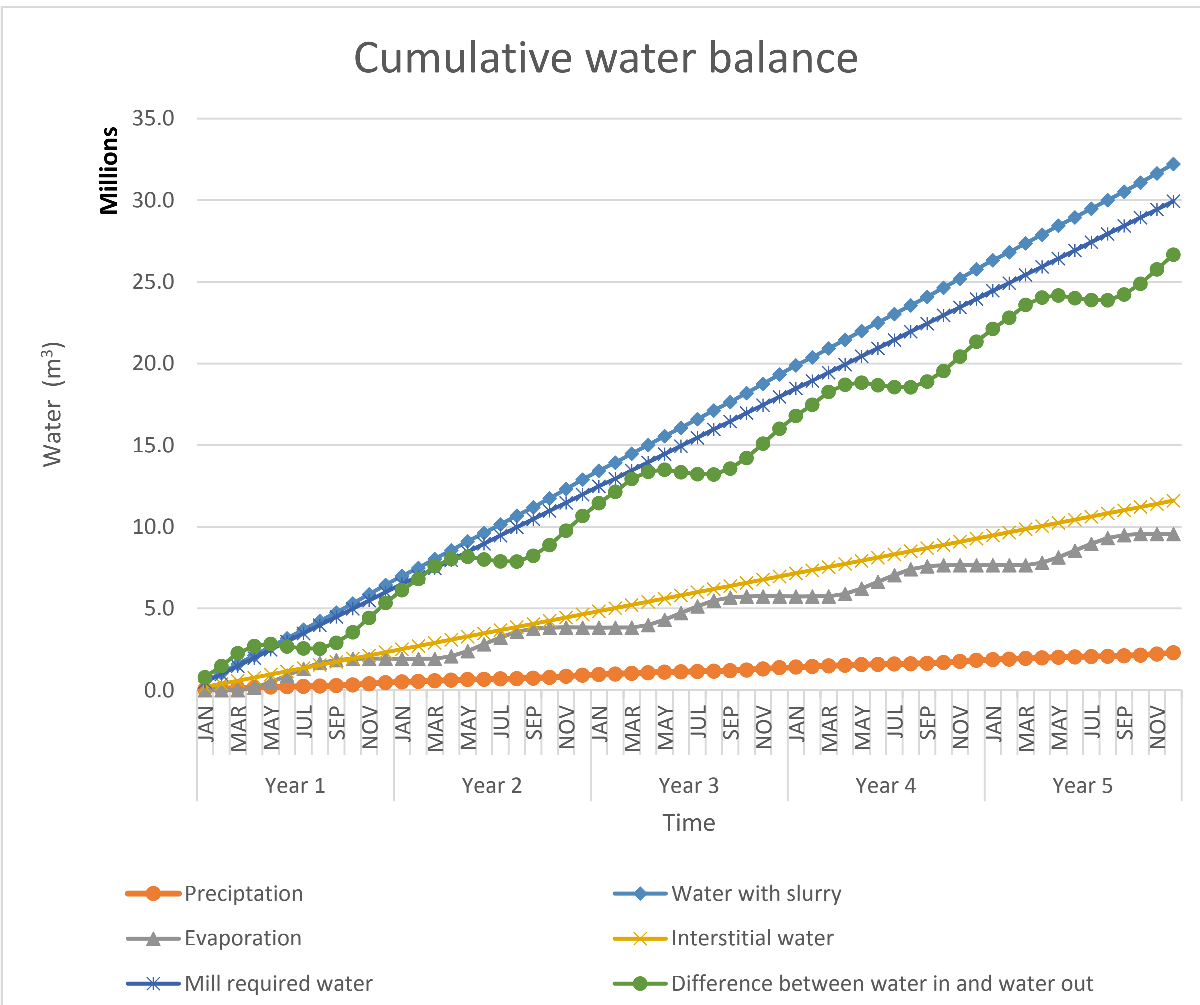


Figure 6.1 Cumulative water balance parameters in the arid condition for a lined impoundment

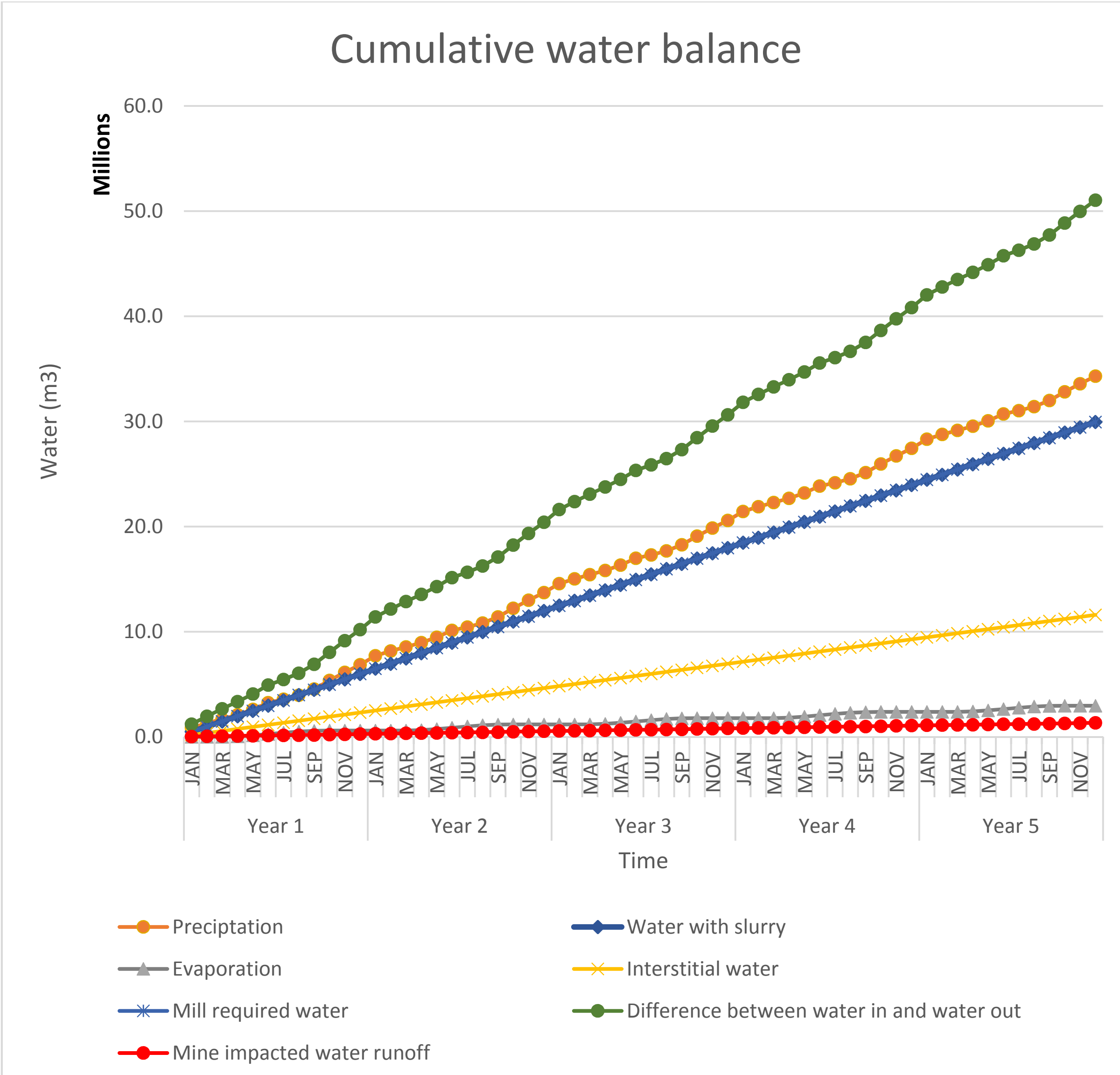


Figure 6.2 Cumulative water balance parameters in wet condition for a lined impoundment

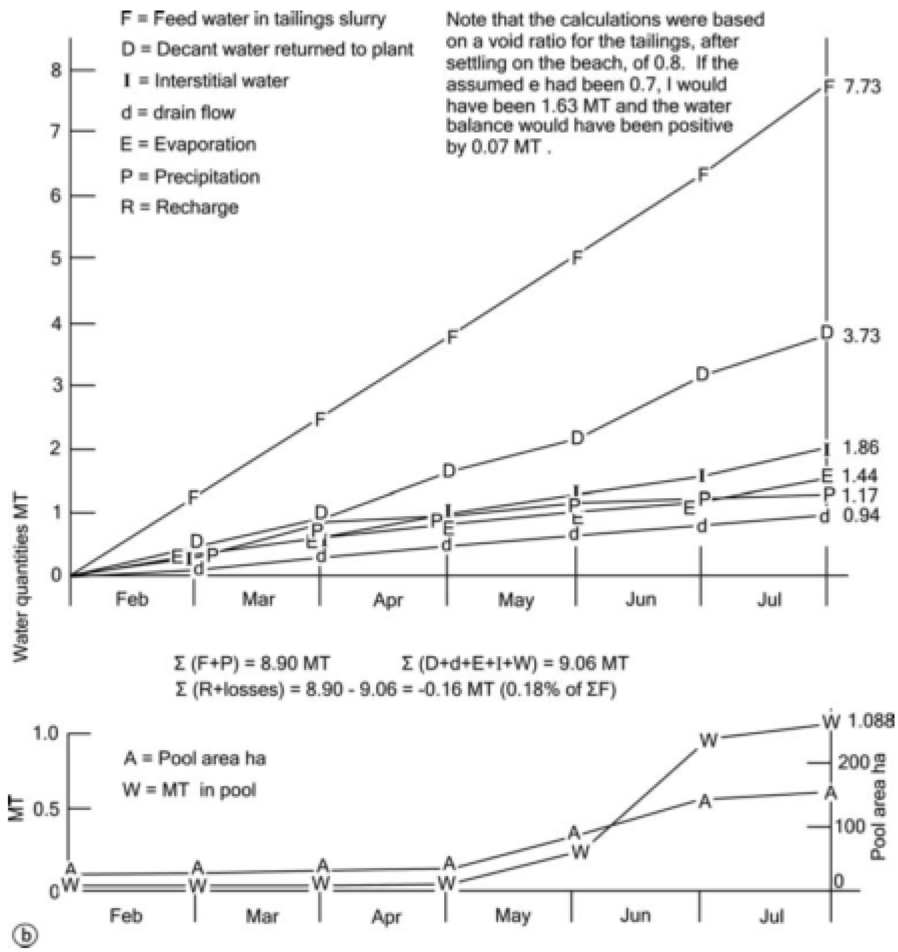


Figure 6.3 Water balance parameters for hydraulic fill TMF (Blight, 2010)

As seen in Figure 6.2, in the arid climate, the difference between “water inflow” and “water outflow” is less than the water that was reported to TMF with tailings. This means that fresh make up water is required to be added to the processing plant. However, in the wet condition, the difference between “water inflow” and “water outflow” is greater than the water required to be returned to the processing plant and there is a water surplus that can be stored in the TMF or a separate reservoir.

In this research, it is assumed that for the lined impoundment, the water loss is only due to the water trapped in the tailings pores after initial settlement and evaporation. Seepage losses are considered to be negligible. Table 6.1 shows the water losses in different scenarios.

Table 6.1 Water loss proportion in different scenarios

				Water loss (m3/tonne)							
			Water with tailings	**Evaporation from pond**		**Entrainment**		**Seepage loss**		**Total**	
		Solids content (%)	**m^3 per tonne throughput**	**m^3 per tonne throughput**	**Ratio to water with tailings**	**m^3 per tonne throughput**	**Ratio to water with tailings**	**m^3 per tonne throughput**	**Ratio to water with tailings**	**m^3 per tonne throughput**	**Ratio to water with tailings**
Wet Climate	Lined Imppoundment	45	1.22	0.12	0.10	0.47	0.39	0.00	0.00	0.59	0.48
		60	0.67	0.12	0.18	0.29	0.43	0.00	0.00	0.41	0.61
		70	0.43	0.10	0.23	0.23	0.53	0.00	0.00	0.33	0.77
		80	0.25	0.10	0.40	0.20	0.80	0.00	0.00	0.30	1.20
	Unlined Imppoundment	45	1.22	0.12	0.10	0.47	0.39	0.04	0.03	0.63	0.52
		60	0.67	0.12	0.18	0.29	0.43	0.04	0.06	0.45	0.67
		70	0.43	0.10	0.23	0.23	0.53	0.04	0.09	0.37	0.86
		80	0.25	0.10	0.40	0.20	0.80	0.04	0.16	0.34	1.36
Dry Climate	Lined Imppoundment	45	1.22	0.39	0.32	0.47	0.39	0.00	0.00	0.86	0.70
		60	0.67	0.35	0.52	0.29	0.43	0.00	0.00	0.64	0.96
		70	0.43	0.28	0.65	0.23	0.53	0.00	0.00	0.51	1.19
		80	0.25	0.16	0.64	0.21	0.84	0.00	0.00	0.37	1.48
	unlined Imppoundment	45	1.22	0.39	0.32	0.47	0.39	0.01	0.01	0.87	0.71
		60	0.67	0.35	0.52	0.29	0.43	0.01	0.01	0.65	0.97
		70	0.43	0.28	0.65	0.23	0.53	0.01	0.02	0.52	1.21
		80	0.25	0.16	0.64	0.21	0.84	0.01	0.04	0.38	1.52

The water deficit/ water suplus for dry and wet climate in the month with highest precipitation and for the month with highest evaporation is showed in Table 6.2.

Table 6.2 Water deficit/water surplus for the month with highest precipitation and the month with highest evaporation

		Solids content (%)	Water with tailings (m3/month)		Highest precipitation		Highest evaporation		Entrainment		Water surplus/deficit for the month with highest precipitation in year 4		Water surplus/deficit for the month with the highest evaporation in year 4	
			(m3/ month)	Ratio to water with tailings	(m3/ month)	Ratio to water with tailings	(m3/ month)	Ratio to water with tailings	(m3/ month)	Ratio to water with tailings	(m3/ month)	Ratio to water with tailings	(m3/ month)	Ratio to water with tailings
Wet	Lined	45	508,658.3	1.00	858,107.0	1.69	128,977.1	0.25	190,750.9	0.38	694,575.8	1.37	358,123.8	0.70
		80	100,687.5	1.00	858,107.0	8.52	110,551.8	1.10	81,505.1	0.81	810,180.0	8.05	488,424.1	4.85
	Unlined	45	508,658.3	1.00	858,107.0	1.69	128,977.1	0.25	190,750.9	0.38	679,671.8	1.34	343,219.8	0.67
		80	100,687.5	1.00	858,107.0	8.52	110,551.8	1.10	81,505.1	0.81	795,276.0	7.90	473,520.1	4.70
Dry	Lined	45	508,658.3	1.00	70,840.0	0.14	416,587.5	0.82	190,750.9	0.38	-126,269.3	- 0.25	-492,250.0	- 0.97
		80	100,687.5	1.00	70,840.0	0.70	174,570.0	1.73	81,505.1	0.81	-17,271.0	- 0.17	-100,687.5	- 1.00
	Unlined	45	508,658.3	1.00	70,840.0	0.14	416,587.5	0.82	190,750.9	0.38	-131,237.3	- 0.26	-492,250.0	- 0.97
		80	100,687.5	1.00	70,840.0	0.70	174,570.0	1.73	81,505.1	0.81	-22,239.0	- 0.22	-100,687.5	- 1.00

The comparison of losses from Table 6.1 and the total evaporation loss from TMF and entrainment loss (including rewetting) from Gunson's study (2012) is showed in Table 6.3. The difference in results can be due to the difference in: pan evaporation, dry densities, and other assumptions (pond and beaches areas, and related pan evaporation factors).

Table 6.3 Comparison of Gunson's study (2012) with this study: Evaporation and entrainment losses in different scenarios

	Gunson's study (based on Table 2.5)		This research (based on Table 6.1)	
	Evaporation (m3/tonne)	Entrainment and rewetting (m3/tonne)	Evaporation (m3/tonne throughput)	Entrainment (m3/tonne throughput)
70% solids content	0.11	0.41	0.28	0.23
80% solids content	0.18	0.24	0.16	0.21

The most significant loss from the TMF in both the dry and the wet climate conditions is related to entrainment, which over the 5 year perating life of the lined TMF reached up to 84 % of the total water loss for wet climate and 55% of the total water loss for the dry climate when the solids content was 45%. The entrainment loss in the water balance model of Wels et al (2004) reached almost 75% water loss for Pampa Pabellon tailings impoundment. The entrained water loss to the total loss ratio depends on the tailings dry densities after the initial settlement, evaporation and seepage losses.

The initial and final dry densities of the tailings which present the void ratio of the tailings before deposition and after settlement respectively are important assumptions in the model, particularly at higher solids contents where the pores are not fully saturated. Typically, in dry seasons settled solids have higher dry density, because an increase in evaporation rate increases the density due to dessication.

Evaporation in arid climate is significant and can reach up to 65% of the total loss in a lined impoundment. Evaporation is a function of pan evaporation and the evaporation pan factor.

Table 6.4 shows the average water deficit/surplus over the last 3 years of the mine life (after the 2nd year, the water deficit/surplus graphs reach to steady states). The 95th percentile of lined impoundment water surplus in the wet condition reached 1.6 m^3/tonne of mill throughput. The 5th percentile of the lined impoundment water deficit results in the dry condition ranged between 0.16 and 0.74 m^3/tonne of mill throughput.

Table 6.4 Cumulative water deficit/surplus averaged over the last 3 years of mine life

		Solids contents (%)	Deterministic model	Probabilistic model		
			Mean (m3/tonne)	Mean (m3/tonne)	5th percentile (m3/tonne)	95th percentile (m3/tonne)
Wet Climate	Lined Impoundment	45	0.86	0.93	0.56	1.31
		60	1.05	1.13	0.77	1.49
		70	1.12	1.20	0.84	1.56
		80	1.16	1.23	0.86	1.60
	Unlined Impoundment	45	0.83	0.90	0.53	1.27
		60	1.01	1.09	0.73	1.46
		70	1.09	1.16	0.80	1.53
		80	1.12	1.19	0.83	1.56
Dry Climate	Lined Impoundment	45	-0.70	-0.63	-0.74	-0.50
		60	-0.40	-0.33	-0.40	-0.25
		70	-0.27	-0.21	-0.27	-0.14
		80	-0.18	-0.11	-0.16	-0.05
	unlined Impoundment	45	-0.70	-0.64	-0.75	-0.51
		60	-0.40	-0.34	-0.41	-0.26
		70	-0.27	-0.22	-0.27	-0.15
		80	-0.18	-0.12	-0.17	-0.05

The mean deterministic water deficit for the slurry tailings (45% solids content) in the lined impoundment is 0.70 m^3/tonne. The reported average required make-up water in mines are between 0.4 and 0.7 m^3/tonne (Obermeyer et al., 2013).

Gunson (2013) in his study estimated the water consumption for paste tailings and filtered tailings to be respectively 0.59 and 0.31 m^3/tonne. The difference of his results with the results of this research (water deficits of 0.27 m^3/tonne for paste tailings and 0.17 m^3/tonne for filtered tailings) is that Gunson (2013) used the Water Recovery (RGC) Model. This model only considers the water with tailings as the water inflow and do not consider the water inflows from precipitation and run offs.

For another comparison, results of the study on "platinum project on the eastern limb of the Bushveld Complex" (Moolman and Vietti, 2012), located in a semi arid climate, are presented here. The case study included three tailings concentrations of low, medium and high density respectiely of 50%, 60%, and 75% solids contents. The study was conducted to find the optimum scenario with lowest cost per ton and the lowest water consumption. Water consumptions of these three cases are listed in Table 6.5.

Table 6.5 Water consumption (m^3/t solids) for a platinum project on the eastern limb of the Bushveld Complex (Moolman and Vietti, 2012)

	Water consumption (m^3/t solids)	
	Winter	Annual average
Low-density tailings	0.57	0.39
Medium-density tailings	0.46	0.28
High-density tailings	0.29	0.11

It was assumed that the seepage loss in wet climate condition was 25% of the total seepage (calculated from Darcy's equation). If the seepage loss varies to 50% and 75% of the total seepage, water surplus for different solids contents changes according to Table 6.6.

Table 6.6 Effect of changing seepage losses on water surplus for different solids contents in wet condition

	Solids content (%)	Seepage loss= 25% of total seepage	Seepage loss= 50% of total seepage	Seepage loss= 75% of total seepage
Water surplus (m^3/ tonne mill throughput)	45	0.83	0.79	0.75
	60	1.01	0.98	0.94
	70	1.09	1.05	1.01
	80	1.12	1.08	1.05

Figure 6.4 shows the certainty levels of the results of the lined TMF water surpluses in wet condition for the 45% solids content. The percentiles of the water surpluses were derived from the monthly cumulative water surpluse histograms. In this example, the required reservoir capacity according to the mean of cumulative water surpluses is 22 million m^3. Whereas, the required capacity based on the 95^{th} percentile is 30% greater (29 million $m^{3)}$. As it is seen depending on how risk averse one can be. They might choose the values with the higher degree of certanity (95^{th} percentile).

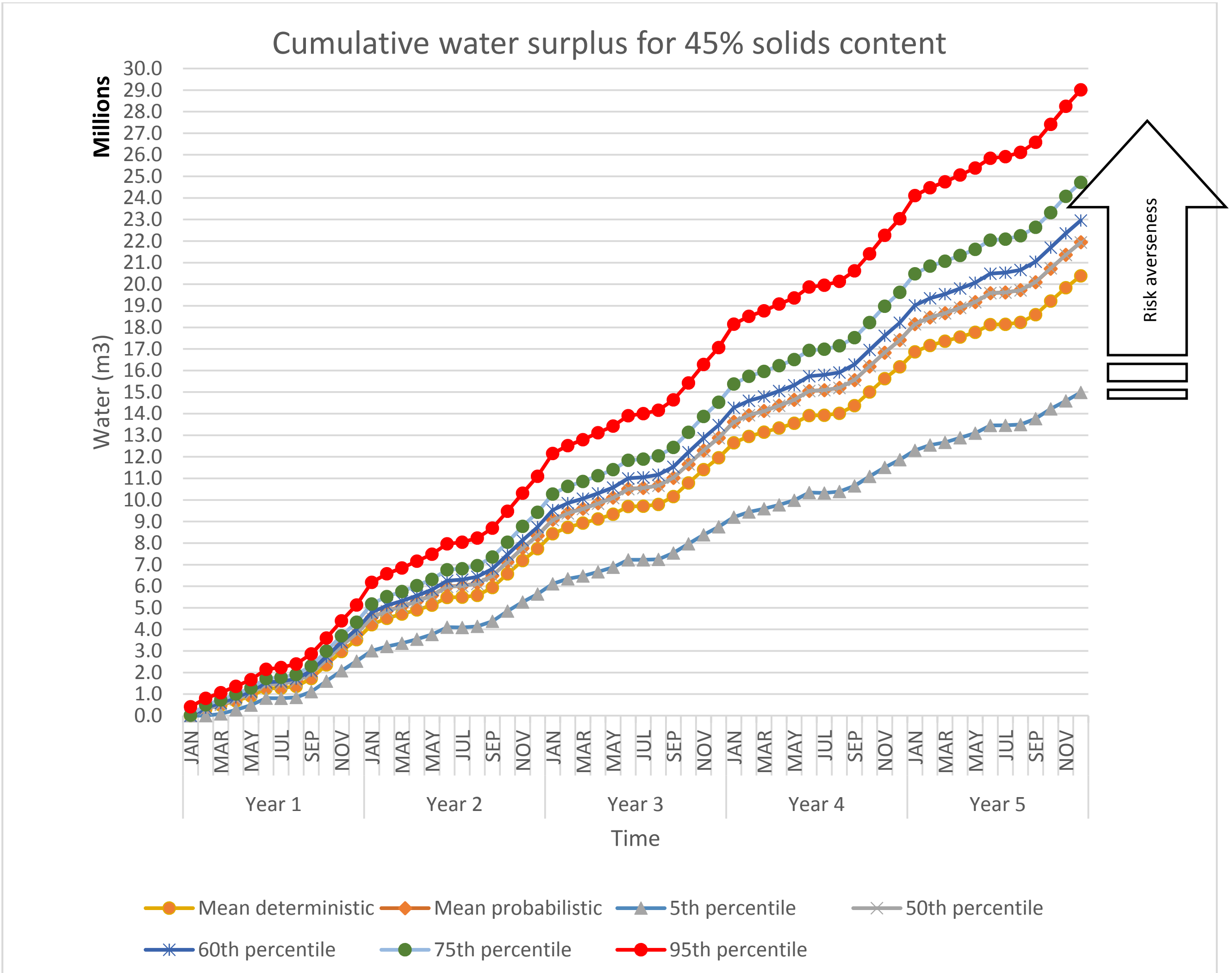


Figure 6.4 Cumulative water surplus percentiles for 45% solids content in wet climate for a lined impoundment

Figure 6.5 shows the water entrainment percentiles relative to the water with tailings. Beta distributioins were the best fits to the entrainment histograms. For slurry tailings case, 32% to 48% of the water with slurry is lost due to the entrainment. For filtered tailings case, the entrainment loss accounts for 63% to 97% of the water with tailings.

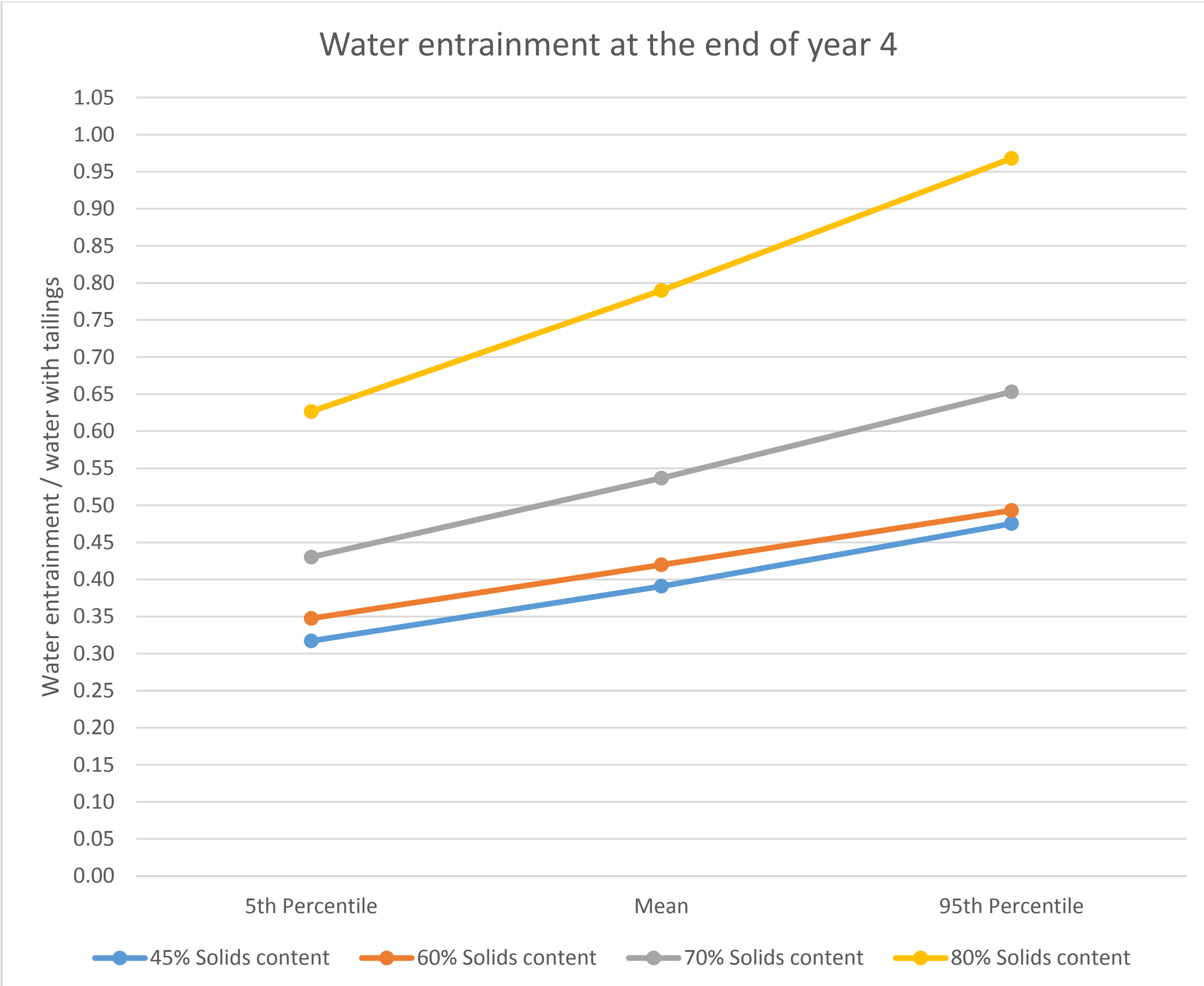


Figure 6.5 The entrainment loss realative to the water with tailings at the end of year 4

Figure 6.6 compares the 5th percentile, mean and 95th percentile of water deficits and water surplus for lined and unlined impoundments in wet and dry conditions for different solids contents.

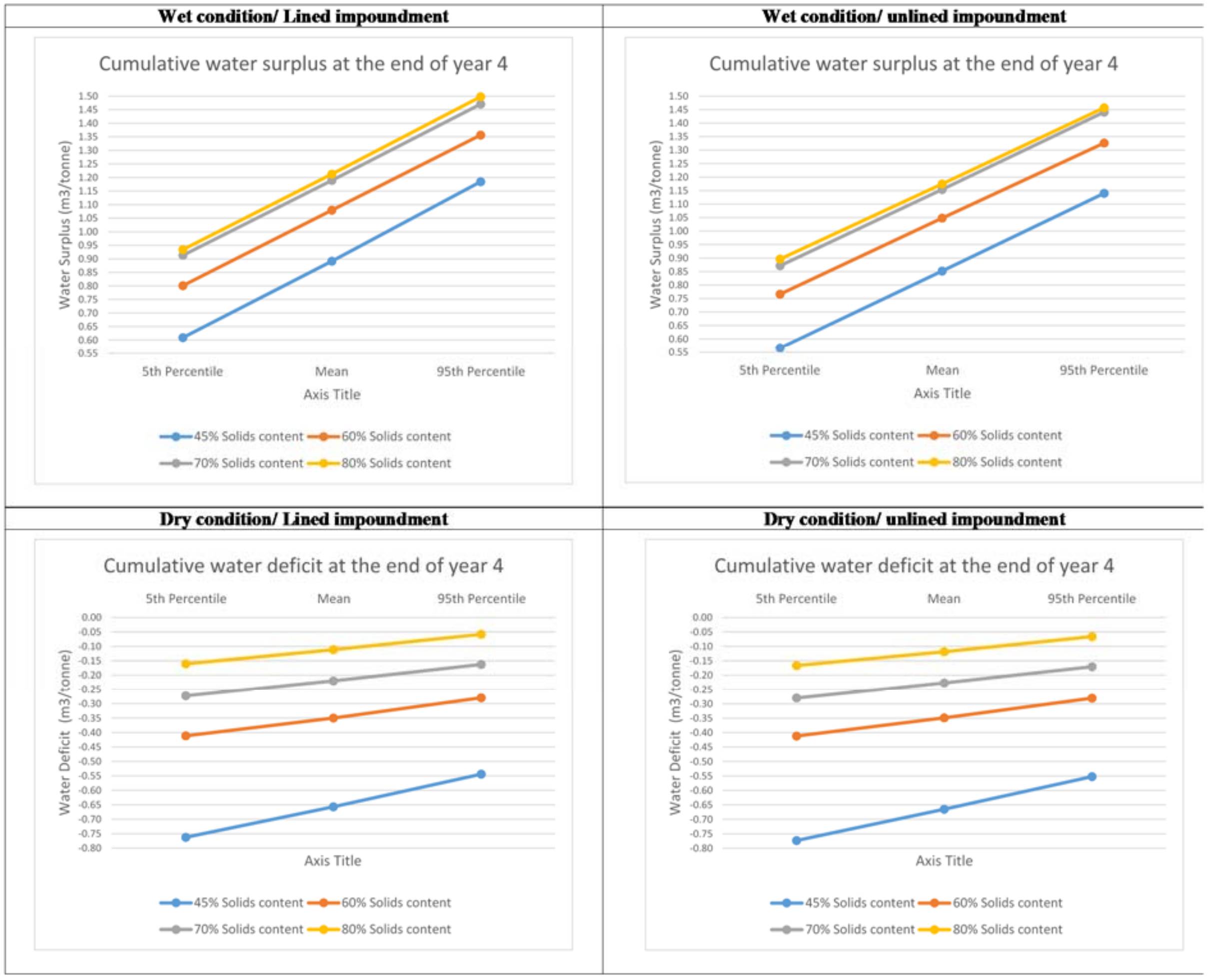


Figure 6.6 Range of water deficits and water surplus for different conditions at the end of year 4

Chapter 7: Conclusion and recommendations

The question to be answered by this research was: How do different tailings management options in differentt climates affect mine water requirements and surpluses? To answer to this question, the research objectives were set to:

- Review and compare available methods for tailings water balance.
- Extract and analyze climate data for wet and dry conditions. Statistical analyses of climate data are used to reflect the uncertainty of the input data.
- Develop both a deterministic and probabilistic water balances.
- Conduct analyses on different tailings management options.

Water balance models were developed in this research. The study for two scenarios of lined and unlined impoundments included:

- a deterministic water balance for two different climate conditions
- analyses of the models for four different management options
- a probabilistic water balance for these same climate conditions and management options

For the dry climate condition, due to the high rate of evaporation, free water did not exist in the TMF at the end of some months to be reclaimed and returned to the processing plant. In contrast, in the wet climate condition, because of the high intensity of precipitation and relatively low evaporation rates, water was available to be returned to the plant.

The results of modelling indicated that a hypothetical unlined TMF located in an arid region could reduce water withdrawals from 0.70 m^3/tonne to 0.18 m^3/tonne, when the solids content was elevated from 45% to 80%. The same lined TMF in a wet condition could increase the excess water from 0.86 m^3/tonne to 1.16 m^3/tonne with the tailings dewatered from 45% solids content to 80%. Dewatering techniques can be the best techniques for dry climates if the rate of mill production is within the range appropriate for these techniques. The difference between cumulative water surplus per tonne mill throughput in the wet climate condition for paste tailings and filtered tailings were minor. Overall, if the water balance models with the assumptions in this research are considered, it is not recommended to use paste and filtered tailings in a wet climate condition due to the large surpluses that must be stored and/or treated.

In a dry condition, it is better to use the water recovery model developed by Wels & Robertson (2003) because precipitation is very low. The amount of water due to direct precipitation into the pond, and runoff from beaches and catchment areas surrounding the TMF (even with a high coefficient of runoff), would constitute a very small portion of total water input even during the wettest months. It is recommended the water balance be developed by adding the refinements to the developed model in this research. RGC Water Recovery Model and Consolidation/ Seepage Model can be used.

Future Research

For future research, the influence of different input assumptions distributions such as Beta distribution on the water balance could be studied.

For specific case studies, a mass balance could be added to the model to calculate the required capacity of the impoundments for design purposes. A chemical balance could be done to make decisions about how to best recycle, treat or repurpose the excess water.

Mine water management does not only include the TMF water balance, therfore the water circulations in other units of the mine and processing plant could be added to the model.

An analysis could be done to study the effect of the size of the areas of active and inactive beaches on evaporation, seepage, rewetting and entrainment losses.

In a wet climate, an economical analysis could be done for a specific case study to evaluate the financial benefits of implementing a reservoir.

Consideration of extreme storm events in the models is crucial because these events are important in calculating the embankment capacity and the water levels required to comply with the regulations. Further analyses could be done to investigate the most appropriate way to implement the evaluation of the extreme storm events on the overall water balance outcomes.

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[1] In the original citation the authors' name were mistakenly entered Oliveira-Filho, W. & van Zyl, D.
[2] In the original citation the authors' name were mistakenly entered Oliveira-Filho, W. & van Zyl, D.

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Appendices

Appendix A Data input and methodology

Table A.1 Average monthly rainfall obtained through ClimateBC from 1970 to 2013 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970	240	116	116	79	119	63	111	121	282	328	171	175
1971	590	167	179	134	47	92	20	148	184	439	486	249
1972	371	315	196	133	70	91	80	114	242	464	400	233
1973	530	138	167	50	93	77	73	97	327	294	194	229
1974	439	239	170	96	95	116	89	68	226	734	297	376
1975	398	135	112	54	72	108	97	125	168	242	385	286
1976	557	174	168	82	130	116	94	126	243	333	268	432
1977	342	168	219	91	63	122	91	102	134	310	381	186
1978	138	108	126	77	51	40	35	200	221	426	596	377
1979	260	246	143	36	129	133	67	56	289	246	232	560
1980	290	163	207	93	84	46	155	166	265	348	375	569
1981	273	207	160	188	125	118	34	121	267	291	497	206
1982	903	149	183	77	95	18	74	133	147	377	280	158
1983	340	162	48	67	97	104	139	162	335	289	173	94
1984	557	215	144	71	73	98	96	194	175	364	239	287
1985	297	257	183	80	117	65	58	88	252	364	324	277
1986	417	95	183	79	103	60	118	93	178	614	464	194
1987	385	210	129	104	159	156	51	119	341	290	559	309
1988	368	184	195	83	117	91	150	133	219	287	412	264
1989	632	10	116	36	59	34	55	94	186	372	601	477
1990	378	237	142	87	93	121	65	134	139	430	332	514
1991	270	162	115	65	80	116	131	289	311	506	694	671
1992	341	130	137	314	111	53	63	95	434	285	322	406
1993	254	250	103	62	140	128	101	91	122	342	388	277
1994	718	197	188	115	140	86	122	120	400	337	337	230
1995	105	204	156	101	65	57	104	181	139	345	462	282
1996	257	379	199	138	46	124	83	218	215	353	221	251
1997	328	333	295	171	64	148	153	189	175	413	226	423
1998	258	190	133	221	70	101	88	235	185	377	194	349
1999	400	248	147	167	186	139	78	224	249	324	337	367
2000	316	125	221	243	82	81	179	271	340	279	286	272
2001	479	134	197	112	181	139	131	284	328	329	280	225
2002	255	280	135	143	113	139	137	179	299	206	279	278
2003	299	192	212	116	123	142	92	287	328	391	276	273

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	362	144	176	150	63	81	88	139	259	333	330	317
2005	415	303	258	142	49	91	191	195	183	346	395	297
2006	319	153	108	198	101	90	121	161	279	272	266	423
2007	345	237	235	204	82	88	141	175	190	507	230	267
2008	247	311	194	124	129	89	161	312	178	336	360	262
2009	370	207	164	144	87	77	91	216	317	295	293	145
2010	324	187	261	123	73	149	83	161	317	445	261	259
2011	357	128	135	103	93	76	157	252	271	315	232	296
2012	378	174	183	78	154	172	177	132	276	199	202	294
2013	314	334	117	152	110	89	100	196	217	236	332	456

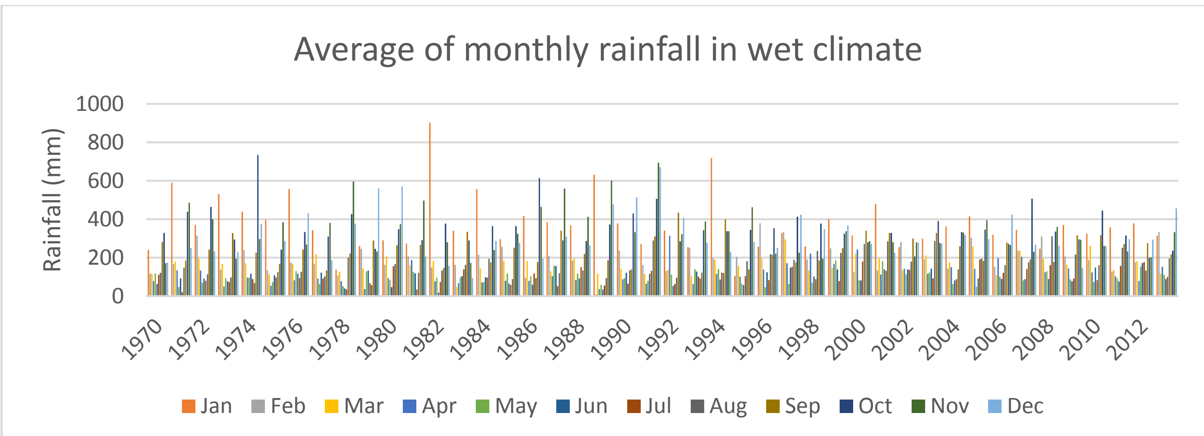

Figure A.1 Distribution of average monthly rainfall obtained through ClimateBC over the period of 1970-2013 (mm)

Table A.2 Average monthly snowfall obtained through ClimateBC over the period of 1970-2013 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970	223	69	94	59	41	3	5	6	22	37	386	112
1971	561	150	172	106	20	7	0	8	54	114	131	165
1972	366	307	186	121	28	11	2	4	26	285	322	242
1973	480	129	149	38	29	7	3	5	41	287	234	220
1974	429	209	162	58	31	12	4	2	52	182	185	188
1975	351	132	109	45	28	10	3	6	19	310	189	211
1976	430	166	163	64	66	13	5	5	21	89	298	227
1977	265	76	190	46	15	7	3	2	31	151	137	254
1978	125	87	114	37	14	1	1	7	17	119	308	181
1979	252	244	129	25	44	12	1	1	35	110	492	340
1980	275	121	191	51	13	1	6	6	31	56	137	409
1981	115	160	113	137	13	8	1	3	37	67	144	514
1982	886	144	169	67	38	0	2	5	30	85	254	164
1983	203	99	39	22	11	3	4	8	15	154	232	126
1984	361	123	90	37	22	7	4	9	59	120	103	91
1985	167	236	166	65	38	7	1	5	31	202	201	277
1986	244	91	132	62	37	3	3	4	36	226	319	215
1987	259	145	120	75	52	10	1	3	23	76	342	111
1988	316	154	159	45	34	7	8	5	41	90	246	162
1989	540	9	111	20	13	1	1	2	33	60	208	229
1990	273	230	134	46	14	3	1	2	10	105	354	167
1991	249	105	114	38	13	3	3	6	8	191	314	470
1992	127	112	125	193	36	1	1	2	21	280	526	219
1993	231	229	100	25	8	3	2	2	70	122	225	372
1994	467	196	168	53	29	2	2	1	7	38	282	100
1995	81	189	154	48	6	1	2	4	35	70	302	188
1996	254	341	196	87	15	4	2	6	11	94	397	179
1997	291	246	292	111	9	3	3	3	23	163	205	241
1998	223	119	124	111	5	1	1	6	11	145	157	103
1999	336	225	142	119	82	5	2	5	16	74	158	273
2000	280	112	204	184	30	2	3	8	24	63	259	133
2001	227	127	194	79	89	8	4	6	30	83	187	205
2002	170	262	135	115	37	3	4	5	28	116	232	163
2003	143	176	210	70	39	4	1	8	28	36	159	112
2004	324	104	166	65	8	0	1	2	27	60	245	143
2005	361	261	233	57	4	1	5	4	30	125	245	148
2006	195	146	107	135	26	1	2	4	16	96	271	120
2007	166	224	233	152	21	2	2	3	18	78	262	134
2008	203	294	187	101	21	5	5	7	16	141	190	237

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	302	201	163	99	24	1	1	4	13	79	259	252
2010	208	115	225	65	11	4	1	2	20	99	230	132
2011	237	125	134	79	16	2	3	7	24	102	214	236
2012	300	137	179	38	57	6	3	3	21	76	211	124
2013	149	205	116	127	20	1	1	3	22	114	186	258

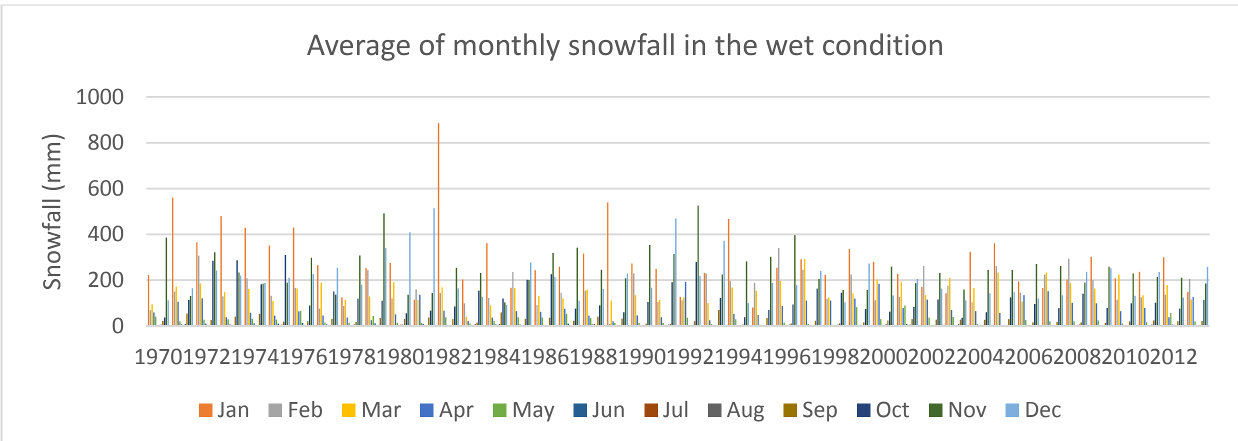

Figure A.2 Distribution of average monthly snowfall obtained through ClimateBC over the period of 1970-2013 (mm)

Table A.3 Average monthly pan evaporation obtained through ClimateBC over the period of 1970-2013 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970	0	0	0	33	50	77	68	62	30	14	0	0
1971	0	0	0	0	52	69	81	50	35	0	0	0
1972	0	0	0	0	63	69	87	67	33	14	0	0
1973	0	0	0	34	59	71	77	65	35	12	0	0
1974	0	0	0	30	55	63	76	78	40	14	0	0
1975	0	0	0	0	59	65	70	59	34	12	0	0
1976	0	0	0	31	45	67	68	60	33	14	0	0
1977	0	0	0	32	61	69	71	84	35	13	0	0
1978	0	0	0	36	56	87	85	67	34	11	0	0
1979	0	0	0	38	47	63	80	81	33	14	0	0
1980	0	0	0	32	64	88	64	65	31	14	0	0
1981	0	0	0	26	68	68	85	74	32	14	0	0
1982	0	0	0	0	55	97	79	63	37	12	0	0
1983	0	0	0	43	61	70	72	57	31	12	0	0
1984	0	0	0	36	56	67	68	60	35	12	0	0
1985	0	0	0	0	62	74	89	63	35	11	0	0
1986	0	0	0	0	57	83	74	72	41	14	0	0
1987	0	0	0	30	52	76	89	78	31	14	0	0
1988	0	0	0	38	54	66	62	63	33	14	0	0
1989	0	0	0	42	60	91	81	67	37	12	0	0
1990	0	0	0	42	64	79	95	71	36	13	0	0
1991	0	0	0	41	68	85	72	66	31	13	0	0
1992	0	0	0	37	59	92	87	74	28	14	0	0
1993	0	0	0	43	78	78	84	75	42	17	0	0
1994	0	0	0	42	64	77	83	79	32	14	0	0
1995	0	0	0	45	75	91	84	71	36	14	0	0
1996	0	0	0	39	66	82	82	58	33	13	0	0
1997	0	0	0	42	74	82	73	72	36	13	0	0
1998	0	0	0	41	78	98	87	65	37	14	0	0
1999	0	0	0	38	53	78	83	69	33	14	0	0
2000	0	0	0	35	61	82	74	63	35	14	0	0
2001	0	0	0	39	53	77	69	68	33	14	0	0
2002	0	0	0	0	59	87	69	63	34	15	0	0
2003	0	0	0	41	61	79	82	67	32	17	0	0
2004	0	0	0	43	70	101	87	79	34	14	0	0
2005	0	0	0	43	75	87	70	68	36	14	0	0
2006	0	0	0	40	64	93	87	68	37	16	0	0
2007	0	0	0	35	64	82	79	72	34	13	0	0
2008	0	0	0	0	64	81	74	67	37	15	0	0

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	0	0	0	39	65	93	97	71	35	15	0	0
2010	0	0	0	42	71	84	89	77	38	16	0	0
2011	0	0	0	38	69	84	78	66	35	15	0	0
2012	0	0	0	43	57	80	87	70	39	14	0	0
2013	0	0	0	0	68	93	88	72	40	16	0	0

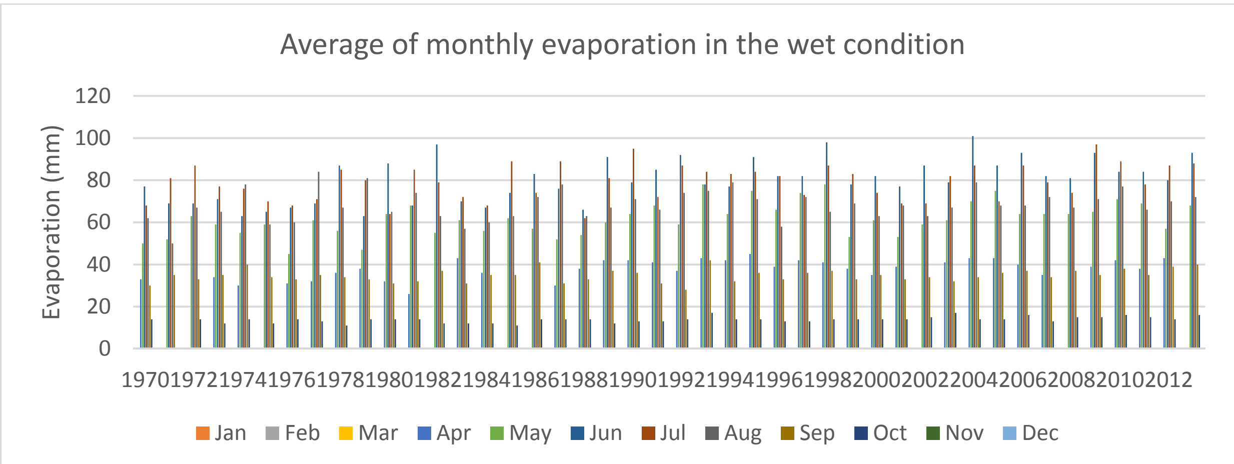

Figure A.3 Distribution of average monthly evaporation obtained through ClimateBC over the period of 1970-2013 (mm)

Table A.4 Rainfall (mm/month) over the period of 1978-2012 recorded in Project Site Weather Station (EMA BN) (after Wade, 2014)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1979	0	0	0	15.2	84.9	65.7	47.3	30.1	38.5	0	0	0
1980	0	0	0	82.2	39.3	14.4	43.3	17.6	11.2	0	0	0
1981	19.2	0	12.8	24	33.7	56.1	6.4	0	27.2	0	0	0
1982	0	0	0	16	33.7	17.6	0	20.8	32.1	27.2	0	0
1983	0	0	27.2	0	32.1	0	0	4.8	0	14.4	0	0
1984	0	14.4	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	138.5	0	0	4	64.9	0	2.4
1986	0	0	0	46.2	14.4	27.2	6.4	0	28.8	51.3	62.5	0
1987	0	0	0	0	24	109	91.4	0	0	0	0	0.8
1988	0	0	0	0	4.8	4.8	0	0	0	0	0	0
1989	0	0	0	0	0	0	7.2	42.5	3.2	0	0	1.6
1990	0	0	0	30.1	47.6	20.8	0	0	6.4	48.1	0	0
1991	46	0	2.4	6.4	25.6	46.5	4.8	0	51.3	8	0	17.6
1992	0	14.4	22.4	54.5	122.6	68.9	23.9	8	33.7	16	222.8	0
1993	0	0	44.9	24	57.7	62.5	41.7	35.3	9.6	24	17.6	25.6
1994	97.8	0	34.5	3.2	34.5	36.9	83.3	0	17.6	4.8	4	13.6
1995	5.6	52.7	72.4	16.8	25.6	34.5	12.8	13.6	0	31.7	6.4	5.6
1996	8	23.7	0.8	8.5	15.7	22.4	6.6	9.3	2.9	23.2	1.6	0
1997	23.4	5.8	6.4	43.9	26.3	53.7	38.5	14.4	58.7	17.6	7.7	4.8
1998	0	0	0	77.4	80.8	34.1	14.6	2.1	1.1	0	30.6	4.2
1999	9.3	4.8	18.3	2.4	9.1	6.3	0.8	59.6	30.6	25.3	1.6	2.2
2000	2.9	6.4	21.6	0	27.2	20.4	27.1	0	48.1	23.7	28.4	0
2001	0	0	45.5	4.5	11.9	10.9	21.2	39.1	20.5	7.4	0	0
2002	17.3	9.3	26.9	4.2	51.4	0	11.9	46.5	8.3	5.8	7.2	4
2003	22.1	0	21.2	3.2	46.8	32.4	2.2	30.1	44.9	54.8	34.6	3.8
2004	4.2	0.6	3.5	34	29.8	45.8	20.2	24	22.4	5.6	36.7	6.6
2005	11.9	9	5.1	20.8	29.5	47.4	7.4	19.9	8.7	4.2	0	3.8
2006	2.2	21.5	1.3	29.2	28.2	22.8	46.2	12.7	9.6	3.8	0.6	0.2
2007	0.2	2.4	1.3	0.5	10.4	1	3.2	1	18	1.6	4.2	0
2008	0	2.7	5.8	19.2	3.5	6.3	11.4	2.54	4.6	12.4	4.8	14
2009	4.3	9.7	3.3	10.9	26.2	2	4.8	13.7	6.1	15.2	5.8	21.3
2010	9.9	51.8	12.2	7.4	1.5	18	0.5	8.6	16.3	38.1	19.1	78.7
2011	7.4	11.4	15	31.8	22.4	13.5	3	10.7	16.8	30.2	27.4	21.3
2012	10.9	32.8	18.8	5.8	32.5	6.1	9.4	1	10.7	10.2	16	32.5

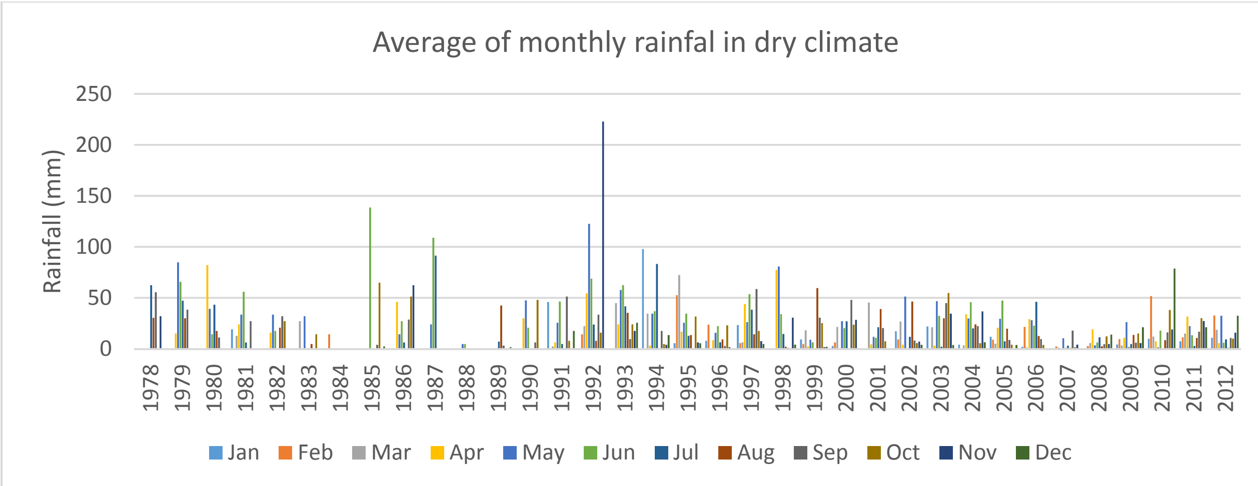

Figure A.4 Distribution of average monthly rainfall over the period of 1978-2012 recorded in Project Site Weather Station (EMA BN) (mm)

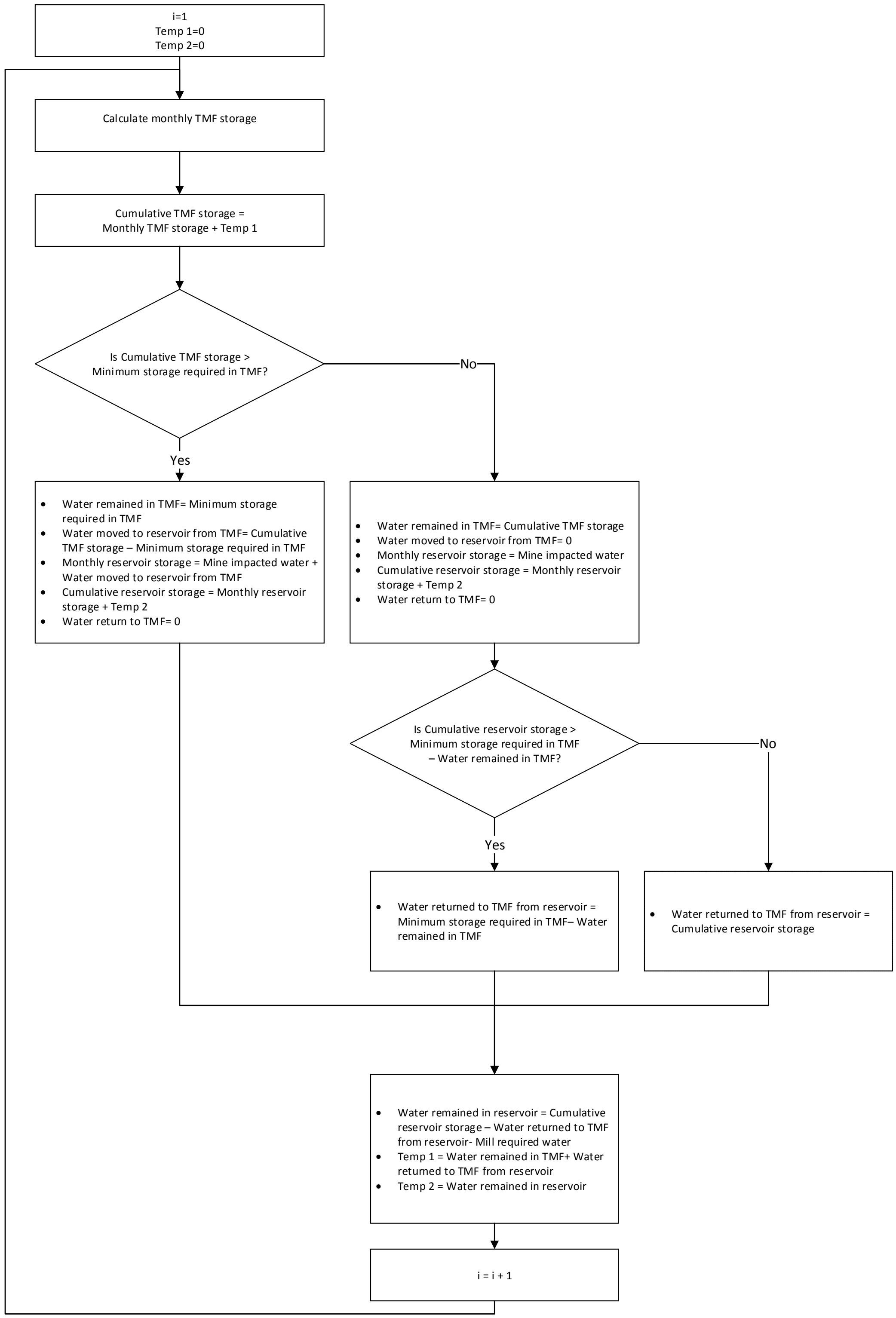

Figure A.5 Flow chart of water balance simulation in the wet condition

Appendix B Results of wet climate simulation

B.1 Lined impoundment

Table B.1 Deterministic model for solids content of 60% in the wet condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)			Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Total Water Input	Evaporation	Entrainment	Total Water Output	Water with tailings	Total mill required water	Monthly change in storage	Water moved to reservoir	Cumulative change in storage	Water remained in TMF	Mine impacted water runoff	Monthly reservoir storage	Cumulative reservoir storage	Water returned to TMF from reservoir	Water remained in reservoir	Water remained in TMF+ Water returned to TMF from reservoir
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	1,135,557.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	1,016,760.2	16,760.2	1,016,760.2	1,000,000.0	33,578.1	50,338.3	50,338.3	0.0	0.0	1,000,000.0
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	705,218.0	0.0	107,300.3	107,300.3	250,600.0	250,600.0	597,917.7	597,917.7	1,597,917.7	1,000,000.0	17,789.4	615,707.1	615,707.1	0.0	365,107.1	1,000,000.0
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	661,918.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	543,121.2	543,121.2	1,543,121.2	1,000,000.0	15,044.4	558,165.6	923,272.7	0.0	645,822.7	1,000,000.0
	APR	30.0	117.8	60.6	268,500.0	410,297.0	678,797.0	48,622.0	114,964.6	163,586.6	268,500.0	268,500.0	515,210.4	515,210.4	1,515,210.4	1,000,000.0	16,055.1	531,265.5	1,177,088.2	0.0	908,588.2	1,000,000.0
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	777,355.0	99,385.3	118,796.8	218,182.1	277,450.0	277,450.0	559,172.9	559,172.9	1,559,172.9	1,000,000.0	19,561.5	578,734.4	1,487,322.6	0.0	1,209,872.6	1,000,000.0
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	920,826.0	128,977.1	114,964.6	243,941.7	268,500.0	268,500.0	676,884.3	676,884.3	1,676,884.3	1,000,000.0	25,525.8	702,410.1	1,912,282.7	0.0	1,643,782.7	1,000,000.0
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	600,393.0	127,560.3	118,796.8	246,357.1	277,450.0	277,450.0	354,035.9	354,035.9	1,354,035.9	1,000,000.0	12,636.9	366,672.8	2,010,455.5	0.0	1,733,005.5	1,000,000.0
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	656,835.0	109,995.2	118,796.8	228,792.0	277,450.0	277,450.0	428,043.0	428,043.0	1,428,043.0	1,000,000.0	14,845.5	442,888.5	2,175,894.0	0.0	1,898,444.0	1,000,000.0
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	853,804.0	55,915.3	114,964.6	170,879.9	268,500.0	268,500.0	682,924.1	682,924.1	1,682,924.1	1,000,000.0	22,903.2	705,827.3	2,604,271.3	0.0	2,335,771.3	1,000,000.0
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	1,093,582.0	21,735.0	118,796.8	140,531.8	277,450.0	277,450.0	953,050.2	953,050.2	1,953,050.2	1,000,000.0	31,935.6	984,985.8	3,320,757.1	0.0	3,043,307.1	1,000,000.0
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	1,045,739.0	0.0	114,964.6	114,964.6	268,500.0	268,500.0	930,774.4	930,774.4	1,930,774.4	1,000,000.0	30,413.7	961,188.1	4,004,495.2	0.0	3,735,995.2	1,000,000.0
Year 1	DEC	31.0	313.0	0.0	277,450.0	719,900.0	997,350.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	878,553.2	878,553.2	1,878,553.2	1,000,000.0	28,170.0	906,723.2	4,642,718.4	0.0	4,365,268.4	1,000,000.0
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	1,135,557.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	1,016,760.2	1,016,760.2	2,016,760.2	1,000,000.0	33,578.1	1,050,338.3	5,415,606.7	0.0	5,138,156.7	1,000,000.0
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	705,218.0	0.0	107,300.3	107,300.3	250,600.0	250,600.0	597,917.7	597,917.7	1,597,917.7	1,000,000.0	17,789.4	615,707.1	5,753,863.8	0.0	5,503,263.8	1,000,000.0
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	661,918.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	543,121.2	543,121.2	1,543,121.2	1,000,000.0	15,044.4	558,165.6	6,061,429.4	0.0	5,783,979.4	1,000,000.0
	APR	30.0	117.8	60.6	268,500.0	410,297.0	678,797.0	48,622.0	114,964.6	163,586.6	268,500.0	268,500.0	515,210.4	515,210.4	1,515,210.4	1,000,000.0	16,055.1	531,265.5	6,315,244.9	0.0	6,046,744.9	1,000,000.0
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	777,355.0	99,385.3	118,796.8	218,182.1	277,450.0	277,450.0	559,172.9	559,172.9	1,559,172.9	1,000,000.0	19,561.5	578,734.4	6,625,479.3	0.0	6,348,029.3	1,000,000.0
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	920,826.0	128,977.1	114,964.6	243,941.7	268,500.0	268,500.0	676,884.3	676,884.3	1,676,884.3	1,000,000.0	25,525.8	702,410.1	7,050,439.4	0.0	6,781,939.4	1,000,000.0
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	600,393.0	127,560.3	118,796.8	246,357.1	277,450.0	277,450.0	354,035.9	354,035.9	1,354,035.9	1,000,000.0	12,636.9	366,672.8	7,148,612.2	0.0	6,871,162.2	1,000,000.0
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	656,835.0	109,995.2	118,796.8	228,792.0	277,450.0	277,450.0	428,043.0	428,043.0	1,428,043.0	1,000,000.0	14,845.5	442,888.5	7,314,050.7	0.0	7,036,600.7	1,000,000.0
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	853,804.0	55,915.3	114,964.6	170,879.9	268,500.0	268,500.0	682,924.1	682,924.1	1,682,924.1	1,000,000.0	22,903.2	705,827.3	7,742,428.0	0.0	7,473,928.0	1,000,000.0
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	1,093,582.0	21,735.0	118,796.8	140,531.8	277,450.0	277,450.0	953,050.2	953,050.2	1,953,050.2	1,000,000.0	31,935.6	984,985.8	8,458,913.8	0.0	8,181,463.8	1,000,000.0
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	1,045,739.0	0.0	114,964.6	114,964.6	268,500.0	268,500.0	930,774.4	930,774.4	1,930,774.4	1,000,000.0	30,413.7	961,188.1	9,142,651.9	0.0	8,874,151.9	1,000,000.0
Year 2	DEC	31.0	313.0	0.0	277,450.0	719,900.0	997,350.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	878,553.2	878,553.2	1,878,553.2	1,000,000.0	28,170.0	906,723.2	9,780,875.1	0.0	9,503,425.1	1,000,000.0
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	1,135,557.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	1,016,760.2	1,016,760.2	2,016,760.2	1,000,000.0	33,578.1	1,050,338.3	10,553,763.4	0.0	10,276,313.4	1,000,000.0
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	705,218.0	0.0	107,300.3	107,300.3	250,600.0	250,600.0	597,917.7	597,917.7	1,597,917.7	1,000,000.0	17,789.4	615,707.1	10,892,020.5	0.0	10,641,420.5	1,000,000.0
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	661,918.0	0.0	118,796.8	118,796.8	277,450.0	277,450.0	543,121.2	543,121.2	1,543,121.2	1,000,000.0	15,044.4	558,165.6	11,199,586.1	0.0	10,922,136.1	1,000,000.0
	APR	30.0	117.8	60.6	268,500.0	410,297.0	678,797.0	48,622.0	114,964.6	163,586.6	268,500.0	268,500.0	515,210.4	515,210.4	1,515,210.4	1,000,000.0	16,055.1	531,265.5	11,453,401.6	0.0	11,184,901.6	1,000,000.0
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	777,355.0	99,385.3	118,796.8	218,182.1	277,450.0	277,450.0	559,172.9	559,172.9	1,559,172.9	1,000,000.0	19,561.5	578,734.4	11,763,636.0	0.0	11,486,186.0	1,000,000.0
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	920,826.0	128,977.1	114,964.6	243,941.7	268,500.0	268,500.0	676,884.3	676,884.3	1,676,884.3	1,000,000.0	25,525.8	702,410.1	12,188,596.1	0.0	11,920,096.1	1,000,000.0
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	600,393.0	127,560.3	118,796.8	246,357.1	277,450.0	277,450.0	354,035.9	354,035.9	1,354,035.9	1,000,000.0	12,636.9	366,672.8	12,286,768.9	0.0	12,009,318.9	1,000,000.0
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	656,835.0	109,995.2	118,796.8	228,792.0	277,450.0	277,450.0	428,043.0	428,043.0	1,428,043.0	1,000,000.0	14,845.5	442,888.5	12,452,207.4	0.0	12,174,757.4	1,000,000.0
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	853,804.0	55,915.3	114,964.6	170,879.9	268,500.0	268,500.0	682,924.1	682,924.1	1,682,924.1	1,000,000.0	22,903.2	705,827.3	12,880,584.7	0.0	12,612,084.7	1,000,000.0
Year 3	OCT	31.0	354.8	0.0	277,450.0	816,132.0	1,093,582.0	21,735.0	118,796.8	140,531.8	277,450.0	277,450.0	953,050.2	953,050.2	1,953,050.2	1,000,000.0	31,935.6	984,985.8	13,597,070.5	0.0	13,319,620.5	1,000,000.0

			Precipitation water (mm/month)		Water in (m³)			Water out (m³)			Mill required water (m³)		Water in the TMF (m³)					Reservoir storage (m³)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water moved to reservoir**	**Cumulative change in storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Water returned to TMF from reservoir**	**Water remained in reservoir**	**Water remained in TMF+ Water returned to TMF from reservoir**
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	930,774.4	930,774.4	1,930,774.4	**1,000,000.0**	30,413.7	**961,188.1**	**14,280,808.6**	**0.0**	**14,012,308.6**	**1,000,000.0**
	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	878,553.2	878,553.2	1,878,553.2	**1,000,000.0**	28,170.0	**906,723.2**	**14,919,031.8**	**0.0**	**14,641,581.8**	**1,000,000.0**
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	**1,135,557.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	1,016,760.2	1,016,760.2	2,016,760.2	**1,000,000.0**	33,578.1	**1,050,338.3**	**15,691,920.1**	**0.0**	**15,414,470.1**	**1,000,000.0**
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	**705,218.0**	0.0	107,300.3	**107,300.3**	250,600.0	**250,600.0**	597,917.7	597,917.7	1,597,917.7	**1,000,000.0**	17,789.4	**615,707.1**	**16,030,177.2**	**0.0**	**15,779,577.2**	**1,000,000.0**
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	**661,918.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	543,121.2	543,121.2	1,543,121.2	**1,000,000.0**	15,044.4	**558,165.6**	**16,337,742.8**	**0.0**	**16,060,292.8**	**1,000,000.0**
	APR	30.0	117.8	60.6	268,500.0	410,297.0	**678,797.0**	48,622.0	114,964.6	**163,586.6**	268,500.0	**268,500.0**	515,210.4	515,210.4	1,515,210.4	**1,000,000.0**	16,055.1	**531,265.5**	**16,591,558.3**	**0.0**	**16,323,058.3**	**1,000,000.0**
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	**777,355.0**	99,385.3	118,796.8	**218,182.1**	277,450.0	**277,450.0**	559,172.9	559,172.9	1,559,172.9	**1,000,000.0**	19,561.5	**578,734.4**	**16,901,792.7**	**0.0**	**16,624,342.7**	**1,000,000.0**
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	**920,826.0**	128,977.1	114,964.6	**243,941.7**	268,500.0	**268,500.0**	676,884.3	676,884.3	1,676,884.3	**1,000,000.0**	25,525.8	**702,410.1**	**17,326,752.8**	**0.0**	**17,058,252.8**	**1,000,000.0**
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	**600,393.0**	127,560.3	118,796.8	**246,357.1**	277,450.0	**277,450.0**	354,035.9	354,035.9	1,354,035.9	**1,000,000.0**	12,636.9	**366,672.8**	**17,424,925.6**	**0.0**	**17,147,475.6**	**1,000,000.0**
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	**656,835.0**	109,995.2	118,796.8	**228,792.0**	277,450.0	**277,450.0**	428,043.0	428,043.0	1,428,043.0	**1,000,000.0**	14,845.5	**442,888.5**	**17,590,364.1**	**0.0**	**17,312,914.1**	**1,000,000.0**
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	**853,804.0**	55,915.3	114,964.6	**170,879.9**	268,500.0	**268,500.0**	682,924.1	682,924.1	1,682,924.1	**1,000,000.0**	22,903.2	**705,827.3**	**18,018,741.4**	**0.0**	**17,750,241.4**	**1,000,000.0**
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	**1,093,582.0**	21,735.0	118,796.8	**140,531.8**	277,450.0	**277,450.0**	953,050.2	953,050.2	1,953,050.2	**1,000,000.0**	31,935.6	**984,985.8**	**18,735,227.2**	**0.0**	**18,457,777.2**	**1,000,000.0**
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	930,774.4	930,774.4	1,930,774.4	**1,000,000.0**	30,413.7	**961,188.1**	**19,418,965.3**	**0.0**	**19,150,465.3**	**1,000,000.0**
Year 4	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	878,553.2	878,553.2	1,878,553.2	**1,000,000.0**	28,170.0	**906,723.2**	**20,057,188.5**	**0.0**	**19,779,738.5**	**1,000,000.0**
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	**1,135,557.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	1,016,760.2	1,016,760.2	2,016,760.2	**1,000,000.0**	33,578.1	**1,050,338.3**	**20,830,076.8**	**0.0**	**20,552,626.8**	**1,000,000.0**
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	**705,218.0**	0.0	107,300.3	**107,300.3**	250,600.0	**250,600.0**	597,917.7	597,917.7	1,597,917.7	**1,000,000.0**	17,789.4	**615,707.1**	**21,168,333.9**	**0.0**	**20,917,733.9**	**1,000,000.0**
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	**661,918.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	543,121.2	543,121.2	1,543,121.2	**1,000,000.0**	15,044.4	**558,165.6**	**21,475,899.5**	**0.0**	**21,198,449.5**	**1,000,000.0**
	APR	30.0	117.8	60.6	268,500.0	410,297.0	**678,797.0**	48,622.0	114,964.6	**163,586.6**	268,500.0	**268,500.0**	515,210.4	515,210.4	1,515,210.4	**1,000,000.0**	16,055.1	**531,265.5**	**21,729,715.0**	**0.0**	**21,461,215.0**	**1,000,000.0**
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	**777,355.0**	99,385.3	118,796.8	**218,182.1**	277,450.0	**277,450.0**	559,172.9	559,172.9	1,559,172.9	**1,000,000.0**	19,561.5	**578,734.4**	**22,039,949.4**	**0.0**	**21,762,499.4**	**1,000,000.0**
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	**920,826.0**	128,977.1	114,964.6	**243,941.7**	268,500.0	**268,500.0**	676,884.3	676,884.3	1,676,884.3	**1,000,000.0**	25,525.8	**702,410.1**	**22,464,909.5**	**0.0**	**22,196,409.5**	**1,000,000.0**
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	**600,393.0**	127,560.3	118,796.8	**246,357.1**	277,450.0	**277,450.0**	354,035.9	354,035.9	1,354,035.9	**1,000,000.0**	12,636.9	**366,672.8**	**22,563,082.3**	**0.0**	**22,285,632.3**	**1,000,000.0**
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	**656,835.0**	109,995.2	118,796.8	**228,792.0**	277,450.0	**277,450.0**	428,043.0	428,043.0	1,428,043.0	**1,000,000.0**	14,845.5	**442,888.5**	**22,728,520.8**	**0.0**	**22,451,070.8**	**1,000,000.0**
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	**853,804.0**	55,915.3	114,964.6	**170,879.9**	268,500.0	**268,500.0**	682,924.1	682,924.1	1,682,924.1	**1,000,000.0**	22,903.2	**705,827.3**	**23,156,898.1**	**0.0**	**22,888,398.1**	**1,000,000.0**
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	**1,093,582.0**	21,735.0	118,796.8	**140,531.8**	277,450.0	**277,450.0**	953,050.2	953,050.2	1,953,050.2	**1,000,000.0**	31,935.6	**984,985.8**	**23,873,383.9**	**0.0**	**23,595,933.9**	**1,000,000.0**
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	930,774.4	930,774.4	1,930,774.4	**1,000,000.0**	30,413.7	**961,188.1**	**24,557,122.0**	**0.0**	**24,288,622.0**	**1,000,000.0**
Year 5	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	878,553.2	878,553.2	1,878,553.2	**1,000,000.0**	28,170.0	**906,723.2**	**25,195,345.2**	**0.0**	**24,917,895.2**	**1,000,000.0**

Table B.2 Deterministic model for solids content of 70% in the wet condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)			Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Total Water Input	Evaporation	Entrainment	Total Water Output	Water with tailings	Total mill required water	Monthly change in storage	Water moved to reservoir	Cumulative change in storage	Water remained in TMF	Mine impacted water runoff	Monthly reservoir storage	Cumulative reservoir storage	Water returned to TMF from reservoir	Water remained in reservoir	Water remained in TMF+ Water returned to TMF from reservoir
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	1,036,467.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	941,362.1	941,362.1	941,362.1	0.0	33,578.1	974,940.2	974,940.2	0.0	796,579.5	0.0
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	615,718.0	0.0	85,901.8	85,901.8	161,100.0	161,100.0	529,816.2	529,816.2	529,816.2	0.0	17,789.4	547,605.6	1,344,185.1	0.0	1,183,085.1	0.0
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	562,828.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	467,723.1	467,723.1	467,723.1	0.0	15,044.4	482,767.5	1,665,852.6	0.0	1,487,491.9	0.0
	APR	30.0	117.8	60.6	172,607.1	410,297.0	582,904.1	41,676.0	92,037.7	133,713.7	172,607.1	172,607.1	449,190.4	449,190.4	449,190.4	0.0	16,055.1	465,245.5	1,952,737.4	0.0	1,780,130.3	0.0
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	678,265.7	85,187.4	95,105.6	180,293.0	178,360.7	178,360.7	497,972.7	497,972.7	497,972.7	0.0	19,561.5	517,534.2	2,297,664.5	0.0	2,119,303.8	0.0
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	824,933.1	110,551.8	92,037.7	202,589.5	172,607.1	172,607.1	622,343.6	622,343.6	622,343.6	0.0	25,525.8	647,869.4	2,767,173.2	0.0	2,594,566.1	0.0
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	501,303.7	109,337.4	95,105.6	204,443.0	178,360.7	178,360.7	296,860.7	296,860.7	296,860.7	0.0	12,636.9	309,497.6	2,904,063.7	0.0	2,725,703.0	0.0
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	557,745.7	94,281.6	95,105.6	189,387.2	178,360.7	178,360.7	368,358.5	368,358.5	368,358.5	0.0	14,845.5	383,204.0	3,108,907.0	0.0	2,930,546.3	0.0
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	757,911.1	47,927.4	92,037.7	139,965.1	172,607.1	172,607.1	617,946.0	617,946.0	617,946.0	0.0	22,903.2	640,849.2	3,571,395.5	0.0	3,398,788.4	0.0
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	994,492.7	18,630.0	95,105.6	113,735.6	178,360.7	178,360.7	880,757.1	880,757.1	880,757.1	0.0	31,935.6	912,692.7	4,311,481.1	0.0	4,133,120.4	0.0
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	949,846.1	0.0	92,037.7	92,037.7	172,607.1	172,607.1	857,808.4	857,808.4	857,808.4	0.0	30,413.7	888,222.1	5,021,342.5	0.0	4,848,735.4	0.0
Year 1	DEC	31.0	313.0	0.0	178,360.7	719,900.0	898,260.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	803,155.1	803,155.1	803,155.1	0.0	28,170.0	831,325.1	5,680,060.5	0.0	5,501,699.8	0.0
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	1,036,467.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	941,362.1	941,362.1	941,362.1	0.0	33,578.1	974,940.2	6,476,640.0	0.0	6,298,279.3	0.0
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	615,718.0	0.0	85,901.8	85,901.8	161,100.0	161,100.0	529,816.2	529,816.2	529,816.2	0.0	17,789.4	547,605.6	6,845,884.9	0.0	6,684,784.9	0.0
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	562,828.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	467,723.1	467,723.1	467,723.1	0.0	15,044.4	482,767.5	7,167,552.4	0.0	6,989,191.7	0.0
	APR	30.0	117.8	60.6	172,607.1	410,297.0	582,904.1	41,676.0	92,037.7	133,713.7	172,607.1	172,607.1	449,190.4	449,190.4	449,190.4	0.0	16,055.1	465,245.5	7,454,437.2	0.0	7,281,830.1	0.0
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	678,265.7	85,187.4	95,105.6	180,293.0	178,360.7	178,360.7	497,972.7	497,972.7	497,972.7	0.0	19,561.5	517,534.2	7,799,364.3	0.0	7,621,003.6	0.0
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	824,933.1	110,551.8	92,037.7	202,589.5	172,607.1	172,607.1	622,343.6	622,343.6	622,343.6	0.0	25,525.8	647,869.4	8,268,873.0	0.0	8,096,265.9	0.0
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	501,303.7	109,337.4	95,105.6	204,443.0	178,360.7	178,360.7	296,860.7	296,860.7	296,860.7	0.0	12,636.9	309,497.6	8,405,763.5	0.0	8,227,402.8	0.0
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	557,745.7	94,281.6	95,105.6	189,387.2	178,360.7	178,360.7	368,358.5	368,358.5	368,358.5	0.0	14,845.5	383,204.0	8,610,606.8	0.0	8,432,246.1	0.0
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	757,911.1	47,927.4	92,037.7	139,965.1	172,607.1	172,607.1	617,946.0	617,946.0	617,946.0	0.0	22,903.2	640,849.2	9,073,095.3	0.0	8,900,488.2	0.0
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	994,492.7	18,630.0	95,105.6	113,735.6	178,360.7	178,360.7	880,757.1	880,757.1	880,757.1	0.0	31,935.6	912,692.7	9,813,180.9	0.0	9,634,820.2	0.0
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	949,846.1	0.0	92,037.7	92,037.7	172,607.1	172,607.1	857,808.4	857,808.4	857,808.4	0.0	30,413.7	888,222.1	10,523,042.3	0.0	10,350,435.2	0.0
Year 2	DEC	31.0	313.0	0.0	178,360.7	719,900.0	898,260.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	803,155.1	803,155.1	803,155.1	0.0	28,170.0	831,325.1	11,181,760.3	0.0	11,003,399.6	0.0
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	1,036,467.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	941,362.1	941,362.1	941,362.1	0.0	33,578.1	974,940.2	11,978,339.8	0.0	11,799,979.1	0.0
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	615,718.0	0.0	85,901.8	85,901.8	161,100.0	161,100.0	529,816.2	529,816.2	529,816.2	0.0	17,789.4	547,605.6	12,347,584.7	0.0	12,186,484.7	0.0
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	562,828.7	0.0	95,105.6	95,105.6	178,360.7	178,360.7	467,723.1	467,723.1	467,723.1	0.0	15,044.4	482,767.5	12,669,252.2	0.0	12,490,891.5	0.0
	APR	30.0	117.8	60.6	172,607.1	410,297.0	582,904.1	41,676.0	92,037.7	133,713.7	172,607.1	172,607.1	449,190.4	449,190.4	449,190.4	0.0	16,055.1	465,245.5	12,956,137.0	0.0	12,783,529.9	0.0
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	678,265.7	85,187.4	95,105.6	180,293.0	178,360.7	178,360.7	497,972.7	497,972.7	497,972.7	0.0	19,561.5	517,534.2	13,301,064.1	0.0	13,122,703.4	0.0
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	824,933.1	110,551.8	92,037.7	202,589.5	172,607.1	172,607.1	622,343.6	622,343.6	622,343.6	0.0	25,525.8	647,869.4	13,770,572.8	0.0	13,597,965.7	0.0
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	501,303.7	109,337.4	95,105.6	204,443.0	178,360.7	178,360.7	296,860.7	296,860.7	296,860.7	0.0	12,636.9	309,497.6	13,907,463.3	0.0	13,729,102.6	0.0
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	557,745.7	94,281.6	95,105.6	189,387.2	178,360.7	178,360.7	368,358.5	368,358.5	368,358.5	0.0	14,845.5	383,204.0	14,112,306.6	0.0	13,933,945.9	0.0
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	757,911.1	47,927.4	92,037.7	139,965.1	172,607.1	172,607.1	617,946.0	617,946.0	617,946.0	0.0	22,903.2	640,849.2	14,574,795.1	0.0	14,402,188.0	0.0
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	994,492.7	18,630.0	95,105.6	113,735.6	178,360.7	178,360.7	880,757.1	880,757.1	880,757.1	0.0	31,935.6	912,692.7	15,314,880.7	0.0	15,136,520.0	0.0
Year 3	NOV	30.0	337.9	0.0	172,607.1	777,239.0	949,846.1	0.0	92,037.7	92,037.7	172,607.1	172,607.1	857,808.4	857,808.4	857,808.4	0.0	30,413.7	888,222.1	16,024,742.1	0.0	15,852,135.0	0.0

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)			Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water moved to reservoir**	**Cumulative change in storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Water returned to TMF from reservoir**	**Water remained in reservoir**	**Water remained in TMF+ Water returned to TMF from reservoir**
	DEC	31.0	313.0	0.0	178,360.7	719,900.0	**898,260.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	803,155.1	803,155.1	803,155.1	**0.0**	28,170.0	**831,325.1**	**16,683,460.1**	**0.0**	**16,505,099.4**	**0.0**
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	**1,036,467.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	941,362.1	941,362.1	941,362.1	**0.0**	33,578.1	**974,940.2**	**17,480,039.6**	**0.0**	**17,301,678.9**	**0.0**
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	**615,718.0**	0.0	85,901.8	**85,901.8**	161,100.0	**161,100.0**	529,816.2	529,816.2	529,816.2	**0.0**	17,789.4	**547,605.6**	**17,849,284.5**	**0.0**	**17,688,184.5**	**0.0**
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	**562,828.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	467,723.1	467,723.1	467,723.1	**0.0**	15,044.4	**482,767.5**	**18,170,952.0**	**0.0**	**17,992,591.3**	**0.0**
	APR	30.0	117.8	60.6	172,607.1	410,297.0	**582,904.1**	41,676.0	92,037.7	**133,713.7**	172,607.1	**172,607.1**	449,190.4	449,190.4	449,190.4	**0.0**	16,055.1	**465,245.5**	**18,457,836.8**	**0.0**	**18,285,229.7**	**0.0**
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	**678,265.7**	85,187.4	95,105.6	**180,293.0**	178,360.7	**178,360.7**	497,972.7	497,972.7	497,972.7	**0.0**	19,561.5	**517,534.2**	**18,802,763.9**	**0.0**	**18,624,403.2**	**0.0**
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	**824,933.1**	110,551.8	92,037.7	**202,589.5**	172,607.1	**172,607.1**	622,343.6	622,343.6	622,343.6	**0.0**	25,525.8	**647,869.4**	**19,272,272.6**	**0.0**	**19,099,665.5**	**0.0**
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	**501,303.7**	109,337.4	95,105.6	**204,443.0**	178,360.7	**178,360.7**	296,860.7	296,860.7	296,860.7	**0.0**	12,636.9	**309,497.6**	**19,409,163.1**	**0.0**	**19,230,802.4**	**0.0**
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	**557,745.7**	94,281.6	95,105.6	**189,387.2**	178,360.7	**178,360.7**	368,358.5	368,358.5	368,358.5	**0.0**	14,845.5	**383,204.0**	**19,614,006.4**	**0.0**	**19,435,645.7**	**0.0**
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	**757,911.1**	47,927.4	92,037.7	**139,965.1**	172,607.1	**172,607.1**	617,946.0	617,946.0	617,946.0	**0.0**	22,903.2	**640,849.2**	**20,076,494.9**	**0.0**	**19,903,887.8**	**0.0**
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	**994,492.7**	18,630.0	95,105.6	**113,735.6**	178,360.7	**178,360.7**	880,757.1	880,757.1	880,757.1	**0.0**	31,935.6	**912,692.7**	**20,816,580.5**	**0.0**	**20,638,219.8**	**0.0**
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	**949,846.1**	0.0	92,037.7	**92,037.7**	172,607.1	**172,607.1**	857,808.4	857,808.4	857,808.4	**0.0**	30,413.7	**888,222.1**	**21,526,441.9**	**0.0**	**21,353,834.8**	**0.0**
Year 4	DEC	31.0	313.0	0.0	178,360.7	719,900.0	**898,260.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	803,155.1	803,155.1	803,155.1	**0.0**	28,170.0	**831,325.1**	**22,185,159.9**	**0.0**	**22,006,799.2**	**0.0**
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	**1,036,467.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	941,362.1	941,362.1	941,362.1	**0.0**	33,578.1	**974,940.2**	**22,981,739.4**	**0.0**	**22,803,378.7**	**0.0**
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	**615,718.0**	0.0	85,901.8	**85,901.8**	161,100.0	**161,100.0**	529,816.2	529,816.2	529,816.2	**0.0**	17,789.4	**547,605.6**	**23,350,984.3**	**0.0**	**23,189,884.3**	**0.0**
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	**562,828.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	467,723.1	467,723.1	467,723.1	**0.0**	15,044.4	**482,767.5**	**23,672,651.8**	**0.0**	**23,494,291.1**	**0.0**
	APR	30.0	117.8	60.6	172,607.1	410,297.0	**582,904.1**	41,676.0	92,037.7	**133,713.7**	172,607.1	**172,607.1**	449,190.4	449,190.4	449,190.4	**0.0**	16,055.1	**465,245.5**	**23,959,536.6**	**0.0**	**23,786,929.5**	**0.0**
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	**678,265.7**	85,187.4	95,105.6	**180,293.0**	178,360.7	**178,360.7**	497,972.7	497,972.7	497,972.7	**0.0**	19,561.5	**517,534.2**	**24,304,463.7**	**0.0**	**24,126,103.0**	**0.0**
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	**824,933.1**	110,551.8	92,037.7	**202,589.5**	172,607.1	**172,607.1**	622,343.6	622,343.6	622,343.6	**0.0**	25,525.8	**647,869.4**	**24,773,972.4**	**0.0**	**24,601,365.3**	**0.0**
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	**501,303.7**	109,337.4	95,105.6	**204,443.0**	178,360.7	**178,360.7**	296,860.7	296,860.7	296,860.7	**0.0**	12,636.9	**309,497.6**	**24,910,862.9**	**0.0**	**24,732,502.2**	**0.0**
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	**557,745.7**	94,281.6	95,105.6	**189,387.2**	178,360.7	**178,360.7**	368,358.5	368,358.5	368,358.5	**0.0**	14,845.5	**383,204.0**	**25,115,706.2**	**0.0**	**24,937,345.5**	**0.0**
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	**757,911.1**	47,927.4	92,037.7	**139,965.1**	172,607.1	**172,607.1**	617,946.0	617,946.0	617,946.0	**0.0**	22,903.2	**640,849.2**	**25,578,194.7**	**0.0**	**25,405,587.6**	**0.0**
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	**994,492.7**	18,630.0	95,105.6	**113,735.6**	178,360.7	**178,360.7**	880,757.1	880,757.1	880,757.1	**0.0**	31,935.6	**912,692.7**	**26,318,280.3**	**0.0**	**26,139,919.6**	**0.0**
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	**949,846.1**	0.0	92,037.7	**92,037.7**	172,607.1	**172,607.1**	857,808.4	857,808.4	857,808.4	**0.0**	30,413.7	**888,222.1**	**27,028,141.7**	**0.0**	**26,855,534.6**	**0.0**
Year 5	DEC	31.0	313.0	0.0	178,360.7	719,900.0	**898,260.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	803,155.1	803,155.1	803,155.1	**0.0**	28,170.0	**831,325.1**	**27,686,859.7**	**0.0**	**27,508,499.0**	**0.0**

Table B.3 Deterministic model for solids content of 80% in the wet condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)			Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Total Water Input	Evaporation	Entrainment	Total Water Output	Water with tailings	Total mill required water	Monthly change in storage	Water moved to reservoir	Cumulative change in storage	Water remained in TMF	Mine impacted water runoff	Monthly reservoir storage	Cumulative reservoir storage	Water returned to TMF from reservoir	Water remained in reservoir	Water remained in TMF+ Water returned to TMF from reservoir
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	880,645.7	880,645.7	880,645.7	0.0	33,578.1	914,223.8	914,223.8	0.0	810,180.0	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	73,617.5	93,975.0	93,975.0	474,975.5	474,975.5	474,975.5	0.0	17,789.4	492,764.9	1,302,944.9	0.0	1,208,969.9	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	407,006.7	407,006.7	407,006.7	0.0	15,044.4	422,051.1	1,631,021.0	0.0	1,526,977.2	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	120,551.9	100,687.5	100,687.5	390,432.6	390,432.6	390,432.6	0.0	16,055.1	406,487.7	1,933,464.9	0.0	1,832,777.4	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	166,692.5	104,043.8	104,043.8	437,256.3	437,256.3	437,256.3	0.0	19,561.5	456,817.8	2,289,595.2	0.0	2,185,551.4	0.0
	JUN	30.0	5.0	185.4	100,687.5	437,805.0	538,492.5	110,551.8	78,875.9	189,427.7	100,687.5	100,687.5	349,064.8	349,064.8	349,064.8	0.0	17,131.5	366,196.3	2,551,747.7	0.0	2,451,060.2	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	190,842.5	104,043.8	104,043.8	236,144.3	236,144.3	236,144.3	0.0	12,636.9	248,781.2	2,699,841.4	0.0	2,595,797.6	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	175,786.7	104,043.8	104,043.8	307,642.1	307,642.1	307,642.1	0.0	14,845.5	322,487.6	2,918,285.2	0.0	2,814,241.4	0.0
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	126,803.3	100,687.5	100,687.5	559,188.2	559,188.2	559,188.2	0.0	22,903.2	582,091.4	3,396,332.8	0.0	3,295,645.3	0.0
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	920,175.8	18,630.0	81,505.1	100,135.1	104,043.8	104,043.8	820,040.7	820,040.7	820,040.7	0.0	31,935.6	851,976.3	4,147,621.6	0.0	4,043,577.8	0.0
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	877,926.5	0.0	78,875.9	78,875.9	100,687.5	100,687.5	799,050.6	799,050.6	799,050.6	0.0	30,413.7	829,464.3	4,873,042.1	0.0	4,772,354.6	0.0
Year 1	DEC	31.0	313.0	0.0	104,043.8	719,900.0	823,943.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	742,438.7	742,438.7	742,438.7	0.0	28,170.0	770,608.7	5,542,963.3	0.0	5,438,919.5	0.0
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	880,645.7	880,645.7	880,645.7	0.0	33,578.1	914,223.8	6,353,143.3	0.0	6,249,099.5	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	73,617.5	93,975.0	93,975.0	474,975.5	474,975.5	474,975.5	0.0	17,789.4	492,764.9	6,741,864.4	0.0	6,647,889.4	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	407,006.7	407,006.7	407,006.7	0.0	15,044.4	422,051.1	7,069,940.5	0.0	6,965,896.7	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	120,551.9	100,687.5	100,687.5	390,432.6	390,432.6	390,432.6	0.0	16,055.1	406,487.7	7,372,384.4	0.0	7,271,696.9	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	166,692.5	104,043.8	104,043.8	437,256.3	437,256.3	437,256.3	0.0	19,561.5	456,817.8	7,728,514.7	0.0	7,624,470.9	0.0
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	753,013.5	110,551.8	78,875.9	189,427.7	100,687.5	100,687.5	563,585.8	563,585.8	563,585.8	0.0	25,525.8	589,111.6	8,213,582.5	0.0	8,112,895.0	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	190,842.5	104,043.8	104,043.8	236,144.3	236,144.3	236,144.3	0.0	12,636.9	248,781.2	8,361,676.2	0.0	8,257,632.4	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	175,786.7	104,043.8	104,043.8	307,642.1	307,642.1	307,642.1	0.0	14,845.5	322,487.6	8,580,120.0	0.0	8,476,076.2	0.0
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	126,803.3	100,687.5	100,687.5	559,188.2	559,188.2	559,188.2	0.0	22,903.2	582,091.4	9,058,167.6	0.0	8,957,480.1	0.0
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	920,175.8	18,630.0	81,505.1	100,135.1	104,043.8	104,043.8	820,040.7	820,040.7	820,040.7	0.0	31,935.6	851,976.3	9,809,456.4	0.0	9,705,412.6	0.0
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	877,926.5	0.0	78,875.9	78,875.9	100,687.5	100,687.5	799,050.6	799,050.6	799,050.6	0.0	30,413.7	829,464.3	10,534,876.9	0.0	10,434,189.4	0.0
Year 2	DEC	31.0	313.0	0.0	104,043.8	719,900.0	823,943.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	742,438.7	742,438.7	742,438.7	0.0	28,170.0	770,608.7	11,204,798.1	0.0	11,100,754.3	0.0
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	880,645.7	880,645.7	880,645.7	0.0	33,578.1	914,223.8	12,014,978.1	0.0	11,910,934.3	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	73,617.5	93,975.0	93,975.0	474,975.5	474,975.5	474,975.5	0.0	17,789.4	492,764.9	12,403,699.2	0.0	12,309,724.2	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	407,006.7	407,006.7	407,006.7	0.0	15,044.4	422,051.1	12,731,775.3	0.0	12,627,731.5	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	120,551.9	100,687.5	100,687.5	390,432.6	390,432.6	390,432.6	0.0	16,055.1	406,487.7	13,034,219.2	0.0	12,933,531.7	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	166,692.5	104,043.8	104,043.8	437,256.3	437,256.3	437,256.3	0.0	19,561.5	456,817.8	13,390,349.5	0.0	13,286,305.7	0.0
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	753,013.5	110,551.8	78,875.9	189,427.7	100,687.5	100,687.5	563,585.8	563,585.8	563,585.8	0.0	25,525.8	589,111.6	13,875,417.3	0.0	13,774,729.8	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	190,842.5	104,043.8	104,043.8	236,144.3	236,144.3	236,144.3	0.0	12,636.9	248,781.2	14,023,511.0	0.0	13,919,467.2	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	175,786.7	104,043.8	104,043.8	307,642.1	307,642.1	307,642.1	0.0	14,845.5	322,487.6	14,241,954.8	0.0	14,137,911.0	0.0
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	126,803.3	100,687.5	100,687.5	559,188.2	559,188.2	559,188.2	0.0	22,903.2	582,091.4	14,720,002.4	0.0	14,619,314.9	0.0
Year 3	OCT	31.0	354.8	0.0	104,043.8	816,132.0	920,175.8	18,630.0	81,505.1	100,135.1	104,043.8	104,043.8	820,040.7	820,040.7	820,040.7	0.0	31,935.6	851,976.3	15,471,291.2	0.0	15,367,247.4	0.0

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)			Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Total Water Input	Evaporation	Entrainment	Total Water Output	Water with tailings	Total mill required water	Monthly change in storage	Water moved to reservoir	Cumulative change in storage	Water remained in TMF	Mine impacted water runoff	Monthly reservoir storage	Cumulative reservoir storage	Water returned to TMF from reservoir	Water remained in reservoir	Water remained in TMF+ Water returned to TMF from reservoir
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	877,926.5	0.0	78,875.9	78,875.9	100,687.5	100,687.5	799,050.6	799,050.6	799,050.6	0.0	30,413.7	829,464.3	16,196,711.7	0.0	16,096,024.2	0.0
	DEC	31.0	313.0	0.0	104,043.8	719,900.0	823,943.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	742,438.7	742,438.7	742,438.7	0.0	28,170.0	770,608.7	16,866,632.9	0.0	16,762,589.1	0.0
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	880,645.7	880,645.7	880,645.7	0.0	33,578.1	914,223.8	17,676,812.9	0.0	17,572,769.1	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	73,617.5	93,975.0	93,975.0	474,975.5	474,975.5	474,975.5	0.0	17,789.4	492,764.9	18,065,534.0	0.0	17,971,559.0	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	407,006.7	407,006.7	407,006.7	0.0	15,044.4	422,051.1	18,393,610.1	0.0	18,289,566.3	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	120,551.9	100,687.5	100,687.5	390,432.6	390,432.6	390,432.6	0.0	16,055.1	406,487.7	18,696,054.0	0.0	18,595,366.5	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	166,692.5	104,043.8	104,043.8	437,256.3	437,256.3	437,256.3	0.0	19,561.5	456,817.8	19,052,184.3	0.0	18,948,140.5	0.0
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	753,013.5	110,551.8	78,875.9	189,427.7	100,687.5	100,687.5	563,585.8	563,585.8	563,585.8	0.0	25,525.8	589,111.6	19,537,252.1	0.0	19,436,564.6	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	190,842.5	104,043.8	104,043.8	236,144.3	236,144.3	236,144.3	0.0	12,636.9	248,781.2	19,685,345.8	0.0	19,581,302.0	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	175,786.7	104,043.8	104,043.8	307,642.1	307,642.1	307,642.1	0.0	14,845.5	322,487.6	19,903,789.6	0.0	19,799,745.8	0.0
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	126,803.3	100,687.5	100,687.5	559,188.2	559,188.2	559,188.2	0.0	22,903.2	582,091.4	20,381,837.2	0.0	20,281,149.7	0.0
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	920,175.8	18,630.0	81,505.1	100,135.1	104,043.8	104,043.8	820,040.7	820,040.7	820,040.7	0.0	31,935.6	851,976.3	21,133,126.0	0.0	21,029,082.2	0.0
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	877,926.5	0.0	78,875.9	78,875.9	100,687.5	100,687.5	799,050.6	799,050.6	799,050.6	0.0	30,413.7	829,464.3	21,858,546.5	0.0	21,757,859.0	0.0
Year 4	DEC	31.0	313.0	0.0	104,043.8	719,900.0	823,943.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	742,438.7	742,438.7	742,438.7	0.0	28,170.0	770,608.7	22,528,467.7	0.0	22,424,423.9	0.0
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	880,645.7	880,645.7	880,645.7	0.0	33,578.1	914,223.8	23,338,647.7	0.0	23,234,603.9	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	73,617.5	93,975.0	93,975.0	474,975.5	474,975.5	474,975.5	0.0	17,789.4	492,764.9	23,727,368.8	0.0	23,633,393.8	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	407,006.7	407,006.7	407,006.7	0.0	15,044.4	422,051.1	24,055,444.9	0.0	23,951,401.1	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	120,551.9	100,687.5	100,687.5	390,432.6	390,432.6	390,432.6	0.0	16,055.1	406,487.7	24,357,888.8	0.0	24,257,201.3	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	166,692.5	104,043.8	104,043.8	437,256.3	437,256.3	437,256.3	0.0	19,561.5	456,817.8	24,714,019.1	0.0	24,609,975.3	0.0
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	753,013.5	110,551.8	78,875.9	189,427.7	100,687.5	100,687.5	563,585.8	563,585.8	563,585.8	0.0	25,525.8	589,111.6	25,199,086.9	0.0	25,098,399.4	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	190,842.5	104,043.8	104,043.8	236,144.3	236,144.3	236,144.3	0.0	12,636.9	248,781.2	25,347,180.6	0.0	25,243,136.8	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	175,786.7	104,043.8	104,043.8	307,642.1	307,642.1	307,642.1	0.0	14,845.5	322,487.6	25,565,624.4	0.0	25,461,580.6	0.0
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	126,803.3	100,687.5	100,687.5	559,188.2	559,188.2	559,188.2	0.0	22,903.2	582,091.4	26,043,672.0	0.0	25,942,984.5	0.0
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	920,175.8	18,630.0	81,505.1	100,135.1	104,043.8	104,043.8	820,040.7	820,040.7	820,040.7	0.0	31,935.6	851,976.3	26,794,960.8	0.0	26,690,917.0	0.0
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	877,926.5	0.0	78,875.9	78,875.9	100,687.5	100,687.5	799,050.6	799,050.6	799,050.6	0.0	30,413.7	829,464.3	27,520,381.3	0.0	27,419,693.8	0.0
Year 5	DEC	31.0	313.0	0.0	104,043.8	719,900.0	823,943.8	0.0	81,505.1	81,505.1	104,043.8	104,043.8	742,438.7	742,438.7	742,438.7	0.0	28,170.0	770,608.7	28,190,302.5	0.0	28,086,258.7	0.0

B.2 Unlined impoundment

Table B.4 Deterministic model for solids content of 60% in the wet condition for an unlined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)				Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly storage**	**Water move to reservoir**	**Cumulative storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Returned to pond**	**Water remained in reservoir**	**Water remained on TMF+ return from reservoir**
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	**1,135,557.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	1,001,856.2	1,856.2	1,001,856.2	**1,000,000.0**	33,578.1	**35,434.3**	**35,434.3**	**0.0**	**0.0**	**1,000,000.0**
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	**705,218.0**	0.0	107,300.3	14,904.0	**122,204.3**	250,600.0	**250,600.0**	583,013.7	583,013.7	1,583,013.7	**1,000,000.0**	17,789.4	**600,803.1**	**600,803.1**	**0.0**	**350,203.1**	**1,000,000.0**
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	**661,918.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	528,217.2	528,217.2	1,528,217.2	**1,000,000.0**	15,044.4	**543,261.6**	**893,464.7**	**0.0**	**616,014.7**	**1,000,000.0**
	APR	30.0	117.8	60.6	268,500.0	410,297.0	**678,797.0**	48,622.0	114,964.6	14,904.0	**178,490.6**	268,500.0	**268,500.0**	500,306.4	500,306.4	1,500,306.4	**1,000,000.0**	16,055.1	**516,361.5**	**1,132,376.2**	**0.0**	**863,876.2**	**1,000,000.0**
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	**777,355.0**	99,385.3	118,796.8	14,904.0	**233,086.1**	277,450.0	**277,450.0**	544,268.9	544,268.9	1,544,268.9	**1,000,000.0**	19,561.5	**563,830.4**	**1,427,706.6**	**0.0**	**1,150,256.6**	**1,000,000.0**
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	**920,826.0**	128,977.1	114,964.6	14,904.0	**258,845.7**	268,500.0	**268,500.0**	661,980.3	661,980.3	1,661,980.3	**1,000,000.0**	25,525.8	**687,506.1**	**1,837,762.7**	**0.0**	**1,569,262.7**	**1,000,000.0**
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	**600,393.0**	127,560.3	118,796.8	14,904.0	**261,261.1**	277,450.0	**277,450.0**	339,131.9	339,131.9	1,339,131.9	**1,000,000.0**	12,636.9	**351,768.8**	**1,921,031.5**	**0.0**	**1,643,581.5**	**1,000,000.0**
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	**656,835.0**	109,995.2	118,796.8	14,904.0	**243,696.0**	277,450.0	**277,450.0**	413,139.0	413,139.0	1,413,139.0	**1,000,000.0**	14,845.5	**427,984.5**	**2,071,566.0**	**0.0**	**1,794,116.0**	**1,000,000.0**
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	**853,804.0**	55,915.3	114,964.6	14,904.0	**185,783.9**	268,500.0	**268,500.0**	668,020.1	668,020.1	1,668,020.1	**1,000,000.0**	22,903.2	**690,923.3**	**2,485,039.3**	**0.0**	**2,216,539.3**	**1,000,000.0**
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	**1,093,582.0**	21,735.0	118,796.8	14,904.0	**155,435.8**	277,450.0	**277,450.0**	938,146.2	938,146.2	1,938,146.2	**1,000,000.0**	31,935.6	**970,081.8**	**3,186,621.1**	**0.0**	**2,909,171.1**	**1,000,000.0**
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	14,904.0	**129,868.6**	268,500.0	**268,500.0**	915,870.4	915,870.4	1,915,870.4	**1,000,000.0**	30,413.7	**946,284.1**	**3,855,455.2**	**0.0**	**3,586,955.2**	**1,000,000.0**
Year 1	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	863,649.2	863,649.2	1,863,649.2	**1,000,000.0**	28,170.0	**891,819.2**	**4,478,774.4**	**0.0**	**4,201,324.4**	**1,000,000.0**
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	**1,135,557.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	1,001,856.2	1,001,856.2	2,001,856.2	**1,000,000.0**	33,578.1	**1,035,434.3**	**5,236,758.7**	**0.0**	**4,959,308.7**	**1,000,000.0**
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	**705,218.0**	0.0	107,300.3	14,904.0	**122,204.3**	250,600.0	**250,600.0**	583,013.7	583,013.7	1,583,013.7	**1,000,000.0**	17,789.4	**600,803.1**	**5,560,111.8**	**0.0**	**5,309,511.8**	**1,000,000.0**
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	**661,918.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	528,217.2	528,217.2	1,528,217.2	**1,000,000.0**	15,044.4	**543,261.6**	**5,852,773.4**	**0.0**	**5,575,323.4**	**1,000,000.0**
	APR	30.0	117.8	60.6	268,500.0	410,297.0	**678,797.0**	48,622.0	114,964.6	14,904.0	**178,490.6**	268,500.0	**268,500.0**	500,306.4	500,306.4	1,500,306.4	**1,000,000.0**	16,055.1	**516,361.5**	**6,091,684.9**	**0.0**	**5,823,184.9**	**1,000,000.0**
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	**777,355.0**	99,385.3	118,796.8	14,904.0	**233,086.1**	277,450.0	**277,450.0**	544,268.9	544,268.9	1,544,268.9	**1,000,000.0**	19,561.5	**563,830.4**	**6,387,015.3**	**0.0**	**6,109,565.3**	**1,000,000.0**
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	**920,826.0**	128,977.1	114,964.6	14,904.0	**258,845.7**	268,500.0	**268,500.0**	661,980.3	661,980.3	1,661,980.3	**1,000,000.0**	25,525.8	**687,506.1**	**6,797,071.4**	**0.0**	**6,528,571.4**	**1,000,000.0**
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	**600,393.0**	127,560.3	118,796.8	14,904.0	**261,261.1**	277,450.0	**277,450.0**	339,131.9	339,131.9	1,339,131.9	**1,000,000.0**	12,636.9	**351,768.8**	**6,880,340.2**	**0.0**	**6,602,890.2**	**1,000,000.0**
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	**656,835.0**	109,995.2	118,796.8	14,904.0	**243,696.0**	277,450.0	**277,450.0**	413,139.0	413,139.0	1,413,139.0	**1,000,000.0**	14,845.5	**427,984.5**	**7,030,874.7**	**0.0**	**6,753,424.7**	**1,000,000.0**
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	**853,804.0**	55,915.3	114,964.6	14,904.0	**185,783.9**	268,500.0	**268,500.0**	668,020.1	668,020.1	1,668,020.1	**1,000,000.0**	22,903.2	**690,923.3**	**7,444,348.0**	**0.0**	**7,175,848.0**	**1,000,000.0**
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	**1,093,582.0**	21,735.0	118,796.8	14,904.0	**155,435.8**	277,450.0	**277,450.0**	938,146.2	938,146.2	1,938,146.2	**1,000,000.0**	31,935.6	**970,081.8**	**8,145,929.8**	**0.0**	**7,868,479.8**	**1,000,000.0**
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	14,904.0	**129,868.6**	268,500.0	**268,500.0**	915,870.4	915,870.4	1,915,870.4	**1,000,000.0**	30,413.7	**946,284.1**	**8,814,763.9**	**0.0**	**8,546,263.9**	**1,000,000.0**
Year 2	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	863,649.2	863,649.2	1,863,649.2	**1,000,000.0**	28,170.0	**891,819.2**	**9,438,083.1**	**0.0**	**9,160,633.1**	**1,000,000.0**
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	**1,135,557.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	1,001,856.2	1,001,856.2	2,001,856.2	**1,000,000.0**	33,578.1	**1,035,434.3**	**10,196,067.4**	**0.0**	**9,918,617.4**	**1,000,000.0**
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	**705,218.0**	0.0	107,300.3	14,904.0	**122,204.3**	250,600.0	**250,600.0**	583,013.7	583,013.7	1,583,013.7	**1,000,000.0**	17,789.4	**600,803.1**	**10,519,420.5**	**0.0**	**10,268,820.5**	**1,000,000.0**
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	**661,918.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	528,217.2	528,217.2	1,528,217.2	**1,000,000.0**	15,044.4	**543,261.6**	**10,812,082.1**	**0.0**	**10,534,632.1**	**1,000,000.0**
	APR	30.0	117.8	60.6	268,500.0	410,297.0	**678,797.0**	48,622.0	114,964.6	14,904.0	**178,490.6**	268,500.0	**268,500.0**	500,306.4	500,306.4	1,500,306.4	**1,000,000.0**	16,055.1	**516,361.5**	**11,050,993.6**	**0.0**	**10,782,493.6**	**1,000,000.0**
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	**777,355.0**	99,385.3	118,796.8	14,904.0	**233,086.1**	277,450.0	**277,450.0**	544,268.9	544,268.9	1,544,268.9	**1,000,000.0**	19,561.5	**563,830.4**	**11,346,324.0**	**0.0**	**11,068,874.0**	**1,000,000.0**
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	**920,826.0**	128,977.1	114,964.6	14,904.0	**258,845.7**	268,500.0	**268,500.0**	661,980.3	661,980.3	1,661,980.3	**1,000,000.0**	25,525.8	**687,506.1**	**11,756,380.1**	**0.0**	**11,487,880.1**	**1,000,000.0**
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	**600,393.0**	127,560.3	118,796.8	14,904.0	**261,261.1**	277,450.0	**277,450.0**	339,131.9	339,131.9	1,339,131.9	**1,000,000.0**	12,636.9	**351,768.8**	**11,839,648.9**	**0.0**	**11,562,198.9**	**1,000,000.0**
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	**656,835.0**	109,995.2	118,796.8	14,904.0	**243,696.0**	277,450.0	**277,450.0**	413,139.0	413,139.0	1,413,139.0	**1,000,000.0**	14,845.5	**427,984.5**	**11,990,183.4**	**0.0**	**11,712,733.4**	**1,000,000.0**
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	**853,804.0**	55,915.3	114,964.6	14,904.0	**185,783.9**	268,500.0	**268,500.0**	668,020.1	668,020.1	1,668,020.1	**1,000,000.0**	22,903.2	**690,923.3**	**12,403,656.7**	**0.0**	**12,135,156.7**	**1,000,000.0**
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	**1,093,582.0**	21,735.0	118,796.8	14,904.0	**155,435.8**	277,450.0	**277,450.0**	938,146.2	938,146.2	1,938,146.2	**1,000,000.0**	31,935.6	**970,081.8**	**13,105,238.5**	**0.0**	**12,827,788.5**	**1,000,000.0**
Year 3	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	14,904.0	**129,868.6**	268,500.0	**268,500.0**	915,870.4	915,870.4	1,915,870.4	**1,000,000.0**	30,413.7	**946,284.1**	**13,774,072.6**	**0.0**	**13,505,572.6**	**1,000,000.0**

			Precipitation water (mm/month)		Water in (m³)			Water out (m³)				Mill required water (m³)		Water in the TMF (m³)					Reservoir storage (m³)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly storage**	**Water move to reservoir**	**Cumulative storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Returned to pond**	**Water remained in reservoir**	**Water remained on TMF+ return from reservoir**
	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	863,649.2	863,649.2	1,863,649.2	**1,000,000.0**	28,170.0	**891,819.2**	**14,397,391.8**	**0.0**	**14,119,941.8**	**1,000,000.0**
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	**1,135,557.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	1,001,856.2	1,001,856.2	2,001,856.2	**1,000,000.0**	33,578.1	**1,035,434.3**	**15,155,376.1**	**0.0**	**14,877,926.1**	**1,000,000.0**
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	**705,218.0**	0.0	107,300.3	14,904.0	**122,204.3**	250,600.0	**250,600.0**	583,013.7	583,013.7	1,583,013.7	**1,000,000.0**	17,789.4	**600,803.1**	**15,478,729.2**	**0.0**	**15,228,129.2**	**1,000,000.0**
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	**661,918.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	528,217.2	528,217.2	1,528,217.2	**1,000,000.0**	15,044.4	**543,261.6**	**15,771,390.8**	**0.0**	**15,493,940.8**	**1,000,000.0**
	APR	30.0	117.8	60.6	268,500.0	410,297.0	**678,797.0**	48,622.0	114,964.6	14,904.0	**178,490.6**	268,500.0	**268,500.0**	500,306.4	500,306.4	1,500,306.4	**1,000,000.0**	16,055.1	**516,361.5**	**16,010,302.3**	**0.0**	**15,741,802.3**	**1,000,000.0**
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	**777,355.0**	99,385.3	118,796.8	14,904.0	**233,086.1**	277,450.0	**277,450.0**	544,268.9	544,268.9	1,544,268.9	**1,000,000.0**	19,561.5	**563,830.4**	**16,305,632.7**	**0.0**	**16,028,182.7**	**1,000,000.0**
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	**920,826.0**	128,977.1	114,964.6	14,904.0	**258,845.7**	268,500.0	**268,500.0**	661,980.3	661,980.3	1,661,980.3	**1,000,000.0**	25,525.8	**687,506.1**	**16,715,688.8**	**0.0**	**16,447,188.8**	**1,000,000.0**
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	**600,393.0**	127,560.3	118,796.8	14,904.0	**261,261.1**	277,450.0	**277,450.0**	339,131.9	339,131.9	1,339,131.9	**1,000,000.0**	12,636.9	**351,768.8**	**16,798,957.6**	**0.0**	**16,521,507.6**	**1,000,000.0**
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	**656,835.0**	109,995.2	118,796.8	14,904.0	**243,696.0**	277,450.0	**277,450.0**	413,139.0	413,139.0	1,413,139.0	**1,000,000.0**	14,845.5	**427,984.5**	**16,949,492.1**	**0.0**	**16,672,042.1**	**1,000,000.0**
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	**853,804.0**	55,915.3	114,964.6	14,904.0	**185,783.9**	268,500.0	**268,500.0**	668,020.1	668,020.1	1,668,020.1	**1,000,000.0**	22,903.2	**690,923.3**	**17,362,965.4**	**0.0**	**17,094,465.4**	**1,000,000.0**
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	**1,093,582.0**	21,735.0	118,796.8	14,904.0	**155,435.8**	277,450.0	**277,450.0**	938,146.2	938,146.2	1,938,146.2	**1,000,000.0**	31,935.6	**970,081.8**	**18,064,547.2**	**0.0**	**17,787,097.2**	**1,000,000.0**
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	14,904.0	**129,868.6**	268,500.0	**268,500.0**	915,870.4	915,870.4	1,915,870.4	**1,000,000.0**	30,413.7	**946,284.1**	**18,733,381.3**	**0.0**	**18,464,881.3**	**1,000,000.0**
Year 4	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	863,649.2	863,649.2	1,863,649.2	**1,000,000.0**	28,170.0	**891,819.2**	**19,356,700.5**	**0.0**	**19,079,250.5**	**1,000,000.0**
	JAN	31.0	373.1	0.0	277,450.0	858,107.0	**1,135,557.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	1,001,856.2	1,001,856.2	2,001,856.2	**1,000,000.0**	33,578.1	**1,035,434.3**	**20,114,684.8**	**0.0**	**19,837,234.8**	**1,000,000.0**
	FEB	28.0	197.7	0.0	250,600.0	454,618.0	**705,218.0**	0.0	107,300.3	14,904.0	**122,204.3**	250,600.0	**250,600.0**	583,013.7	583,013.7	1,583,013.7	**1,000,000.0**	17,789.4	**600,803.1**	**20,438,037.9**	**0.0**	**20,187,437.9**	**1,000,000.0**
	MAR	31.0	167.2	0.0	277,450.0	384,468.0	**661,918.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	528,217.2	528,217.2	1,528,217.2	**1,000,000.0**	15,044.4	**543,261.6**	**20,730,699.5**	**0.0**	**20,453,249.5**	**1,000,000.0**
	APR	30.0	117.8	60.6	268,500.0	410,297.0	**678,797.0**	48,622.0	114,964.6	14,904.0	**178,490.6**	268,500.0	**268,500.0**	500,306.4	500,306.4	1,500,306.4	**1,000,000.0**	16,055.1	**516,361.5**	**20,969,611.0**	**0.0**	**20,701,111.0**	**1,000,000.0**
	MAY	31.0	98.5	118.9	277,450.0	499,905.0	**777,355.0**	99,385.3	118,796.8	14,904.0	**233,086.1**	277,450.0	**277,450.0**	544,268.9	544,268.9	1,544,268.9	**1,000,000.0**	19,561.5	**563,830.4**	**21,264,941.4**	**0.0**	**20,987,491.4**	**1,000,000.0**
	JUN	30.0	98.3	185.4	268,500.0	652,326.0	**920,826.0**	128,977.1	114,964.6	14,904.0	**258,845.7**	268,500.0	**268,500.0**	661,980.3	661,980.3	1,661,980.3	**1,000,000.0**	25,525.8	**687,506.1**	**21,674,997.5**	**0.0**	**21,406,497.5**	**1,000,000.0**
	JUL	31.0	102.8	37.6	277,450.0	322,943.0	**600,393.0**	127,560.3	118,796.8	14,904.0	**261,261.1**	277,450.0	**277,450.0**	339,131.9	339,131.9	1,339,131.9	**1,000,000.0**	12,636.9	**351,768.8**	**21,758,266.3**	**0.0**	**21,480,816.3**	**1,000,000.0**
	AUG	31.0	163.6	1.4	277,450.0	379,385.0	**656,835.0**	109,995.2	118,796.8	14,904.0	**243,696.0**	277,450.0	**277,450.0**	413,139.0	413,139.0	1,413,139.0	**1,000,000.0**	14,845.5	**427,984.5**	**21,908,800.8**	**0.0**	**21,631,350.8**	**1,000,000.0**
	SEP	30.0	246.2	8.3	268,500.0	585,304.0	**853,804.0**	55,915.3	114,964.6	14,904.0	**185,783.9**	268,500.0	**268,500.0**	668,020.1	668,020.1	1,668,020.1	**1,000,000.0**	22,903.2	**690,923.3**	**22,322,274.1**	**0.0**	**22,053,774.1**	**1,000,000.0**
	OCT	31.0	354.8	0.0	277,450.0	816,132.0	**1,093,582.0**	21,735.0	118,796.8	14,904.0	**155,435.8**	277,450.0	**277,450.0**	938,146.2	938,146.2	1,938,146.2	**1,000,000.0**	31,935.6	**970,081.8**	**23,023,855.9**	**0.0**	**22,746,405.9**	**1,000,000.0**
	NOV	30.0	337.9	0.0	268,500.0	777,239.0	**1,045,739.0**	0.0	114,964.6	14,904.0	**129,868.6**	268,500.0	**268,500.0**	915,870.4	915,870.4	1,915,870.4	**1,000,000.0**	30,413.7	**946,284.1**	**23,692,690.0**	**0.0**	**23,424,190.0**	**1,000,000.0**
Year 5	DEC	31.0	313.0	0.0	277,450.0	719,900.0	**997,350.0**	0.0	118,796.8	14,904.0	**133,700.8**	277,450.0	**277,450.0**	863,649.2	863,649.2	1,863,649.2	**1,000,000.0**	28,170.0	**891,819.2**	**24,316,009.2**	**0.0**	**24,038,559.2**	**1,000,000.0**

Table B.5 Deterministic model for solids content of 70% in the wet condition for an unlined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)				Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly storage**	**Water move to reservoir**	**Cumulative storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Returned to pond**	**Water remained in reservoir**	**Water remained on TMF+ return from reservoir**
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	**1,036,467.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	926,458.1	926,458.1	926,458.1	**0.0**	33,578.1	**960,036.2**	**960,036.2**	**0.0**	**781,675.5**	**0.0**
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	**615,718.0**	0.0	85,901.8	14,904.0	**100,805.8**	161,100.0	**161,100.0**	514,912.2	514,912.2	514,912.2	**0.0**	17,789.4	**532,701.6**	**1,314,377.1**	**0.0**	**1,153,277.1**	**0.0**
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	**562,828.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	452,819.1	452,819.1	452,819.1	**0.0**	15,044.4	**467,863.5**	**1,621,140.6**	**0.0**	**1,442,779.9**	**0.0**
	APR	30.0	117.8	60.6	172,607.1	410,297.0	**582,904.1**	41,676.0	92,037.7	14,904.0	**148,617.7**	172,607.1	**172,607.1**	434,286.4	434,286.4	434,286.4	**0.0**	16,055.1	**450,341.5**	**1,893,121.4**	**0.0**	**1,720,514.3**	**0.0**
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	**678,265.7**	85,187.4	95,105.6	14,904.0	**195,197.0**	178,360.7	**178,360.7**	483,068.7	483,068.7	483,068.7	**0.0**	19,561.5	**502,630.2**	**2,223,144.5**	**0.0**	**2,044,783.8**	**0.0**
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	**824,933.1**	110,551.8	92,037.7	14,904.0	**217,493.5**	172,607.1	**172,607.1**	607,439.6	607,439.6	607,439.6	**0.0**	25,525.8	**632,965.4**	**2,677,749.2**	**0.0**	**2,505,142.1**	**0.0**
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	**501,303.7**	109,337.4	95,105.6	14,904.0	**219,347.0**	178,360.7	**178,360.7**	281,956.7	281,956.7	281,956.7	**0.0**	12,636.9	**294,593.6**	**2,799,735.7**	**0.0**	**2,621,375.0**	**0.0**
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	**557,745.7**	94,281.6	95,105.6	14,904.0	**204,291.2**	178,360.7	**178,360.7**	353,454.5	353,454.5	353,454.5	**0.0**	14,845.5	**368,300.0**	**2,989,675.0**	**0.0**	**2,811,314.3**	**0.0**
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	**757,911.1**	47,927.4	92,037.7	14,904.0	**154,869.1**	172,607.1	**172,607.1**	603,042.0	603,042.0	603,042.0	**0.0**	22,903.2	**625,945.2**	**3,437,259.5**	**0.0**	**3,264,652.4**	**0.0**
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	**994,492.7**	18,630.0	95,105.6	14,904.0	**128,639.6**	178,360.7	**178,360.7**	865,853.1	865,853.1	865,853.1	**0.0**	31,935.6	**897,788.7**	**4,162,441.1**	**0.0**	**3,984,080.4**	**0.0**
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	**949,846.1**	0.0	92,037.7	14,904.0	**106,941.7**	172,607.1	**172,607.1**	842,904.4	842,904.4	842,904.4	**0.0**	30,413.7	**873,318.1**	**4,857,398.5**	**0.0**	**4,684,791.4**	**0.0**
Year 1	DEC	31.0	313.0	0.0	178,360.7	719,900.0	**898,260.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	788,251.1	788,251.1	788,251.1	**0.0**	28,170.0	**816,421.1**	**5,501,212.5**	**0.0**	**5,322,851.8**	**0.0**
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	**1,036,467.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	926,458.1	926,458.1	926,458.1	**0.0**	33,578.1	**960,036.2**	**6,282,888.0**	**0.0**	**6,104,527.3**	**0.0**
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	**615,718.0**	0.0	85,901.8	14,904.0	**100,805.8**	161,100.0	**161,100.0**	514,912.2	514,912.2	514,912.2	**0.0**	17,789.4	**532,701.6**	**6,637,228.9**	**0.0**	**6,476,128.9**	**0.0**
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	**562,828.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	452,819.1	452,819.1	452,819.1	**0.0**	15,044.4	**467,863.5**	**6,943,992.4**	**0.0**	**6,765,631.7**	**0.0**
	APR	30.0	117.8	60.6	172,607.1	410,297.0	**582,904.1**	41,676.0	92,037.7	14,904.0	**148,617.7**	172,607.1	**172,607.1**	434,286.4	434,286.4	434,286.4	**0.0**	16,055.1	**450,341.5**	**7,215,973.2**	**0.0**	**7,043,366.1**	**0.0**
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	**678,265.7**	85,187.4	95,105.6	14,904.0	**195,197.0**	178,360.7	**178,360.7**	483,068.7	483,068.7	483,068.7	**0.0**	19,561.5	**502,630.2**	**7,545,996.3**	**0.0**	**7,367,635.6**	**0.0**
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	**824,933.1**	110,551.8	92,037.7	14,904.0	**217,493.5**	172,607.1	**172,607.1**	607,439.6	607,439.6	607,439.6	**0.0**	25,525.8	**632,965.4**	**8,000,601.0**	**0.0**	**7,827,993.9**	**0.0**
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	**501,303.7**	109,337.4	95,105.6	14,904.0	**219,347.0**	178,360.7	**178,360.7**	281,956.7	281,956.7	281,956.7	**0.0**	12,636.9	**294,593.6**	**8,122,587.5**	**0.0**	**7,944,226.8**	**0.0**
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	**557,745.7**	94,281.6	95,105.6	14,904.0	**204,291.2**	178,360.7	**178,360.7**	353,454.5	353,454.5	353,454.5	**0.0**	14,845.5	**368,300.0**	**8,312,526.8**	**0.0**	**8,134,166.1**	**0.0**
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	**757,911.1**	47,927.4	92,037.7	14,904.0	**154,869.1**	172,607.1	**172,607.1**	603,042.0	603,042.0	603,042.0	**0.0**	22,903.2	**625,945.2**	**8,760,111.3**	**0.0**	**8,587,504.2**	**0.0**
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	**994,492.7**	18,630.0	95,105.6	14,904.0	**128,639.6**	178,360.7	**178,360.7**	865,853.1	865,853.1	865,853.1	**0.0**	31,935.6	**897,788.7**	**9,485,292.9**	**0.0**	**9,306,932.2**	**0.0**
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	**949,846.1**	0.0	92,037.7	14,904.0	**106,941.7**	172,607.1	**172,607.1**	842,904.4	842,904.4	842,904.4	**0.0**	30,413.7	**873,318.1**	**10,180,250.3**	**0.0**	**10,007,643.2**	**0.0**
Year 2	DEC	31.0	313.0	0.0	178,360.7	719,900.0	**898,260.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	788,251.1	788,251.1	788,251.1	**0.0**	28,170.0	**816,421.1**	**10,824,064.3**	**0.0**	**10,645,703.6**	**0.0**
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	**1,036,467.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	926,458.1	926,458.1	926,458.1	**0.0**	33,578.1	**960,036.2**	**11,605,739.8**	**0.0**	**11,427,379.1**	**0.0**
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	**615,718.0**	0.0	85,901.8	14,904.0	**100,805.8**	161,100.0	**161,100.0**	514,912.2	514,912.2	514,912.2	**0.0**	17,789.4	**532,701.6**	**11,960,080.7**	**0.0**	**11,798,980.7**	**0.0**
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	**562,828.7**	0.0	95,105.6	14,904.0	**110,009.6**	178,360.7	**178,360.7**	452,819.1	452,819.1	452,819.1	**0.0**	15,044.4	**467,863.5**	**12,266,844.2**	**0.0**	**12,088,483.5**	**0.0**
	APR	30.0	117.8	60.6	172,607.1	410,297.0	**582,904.1**	41,676.0	92,037.7	14,904.0	**148,617.7**	172,607.1	**172,607.1**	434,286.4	434,286.4	434,286.4	**0.0**	16,055.1	**450,341.5**	**12,538,825.0**	**0.0**	**12,366,217.9**	**0.0**
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	**678,265.7**	85,187.4	95,105.6	14,904.0	**195,197.0**	178,360.7	**178,360.7**	483,068.7	483,068.7	483,068.7	**0.0**	19,561.5	**502,630.2**	**12,868,848.1**	**0.0**	**12,690,487.4**	**0.0**
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	**824,933.1**	110,551.8	92,037.7	14,904.0	**217,493.5**	172,607.1	**172,607.1**	607,439.6	607,439.6	607,439.6	**0.0**	25,525.8	**632,965.4**	**13,323,452.8**	**0.0**	**13,150,845.7**	**0.0**
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	**501,303.7**	109,337.4	95,105.6	14,904.0	**219,347.0**	178,360.7	**178,360.7**	281,956.7	281,956.7	281,956.7	**0.0**	12,636.9	**294,593.6**	**13,445,439.3**	**0.0**	**13,267,078.6**	**0.0**
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	**557,745.7**	94,281.6	95,105.6	14,904.0	**204,291.2**	178,360.7	**178,360.7**	353,454.5	353,454.5	353,454.5	**0.0**	14,845.5	**368,300.0**	**13,635,378.6**	**0.0**	**13,457,017.9**	**0.0**
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	**757,911.1**	47,927.4	92,037.7	14,904.0	**154,869.1**	172,607.1	**172,607.1**	603,042.0	603,042.0	603,042.0	**0.0**	22,903.2	**625,945.2**	**14,082,963.1**	**0.0**	**13,910,356.0**	**0.0**
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	**994,492.7**	18,630.0	95,105.6	14,904.0	**128,639.6**	178,360.7	**178,360.7**	865,853.1	865,853.1	865,853.1	**0.0**	31,935.6	**897,788.7**	**14,808,144.7**	**0.0**	**14,629,784.0**	**0.0**
Year 3	NOV	30.0	337.9	0.0	172,607.1	777,239.0	**949,846.1**	0.0	92,037.7	14,904.0	**106,941.7**	172,607.1	**172,607.1**	842,904.4	842,904.4	842,904.4	**0.0**	30,413.7	**873,318.1**	**15,503,102.1**	**0.0**	**15,330,495.0**	**0.0**

			Precipitation water (mm/month)		Water in (m³)			Water out (m³)				Mill required water (m³)		Water in the TMF (m³)					Reservoir storage (m³)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Total Water Input	Evaporation	Entrainment	Seepage loss	Total Water Output	Water with tailings	Total mill required water	Monthly storage	Water move to reservoir	Cumulative storage	Water remained in TMF	Mine impacted water runoff	Monthly reservoir storage	Cumulative reservoir storage	Returned to pond	Water remained in reservoir	Water remained on TMF+ return from reservoir
	DEC	31.0	313.0	0.0	178,360.7	719,900.0	898,260.7	0.0	95,105.6	14,904.0	110,009.6	178,360.7	178,360.7	788,251.1	788,251.1	788,251.1	0.0	28,170.0	816,421.1	16,146,916.1	0.0	15,968,555.4	0.0
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	1,036,467.7	0.0	95,105.6	14,904.0	110,009.6	178,360.7	178,360.7	926,458.1	926,458.1	926,458.1	0.0	33,578.1	960,036.2	16,928,591.6	0.0	16,750,230.9	0.0
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	615,718.0	0.0	85,901.8	14,904.0	100,805.8	161,100.0	161,100.0	514,912.2	514,912.2	514,912.2	0.0	17,789.4	532,701.6	17,282,932.5	0.0	17,121,832.5	0.0
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	562,828.7	0.0	95,105.6	14,904.0	110,009.6	178,360.7	178,360.7	452,819.1	452,819.1	452,819.1	0.0	15,044.4	467,863.5	17,589,696.0	0.0	17,411,335.3	0.0
	APR	30.0	117.8	60.6	172,607.1	410,297.0	582,904.1	41,676.0	92,037.7	14,904.0	148,617.7	172,607.1	172,607.1	434,286.4	434,286.4	434,286.4	0.0	16,055.1	450,341.5	17,861,676.8	0.0	17,689,069.7	0.0
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	678,265.7	85,187.4	95,105.6	14,904.0	195,197.0	178,360.7	178,360.7	483,068.7	483,068.7	483,068.7	0.0	19,561.5	502,630.2	18,191,699.9	0.0	18,013,339.2	0.0
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	824,933.1	110,551.8	92,037.7	14,904.0	217,493.5	172,607.1	172,607.1	607,439.6	607,439.6	607,439.6	0.0	25,525.8	632,965.4	18,646,304.6	0.0	18,473,697.5	0.0
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	501,303.7	109,337.4	95,105.6	14,904.0	219,347.0	178,360.7	178,360.7	281,956.7	281,956.7	281,956.7	0.0	12,636.9	294,593.6	18,768,291.1	0.0	18,589,930.4	0.0
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	557,745.7	94,281.6	95,105.6	14,904.0	204,291.2	178,360.7	178,360.7	353,454.5	353,454.5	353,454.5	0.0	14,845.5	368,300.0	18,958,230.4	0.0	18,779,869.7	0.0
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	757,911.1	47,927.4	92,037.7	14,904.0	154,869.1	172,607.1	172,607.1	603,042.0	603,042.0	603,042.0	0.0	22,903.2	625,945.2	19,405,814.9	0.0	19,233,207.8	0.0
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	994,492.7	18,630.0	95,105.6	14,904.0	128,639.6	178,360.7	178,360.7	865,853.1	865,853.1	865,853.1	0.0	31,935.6	897,788.7	20,130,996.5	0.0	19,952,635.8	0.0
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	949,846.1	0.0	92,037.7	14,904.0	106,941.7	172,607.1	172,607.1	842,904.4	842,904.4	842,904.4	0.0	30,413.7	873,318.1	20,825,953.9	0.0	20,653,346.8	0.0
Year 4	DEC	31.0	313.0	0.0	178,360.7	719,900.0	898,260.7	0.0	95,105.6	14,904.0	110,009.6	178,360.7	178,360.7	788,251.1	788,251.1	788,251.1	0.0	28,170.0	816,421.1	21,469,767.9	0.0	21,291,407.2	0.0
	JAN	31.0	373.1	0.0	178,360.7	858,107.0	1,036,467.7	0.0	95,105.6	14,904.0	110,009.6	178,360.7	178,360.7	926,458.1	926,458.1	926,458.1	0.0	33,578.1	960,036.2	22,251,443.4	0.0	22,073,082.7	0.0
	FEB	28.0	197.7	0.0	161,100.0	454,618.0	615,718.0	0.0	85,901.8	14,904.0	100,805.8	161,100.0	161,100.0	514,912.2	514,912.2	514,912.2	0.0	17,789.4	532,701.6	22,605,784.3	0.0	22,444,684.3	0.0
	MAR	31.0	167.2	0.0	178,360.7	384,468.0	562,828.7	0.0	95,105.6	14,904.0	110,009.6	178,360.7	178,360.7	452,819.1	452,819.1	452,819.1	0.0	15,044.4	467,863.5	22,912,547.8	0.0	22,734,187.1	0.0
	APR	30.0	117.8	60.6	172,607.1	410,297.0	582,904.1	41,676.0	92,037.7	14,904.0	148,617.7	172,607.1	172,607.1	434,286.4	434,286.4	434,286.4	0.0	16,055.1	450,341.5	23,184,528.6	0.0	23,011,921.5	0.0
	MAY	31.0	98.5	118.9	178,360.7	499,905.0	678,265.7	85,187.4	95,105.6	14,904.0	195,197.0	178,360.7	178,360.7	483,068.7	483,068.7	483,068.7	0.0	19,561.5	502,630.2	23,514,551.7	0.0	23,336,191.0	0.0
	JUN	30.0	98.3	185.4	172,607.1	652,326.0	824,933.1	110,551.8	92,037.7	14,904.0	217,493.5	172,607.1	172,607.1	607,439.6	607,439.6	607,439.6	0.0	25,525.8	632,965.4	23,969,156.4	0.0	23,796,549.3	0.0
	JUL	31.0	102.8	37.6	178,360.7	322,943.0	501,303.7	109,337.4	95,105.6	14,904.0	219,347.0	178,360.7	178,360.7	281,956.7	281,956.7	281,956.7	0.0	12,636.9	294,593.6	24,091,142.9	0.0	23,912,782.2	0.0
	AUG	31.0	163.6	1.4	178,360.7	379,385.0	557,745.7	94,281.6	95,105.6	14,904.0	204,291.2	178,360.7	178,360.7	353,454.5	353,454.5	353,454.5	0.0	14,845.5	368,300.0	24,281,082.2	0.0	24,102,721.5	0.0
	SEP	30.0	246.2	8.3	172,607.1	585,304.0	757,911.1	47,927.4	92,037.7	14,904.0	154,869.1	172,607.1	172,607.1	603,042.0	603,042.0	603,042.0	0.0	22,903.2	625,945.2	24,728,666.7	0.0	24,556,059.6	0.0
	OCT	31.0	354.8	0.0	178,360.7	816,132.0	994,492.7	18,630.0	95,105.6	14,904.0	128,639.6	178,360.7	178,360.7	865,853.1	865,853.1	865,853.1	0.0	31,935.6	897,788.7	25,453,848.3	0.0	25,275,487.6	0.0
	NOV	30.0	337.9	0.0	172,607.1	777,239.0	949,846.1	0.0	92,037.7	14,904.0	106,941.7	172,607.1	172,607.1	842,904.4	842,904.4	842,904.4	0.0	30,413.7	873,318.1	26,148,805.7	0.0	25,976,198.6	0.0
Year 5	DEC	31.0	313.0	0.0	178,360.7	719,900.0	898,260.7	0.0	95,105.6	14,904.0	110,009.6	178,360.7	178,360.7	788,251.1	788,251.1	788,251.1	0.0	28,170.0	816,421.1	26,792,619.7	0.0	26,614,259.0	0.0

Table B.6 Deterministic model for solids content of 80% in the wet condition for an unlined impoundment

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)				Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Total Water Input	Evaporation	Entrainment	Seepage loss	Total Water Output	Water with tailings	Total mill required water	Monthly storage	Water move to reservoir	Cumulative storage	Water remained in TMF	Mine impacted water runoff	Monthly reservoir storage	Cumulative reservoir storage	Returned to pond	Water remained in reservoir	Water remained on TMF+ return from reservoir
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	865,741.7	865,741.7	865,741.7	0.0	33,578.1	899,319.8	899,319.8	0.0	795,276.0	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	14,904.0	88,521.5	93,975.0	93,975.0	460,071.5	460,071.5	460,071.5	0.0	17,789.4	477,860.9	1,273,136.9	0.0	1,179,161.9	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	392,102.7	392,102.7	392,102.7	0.0	15,044.4	407,147.1	1,586,309.0	0.0	1,482,265.2	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	14,904.0	135,455.9	100,687.5	100,687.5	375,528.6	375,528.6	375,528.6	0.0	16,055.1	391,583.7	1,873,848.9	0.0	1,773,161.4	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	14,904.0	181,596.5	104,043.8	104,043.8	422,352.3	422,352.3	422,352.3	0.0	19,561.5	441,913.8	2,215,075.2	0.0	2,111,031.4	0.0
	JUN	30.0	5.0	185.4	100,687.5	437,805.0	538,492.5	110,551.8	78,875.9	14,904.0	204,331.7	100,687.5	100,687.5	334,160.8	334,160.8	334,160.8	0.0	17,131.5	351,292.3	2,462,323.7	0.0	2,361,636.2	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	14,904.0	205,746.5	104,043.8	104,043.8	221,240.3	221,240.3	221,240.3	0.0	12,636.9	233,877.2	2,595,513.4	0.0	2,491,469.6	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	14,904.0	190,690.7	104,043.8	104,043.8	292,738.1	292,738.1	292,738.1	0.0	14,845.5	307,583.6	2,799,053.2	0.0	2,695,009.4	0.0
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	14,904.0	141,707.3	100,687.5	100,687.5	544,284.2	544,284.2	544,284.2	0.0	22,903.2	567,187.4	3,262,196.8	0.0	3,161,509.3	0.0
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	920,175.8	18,630.0	81,505.1	14,904.0	115,039.1	104,043.8	104,043.8	805,136.7	805,136.7	805,136.7	0.0	31,935.6	837,072.3	3,998,581.6	0.0	3,894,537.8	0.0
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	877,926.5	0.0	78,875.9	14,904.0	93,779.9	100,687.5	100,687.5	784,146.6	784,146.6	784,146.6	0.0	30,413.7	814,560.3	4,709,098.1	0.0	4,608,410.6	0.0
Year 1	DEC	31.0	313.0	0.0	104,043.8	719,900.0	823,943.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	727,534.7	727,534.7	727,534.7	0.0	28,170.0	755,704.7	5,364,115.3	0.0	5,260,071.5	0.0
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	865,741.7	865,741.7	865,741.7	0.0	33,578.1	899,319.8	6,159,391.3	0.0	6,055,347.5	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	14,904.0	88,521.5	93,975.0	93,975.0	460,071.5	460,071.5	460,071.5	0.0	17,789.4	477,860.9	6,533,208.4	0.0	6,439,233.4	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	392,102.7	392,102.7	392,102.7	0.0	15,044.4	407,147.1	6,846,380.5	0.0	6,742,336.7	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	14,904.0	135,455.9	100,687.5	100,687.5	375,528.6	375,528.6	375,528.6	0.0	16,055.1	391,583.7	7,133,920.4	0.0	7,033,232.9	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	14,904.0	181,596.5	104,043.8	104,043.8	422,352.3	422,352.3	422,352.3	0.0	19,561.5	441,913.8	7,475,146.7	0.0	7,371,102.9	0.0
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	753,013.5	110,551.8	78,875.9	14,904.0	204,331.7	100,687.5	100,687.5	548,681.8	548,681.8	548,681.8	0.0	25,525.8	574,207.6	7,945,310.5	0.0	7,844,623.0	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	14,904.0	205,746.5	104,043.8	104,043.8	221,240.3	221,240.3	221,240.3	0.0	12,636.9	233,877.2	8,078,500.2	0.0	7,974,456.4	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	14,904.0	190,690.7	104,043.8	104,043.8	292,738.1	292,738.1	292,738.1	0.0	14,845.5	307,583.6	8,282,040.0	0.0	8,177,996.2	0.0
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	14,904.0	141,707.3	100,687.5	100,687.5	544,284.2	544,284.2	544,284.2	0.0	22,903.2	567,187.4	8,745,183.6	0.0	8,644,496.1	0.0
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	920,175.8	18,630.0	81,505.1	14,904.0	115,039.1	104,043.8	104,043.8	805,136.7	805,136.7	805,136.7	0.0	31,935.6	837,072.3	9,481,568.4	0.0	9,377,524.6	0.0
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	877,926.5	0.0	78,875.9	14,904.0	93,779.9	100,687.5	100,687.5	784,146.6	784,146.6	784,146.6	0.0	30,413.7	814,560.3	10,192,084.9	0.0	10,091,397.4	0.0
Year 2	DEC	31.0	313.0	0.0	104,043.8	719,900.0	823,943.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	727,534.7	727,534.7	727,534.7	0.0	28,170.0	755,704.7	10,847,102.1	0.0	10,743,058.3	0.0
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	962,150.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	865,741.7	865,741.7	865,741.7	0.0	33,578.1	899,319.8	11,642,378.1	0.0	11,538,334.3	0.0
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	548,593.0	0.0	73,617.5	14,904.0	88,521.5	93,975.0	93,975.0	460,071.5	460,071.5	460,071.5	0.0	17,789.4	477,860.9	12,016,195.2	0.0	11,922,220.2	0.0
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	488,511.8	0.0	81,505.1	14,904.0	96,409.1	104,043.8	104,043.8	392,102.7	392,102.7	392,102.7	0.0	15,044.4	407,147.1	12,329,367.3	0.0	12,225,323.5	0.0
	APR	30.0	117.8	60.6	100,687.5	410,297.0	510,984.5	41,676.0	78,875.9	14,904.0	135,455.9	100,687.5	100,687.5	375,528.6	375,528.6	375,528.6	0.0	16,055.1	391,583.7	12,616,907.2	0.0	12,516,219.7	0.0
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	603,948.8	85,187.4	81,505.1	14,904.0	181,596.5	104,043.8	104,043.8	422,352.3	422,352.3	422,352.3	0.0	19,561.5	441,913.8	12,958,133.5	0.0	12,854,089.7	0.0
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	753,013.5	110,551.8	78,875.9	14,904.0	204,331.7	100,687.5	100,687.5	548,681.8	548,681.8	548,681.8	0.0	25,525.8	574,207.6	13,428,297.3	0.0	13,327,609.8	0.0
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	426,986.8	109,337.4	81,505.1	14,904.0	205,746.5	104,043.8	104,043.8	221,240.3	221,240.3	221,240.3	0.0	12,636.9	233,877.2	13,561,487.0	0.0	13,457,443.2	0.0
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	483,428.8	94,281.6	81,505.1	14,904.0	190,690.7	104,043.8	104,043.8	292,738.1	292,738.1	292,738.1	0.0	14,845.5	307,583.6	13,765,026.8	0.0	13,660,983.0	0.0
Year 3	SEP	30.0	246.2	8.3	100,687.5	585,304.0	685,991.5	47,927.4	78,875.9	14,904.0	141,707.3	100,687.5	100,687.5	544,284.2	544,284.2	544,284.2	0.0	22,903.2	567,187.4	14,228,170.4	0.0	14,127,482.9	0.0

			Precipitation water (mm/month)		Water in (m^3)			Water out (m^3)				Mill required water (m^3)		Water in the TMF (m^3)					Reservoir storage (m^3)				
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	**Total Water Input**	Evaporation	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly storage**	**Water move to reservoir**	**Cumulative storage**	**Water remained in TMF**	**Mine impacted water runoff**	**Monthly reservoir storage**	**Cumulative reservoir storage**	**Returned to pond**	**Water remained in reservoir**	**Water remained on TMF+ return from reservoir**
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	**920,175.8**	18,630.0	81,505.1	14,904.0	**115,039.1**	104,043.8	**104,043.8**	805,136.7	805,136.7	805,136.7	**0.0**	31,935.6	**837,072.3**	**14,964,555.2**	**0.0**	**14,860,511.4**	**0.0**
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	**877,926.5**	0.0	78,875.9	14,904.0	**93,779.9**	100,687.5	**100,687.5**	784,146.6	784,146.6	784,146.6	**0.0**	30,413.7	**814,560.3**	**15,675,071.7**	**0.0**	**15,574,384.2**	**0.0**
	DEC	31.0	313.0	0.0	104,043.8	719,900.0	**823,943.8**	0.0	81,505.1	14,904.0	**96,409.1**	104,043.8	**104,043.8**	727,534.7	727,534.7	727,534.7	**0.0**	28,170.0	**755,704.7**	**16,330,088.9**	**0.0**	**16,226,045.1**	**0.0**
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	**962,150.8**	0.0	81,505.1	14,904.0	**96,409.1**	104,043.8	**104,043.8**	865,741.7	865,741.7	865,741.7	**0.0**	33,578.1	**899,319.8**	**17,125,364.9**	**0.0**	**17,021,321.1**	**0.0**
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	**548,593.0**	0.0	73,617.5	14,904.0	**88,521.5**	93,975.0	**93,975.0**	460,071.5	460,071.5	460,071.5	**0.0**	17,789.4	**477,860.9**	**17,499,182.0**	**0.0**	**17,405,207.0**	**0.0**
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	**488,511.8**	0.0	81,505.1	14,904.0	**96,409.1**	104,043.8	**104,043.8**	392,102.7	392,102.7	392,102.7	**0.0**	15,044.4	**407,147.1**	**17,812,354.1**	**0.0**	**17,708,310.3**	**0.0**
	APR	30.0	117.8	60.6	100,687.5	410,297.0	**510,984.5**	41,676.0	78,875.9	14,904.0	**135,455.9**	100,687.5	**100,687.5**	375,528.6	375,528.6	375,528.6	**0.0**	16,055.1	**391,583.7**	**18,099,894.0**	**0.0**	**17,999,206.5**	**0.0**
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	**603,948.8**	85,187.4	81,505.1	14,904.0	**181,596.5**	104,043.8	**104,043.8**	422,352.3	422,352.3	422,352.3	**0.0**	19,561.5	**441,913.8**	**18,441,120.3**	**0.0**	**18,337,076.5**	**0.0**
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	**753,013.5**	110,551.8	78,875.9	14,904.0	**204,331.7**	100,687.5	**100,687.5**	548,681.8	548,681.8	548,681.8	**0.0**	25,525.8	**574,207.6**	**18,911,284.1**	**0.0**	**18,810,596.6**	**0.0**
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	**426,986.8**	109,337.4	81,505.1	14,904.0	**205,746.5**	104,043.8	**104,043.8**	221,240.3	221,240.3	221,240.3	**0.0**	12,636.9	**233,877.2**	**19,044,473.8**	**0.0**	**18,940,430.0**	**0.0**
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	**483,428.8**	94,281.6	81,505.1	14,904.0	**190,690.7**	104,043.8	**104,043.8**	292,738.1	292,738.1	292,738.1	**0.0**	14,845.5	**307,583.6**	**19,248,013.6**	**0.0**	**19,143,969.8**	**0.0**
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	**685,991.5**	47,927.4	78,875.9	14,904.0	**141,707.3**	100,687.5	**100,687.5**	544,284.2	544,284.2	544,284.2	**0.0**	22,903.2	**567,187.4**	**19,711,157.2**	**0.0**	**19,610,469.7**	**0.0**
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	**920,175.8**	18,630.0	81,505.1	14,904.0	**115,039.1**	104,043.8	**104,043.8**	805,136.7	805,136.7	805,136.7	**0.0**	31,935.6	**837,072.3**	**20,447,542.0**	**0.0**	**20,343,498.2**	**0.0**
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	**877,926.5**	0.0	78,875.9	14,904.0	**93,779.9**	100,687.5	**100,687.5**	784,146.6	784,146.6	784,146.6	**0.0**	30,413.7	**814,560.3**	**21,158,058.5**	**0.0**	**21,057,371.0**	**0.0**
Year 4	DEC	31.0	313.0	0.0	104,043.8	719,900.0	**823,943.8**	0.0	81,505.1	14,904.0	**96,409.1**	104,043.8	**104,043.8**	727,534.7	727,534.7	727,534.7	**0.0**	28,170.0	**755,704.7**	**21,813,075.7**	**0.0**	**21,709,031.9**	**0.0**
	JAN	31.0	373.1	0.0	104,043.8	858,107.0	**962,150.8**	0.0	81,505.1	14,904.0	**96,409.1**	104,043.8	**104,043.8**	865,741.7	865,741.7	865,741.7	**0.0**	33,578.1	**899,319.8**	**22,608,351.7**	**0.0**	**22,504,307.9**	**0.0**
	FEB	28.0	197.7	0.0	93,975.0	454,618.0	**548,593.0**	0.0	73,617.5	14,904.0	**88,521.5**	93,975.0	**93,975.0**	460,071.5	460,071.5	460,071.5	**0.0**	17,789.4	**477,860.9**	**22,982,168.8**	**0.0**	**22,888,193.8**	**0.0**
	MAR	31.0	167.2	0.0	104,043.8	384,468.0	**488,511.8**	0.0	81,505.1	14,904.0	**96,409.1**	104,043.8	**104,043.8**	392,102.7	392,102.7	392,102.7	**0.0**	15,044.4	**407,147.1**	**23,295,340.9**	**0.0**	**23,191,297.1**	**0.0**
	APR	30.0	117.8	60.6	100,687.5	410,297.0	**510,984.5**	41,676.0	78,875.9	14,904.0	**135,455.9**	100,687.5	**100,687.5**	375,528.6	375,528.6	375,528.6	**0.0**	16,055.1	**391,583.7**	**23,582,880.8**	**0.0**	**23,482,193.3**	**0.0**
	MAY	31.0	98.5	118.9	104,043.8	499,905.0	**603,948.8**	85,187.4	81,505.1	14,904.0	**181,596.5**	104,043.8	**104,043.8**	422,352.3	422,352.3	422,352.3	**0.0**	19,561.5	**441,913.8**	**23,924,107.1**	**0.0**	**23,820,063.3**	**0.0**
	JUN	30.0	98.3	185.4	100,687.5	652,326.0	**753,013.5**	110,551.8	78,875.9	14,904.0	**204,331.7**	100,687.5	**100,687.5**	548,681.8	548,681.8	548,681.8	**0.0**	25,525.8	**574,207.6**	**24,394,270.9**	**0.0**	**24,293,583.4**	**0.0**
	JUL	31.0	102.8	37.6	104,043.8	322,943.0	**426,986.8**	109,337.4	81,505.1	14,904.0	**205,746.5**	104,043.8	**104,043.8**	221,240.3	221,240.3	221,240.3	**0.0**	12,636.9	**233,877.2**	**24,527,460.6**	**0.0**	**24,423,416.8**	**0.0**
	AUG	31.0	163.6	1.4	104,043.8	379,385.0	**483,428.8**	94,281.6	81,505.1	14,904.0	**190,690.7**	104,043.8	**104,043.8**	292,738.1	292,738.1	292,738.1	**0.0**	14,845.5	**307,583.6**	**24,731,000.4**	**0.0**	**24,626,956.6**	**0.0**
	SEP	30.0	246.2	8.3	100,687.5	585,304.0	**685,991.5**	47,927.4	78,875.9	14,904.0	**141,707.3**	100,687.5	**100,687.5**	544,284.2	544,284.2	544,284.2	**0.0**	22,903.2	**567,187.4**	**25,194,144.0**	**0.0**	**25,093,456.5**	**0.0**
	OCT	31.0	354.8	0.0	104,043.8	816,132.0	**920,175.8**	18,630.0	81,505.1	14,904.0	**115,039.1**	104,043.8	**104,043.8**	805,136.7	805,136.7	805,136.7	**0.0**	31,935.6	**837,072.3**	**25,930,528.8**	**0.0**	**25,826,485.0**	**0.0**
	NOV	30.0	337.9	0.0	100,687.5	777,239.0	**877,926.5**	0.0	78,875.9	14,904.0	**93,779.9**	100,687.5	**100,687.5**	784,146.6	784,146.6	784,146.6	**0.0**	30,413.7	**814,560.3**	**26,641,045.3**	**0.0**	**26,540,357.8**	**0.0**
Year 5	DEC	31.0	313.0	0.0	104,043.8	719,900.0	**823,943.8**	0.0	81,505.1	14,904.0	**96,409.1**	104,043.8	**104,043.8**	727,534.7	727,534.7	727,534.7	**0.0**	28,170.0	**755,704.7**	**27,296,062.5**	**0.0**	**27,192,018.7**	**0.0**

Appendix C Results of dry climate simulation

C.1 Lined impoundment

Table C.1 Deterministic model for solids content of 60% in the dry condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-78,316.8**	-0.2
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-153,877.1**	-0.2
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-232,653.8**	-0.2
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-449,616.5**	-0.3
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-727,066.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-995,566.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-1,273,016.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-1,550,466.5**	-0.5
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-1,798,398.7**	-0.5
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-1,937,911.6**	-0.5
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-1,982,956.2**	-0.4
Year 1	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-2,030,913.0**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-2,109,229.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-2,184,790.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-2,263,566.8**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-2,480,529.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-2,757,979.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-3,026,479.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-3,303,929.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-3,581,379.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-3,829,311.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-3,968,824.6**	-0.4
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-4,013,869.2**	-0.4
Year 2	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-4,061,826.0**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-4,140,142.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-4,215,703.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-4,294,479.8**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-4,511,442.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-4,788,892.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-5,057,392.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-5,334,842.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-5,612,292.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-5,860,224.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-5,999,737.6**	-0.4
Year 3	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-6,044,782.2**	-0.4

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-6,092,738.9**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-6,171,055.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-6,246,616.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-6,325,392.8**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-6,542,355.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-6,819,805.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-7,088,305.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-7,365,755.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-7,643,205.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-7,891,137.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-8,030,650.5**	-0.4
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-8,075,695.2**	-0.4
Year 4	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-8,123,651.9**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-8,201,968.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-8,277,529.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-8,356,305.7**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-8,573,268.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-8,850,718.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-9,119,218.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-9,396,668.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-9,674,118.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-9,922,050.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-10,061,563.5**	-0.4
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-10,106,608.1**	-0.4
Year 5	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-10,154,564.9**	-0.4

Table C.2 Deterministic model for solids content of 70% in the dry condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,735.1	178,360.7	**-54,625.6**	-0.1
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	**85,901.8**	161,100.0	**161,100.0**	106,938.2	161,100.0	**-108,787.4**	-0.1
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,275.1	178,360.7	**-163,873.0**	-0.1
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	**205,745.1**	172,607.1	**172,607.1**	5,502.1	172,607.1	**-330,978.1**	-0.2
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	**327,414.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-509,338.8**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	**393,567.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-681,945.9**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	**393,314.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-860,306.6**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	**352,236.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-1,038,667.3**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	**222,788.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-1,211,274.5**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	**145,885.0**	178,360.7	**178,360.7**	74,565.7	178,360.7	**-1,315,069.5**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	**92,037.7**	172,607.1	**172,607.1**	150,489.5	172,607.1	**-1,337,187.1**	-0.3
Year 1	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	154,095.1	178,360.7	**-1,361,452.7**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,735.1	178,360.7	**-1,416,078.3**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	**85,901.8**	161,100.0	**161,100.0**	106,938.2	161,100.0	**-1,470,240.1**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,275.1	178,360.7	**-1,525,325.7**	-0.2
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	**205,745.1**	172,607.1	**172,607.1**	5,502.1	172,607.1	**-1,692,430.8**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	**327,414.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-1,870,791.5**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	**393,567.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-2,043,398.6**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	**393,314.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-2,221,759.3**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	**352,236.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-2,400,120.1**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	**222,788.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-2,572,727.2**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	**145,885.0**	178,360.7	**178,360.7**	74,565.7	178,360.7	**-2,676,522.2**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	**92,037.7**	172,607.1	**172,607.1**	150,489.5	172,607.1	**-2,698,639.9**	-0.3
Year 2	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	154,095.1	178,360.7	**-2,722,905.4**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,735.1	178,360.7	**-2,777,531.0**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	**85,901.8**	161,100.0	**161,100.0**	106,938.2	161,100.0	**-2,831,692.8**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,275.1	178,360.7	**-2,886,778.4**	-0.3
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	**205,745.1**	172,607.1	**172,607.1**	5,502.1	172,607.1	**-3,053,883.5**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	**327,414.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-3,232,244.2**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	**393,567.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-3,404,851.4**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	**393,314.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-3,583,212.1**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	**352,236.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-3,761,572.8**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	**222,788.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-3,934,179.9**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	**145,885.0**	178,360.7	**178,360.7**	74,565.7	178,360.7	**-4,037,974.9**	-0.3
Year 3	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	**92,037.7**	172,607.1	**172,607.1**	150,489.5	172,607.1	**-4,060,092.6**	-0.3

			Precipitation water (mm/month)		Water in (m^3)				Water out (m^3)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m^3)**	**Water deficit (m^3/tonne)**
	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	154,095.1	178,360.7	**-4,084,358.2**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,735.1	178,360.7	**-4,138,983.7**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	**85,901.8**	161,100.0	**161,100.0**	106,938.2	161,100.0	**-4,193,145.6**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,275.1	178,360.7	**-4,248,231.2**	-0.3
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	**205,745.1**	172,607.1	**172,607.1**	5,502.1	172,607.1	**-4,415,336.2**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	**327,414.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-4,593,696.9**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	**393,567.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-4,766,304.1**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	**393,314.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-4,944,664.8**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	**352,236.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-5,123,025.5**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	**222,788.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-5,295,632.6**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	**145,885.0**	178,360.7	**178,360.7**	74,565.7	178,360.7	**-5,399,427.6**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	**92,037.7**	172,607.1	**172,607.1**	150,489.5	172,607.1	**-5,421,545.3**	-0.3
Year 4	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	154,095.1	178,360.7	**-5,445,810.9**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,735.1	178,360.7	**-5,500,436.5**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	**85,901.8**	161,100.0	**161,100.0**	106,938.2	161,100.0	**-5,554,598.3**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	123,275.1	178,360.7	**-5,609,683.9**	-0.3
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	**205,745.1**	172,607.1	**172,607.1**	5,502.1	172,607.1	**-5,776,788.9**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	**327,414.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-5,955,149.7**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	**393,567.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-6,127,756.8**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	**393,314.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-6,306,117.5**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	**352,236.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-6,484,478.2**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	**222,788.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-6,657,085.4**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	**145,885.0**	178,360.7	**178,360.7**	74,565.7	178,360.7	**-6,760,880.4**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	**92,037.7**	172,607.1	**172,607.1**	150,489.5	172,607.1	**-6,782,998.0**	-0.3
Year 5	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	**95,105.6**	178,360.7	**178,360.7**	154,095.1	178,360.7	**-6,807,263.6**	-0.3

Table C.3 Deterministic model for solids content of 80% in the dry condition for a lined impoundment

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m^3)**	**Water deficit (m^3/tonne)**
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-47,631.0**	-0.1
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-95,475.2**	-0.1
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-143,566.3**	-0.1
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-244,253.8**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-348,297.5**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-448,985.0**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-553,028.8**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-657,072.5**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-757,760.0**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-833,179.7**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-848,528.4**	-0.2
Year 1	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-865,799.5**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-913,430.5**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-961,274.7**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-1,009,365.7**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,110,053.2**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,214,097.0**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,314,784.5**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,418,828.2**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,522,872.0**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,623,559.5**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-1,698,979.1**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-1,714,327.9**	-0.2
Year 2	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-1,731,598.9**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-1,779,230.0**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-1,827,074.2**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-1,875,165.2**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,975,852.7**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,079,896.5**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,180,584.0**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,284,627.7**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,388,671.5**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,489,359.0**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-2,564,778.6**	-0.2
Year 3	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-2,580,127.4**	-0.2

			Precipitation water (mm/month)		Water in (m^3)				Water out (m^3)			Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from TMF	Entrainment	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m^3)**	**Water deficit (m^3/tonne)**
	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-2,597,398.4**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-2,645,029.5**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-2,692,873.6**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-2,740,964.7**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,841,652.2**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,945,695.9**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,046,383.4**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-3,150,427.2**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-3,254,470.9**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,355,158.4**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-3,430,578.1**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-3,445,926.8**	-0.2
Year 4	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-3,463,197.9**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	56,412.7	104,043.8	**-3,510,828.9**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	**79,584.2**	93,975.0	**93,975.0**	46,130.8	93,975.0	**-3,558,673.1**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	55,952.7	104,043.8	**-3,606,764.2**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	**151,099.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,707,451.7**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	**222,605.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-3,811,495.4**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	**259,838.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-3,912,182.9**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	**260,758.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-4,016,226.7**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	**236,976.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-4,120,270.4**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	**160,966.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-4,220,957.9**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	**117,509.6**	104,043.8	**104,043.8**	28,624.1	104,043.8	**-4,296,377.6**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	**85,268.8**	100,687.5	**100,687.5**	85,338.7	100,687.5	**-4,311,726.3**	-0.2
Year 5	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	**88,111.0**	104,043.8	**104,043.8**	86,772.7	104,043.8	**-4,328,997.4**	-0.2

C.2 Unlined impoundment

Table C.4 Deterministic model for solids content of 60% in the dry condition for an unlined impoundment

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)				Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from pond	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	4,968.0	**123,764.8**	277,450.0	**277,450.0**	194,165.2	277,450.0	**-83,284.8**	-0.2
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	4,968.0	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-158,845.1**	-0.2
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-237,621.8**	-0.2
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	4,968.0	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-454,584.5**	-0.3
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	4,968.0	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-732,034.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	4,968.0	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-1,000,534.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	4,968.0	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-1,277,984.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	4,968.0	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-1,555,434.5**	-0.5
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	4,968.0	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-1,803,366.7**	-0.5
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	4,968.0	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-1,942,879.6**	-0.5
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	4,968.0	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-1,987,924.2**	-0.4
Year 1	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-2,035,881.0**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-2,114,197.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	4,968.0	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-2,189,758.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-2,268,534.8**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	4,968.0	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-2,485,497.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	4,968.0	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-2,762,947.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	4,968.0	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-3,031,447.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	4,968.0	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-3,308,897.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	4,968.0	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-3,586,347.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	4,968.0	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-3,834,279.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	4,968.0	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-3,973,792.6**	-0.4
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	4,968.0	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-4,018,837.2**	-0.4
Year 2	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-4,066,794.0**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-4,145,110.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	4,968.0	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-4,220,671.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-4,299,447.8**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	4,968.0	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-4,516,410.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	4,968.0	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-4,793,860.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	4,968.0	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-5,062,360.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	4,968.0	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-5,339,810.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	4,968.0	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-5,617,260.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	4,968.0	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-5,865,192.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	4,968.0	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-6,004,705.6**	-0.4
Year 3	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	4,968.0	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-6,049,750.2**	-0.4

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)				Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from pond	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m^3)**	**Water deficit (m^3/tonne)**
	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-6,097,706.9**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-6,176,023.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	4,968.0	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-6,251,584.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-6,330,360.8**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	4,968.0	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-6,547,323.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	4,968.0	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-6,824,773.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	4,968.0	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-7,093,273.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	4,968.0	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-7,370,723.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	4,968.0	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-7,648,173.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	4,968.0	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-7,896,105.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	4,968.0	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-8,035,618.5**	-0.4
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	4,968.0	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-8,080,663.2**	-0.4
Year 4	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-8,128,619.9**	-0.4
	JAN	31.0	17.6	0.0	277,450.0	40,480.0	0.0	**317,930.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	199,133.2	277,450.0	**-8,206,936.7**	-0.4
	FEB	28.0	13.8	0.0	250,600.0	31,740.0	0.0	**282,340.0**	0.0	107,300.3	4,968.0	**107,300.3**	250,600.0	**250,600.0**	175,039.7	250,600.0	**-8,282,497.0**	-0.4
	MAR	31.0	17.4	0.0	277,450.0	40,020.0	0.0	**317,470.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	198,673.2	277,450.0	**-8,361,273.7**	-0.4
	APR	30.0	16.8	0.0	268,500.0	38,640.0	0.0	**307,140.0**	140,638.1	114,964.6	4,968.0	**255,602.7**	268,500.0	**268,500.0**	51,537.3	268,500.0	**-8,578,236.5**	-0.4
	MAY	31.0	15.9	0.0	277,450.0	36,570.0	0.0	**314,020.0**	287,329.8	118,796.8	4,968.0	**406,126.6**	277,450.0	**277,450.0**	0.0	277,450.0	**-8,855,686.5**	-0.4
	JUN	30.0	7.8	0.0	268,500.0	17,940.0	0.0	**286,440.0**	372,945.0	114,964.6	4,968.0	**487,909.6**	268,500.0	**268,500.0**	0.0	268,500.0	**-9,124,186.5**	-0.4
	JUL	31.0	8.9	0.0	277,450.0	20,470.0	0.0	**297,920.0**	368,837.2	118,796.8	4,968.0	**487,634.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-9,401,636.5**	-0.4
	AUG	31.0	8.0	0.0	277,450.0	18,400.0	0.0	**295,850.0**	318,030.2	118,796.8	4,968.0	**436,827.0**	277,450.0	**277,450.0**	0.0	277,450.0	**-9,679,086.5**	-0.4
	SEP	30.0	12.5	0.0	268,500.0	28,750.0	0.0	**297,250.0**	161,717.6	114,964.6	4,968.0	**276,682.2**	268,500.0	**268,500.0**	20,567.8	268,500.0	**-9,927,018.7**	-0.4
	OCT	31.0	18.3	0.0	277,450.0	42,090.0	0.0	**319,540.0**	62,806.1	118,796.8	4,968.0	**181,602.9**	277,450.0	**277,450.0**	137,937.1	277,450.0	**-10,066,531.5**	-0.4
	NOV	30.0	30.4	0.0	268,500.0	69,920.0	0.0	**338,420.0**	0.0	114,964.6	4,968.0	**114,964.6**	268,500.0	**268,500.0**	223,455.4	268,500.0	**-10,111,576.1**	-0.4
Year 5	DEC	31.0	30.8	0.0	277,450.0	70,840.0	0.0	**348,290.0**	0.0	118,796.8	4,968.0	**118,796.8**	277,450.0	**277,450.0**	229,493.2	277,450.0	**-10,159,532.9**	-0.4

Table C.5 Deterministic model for solids content of 70% in the dry condition for an unlined impoundment

			Precipitation water (mm/month)		Water in (m^3)				Water out (m^3)				Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from pond	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m^3)**	**Water deficit (m^3/tonne)**
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,767.1	178,360.7	**-59,593.6**	-0.1
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	4,968.0	**90,869.8**	161,100.0	**161,100.0**	101,970.2	161,100.0	**-118,723.4**	-0.1
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,307.1	178,360.7	**-178,777.0**	-0.1
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	4,968.0	**210,713.1**	172,607.1	**172,607.1**	534.1	172,607.1	**-350,850.1**	-0.2
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	4,968.0	**332,382.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-529,210.8**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	4,968.0	**398,535.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-701,817.9**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	4,968.0	**398,282.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-880,178.6**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	4,968.0	**357,204.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-1,058,539.3**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	4,968.0	**227,756.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-1,231,146.5**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	4,968.0	**150,853.0**	178,360.7	**178,360.7**	69,597.7	178,360.7	**-1,339,909.5**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	4,968.0	**97,005.7**	172,607.1	**172,607.1**	145,521.5	172,607.1	**-1,366,995.1**	-0.3
Year 1	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	149,127.1	178,360.7	**-1,396,228.7**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,767.1	178,360.7	**-1,455,822.3**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	4,968.0	**90,869.8**	161,100.0	**161,100.0**	101,970.2	161,100.0	**-1,514,952.1**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,307.1	178,360.7	**-1,575,005.7**	-0.3
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	4,968.0	**210,713.1**	172,607.1	**172,607.1**	534.1	172,607.1	**-1,747,078.8**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	4,968.0	**332,382.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-1,925,439.5**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	4,968.0	**398,535.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-2,098,046.6**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	4,968.0	**398,282.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-2,276,407.3**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	4,968.0	**357,204.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-2,454,768.1**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	4,968.0	**227,756.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-2,627,375.2**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	4,968.0	**150,853.0**	178,360.7	**178,360.7**	69,597.7	178,360.7	**-2,736,138.2**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	4,968.0	**97,005.7**	172,607.1	**172,607.1**	145,521.5	172,607.1	**-2,763,223.9**	-0.3
Year 2	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	149,127.1	178,360.7	**-2,792,457.4**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,767.1	178,360.7	**-2,852,051.0**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	4,968.0	**90,869.8**	161,100.0	**161,100.0**	101,970.2	161,100.0	**-2,911,180.8**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,307.1	178,360.7	**-2,971,234.4**	-0.3
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	4,968.0	**210,713.1**	172,607.1	**172,607.1**	534.1	172,607.1	**-3,143,307.5**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	4,968.0	**332,382.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-3,321,668.2**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	4,968.0	**398,535.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-3,494,275.4**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	4,968.0	**398,282.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-3,672,636.1**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	4,968.0	**357,204.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-3,850,996.8**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	4,968.0	**227,756.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-4,023,603.9**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	4,968.0	**150,853.0**	178,360.7	**178,360.7**	69,597.7	178,360.7	**-4,132,366.9**	-0.3
Year 3	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	4,968.0	**97,005.7**	172,607.1	**172,607.1**	145,521.5	172,607.1	**-4,159,452.6**	-0.3

			Precipitation water (mm/month)		Water in (m^3)				Water out (m^3)				Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from pond	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m^3)**	**Water deficit (m^3/tonne)**
	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	149,127.1	178,360.7	**-4,188,686.2**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,767.1	178,360.7	**-4,248,279.7**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	4,968.0	**90,869.8**	161,100.0	**161,100.0**	101,970.2	161,100.0	**-4,307,409.6**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,307.1	178,360.7	**-4,367,463.2**	-0.3
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	4,968.0	**210,713.1**	172,607.1	**172,607.1**	534.1	172,607.1	**-4,539,536.2**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	4,968.0	**332,382.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-4,717,896.9**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	4,968.0	**398,535.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-4,890,504.1**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	4,968.0	**398,282.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-5,068,864.8**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	4,968.0	**357,204.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-5,247,225.5**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	4,968.0	**227,756.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-5,419,832.6**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	4,968.0	**150,853.0**	178,360.7	**178,360.7**	69,597.7	178,360.7	**-5,528,595.6**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	4,968.0	**97,005.7**	172,607.1	**172,607.1**	145,521.5	172,607.1	**-5,555,681.3**	-0.3
Year 4	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	149,127.1	178,360.7	**-5,584,914.9**	-0.3
	JAN	31.0	17.6	0.0	178,360.7	40,480.0	0.0	**218,840.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,767.1	178,360.7	**-5,644,508.5**	-0.3
	FEB	28.0	13.8	0.0	161,100.0	31,740.0	0.0	**192,840.0**	0.0	85,901.8	4,968.0	**90,869.8**	161,100.0	**161,100.0**	101,970.2	161,100.0	**-5,703,638.3**	-0.3
	MAR	31.0	17.4	0.0	178,360.7	40,020.0	0.0	**218,380.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	118,307.1	178,360.7	**-5,763,691.9**	-0.3
	APR	30.0	16.8	0.0	172,607.1	38,640.0	0.0	**211,247.1**	113,707.4	92,037.7	4,968.0	**210,713.1**	172,607.1	**172,607.1**	534.1	172,607.1	**-5,935,764.9**	-0.3
	MAY	31.0	15.9	0.0	178,360.7	36,570.0	0.0	**214,930.7**	232,309.2	95,105.6	4,968.0	**332,382.8**	178,360.7	**178,360.7**	0.0	178,360.7	**-6,114,125.7**	-0.3
	JUN	30.0	7.8	0.0	172,607.1	17,940.0	0.0	**190,547.1**	301,530.0	92,037.7	4,968.0	**398,535.7**	172,607.1	**172,607.1**	0.0	172,607.1	**-6,286,732.8**	-0.3
	JUL	31.0	8.9	0.0	178,360.7	20,470.0	0.0	**198,830.7**	298,208.8	95,105.6	4,968.0	**398,282.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-6,465,093.5**	-0.3
	AUG	31.0	8.0	0.0	178,360.7	18,400.0	0.0	**196,760.7**	257,130.8	95,105.6	4,968.0	**357,204.4**	178,360.7	**178,360.7**	0.0	178,360.7	**-6,643,454.2**	-0.3
	SEP	30.0	12.5	0.0	172,607.1	28,750.0	0.0	**201,357.1**	130,750.4	92,037.7	4,968.0	**227,756.1**	172,607.1	**172,607.1**	0.0	172,607.1	**-6,816,061.4**	-0.3
	OCT	31.0	18.3	0.0	178,360.7	42,090.0	0.0	**220,450.7**	50,779.4	95,105.6	4,968.0	**150,853.0**	178,360.7	**178,360.7**	69,597.7	178,360.7	**-6,924,824.4**	-0.3
	NOV	30.0	30.4	0.0	172,607.1	69,920.0	0.0	**242,527.1**	0.0	92,037.7	4,968.0	**97,005.7**	172,607.1	**172,607.1**	145,521.5	172,607.1	**-6,951,910.0**	-0.3
Year 5	DEC	31.0	30.8	0.0	178,360.7	70,840.0	0.0	**249,200.7**	0.0	95,105.6	4,968.0	**100,073.6**	178,360.7	**178,360.7**	149,127.1	178,360.7	**-6,981,143.6**	-0.3

Table C.6 Deterministic model for solids content of 80% in the dry condition for an unlined impoundment

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)				Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	**Total Water Input**	Evaporation from pond	Entrainment	Seepage loss	**Total Water Output**	Water with tailings	**Total mill required water**	**Monthly change in storage**	**Water Return to the mill**	**Cumulative water deficit (m³)**	**Water deficit (m³/tonne)**
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	51,444.7	104,043.8	**-52,599.0**	-0.1
	FEB	28.0	13 .8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	4,968.0	**84,552.2**	93,975.0	**93,975.0**	41,162.8	93,975.0	**-105,411.2**	-0.1
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	50,984.7	104,043.8	**-158,470.3**	-0.1
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	4,968.0	**156,067.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-259,157.8**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	4,968.0	**227,573.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-363,201.5**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	4,968.0	**264,806.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-463,889.0**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	4,968.0	**265,726.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-567,932.8**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	4,968.0	**241,944.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-671,976.5**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	4,968.0	**165,934.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-772,664.0**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	4,968.0	**122,477.6**	104,043.8	**104,043.8**	23,656.1	104,043.8	**-853,051.7**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	4,968.0	**90,236.8**	100,687.5	**100,687.5**	80,370.7	100,687.5	**-873,368.4**	-0.2
Year 1	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	81,804.7	104,043.8	**-895,607.5**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	51,444.7	104,043.8	**-948,206.5**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	4,968.0	**84,552.2**	93,975.0	**93,975.0**	41,162.8	93,975.0	**-1,001,018.7**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	50,984.7	104,043.8	**-1,054,077.7**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	4,968.0	**156,067.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,154,765.2**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	4,968.0	**227,573.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,258,809.0**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	4,968.0	**264,806.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,359,496.5**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	4,968.0	**265,726.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,463,540.2**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	4,968.0	**241,944.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-1,567,584.0**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	4,968.0	**165,934.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-1,668,271.5**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	4,968.0	**122,477.6**	104,043.8	**104,043.8**	23,656.1	104,043.8	**-1,748,659.1**	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	4,968.0	**90,236.8**	100,687.5	**100,687.5**	80,370.7	100,687.5	**-1,768,975.9**	-0.2
Year 2	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	**174,883.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	81,804.7	104,043.8	**-1,791,214.9**	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	**144,523.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	51,444.7	104,043.8	**-1,843,814.0**	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	**125,715.0**	0.0	79,584.2	4,968.0	**84,552.2**	93,975.0	**93,975.0**	41,162.8	93,975.0	**-1,896,626.2**	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	**144,063.8**	0.0	88,111.0	4,968.0	**93,079.0**	104,043.8	**104,043.8**	50,984.7	104,043.8	**-1,949,685.2**	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	**139,327.5**	65,830.6	85,268.8	4,968.0	**156,067.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,050,372.7**	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	**140,613.8**	134,494.8	88,111.0	4,968.0	**227,573.8**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,154,416.5**	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	**118,627.5**	174,570.0	85,268.8	4,968.0	**264,806.8**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,255,104.0**	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	**124,513.8**	172,647.2	88,111.0	4,968.0	**265,726.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,359,147.7**	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	**122,443.8**	148,865.2	88,111.0	4,968.0	**241,944.2**	104,043.8	**104,043.8**	0.0	104,043.8	**-2,463,191.5**	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	**129,437.5**	75,697.6	85,268.8	4,968.0	**165,934.4**	100,687.5	**100,687.5**	0.0	100,687.5	**-2,563,879.0**	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	**146,133.8**	29,398.6	88,111.0	4,968.0	**122,477.6**	104,043.8	**104,043.8**	23,656.1	104,043.8	**-2,644,266.6**	-0.2
Year 3	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	**170,607.5**	0.0	85,268.8	4,968.0	**90,236.8**	100,687.5	**100,687.5**	80,370.7	100,687.5	**-2,664,583.4**	-0.2

			Precipitation water (mm/month)		Water in (m³)				Water out (m³)				Water required in the mill (m3)		Water in the TMF (m3)		Water deficit	
	Month	Number of days in month	Rainfall	Snow water equivalent from snow melt	Water with tailings	Precipitation onto impoundment	Recovery from open pit	Total Water Input	Evaporation from pond	Entrainment	Seepage loss	Total Water Output	Water with tailings	Total mill required water	Monthly change in storage	Water Return to the mill	Cumulative water deficit (m³)	Water deficit (m³/tonne)
	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	174,883.8	0.0	88,111.0	4,968.0	93,079.0	104,043.8	104,043.8	81,804.7	104,043.8	-2,686,822.4	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	144,523.8	0.0	88,111.0	4,968.0	93,079.0	104,043.8	104,043.8	51,444.7	104,043.8	-2,739,421.5	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	125,715.0	0.0	79,584.2	4,968.0	84,552.2	93,975.0	93,975.0	41,162.8	93,975.0	-2,792,233.6	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	144,063.8	0.0	88,111.0	4,968.0	93,079.0	104,043.8	104,043.8	50,984.7	104,043.8	-2,845,292.7	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	139,327.5	65,830.6	85,268.8	4,968.0	156,067.4	100,687.5	100,687.5	0.0	100,687.5	-2,945,980.2	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	140,613.8	134,494.8	88,111.0	4,968.0	227,573.8	104,043.8	104,043.8	0.0	104,043.8	-3,050,023.9	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	118,627.5	174,570.0	85,268.8	4,968.0	264,806.8	100,687.5	100,687.5	0.0	100,687.5	-3,150,711.4	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	124,513.8	172,647.2	88,111.0	4,968.0	265,726.2	104,043.8	104,043.8	0.0	104,043.8	-3,254,755.2	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	122,443.8	148,865.2	88,111.0	4,968.0	241,944.2	104,043.8	104,043.8	0.0	104,043.8	-3,358,798.9	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	129,437.5	75,697.6	85,268.8	4,968.0	165,934.4	100,687.5	100,687.5	0.0	100,687.5	-3,459,486.4	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	146,133.8	29,398.6	88,111.0	4,968.0	122,477.6	104,043.8	104,043.8	23,656.1	104,043.8	-3,539,874.1	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	170,607.5	0.0	85,268.8	4,968.0	90,236.8	100,687.5	100,687.5	80,370.7	100,687.5	-3,560,190.8	-0.2
Year 4	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	174,883.8	0.0	88,111.0	4,968.0	93,079.0	104,043.8	104,043.8	81,804.7	104,043.8	-3,582,429.9	-0.2
	JAN	31.0	17.6	0.0	104,043.8	40,480.0	0.0	144,523.8	0.0	88,111.0	4,968.0	93,079.0	104,043.8	104,043.8	51,444.7	104,043.8	-3,635,028.9	-0.2
	FEB	28.0	13.8	0.0	93,975.0	31,740.0	0.0	125,715.0	0.0	79,584.2	4,968.0	84,552.2	93,975.0	93,975.0	41,162.8	93,975.0	-3,687,841.1	-0.2
	MAR	31.0	17.4	0.0	104,043.8	40,020.0	0.0	144,063.8	0.0	88,111.0	4,968.0	93,079.0	104,043.8	104,043.8	50,984.7	104,043.8	-3,740,900.2	-0.2
	APR	30.0	16.8	0.0	100,687.5	38,640.0	0.0	139,327.5	65,830.6	85,268.8	4,968.0	156,067.4	100,687.5	100,687.5	0.0	100,687.5	-3,841,587.7	-0.2
	MAY	31.0	15.9	0.0	104,043.8	36,570.0	0.0	140,613.8	134,494.8	88,111.0	4,968.0	227,573.8	104,043.8	104,043.8	0.0	104,043.8	-3,945,631.4	-0.2
	JUN	30.0	7.8	0.0	100,687.5	17,940.0	0.0	118,627.5	174,570.0	85,268.8	4,968.0	264,806.8	100,687.5	100,687.5	0.0	100,687.5	-4,046,318.9	-0.2
	JUL	31.0	8.9	0.0	104,043.8	20,470.0	0.0	124,513.8	172,647.2	88,111.0	4,968.0	265,726.2	104,043.8	104,043.8	0.0	104,043.8	-4,150,362.7	-0.2
	AUG	31.0	8.0	0.0	104,043.8	18,400.0	0.0	122,443.8	148,865.2	88,111.0	4,968.0	241,944.2	104,043.8	104,043.8	0.0	104,043.8	-4,254,406.4	-0.2
	SEP	30.0	12.5	0.0	100,687.5	28,750.0	0.0	129,437.5	75,697.6	85,268.8	4,968.0	165,934.4	100,687.5	100,687.5	0.0	100,687.5	-4,355,093.9	-0.2
	OCT	31.0	18.3	0.0	104,043.8	42,090.0	0.0	146,133.8	29,398.6	88,111.0	4,968.0	122,477.6	104,043.8	104,043.8	23,656.1	104,043.8	-4,435,481.6	-0.2
	NOV	30.0	30.4	0.0	100,687.5	69,920.0	0.0	170,607.5	0.0	85,268.8	4,968.0	90,236.8	100,687.5	100,687.5	80,370.7	100,687.5	-4,455,798.3	-0.2
Year 5	DEC	31.0	30.8	0.0	104,043.8	70,840.0	0.0	174,883.8	0.0	88,111.0	4,968.0	93,079.0	104,043.8	104,043.8	81,804.7	104,043.8	-4,478,037.4	-0.2