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The importance of a good Mine Water Balance and the benefit of early data collection

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An evaluation of the surface water and groundwater systems for an existing or proposed mining project is important for almost all mines. There is either too much, too little or there are issues of managing water quality either on the mine site or for discharge during operation and after closure. In all environments, water conservation and management has to be an important factor for costs, environmental management and corporate image. Water is the one thing that is likely to be impacted further from the mine than most other activities and therefore often has a high profile in people's minds.

Mining and processing of related products has the potential to place excessive strain on available water resources. The dynamic calculation of a site water-balance associated with a varying water-demand through the seasons, are often poorly understood by plant managers. Excessive costs can then result from both poor understanding of water resource availability, incomplete information relating to water-use, and resulting water management decisions. Significant financial and resource savings can therefore be made by a dynamic analysis of daily, seasonal and annual variation in water availability, supply potential and demand

In order to characterise site and plant water balance more effectively. Decision support software can be used to dynamically model complex systems using Monte Carlo simulation techniques. By representing uncertainty within both natural systems outside the plant, and controlled systems within it, performance of processing and plant can be effectively modelled and risk analysis performed for a number of different water-use scenarios. The various elements of a site water balance such as the make up water sources, on site storage, the various uses and requirements for different volumes and chemistry and treatment of water and the off site losses or discharges. The model can assist in identifying opportunities for minimising waste and minimising cost.

Once a water balance model has been established, the potential variation in raw water requirements can be compared against available resources (whether they be from a nearby surface water flows, reservoirs or groundwater. The likely volumes of water that may be available are often established from published data and publicly available records, but may also require statistical analysis from partial data sets or new instrumentation and investigation.

Figure 1 illustrates a part of a dynamic water balance for a mining project. Each of the functions can be dynamic functions of time, cost, risk, or whatever type of information is available and relevant to derive an optimum system. The TSF (Tailings Storage Facility) has its own subset of functions covering the geotechnical aspects, water input, rainfall, catchment runoff, evaporation, lockup and seepage losses.

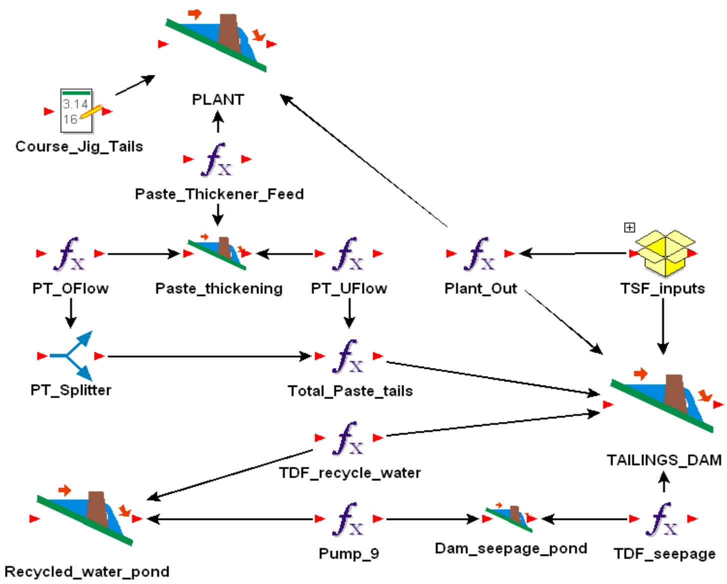

Figure 1: Part of numerical water balance model

The value of the water balance is a function of the data available to populate the various elements of the system. The internal elements such as the process and plant water requirements can be defined reasonably accurately. Greater uncertainty exists in the make up water sources, especially in arid and semi arid environments. The benefits of early data collection and can provide much higher levels of understanding of the surface water and groundwater systems which will reduce the geological and engineering uncertainty for aspects such as water supply or mine dewatering and depressurisation.

Often a key area of uncertainty is the water supply especially if a significant contribution can be obtained from mine dewatering whether underground or open pit. The studies for the mine water must be integrated with the overall water balance planning to obtain maximum benefit.

In a recent study in Africa a proposed mine was based on a water supply from surface water. At the level of full feasibility study it was strongly recommended to look at the potential pit inflows from adjacent alluvial sediments in the river valley. The profile was the typical African sequence of saprolite underlain by partially weathered and fractured bedrock, overlying low permeability rock, in which the partially weathered horizon of a few metres thickness is usually water bearing to some degree and provides much of the groundwater for village wells. Five boreholes were drilled for a combination of piezometer installation and test pumping. It was identified that the main aquifer was the underlying fractured bedrock so far drilled and tested to depths of around 100m and all holes with consistently very high yields (Figure 1). Earlier investigation or data collection at exploration stage would have identified potential problems for pit drainage but also identify a plentiful water supply.

Figure 2: Unexpected high groundwater flows from Basement rocks in Africa

Mine dewatering inputs to the water balance will vary with time. Initial dewatering will require removal of groundwater from storage in the aquifer has to be removed to achieve significant drawdown and ongoing pumping will match the recharge to the system. The storage can be very high but recharge low which means that initial dewatering rates will be high but long term pumping may be several times lower. The depth of the production zone will dictate how much dewatering is required prior to the water being required for production. If this water cannot be stored then it is lost as part of the water supply. By the time the water will be required for the plant, the rate of discharge from a dewatering system will have reduced perhaps almost to a steady state. The water balance will therefore reflect the time variation of dewatering as well as water supply and enable the costs for dewatering to be optimised.

Another illustration of the benefit of dynamic modelling of the water balance is from the Emperor Gold Mine in Fiji. Water supply is not an issue due to the very high rainfall. However, the underground mine has inflows of hot water from a structurally controlled, fractured rock. Water temperature can be up to 60ºC which creates impossible working conditions unless the water is removed before mining. Cool air ventilation and ice jackets are a necessity. Water management is based on extensive grouting in development drives, pre-drainage of hot water through underground drain holes and removal to surface as directly as possible through boreholes to limit heating of workings. Hydraulic and chemical test work was carried out to characterise the groundwater system (Figure 3). Note that the test water had to be controlled and piped to avoid direct contact with workers. The heat from the hot water was dissipated by air spraying before discharge to the environment. (Figure 4) At the same time, water supply for the plant was being pumped up gradient from a river to the plant. A system of flow gauging in the plant was recommended to understand the complex water system which had built up piece by piece over a period of 70 years operation and was now considerably inefficient. It was logical to use the water pumped from underground as make up water but also to use the pre-heated water in the on site power station. Perhaps some of the condensate could be used to produce‘pure’ water.

The study was done before the general use of dynamic water balance models but is a good illustration of how it could have been used to identify lost opportunity to minimise water pumping and reduce costs. The costs for various activities could have been one of the functions in the model.

Summary

Mine water management is becoming increasingly recognised as very important with the decrease in availability of water in many areas, the increasing need to conserve water and increasing energy costs to pump and to treat water. Water use therefore has to be minimised and optimised. Dynamic models have been around for some time but not utilised to any great extent in mine water management. The ability to model complex functions and include cost functions makes them ideal to use for mine and plant water management and achieve the objectives of minimising waste and minimising costs.

Early collection of water data will significantly improve the opportunity to minimise waste and costs using a dynamic model, by enabling scenarios to be modelled from an early stage and maximise opportunity. Even for operating mines however, high energy costs and the need to minimise waste, mean that dynamic water balance modelling offers the opportunity to understand the details of a water system and to achieve the objectives of minimising cost and maximising the best use of available water.

Figure 3: Underground hydraulic testing.

Figure 4: heat dissipation from hot groundwater