Water management: life of mine and beyond

Water is an essential ingredient at any mine. Once considered free, clean and plentiful, water's status has changed. Andrew Watson and Resa Furey of MWH explain

Water scarcity, stricter regulations and increased community influence over how mines use water have all helped to elevate the importance of water at mines around the world.

To minimise water-related risks and to strengthen a mine's social licence to operate, miners can use approaches, tools and techniques that enable them to better manage their water during operation and at closure.

TAKE ONLY WHAT YOU NEED

Mines are often 'thirsty' operations, yet cost and limited supplies of freshwater, plus the desire to minimise what is left over after mining, often dictate that mines limit the amount of freshwater they use. This requires the efficient use and re-use of water once in the process, and elimination of losses through leaks, seepage, evaporation and waste.

Some mines are located in environments where nature brings more water than is required. In these cases, immediate as well as long-term effects over the life of the mine require us to minimise the operation's potential impact on local surface and groundwater resources, and reduce the need to treat excess water.

Prudent water-management techniques and industry best practices include: separating water streams through the use of surface-water diversion channels; diverting clean surface water away from the mine; keeping affected water away from clean surface and ground water; re-use and recycling wherever possible; and adoption of processes that require less water in the first place. Heap leaching, for example, requires less water than milling, and filtering tailings can significantly reduce water demand.

IMMOBILISE CHEMICAL MASS

Affected mine water can take a variety of forms, from water with heavy chemical mass loads and sediment-laden runoff, to process water that is contained in the tailing slurry. Characterising the water and concentrating waste streams through evaporation or recirculation are effective pre-closure strategies to immobilise the chemical constituents. Tailing storage facility (TSF), heap-leach pad and waste rock pile covers are generally designed to limit the ingress of water and oxygen, thereby immobilising residual constituents of concern contained in the waste.

Some metal-mine operators have taken the idea of constituent immobilisation seriously: they add a rougher flotation circuit to separate pyrite from the remaining tailings, separate the fraction of tailings to be treated with cyanide, and segregate more reactive mine waste. These examples of industry best practices, while costly, allow the mine to produce cleaner products and waste materials. The undesirable ►

Surface-water diversion channels keep contaminated water away from clean surfaces and ground water, and facilitate re-use and recycling

"Best practices, while costly, allow the mine to produce cleaner products and waste materials"

Mine water management includes a myriad of tools. Water treatment is an important tool and is often considered only as a last resort

material is encapsulated, effectively removing considerable mass from future water flows from the mine.

INTERCEPT CLOSE TO SOURCE

Unfortunately, many natural reactions, such as the oxidation of sulphide minerals and leaching of metals, are enhanced through mining activities, and efforts to stop them during and after the disposal of mine-waste materials are only partially effective.

The control of mass transfer requires controlling reaction rates, limiting opportunities for leaching into solution and separating affected water from natural waters. An important and often neglected water-management principle is to intercept the water as close to the source of contamination as possible. Isolating the most concentrated water before it is diluted lowers the cost per unit of mass removed.

At a mine in South America, the majority of the seepage from a TSF was identified to be passing through three joint structures in the foundation. Rather than building a seepage collection gallery along the full toe of the embankment, individual sumps were installed at a lower cost, and a less diluted stream of affected water is intercepted for re-use.

"The need for water management does not end when mining ends"

IMMOBILISE WHAT YOU REMOVE

A cynic will say that all mitigation measures are just delaying or attenuating the inevitable flow of metals and salts into the environment. Be that as it may, at mines that are not zero discharge, there is a responsibility to limit the rate at which mass is released from the mine site to that which can be supported by the receiving environment and all of its inhabitants.

Often, to avoid discharging to the environment, mine water is recirculated at great expense without effectively immobilising the mass of concern. The risk then is that over time, the mass will find its way back into the environment or, worse, the concentrated mass is accidentally released, doing more harm.

A good example of how miners are responding to this challenge is the effort of precious-metal miners to permanently immobilise mercury, a by-product of gold and silver extraction, and contain it on site. Another is the reuse of reactive tailings as mine backfill, essentially returning it to a condition similar to that prior to mining. Effective covers over waste piles, tailings and heap-leach facilities are also essential for the long-term control of discharge from mine sites.

Membrane filtration has been a breakthrough in treating water to high-quality standards through concentrating mass in a portion of the stream, with the balance being of superior quality. One of the greater challenges to this technology is the disposal of the brine in a permanent manner; when the impurities remain in solution, their entry to the environment is merely delayed, with the risk that they might accidentally be released at a higher mass loading than before. This issue is receiving considerable attention from miners and water technologists as they work to control effluent quality at their operations.

A thorough geochemical characterisation of the orebody is useful. Whereas the principal constituents of interest are the immediately recoverable and valuable metals and minerals, contaminants may detract from their value. Understanding the potentially deleterious constituents that could accumulate in the process water, and potentially leach to surface and groundwater, completes the basis for a thorough economic evaluation of project.

One of the more interesting opportunities recently reported involves the recovery of metals from leachate streams, accumulated and concentrated by many years of recirculation through waste piles and heap-leach operations. These low concentrations of sometimes exotic metals, previously considered waste streams and liabilities, are now the focus of research in water treatment aimed at economic extraction and beneficial reuse.

MORE EFFECTIVE MEASURES

As we gain a greater appreciation of the long-term processes initiated by mining operations, and are held accountable for the impacts these have on local water supplies, more effective measures must be engineered to avoid, manage and mitigate impacts, in that order.

All of these measures must originate during the mine planning phase and consider the full arsenal of tools available today. These might include: mining methods that minimise the volume of waste material; limiting exposure of waste material to the elements; encapsulation of waste to limit contact with groundwater and surface water; and selection of waste-rock pile and tailings impoundment geometries that facilitate the installation and maintenance of effective long-term covers.

A thorough investigation of all the potential contributors to water quality (good and bad) during operations and after closure, and what can be done about them, may result in better outcomes for mines and the environment in the future.

In short, the need for water management does not end when mining ends.

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