Water Treatment as a Mitigation

James R. Kuipers, P.E. *– Center for Science in Public Participation*

When pit lakes exceed applicable state or federal surface water quality standards, or may cause exceedances of groundwater standards, various forms of mitigation may be employed. Three primary options are:

- Neutralize the pit lake in place through treatment.
- Prevent the formation of a pit lake by pumping groundwater.
- Regulate the pit lake level at a certain height.

This last option is done either to maintain a pit lake as a hydraulic sink or to prevent it from commingling with other aquifers. Both of the latter options require treatment of the pit lake water prior to discharge.

Treatment Options

Pit lake water can be treated by a variety of physical, chemical, and biological processes that are capable of economically and effectively removing sulfate, metals, and other elements. Recent technological innovations continue to make these processes more effective and more economical.

Physical treatment processes primarily address suspended solids and consist of screening and filtration techniques to remove particulate matter down to around 10 micrometers (µm). For example, nanofiltration and reverse osmosis employ engineered membranes to separate different sized dissolved matter of less than 1µm. Physical processes also include solids/liquid separation such as thickening of sludge products.

Chemical treatment processes are the most common. They are typically used to treat acid drainage-affected pit lake water or to treat specific contaminants such as arsenic. Chemical treatment processes include lime precipitation for sulfates and other methods that remove contaminants by precipitation, adsorption, and cementation, or by other means such as ion exchange. The processes are typically designed to treat specific contaminants or characteristics of the influent stream.

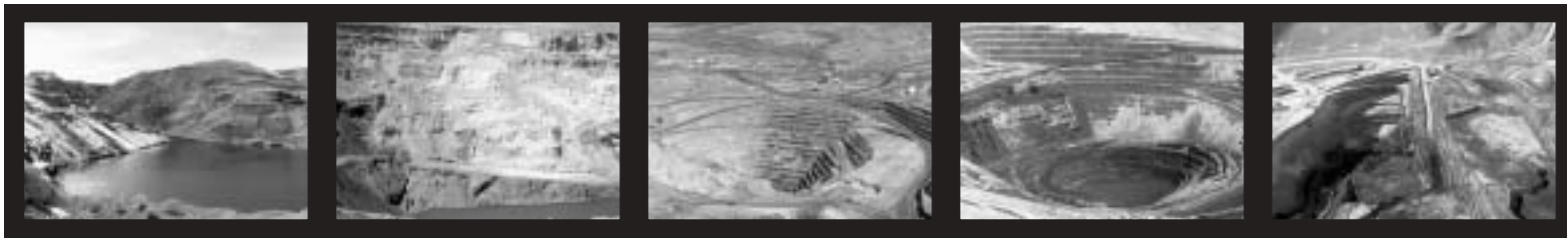
> *There are proven, practical and cost effective means to achieve stringent water quality standards if the treatment of pit lake water is necessary.*

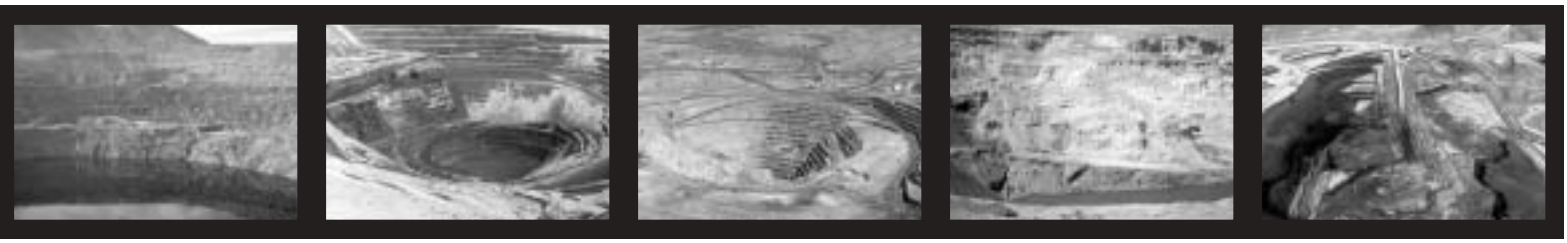
Biological processes have yet to be extensively used in pit lake treatment except in limited circumstances involving small lakes or restricted flows. Biological treatments include sulfate reduction processes to treat acid drainage and remove sulfate and metals. Biological processes can also be used to treat metals under other conditions and to reduce nutrients such as nitrogen.

Treatment Applications

In most applications, a combination of physical and chemical processes has been proposed. The lake located in the Berkeley Pit adjacent to Butte, Montana is one of the largest and most toxic pit lakes in existence with a volume of more than 30 billion gallons and a pH less than 2. The lake contains high levels of sulfate, and metals such as aluminum, cadmium, copper, iron, lead, zinc, and arsenic.

ARCO, the primary responsible party for the Berkeley Pit Superfund site, has received the EPA's approval for an eventual 5,000-gallon per minute capacity lime precipitation high-density sludge (HDS) treatment process to reduce sulfate. The process will produce an effluent of approximately 1,500 milligrams per liter (mg/l) sulfate that will be discharged to surface water (Montana does not have numeric surface water standards for sulfate). The plant is expected to cost $25 million and be operational by 2004. The plant will be operated in perpetuity in order to keep the pit lake at a certain level so as not to contaminate shallow alluvial aquifers and





Method for Pit Lakes

surface waters in the headwaters of the Upper Clark Fork River basin.

In New Mexico, Phelps Dodge Corporation recently announced that they will continue to pump groundwater in perpetuity at their Chino and Tyrone copper mines near Silver City to prevent the formation of surface water in the existing mine pits. The Tyrone pit water contains approximately 2200 mg/l sulfate at a pH of approximately 3.5. The company has also proposed an innovative approach to future pit lake water treatment at their Tyrone mine using the same lime precipitation and HDS method as will be used at the Berkeley Pit in Montana, combined with nanofiltration technology.

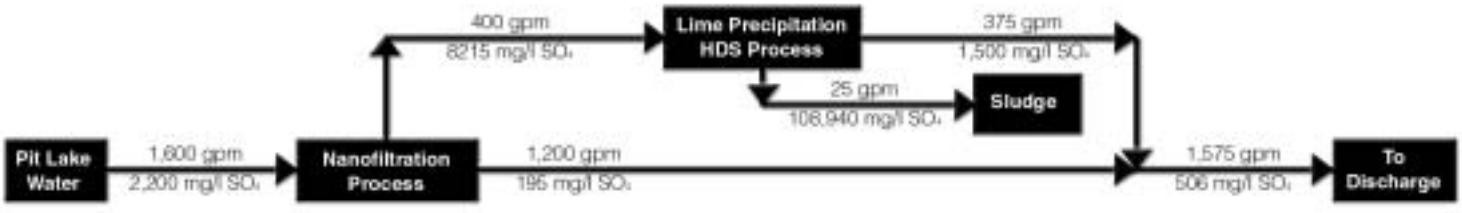
Historically, engineered membrane separation processes such as nanofiltration and reverse osmosis have only been used as a polishing step to remove trace amounts of metals or other elements. However, with recent improvements in membrane manufacturing processes and new materials, greater durability and flexibility have been achieved, allowing for the application of the nanofiltration process as an up-front treatment method that produces both a high-purity effluent and a concentrate that can then be treated by conventional processes.

The advantage of the process, which is licensed by HW Process Technologies, is that it can be used to produce an effluent that meets stringent water quality standards more efficiently than lime precipitation and chemical treatment alone, which also requires additional dilution with clean water to meet standards. In addition, the new process reduces capital and operating costs. The flowsheet below shows the nanofiltration lime precipitation HDS process.

In conclusion, there are proven, practical and cost effective means to achieve stringent water quality standards if the treatment of pit lake water is necessary. This avoids the need for other means of pit lake water disposal that are less acceptable environmentally and socially, such as using clean water for dilution, or relying on faulty land application disposal systems.

Contact James Kuipers at jke@montana.com.

Tyrone Mine Pit Water Treatment Process Flowsheet



Nanofiltration treats the full volume of pit water and produces a low dissolved-solids effluent and a high dissolved-solids concentrate (or reject stream). The nanofiltration concentrate is then neutralized with lime to precipitate metals and salts such as sulfate. The neutralized solution from the lime precipitation process is then combined with the permeate prior to discharge to achieve regulatory compliance.

As shown on the flowsheet, the process can be used to remove approximately 95 percent of the sulfate from the Tyrone pit lake water, resulting in a final effluent of 506 mg/l sulfate, below New Mexico's groundwater standard of 600 mg/l. The estimated cost of a 1,600 gallon per minute capacity plant is expected to be approximately $23 million with an annual operating cost of $1.4 million ($1.50/1,000 gallons). This design was developed by Van Riper Consulting and Hazen Research.