Proceedings of Elko 2009: mine closure and cover design

Roundtable 2009, a Knight Piésold and Co.-hosted roundtable discussion on mine closure and cover design was held at the Red Lion Inn and Casino in Elko, NV on Feb. 12, 2009. Knight Piésold's Bryan Ulrich and Steve Boyce, as well as Knight Piésold representatives Cynthia Parnow and Corey Conrad from Denver, CO, and Rick Frechette from the Tucson, AZ office were on hand to help facilitate the discussion. The meeting played host to approximately three-dozen attendees from four states. Attendees included personnel from seven mining properties and attendees from corporate offices. The majority of attendees were people directly involved with environmental work on a day-to-day basis. Other attendees were project managers whose jobs involve some level of environmental focus.

The purpose of Roundtable 2009 was to exchange ideas and information pertaining to mine closure and cover design associated with almost any aspect of a mining operation. This type of forum provides a less inhibited format for discussion, when compared with traditional conferences and symposia. In the roundtable format, lively discussions are encouraged.

This discussion was the fourth in the series of Elko Roundtable events. Previous roundtables pertained to heap leach pad design, construction and operation; design, construction and operation of tailings storage facilities and site-wide water considerations.

The initial subtopics for Roundtable 2009 included:

The basics

- Up front goals and closure objectives.
- Conceptual design: risk-based screening of design criteria and elements.
- Level of up-front closure planning.
- Project setting and site specific requirements.
- Design and performance criteria.
- Costs of various designs.

Covers

- Infiltration barriers vs. store and release covers.
- Geomembranes versus soil.
- Stability and erosion issues.
- Usage of capillary breaks.
- Freeze-thaw, vegetation and geochemical effects on soil cover matrix properties.
- Structured versus unstructured runoff (e.g. riprap channels, diffuse flow patterns).
- Cover performance instrumentation techniques.

Modeling

- Modeling software and techniques.
- Which cover design parameters are important and how are they measured/estimated?
- Final closure validation/calibration/design prior to closure.

Draindown fluid management

- Passive treatment/management.
- Perpetual treatment.
- Infiltration.
- Pit lake discharge.

Case studies

- Effectiveness success.
- Success and failure studies.

Prior to summarizing the roundtable, a brief tangential discussion provides a useful background. At the June 2004 Tailings Impoundment Closure Workshop held in Elko and sponsored by the Mackay School of Earth Sciences and Engineering (University of Nevada, Reno) and the Mining Life-Cycle Center, a presentation titled "Tailings dam closure: designing inside out and backwards" was given by the author of this article. That presentation focused on the need to ascertain a priority of the characteristics an owner desires their facility to exhibit upon closure, and then using analytical means such as geotechnical and geochemical tools to arrive at a closure process that will satisfy those goals. As much of this as possible should occur during the early design stages. These sentiments were echoed throughout this year's roundtable. One attendee of the roundtable indicated that closure designers need to "know what the end-product is going to look like" in order to develop a design that actually gets you there.

Since many of the roundtable attendees work domestically as well as internationally, there was considerable conversation pertaining to the difference in regulations, practices, traditions and customs in the U.S. and abroad. Several international mining companies have corporate policies to use the best available technologies to construct facilities of various types (heap leach pads, tailings storage facilities, waste rock facilities, etc) to meet the social, physiographic, climatic, biological and geochemical nature of the materials and the site while maintaining core corporate standards. More and more, such facilities are designed not only to meet regulatory requirements for safety and environmental protection, but also to meet commitments made to surrounding communities. Some mining companies have adopted international standards to help accomplish these goals, such as the Mining Association of Canada's A Guide to the Management of Tailings Facilities to guide the design, operation and closure of tailings facilities. Other mining companies have authored their own in-house guidelines for the design of such facilities.

Indeed, Web sites for many of the international mining companies reflect their

Bryan Ulrich

Bryan Ulrich, member SME, is vice president - Nevada Operations, Knight Piésold & Co. e-mail bulrich@knightpiesold.com.

requirements, philosophies and goals for environmental compliance, closure and reclamation, using phrases such as:

- Commitment to leaving a positive legacy for the communities and the environment where we operate.
- Planning for closure and reclamation commences during the earliest stages of a project, before operations start at a new site, and continues throughout the development of the mine.
- The earlier closure is considered during the life of a mine, the stronger the opportunity a site will have to establish sustainable benefits beyond the end of the mine life.

Typically, such corporate objectives go above and beyond the current legislated requirements for mine construction. To meet these company-wide obligations, it is often vital for members of the corporate arena to have early involvement in the decision making process for facility design, reclamation and closure regardless of where the mine may exist. By ensuring company objectives are satisfied during the early development of a project, the mine design team may make a coordinated effort to achieve these goals.

In a book review for the Australian Center for Geomechanics' *Mine Closure 2006, Proceedings of the First International Seminar on Mine Closure*, (editors: Andy Fourie and Mark Tibbett), the author of this paper wrote:

"Mine closure, in part or in whole, rightly deserves the undivided attention of mining companies, their consultants and their contractors in order to meet sustainability targets and to minimize negative environmental, social and economic impacts, as the project, in its post-closure years, will become the legacy we leave to our children and grandchildren. The actual performance of mine closure, that is, nature's determination of the success of the closure, is a key deciding factor of the public's assessment of the future viability of the mining industry. Without society's consent, it may be quite difficult for the mining industry to carry on mining in many areas of the world. Thus, establishing good mine closure practices is paramount to the continued good reputation of all world-class mine operators."

The economical, environmental and socially acceptable closure of mines is one of the foremost challenges currently facing the mining industry. The future approval of new mines and the continued social license to operate at existing mines will increasingly become conditional on a company displaying a proven track record of appropriate and successful closure of old or uneconomic mines. Despite the fact that there are numerous examples of good closure practice, there are also many that have been unsuccessful. It is the former that the industry projects as shining beacons of achievement, but it is the latter that generate the most public scrutiny. A consequence of this scrutiny, and the desire of mining companies to adopt best practices in mine closure, has seen a rapid increase in the financial expenditures that are being made for closure. When these expenditures are made in reaction to poorly planned systems, the cost must be higher ultimately than those for which closure was a well-planned event.

Hydroseeding a newly reclaimed area.

The roundtable created a good environment to discuss the current practice and challenges of mine closure and reclamation. Since there is considerable overlap between the roundtable's subtopics, the conversations frequently wandered from topic to topic and back again. The following is a brief synopsis of the content discussed during Roundtable 2009.

It was said in the roundtable that closure planning should start in earnest at the commencement of the project. This was expanded to indicate that conceptual designs have to be much more than just "really good ideas." They have to be conceptually accurate. It was broadly acknowledged by the group that today there is significantly more work put into conceptual closure designs than ever before, and that today it is a normal procedure to have a well-developed closure plan at the final design stage for tailings, heap leach and waste rock facilities.

The success of any closure plan is highly dependent upon the up front quality of information and the level of effort that goes into establishing a closure. The success of a closure plan can be gauged by assessing how close the initial closure plan and its objectives approximate the closure plan that is actually constructed at the termination of the project. Optimally, improved information can be gathered during the operational life of a facility to allow updating of the closure model, and the closure plans can be updated and modified as appropriate. With this goal in mind, however, the attendees discussed new technologies developed over time and that, when possible, closure plans should be formulated to allow for flexibility in the event that such new technologies offer improved closure opportunities. In this way, a closure plan may be treated as a "living document" that can be updated over time. An extreme example, though not an altogether uncommon one, would be when a copper mine becomes a gold mine. Adopting general closure philosophies that can change with the times can be the best way to arrive at a closure design that can be well implemented at the end of a mine's operational life.

A good deal of the day's discussion revolved around drain-down modeling. There was conversation pertaining to specific commercially available models and the advantages and uses thereof. Some models, it was said, are good for generally bracketing potential cover scenarios

New growth on a recently planted slope.

and some allow for sophisticated modeling of freeze/thaw zones and of capillary barriers. Some models are particularly good for designing covers. Some models allow for the assessment of snowmelt, which can be an important factor in cover design. One key piece of advice to come from this discussion is to make certain that the model is sufficiently calibrated. This calibration can be completed using historic data and performing a history match with the model. Deviations between the model and the actual performance data can be helpful in reassessing key input parameters such as soil properties and parameters. In fact, it was said, you should tend to disbelieve a model unless it has been calibrated.

Cover performance was also a topic of particular interest. Panelists discussed particularly successful closure projects they have worked with. One participant mentioned that reclamation work carried out many years ago has been failing in some cases, and that such failures are often attributed to an inability of the cover to properly decrease infiltration, and rather act primarily as a growth medium for vegetation. Reclamation and closure cannot be seen as a success if draindown fluids are not adequately reduced to a level that can be accommodated. Even with successful vegetative cover, some historic reclamation projects have been unsuccessful in decreasing infiltration. An adequate vegetation cover clearly is not the primary goal of cover design. This is not to say that vegetation is not important. Quite the opposite is true, and the integrity of the cover can be especially at risk while the vegetative growth is being established.

Much was said about the challenges of constructing a durable cover in high precipitation areas, or where short-duration, high-intensity storms occur. Counter to much of the current considerations in the hydraulic design for covers, it is often not the prescriptive 50- or 100-year storm events that damages covers and their hydraulic features, but rather the short-duration, high-intensity events. On some projects it was found that even very large riprap on relatively shallow slopes did not survive intense storms.

The concept of using analogues is becoming increasingly common in the development of closure designs. The use of an analogy in closure designs is to select an appropriate analogue (say the topographic features of nearby hillsides) and to use that analogue to establish a viable post-closure landform for a waste rock facility. While analogues do not provide an absolute measure or metric of the predicted performance of a closure design, there can be good inference of possible facility performance and the illustrative use of such analogues has been found to be invaluable in obtaining buy-in from interested parties.

There was good general consensus from the attendees that closure designs should be site-specific. Several examples were given of site-specific closure designs initiatives and discussions followed regarding why the designs were selected for each particular site. Two examples of site-specific applications involve pit lakes and underground backfilling with tailings.

Backfilling underground mine openings with tailings is practically unheard of in the United States but is almost commonplace elsewhere. The possibility of placing tailings underground "back where it came from" is desirable from several perspectives, including the reduction of surface disturbance. In places where tailings backfilling is being carried out, it usually serves one of two main purposes, both related to rock mechanics. One application is simply as a void filler, and the other is to perform as a prescribed material with specific strength properties. The second application is usually accomplished by adding a binding agent to the tailings, such as cement or fly ash.

Current mining practice in the United States generally does not consider the placement of tailings as underground backfill due to regulatory complexities. In other words, regulations are not commonly written to specifically allow underground backfilling with tailings. There has been a long tradition by the mining and regulatory communities to defer toward constructing an engineered containment to impound tailings, given the difficulties of establishing geologic containment. The purpose of creating or otherwise proving satisfactory containment of tailings is most commonly to protect nearby ground water from becoming contaminated. Such containment is usually demonstrated through the use of a low permeability layer, such as clay or a geomembrane. Alternatively, containment is sometimes demonstrated by establishing geochemical attenuation of the tailings by the surrounding geologic materials. Similarly, if it can be demonstrated that the tailings are self-contained, and that neither bleed waters nor solids will be liberated in an underground disposal site, then the goals of protecting ground water may be successfully attained. If cement or some other type of binding agent can help geochemically secure the tailings in place, then entire new avenues are opened for tailings disposal, including the possibility of in-pit disposal. These possible applications will require an entirely different thought process by engineers, environmental specialists and the regulatory arena.

By the end of the afternoon, an impressive amount of information had been shared and it was generally agreed that the time was spent productively. By all accounts, Roundtable 2009 was seen as being highly successful. Next year, Knight Piésold will once again be hosting a roundtable discussion in Elko. ■