Some of Overarching Components of a Successful Program to Prevent Impacts from Drainage from Sulphidic Materials

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A Mine Site

During Mining
• Jobs
• Resource Production
• Taxes

During and Afterwards
• Neighboring Land Use
• Potential Contamination of Land and Water*
• Mitigation and Regulation Costs

*If not prevented, there are potential impacts with drainage from most metal and at least some coal and diamond mines
Lots of hard work and resources are required to sustain environmentally sound mining practices. This presentation will describe some of the overarching practical components of a successful program to prevent impacts from the drainage from sulphidic materials.
Long-Term Performance

Structures constructed for mitigation of sulphidic rock, water management and waste storage, such as those shown below, must perform indefinitely.
Where ongoing maintenance, repair or other actions are required for indefinite performance, mining is not a temporary use of the land.
Pro-Active Resolution of Problems

Mine sites should be designed and operated in a manner that allows detection and resolution of problems before there are significant environmental impacts. This requires:

- a design with adequate durability and capacity to handle future weather, water quality, hydrology, ecology, etc.;
- monitoring, maintenance* & contingency plans;
- accurate cost estimates; and
- personnel, financial resources and organizational commitment to conduct the above.

*including repair and replacement
Develop Site-Specific Understanding

The ‘Best Management Practice’ is to conduct site-specific prediction and develop site-specific environmental protection plans.

Development of the required understanding costs $100,000s and takes many years to develop.

However, these costs are minimal compared to the costs when site-specific conditions are not understood and addressed.
Mine site minerals often differ in composition from that in generic geochemical models because of the unique geochemistry of each mine site. These differences may result in differences in mineral solubility and trace element composition. Whenever geochemical models are used, verification of modelling conclusions should be conducted to verify site-specific mineral controls on contaminant concentrations.

Melanterite (FeSO₄ - 7H₂O) in this seep contained 1.2% Cu, 2.4% Zn and 0.14% Al, in addition to 23% Fe and 14.2% S, and was the primary control on dissolved Cu concentrations.
Supportive Mine Plan

- A mine is a waste storage facility and the location of mine workings and wastes can have a large effect on environmental impact and costs.

- The large volumes usually make waste movement after mining prohibitively expensive.

- Need to incorporate environmental protection needs into the mine and waste handling plans.
The long-term costs with drainage treatment has led mines to increasingly use underwater disposal as means of preventing sulphide oxidation and metal leaching.

This has increased the number of water-holding dams, increasing the geotechnical risks.
By flooding potentially acidic tailings and waste rock, this site reduced closure costs to the relatively small costs of maintaining and monitoring dams and other water management features.

Use of one of the pits as a second impoundment, greatly reducing the footprint of the mine and the size of the dams.
Compatible Site Conditions
Mitigation must be compatible with the biogeoclimatic conditions and surrounding land uses.
Identify Potential Failure Mechanisms

An important step in pro-active problem resolution of detection is to identify potential failure mechanisms, evaluate the risks and if necessary provide contingency plans.
Extreme Weather

Mitigation measures must be capable of achieving objectives during and after extreme climate events. Many sites are experiencing more extreme climate events as a result of climate change.
Changing Site Conditions

Closure plans must handle the continually changing geochemical, hydrogeological and environmental properties of a mine site.
Groundwater rebound following mine closure can change the height of the water table, flow rates, flow paths and drainage chemistry.
Rock weathering will change drainage chemistry, which in turn can increase impacts or costs. It may take decades before geochemical changes occur. It took more than 15 years before acidic drainage was observed at Island Copper.
Maximum delay prior to ARD occurring

- “If this rock was potentially acidic, we would have already seen ARD, some of the dumps are over 50 years old.”
- Absence of ARD does not prove it will not occur in the future. Depletion of NP may take 10s to 100s of years.
Monitoring and Maintenance

Mitigation without monitoring and maintenance is equivalent to driving a car without a wind shield or an oil change - breakdowns and crashes will be inevitable.
Maintenance is required to ensure design capacity is sustained even for simplest components of site mitigation.

Maintenance for a diversion or collection ditch includes:

- removal of vegetation and sediment,
- repair erosion, and
- removal of ice from ditches prior to freshet.

An effective maintenance program requires adequate personnel, funding and commitment.
Monitoring is a key part of pro-active management:

- provides early warning of potential problems (e.g., detect a reduction in design capacity);
- informs corrective measures (e.g., direct maintenance); and
- allows adaptive management and the implementation of contingency plan.
Regular Review/Follow-Up

Regular review of the mine plans, site monitoring, material characterization and future costs is required for timely problem detection and to avoid costly problems.
Maintain Site Knowledge

The foundation of every program is the site knowledge.

Project memory and data may be lost with staff changes or downsizing. Consequently, record keeping is very important.

Record keeping should include:

- data bases for baseline, material characterization, waste disposal and monitoring data;
- manuals for operating site facilities, monitoring, maintenance, sampling and analysis;
- as-built drawings for all project components and records of how and where wastes were placed.

Need well maintained and secure storage site.
Limited Long-Term Experience

Limited information on durability and long-term performance for most mitigation measures (e.g., soil covers). This results in uncertainty about repair and replacement costs, when to initiate that work and future costs.
Limited long-term data and many processes that are difficult to predict hamper the prediction of future costs.
Potential Regulatory Overload
- Cumulative increase in mine sites
- More issues being addressed
- More public consultation and meetings

<table>
<thead>
<tr>
<th>Mines with ML/ARD Concerns in BC</th>
<th>Number</th>
<th>Cumulative #</th>
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<tbody>
<tr>
<td>Historic</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Closed 1970-1990</td>
<td>18</td>
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<td>48</td>
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<tr>
<td>Operating</td>
<td>12</td>
<td>60</td>
</tr>
</tbody>
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OPERATING MINES IN B.C.

- **Metal (11)**
  - Acidic drainage concern
  - Neutral pH drainage concern
  - No present concern

- **Coal (8)**
  - Acidic drainage concern
  - Neutral pH drainage concern
  - No present concern

Key:
- Ag - Silver
- Au - Gold
- Ch - Chrysotile
- C1 - Coal
- Cu - Copper
- Ma - Manganite
- Mo - Molybdenum
- Pb - Lead
- Zn - Zinc
There are now more than 60 major mines in B.C. with a potential for significant ML/ARD. 80% are closed.
Due to the site-specific nature of the problems, successful prevention of impacts from sulphidic materials depends on industry and government staff having adequate:

- training;
- motivation;
- time; and
- organizational support.
Requirement: Withstand Political and Financial Pressure

Often strong organizational pressure to approve or reject projects and prematurely announce conclusion before critical details are understood.
Prediction of drainage chemistry prior, during and after mining is a key component of sound environmental and fiscal management.
Operational and post-closure prediction work is needed to complete many aspects of a closure plan. For example, the location of final mine walls will continually change and predictions of final drainage chemistry should be revisited throughout the mine life.
Operational Material Characterization

Operational confirmation of predicted waste composition can be very expensive - 10,000s analyses, $100,000s of work and considerable personnel time.
Objectives of operational material characterization include:

- verify pre-mine predictions and fill gaps;
- create an inventory of excavated and exposed materials;
- segregate materials requiring different materials handling and mitigation.
At this site, detailed operational characterization ensured that potentially acidic rock (on yellow side of the stakes) ended up on the flooded side of the dam.
Learn from Past Mistakes

- Many past mistakes have resulted from decisions based on optimistic professional judgement and inaccurate computer models.
- We need “detailed, comprehensive information” and realistic assessments of information gaps rather than “great experts with great models”.
- Mine site geochemistry involves many complex geochemical interactions and processes in flux and it is important to identify all plausible outcomes and information gaps.
Dealing with Gaps in Information

- Mines need to recognize information gaps and depending on the type of problem, either conduct additional prediction studies or develop contingency plans and use adaptive management to reduce costs and risks.
Sensitivity analysis and risk assessment are required to determine the sufficiency of prediction information.

Safety factors may be required to account for limitations in the precision and accuracy of sampling; analysis; data interpretation; segregation; and other aspects of material handling.
Prediction Criteria (Screaming Criteria)

Prediction is a complex undertaking and practitioners are always searching for simple criteria to guide their decision making.

Criteria should be based on practical and scientific considerations rather than historical considerations.

Criteria provided in guideline documents are commonly:

- used inappropriately or
- quoted out of context.

Always need to consider the specific situations to which the criteria apply and verify the site-specific details concerning their use.
Conclusions

Productive use of mineral resource can only be sustained through environmentally sound, economically viable mining practices.

The drainage from sulfidic materials is therefore very important to the mining sector and the regions in which it operates.
While practices have improved, major challenges still exist:

- complexity of mines sites and large information requirements;
- potentially high costs;
- lack of long-term operating experience; and
- highly specialized, technical nature of the work.
Lots of hard work and resources are required to ensure industry and government sustain environmentally sound mining practices – success depends on significant commitment by all parties.

It is therefore important that all issues are addressed in sufficient detail, by persons with adequate time, resources, experience and expertise, and in a timely manner.
Some Resource Documents:

- Price & Errington (1997) BC MEM ML/ARD Guidelines
- Price (2004) List of Potential Information Requirements in ML/ARD Assessment and Mitigation Work
- Price (1997) BC MEM Guidelines and Recommended Methods for Prediction – criteria are often misused and misquoted
- Morin & Hutt (1997) Environmental Geochemistry of Minesite Drainage (case studies)
- MEND Workshops on theory and performance of dry covers, water covers, prediction, chemical treatment, biological treatment (case studies)