



Components of Successful Drainage Treatment

2009 Northern Latitudes Workshop

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Treatment:

- primary means of environmental protection at many older mine sites.
- often the only feasible mitigation measure for pits and underground workings
- contingency measure where there is significant uncertainty about future drainage chemistry





Treatment includes a diverse group of processes.

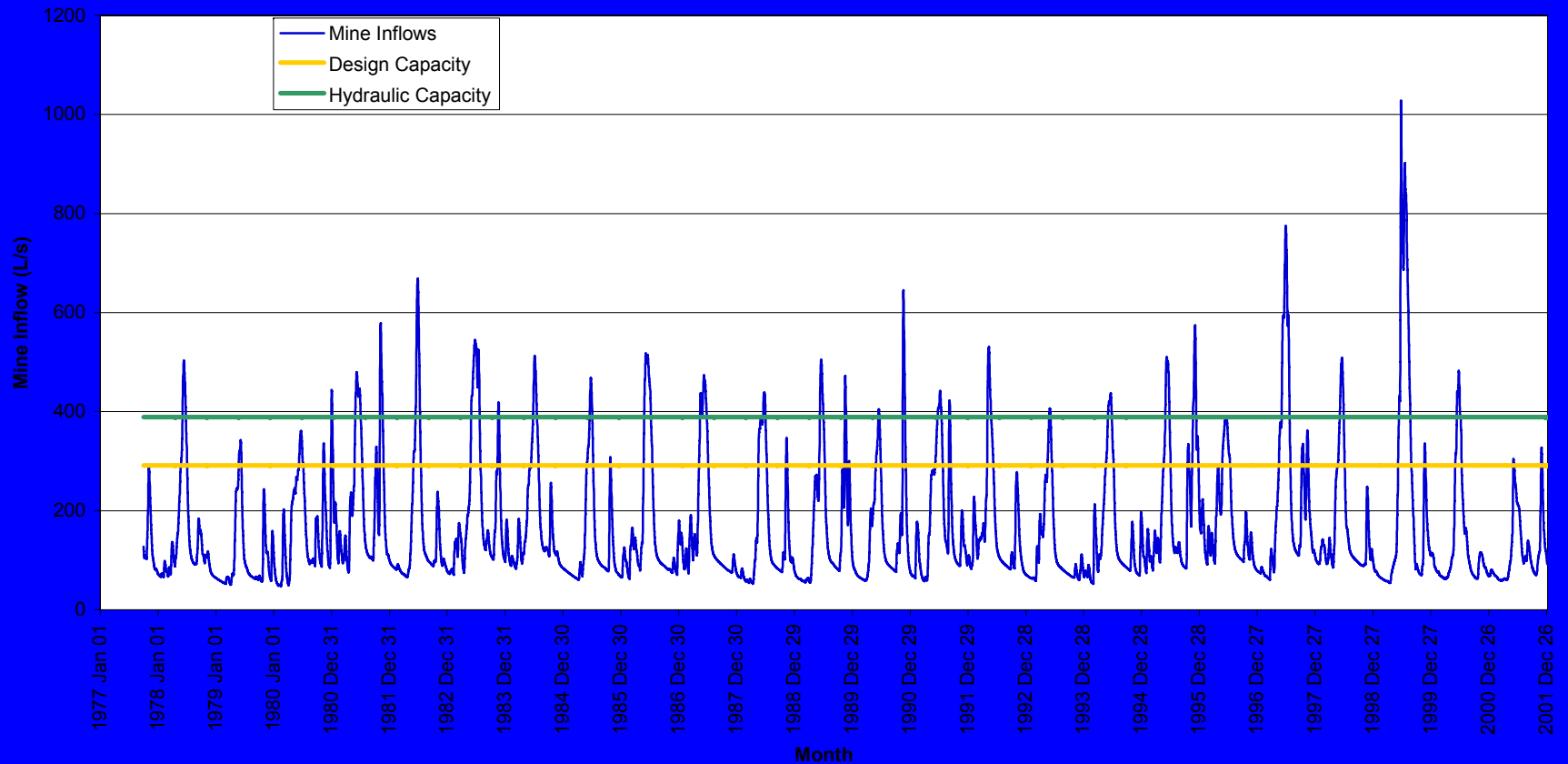
- Treated drainage may be acidic, near-neutral or alkaline
- Treatment may occur one-time or indefinitely
- Cost vary widely



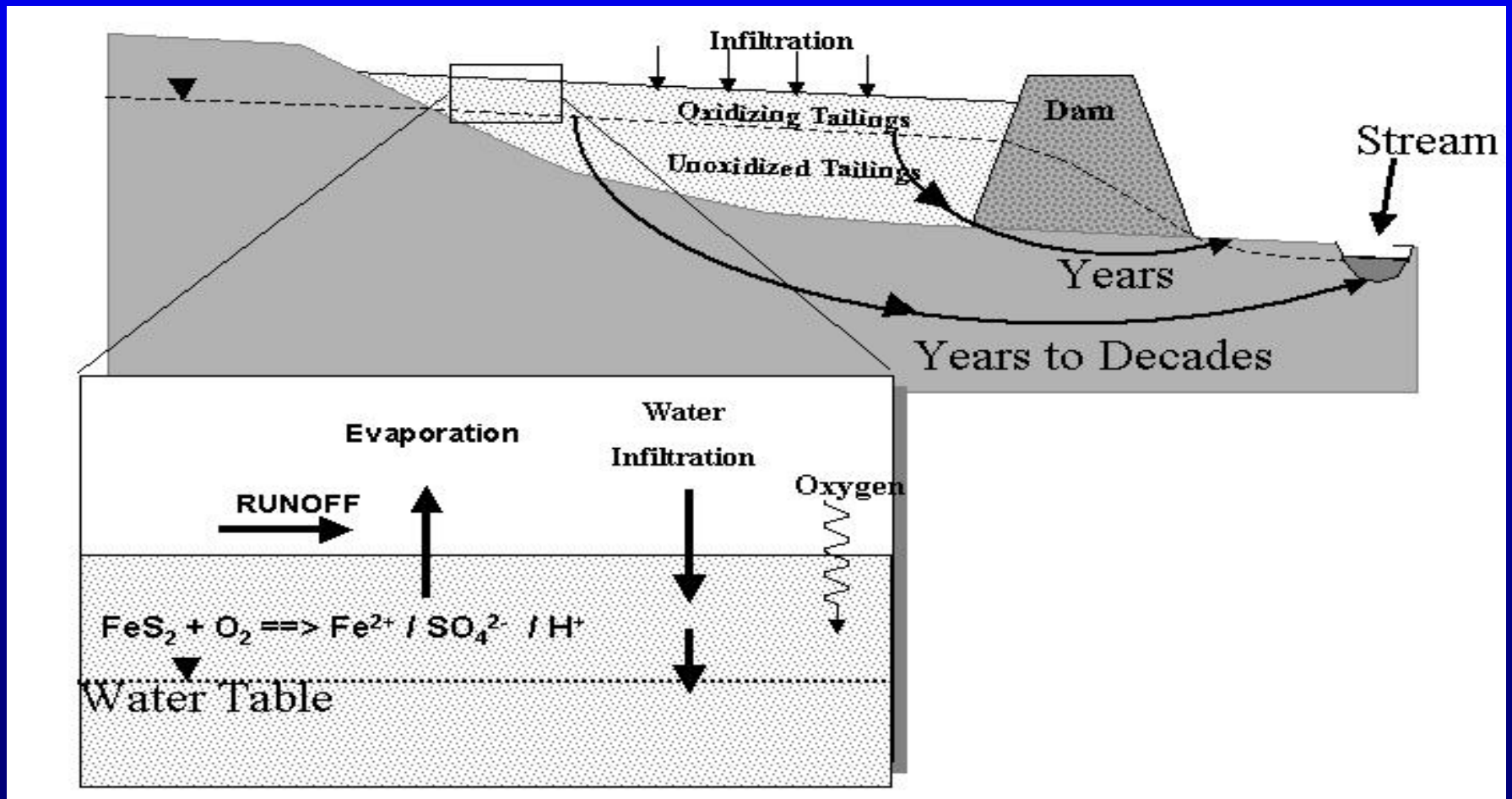
Effective contaminant removal from water requires:

- A system sized to handle the maximum contaminant loads
- Control of key treatment parameters, such as retention time, pH and redox
- Separation of precipitated contaminants from clean water
- Plumbing (getting drainage in, treated and out)

Need to estimate maximum drainage volumes and contaminant loads in order to have sufficient treatment capacity during major runoff events.



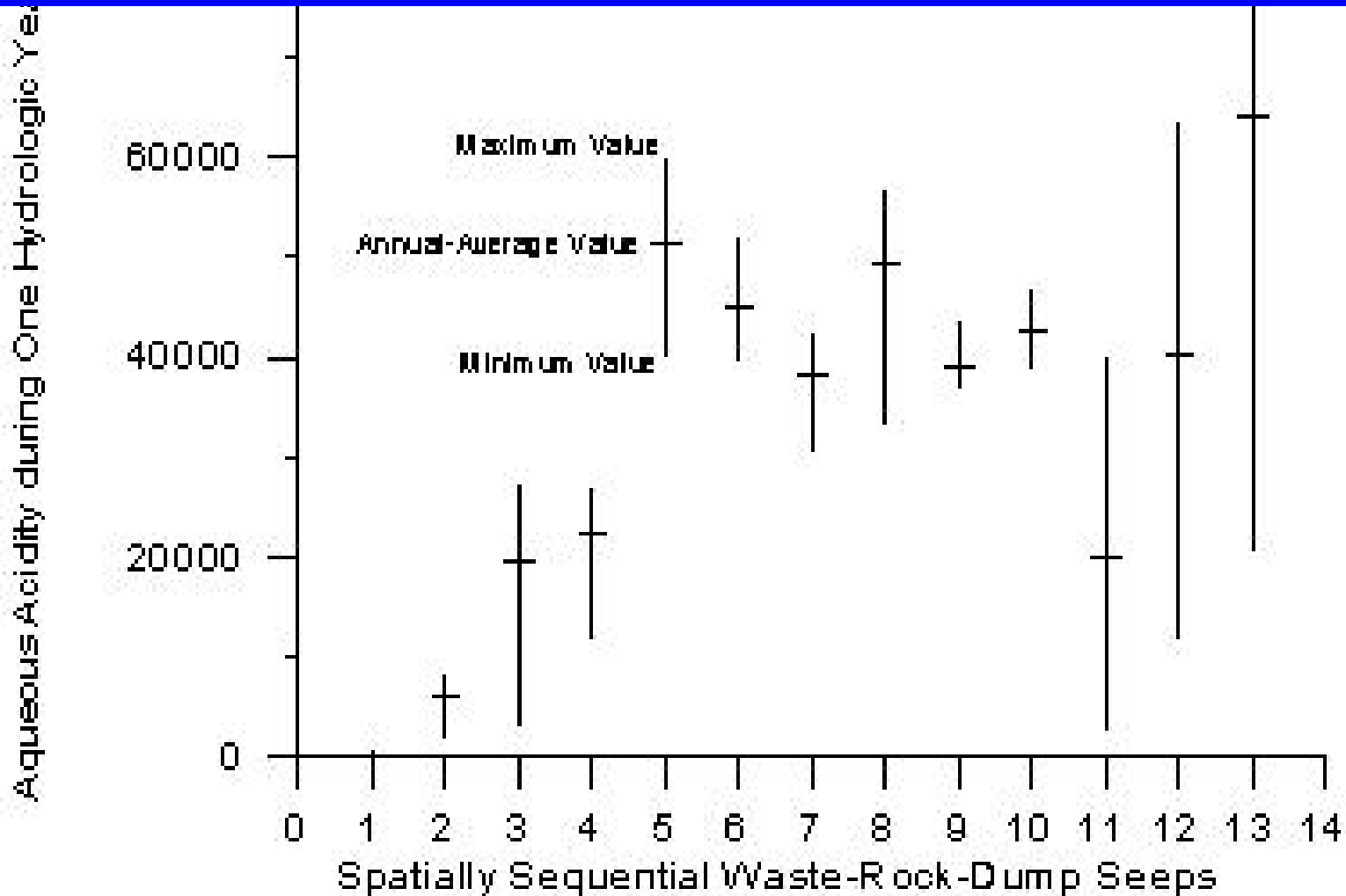
Lack of poor quality drainage to date does not mean it will not occur in the future as weathering products accumulate, attenuation sources, such as NP, are exhausted or slow flow paths are traversed.



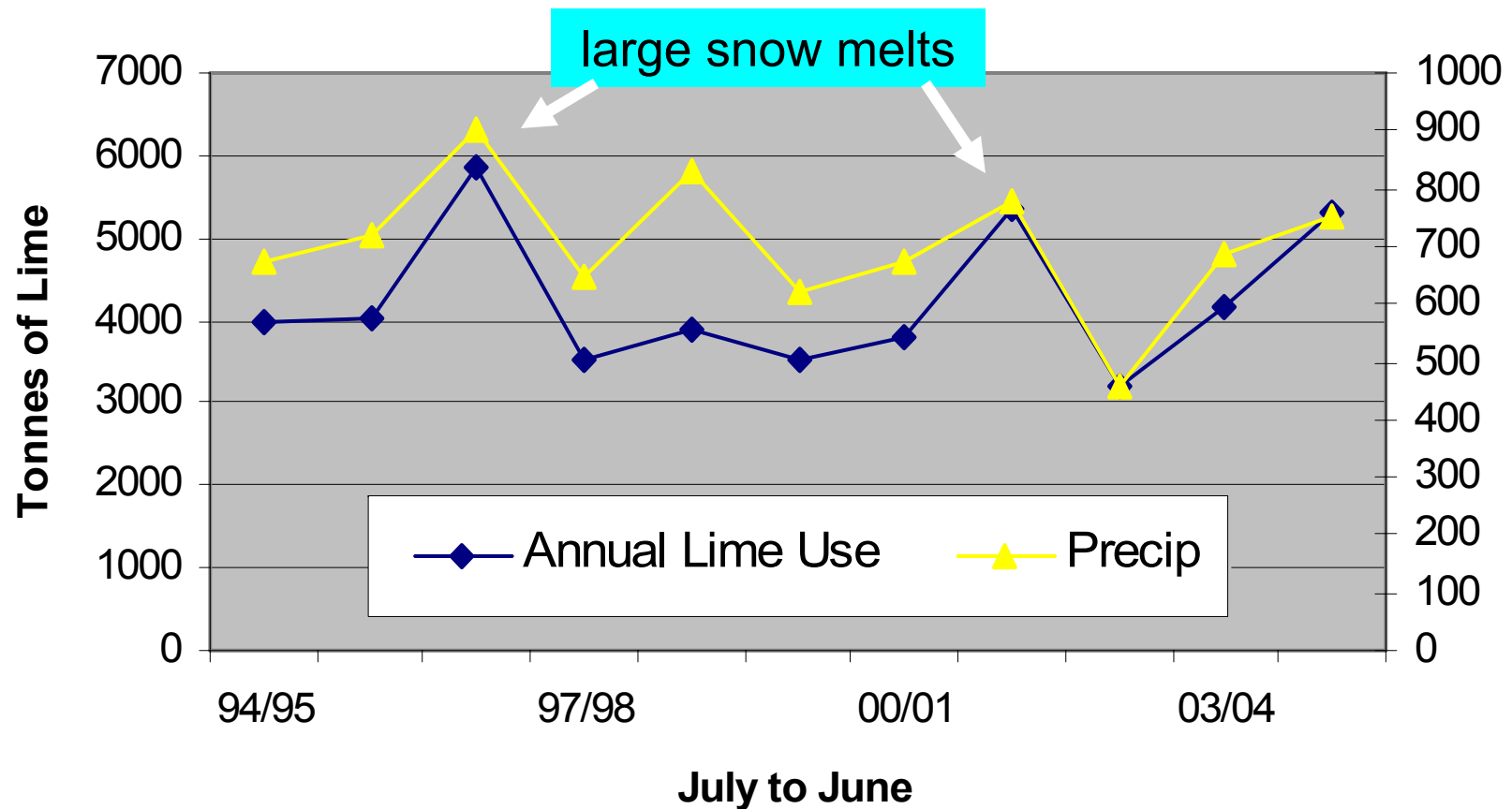
A number of closed mine sites have underestimated future contaminant loads and have had to build new plants to increase their treatment capacity.



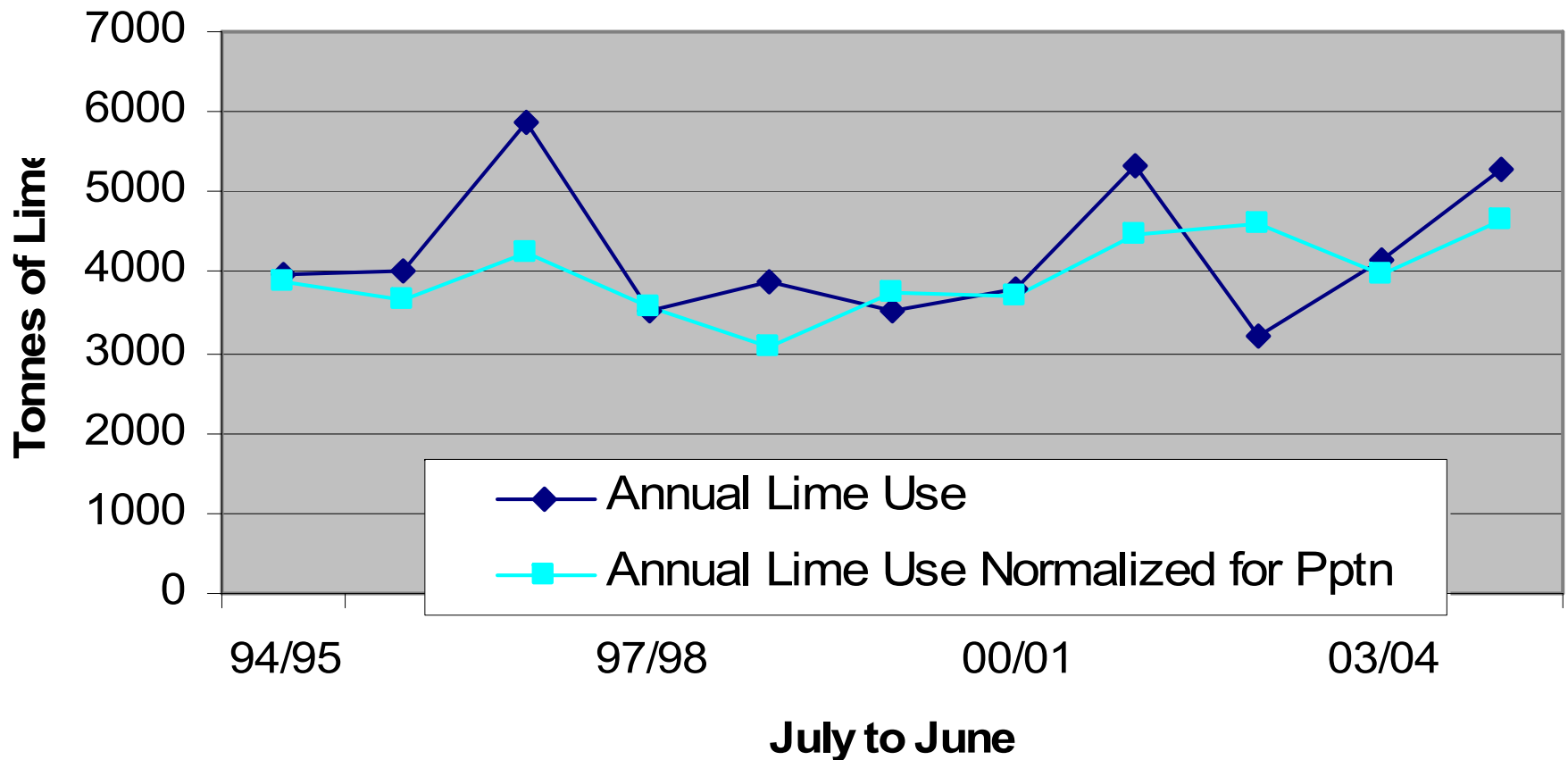
Part of the problem may be that changes in drainage chemistry are masked when combining drainage from different rock types or mine components. Evidence of changes in drainage chemistry may be provided by monitoring individual seeps.



Fluctuations in annual precipitation may also mask increases in load and solubility of contaminants.



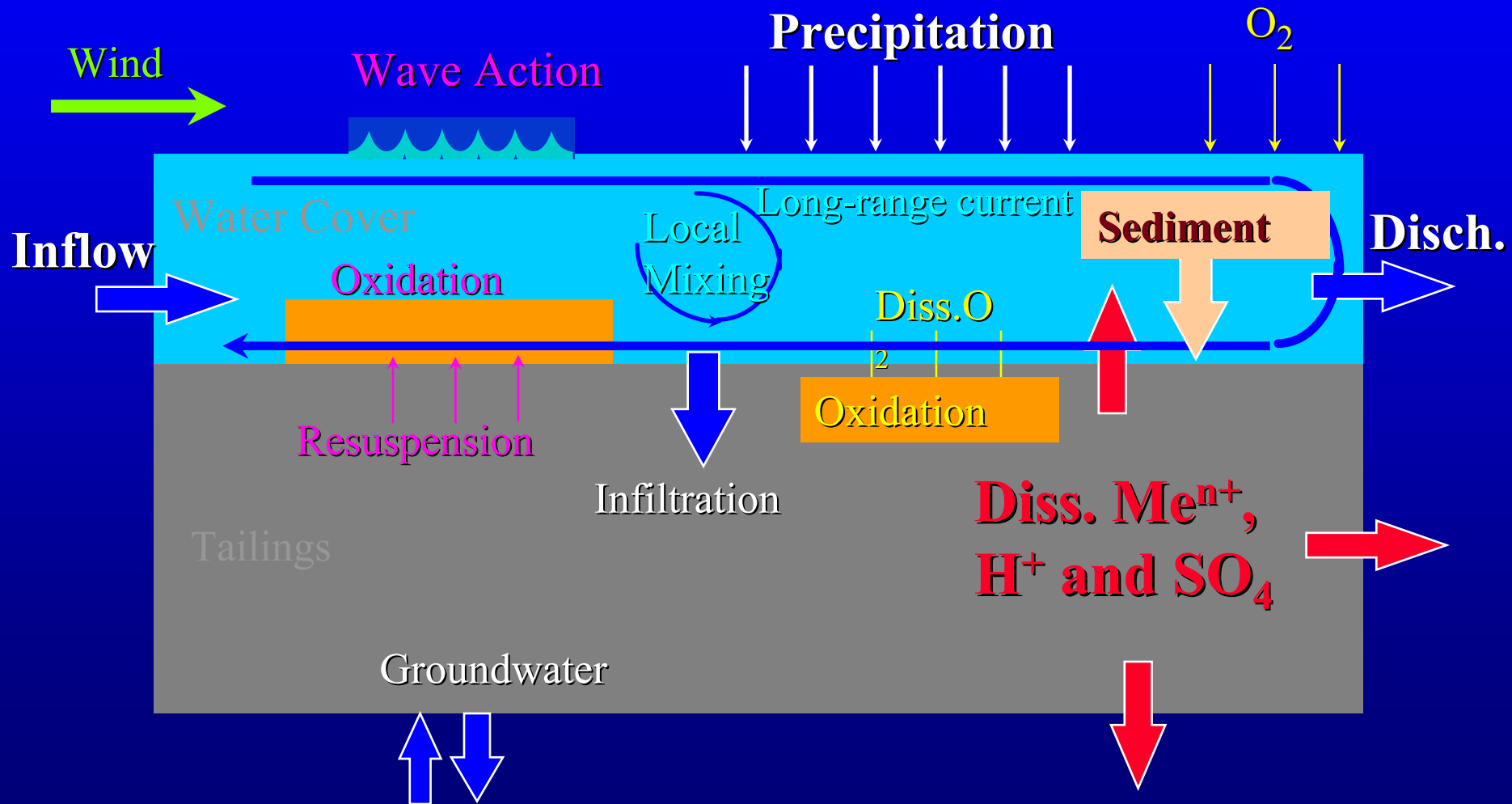
Evidence of changes in drainage chemistry may be provided by normalizing load data for differences from the average annual precipitation.





- Treatment process control may be relatively simple and treatment rapid with lime and ferric sulphate.

Process control and rapid, sustainable treatment is a greater challenge with 'passive' chemical or biological systems.



“So-Called” Passive Treatment

- Better described as ‘less active’. At a minimum passive treatment systems require ongoing monitoring, maintenance, and/or periodic replacement.



Other challenges of flow-through passive treatment:

- maintaining hydraulic properties of organic substrates
- preventing plugging by Fe and Al
- sustaining rapid bacterial activity
- providing sufficient residence time



Successes in biological treatment include metal removal by settling of algal blooms in pit lakes at Island Copper and Highland Valley. These mines are still studying how to sustain this treatment process.



Highland
Valley Copper

In addition to treatment itself, successful treatment of contaminated drainage also requires:

- Collection of contaminated drainage
- Diversion of clean water
- Discharge of treated effluent
- Disposal of treatment wastes





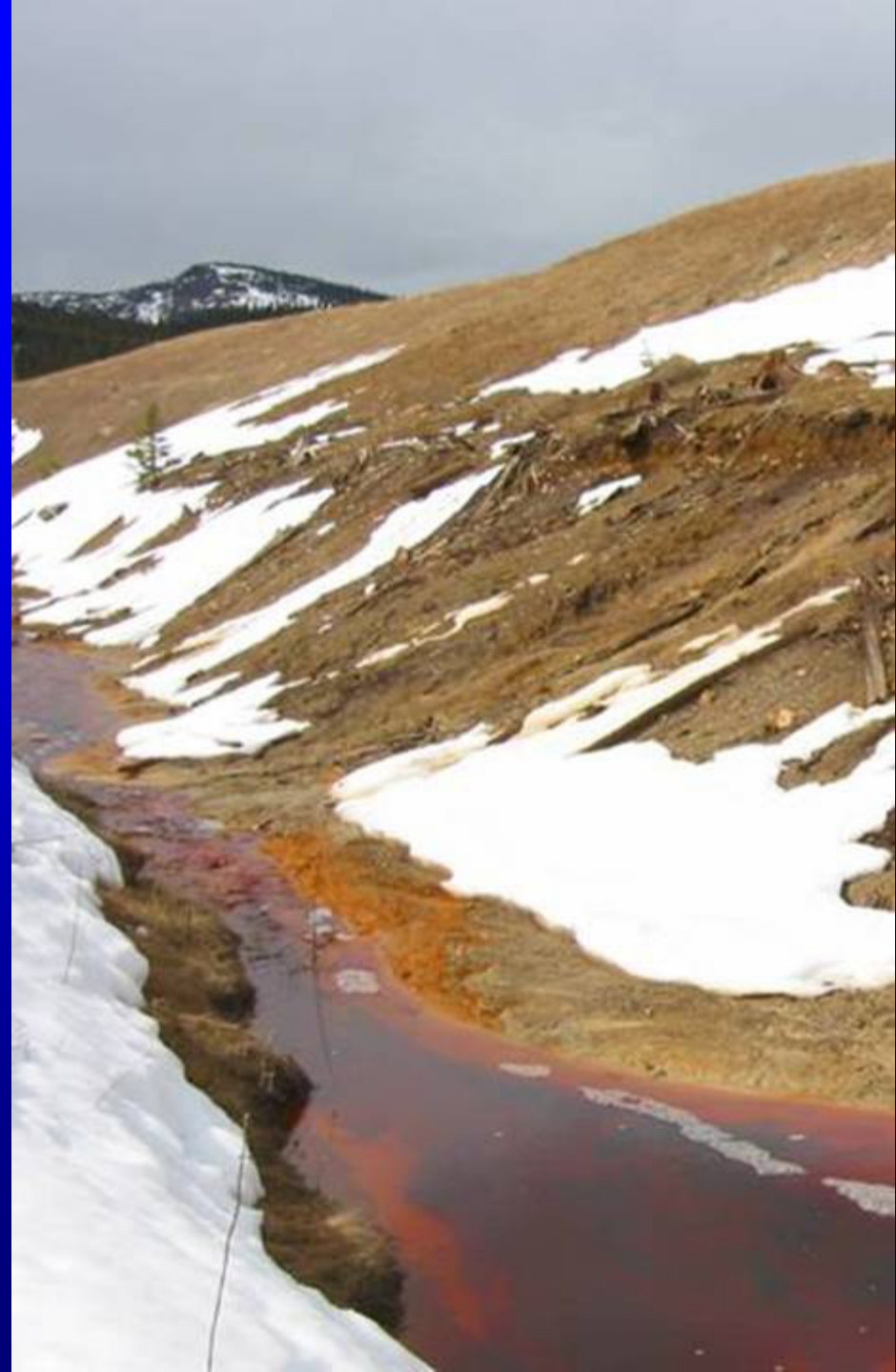
Collection of Contaminated Drainage



Collection Objectives:

- Intercept
- Transport
- Store

contaminated drainage
prior to treatment



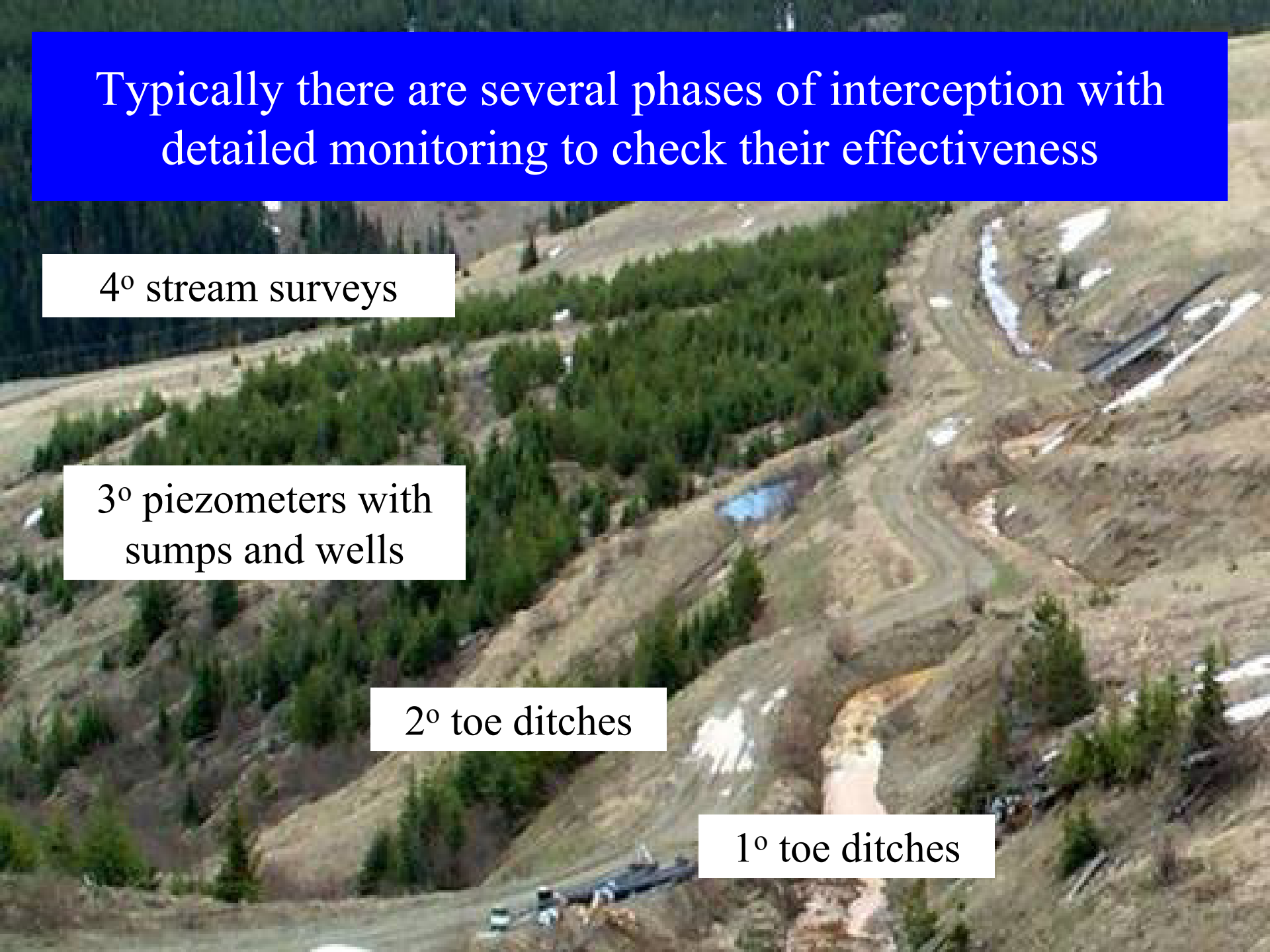
Typically there are several phases of interception with detailed monitoring to check their effectiveness

4^o stream surveys

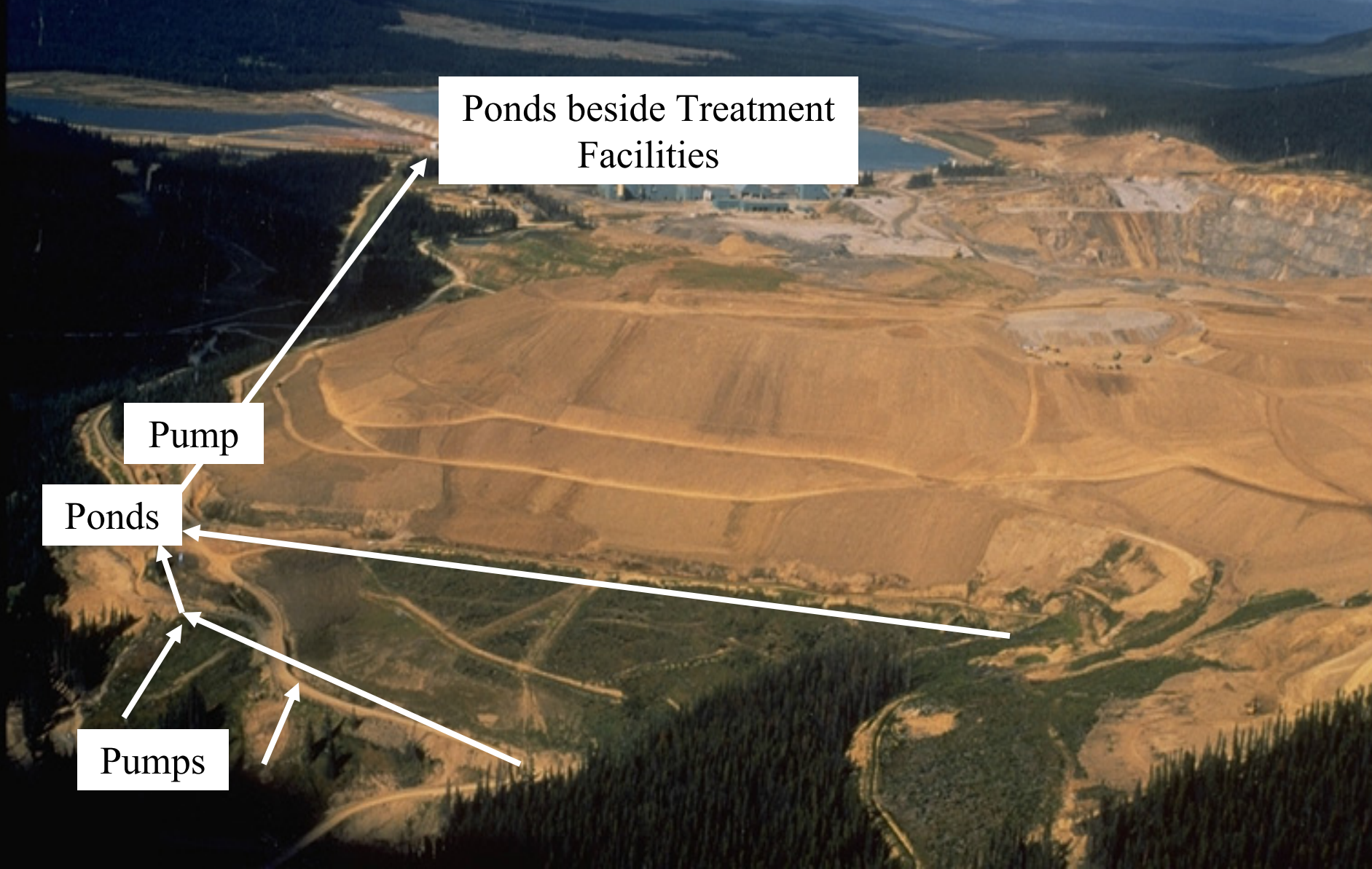
3^o piezometers with
sumps and wells

2^o toe ditches

1^o toe ditches



Transport of the intercepted drainage will depend on transport route, surficial geology and topography.



Storage ponds are required at pumping locations and beside treatment facilities:

- To avoid running pumps and treatment plant during periods of low flow
- For periods of maintenance, upset or when runoff exceeds capacity of pumps and treatment facilities



Pumping capacity must match maximum drainage inputs when there is a lack of space for large storage ponds prior to sensitive resources





Diversion of Clean Water



Objectives of the diversion of clean water:

- Reduce collection and treatment costs
- Reduce required capacity of collection and treatment structures
- Maintain flow and increase dilution of treated effluent in water courses below mine



Cost effective collection and treatment of contaminated drainage often depends on the transport clean water around and over contaminant sources



Ditches and wells above mine

Cover intercepts incident rain and snow melt

Inability to proactively maintain covers may be a concern where their diversion of clean water is needed for successful collect and treat.





Discharge of Treated Effluent



- Discharge requirements will depend on permissible discharge limits and locations*
 - Dilution may be needed for treatment effluent to achieve receiving environment objectives
- * based on sensitivity of downstream environment



Storage of treated effluent:

- ensure maximum discharge concentrations are average rather than worst-case contaminant levels
- allow time for degradation of products such as thiosalts and dilution by other drainage



It can be a challenge finding enough off-site dilution for large volumes of treatment effluent in dry conditions or where surrounding water bodies are relatively small.



Environmental effects monitoring may be needed to verify that discharge of treated effluent has no long-term impacts on receiving environment





Disposal of Treatment Waste



- Need to predict quality and quantity of treatment wastes, and develop disposal plans that provide long-term physical and geochemical stability
- For the iron hydroxide products of lime and ferric sulphate treatment, this means keeping the treatment sludge permanently oxygenated. Oxygenated conditions is achieved here by placing lime sludge sub-aerially on a gravel pad.



Disposal of sludge in a pit lake entrains oxygen and maintains oxygenated conditions throughout the water column as long as there is continuous sludge disposal.



Re-handling treatment wastes, such as low density sludge, may be costly and time consuming



Disposal of Other Waste Products

- Proposals for biological treatment systems also need to provide disposal plans for ‘treatment matrices’ that will be eventually be replaced (e.g., when system plug).





Challenges in Sustaining Successful Treatment



Contingency Plans for Upset Conditions

- Need to identify potential failure mechanisms, evaluate the risks and provide contingency plans for upset conditions to the site, staff and equipment.



Collection and treatment should be capable of withstanding normal periodic events such as power failures, forest fires, flooding, strikes and inflation. Additional options for transportation and supply of reagents should be available in the event access is cut-off or there is a rail or truckers strike.





Provision of additional treatment cells, water storage, structures for spill containment, spare parts, power, pumps and pipelines are all important safeguards.



For example, generators should be available to provide back-up power in the event an ice storm damages transmission lines.

Maintenance and Regular Testing

Operational maintenance and regular testing is needed to ensure design capacity is sustained. For collection system this includes:

- Regular cleaning of pumps, ditches, sumps and ponds
- Ice, snow and sediment removal prior to runoff
- Adequate training, experience and number of staff





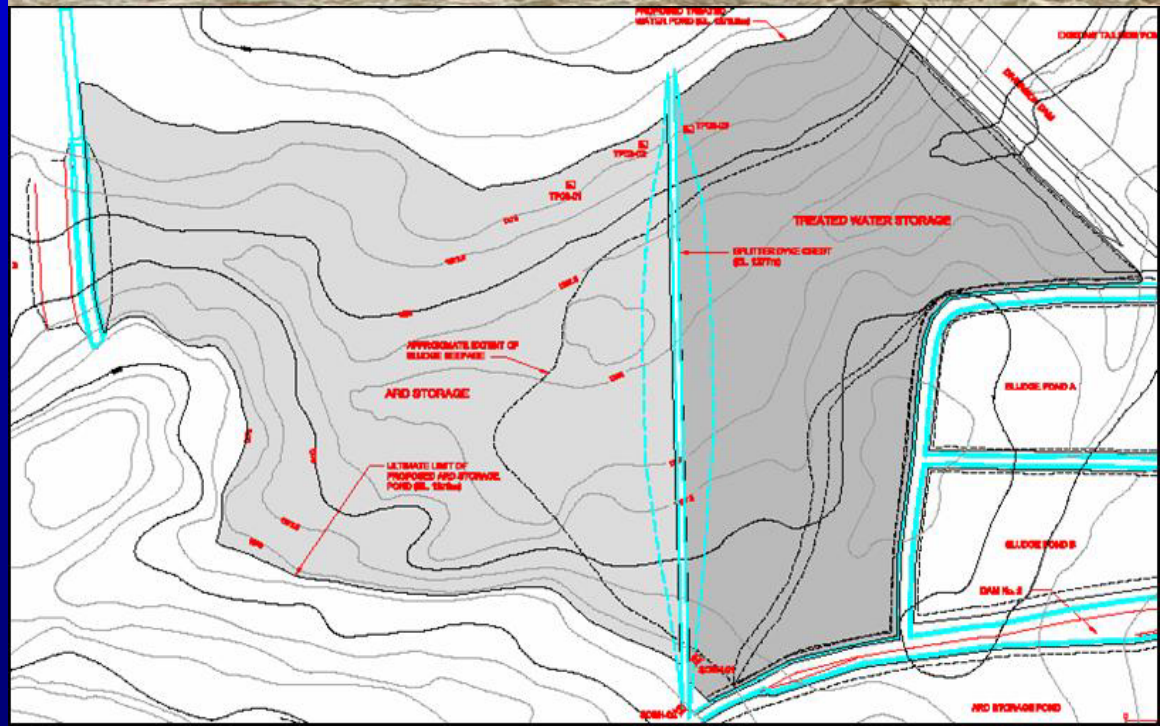
- In the north, the largest runoff events typically result from snow melt.

Monitoring the depth and water content of the snow pack provides early warning of potential problems allowing the provision of extra pumping and storage capacity.



Successful handling of a large runoff event typically requires:

- a well designed and maintained diversion system and
- contingency storage capacity for the excess contaminated drainage.



- Treatment plant can be sized to handle something closer to the average rather than maximum flows and loadings if temporary storage exists for contaminated drainage during larger runoff events.
- Large drainage storage facilities such as open pits also lessen the need for precise prediction of maximum flow and loadings.



Retention of the Collective Knowledge

- Critical knowledge and records often disappear when people leave due temporary or permanent closure.



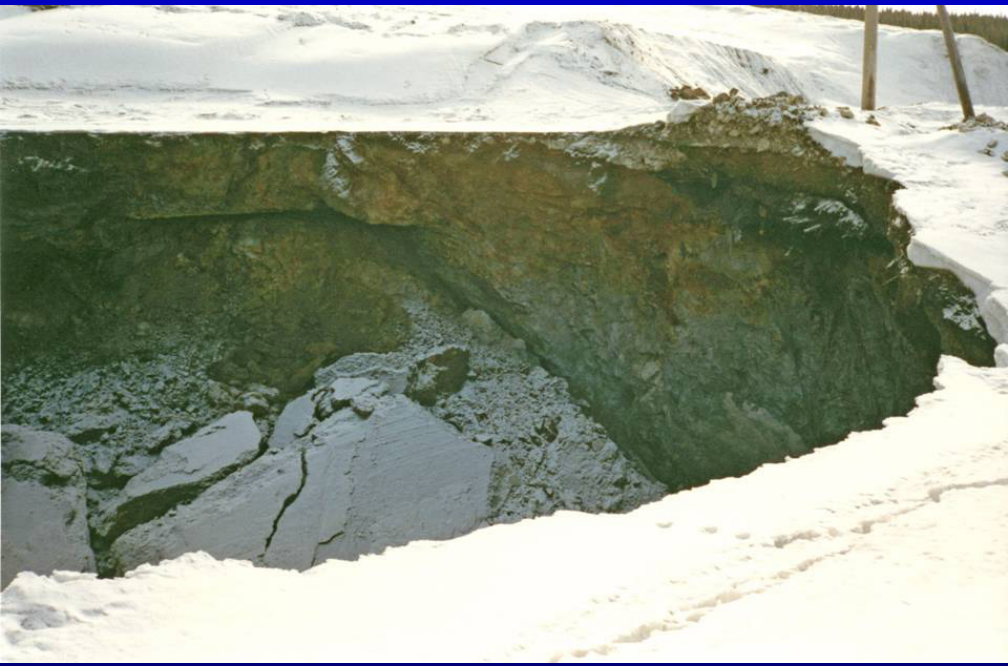
Retention of the Collective Knowledge

- Expert reviews and computer models cannot replace site experience and measurements.
- Sites need have operating manuals and data bases that are regularly updated and kept in a secure place



Financial Security

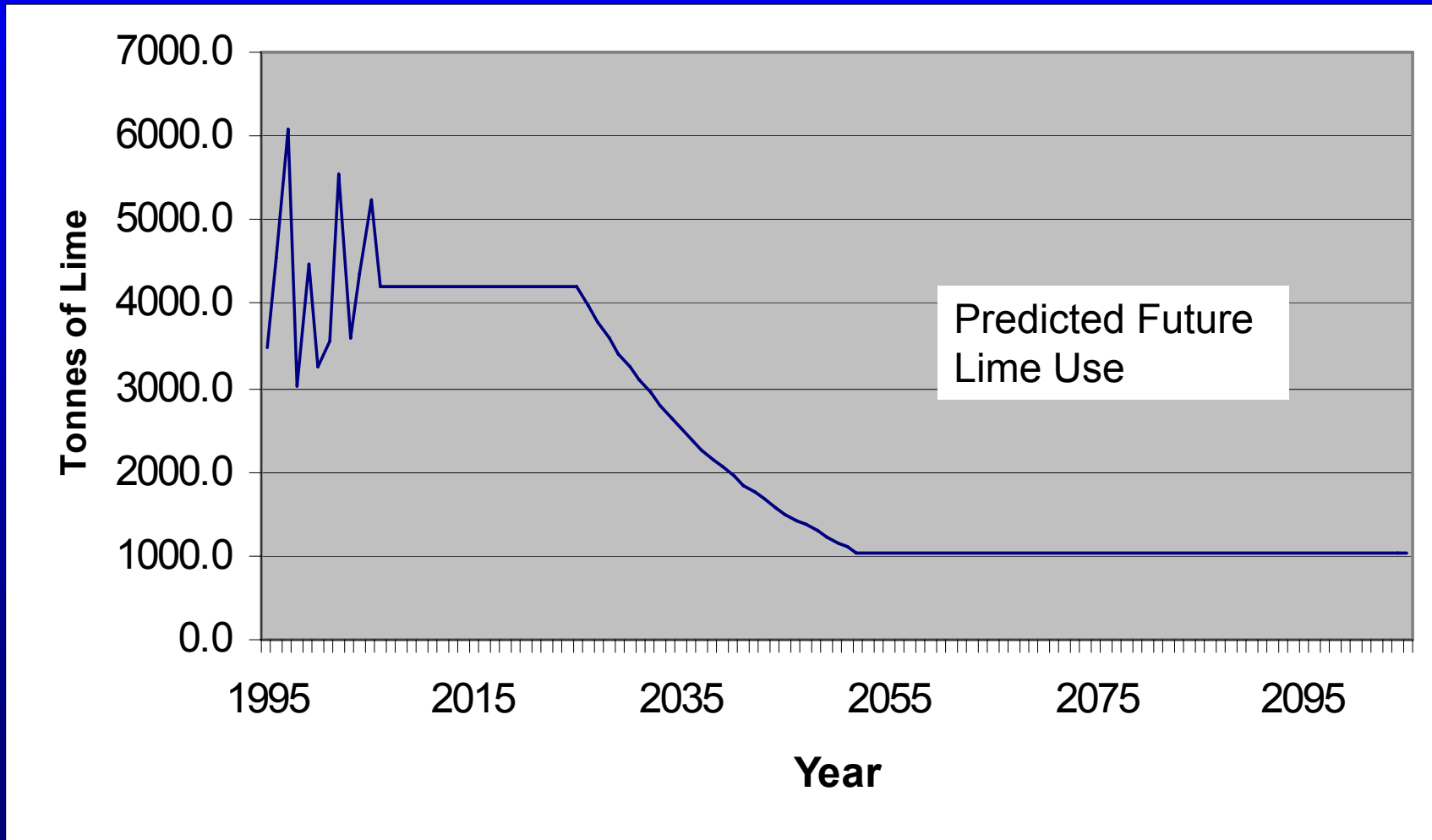
- Total liability may be \$100s of millions with operating costs over \$1.5 million per year
- As with all forms of mitigation, existing and projected future capital and operating costs must be estimated (reagent, power, labour, maintenance/replacement and contingency costs)
- This information will be used to determine the liability and ensure the required financial resources will be available.



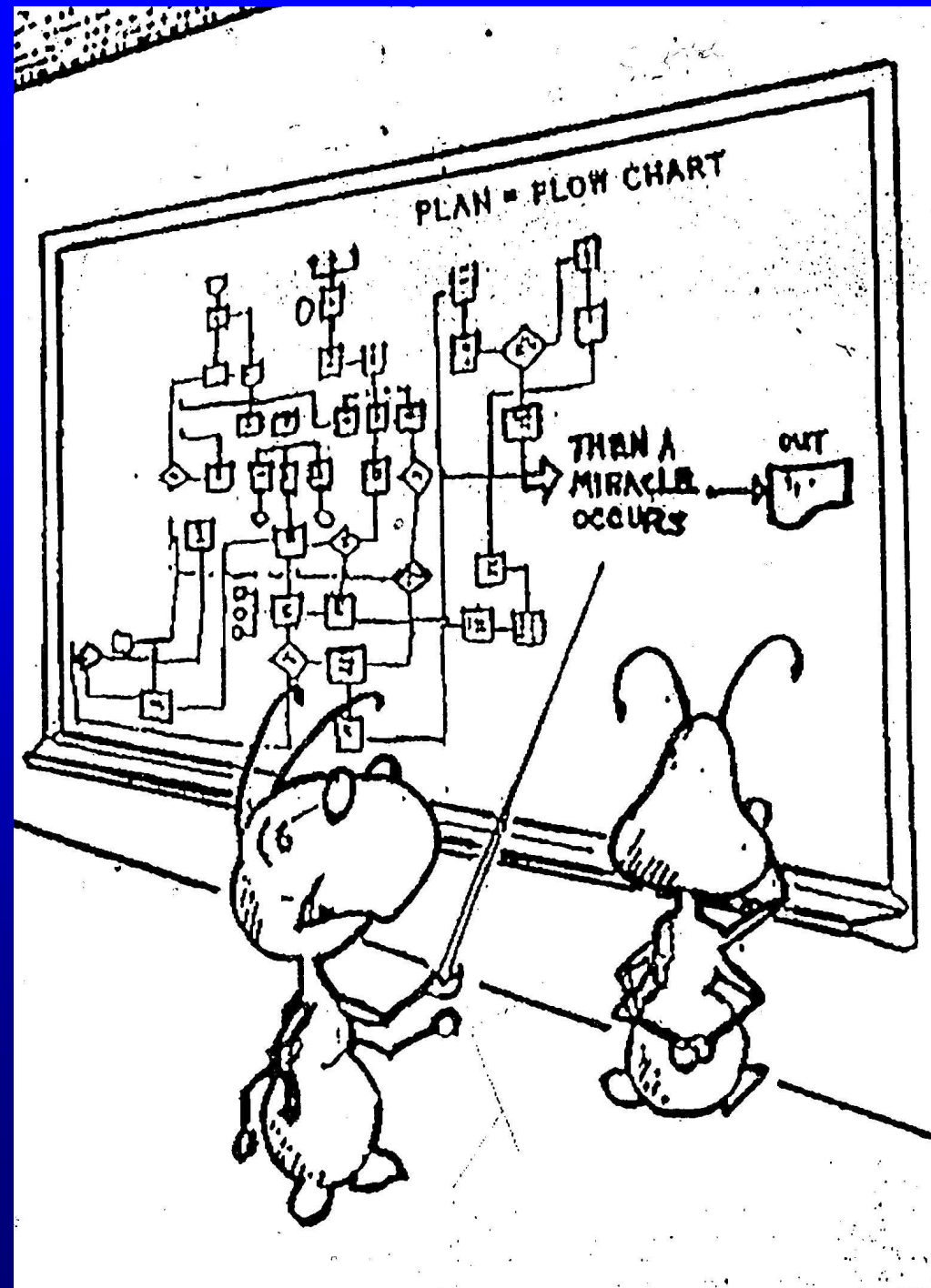
Properties in Flux

- The geological materials and environmental processes on mine sites are complex and continually changing.
- Mine workings filling, changes to the height of the regional water table and solute accumulation in mine wastes may change the magnitude and location of contaminant outputs.
- Many of key properties and processes contributing to drainage volume and chemistry are impossible to predict.

Due to the limited long-term data and processes that are difficult to predict, prediction of future costs is at best an educated guess work.



- It is important to identify information gaps in predictive models.
- Monitoring and studies will hopefully allow proactive adaptive management.





Conclusions



Collection and treatment of contaminated drainage can be a **highly effective and reliable** means of protecting the environment.

In British Columbia approx:

- twelve sites use or will use lime treatment
- three sites use ferric sulphate to treat neutral pH drainage
- several operational examples of biological treatment



Brenda Mine

The Treatment Conundrum

- Reliability and effectiveness of chemical treatment makes it a favoured mitigation strategy for existing mine sites
- High costs, large management requirements, secondary waste production and risk of spills make perpetual treatment the mitigation strategy of last resort for new mines



However treatment is not a slam dunk. Critical questions for any treatment system:

1. At how high a load and flow rate can the system reliably produce dischargeable drainage, for how long and at what cost?
2. What systems are needed to ensure C & T are effective and sustainable?
3. What is required in terms of process control, equipment, personnel, monitoring, maintenance and redundancy in design for diversion of clean water, collection and treatment of contaminated drainage, discharge of treated drainage and disposal of treatment wastes?



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