A HISTORY OF TAILINGS MANAGEMENT AT MYRA FALLS OPERATIONS
MINE SITE OVERVIEW AND TOPOGRAPHY

- Buttle Lake
- Tailings Facility
- Diversion Ditches
- Waste Rock Dumps
- Myra Creek
- HW Mine
- Polishing Ponds
- Super Pond
- Lynx TDF
- Mill Area

[Image of mine site overview and topography]
A HISTORY OF TAILINGS DEPOSITION AT MYRA FALLS OPERATIONS

- 1966 – 1984  Sub-aqueous tailings deposition into Buttle Lake
- 1984 – 2003  Sub-aerial tailings deposition into the Tailings Disposal Facility
- 2003 – 2007  Deposition of paste on top of the old sub-aerial tailings
- 2008 – ????  Cemented paste deposition into the new Lynx Tailings Disposal Facility
- Future ?  Full tails paste underground
TAILINGS PRODUCTION RATES AT MFO

- Ore milled since 1966: 27 million tonnes
- Tailings Produced since 1966: 23 million tonnes
- Tailings deposited above ground since 1966: 11.5 million tonnes

50% of MFO’s tails is used as backfill underground and 50% are deposited above ground
MINERALOGY OF THE TAILINGS

The ore mineralogy consists of the sulphide minerals:

- Pyrite \((FeS_2)\)
- Sphalerite \((ZnS)\)
- Chalcopyrite \((CuFeS_2)\)
- Bornite \((Cu_5FeS_4)\)
- Galena \((PbS)\)

associated with quartz, sericite and barite as the dominant gangue minerals.

In the last 5 yrs the percentage of pyrite has dropped significantly as mining has shifted from the HW ore body to the Battle-Gap ore body, resulting in a less acidic tailings product.

Meanwhile, the sericite percent has increased, producing a more plastic tailings product.
MINERALOGY OF THE TAILINGS

Acid Base Accounting (ABA) of fine tails

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2007</th>
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<tbody>
<tr>
<td>Sulphide</td>
<td>30.2%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Neutralization Potential (NP)</td>
<td>66 kg/t CaCO₃</td>
<td>25 kg/t CaCO₃</td>
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<tr>
<td>Acid Potential (AP)</td>
<td>942 kg/t CaCO₃</td>
<td>306 kg/t CaCO₃</td>
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<tr>
<td>Neutralization Potential Ratio (NPR)</td>
<td>0.07</td>
<td>0.08</td>
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Tailings deposited in Buttle Lake between 1967 and 1984
2 million tonnes of tailings deposited into Buttle Lake over 16 years
Deposition switched to a land based facility in 1984 as a permit condition following expansion and the discovery of the H-W ore body
Community concerns contributed to the decision to change deposition strategies
ZINC CONCENTRATIONS IN BUTTLE LAKE 1966-1995

Surface water quality on Buttle Lake at Gold River Bridge.

- Lynx open pit (most waste rock generated)
- Lynx underground
- Myra underground
- (on-land tailings disposal)
- H-W underground
- 875 tonnes/day (subaqueous tailings disposal)
- 2700 t/d
- 4000 t/d
- 3386 t/d
- Clark report identifies significant changes in water quality and attributes them to the Lynx open pit and waste dumps.
- Diss. Zn occasionally out
- Tailings proven not to be the cause of high metals (Pedersen).
- of compliance at Lynx pond (PE-4077-01)
- Diversion around waste rock and full water treatment in 1982.
- Pollution Control Objectives
- MMLER

Figure 1
Myra Falls Mine Timeline
MODEL OF MYRA VALLEY PRIOR TO LAND BASED TAILINGS DEPOSITION - 1982
LAND BASED TAILINGS DEPOSITION 1984 - 2003
SEISMIC UPGRADE OF TDF 1999 - 2009

- Realigned of Myra Creek
- Dynamic compaction of seismic berm foundation soils
- Upgraded under drain system
- Buttress with PAG rock core, NAG rock “shell”
- Fills placed and compacted in approx. 0.5 m lifts
- Ongoing in staged manner ever since, gradually reducing risk
PASTE STORAGE IN THE TDF 2003 - 2008
Paste Containment Berm floats on previously deposited conventional tailings
CONSTRUCTION OF THE PASTE BERM
**CLOSURE STRATEGIES**

- Cover sloped paste tails with a combination of non-acid generating waste rock and native till.
- Sloped land form will channel surface runoff to an armored spillway.
- Drainage not meeting water quality criteria will be collected via toe drains and treated prior to release (~30 gal/min).
- Under drains will capture any seepage and be pumped to the water treatment facility (~4000 gal/min).
- The cover design facilitates re-vegetation with both trees and grasses.
- Overall goal is to reclaim Myra Valley, including the Tailings Disposal Areas, to a state consistent with Class “A” wilderness parkland.
- Next step is to conduct 2-D land form design work.
PLAN OF THE ULTIMATE LYNX PASTE STORAGE FACILITY

LYNX TDF DESIGN

Plan of the Ultimate Lynx Paste Storage Facility
PROGRESSION OF THE LYNX TDF DEVELOPMENT
LYNX TDF DESIGN

- Lynx TDF to be a waste disposal facility, not just a tailings disposal facility
- Other waste streams to be included:
  - Water treatment system sludge
  - Excess tailings sand that cannot be used as backfill
  - General site refuse
  - Sewage discharge
  - Fines from sump cleanouts
  - Waste Rock
LYNX TDF WATER MANAGEMENT

- Two diversion ditches each designed to accommodate 1 in 200 year, 24-hour flood
- Total catchment 33 ha
  - Upslope area: 23 ha
  - Lynx TDF: 10 ha
- Lynx TDF will accommodate 1 in 1,000 year, 24-hour flood
- This event represents estimated inflow of 78,000 m$^3$
LYNX TDF WATER MANAGEMENT INFRASTRUCTURE
The Lynx Pit sits on top of stopes partially backfilled with hydraulically placed sand.

This is an area of the mine that has not been actively mined since 1993.

These stopes are connected to the active mine workings through a distance of approximately 2 km of drifts and raises.

In order to reduce the risk of an inflow of tailings into active parts of the mine the tailings placed in the Lynx TDF need to be rendered non-liquefiable.
Mine personnel underground are well removed from the area.
LONG AXIS SECTION THROUGH THE LYNX TDF AND UNDERGROUND
CEMENTED PASTE IN LYNX TDF

- Paste typ. 60-65% solids by weight
- Further consolidation has been observed

Paste Mix – 0.033 parts cement : 1 part dry tailings solids : 0.63 parts water
CEMENTED PASTE IN LYNX TDF
Looking north at the test pit after 3.5 hours. Test pit depth is 6 m. Width is approximately 1.3 m (width of digging bucket).

West wall of the test pit looking north after 3.5 hours.

Pile of excavated material after 3.5 hours. Note the cohesion within the material, with no indications of liquefaction-type behaviour under high strains imposed by the excavation process.

Collapsed test pit, June 10. Note the cohesion within the mass, with no indications of liquefaction-type behaviour.
Objectives:
1. Produce material not susceptible to flow liquefaction at minor strains
2. Produce material with enhanced post-liquefaction shear strength
3. Water-tailings-cement ratio sufficient to permit pumping via positive displacement pumps without excessive line pressures

Peak shear strength not an objective – in fact, want to avoid increasing brittleness of the material, do not want to inhibit consolidation and water content reduction
PRACTICAL CHALLENGES TO TAILINGS MANAGEMENT

- Changes in Ownership
  - Four different owners in the last 25 years

- Production changes
  - 875 tonnes/day → 2700 tonnes/day → 4000 tonnes/day → 1600 tonnes/day

- Different deposition facilities require changes to the operation
  - Sub-Aqueous → Land Based → Paste → Cemented Paste
Exploratory drilling in the early 1990’s to investigate the degree of consolidation of the tails in the TDF showed that there had been less consolidation than anticipated and that the tails remained saturated at depth. These conditions lead to an increase in the risk of liquefaction during or after an earthquake.
CHALLENGES – BUTTRESSING THE TDF

- In 1999 a plan was approved to build a buttress around the TDF to improve its seismic resistance.
- The plan utilizes both acid generating material and non-acid generating materials.
- Required moving in excess of 1.5 million m3 of fill.
- One of the largest challenges was achieving fast turnaround times for the acid base accounting test work. The non-acid generating quality of each lift had to be confirmed before being covered by the next lift.
- Working in and along a fish bearing stream.
ARD from tailings has become a challenge in the last two years

Exposed older tailings not covered by paste have started to generate acid

Although ARD contributes only a small percentage of flow to our water treatment system it has a strong potential to disrupt the pH balance of that system

Automation of lime addition to our water treatment system has improved our ability to handle these ARD flows

In situ treatment of the ARD by spreading slaked lime with a water truck has further reduced the strain on our water treatment system
CHALLENGES – WATER MANAGEMENT

- Steep narrow valley
- Flashy runoff
- 2 storms in last two years in excess of our 1:200 year design criteria
- Challenges met by introducing redundancy into our water management system:
  - Redundant diversion ditches
  - Backup pumps
LESSONS LEARNED

- Waste streams such as tailings, effluent and sludge should be treated as products, and given similar quality control as our concentrate.
- Moving forward MFO will focus on a comprehensive waste management plan rather than a tailings management plan.
- Maintain a backup location for tailings deposition under upset conditions.
LESSONS LEARNED

- Utilizing all available material for construction including acid generating waste rock
LESSONS LEARNED

- You can never have too much knowledge when it comes to planning
  - Understand material geochemical (ML/ARD) characteristics in advance and plan accordingly
  - Understand the hydraulic regime to design effective water management strategies
- Where adequate knowledge is unachievable, build in adaptive management and ongoing risk assessment
- Land-based storage may not always be the best solution for tailings disposal
  - Site specific characteristics such as seismic and geotechnical conditions must be taken into account in the design process
- Include stakeholder involvement early in design process