CERM3's Millennium Plug Project at the Britannia Mine

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Brackendale, B.C.
CERM3 Mission Statement

- to foster high regard for sustainable mining practices and concern for the environment
- to develop innovative methods to ensure the future sustainability of the Mining Industry
- to train the next generation of Mining and Processing Engineers for the 21st Century
- to improve the image of Mining in society
Research Participants

10 departments are represented
- Westwater Research Centre
- Chemical and Biological Engineering
- Chemistry
- Civil Engineering
- Earth and Ocean Sciences
- Electrical Engineering
- Metals and Materials Engineering
- Microbiology
- Mining and Mineral Process Engineering
- Occupational Hygiene/Epidemiology

4 Companies (Inco, Syncrude, Nautilus, Rescan)

34 Research Faculty in total

CERM3 Facilities

**Environmental Quality Lab**
- analytical support and research into assay protocols.

**Bioremediation and Reclamation Lab**
- biological solutions for environmental problems.

**Environmental Technology Lab**
- new processes to reduce energy, material use and pollution.

**Mine Health and Safety Lab**
- improvements in the working environment.

**Mine Automation/Environmental Simulation Lab**
- integration of mining and processing; remote-mining.
Annual Activities of CERM3

- monthly research activity meetings (feedback/revision)
- annual review meeting of the TAC (priority setting)
- annual Technical Conference (technology transfer)
- annual public exhibition of research results (public relations)

CERM3 Membership - BRONZE

General Fees

$250 per year

Research Project Support

Not required
Corporate Membership - SILVER

Operating Infrastructure Support

$1,000 per year

Research Project Support per company for 5 years

$ 5,000 per year cash support
$ 5,000 per year in-kind support

Corporate Membership - GOLD

Operating Infrastructure Support

$2,000 per year

Research Project Support per company for 5 years

$ 5,000 per year cash support
$ 5,000 per year cash support for specific projects
$ 10,000 per year in-kind support
Corporate Membership - **GREEN**

**Operating Infrastructure Support per company**

$5,000 per year

**Research Project Support per company for 5 years**

- $10,000 per year cash support
- $10,000 per year cash support for specific projects
- $20,000 per year in-kind support

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**CERM3 Corporate Membership Benefits**

- access to top-quality research into environmental problems of significance to your company
- participation in the direction of **CERM3**'s research
- participation in the annual meeting of the **TAC**
- ability to second employee(s) to work at **CERM3** with office space/UBC campus access
- ability to "buy-in" to intellectual property rights to the outcome of research conducted at **CERM3**
Intellectual Property Rights Policy

- UBC has an excellent and active Industrial-Liaison Office
- all research conducted at UBC is in the public-domain
- all intellectual property derived from CERM3 research will be retained by the University of British Columbia
- CERM3 Corporate Members will be given a Royalty-free limited license to use such property
- licence terms will be negotiated on an individual project and/or corporate basis by UBC-ILO
- purchasing of the property rights can be arranged through negotiations with UBC-ILO

Collaboration with CERM3

- The research provides new approaches for industrial applications
- Funding is essentially multiplied between 2.5 to 4 times
- The companies with positive outlooks on sustainability that we expect to become Corporate Members of CERM3 include:
  - Anglo Am.
  - Barrick
  - BHP-Billiton
  - Boliden
  - Cominco
  - Newmont
  - Falconbridge
  - Fording Coal
  - Hatch
  - Homestake
  - Inco
  - Luscar
  - Noranda
  - Outokumpu
  - Placer Dome
  - Phelps-Dodge
  - Rio Algom
  - Rio Tinto
  - Shell
  - Sherritt
  - Suncor
  - Svedala
  - Synercrude
  - Teck Corp.
  - PRECARN, CanMet and BC Ministry of Mines will also be involved in the Technical Advisory Committee
The Millennium Plug

- Built in much the same way as an earth dam
- Impervious clay core
- Layers of sand, gravel, rabble
- Resistant to acidic conditions
- Cheaper to build
- Improved resistance to seismic events
- Uses locally available materials
- Generates a “walk-away” solution

UBC - Britannia Mine Collaboration

- for over 26 years, > 9000 tonnes of heavy metals have spewed into Howe Sound with no one assuming responsibility to correct the problem
- UBC has need for a research facility to conduct testwork into the design of bulkheads to seal tunnels
- by placing this laboratory at the 2200 level portal of Britannia Mine, two synergistic events occur:
  - UBC installs its research lab at a full-scale field site
  - Britannia Mine closure plan moves nearer to fulfillment
Howe Sound from above Britannia Beach

A place of mystery.....
.....in more ways than one!

Location of Britannia Mine

Britannia Beach, B.C.
Looking towards Squamish

Contaminant Plume from Britannia Creek
Problems at Britannia

**Technical**
- ARD from mine portals impacts Britannia Creek and Howe Sound
  - total flowrate averages ~500 m³/hr.
- ARD from open pits and waste dumps enters the mine workings
- Reclamation of open pits and waste dumps is necessary

**Political/Financial**
- Copper Beach Estates Ltd. has been in default since 1991
- Previous owners are not taking responsibility for the site
- Government has issued numerous clean-up orders since 1981
- meeting of Potentially Responsible Parties on Nov. 30, 2000

Potentially Responsible Parties

<table>
<thead>
<tr>
<th>Alcoa</th>
<th>Canzinco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumax Inc.</td>
<td>Copper Beach Estates Ltd.</td>
</tr>
<tr>
<td>Anaconda/Arco</td>
<td>Howmet Holdings Corporation</td>
</tr>
<tr>
<td>Arrowhead/Ivaco</td>
<td>Intalco Aluminum Corporation</td>
</tr>
<tr>
<td>Province of British Columbia</td>
<td>Government of Canada</td>
</tr>
</tbody>
</table>

Terms of the PRP Agreement:
- Total indemnity for the non-owner PRPs
- C$ 15 million in 2001 and 2002 = a total of $30 million
- C$ 9.5 million from Federal-Provincial Reclamation Fund
- C$ ? million from Copper Beach Estates
Effluent Quantities and Contaminant Levels

<table>
<thead>
<tr>
<th>Item</th>
<th>4100 Level</th>
<th>2200 Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flowrate (m$^3$/hr)</td>
<td>9600</td>
<td>2400</td>
</tr>
<tr>
<td>pH</td>
<td>3.5-4.4</td>
<td>2.7-3.0</td>
</tr>
<tr>
<td>Cu content (mg/L)</td>
<td>12-22</td>
<td>30-100</td>
</tr>
<tr>
<td>Zn content (mg/L)</td>
<td>25-30</td>
<td>28-35</td>
</tr>
</tbody>
</table>

Total Tonnes of Cu & Zn per year ~ 300

Fairview Pit from the Air
Jane Pit Waste Dump and Open Adit (glory hole)
Expected Permit Levels for the Treatment Plant

<table>
<thead>
<tr>
<th>Element</th>
<th>Dissolved (mg/L)</th>
<th>Total (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>0.20</td>
<td>0.50</td>
</tr>
<tr>
<td>Cd</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Cu</td>
<td>0.05</td>
<td>0.20</td>
</tr>
<tr>
<td>Fe</td>
<td>0.01</td>
<td>0.50</td>
</tr>
<tr>
<td>Pb</td>
<td>0.05</td>
<td>0.20</td>
</tr>
<tr>
<td>Mn</td>
<td>0.20</td>
<td>1.00</td>
</tr>
<tr>
<td>Ni</td>
<td>0.20</td>
<td>0.50</td>
</tr>
<tr>
<td>Zn</td>
<td>0.15</td>
<td>0.30</td>
</tr>
</tbody>
</table>

* based on 1999 permit issued to CBEL

4100 Level Discharge Pipeline
Existing Tunnel Plug

- located in the 4100 level adit
- required to throttle and control flow to a future treatment plant

Details of our Agreement with CBEL

- Hand-shake agreement in October 2000
- Negotiations over the past year focused on
  - Indemnity agreement for UBC provided by CBEL
  - CBEL assuming ownership of the plug
  - Shared costs (96,400 from UBC/$73,500 from CBEL)
  - Leasing arrangement for 5-year duration
- CBEL was purchased by Alex Tsakumis in July
- UBC demanded an indemnity from the BC Government
- TSS contracted by CBEL to build the two plugs
- CBEL obtained a permit from MEM in August, 2001
- Construction commenced October 5th, 2001
Jane Creek after confluence with 2200 Level Discharge
Corrosion and Failure of Steel Sets in 2100 Adit
Corrosion of Concrete by ARD at Britannia Mine

Project Supervisor - Rimas Pakalnis
Doctoral Candidate - Brennan Lang

Effluent Channel before Jane Creek
Effluent leaving the 2200 level Portal

Effluent Channel circa 1990
Inside the 2200 level portal

Installing Grout Tubes
Installing Grout Tubes

Installation of the UBC Soil-Testing Laboratory in the 2200 Level Portal at Britannia Mine
Construction Schedule

- Oct 5th – Project Began
- Nov. 5th – Water flow under control
- Nov. 15th – Coffer Dam installed, grout holes drilled
- Dec 5th – Concrete Plug poured – actual date = Dec 17th
- Jan 3rd – Effluent flow stopped – actual date = Dec 31st
- Feb 3rd – Commencement of Millennium Plug construction

Britannia Mine

[Map showing mining levels and areas]
Ministry of Water, Land & Air Protection Reclamation Project

- 3 RFPs have been let so far
  - Hydrology and hydrogeology
  - Contaminated Sites analysis
  - Water treatment plant

- 4100 Level Plug test to be done in mid-December

- Tracer studies of water flows from the Open Pits in December and January

- CERM3/CBEL are working in cooperation with the contractors

- Treatment plant is planned for start-up in 2003

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Working with the Community for Sustainability
Britannia Beach Mining Museum
- opportunities for collaboration with CERM3

The mill is the largest heritage building in British Columbia

But what to do with it –
- a very difficult question!!

One idea – create an amphitheatre for concerts and plays

Imagine – the Annual Britannia Beach Oberammer-gau

Wagner on the Sound!
Britannia Beach Mining Museum
- opportunities for collaboration with CERM3

CERM3 is assisting the Mining Museum to develop ARD exhibits in exchange for space for a research station

Elements of the Reclamation Efforts Required

- 2200 level effluent diversion
- Pit waters diversion (where to, if possible?)
- Treatment plant at 4100 level
- Ground water recovery and treatment
- Sealing dumps and pit walls
- Diversion ditches
- Revegetation of all dumps
- Development plans for the community
- Reclamation around museum property
- Introducing fish into Britannia Creek
- Flood control in the fan area
- Plans for the mill building
CERM3 Projects

Project 7:
Immobilizing Heavy Metals in Lime Sludge by Developing Acid-Resistant Ceramic Materials for Long-Term Storage

Researchers: John Meech, George Oprea, Bern Klein Tom Troczynski, Bill Cullen, N. Banthia

Sponsors: NSERC, Tilbury Cement, C2C Mining, Clayburn Industries, Target Products, Hatch Engineering, Levelton Engineering, Cominco, Copper Beach Estates Limited

Estimated Budget: $425,000 over 3 years

Workshop Symposium at the CIM-AGM

Research Needs and Opportunities in Mining and the Environment

Saturday, April 27th, 2001 and Sunday, April 28th, 2001

Organizers:

John A. Meech, Professor and Director, CERM3
Gilles Tremblay, MEND-2000 Program, NRCan
ARD comes in many colours – let’s work to make it colourless

The Centre for Environmental Research in Minerals, Metals and Materials

- providing sustainable research for the Mining industry…..