Britannia Mine - 4100 Level Plug Test
A Mine Hydrology Investigation

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Britannia Mine 4100 Level Plug Test

- The mine remediation project focuses on reduction of AMD from an abandoned op/ug Cu mine located adjacent to a major fishery.
- The test was commissioned to provide data for the design of a suitable water treatment plan.
- KC/SRK measured AMD storage volume in the sealed underground mine using pressure and flow data obtained only at the tunnel plug.

A network of open pits collects rain and snow, funneling water into the mine.

Courtesy Natural Resources Canada / GSC
Mine Inflow - Jane Basin Glory Holes

- Diversion has been hampered by large scree slopes and mine inflows from multiple drainages. Capping would require enormous volumes of fill.
- Plugging of the caved openings from underground would be difficult due to lack of access, poor records and the large number of potential openings.
- Exposed rock and waste is acid generating.
This “V” notch weir was built to remotely monitor flows into Jane glory hole. The weir may also be used as an intake for a future diversion.
The weir is located on the only area of exposed intact bedrock in the creek. The flow gauging instrumentation is equipped with a solar powered radio link.
Looking Northeast
Showing Volume of Mine
Filled by Plug Test

Britannia Mine Cutaway

Mineral Creek
Britannia Creek
Bluff
2200 L
Victoria Shaft

Britannia Mine
#10 Shaft
Flooded Mine Workings
at Maximum Water Level

Current Water Level
(perpetually filled workings)

Mining Workings
Above Maximum
Flooding Level

Reservoir would
overflow at 3250 Level

4100 Portal
4100 Plug
4100 L
2700 L
2200 L

Howe Sound
Britannia Beach
Underground Installations - 400m into Tunnel. Energy Dissipator, Stainless Valves and Pipes.

- Piping must withstand 300 p.s.i., Flows >700 l/s and pH 3.1 mine waters with high iron content and entrained pebbles.
- Valve Opening, Flow, Pressure and Geotech Sensors are remotely monitored and controlled on line.
4100 Plug Data Logger Station and Instrument Readouts

Instruments include: Pressure and Displacement Transducers, Magnetic Flowmeters, Drainage level sensor and Turbidity. Logger also controls valve automatically.
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Remote Monitoring and Control

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Mine Water Discharging into Tunnel at Plug

• Mine Water Discharge reaches 500 litres/sec or more during freshet.
• Noise is a serious problem in the tunnel.
• Acidic copper/zinc laden mist is harmful to lung and eye tissue.
• Typical Power Dissipated during the Freshet is:
  360 hp = 0.25 Mwatt
Britannia Mine Outflows

- Long-term average outflow from mine = 5.4 million m³ per year (170 L/s or 2700 USgpm)
- The 2200 adit was sealed with a concrete plug in December 2001.
The subdued nature of the mine's outflow record is illustrated by the mine's response to a rain storm that occurred in late July. The resulting peak outflow from the mine occurred 5 to 6 days after the peak was reached in a local, high-elevation stream.
Diversion of Surface Water Into Mine Workings

- Total drainage area of enclosed catchments = 1.57 km²
- Estimated average annual yield of catchments = 2.6 m
- Estimated volume of water diverted into u/g via subsidence zones = 4 million m³/y, or 75% of the mine’s total outflows

New triangular weir
Black Box Experiment

- **Challenge**: estimate storage in mine workings from 0 to 250 m above 4100 concrete plug
- **Method**: exploit existing plug to fill mine with water
- **Governing equation**: $I - O = \Delta S$
- **To apply equation**, a method was sought to make estimates of inflow to the mine
Illustration of Continuity Equation

\[ \text{Inflow} - \text{Outflow} = \frac{\Delta H}{\Delta t} \cdot A \]
Pressure at 4100 Concrete Plug

Start 1st Plug Test on March 26

Begin holding pattern

End 1st Plug Test

Partial drain down to facilitate pipe repairs

Start second filling phase

Start final filling phase

Mine filled to 250 m level on August 13

Water level drawn to dead storage on October 3
Inflow Test: Continuity Equation Applied Twice

First Period (Plug Outflow = 0)
\[ \frac{dH}{dt} = 4.29 \text{ m/d} \]
\[ I = 4.29 \text{ A} \]

Solution:
\[ I = 80 \text{ L/s} \]
\[ A = 1610 \text{ m}^2 \]

Second Period (Plug Outflow = 98 L/s)
\[ \frac{dH}{dt} = -0.99 \text{ m/d} \]
\[ I - 98 = -0.99 \text{ A} \]
\[ I = 80 \text{ L/s} \]
\[ A = 1610 \text{ m}^2 \]
Inflow Test: Pressure Balance

Pressure at plug maintained at a near constant level for 24 hours.

\[ I = O = 101 \text{ L/s.} \]
Evidence of Internal Pervious Blockage

April 19, 2002 Mine Inflow Test

- Inflow test initiated at 14:54 PST. Initial water level = 77.3 m, Initial outflow rate = 104 L/s
- An apparent steady state was reached at 16:53 PST. Initial water level = 68.6 m, Initial outflow rate = 97 L/s
- Valve opened further at 17:23 PST. Initial water level = 68.6 m, Initial outflow rate = 209 L/s
- Valve completely shut off at 18:32 PST. A total of 1760 m$^3$ of water was released during test. Water level = 61.3 m, Outflow rate = 198 L/s
- At about 1:30 PST, the water level recovered to same level as observed at initiation of inflow test (i.e., about 10.5 hours after valve initially opened).
At the start of the drain down, the pressure in the mine was probably near uniform from the western end of the mine reservoir (at the plug) to the eastern end. Throughout the duration of the inflow test, the water level at the eastern end probably remained near the 77.3 m level.

To pass a flow of 97 L/s through the mine, a head differential of about 8.7 m is required from the eastern end of the mine reservoir to the western end.

These data suggest that the flow in the mine varies linearly with head. In other words, the flow doubles if the head differential doubles.

To pass a flow of about 190 L/s through the mine, the head differential would have to increase to about 17 m.

Estimated draw down profile if releases from mine were allowed to continue until a quasi-steady state was reached.
Simple Hydraulic Model

\[ O_2 = \text{measured discharge} \]
\[ O_1 = C (H_1 - H_2) \]
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