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ARD Seepage Gradient Control and Collection System at Island Copper Mine - South Waste Rock Dump, British Columbia

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CONSULTING ENGINEERS AND SCIENTISTS

Edmonton • Calgary • Vancouver • Nanaimo • Kelowna • Inuvik

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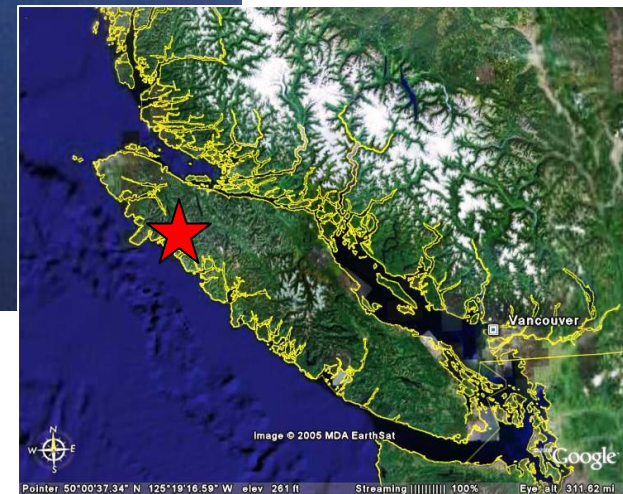


Island Copper Mine Site - Location

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**South Waste
Rock Dump
and Lagoon**



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Project Background

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- Mine site owned by BHP Billiton
ICM is managed by the BHP Billiton Base Metals group out of Tucson, Az. Ben Wichers is the Manager.
- Mine closed in 1995
- Rescan Environmental doing ongoing monitoring and reclamation project management since 1995
- EBA retained to complete engineering design for South Dump seepage collection system
- BHP Billiton committed to reclaiming the site and protection of the environment



Site Photo

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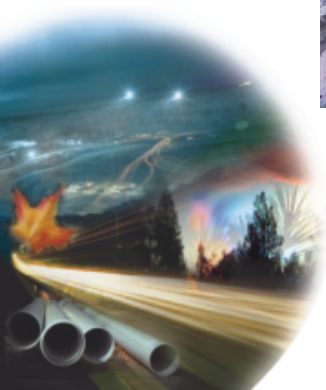
South Dump – Temporary Sump and Pump

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Temporary sump and pump system to collect seepage installed in 2001

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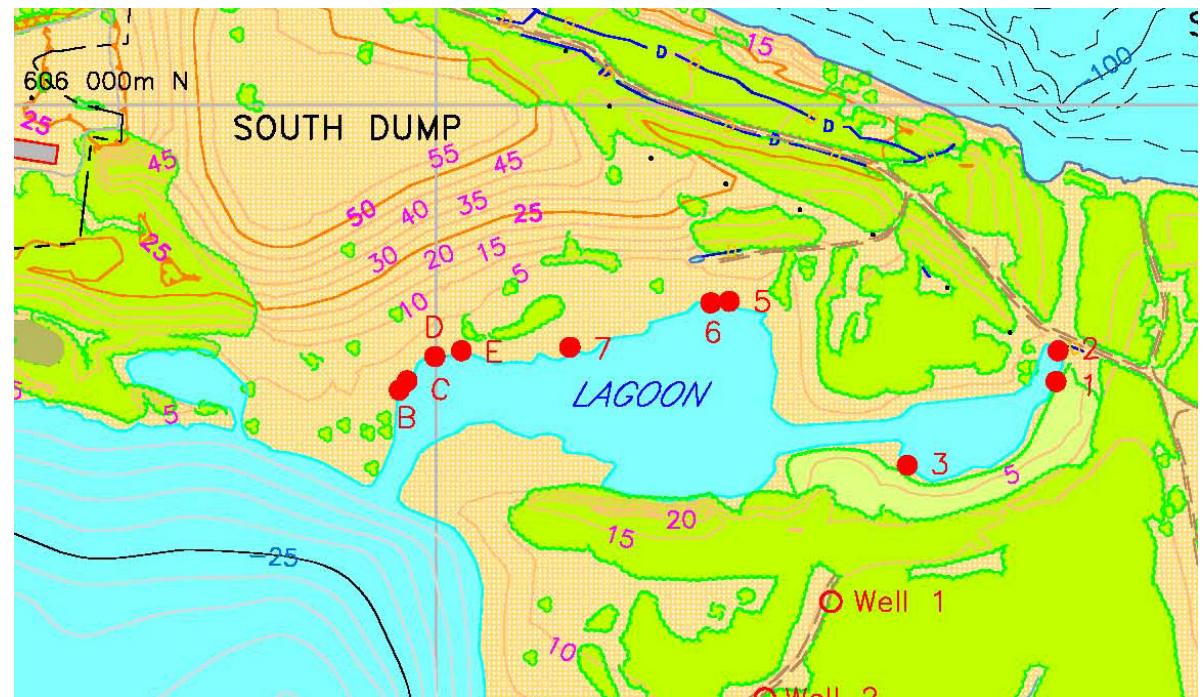


Seepage Monitoring

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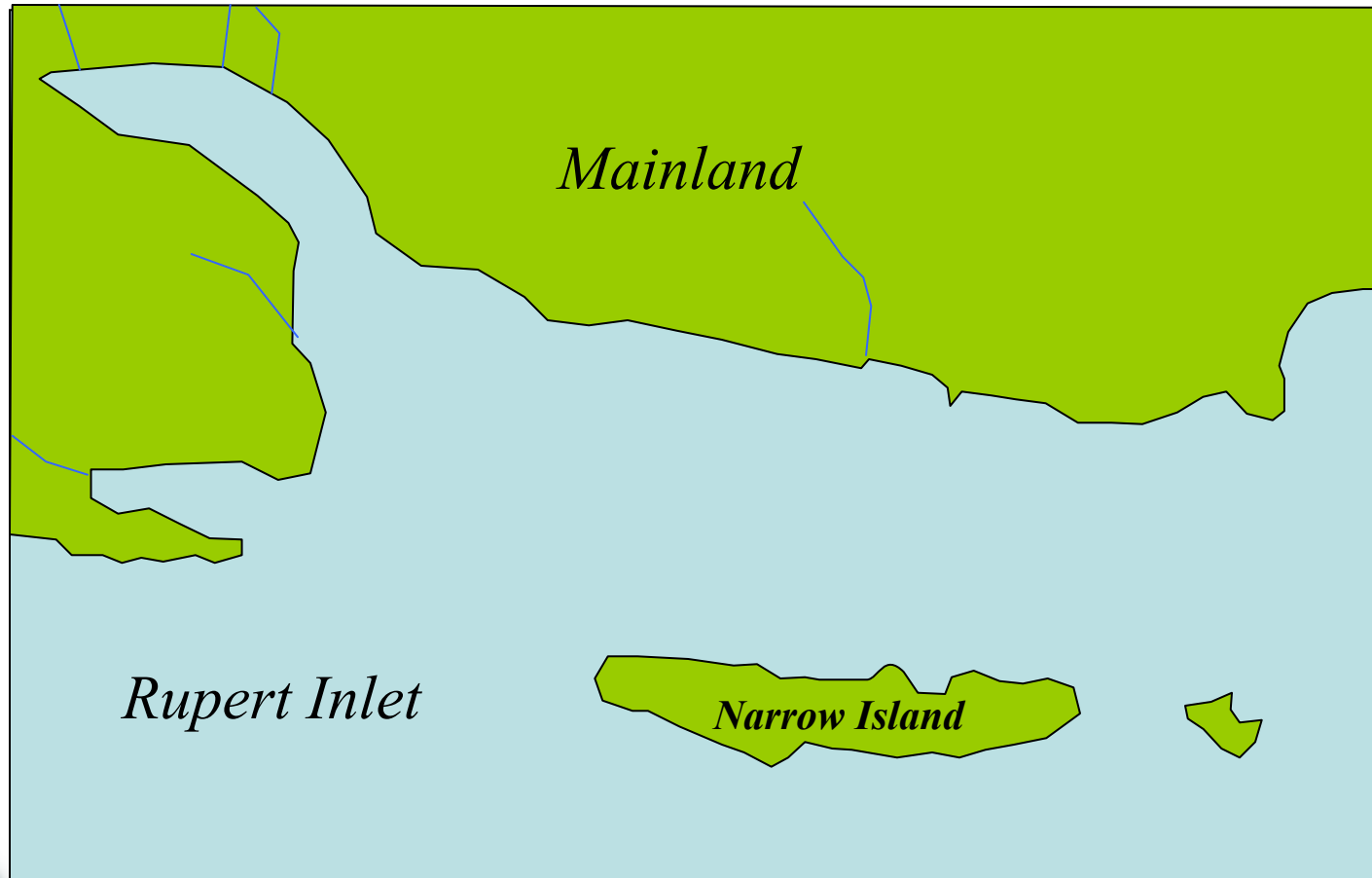
Seepage Monitoring carried out along foreshore of lagoon. Metals of concern were identified as:

- Cadmium
- Zinc
- Copper



Anthropogenic Evolution of Site

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1. Site pre-mining

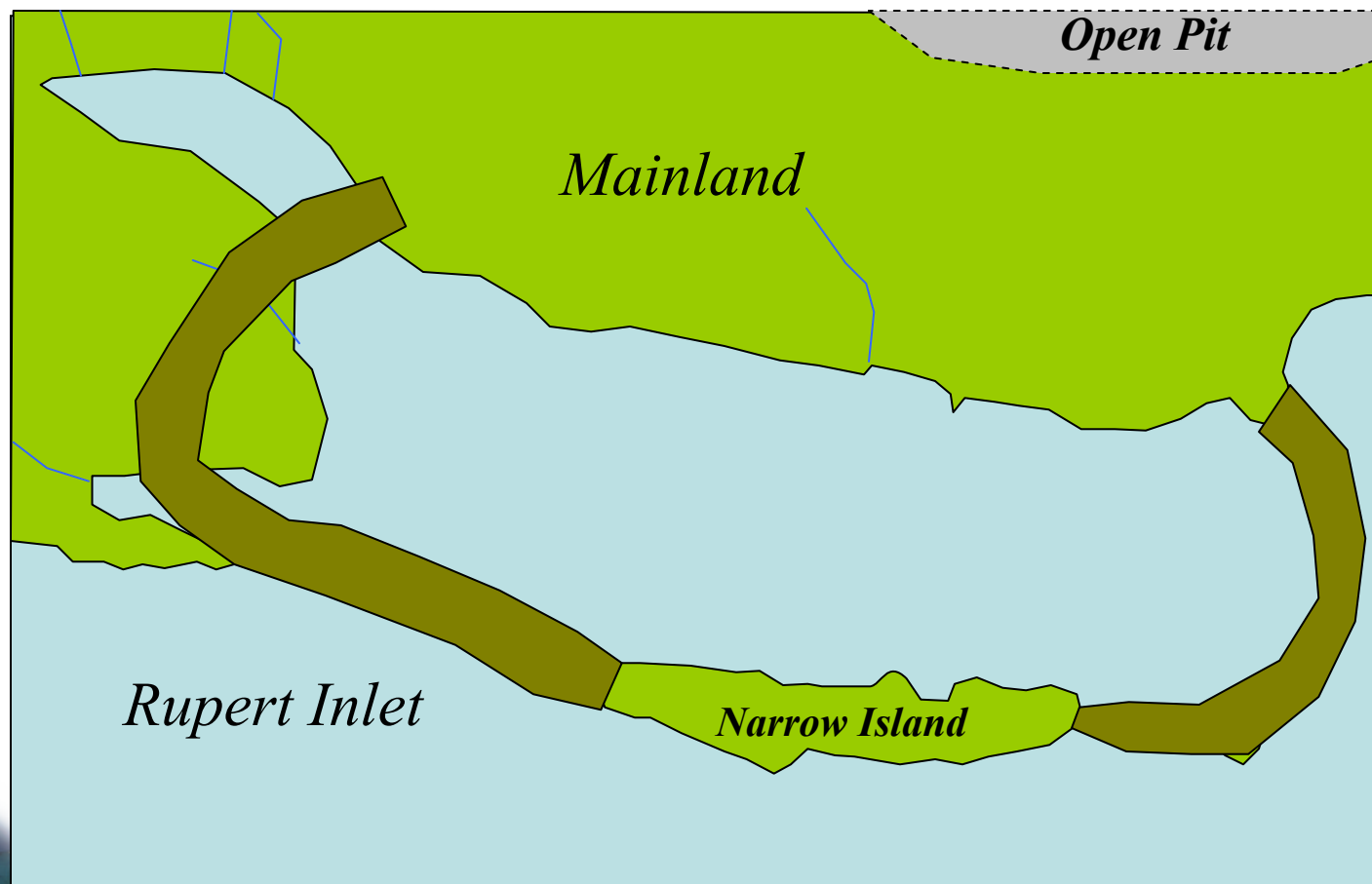


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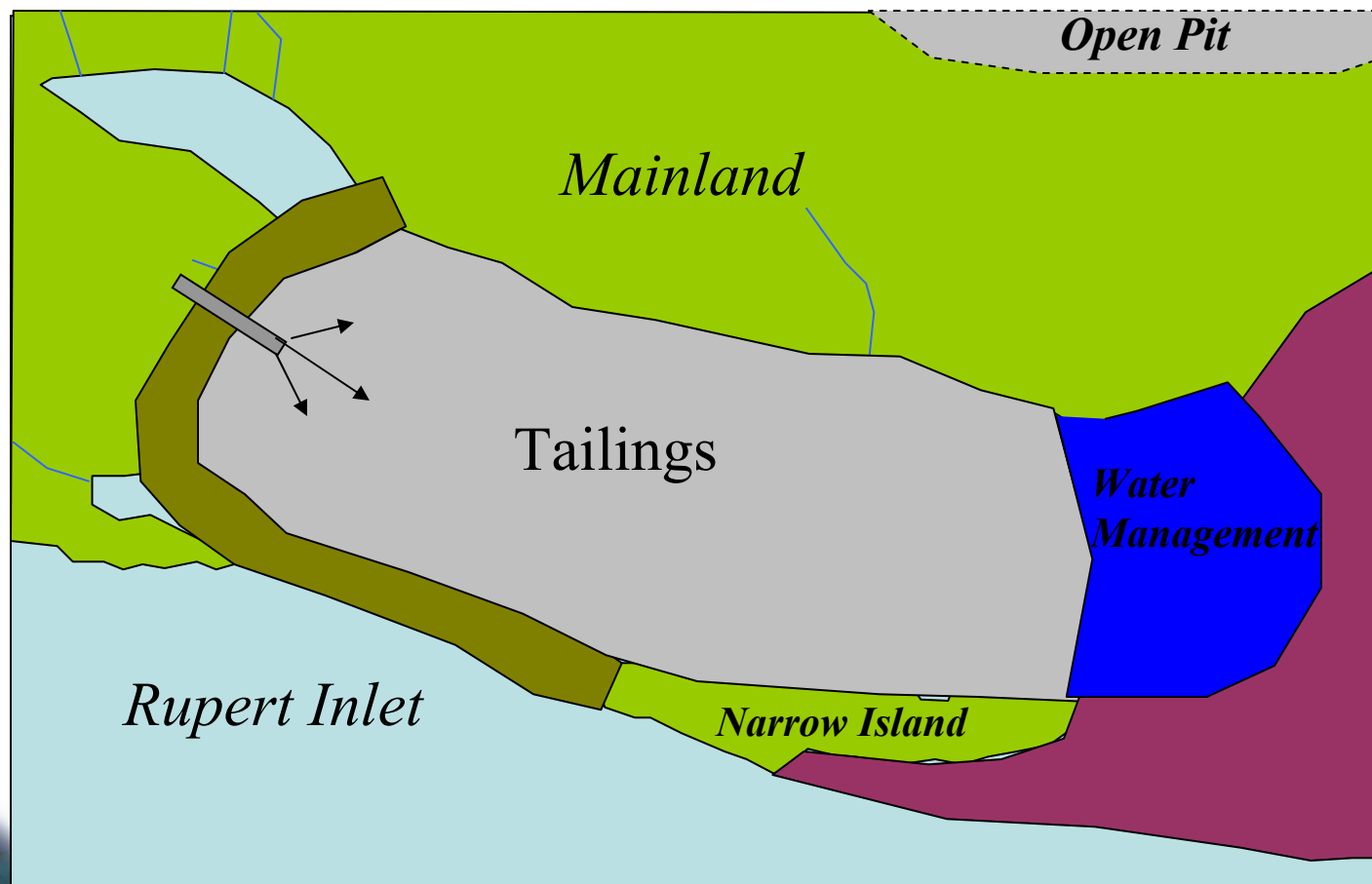
2. Construction of emergency tailings impoundment

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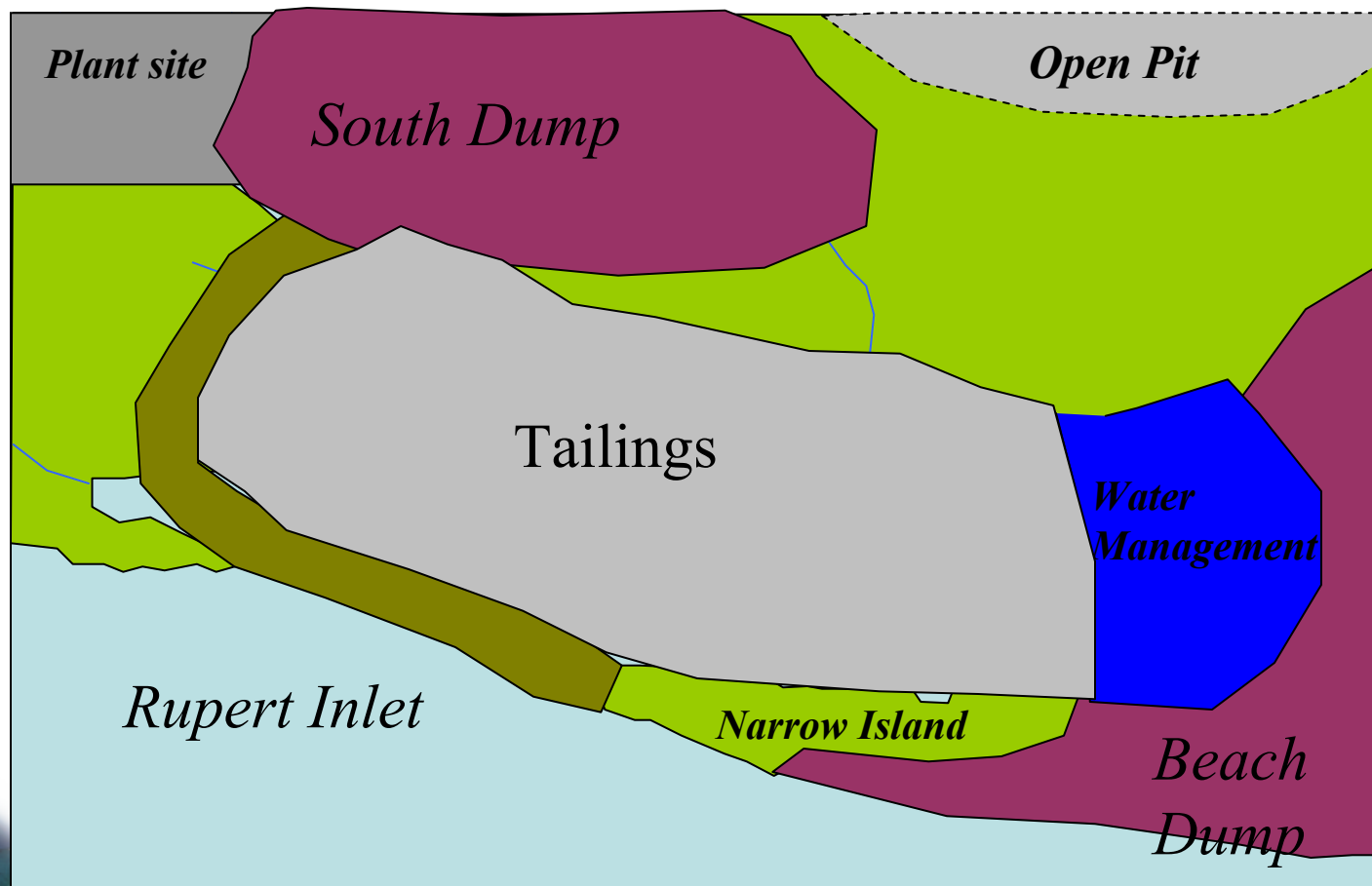
3. Tailings deposition

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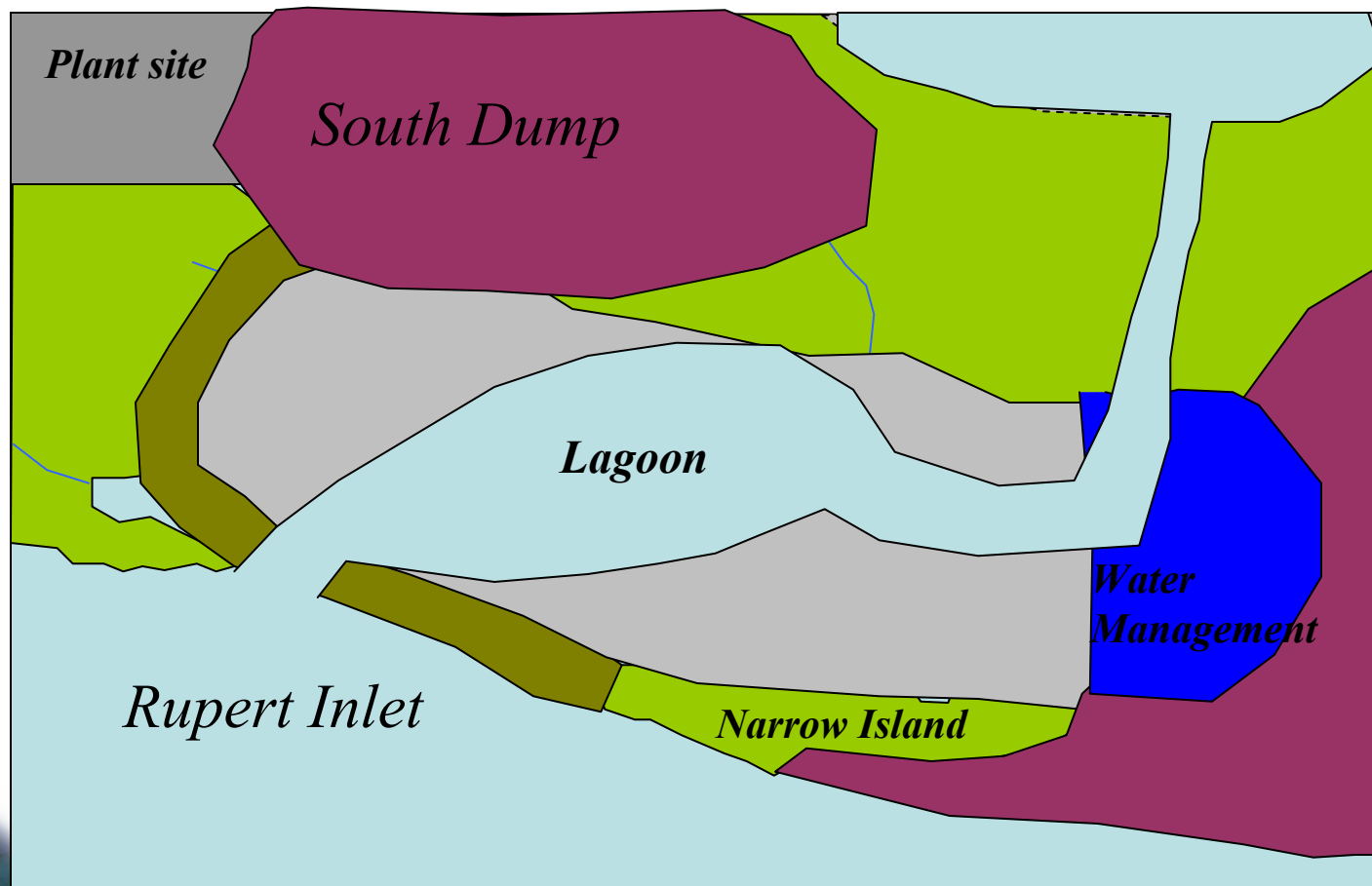
4. Waste Dump Deposition

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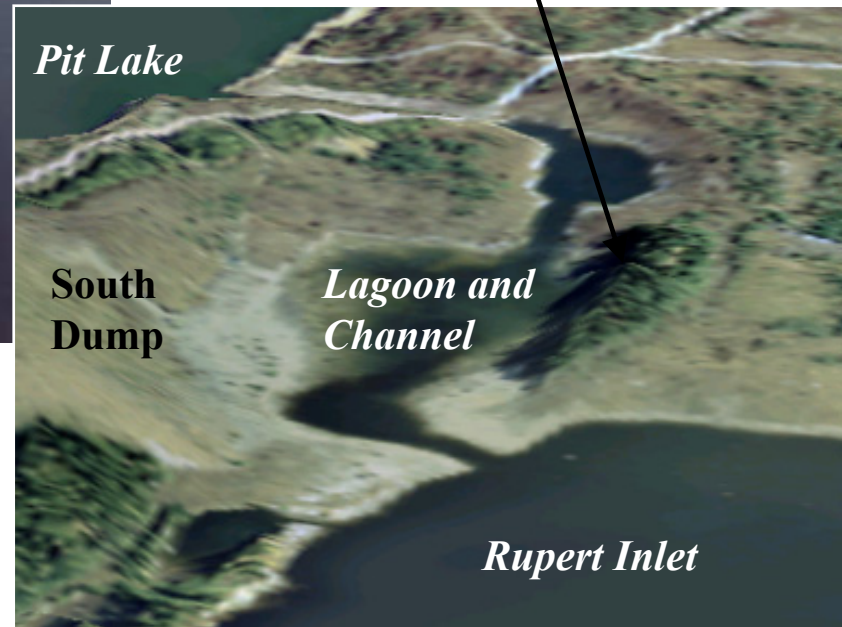
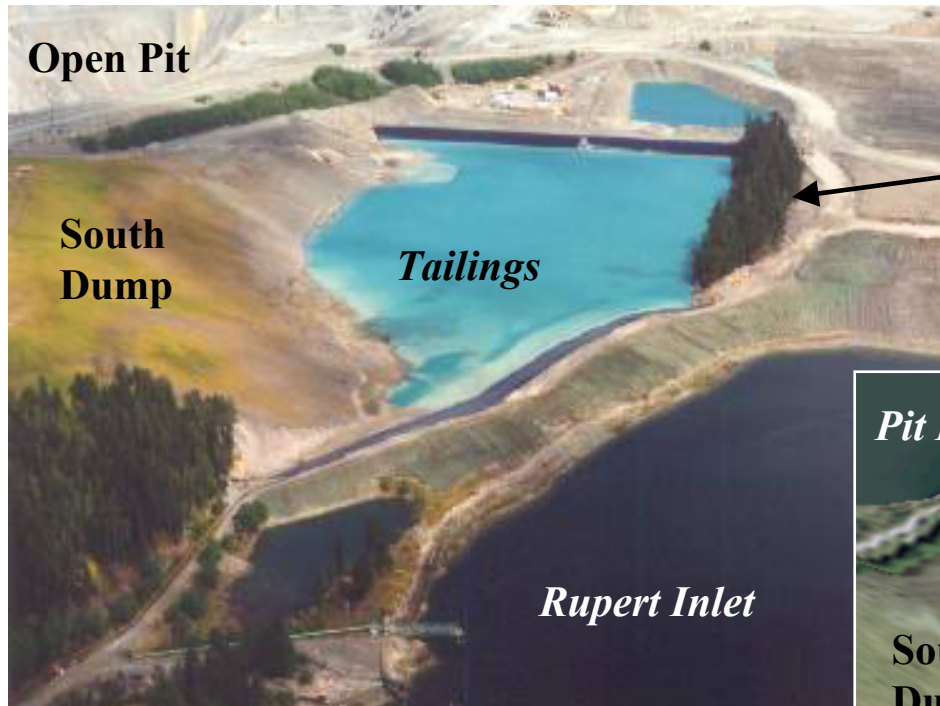
5. End of Mining, Flooding of Open Pit

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Emergency Tailings Pond and Today's Flood Channel

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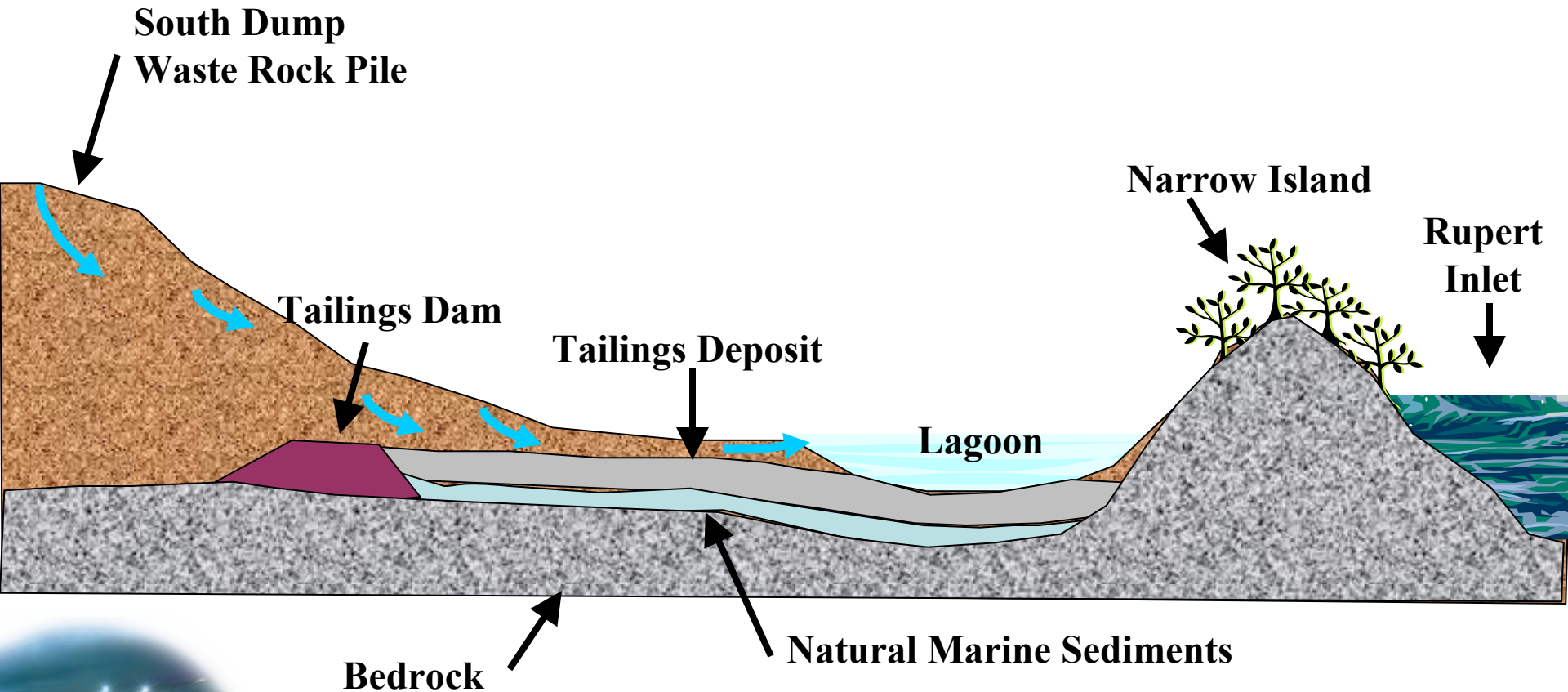


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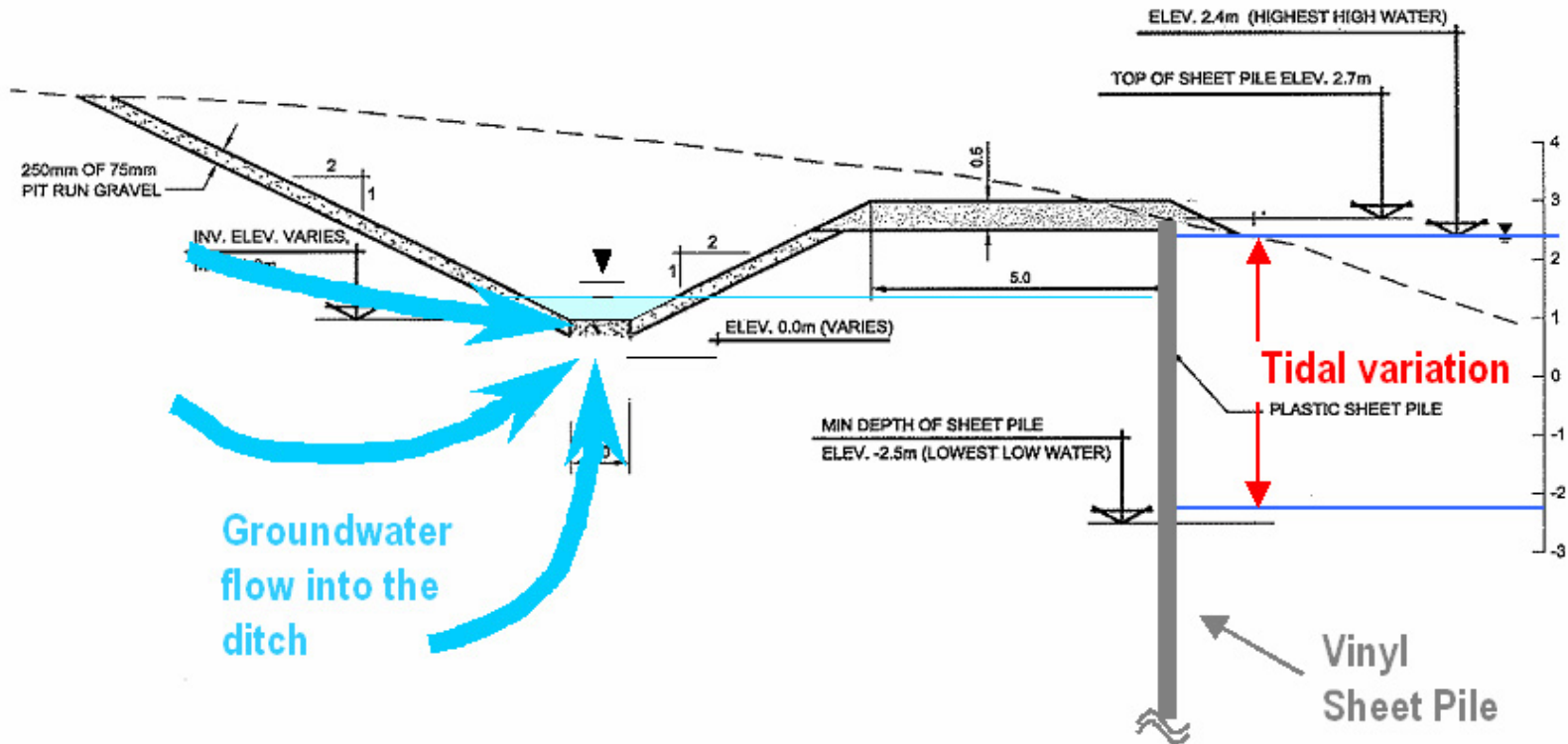
Problem Definition – Seepage Pathways

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Seepage Collection System - Concept

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$$Q = KiA$$

Flow = Permeability x Gradient x Flow Area

Pre-Construction Investigations

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Pre-Construction Investigations

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Site Investigation Findings

- Mixed tailings and waste rock are PAG
- Soil and Groundwater samples slightly alkaline (pH 7.1 – 8.2) due to high buffering potential
- Tailing have low shear strength.

Depth	Stratigraphy	Hydraulic Conductivity (m/s)	% of Total Flow	Water Quality	Metals Flux
Shallow (intertidal)	Mixed waste rock and tailings	1×10^{-4}	80%	Poor	~95%
Moderate (sub-tidal)	Tailings	1×10^{-6}	10%	Moderate	$\leq 5\%$
Deep	Underlying marine sediments	1×10^{-5}	10%	Good	$\leq 5\%$

Location: (As close to high tide line as possible)

- Maximize containment of PAG.
- Minimize excavation volume.
- Minimize geotechnical risk associated with deep excavation at the toe of the South Dump.

Depth: (Cut-off Wall up to 10 m below grade)

- Minimum 1 m into low permeability tailings (up to 6 m below MSL)
- Minimum depth of 2.5 m below MSL (low tide elevation).

Length: (470 m +/-)

- Tie into bedrock at both ends.



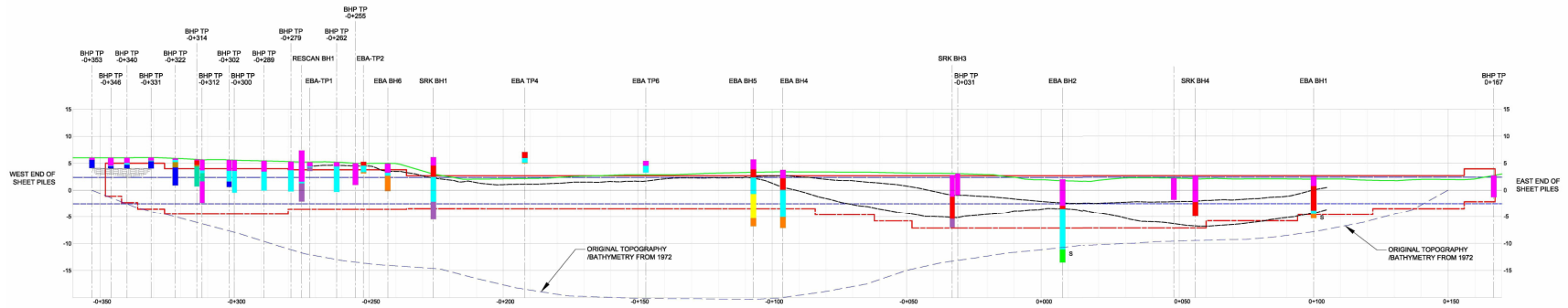
Age Group	Percentage
18-24	10%
25-34	20%
35-44	25%
45-54	20%
55-64	15%
65-74	10%
75-84	5%
85+	5%



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Seepage Collection System – Cut Off Wall Profile

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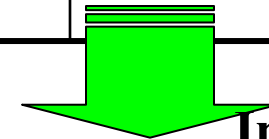
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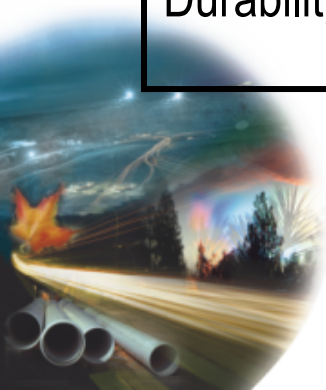
Cut Off Wall Alternatives

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Issues	Plastic Concrete Slurry Wall	Steel Sheet Pile	Plastic Sheet Pile
Cost (est.)	\$ 3.0 M !	\$ 1.6 M	\$ 1.2 M
Permeability	Low	Moderate (Low if joints are sealed)	Moderate (Low if joints are sealed) ?
Construction Risks	<ul style="list-style-type: none"> •Dump stability. ! •Release of bentonite/cement to environment. ! •Excavation of boulders. 	•Refusal on boulders (moderate risk).	•Refusal on boulders (high risk). !
Durability	High.	Poor (potential corrosion). !	Moderate



Further Investigation



Construction Team

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- Port Hardy Bulldozing – Prime Contractors/Site Safety
- Wolf CWC Distributors (Wayne Wolf - now Wolf Remediation) - Vinyl Cut Off Wall
- Stabcat Inc. - Mandrel Supply and Operation
- Ruskin Pile Driving - Crane and Vibratory Hammer
- BHP Billiton – Project Management
- EBA - Construction site inspection/engineering
- Rescan – Environmental monitoring during construction and long term



Construction Phase Components

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- Access road upgrades
- Environmental Protection Measures
- Vinyl Cut Off Wall Installation
- Seepage Collection Ditch
- Temporary Pump system to direct flow to Pit Lake
- Monitoring
- Design of Permanent Pump System



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Cut off Wall Construction - Mandrel

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Cut off Wall Construction – Alignment Guide

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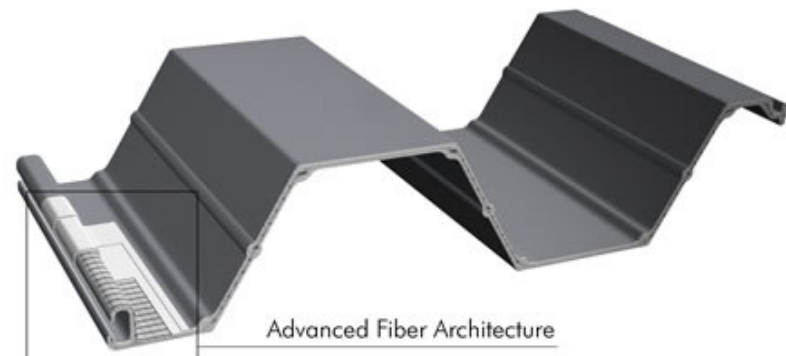


Cut off Wall Construction – Seal Detail

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- “C” with Adeka String Driven over “T” (already in place).



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Cut off Wall Construction - Widget

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Cut off Wall Construction - Production

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Cut off Wall Construction - Starter Trench

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Cut off Wall Construction – Completed Installation

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Shoreline Regrading

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Seepage Collection Ditch - Construction

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Seepage Collection Ditch - Construction

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Seepage Collection Ditch - Sump and Pumps

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Ditch and Cut Off Wall Performance at High Tide

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South Dump Site - After

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Construction Statistics

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Start Date:	July 25, 2005
Functional Completion:	October 21, 2005
Total number of piles:	822
Sheet Pile Area:	3,500 m ²
Average # of piles installed per day:	23
Excavation Volume for ditch:	~10,000 m ³



Post Construction – Environmental Monitoring

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Monitoring completed by Rescan Environmental.

Water Samples:

- Daily August 17th to September 5th 2006.
- Weekly Sept 11th , 2006 to June 2007.
- Bi-weekly since June 2007.

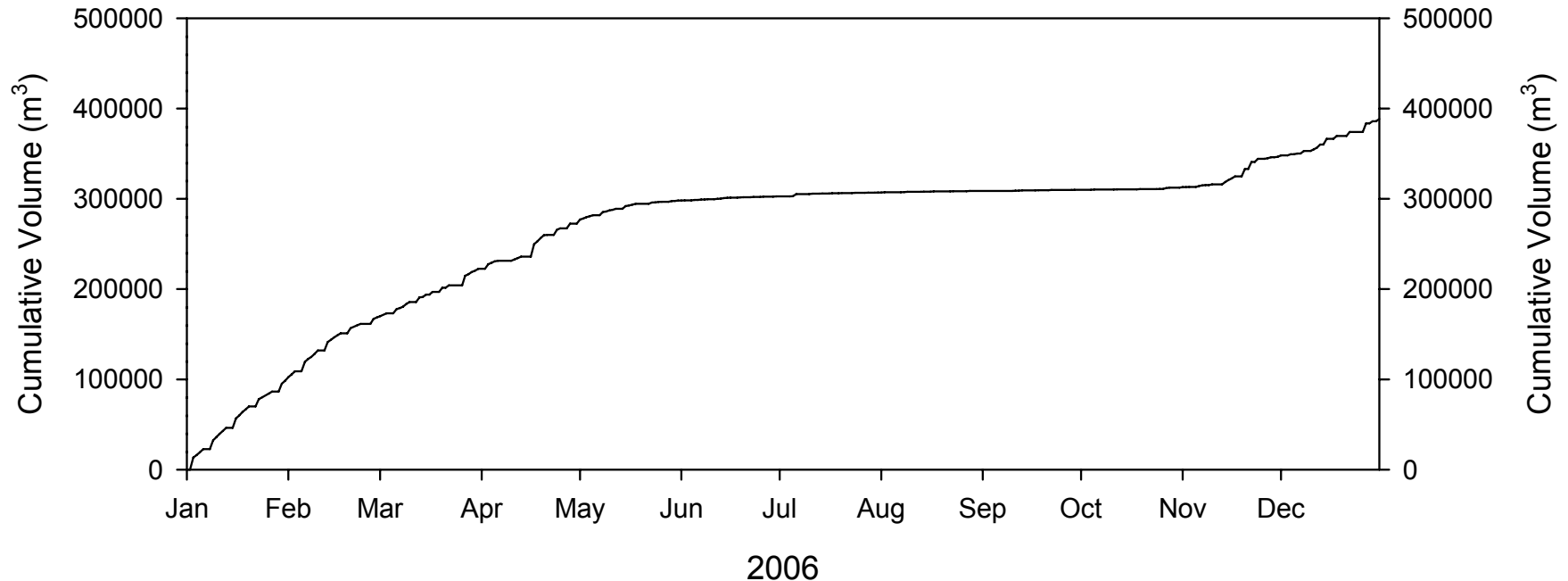
Flow Rates:

- Daily (cumulative flow meter).



Seepage Collection System - Pumping

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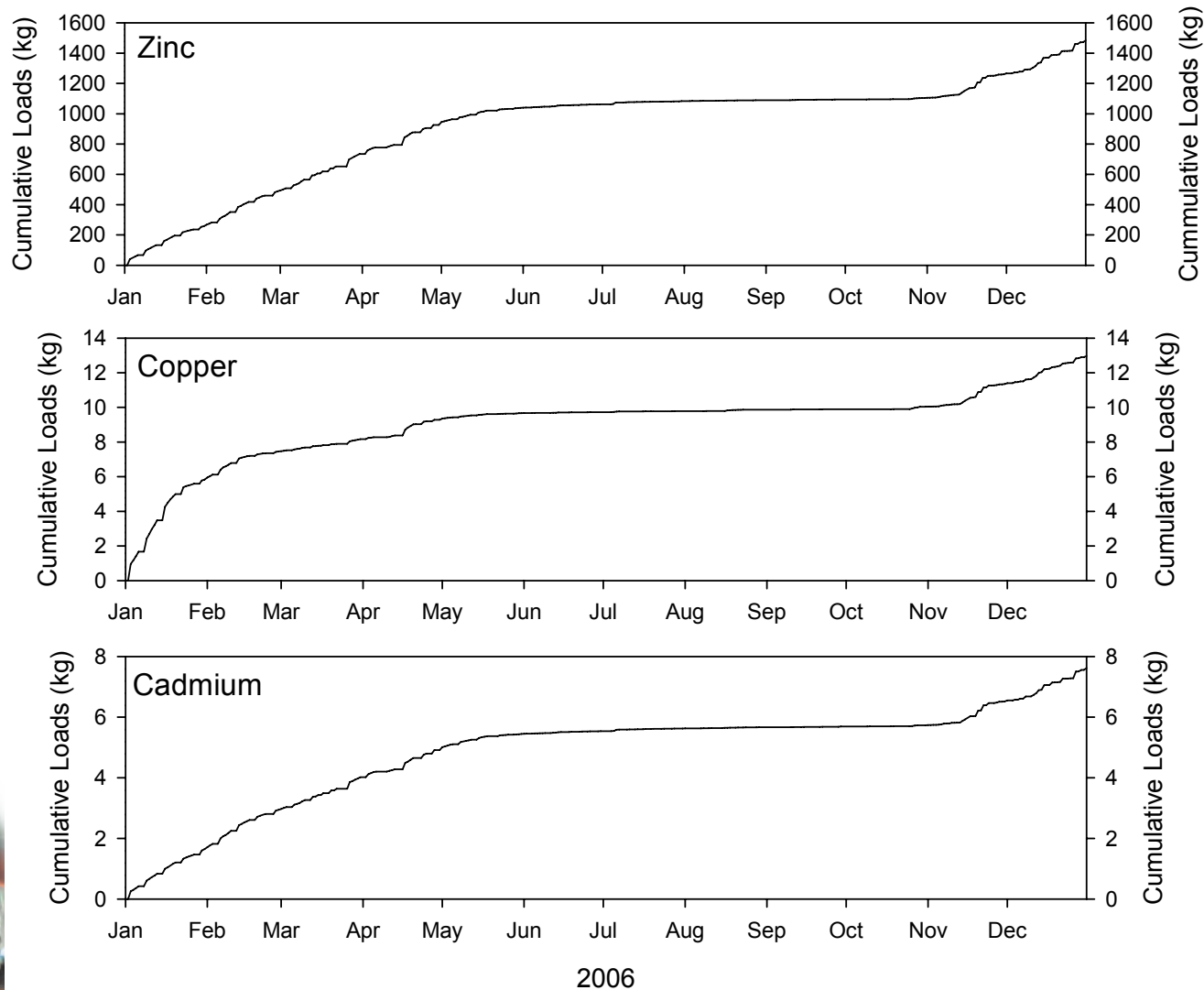


- Average Annual Inflow = 740 litres/minute
- January Average Inflow = 2,200 litres/minute
- Salinity: 1.0 to 1.5 psu (vs. 35 psu for typical seawater)



Metal Loads Diverted to Pit Lake

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Seepage Collection System Monitoring

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- System inspected three times per week.
- Telemetry monitoring for power failure
- Telemetry monitoring for high ditch water levels
- Telemetry system failure alarm
- Dual telemetry data monitoring by Port Hardy Bulldozing and Rescan Environmental



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Permanent Pumping System Design – In Progress

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- Design being finalized based on monitoring results
- Power Supply – Grid Power
- Standby genset can be mobilized to site within 20 minutes

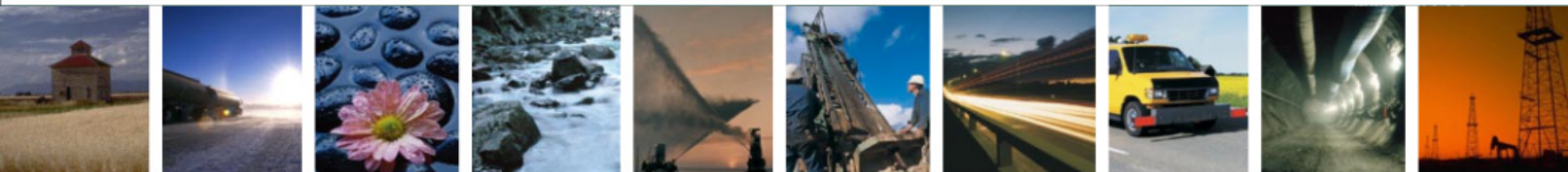


Advancements and Future Applications

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- A pump applied sealant bead (field or factory applied)
- Mandrel system (patented) now used frequently for vinyl sheet pile installations in Canada
- Improved groove cleaning shoe (“Widget”)

Vinyl sheet piles with these advancements have since been used at CVRD Inco Sudbury storm water retention pond, Ontario



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