

D.2. A Chemical and Ecotoxicological Assessment
of the Impact of Marine Tailings Disposal

by

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A Chemical and Ecotoxicological Assessment of the Impact of Marine Tailings Disposal

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Presentation Outline

- Background Project Information
- Project Scope and Progress
 - Chemical Assessment (CANMET)
 - Impact Zone Delineation (DFO and MUN)
 - Ecotoxicological Assessment (DFO)

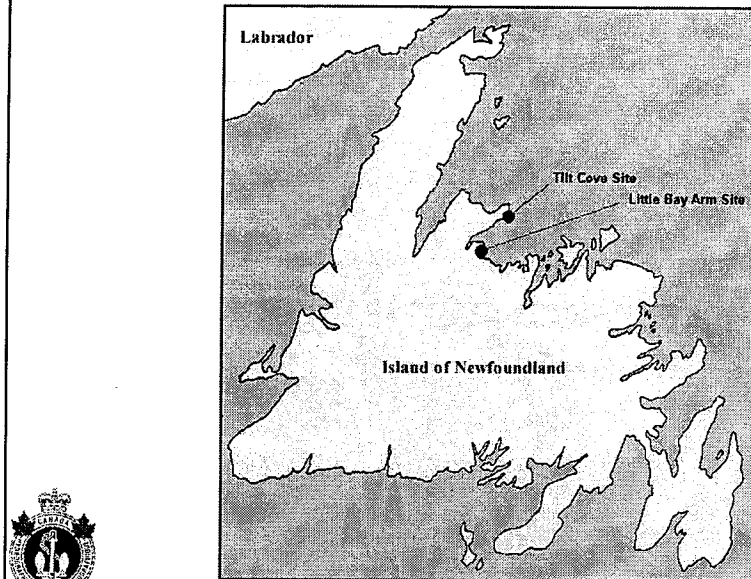
Acknowledgement

- Contributors to the present presentation:
 - M. Blanchette (CANMET, Coordination)
 - J. Kwong (CANMET, Chemical Assessment)
 - J. Payne (DFO, Ecotoxicological Assessment)
 - C. Stirling (DFO, Hydroacoustic Survey)
 - P. Sylvester (MUN, Impact Zone Delineation)
 - G. Veinott (DFO, Impact Zone Assessment)

Project Information

- **Objective:** To assess long-term environmental consequences of submarine tailings disposal by examining the impacts of historic marine tailings discharges off the coast of Newfoundland
- **Research Team:** Scientists from CANMET, DFO and Memorial University (MUN)
- **Steering Committee:** Personnel from NRCan, DFO, HC, EC, Province and MUN
- **Funding:** TSRI and some from INCO

General location sketch of survey sites

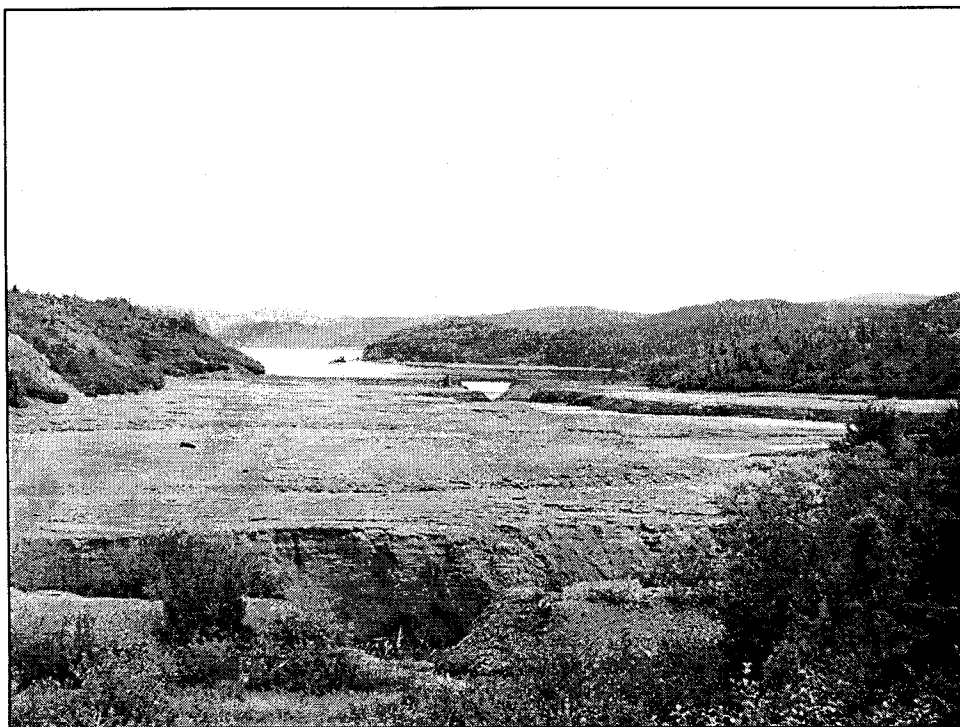


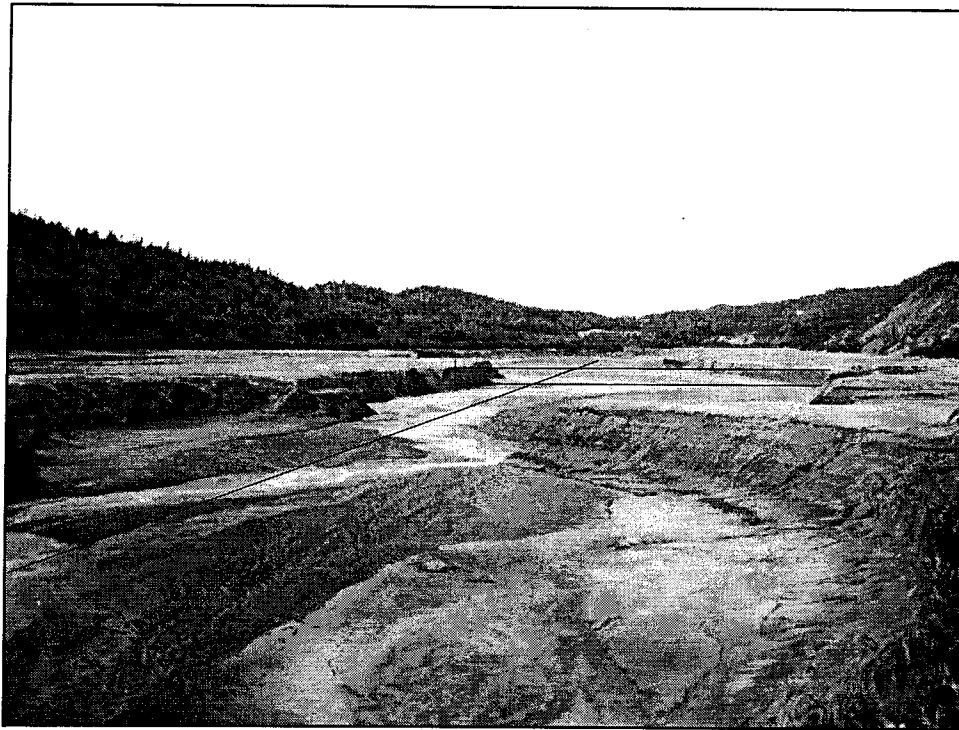
Project Approach and Status

- **Approach:** Integration of physical, chemical, biological and ecotoxicological characteristics of two abandoned mine sites in the Notre Dame Bay area to realistically determine the risks and benefits associated with marine tailings disposal
- **Status:**
 - Project startup: August 1, 1999
 - Field work largely completed Aug. to Oct./99
 - Sample analysis and long-term laboratory test work in progress

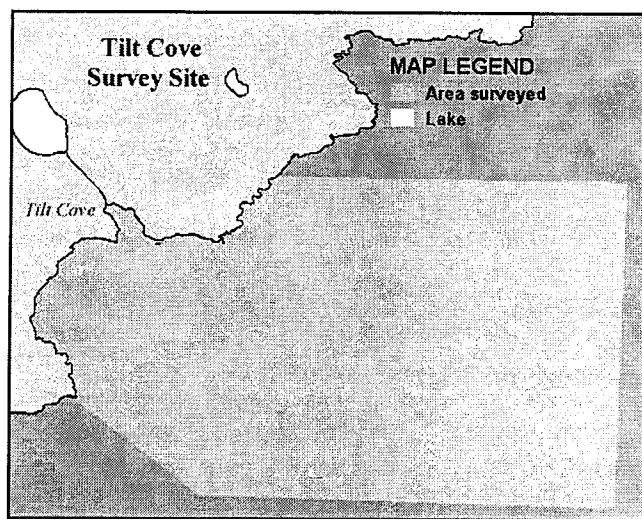
Chemical Assessment: Field-Based Studies

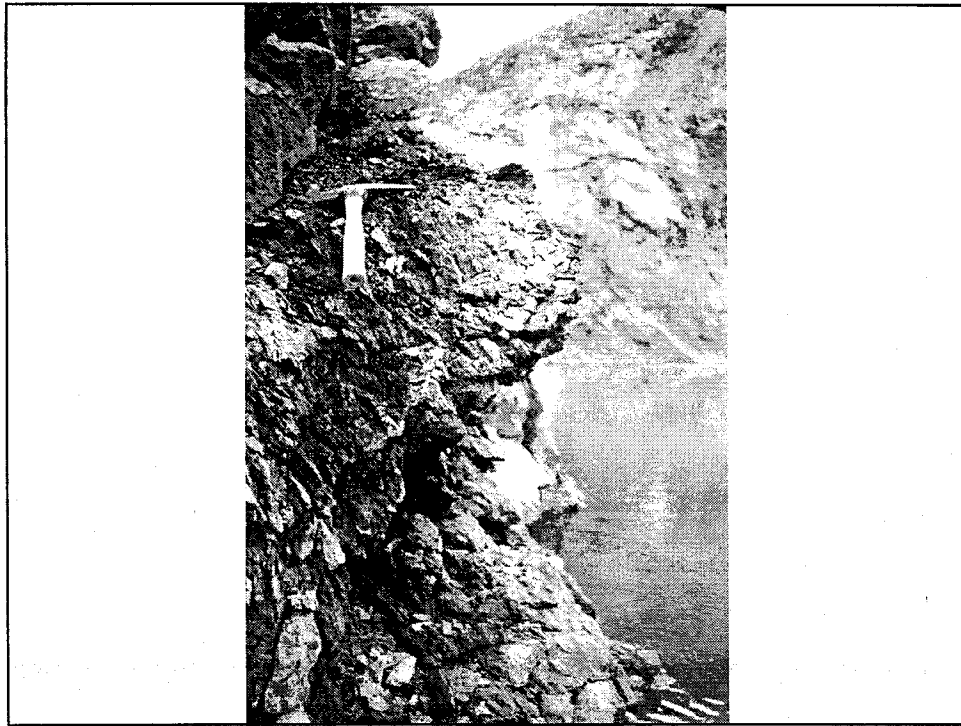
- Reconnaissance Survey
 - understand local geological setting and identify prevalent rock types
 - assess mode and extent of chemical weathering
- Metal Mass Balance at Little Bay
 - channel sampling to determine amount of tailings washed to Little Bay
 - chemical analysis to determine metal loadings

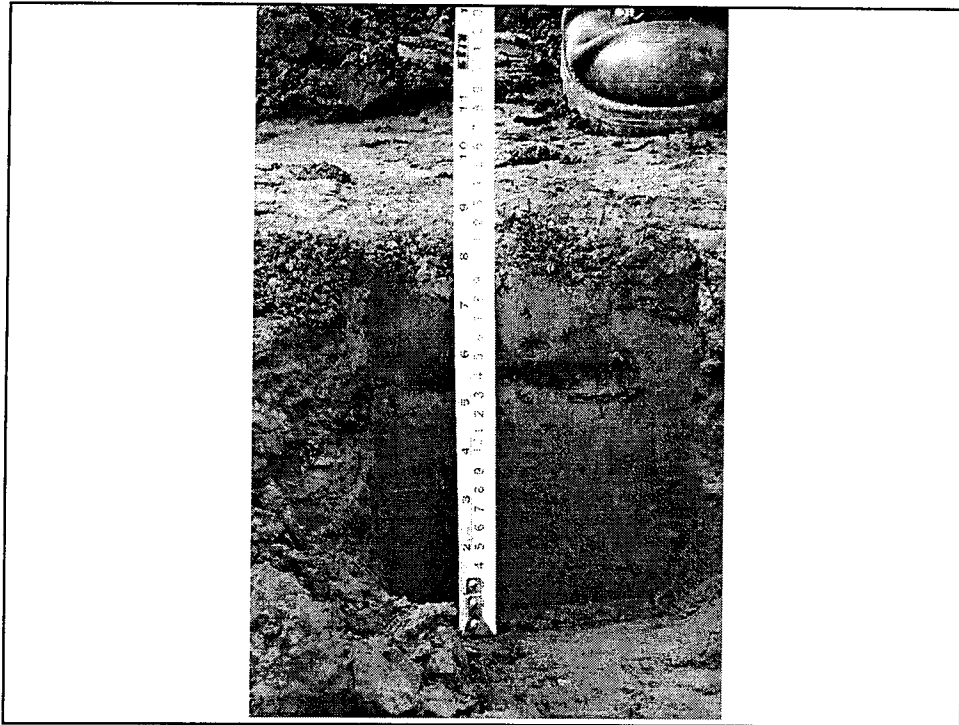




Limits of Em 3000 Multibeam Survey at Tilt Cove

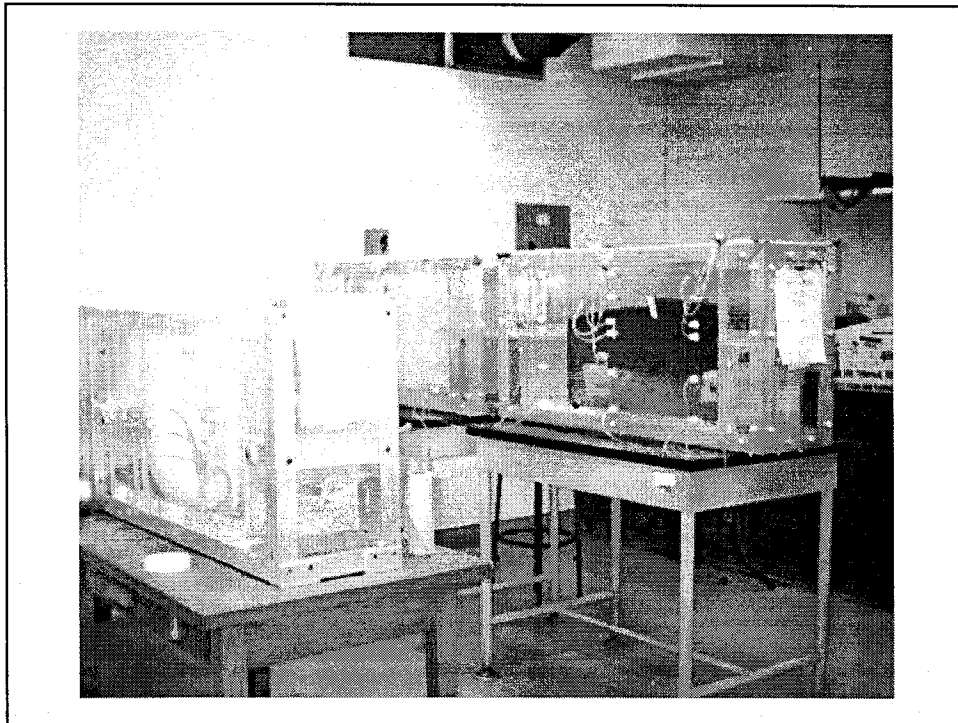




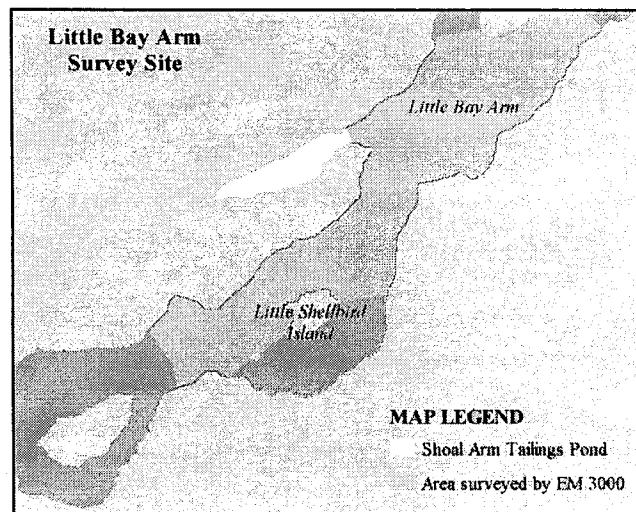


Chemical Assessment: Laboratory Test Work

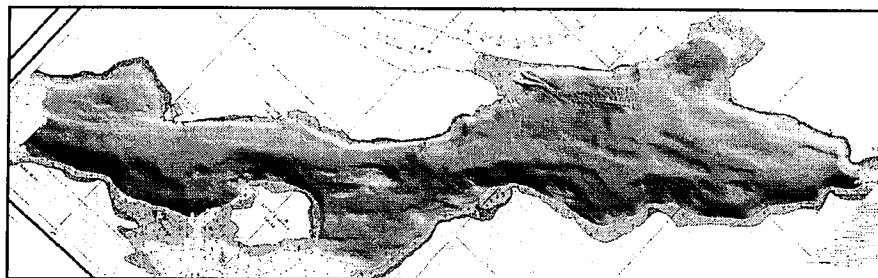
- 18-hr leach test for immediate metal release
- Sequential extraction analysis to determine metal speciation and bioavailability in tailings disposed under various settings
- Investigation of galvanic interaction under a water cover (both fresh and saline)
- 3-yr lysimeter test to compare metal fluxes under a fresh versus a saline water cover



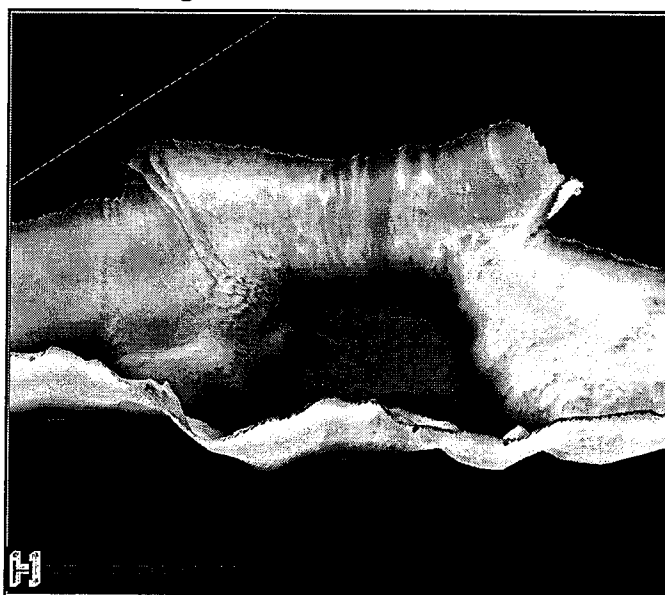
Limits of EM 3000 Multibeam Survey at Little Bay Arm



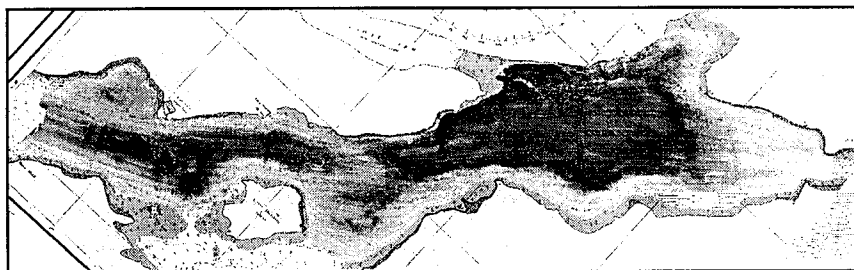
Bathymetry of Little Bay Arm Site



Little Bay Arm 3D Image from HHViewer Software



Backscatter image depicting soft bottom as dark and hard bottom as light



Impact Zone Delineation Sediment Analyses

- Bulk analyses of the sediment will determine what is and what is not tailings.
 - ground truth hydroacoustic survey
 - determine physical dispersal of tailings
- Sequential extractions of the sediment will determine the fraction (organics, silicates, oxides etc.) of the sediment that holds the metals.

Impact Zone Delineation Analyses of Biota

- Analyses of biota will determine if any of the metals are available to the biota.
 - Clams and mussels are filter feeders and should reflect metals available on particles.
 - Sea weeds take up elements and metals from the water in the dissolved form (ions). Metals are often most available and toxic as ions.

Impact Zone Delineation

Tracing the Movement and Fate of Metals into the Marine Environment

Rationale for Hg/Cd and Pb-Isotope Ratio Method

- The bulk of the mercury, cadmium and lead in the tailings may be in the sulphide minerals
- Sulphides have distinctive Hg/Cd and Pb-isotope ratios ($^{208}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, $^{206}\text{Pb}/^{204}\text{Pb}$) inherited from their parental magmas and fluids
- Marine sediments affected by Hg, Cd and Pb contamination from tailings deposition can therefore be identified on the basis of their Hg/Cd and Pb-isotope ratios

Impact Zone Delineation

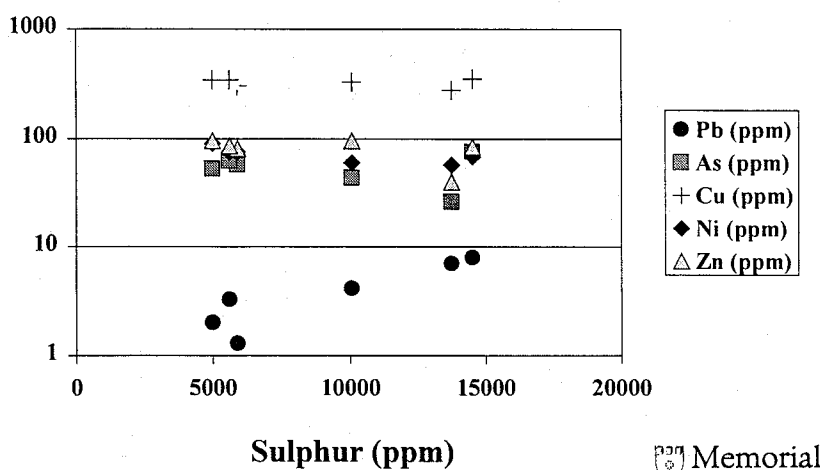
Tracing the Movement and Fate of Metals into the Marine Environment

Approach for Hg/Cd and Pb-Isotope Ratio Method

- Magnetic separation of sulphides from the tailings
- Identification and characterization of the sulphide minerals by XRD and EMP
- ICPMS analyses of the sulphide minerals and some bulk tailings for mercury, cadmium, lead, and lead-isotopes
- ICPMS analyses of bulk and sequential extractions of marine sediments for mercury, cadmium, lead and lead-isotopes



XRF analyses of Little Bay tailings suggest that most of the lead is in sulphide minerals



Ecotoxicological Assessment

- To define and delineate risks associated with chronic as well as acute toxicity using flounder and mussels as test subjects
 - Histopathological studies
 - Effects of metal exposure on the immune system
 - Biochemical toxicology and DNA damage studies

Significant Ecotoxicological Observations To Date at Little Bay

- No acute toxicity or signs of sub-lethal toxicity observed in juvenile American plaice exposed to tailings for up to a month
- Finely ground tailings generate sufficient redox active potential to oxidize cell membranes
- Detailed studies on hepatopancreatic and gill tissues of mussels showed no enhanced level of oxidative stress in mussels.

Summary

- Multi-disciplinary approach to evaluate the movement and fate of metals released from the tailings and their toxicological consequences.
- Integration of data to realistically determine the risks and benefits associated with marine tailings disposal.