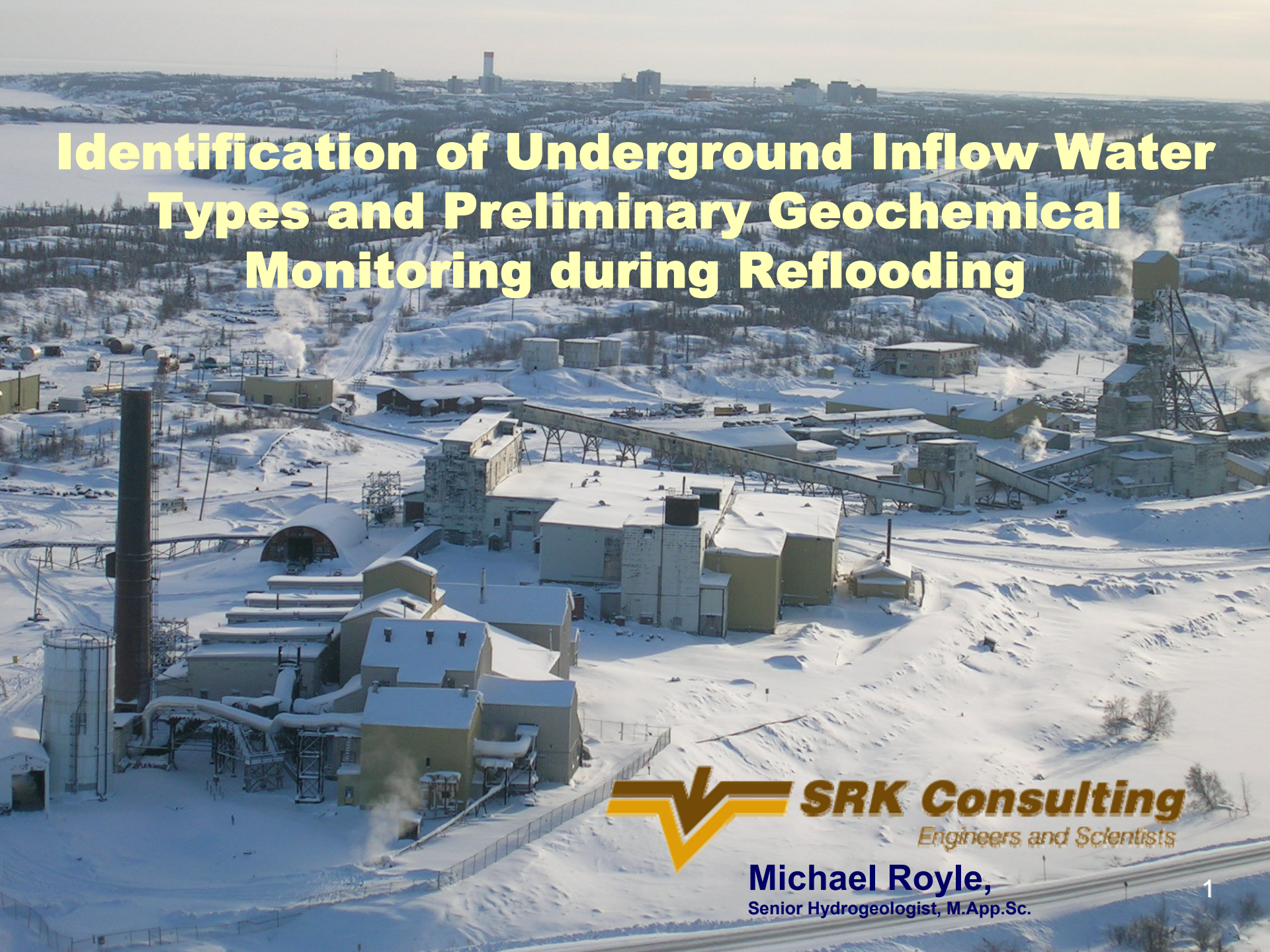
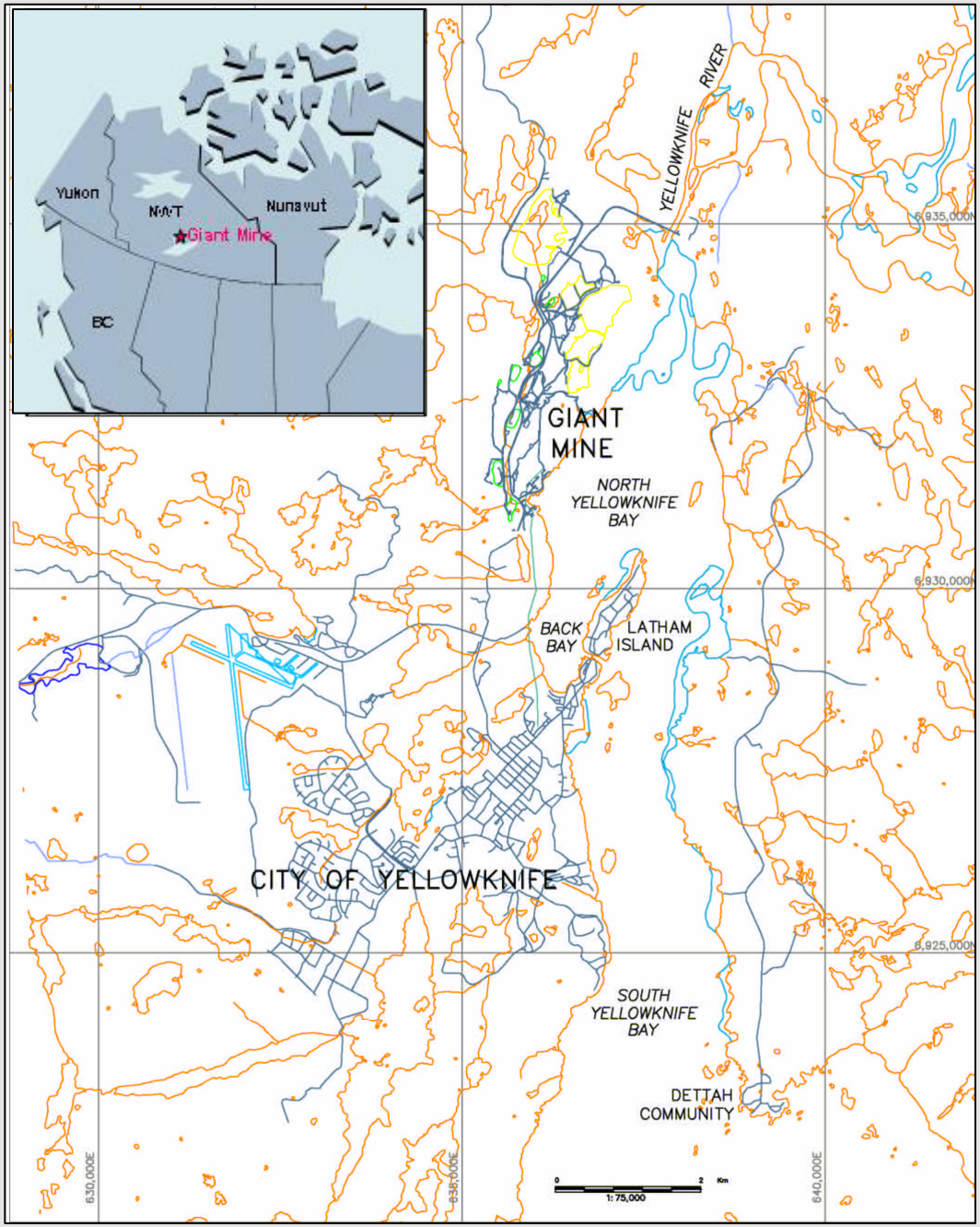
Identification of Underground Inflow Water Types and Preliminary Geochemical Monitoring during Reflooding



SRK Consulting
Engineers and Scientists

Michael Royle,
Senior Hydrogeologist, M.App.Sc.

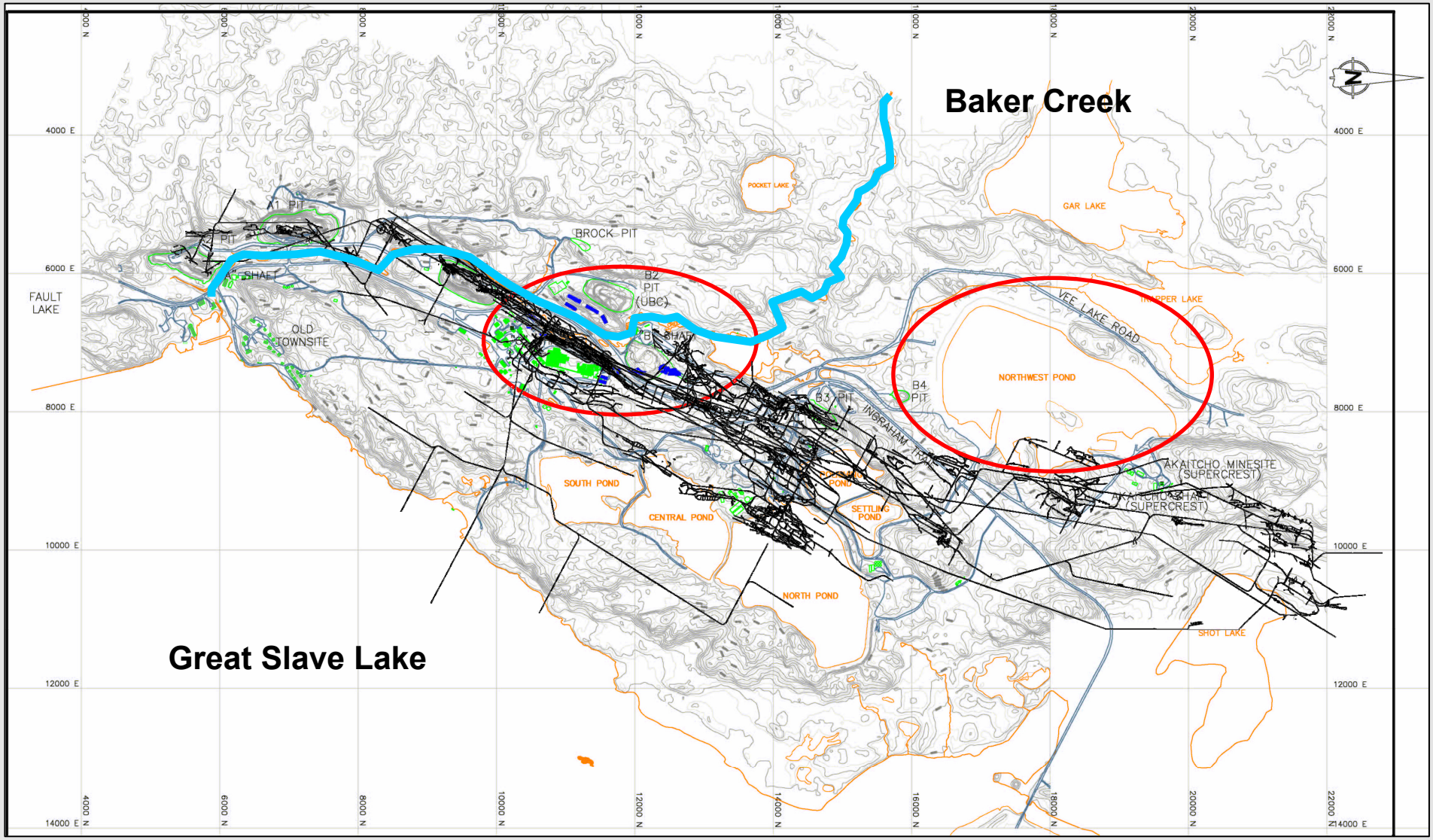
Location


Yukon
NWT
Nunavut
Giant Mine
BC
YELLOWKNIFE RIVER
GIANT MINE
NORTH YELLOWKNIFE BAY
BACK BAY
LATHAM ISLAND
CITY OF YELLOWKNIFE
SOUTH YELLOWKNIFE BAY
DETTAH COMMUNITY
6,935,000N
6,930,000N
6,925,000N
630,000E
635,000E
640,000E
0
2
Km
1: 75,000

GIANT MINE

- Operated 1948 to 1999
  - 7 million ounces gold recovered
  - high arsenopyrite content
  - produced soluble arsenic trioxide dust as waste product
- Dust Handling
  - originally vented up stack
  - 1951: developed UG storage in *frozen ground*
  - 15 stopes and engineered chambers with 237,000 tonnes dust
- 1970s: permafrost found to be discontinuous and warming
- Under Federal control in 1999
- Technical Advisor - recommend frozen block alternative

Site Map


Baker Creek
Great Slave Lake
FAULT LAKE
OLD TOWNSITE
A1 PIT
A1 SHAFT
BROCK PIT
B2 PIT (UBC)
B2 SHAFT
B3 PIT
B4 PIT
POCKET LAKE
GAR LAKE
VEE LAKE ROAD
TROPPER LAKE
NORTHWEST POND
INGRAHAM TRAIL
AKAITCHO MINESITE (SUPERCREST)
AKAITCHO SHAFT (SUPERCREST)
SOUTH POND
CENTRAL POND
SETTLING POND
NORTH POND
SHOT LAKE
4000 E
6000 E
8000 E
10000 E
12000 E
14000 E
4000 N
6000 N
8000 N
10000 N
12000 N
14000 N
16000 N
18000 N
20000 N
22000 N

Objectives

- **Water typing for inflow source identification and control**
- **Long-term arsenic source identification**

The primary objectives of the geochemical sampling program were:

- **Characterize the geochemical and isotopic signatures of water types entering the mine;**
- **Identify and characterize “type” samples representing distinct sources of arsenic within the mine;**
- **Delineate main flow paths within the mine;**
- **Develop overall water and load balance;**
- **Establish seasonal variations in water chemistry in the mine**

Water Quality Sampling

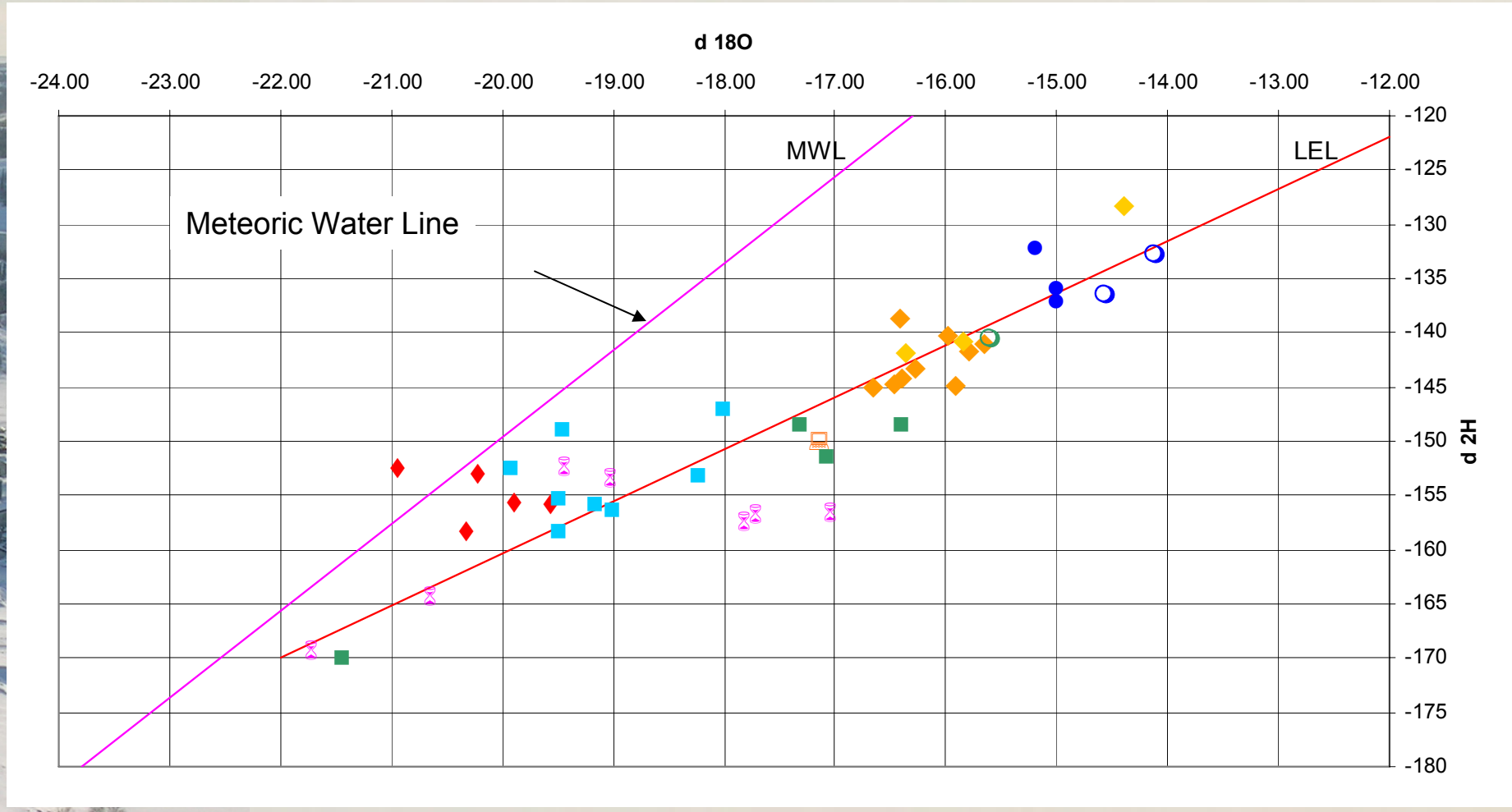
- **Sampling Programs**
  - 1998/1999 Fracflow (Jan98, Mar98, Sept99)
  - DIAND/SRK (Apr00, May00, Nov00)
- **Sample Types**
  - Discrete Flows (seeps in fractures and faults, drill holes)
  - Major Ditch Flows
- **Parameters**
  - Major ions, nutrients, trace metals, isotopes

Definition of Water Types

- **Spatial Information**
  - Used to identify seepage types (e.g. surface water, NW Tailings Pond water, arsenic chamber water etc.)
- **Geochemistry**
  - Plots of major ion chemistry (scatter plots, Piper plots) used to identify characteristics of known waters and to identify unknown seeps
  - Mixed samples were not used as “type” samples.
- **Isotopes**
  - Used to determine source of water (direct infiltration, creek water, lake water, deep groundwater)

Water Types

- Clean Water Entering Mine
  - Precipitation
  - Baker Creek
  - Great Slave Lake (as service water)
- Surface Tailings Ponds
- Water moving through /past
  - Arsenic Chambers
  - Backfill (waste rock and tailings)
  - Mine Walls
- Deep Groundwater



Legend			
creek w ater		NW Tailings/surface	
lake w ater		NW Tailings/underground	
creek/w alls		polishing pond	
infiltration/w alls (shallow)		arsenic chambers	
infiltration/w alls (deeper)		deep groundw ater	

Mass Balance Calculations

- Simple Calculations to see if the amount of arsenic pumped from the mine could be “explained” by our sources
- Plan area weighted average of source concentrations
- Comparison to actual sump concentrations (As, Ca, Mg, Na)

Mass Balance Conclusions

- Preliminary calculations indicated that the arsenic chambers accounted for approximately 50% of the arsenic in sumps
- Later sampling raised this estimate to 80% or more
- "Backfill" could account for most of remainder
  - Other sources might include road beds, spills in drifts…
  - Plan area averaging does not allow other surface sources to be definitively ruled out

Implication is that mine water will not be below discharge criteria (0.5 mg/L) even if all the arsenic trioxide dust could be removed or isolated

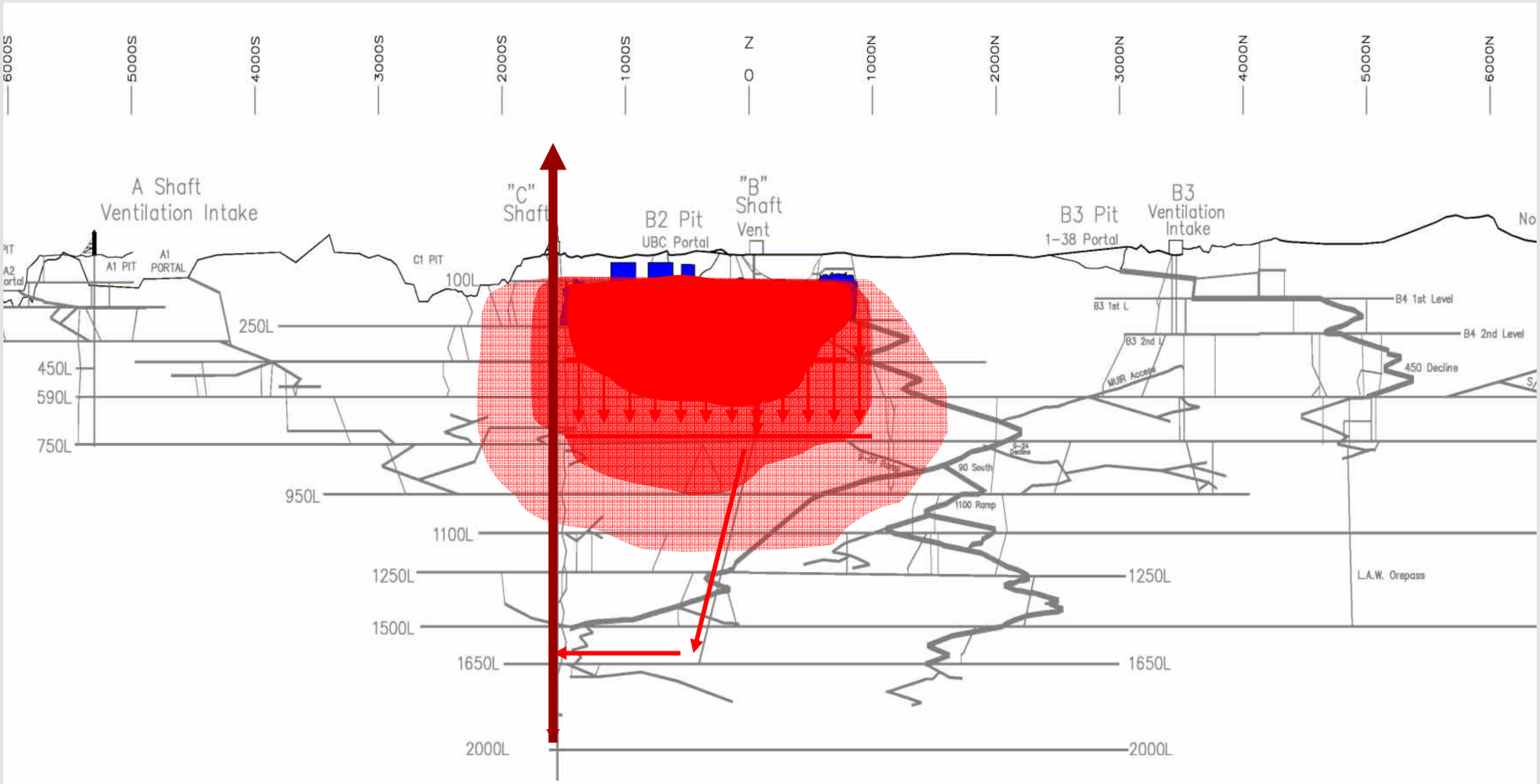
Geochemistry

Source	Arsenic Concentrations (mg/L)
Soils, bedrock, and Mine Walls	0.05
Northwest Tailings Pond Seepage	5
Tailings Backfill	5
Waste Rock Backfill	1.5
Arsenic Chambers & Stopes	4000

Redistribution of Arsenic in Mine

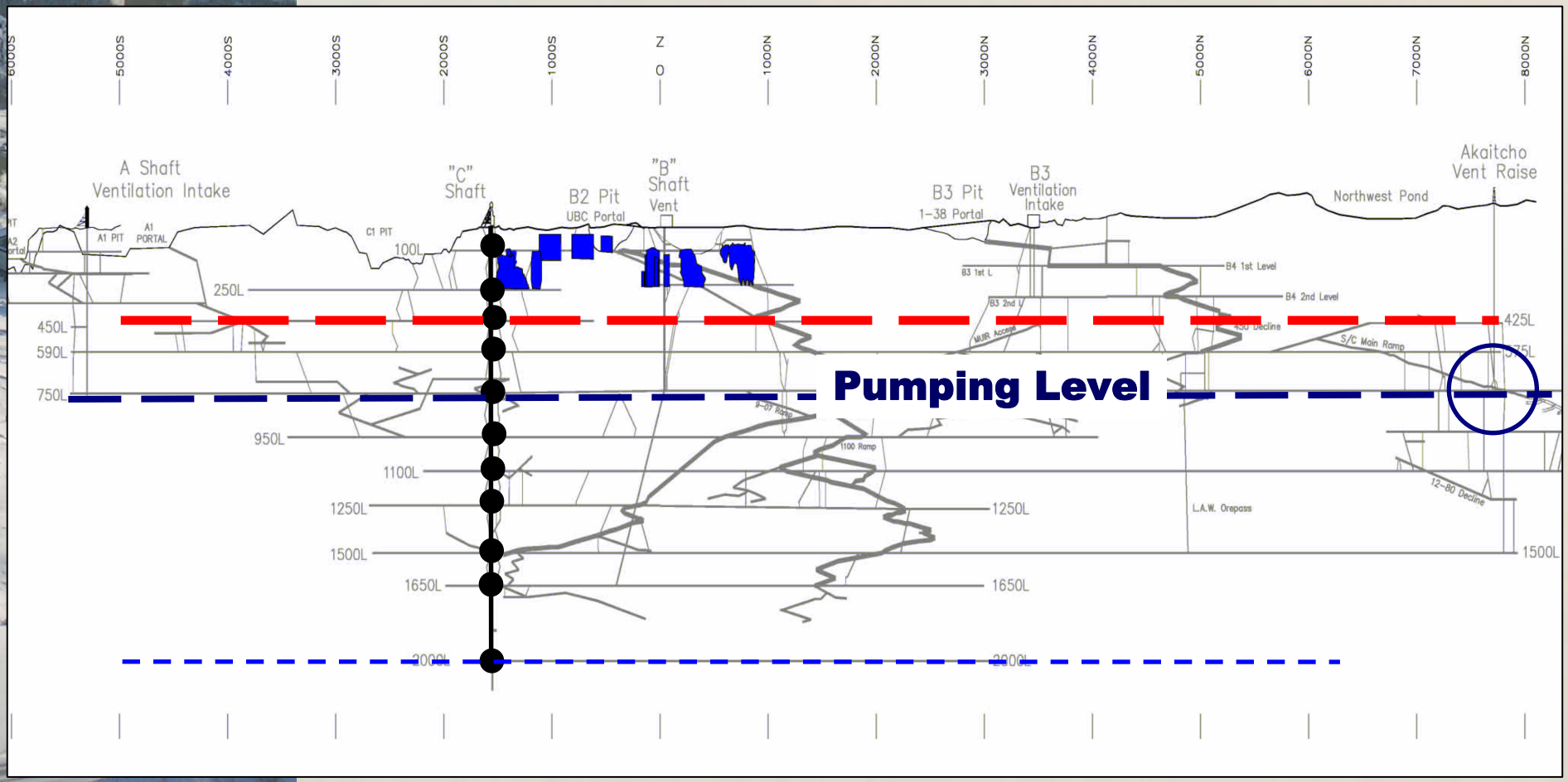
- Surface infiltration flows through arsenic dust
- Dissolved arsenic ~4000 mg/L
- Dissolved arsenic forms precipitates along “high test” flow paths (drifts, stopes, etc.)
- Below 750 Level, dissolved arsenic flows to bottom of mine, but along specific routes (raises and ditches)
- Therefore, there was a limited potential for high arsenic water to spread throughout the mine

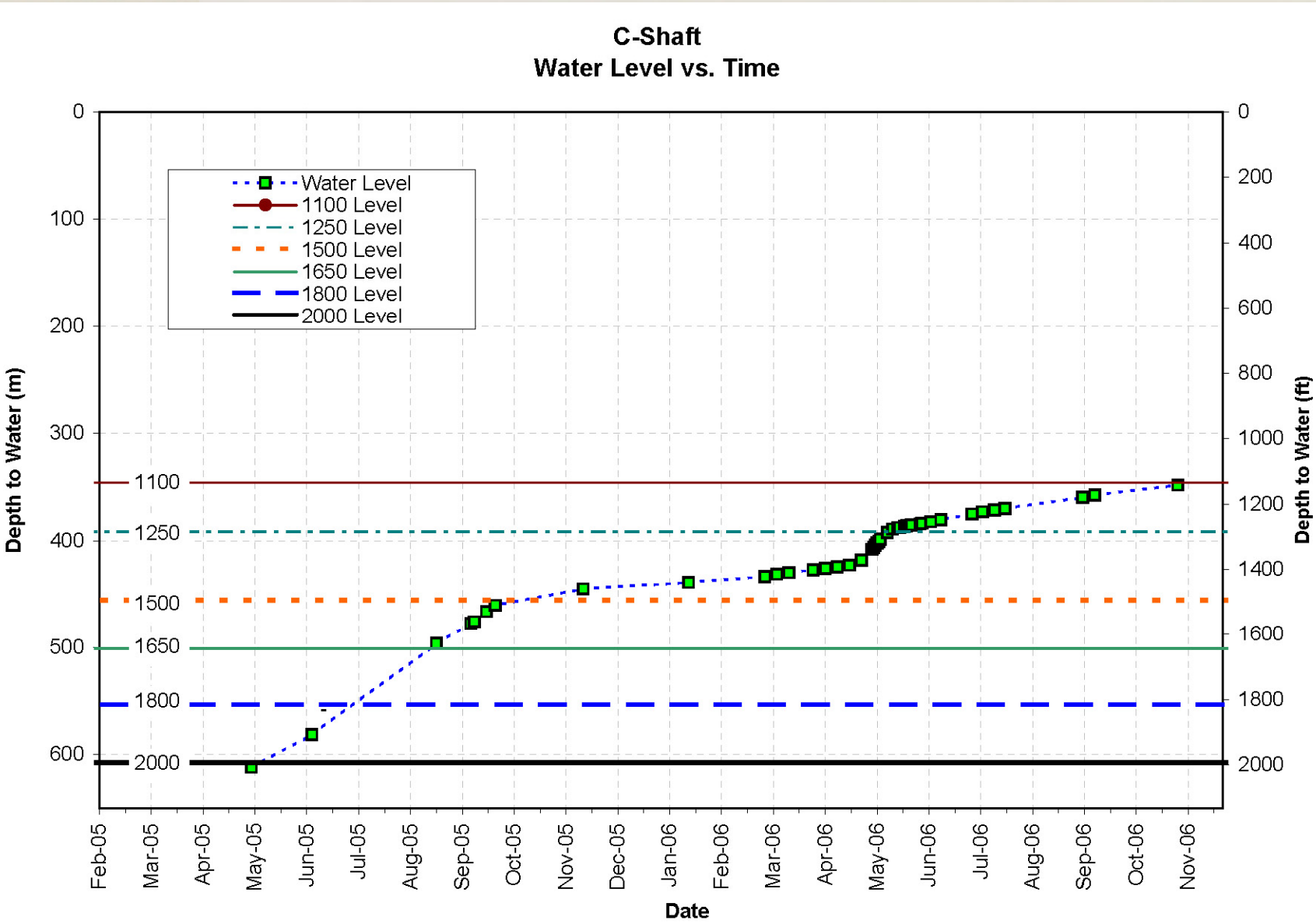
Mine Workings

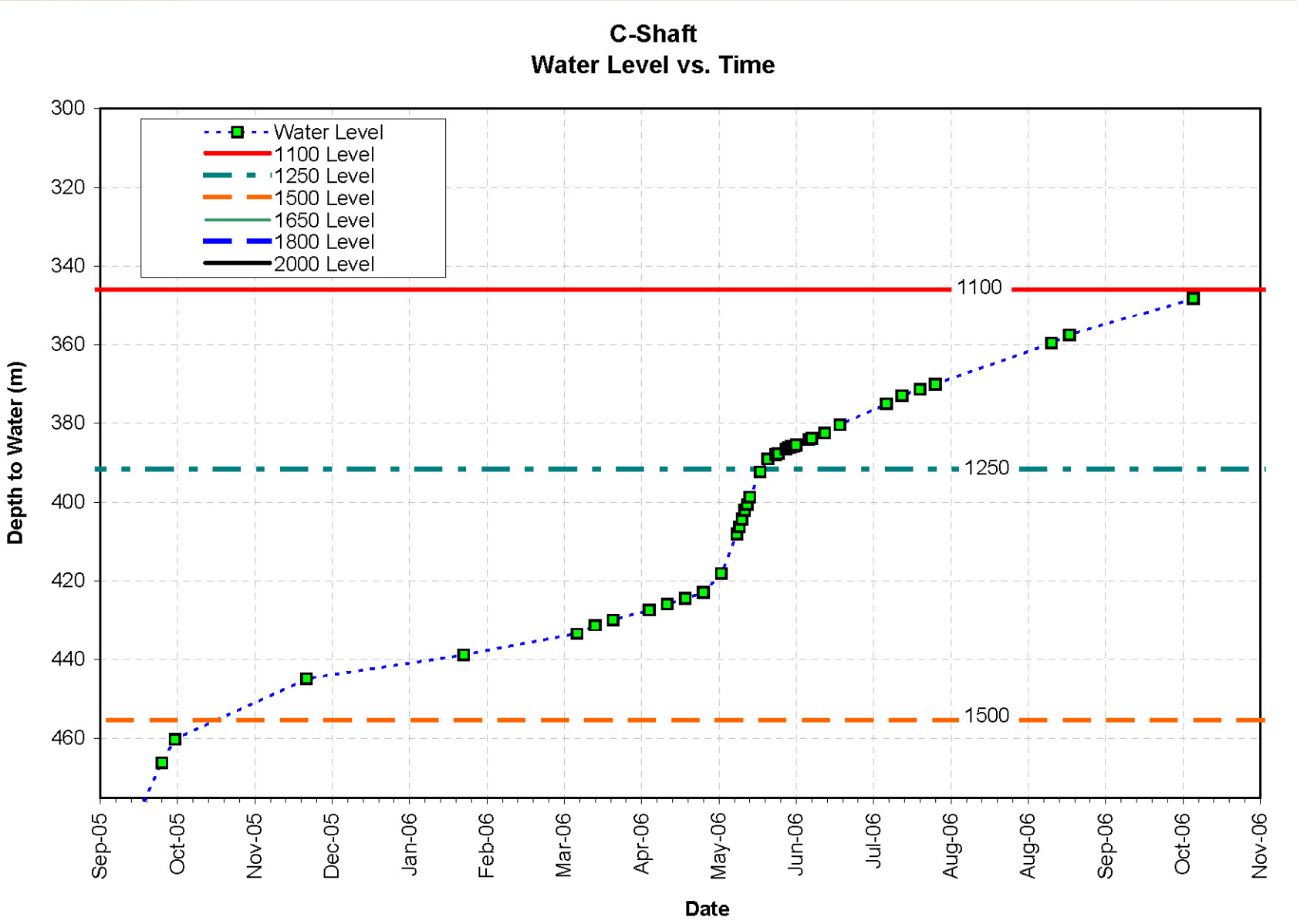


Mine water containing arsenic pumped from mine

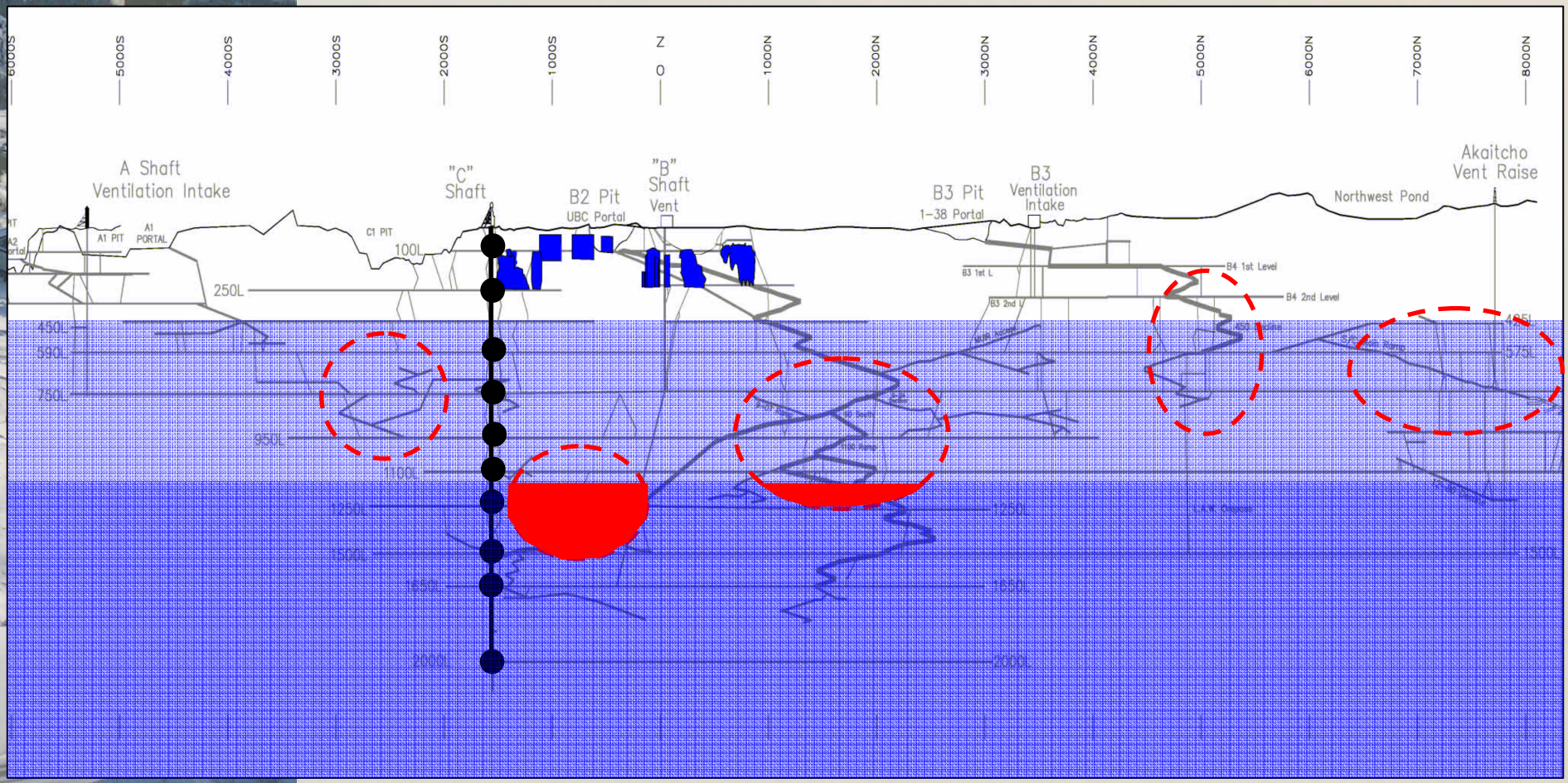
C-Shaft Monitoring System



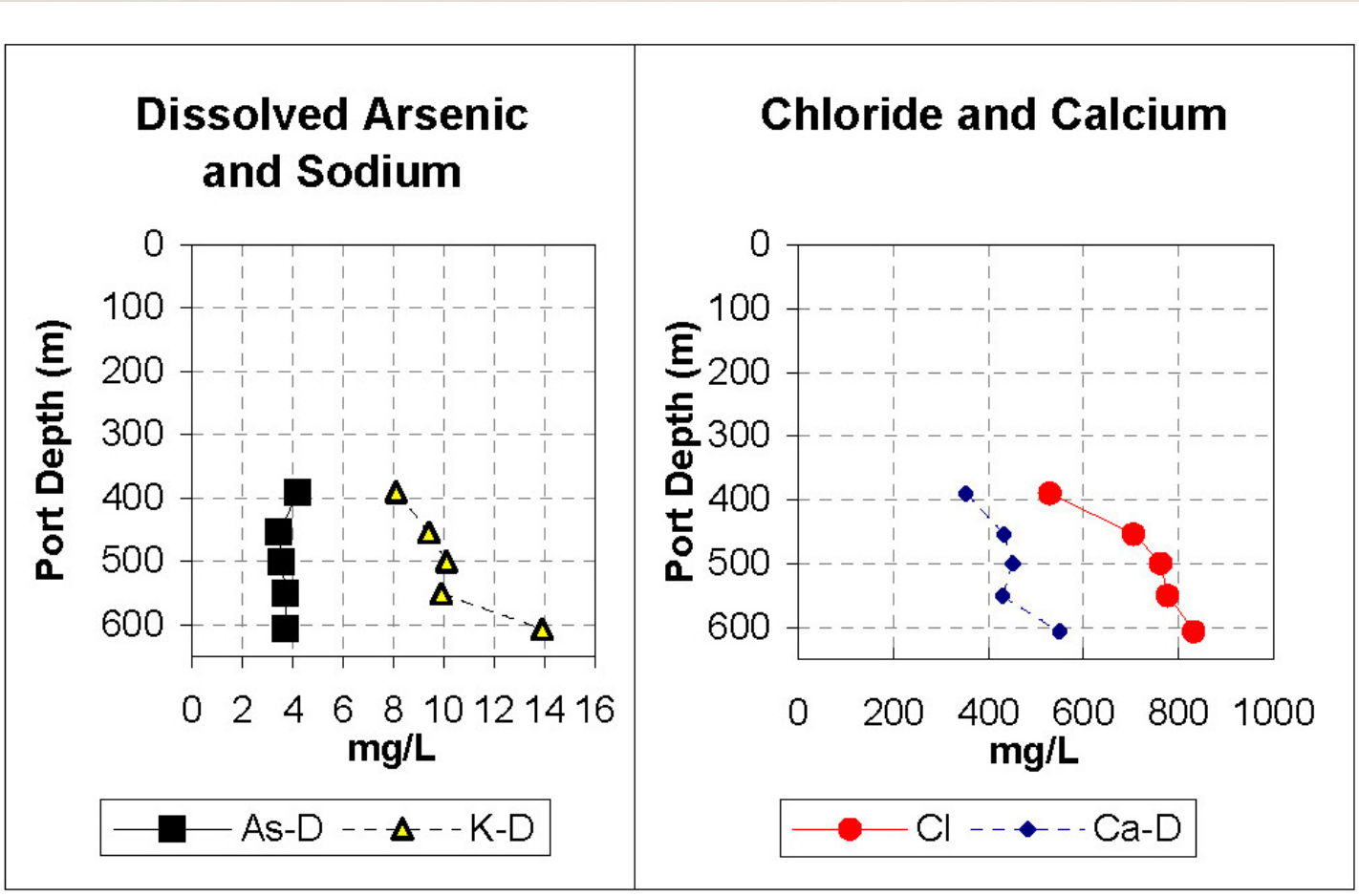

C-Shaft
Water Level vs. Time
Water Level
1100 Level
1250 Level
1500 Level
1650 Level
1800 Level
2000 Level
Depth to Water (m)
Depth to Water (ft)
0
100
200
300
400
500
600
200
400
600
800
1000
1200
1400
1600
1800
2000
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Nov-05
Dec-05
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Date


C-Shaft
Water Level vs. Time
Water Level
1100 Level
1250 Level
1500 Level
1650 Level
1800 Level
2000 Level
1100
1250
1500
Depth to Water (m)
300
320
340
360
380
400
420
440
460
Sep-05
Oct-05
Nov-05
Dec-05
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Aug-06
Sep-06
Oct-06
Nov-06
Date

Location of Underground Tailings Backfill



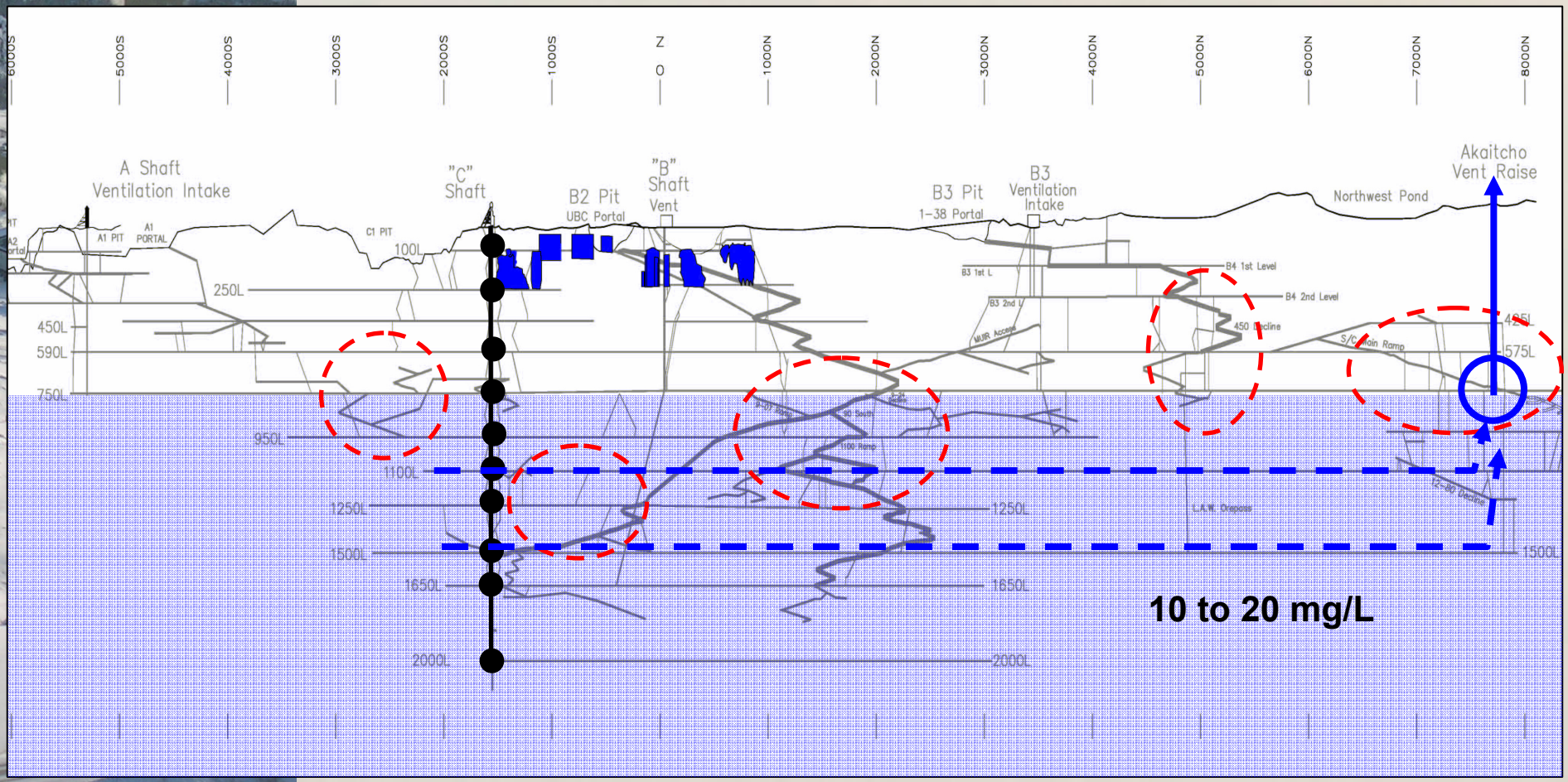
Arsenic and Chloride



Preliminary Conclusions on Mine Reflooding

- Rapid water level rise corresponds to freshet inflow from surface
- Mine water in C-Shaft does not appear to be picking up high arsenic levels from redistributed arsenic at this time
- Gradient of inflow away from shaft
- Arsenic salts may be dissolving, but physical gradient keeping it away from shaft at this time
- Arsenic levels expected to increase once stratification begins to form (diffusion)
- Pumping from Achaitcho Shaft likely to pull “clean” water from south end of mine and higher arsenic water to north end

Mine Water Flow through Tailings Backfill




Thank You