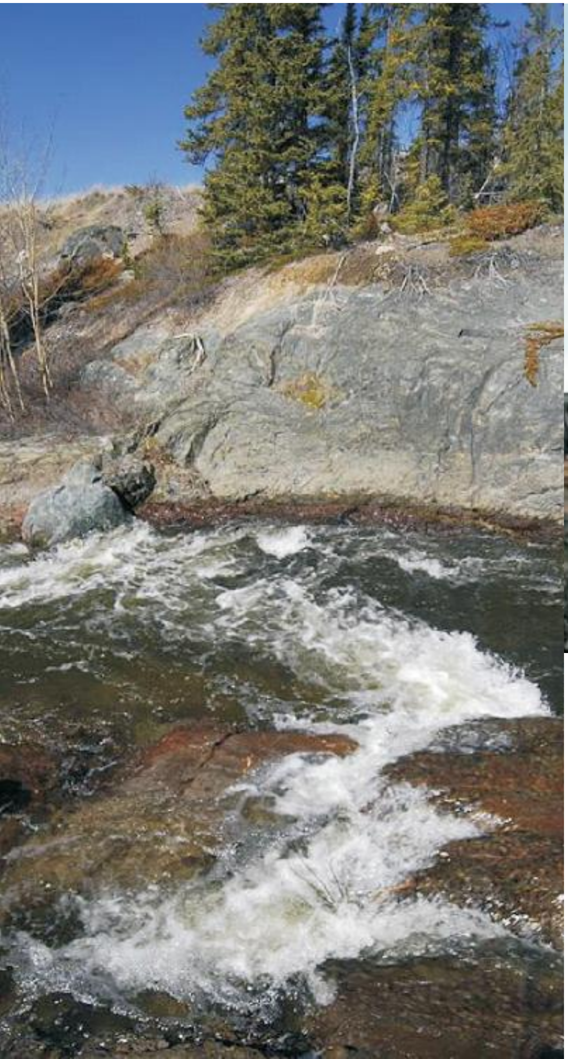
Giant Mine Remediation Project

Northwest Territories

Canada

FREEZE AND UNDERGROUND



Giant Mine Remediation Project Environmental Assessment
Public Hearings – September 10-14, 2012

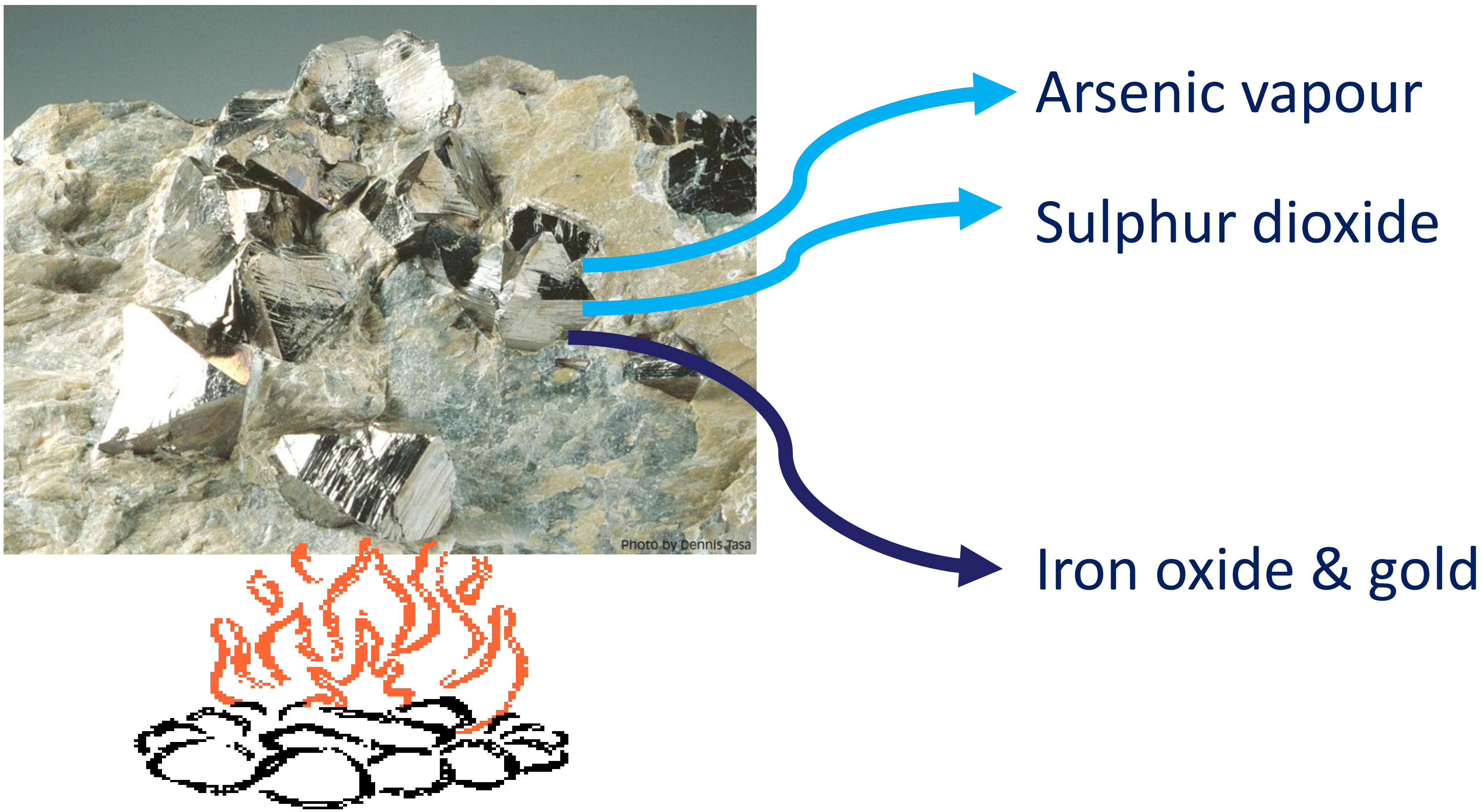
Adrian Paradis (AANDC)
Mike Nahir (AANDC)
Daryl Hockley (Technical Advisor)
Greg Newman (Technical Advisor)
Darren Kennard (Golder Associates)

OVERVIEW OF DEVELOPER'S PRESENTATION

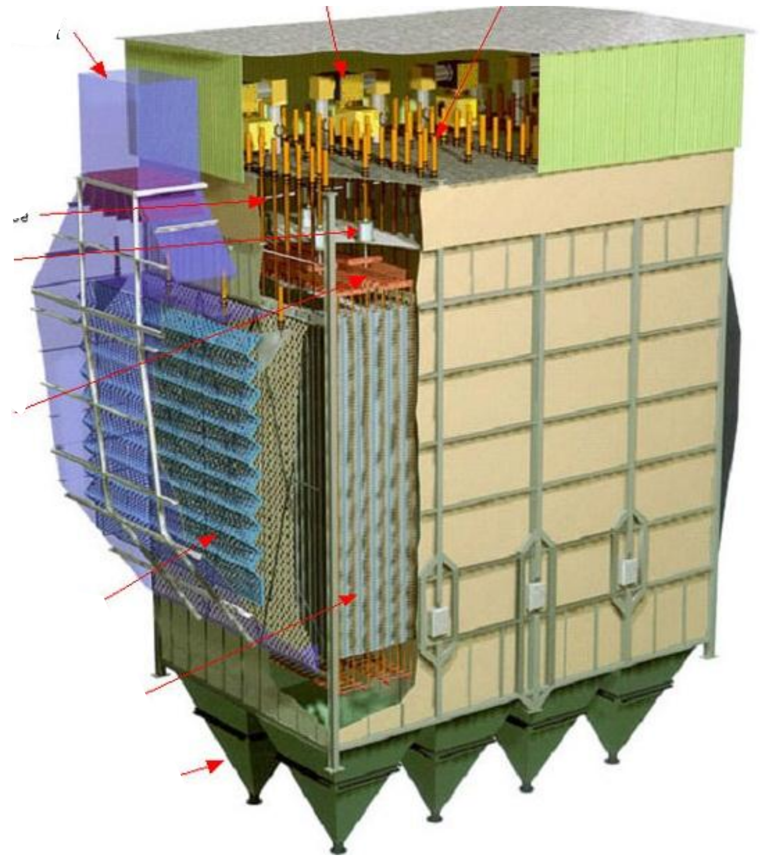
1. Background on arsenic trioxide dust
2. Frozen blocks
3. Questions raised by Board and Parties
4. Freeze Optimization Study
5. Summary

1. Background on Arsenic Trioxide Dust

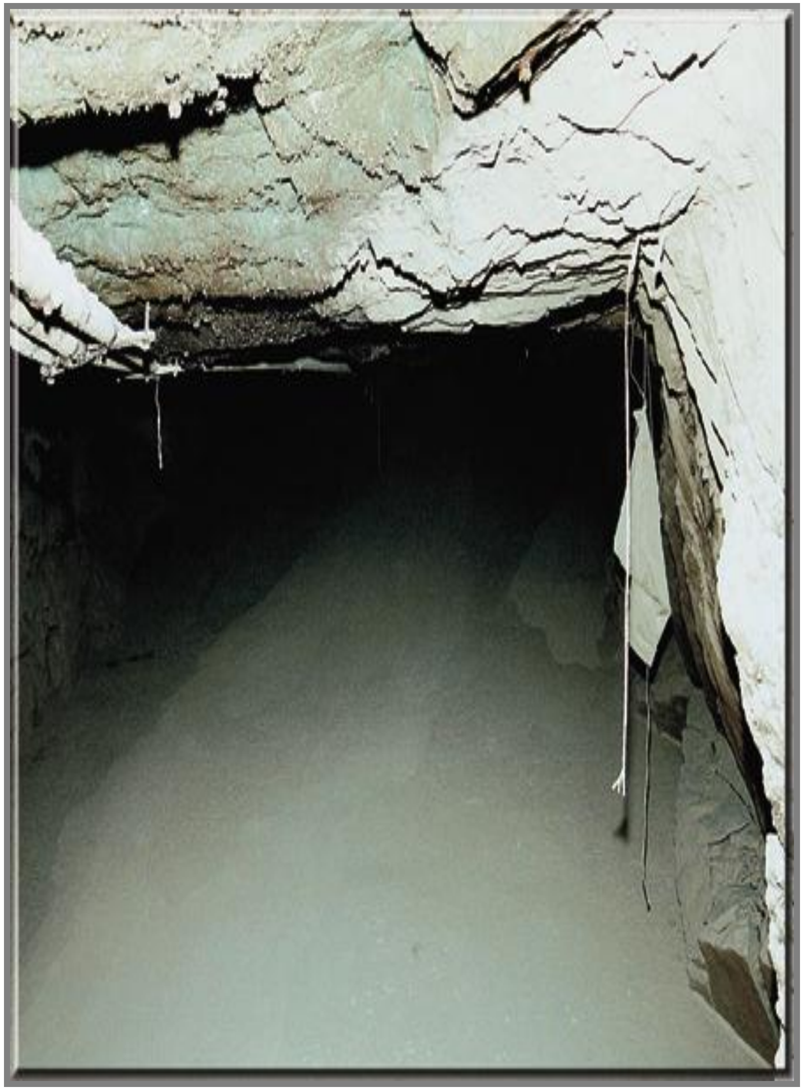
- Gold at Giant Mine is associated with an arsenic mineral called arsenopyrite (FeAsS):



- 1949 - 1951
  - Arsenic vapour released into the air
  - Vapour cools to form arsenic trioxide dust
- 1950's
  - Construction and modification of electrostatic precipitator to capture arsenic vapour & dust
- 1963 - 1999
  - Continuing operation with two precipitators



- Arsenic trioxide dust:
  - Initially a dry powder
  - Very small particles
  - Like fine flour
  - 60% arsenic
  - Dissolves in water up to 9,000 mg/L



Arsenic trioxide dust chambers and stopes

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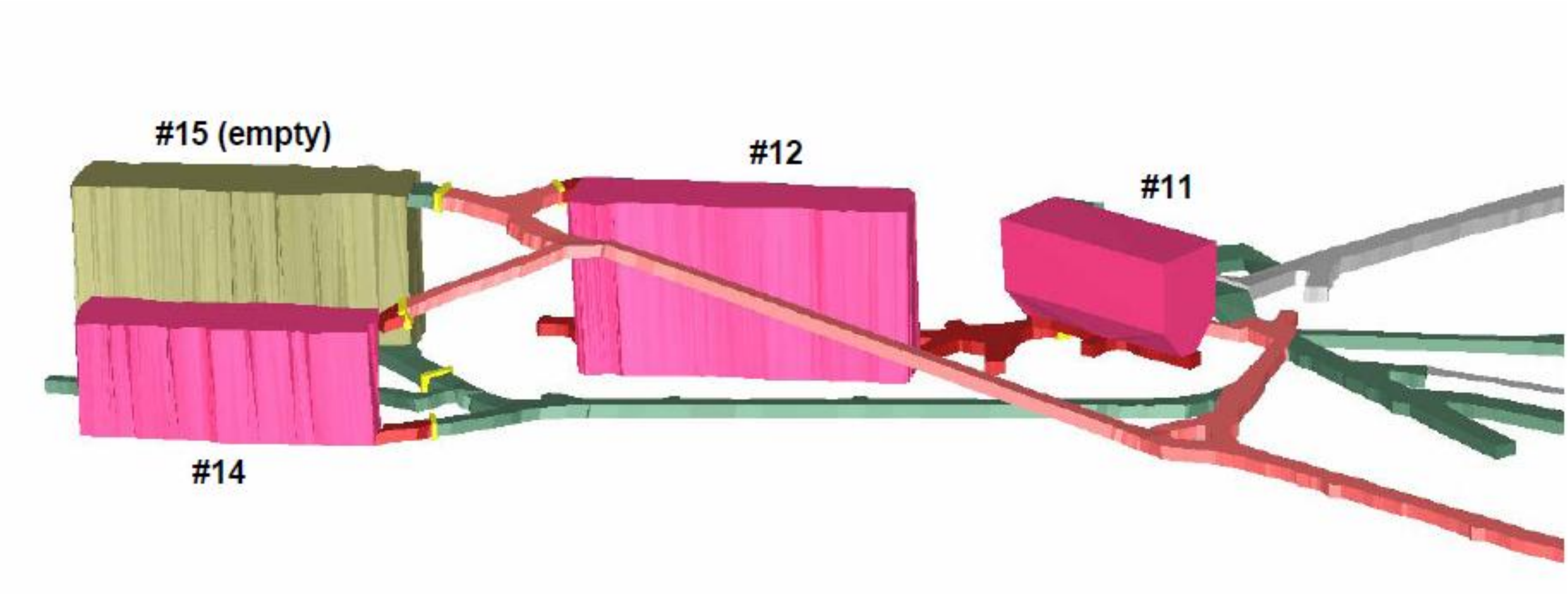
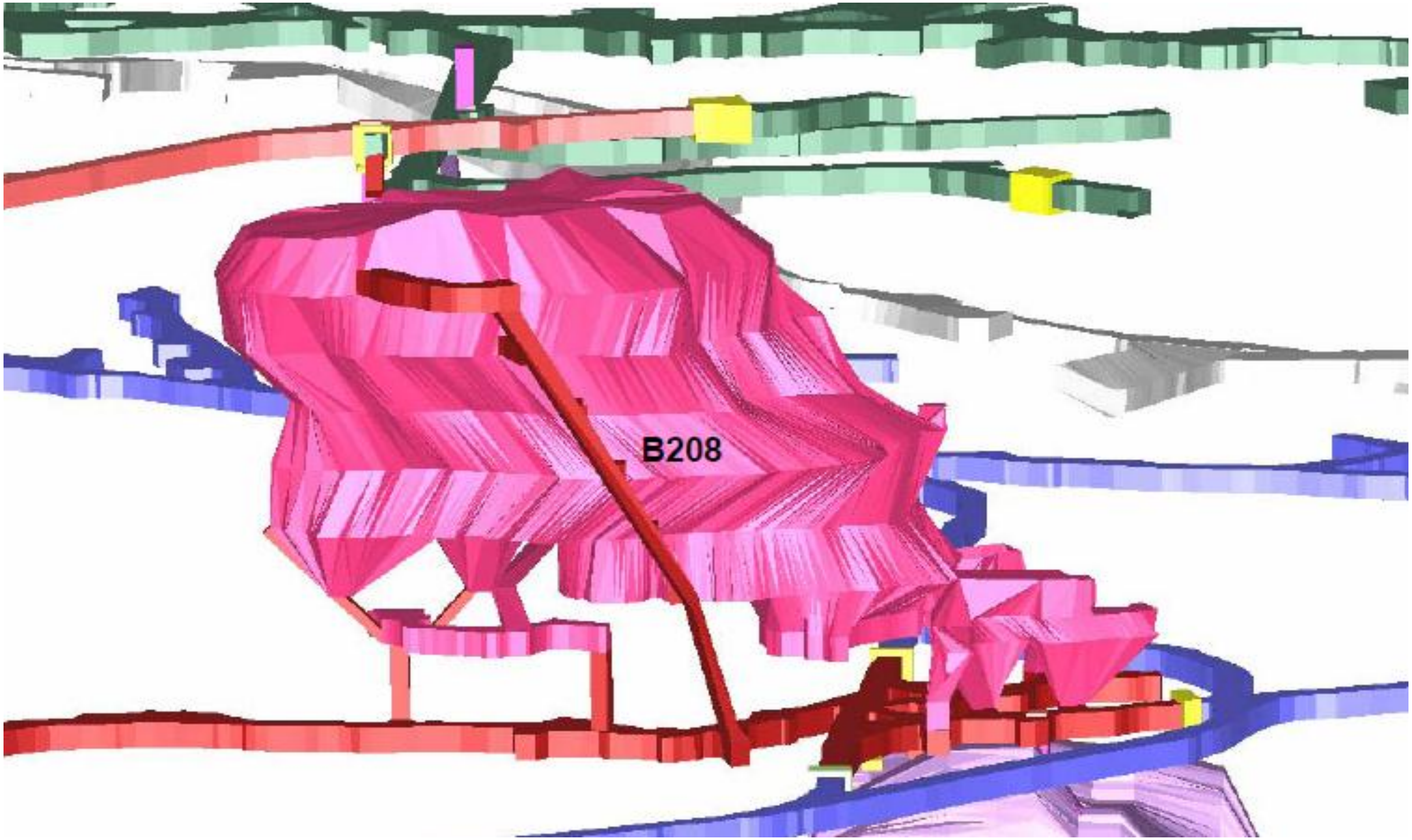
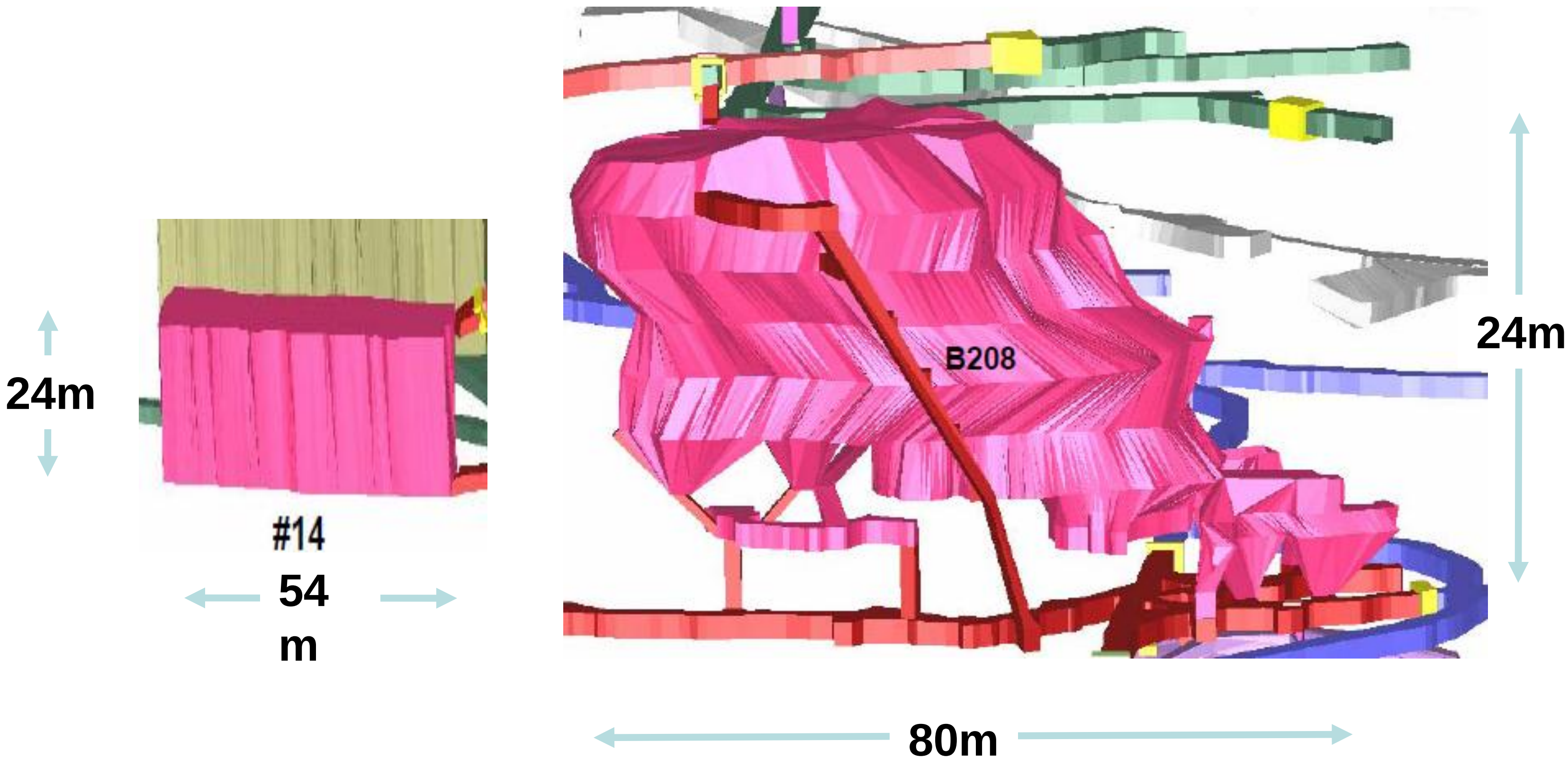
Example chambers



EXAMPLE STOPE



Chamber and Stope Sizes




B1 PIT CREST (EAST WALL)
MINE ROAD
SURFACE (INGRAHAM TRAIL 60 FEET EAST)
PIT EAST WALL
ARS DISTRIBUTION DRIFT
BREAK THROUGH
SERVICE RAISE
#14 ARSENIC CHAMBER
PRECAMBRIAN BLDG.
FOR REFERENCE ONLY
TO B230, B233, & B234 CHAMBERS
B208 ARSENIC CHAMBER
TONS OF DUST - 32,369
DATE FILLED
March 16, 1962 - January 9, 1975
March 11, 1986 - September 26, 1986
TO B235 & B236 CHAMBERS
BULKHEAD #14
BULKHEAD #15
BULKHEAD #1
To 2-10 S DRIFT
#13

BULKHEADS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ARS DISTRIBUTION DRIFT
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BREAK THROUGH
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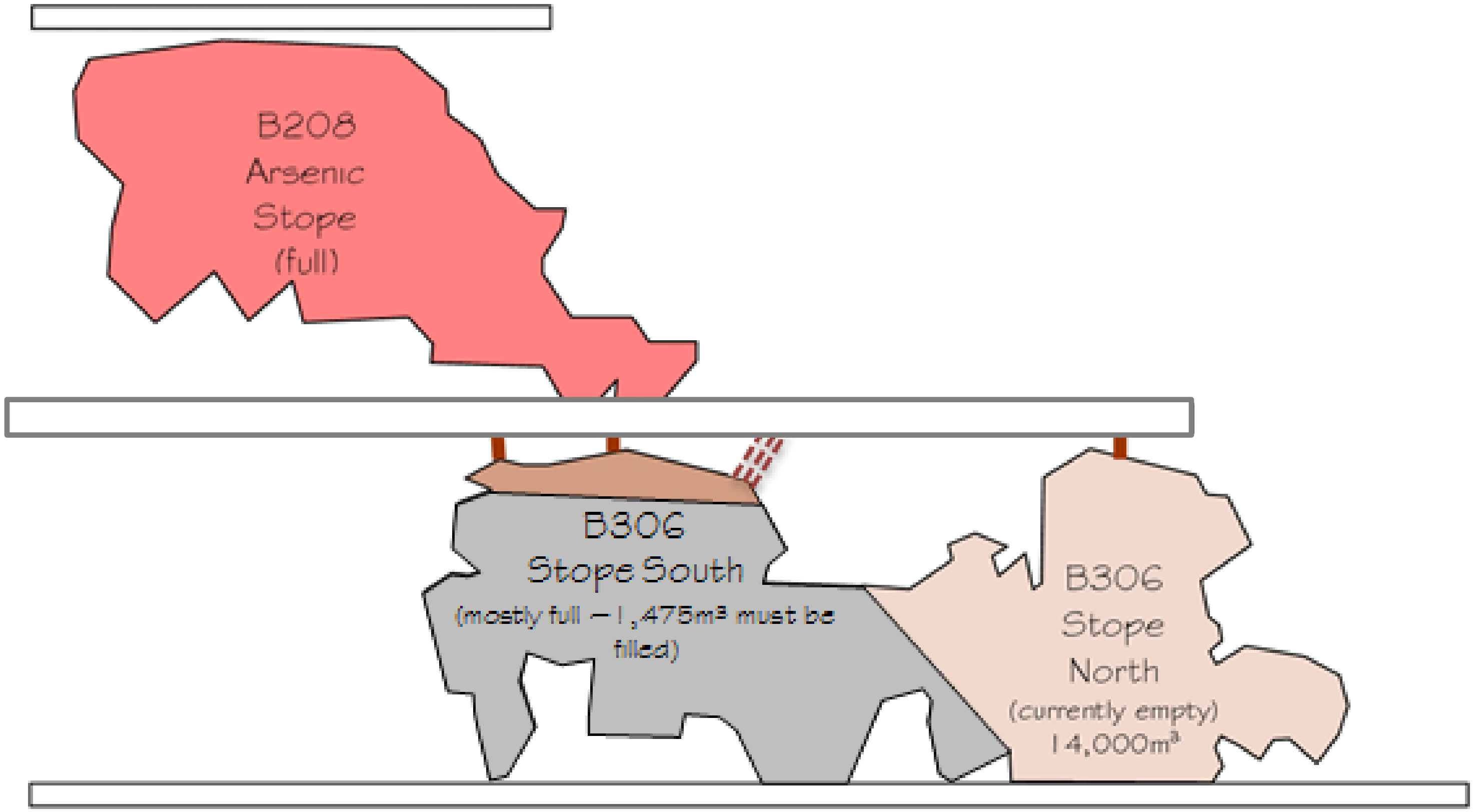
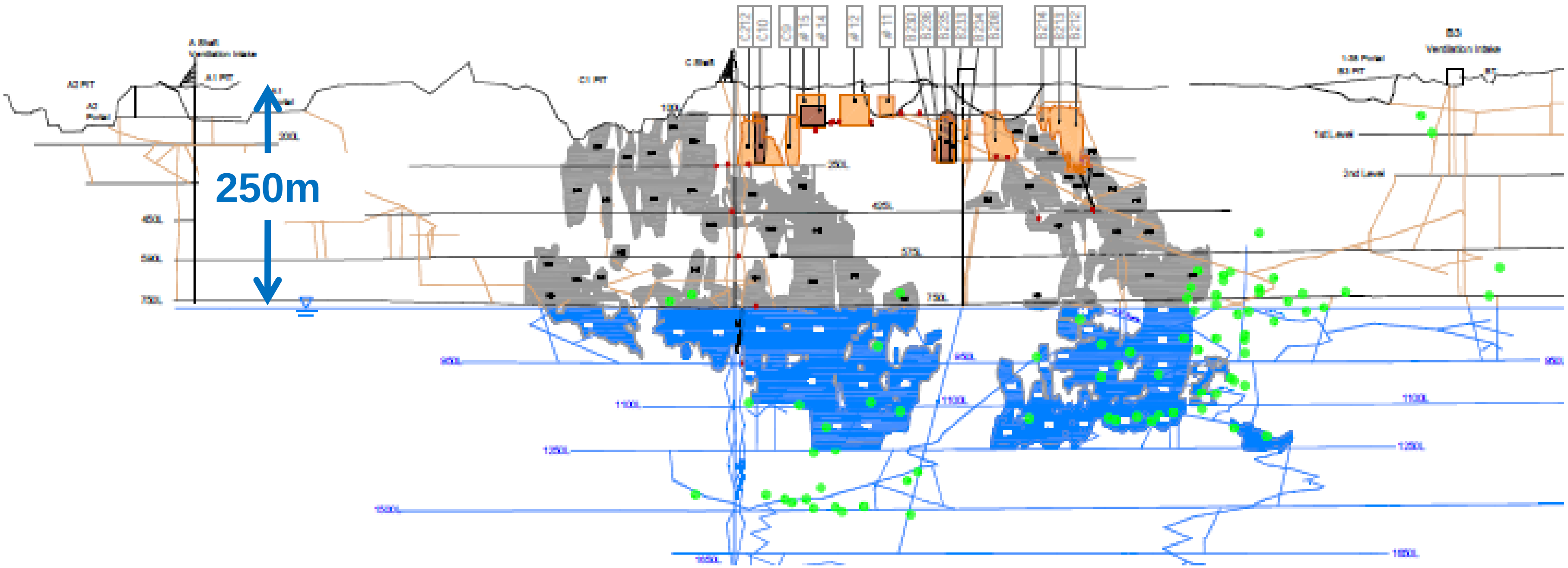
Other Underground Stability Concerns



SUMMARY

- 237,000 tonnes of arsenic trioxide dust
- 14 underground chambers and stopes
- Lower bulkheads
- Crown pillars
- Sill pillars

- Currently completely contained
  - Any water that leaves the mine is treated to remove arsenic



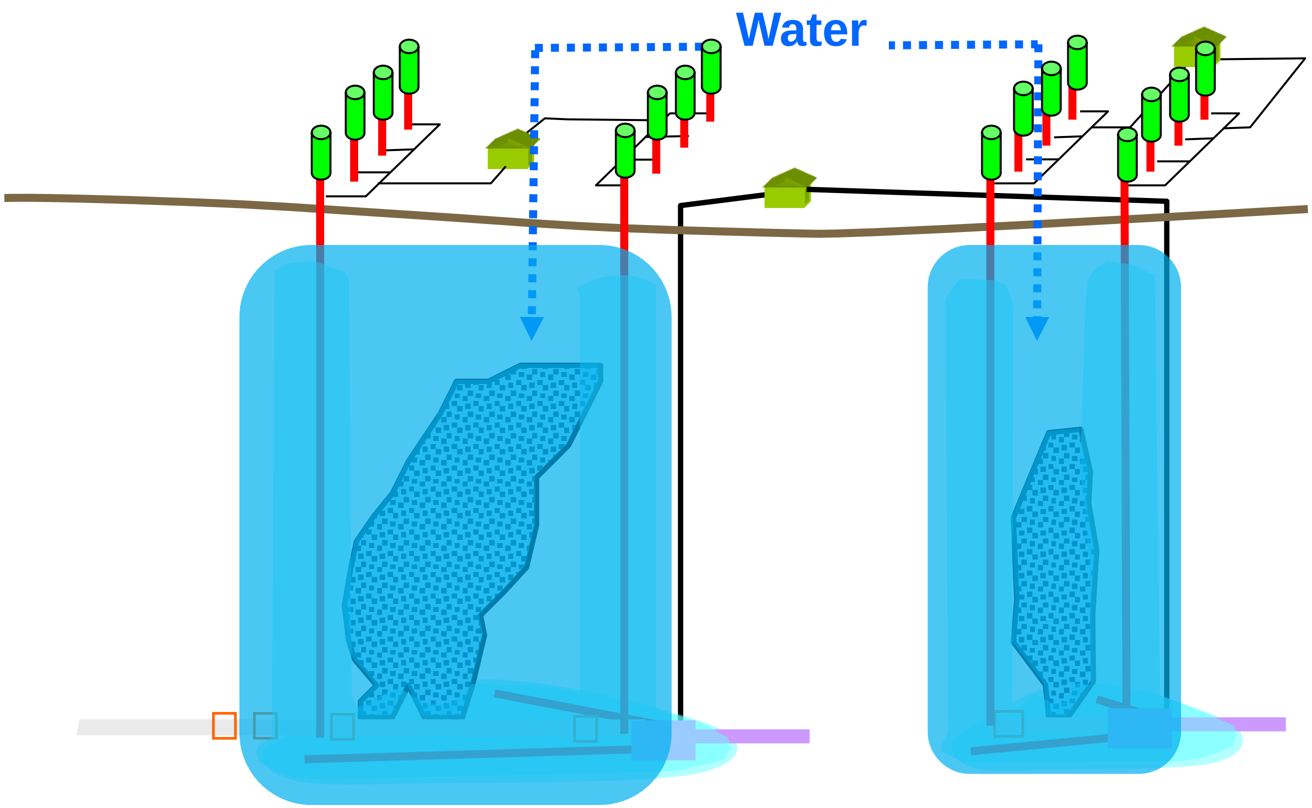
CONCERN IS FOR THE FUTURE

- Long term
  - Without remediation, dust could release 12,000 kg of arsenic per year into groundwater
- Medium term
  - Collapse of underground bulkheads or crown pillars, or flooding of mine by Baker Creek, could lead to escape of arsenic

Those are the risks that the proposed project seeks to address

2. Frozen Blocks

Frozen blocks in DAR



- Long term
  - Thermosyphons
    - Take cold from the winter air and transfer it into the ground
  - "Passive"system
    - No energy input or control required

LONG TERM MONITORING AND MAINTENANCE

- Continuously measure ground temperatures
- Annually survey the thermosyphon
- Water treatment staff will:
  - Monitor water levels
  - Monitor treatment plant influent
  - Carry out maintenance

Options assessment

- 2001 – 2003
- Teams of engineers and Technical Advisor
- Over 40 public consultation sessions
- Three major public workshops
- Independent Peer Review Panel

56 Methods → 4 Groups → First Public Workshop

12 Options → 1 Leave-it-UG Option / 1 Take-it-Out Option → Second Public Workshop

Above plus Combination Option → Third Public Workshop

Draft Option → Independent Peer Review → Recommended Option

Remediation Plan and DAR

- Concluded that keeping the dust in the ground and freezing it was the best option:
  - Low risk to workers
  - Low risk of short-term arsenic release
  - Low risk of long-term arsenic release

3. Questions Raised by Board and Parties

- Clarification of “long term”
- Wetting methods and risks
- Climate warming
- Reversibility
- Success criteria

CLARIFICATION OF "LONG TERM"

- The frozen block option was selected largely because it is the best for the very long term
  - Components have finite design lives
  - But **the system as a whole**, which includes monitoring, maintenance and replacement of components, **will operate as long as needed**
- Assessment of long-term performance included extreme future scenarios
  - The very slow thawing makes the frozen blocks **robust even in these extreme scenarios**

CLARIFICATION OF "LONG TERM" (CONT'D)

- New options should be periodically evaluated
- But the frozen block method should be assessed as if it is here to stay

Wetting Methods and Risks

- Several wetting methods under consideration
- Questions helped to clarify:
  - Requirements for wetting – complete and uniform saturation is not required
  - Parties' concerns about risks

WETTING METHODS AND RISKS (CONT'D)

- Wetting studies
  - No fatal flaws
  - Challenges that required further engineering
- Recent results from the FOS
  - Frozen blocks are equally robust over long term even without wetting

CLIMATE WARMING

- Considered in previous assessments
- Questions helped to identify agreed "worst case" scenarios

Climate Warming

- Reversibility of the frozen block was not considered in our earlier work
- Information Requests led us to review options
  - Feasible methods do exist
  - Choice of thawing would depend on the overall objective

SUCCESS CRITERIA FOR THE FREEZING

- DAR presented target criteria for initial freeze
  - Frozen wall will be complete when a 10m wide perimeter of rock around and below the chamber or stope reaches -10^{o}C or colder
  - Frozen block will be complete when the dust within the chamber or stope reaches -5^{o}C

Success Criteria for the Freezing (cont'd)

- Criteria for judging long-term performance are much more complicated, e.g.
  - "If the temperature in thermistor ABC exceeds -8^{o}C for six months or more, notify engineer and initiate repairs to thermosyphon XYZ"
- Need to be part of further design of the monitoring systems
  - EMS process will allow stakeholder input

4. Freeze Optimization Study

FOS OBJECTIVES

- Inform further engineering design
- Provide input to the environmental assessment and water licensing processes

SITE PREPARATION

Drilling freeze holes

INSTALLING FREEZE PIPES

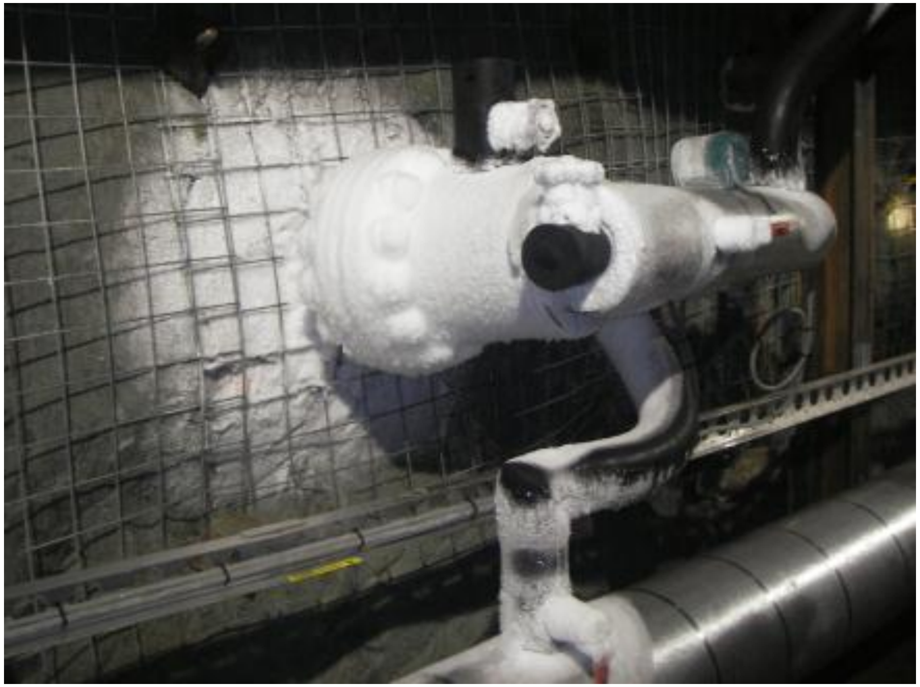
INSTALLING THERMOSYPHONS

Freeze plant

COOLANT DISTRIBUTION PIPING

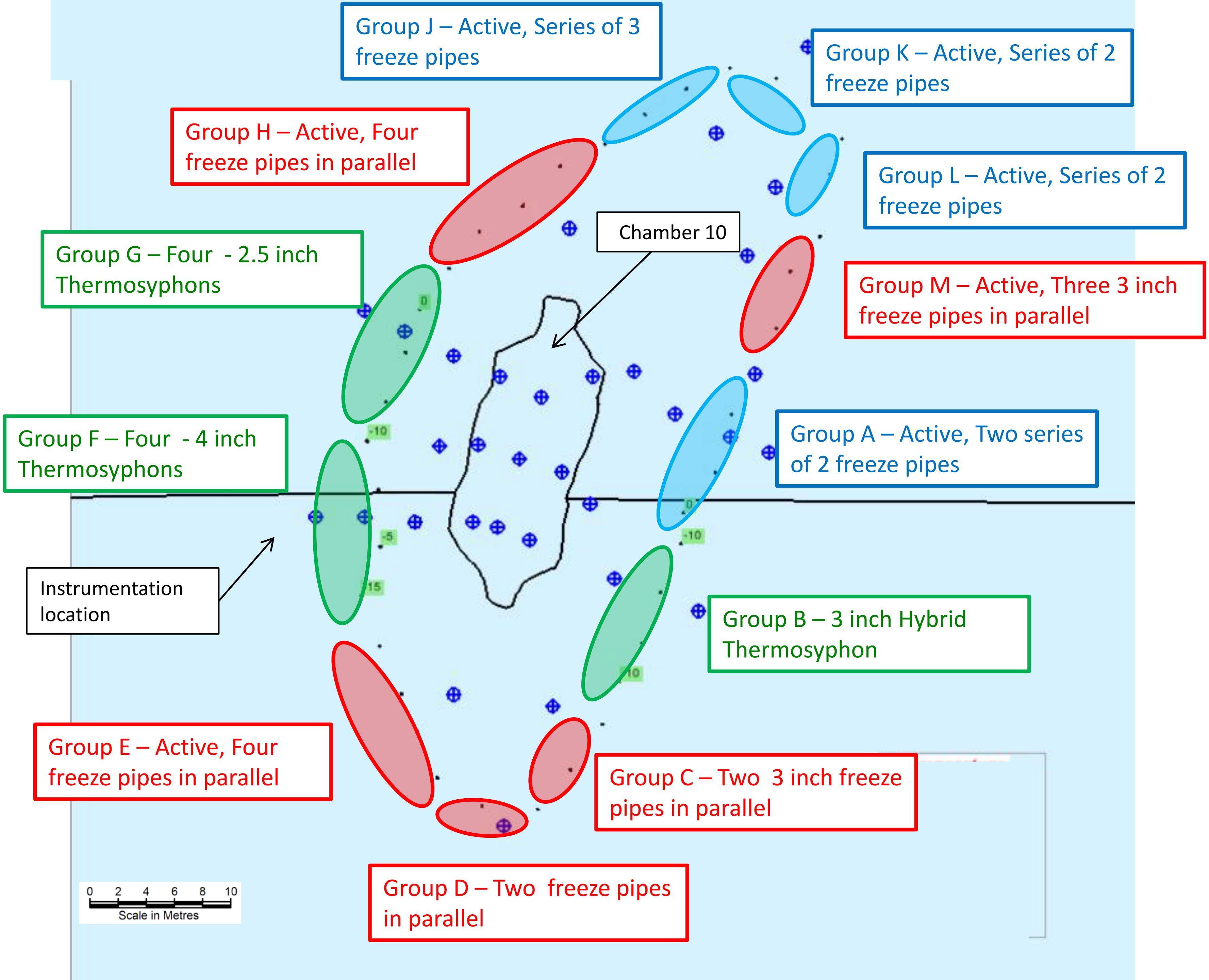
Results to Date

- Ground is freezing faster than expected
- Both active freezing and hybrid freezing systems are working well
- Good data set for further engineering analyses and design optimization

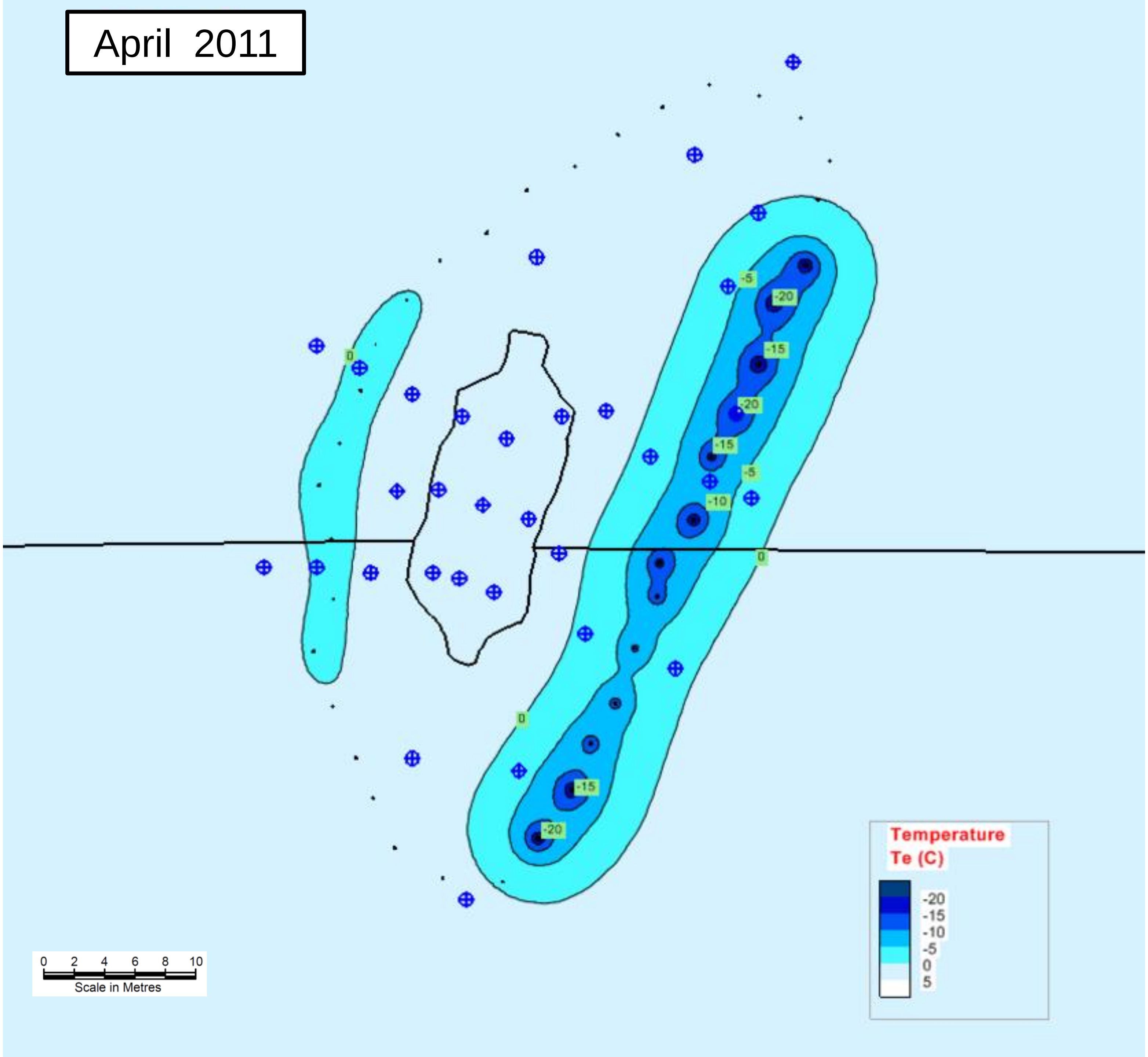


Underground tunnel below Chamber 10 in March 2011

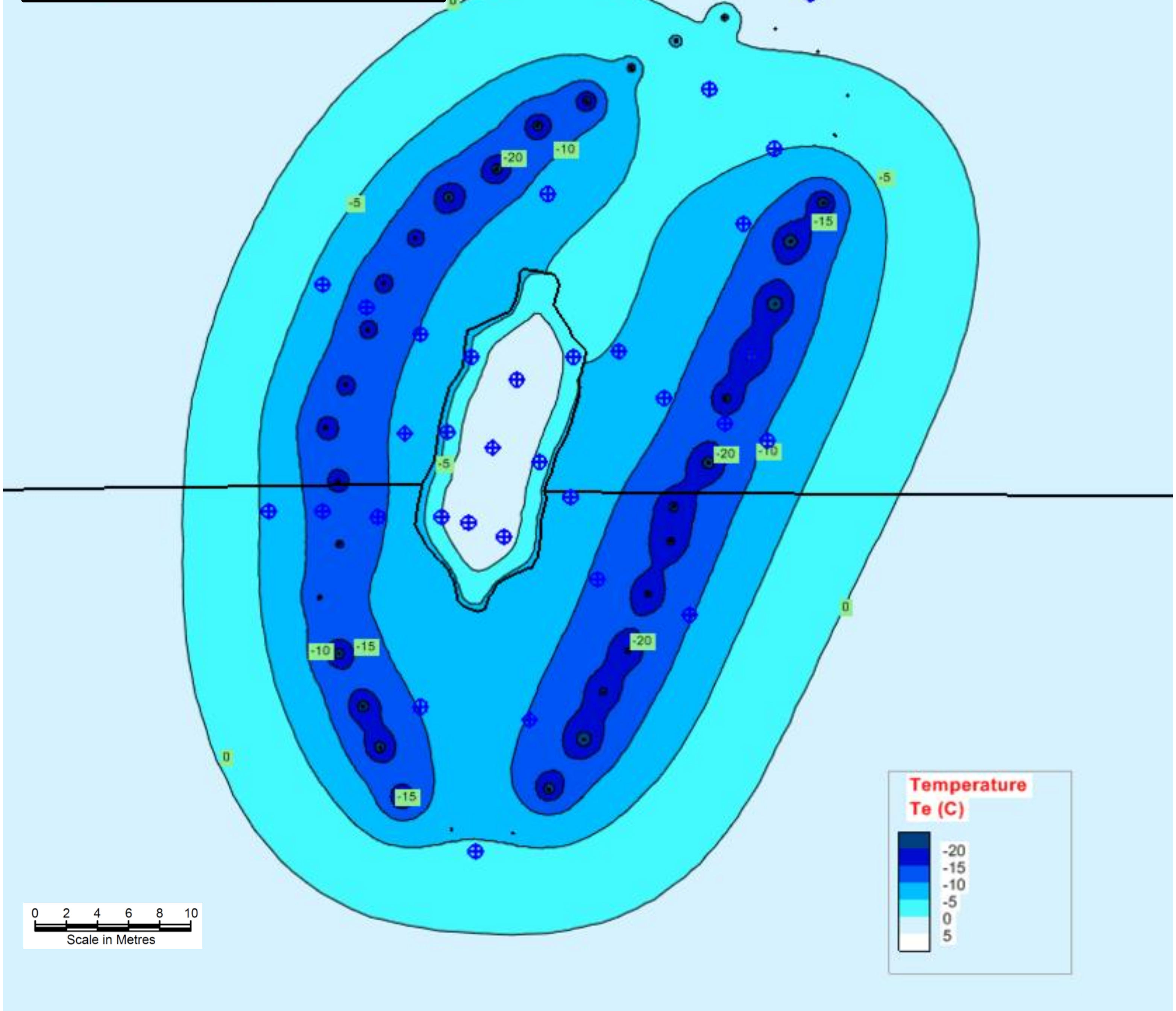
Same tunnel in September 2011



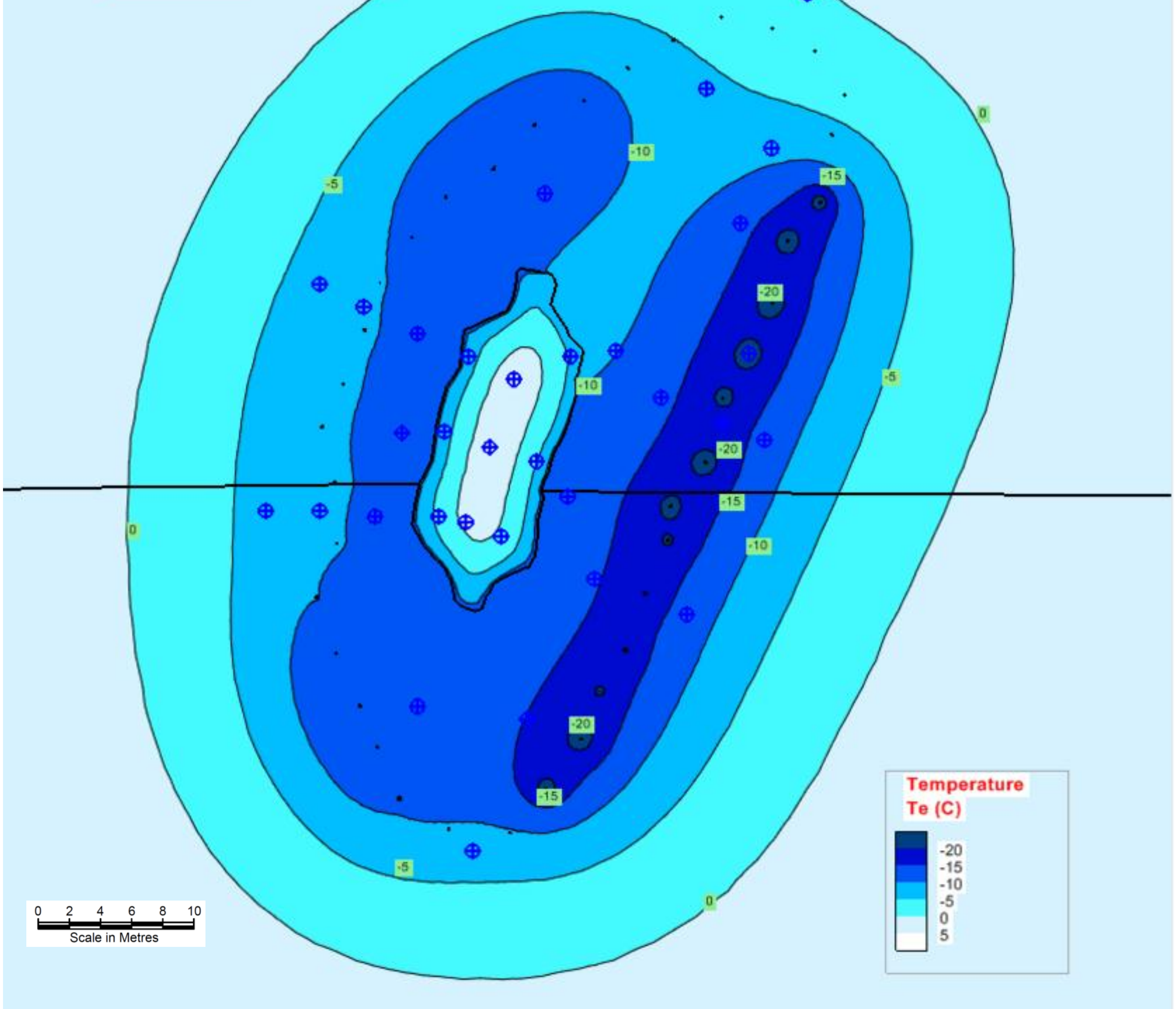
Group J – Active, Series of 3 freeze pipes
Group K – Active, Series of 2 freeze pipes
Group H – Active, Four freeze pipes in parallel
Group L – Active, Series of 2 freeze pipes
Chamber 10
Group G – Four - 2.5 inch Thermosyphons
Group M – Active, Three 3 inch freeze pipes in parallel
Group F – Four - 4 inch Thermosyphons
Group A – Active, Two series of 2 freeze pipes
Instrumentation location
Group B – 3 inch Hybrid Thermosyphon
Group E – Active, Four freeze pipes in parallel
Group C – Two 3 inch freeze pipes in parallel
Group D – Two freeze pipes in parallel
0 2 4 6 8 10
Scale in Metres


April 2011
-5
-20
-15
-20
-15
-5
-10
0
0
0
-15
-20
Temperature
Te (C)
-20
-15
-10
-5
0
5
0 2 4 6 8 10
Scale in Metres

December 22, 2011



June 2012



-10
-15
-5
0
-20
-10
-5
-20
-15
0
-10
-20
-15
-5
0
Temperature
Te (C)
-20
-15
-10
-5
0
5
0 2 4 6 8 10
Scale in Metres

Data Analysis to Date

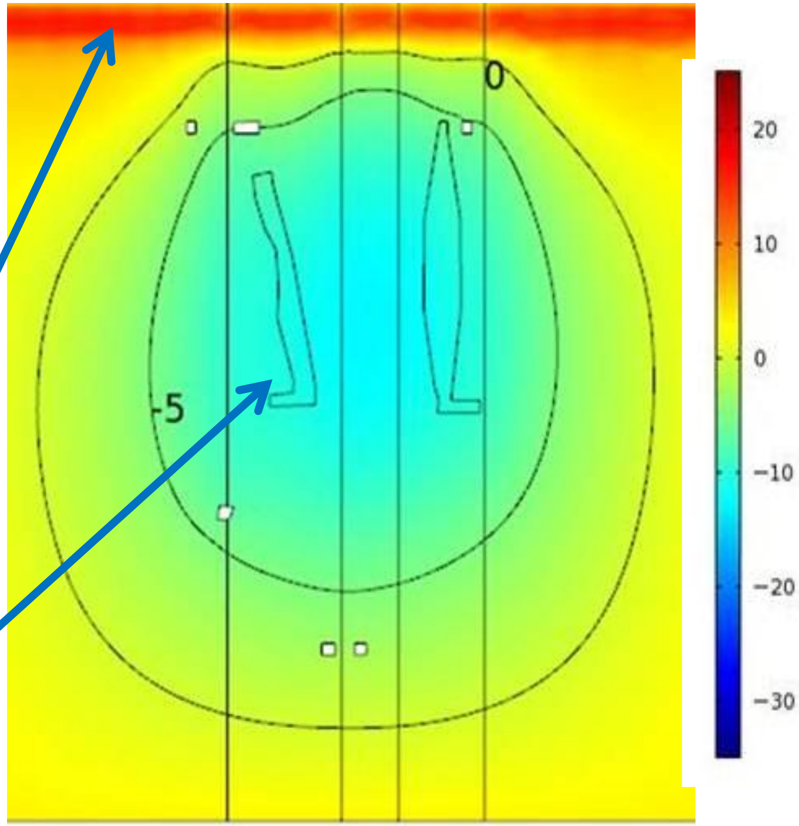
- Estimate material properties
- Show influences on rate of initial freezing
- **Assess long-term performance** under worst case climate change
- **Assess possible design improvements**

Assessing Long Term Performance

- Worst case climate warming
  - 6.1^{o}C warming over 100 years

- Passive freezing (thermosyphons) only

- Thermosyphons maintain the frozen block even under extreme climate warming
- Chambers C10 & C212
  - Ground surface gets quite warm in summer
  - Dust remains at -5C



- Then add worst case governance scenario
  - All the thermosyphons stop working
  - No repairs, no replacements
  - How long will the ground remain frozen?

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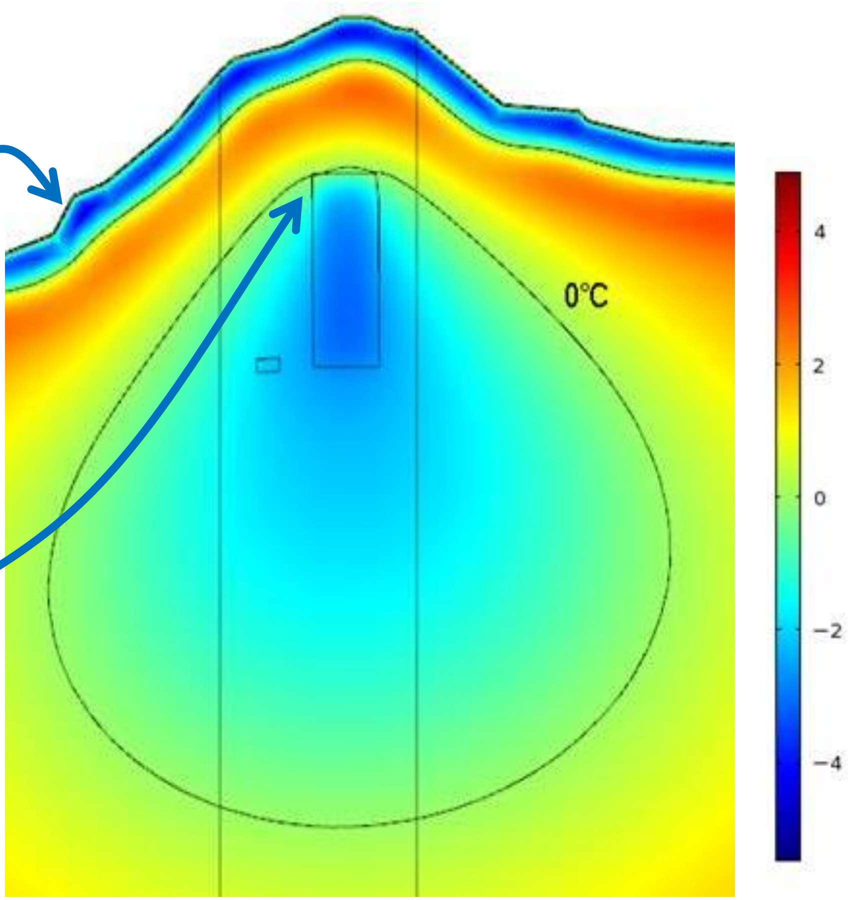
- There would be at least 20 years to fix the thermosyphons
  - Worst case geometry is a chamber next to a pit
  - Still twenty years before the thawing reaches the upper corners of the dust

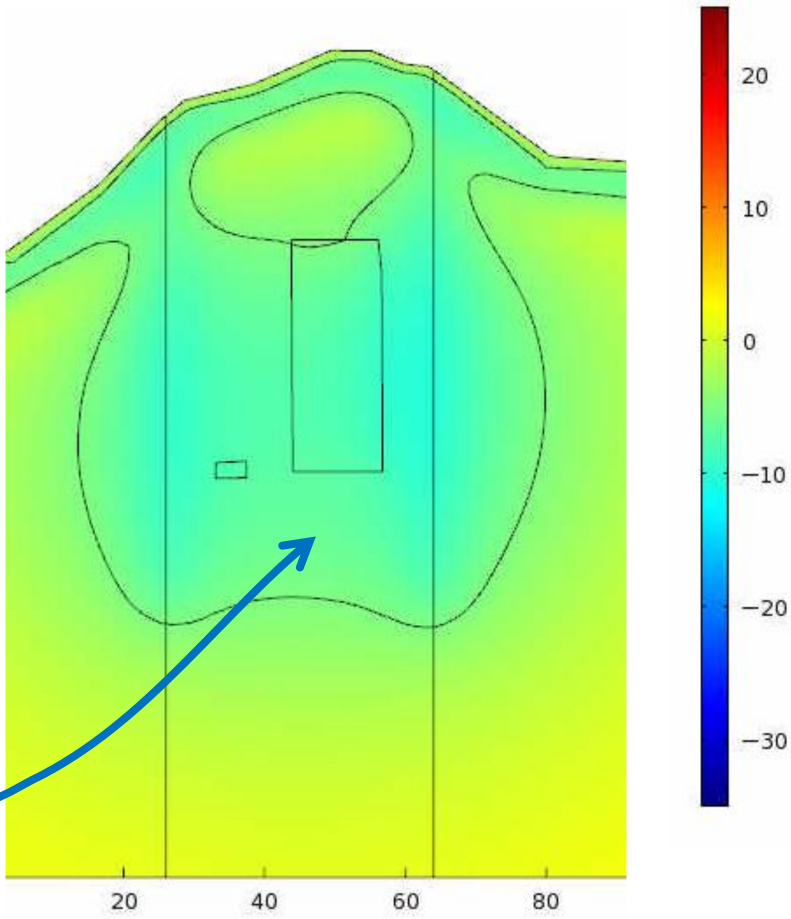


DESIGN IMPROVEMENTS

- Important part of the engineering process
- New information
  - Environmental assessment
  - Stakeholder input
  - Field tests and engineering studies
- Optimization at every step
  - "Is there a way to do this even better?"

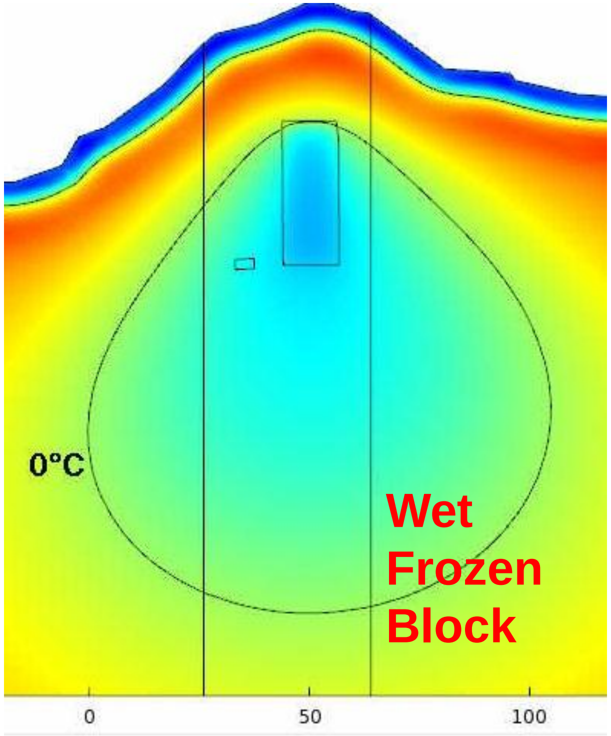
Possible Design Improvements (Example 1)

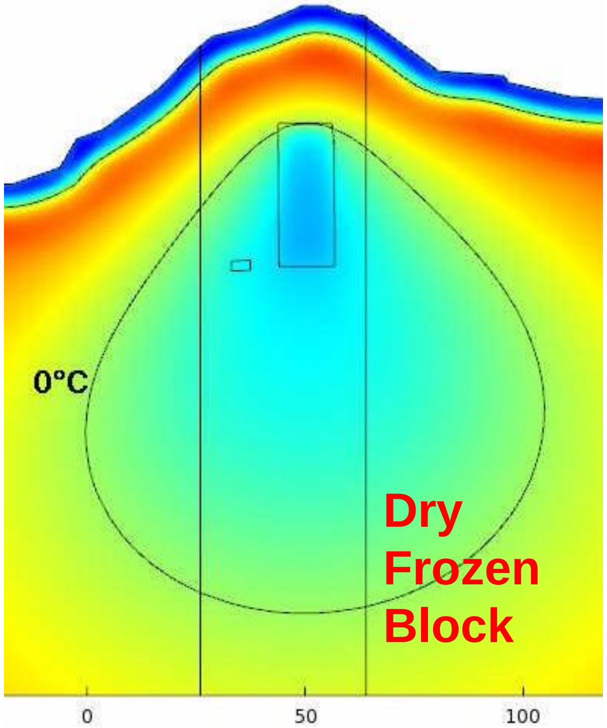
- Rock below chambers and stopes freezes very rapidly
- Might not need horizontal pipes under the arsenic dust
- This example shows freezing with surface thermosyphons only
- Note good freezing of rock below chamber



Possible Design Improvements (Example 2)

– Rock around a dry frozen block stays cold for as long as rock around a wet frozen block
– Might not need to add water





Both figures assume extreme climate warming & all thermosyphons inoperable for 20 years

Possible Design Improvements (many other examples):

- More pipes, less pipes, deeper pipes?
- Active or hybrid, pipe diameter, pipe materials, freeze plant type and size, power supply, etc.
- Temperature monitoring by thermistors or thermocouples, how many, where located, etc.
- Data handling methods, error checking, report generation, remote access, stakeholder access, etc.

All part of further engineering design

- Please note:
  - Possible design improvements will continue to be raised throughout the engineering process
    - Interested in improvements of all kinds
    - No changes that result in negative effects beyond those assessed in this EA

5. Summary

- The arsenic trioxide dust has been a source of public concern for many years
  - We agree with that concern; in its current state, the arsenic trioxide dust represents a real risk

- The frozen block method was selected through a rigorous process and remains the best option for reducing that risk

- Many engineering details are still being discussed, but all results to date confirm that the frozen block method will:
  - Mitigate the immediate risk without creating new risks for the environment or people
  - Be monitorable, adaptable and robust over the very long term