Remedial Action Plan Development for Tundra Mine, NT

Presented by:
Valérie Bertrand, P.Geol.
Co-authors:
Tanya Schulz (Golder)
Lisa Dyer (PWGSC), Brent O'Rea (INAC)

Golder Associates

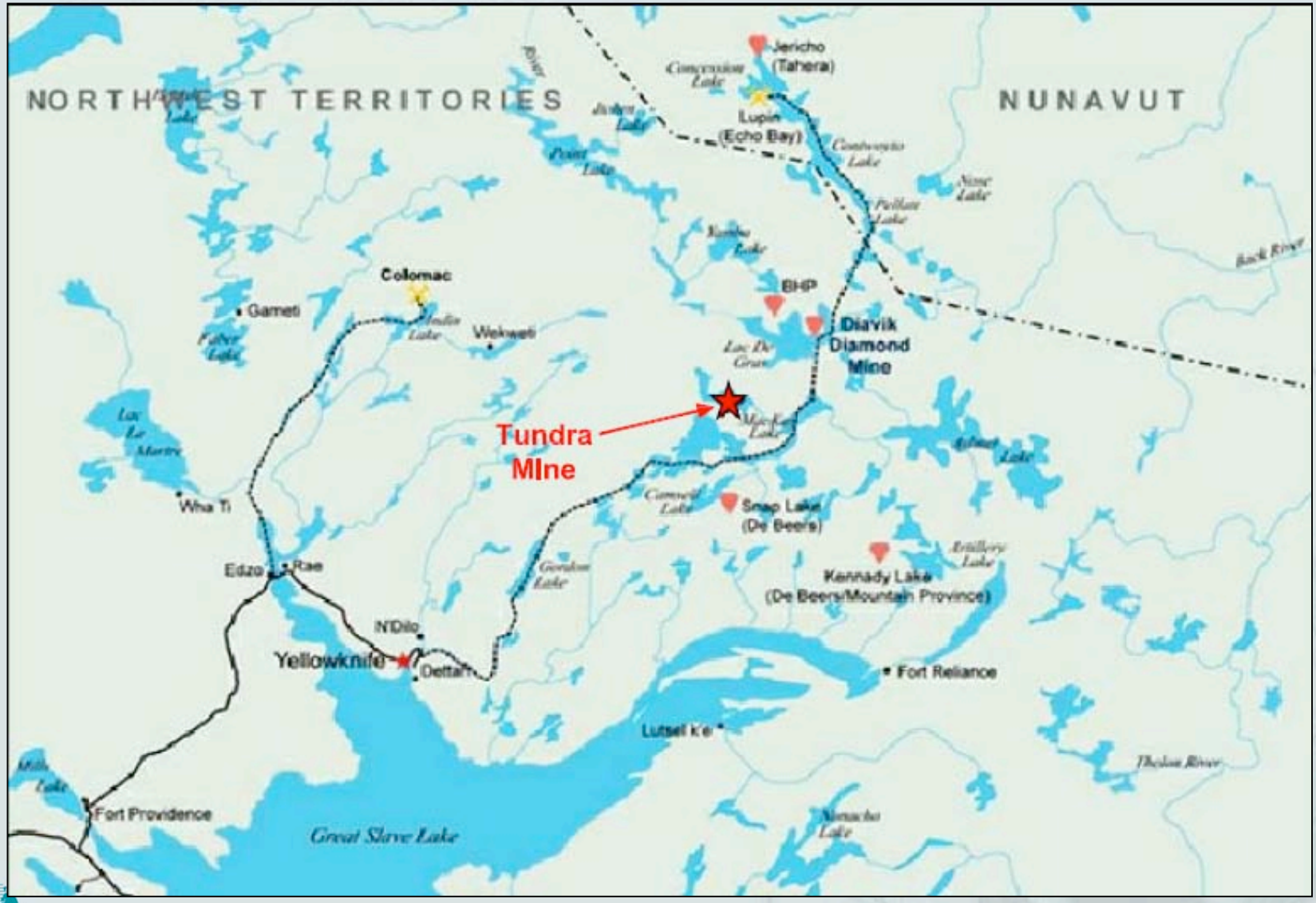
April 29, 2008

Presentation Highlights

- Site characteristics
- Design objectives
  - Evaluation criteria
- Remedial Action Plan synopsis
- RAP options considered and preferred option(s)
  - Waste rock and tailings
  - Water treatment
  - Hydrocarbon-impacted materials
- Conclusion

Golder Associates

Tundra Mine - Location



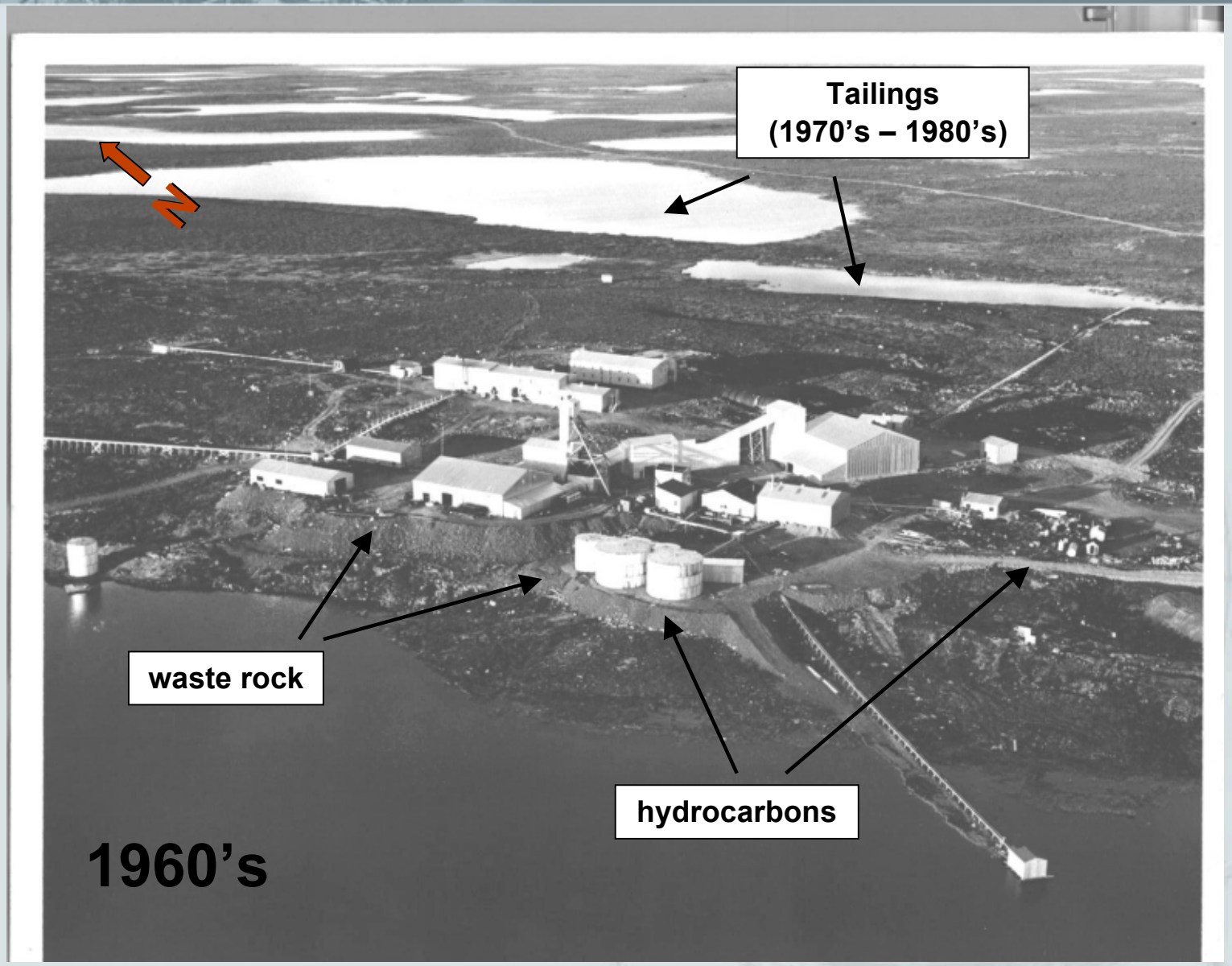
Golder Associates

Tundra Mine

- Abandoned underground gold mine and mill
  - Mine operation 1963 – 1968
  - Mill (Salmita ore) 1983 – 1987
- Mine wastes on site:
  - waste rock in pile and dams: 50,000 m^3
  - tailings pond:
    - 243,000 m^3 tailings
    - 1.2 million m3 contaminated water
  - All leach arsenic, are potentially acid-generating
- Phase I restoration, summer 2007:
  - Mine and mill buildings removed
  - Shafts blocked

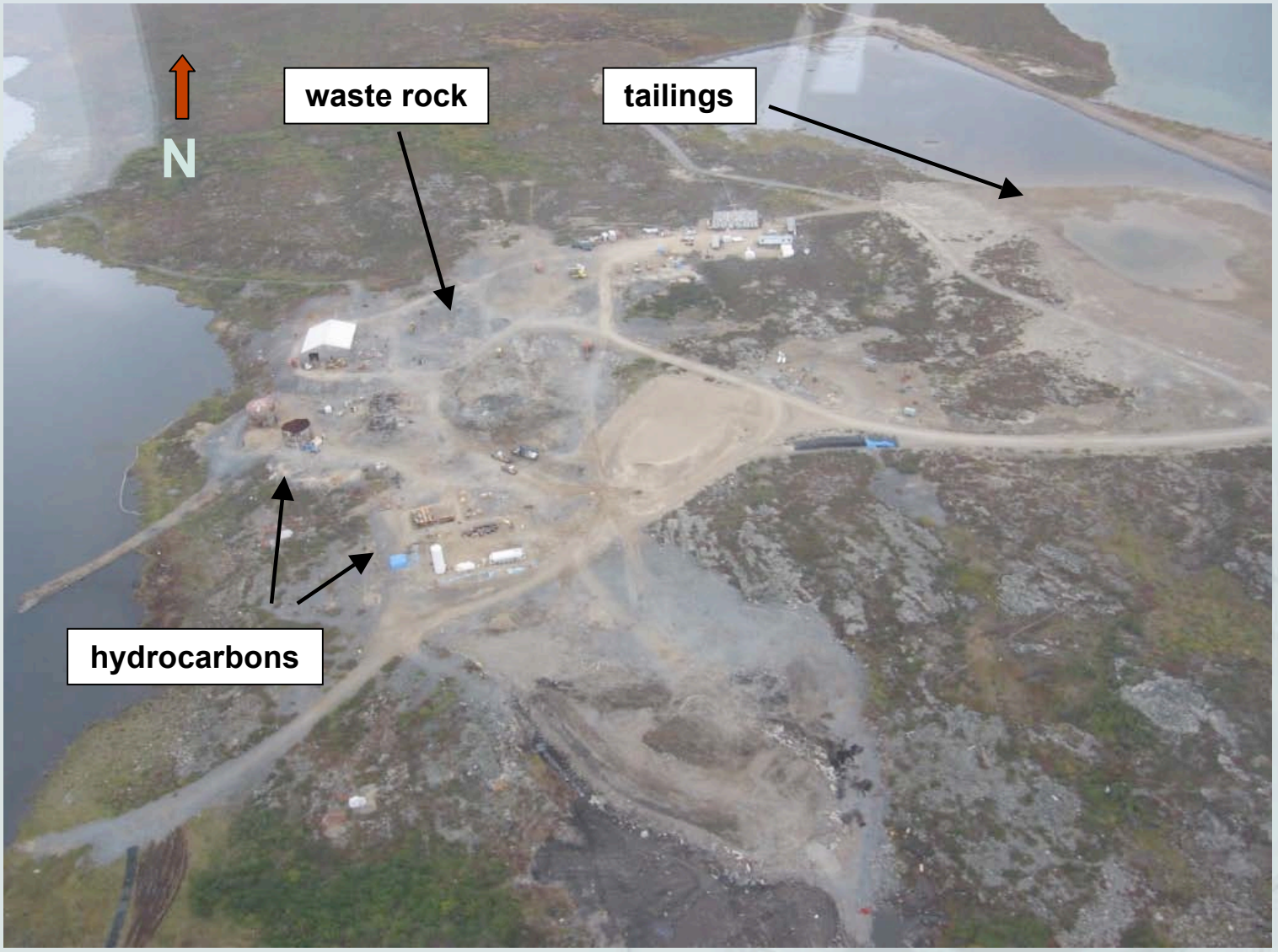
Golder Associates

Tundra Mine - Operation



Golder Associates

Tundra Site, 2007



Golder Associates

Site Characteristics

- 240 km northeast of Yellowknife
- Climate: cold, arid
  - a.a. precipitation 260mm, 140mm rainfall
  - a.a. temperature -8.5^{o}C
- Continuous permafrost – south limit
- Access: airstrip, winter road (to diamond mines and other)
- Flat topography, exposed rock, thin veneer of till

Golder Associates

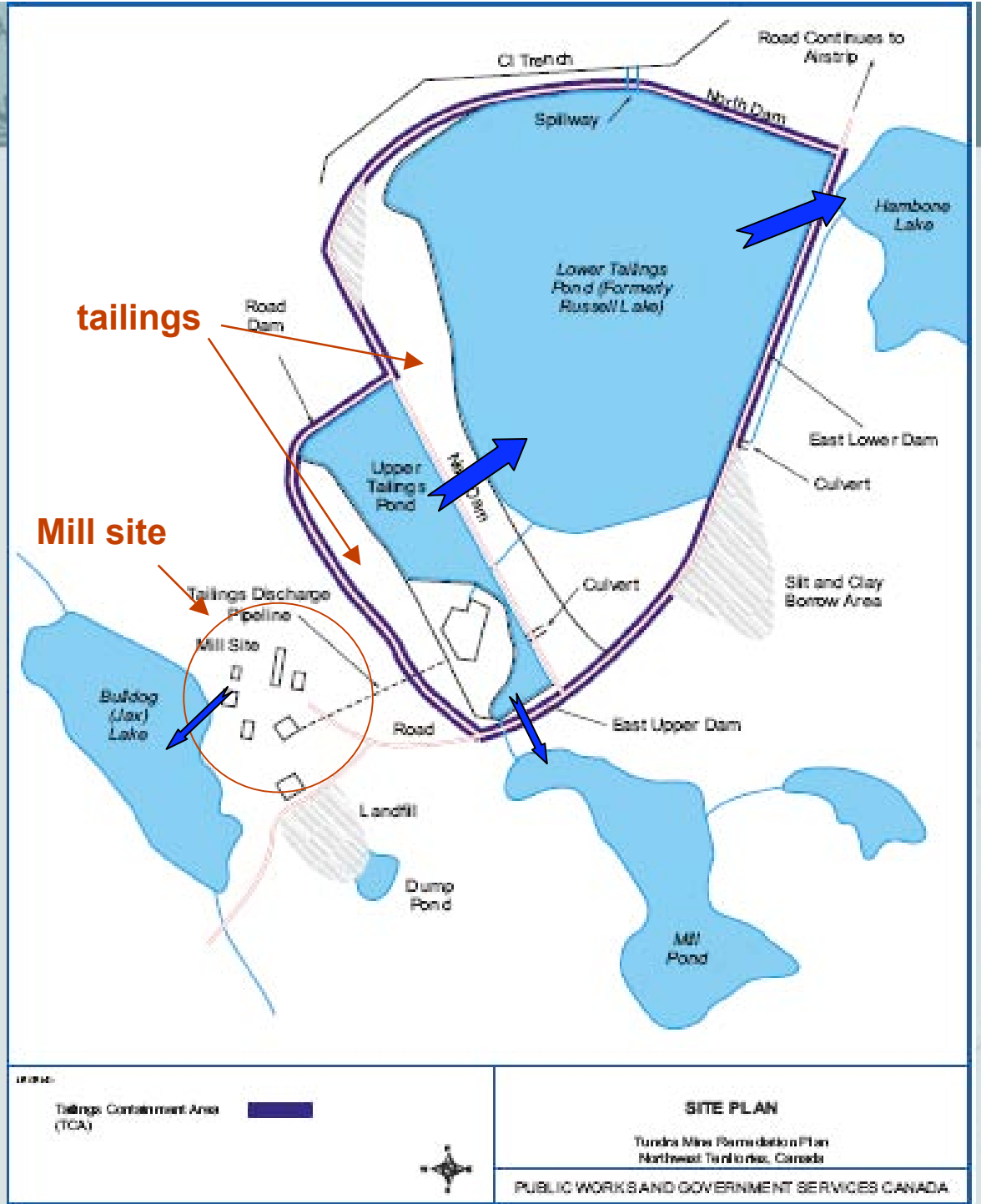
Remedial Action Plan - Synopsis

Objective:

- Develop an integrated remedial action plan (RAP) for closure of Tundra Mine
- Offer solutions that are:
  - Technically sound
  - Fiscally responsible
  - Minimize long-term maintenance
- Numerous studies done to date:
  - Site characterization,
  - Risk assessments,
  - Borrow sources,
  - Water treatability,
  - Conceptual remedial designs, etc.

Golder Associates

Site Layout



Source: URS, 2005

Golder Associates

RAP Technical Design Objectives

- Tailings and waste
  - minimize arsenic mobility
- Hydrocarbon contamination
  - remediate and/or isolate
- Water quality
  - minimize downstream impacts (discharge of untreated water)
  - Minimize future treatment requirements
- Long-term chemical and physical stability
  - Minimize monitoring and maintenance requirements

Golder Associates

Selection Criteria

- Effectiveness
  - minimize arsenic leaching and futur oxidation (acid generation)
- Liability reduction
  - minimize monitoring and maintenance
- Constructability, schedule
  - difficult access, short construction season
- Regulatory and community acceptance
  - long-term water quality, dam reliability, safety
- Cost
  - Construction, monitoring, potential for future remedial action

Golder Associates

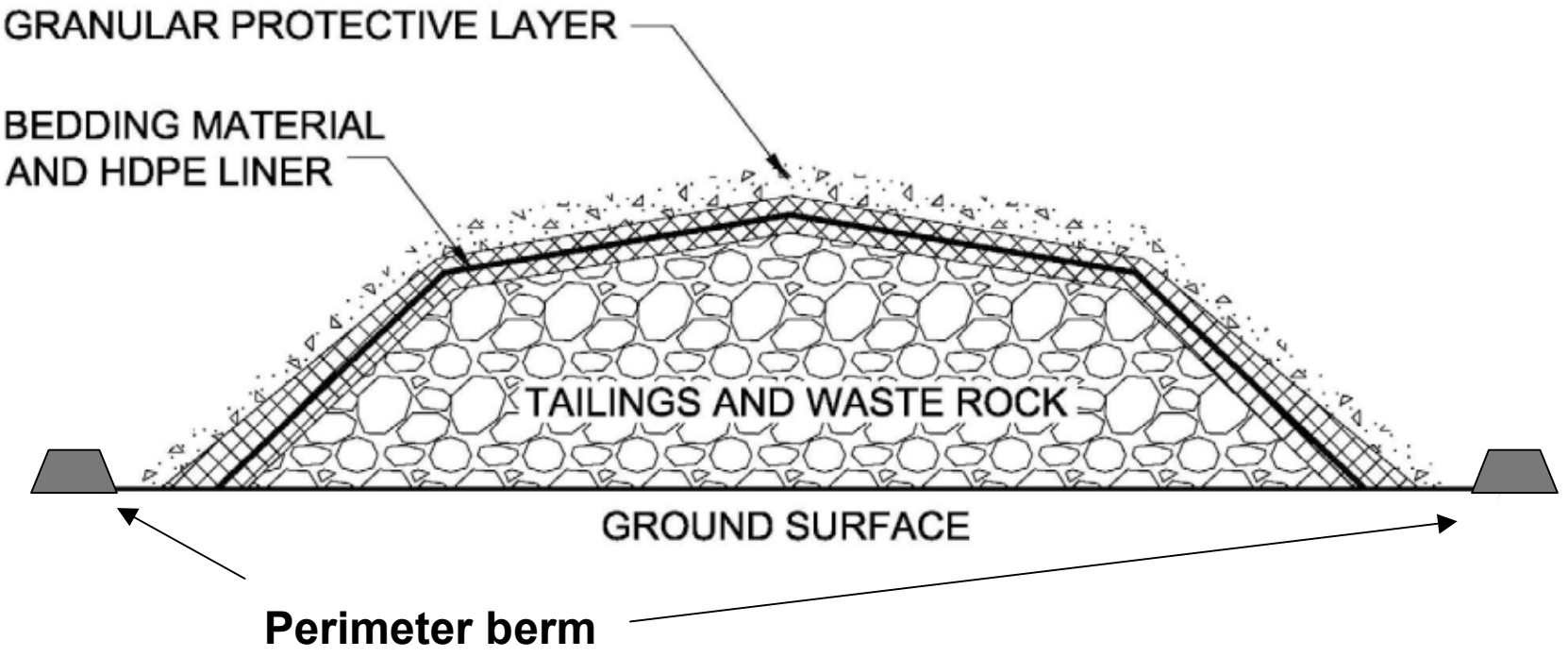
RAP Options – Waste Rock and Tailings

- All options: treat water, move waste rock
- Major considerations:
  - source of borrow, arsenic mobility, constructability

Dry Cover	**Upland**	**Option 1**	**Geo-membrane**
		Option 2	**Capillary Break**
Combination Wet & Dry Cover	**Lower Water Level**	**Option 3**	**Capillary Break**
	Maintain Water Level	**Option 4**	**Capillary Break**
	Raise Water Level	**Option 5**	**Capillary Break**
Dry Cover	**Lower Pond**	**Option 6**	**Geo-membrane**
Wet Cover	**Lower Pond**	**Option 7**	**Water**

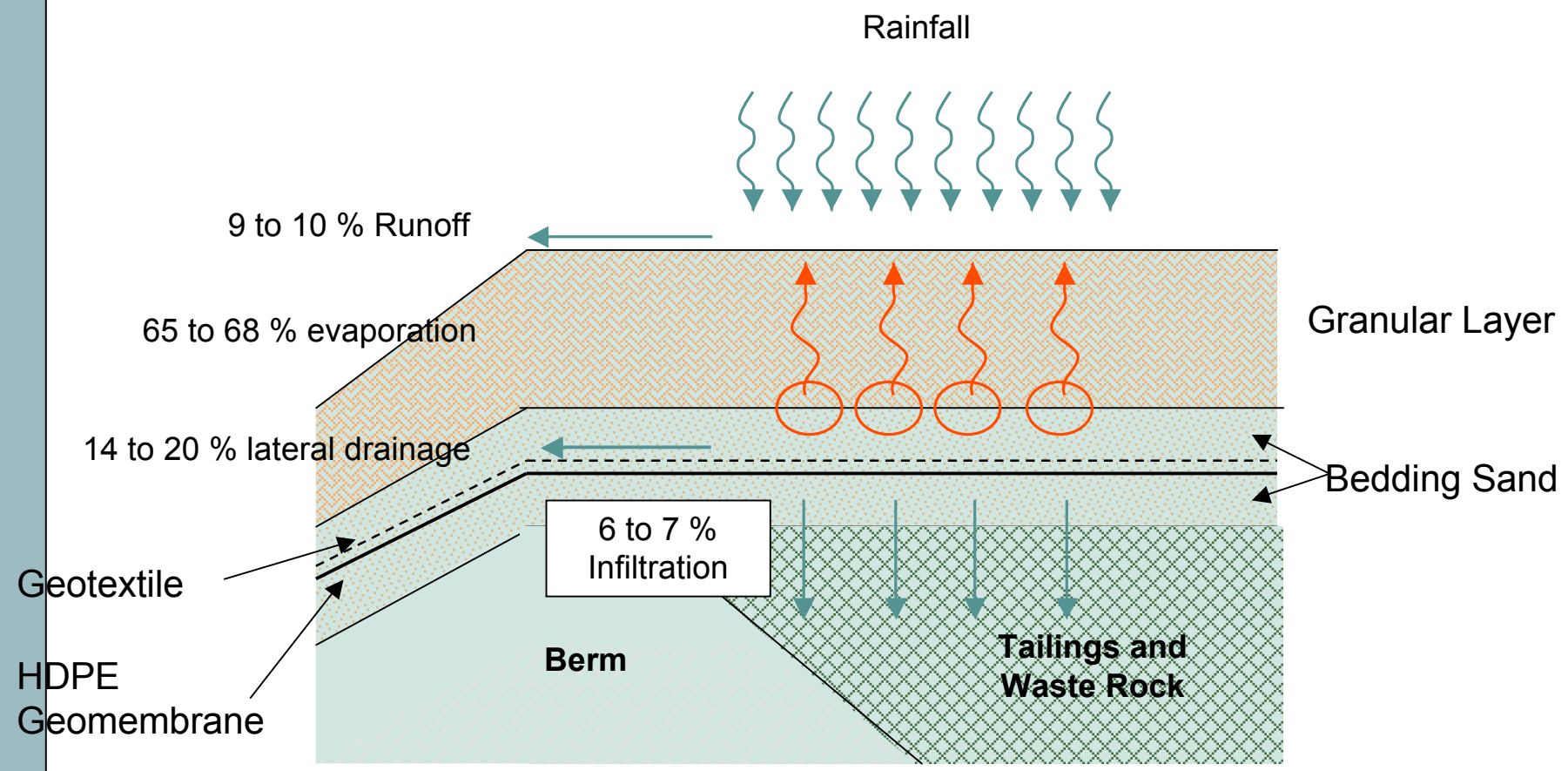
Golder Associates

Cover Options 1 and 2



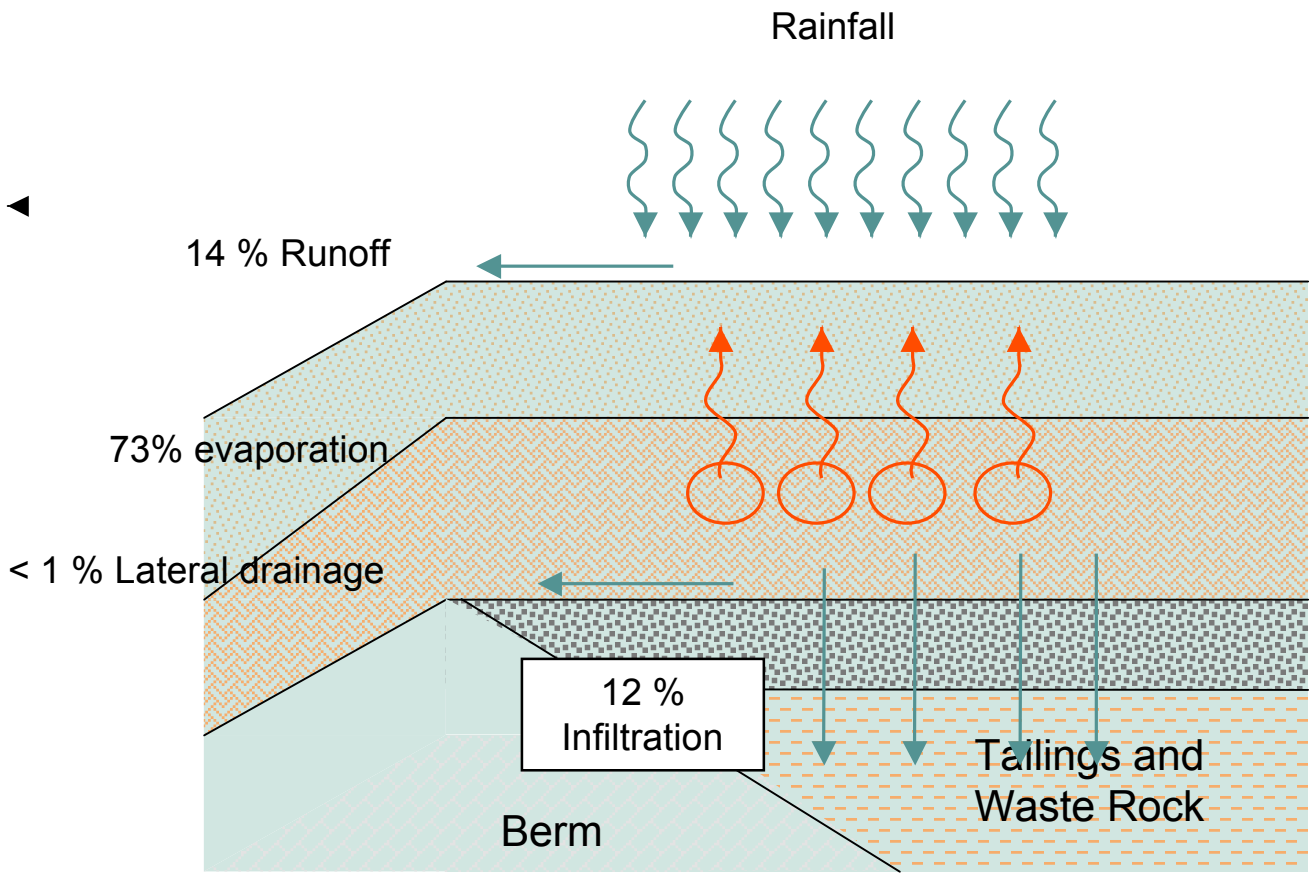
Golder Associates

Cover Option 1 – Geomembrane

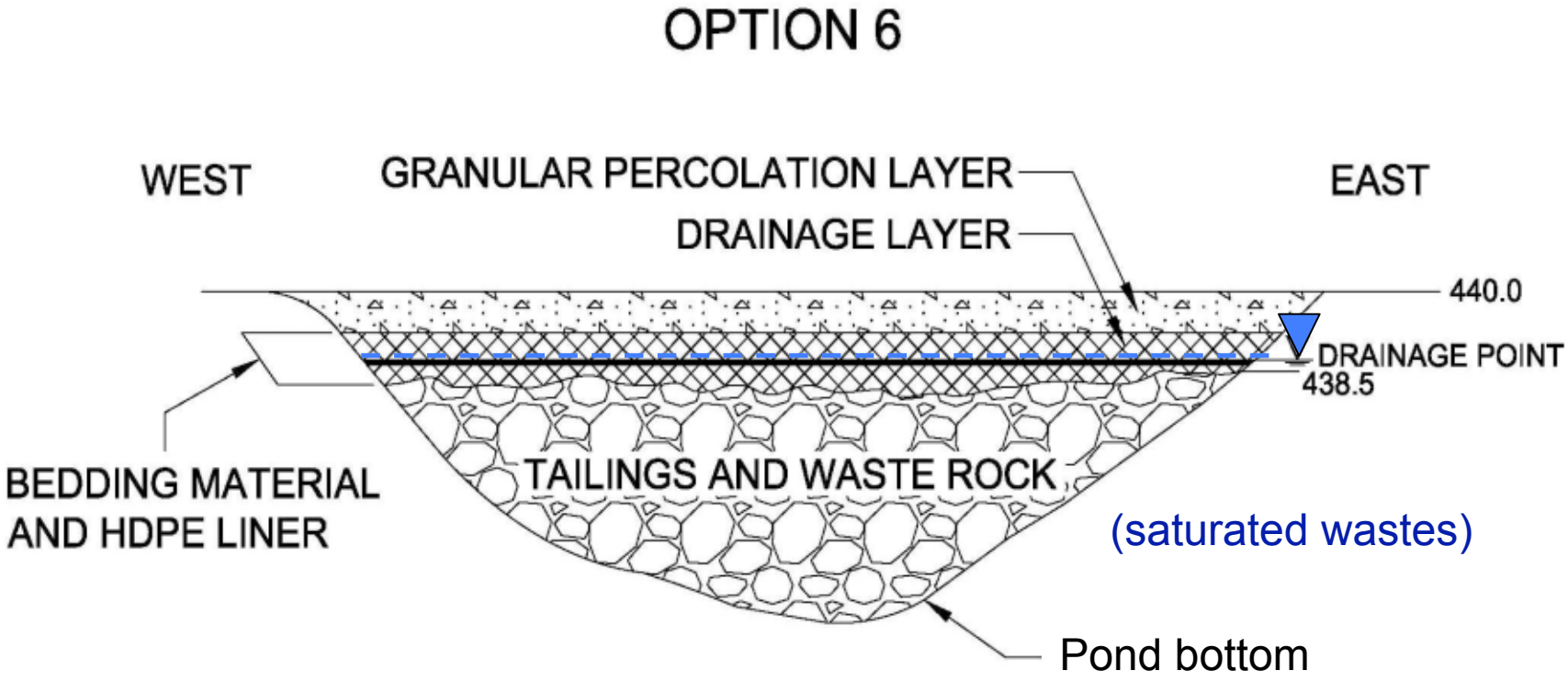


Golder Associates

Cover Option 2 – Capillary Break Cover



Cover Option 6



Golder Associates

RAP Options – Water Treatment

Key Issues

- Upper and Lower ponds: 1.2 million m^3 arsenic-impacted water
- Treatment and removal required to access tailings
- Discharge criteria based on site specific risk analyses
  - maximum acceptable conc. = 0.20 mg/L As
  - Safety target = 0.05 mg/L As

Major Considerations

- Constructability
- Technical difficulty of operation

Golder Associates

RAP Options – Water Treatment

Ferric iron co-precipitation:

- Conventional treatment plant
- Pre-packaged treatment plant
  - Actiflo ™
- In-situ treatment using the following to create cells in the ponds:
  - Aqua Dams
  - Baffle curtains

Adsorption technology

Golder Associates

RAP Options – Water Treatment

- Preferred Option
  - pre-packaged treatment plant, iron co-precipitation
  - Similar effectiveness to conventional treatment plant but easier implementation (smaller size,modular design)
- Other potential application
  - Adsorption technology
    - requires pilot testing, uncertain efficiency
    - Impact on schedule

Golder Associates

RAP Options – Hydrocarbons

- Challenge:
  - hydrocarbon contaminated waste rock also potentially acid generating
- Options considered:
  - off-site disposal: $$$
  - soil washing: not practical in site climate
  - dig and encapsulate into secure landfill: long-term liability
- ★ Preferred option:
  - aeration, soil venting
  - disposal of waste rock into mine waste pile.

Golder Associates

Conclusion

Summary

- 3 technically acceptable cover options
- Need to advance some details of design to select the preferred option

Path Forward

- Selection of option(s) to advance to detailed design
- Community and regulatory approval

Golder Associates

Acknowledgments

Public Works Government Services Canada (PWGSC)

- Lisa Dyer

Indian and Northern Affairs Canada (INAC)

- Brent O'Rea
- Mike Nahir

Golder Associates Ltd.

- Tanya Schulz
- John Hull
- Nural Kuyucak
- Jennifer Gibson
- Don Plenderleith
- Anne-Marie Dagenais
- Jennifer Cole

Golder Associates

Thank You

Questions?

Golder Associates