



Canadian Experience in Uranium Tailings Management

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- History of Development for Uranium Tailings Management in Saskatchewan
- Saskatchewan Experience
 - Beaverlodge, Gunnar, Lorado
 - Key Lake AGTMF, Rabbit Lake AGTMF, Cluff Lake
 - Rabbit Lake In-Pit TMF
 - Key Lake Deilmann TMF
 - McClean Lake JEB TMF
- Ontario Uranium Developments
- Conclusions

Introduction

- Northern Saskatchewan was primary development area for Uranium mill tailings management technology
- No control on mill or mine discharges until 1977
- 4 major phases in development of control of releases from Uranium mines and mills



Introduction (cont'd)

- Phases of development
 - Free discharge of tails until 1977: (1st generation)
 - Engineered surface structures above water table 1979-82: (2nd generation)
 - Pit disposal with pervious surround, 1982-97: (3rd generation)
 - Pit disposal with natural surround and engineered tailings: (4th generation)
- Progressively higher levels of environmental protection achieved

Saskatchewan Uranium Mining Sites



History

- Early focus on radium;
 - Uranium had no commercial value until after 1940
 - Uranium was waste product
- 1933 - Radium mine opened at Port Radium, NWT; Refinery opened at Port Hope, Ontario
- 1934 - Uranium discovered at Goldfields Mine on Lake Athabasca, Saskatchewan
- 1946 - AECB established to administer Atomic Energy Control Act



History (cont'd)

- 1949 - Eldorado started mining at Beaverlodge on Lake Athabasca
- 1952 - Uranium City established
- 1953 - Beaverlodge Mine commenced production
- 1955 - Gunnar Mine commenced production; closed in 1964
- 1957 - Lorado Mine commenced production: closed in 1960
 - IAEA established to administer international safeguards

History (cont'd)

- 1968 - Rabbit Lake deposit discovered
- 1969 - Cluff Lake deposit discovered
- 1975 - Key Lake deposit discovered
 - Rabbit Lake began production
 - First 2nd generation facility



History (cont'd)

- 1977 - Cluff Lake Board of Inquiry established
- 1979 - Mines Pollution Control Branch set up by Saskatchewan Environment
 - Comprehensive environmental regulations established for uranium mines in Saskatchewan
- All mines thereafter subjected to comprehensive joint Federal-Provincial regulation



History (cont'd)

- 1980 - Cluff Lake begins production
- 1982 - Beaverlodge production ceases
 - Key Lake production begins
 - Rabbit Lake pit commissioned
 - First of 3rd generation facilities
- 1983 - Cigar Lake deposit discovered
- 1985 - Beaverlodge decommissioning completed
 - Last of 1st generation facilities



History (cont'd)

- 1987 - McArthur River discovered
- 1989 - Joint federal/provincial panel established to review 5 projects
 - Full review of tailings management practices
- 1997 - Deilmann Pit disposal approved at Key Lake
- 1999 - McClean Lake production begins
 - First of 4th generation facilities



Uranium City Area Mine Sites





Beaverlodge Area

- North shore of Lake Athabasca
- First production in 1953
 - 10 mines in total
- Three mills with capacities of, 2000, 2000, 750 tpd
- Only Beaverlodge produced after 1964
 - Shutdown in 1982

Beaverlodge

- Started milling in 1953
- Slurried tailings discharged at 21% solids
 - Sand fraction removed for backfill
 - Remainder discharged directly to lake

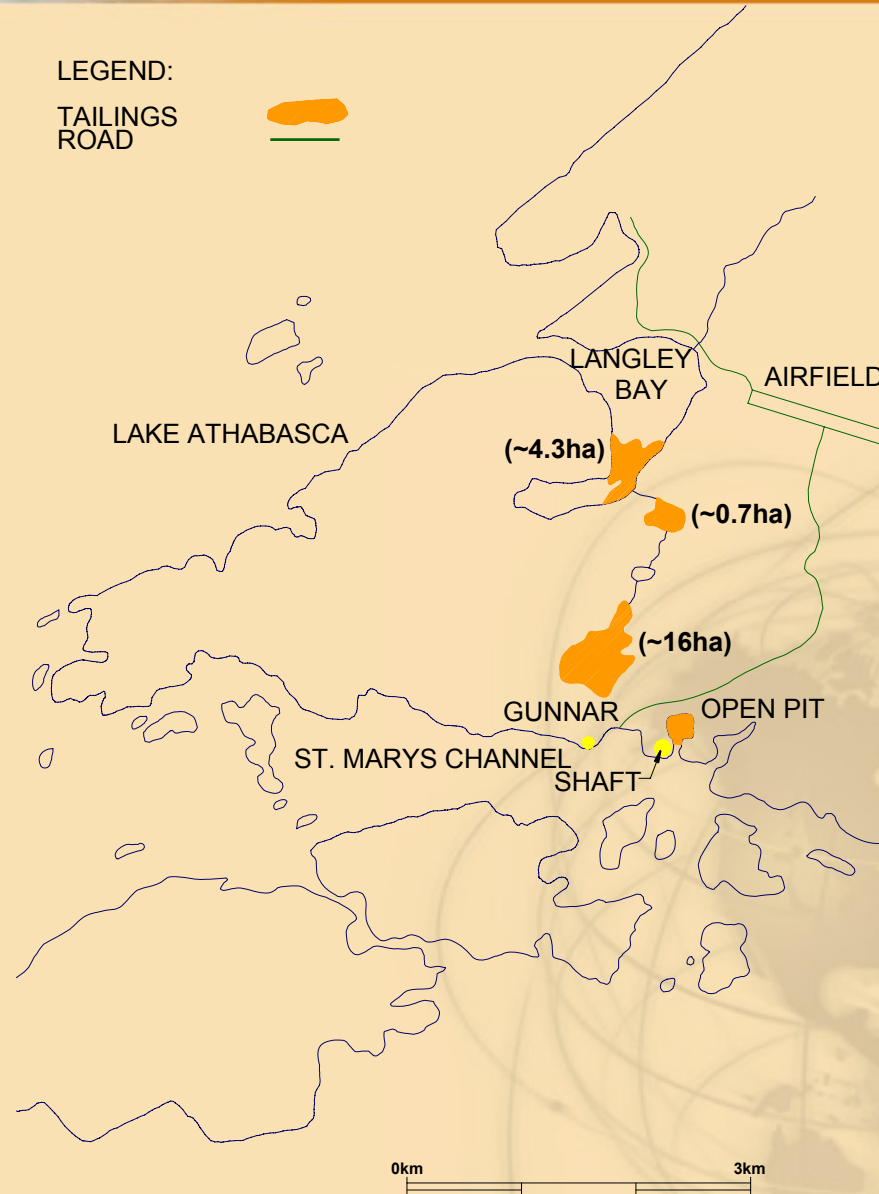
Beaverlodge Tailings System

- 10.1Mt produced
- 4.3Mt used as backfill
- No effluent control until 1977



Gunnar

- Mine opened in 1955
- First open pit uranium mine in Sask.
- Open pit and underground mine
- Milled 5.5 Mt of ore
- Ceased production in 1964



Gunnar Site

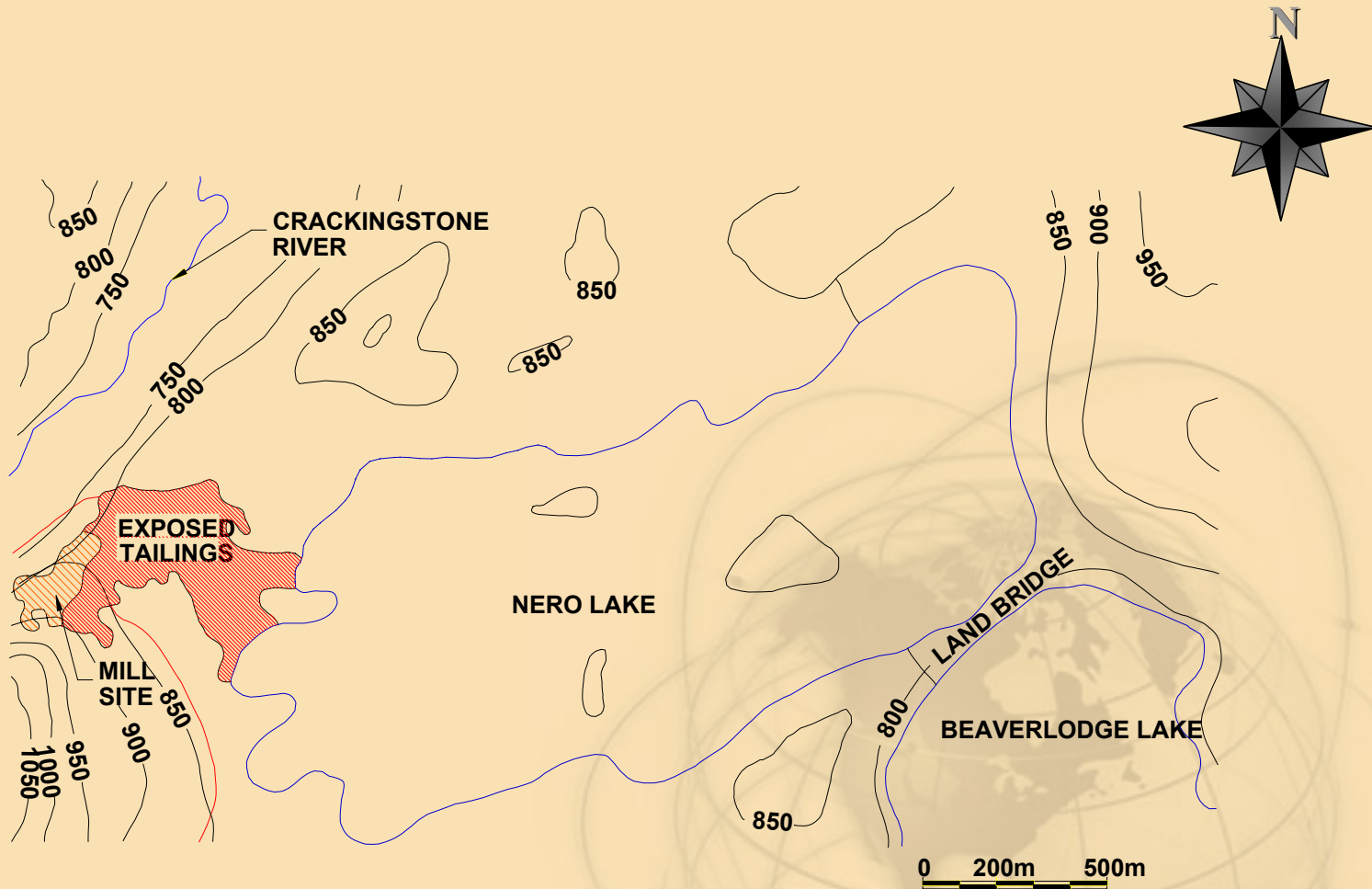


Gunnar Pit & Tailings Area



Lorado Tailings Area

- Mine opened in 1954
- Mill opened in 1957
- Custom Mill ores from several mines
- Milled 0.5Mt of ore
- Ceased operations in 1961



Lorado Site

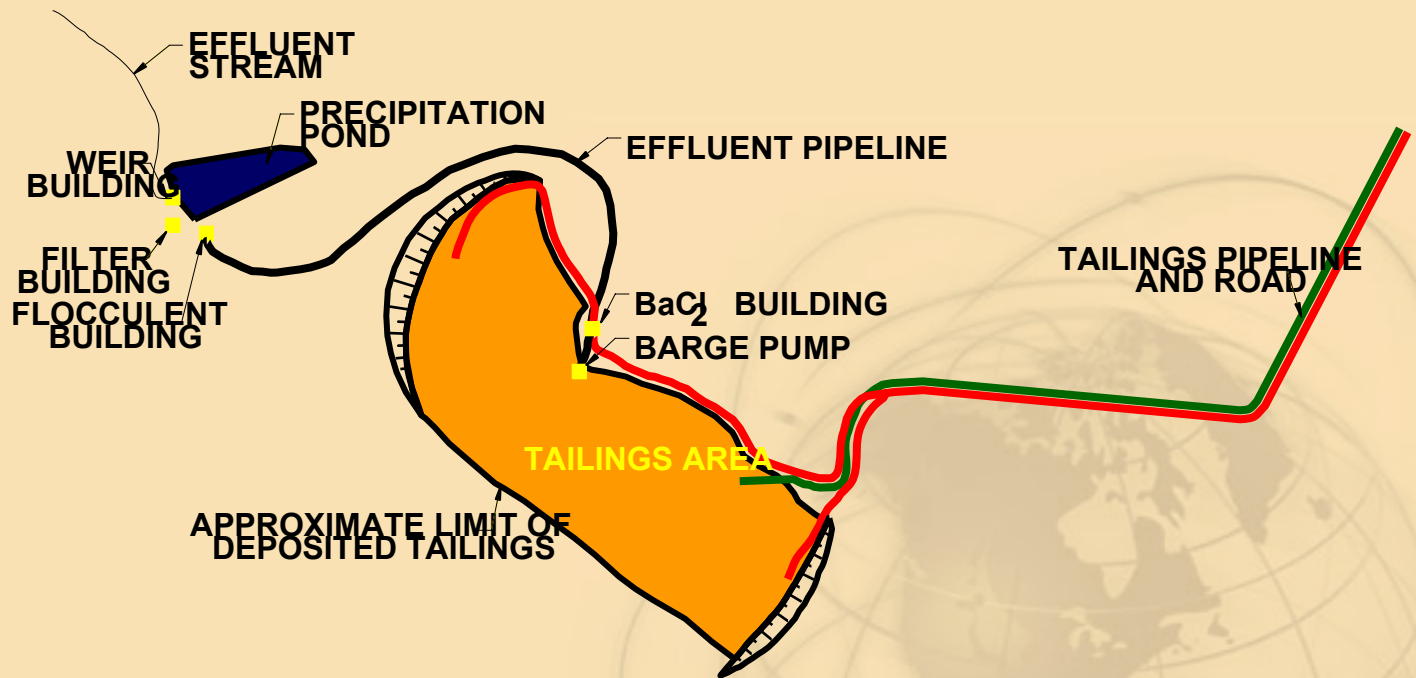


Rabbit Lake Site



Rabbit Lake Tailings - 1975

- Conventional valley dam constructed of cycloned tailings and till
- First fully engineered tailings containment structure (2nd generation)
- Adequate for Rabbit Lake ore only

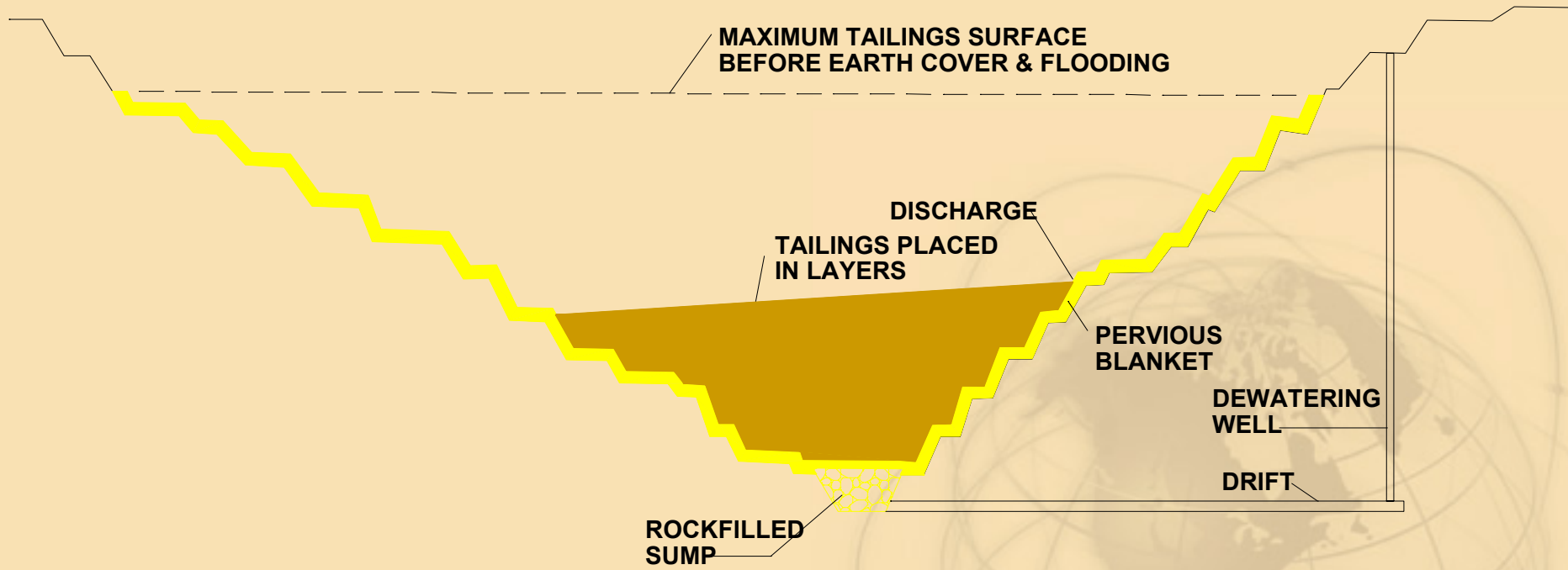


Rabbit Lake Pit - 1985

- First storage of tailings below water table
- First of 3rd generation
- Incorporated pervious surround
- Segregation and freezing detected in hydraulically placed thickened tailings



Rabbit Lake Pit Pervious Surround

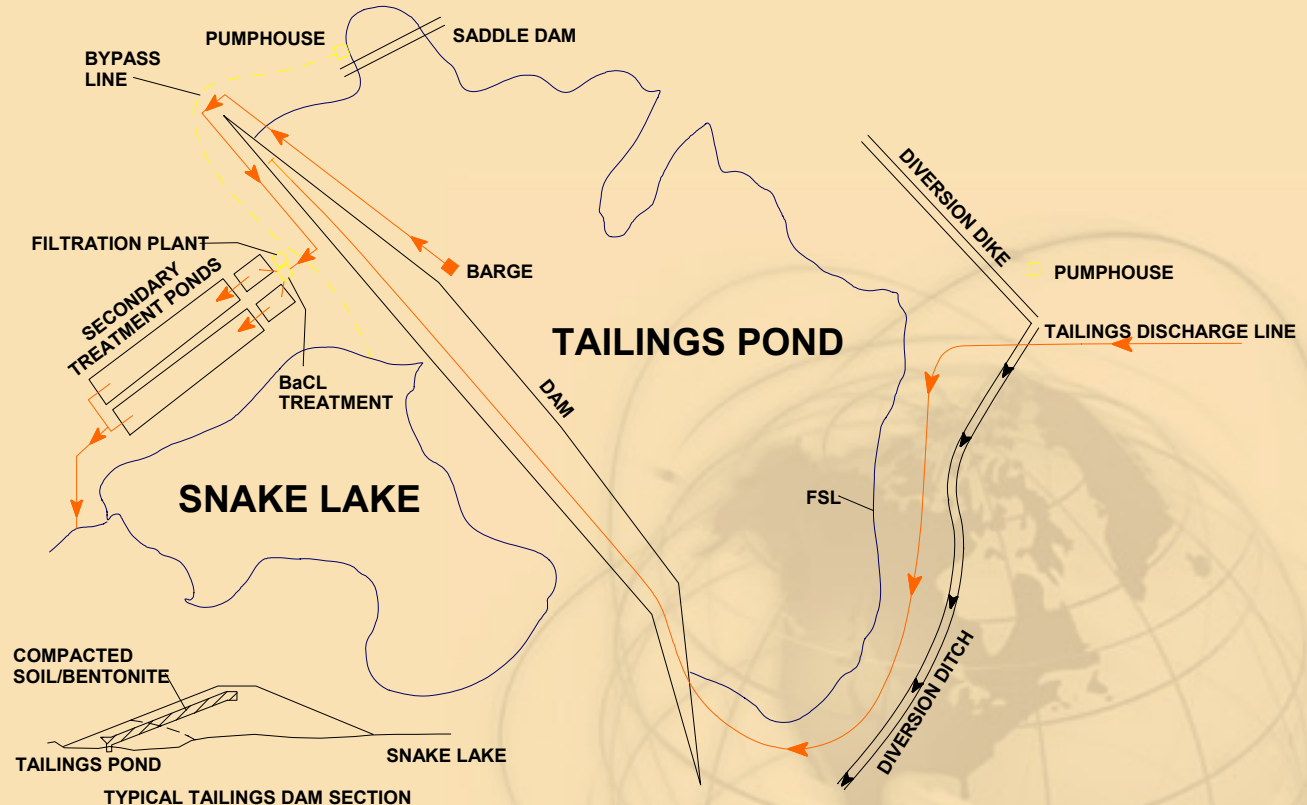


Rabbit Lake Pit Pervious Surround

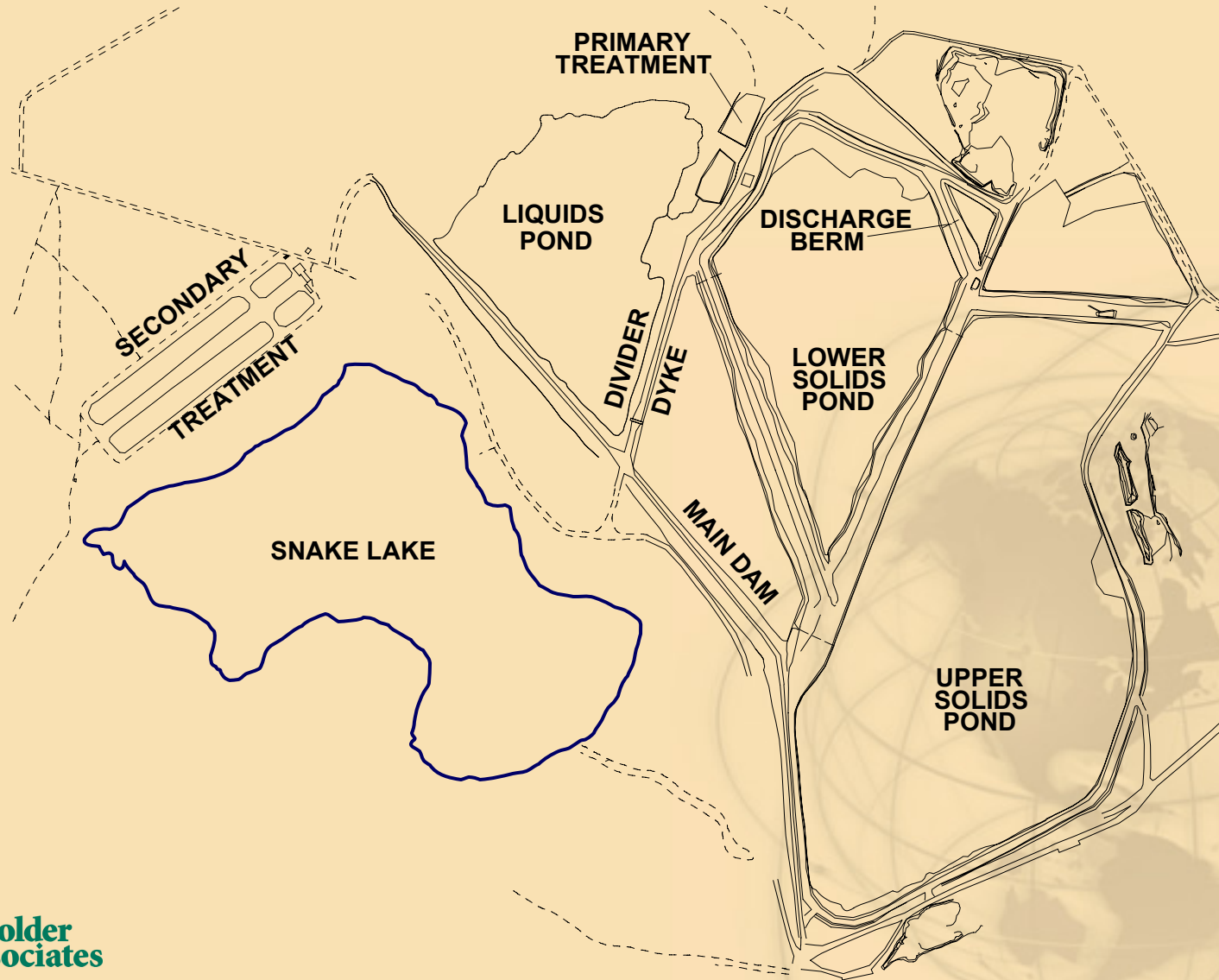


Cluff Lake Waste Mgmt System - 1982

- First jointly regulated tailings facility in Saskatchewan (2nd generation)
- Some segregation, controlled by cross dykes and discharge density
- No evidence of ice build-up
- Site closure in progress



Cluff Lake Water Mgmt System - 1999



Key Lake - 1995

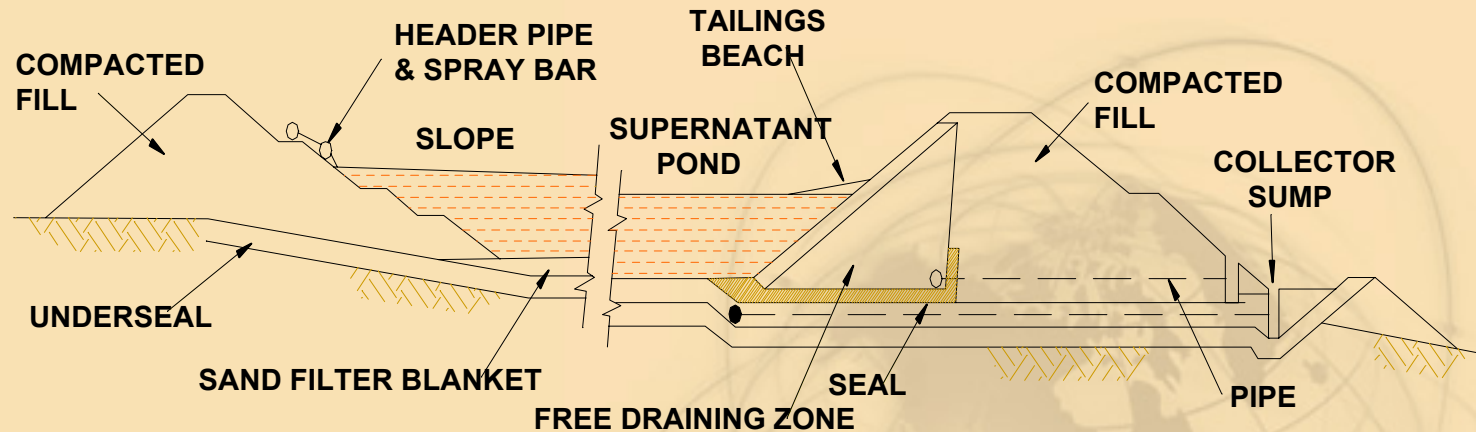


Key Lake - 2008



Key Lake Layered Tailings - 1983

- Designed on “subaerial” principal (2nd generation)
- Segregation and permanent freezing were issues
- Cross dykes installed to control segregation and reduce freezing
- Mechanical thawing undertaken



Key Lake TMF - 1995

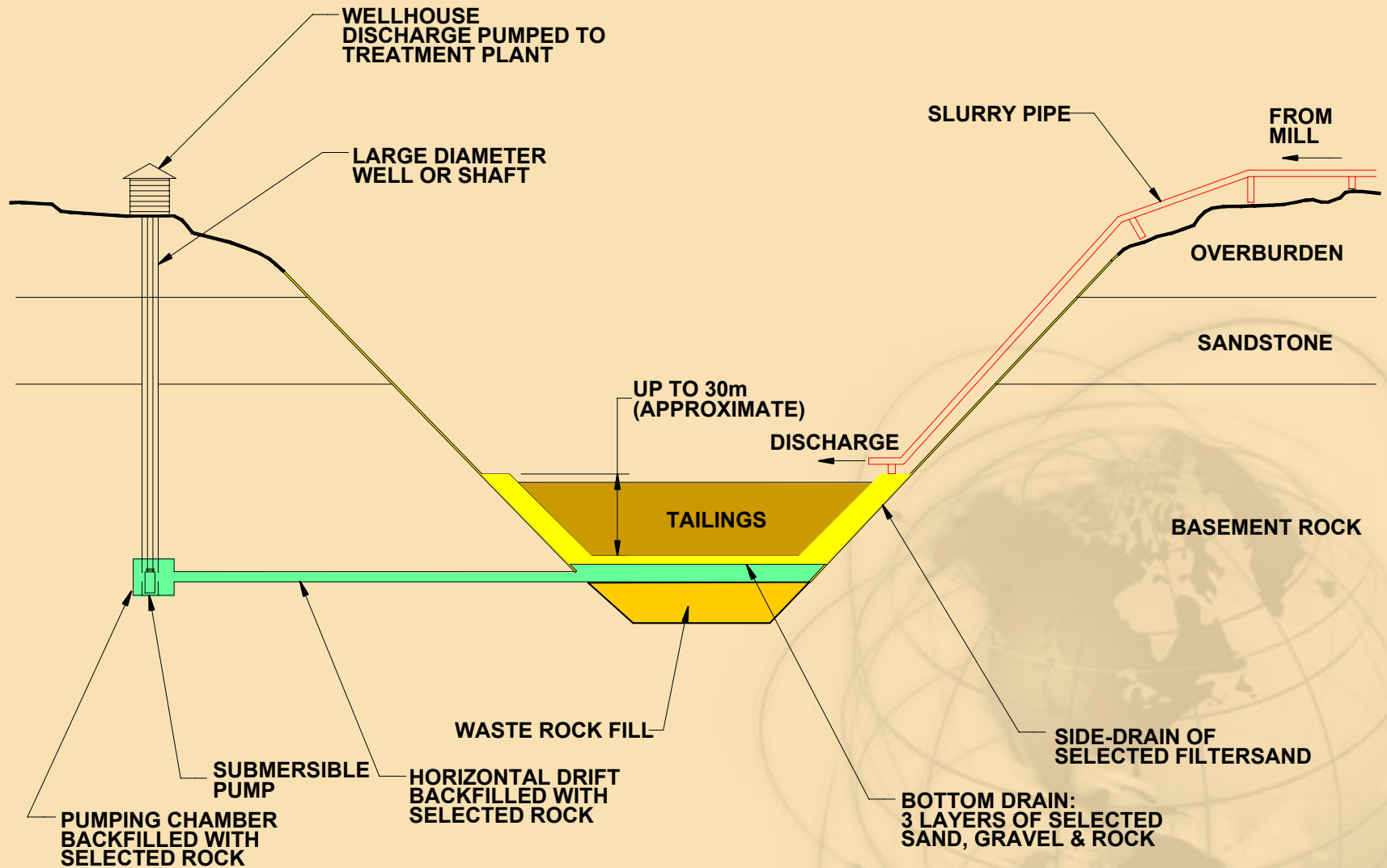


Deilmann Pit - 1995

- Outwash, till, sandstone, basement
- Dynamic groundwater system
- Composite design (3rd generation)
- Pervious surround on lower level
- Hydraulic placement of thickened tailings



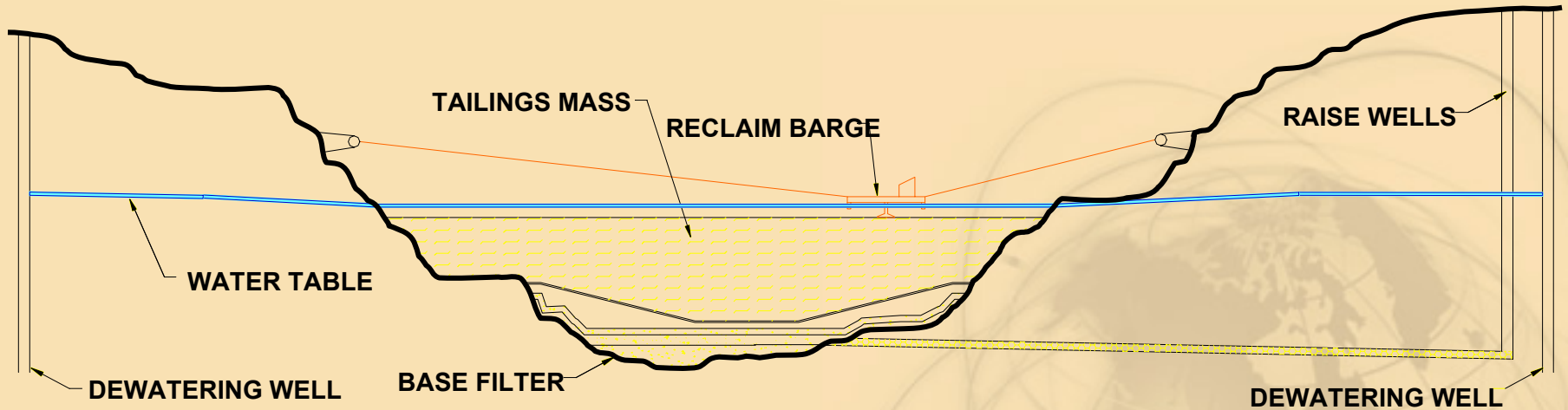
Key Lake DTMF - 1996



McClellan Site - 1995



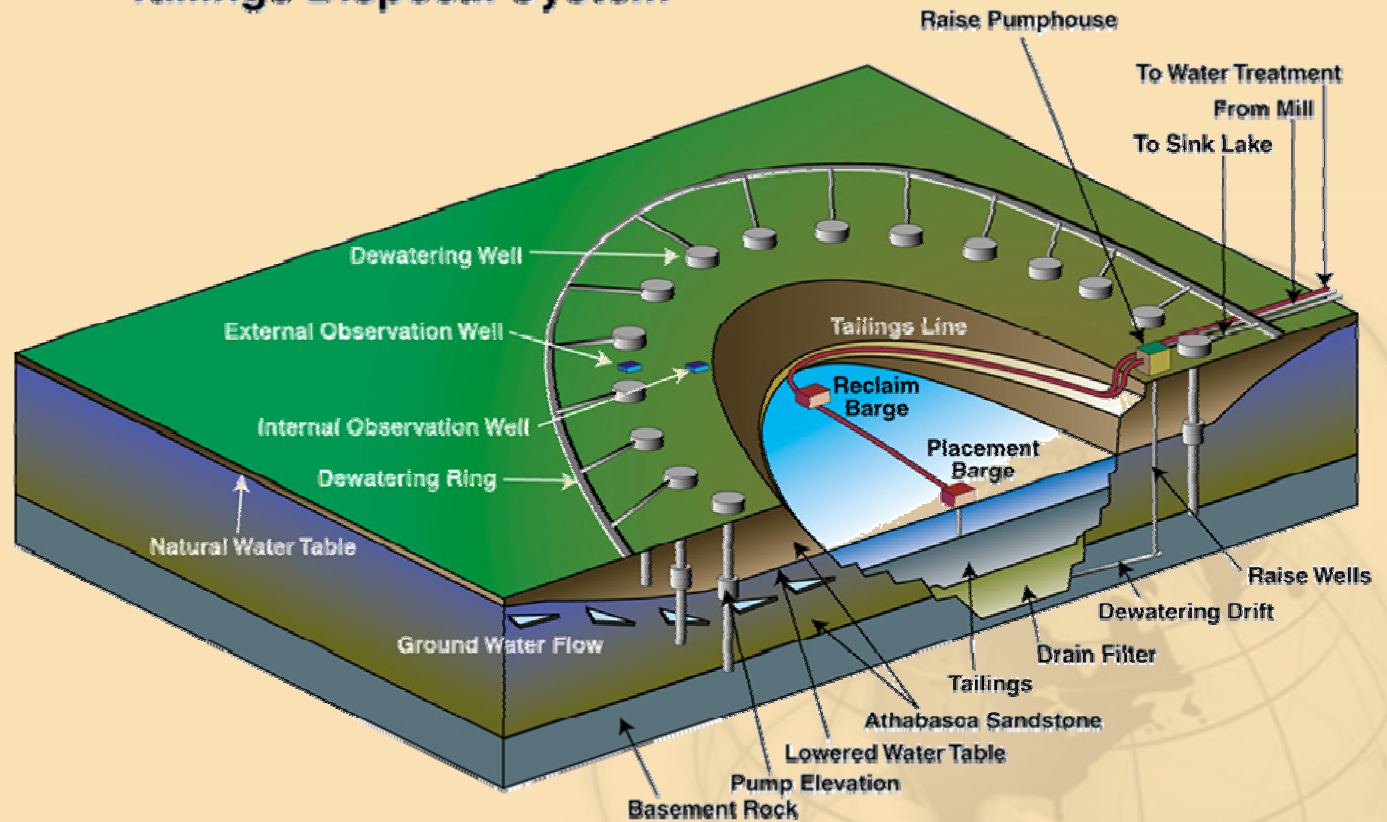
Jeb Pit Natural Surround - 1999



Jeb Pit

- 4th generation
- Hydrological and hydro-geological containment
- Engineered tailings
- Geo-chemical containment
- Passive system upon closure

Tailings Disposal System



Conclusions

- 4 distinct stages of tailings development in Saskatchewan uranium mines
- Prior to 1977, disposal was in most convenient fashion
 - First discharged water treatment undertaken in 1977
- Comprehensive regulations instituted in 1979
- Key Lake, Cluff Lake and Rabbit Lake tails 2nd generation facilities
 - Engineered structures above water table



Conclusions (cont'd)

- Rabbit Lake pit, Deilmann pit and JEB pit are 3rd generation facilities
 - Thickened railings below water table: pit disposal schemes
 - Migration from sub-aerial to sub-aqueous discharge to overcome climatic issues
- McClean Lake (JEB pit) is first of 4th generation facilities incorporating “engineered tailings” to address source term concerns



Conclusions (cont'd)

- Geotechnical engineering has delivered progressively greater degree of environmental protection even though ore grade and complexity has increased dramatically



Ontario Uranium Production

- Thirteen (13) Uranium mines with nine (9) associated tailings facilities operated in the Elliot Lake area
- Over 160 million tonnes of tailings generated during approximately 40 years of operations
- Operations at four mines continued into 1990's
 - Quirke (1990)
 - Panel (1990)
 - Denison (1992)
 - Stanleigh (1996)

Ontario Uranium Production (cont'd)

- The tailings facilities for the four mines of interest contain approx. 145 million tonnes of tailings
- Tailings have relatively high pyrite content
- Acid generation from oxidation of tailings is most serious problem with the tailings
- 85 per cent of the radioactivity from the original ore remains in the tailings

Elliot Lake Uranium Mines



Denison Mine TMA-1



Denison Mine TMA-2



Stanrock TMA



Quirke TMA



Quirke TMA



Panel TMA



Spanish American TMA



Stanleigh TMA



Lacnor TMA



Nordic TMA



Pronto TMA





Thank-you!
Questions?

