Climate Change, a Challenge to Mine Reclamation in the North

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Northern Latitudes Mine Reclamation Workshop

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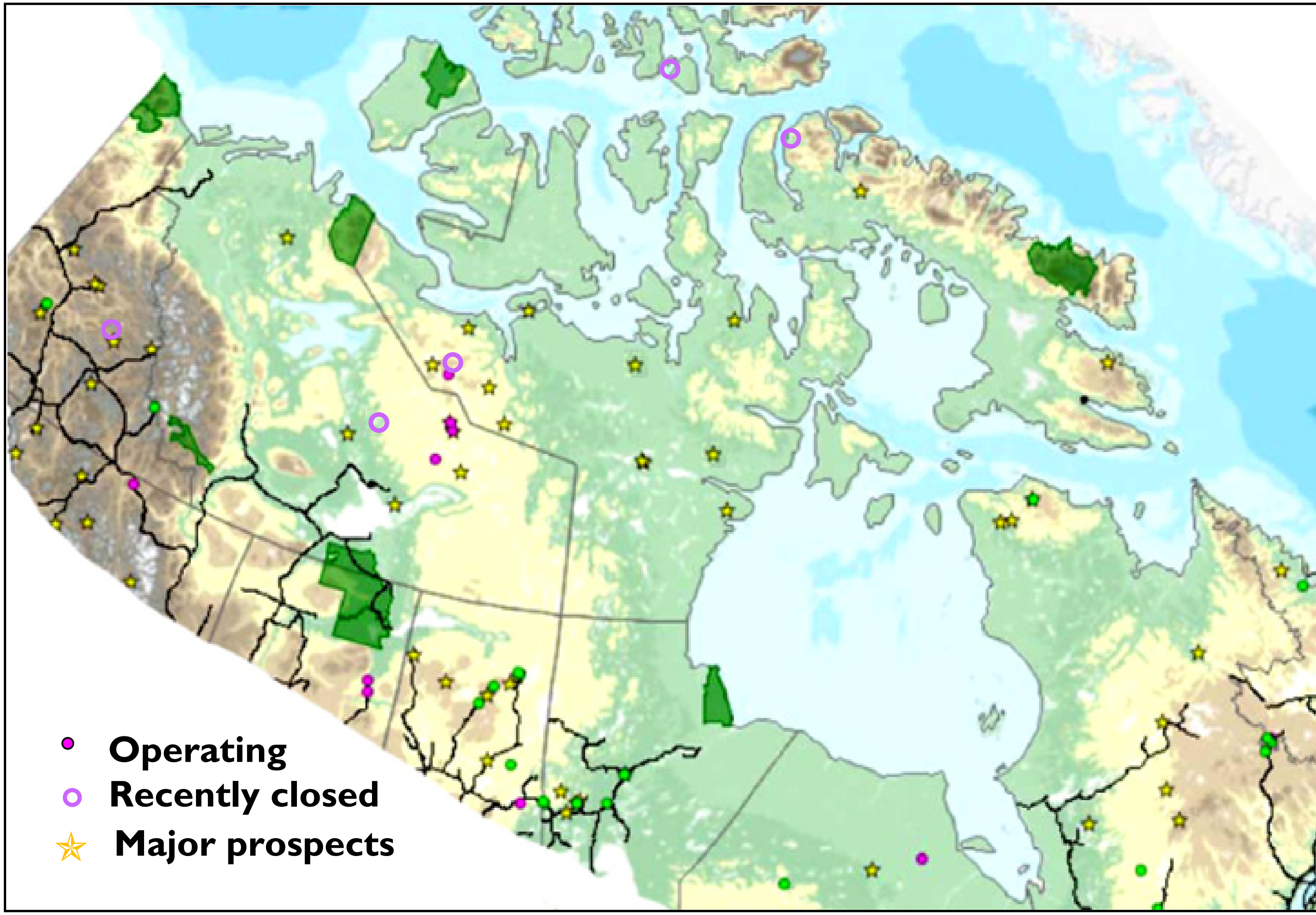
MAJOR CHALLENGES

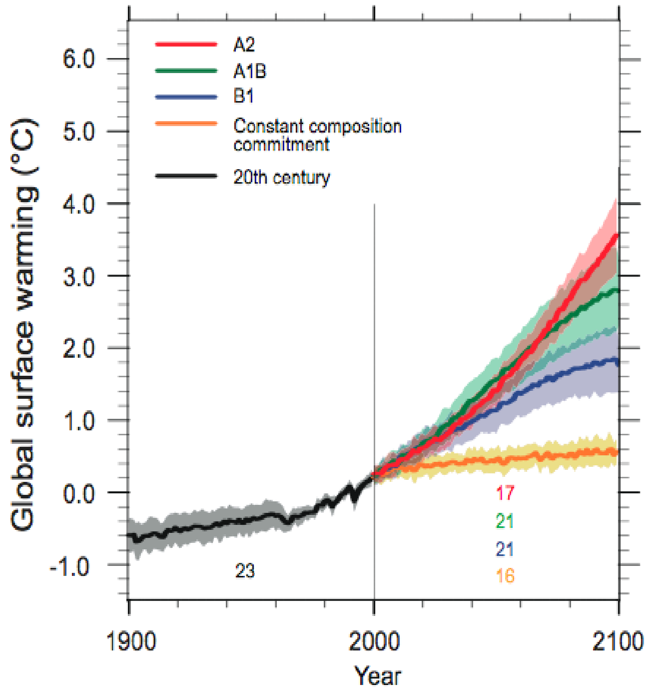
- Mines are remote
- Climate warming
- Permafrost – ground temperature warming
- Erosion
- Durability of reclamation – long-term
- Monitoring & maintenance, if necessary
- Conclusions
- Some design options

Operating, recently closed & future mines

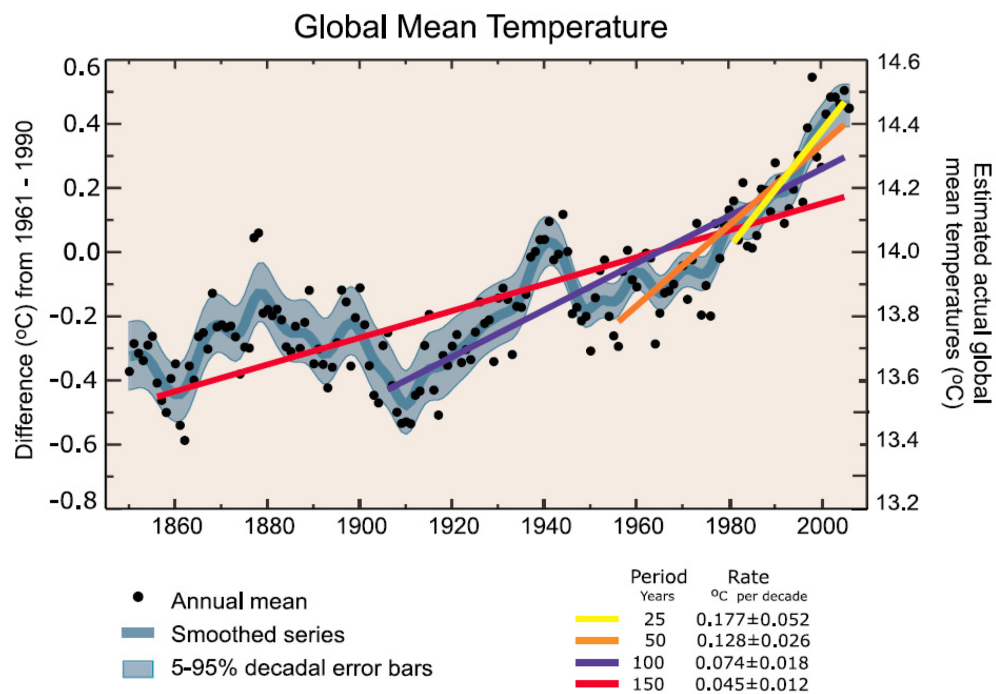


NRCan Maps

Global Projections of Climate Changes



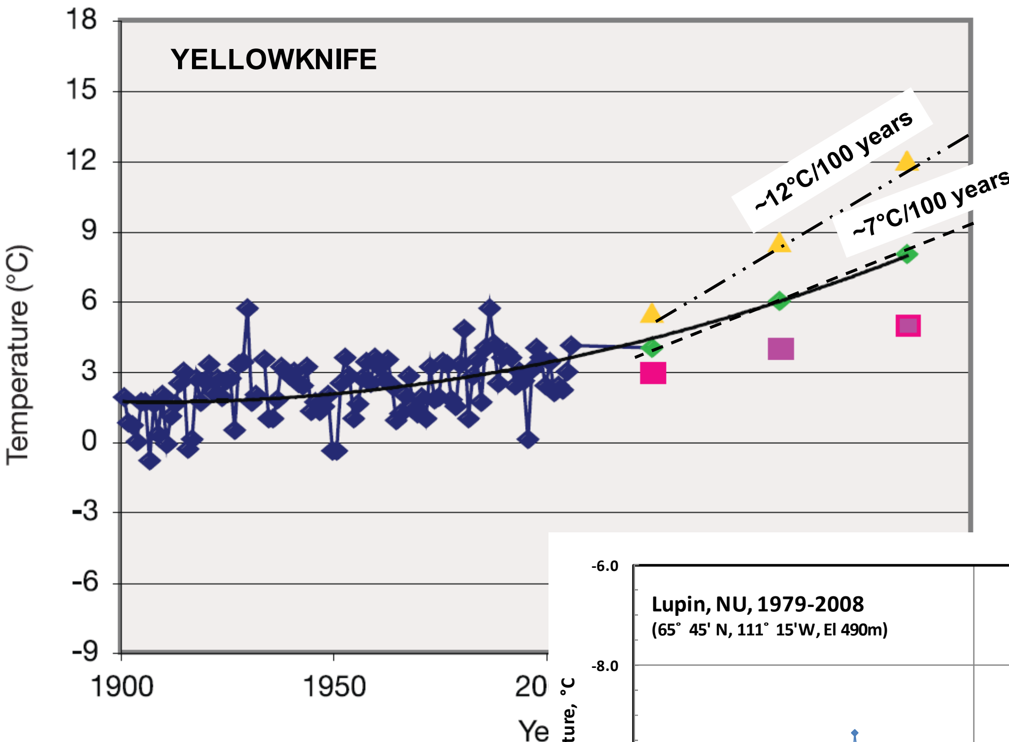
From IPCC 2007 AR4 Reports



Global mean temperature anomalies (compared to 1961-1990) for the years 1850 to 2005

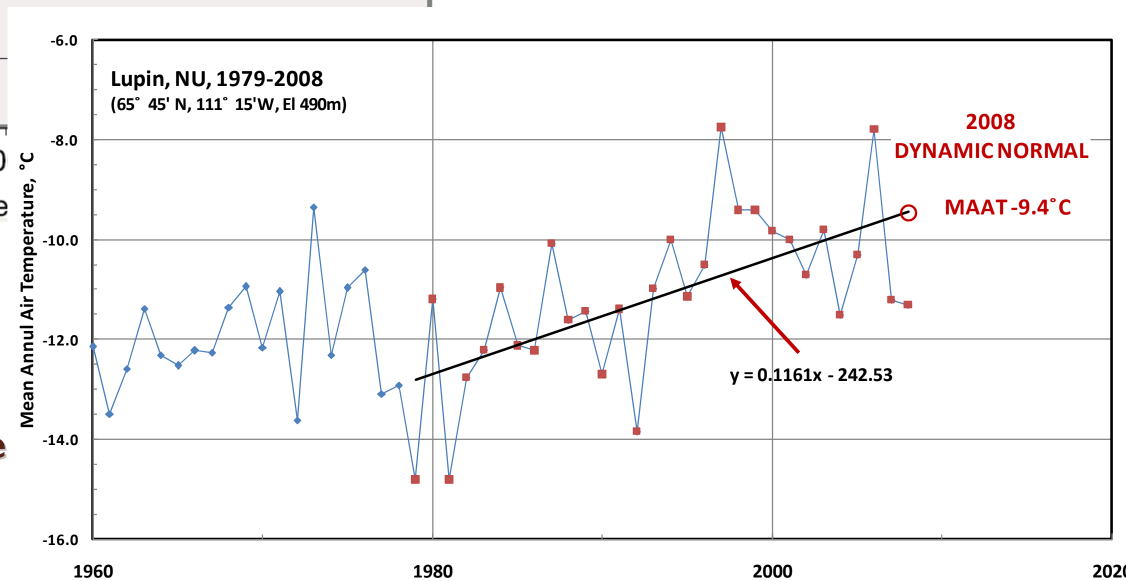
Canadian Climate Change Projections

& Historic Trends

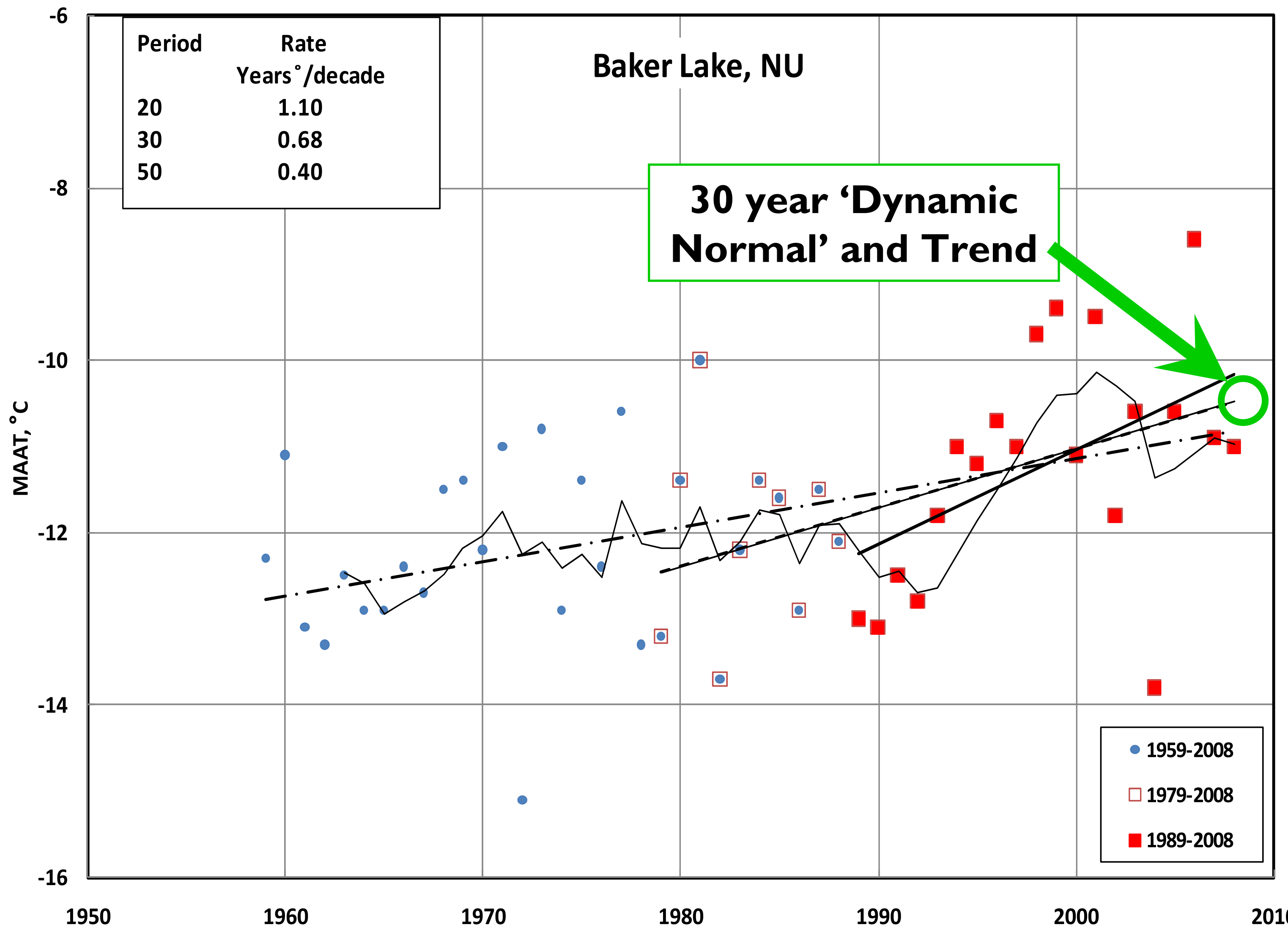


Environment Canada and NRCan 2007 Assessment

Trend analyses of Mean Annual Air Temperature



Mean Annual Air Temperature Changes



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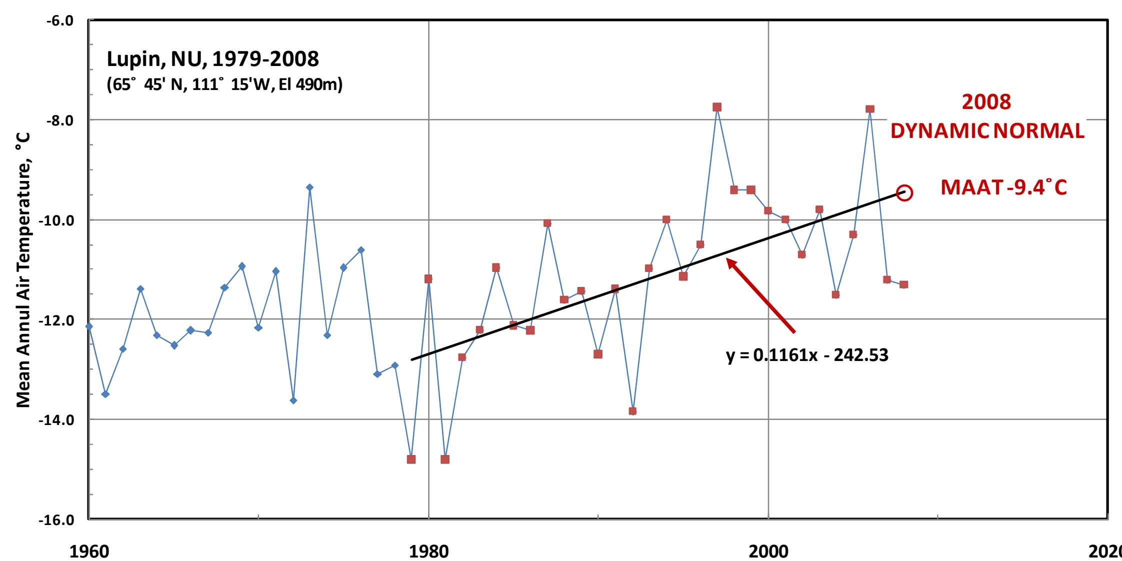
Air Temperature Normals

- Present Normals are average values over 30 years.
- Last available Normals are for 1971 to 2000.
- Dynamic Normals.
- More representative of temperatures undergoing climate warming.
- 2008 - 30Year Dynamic Normals are:
- 0.6°C warmer in Yukon and Mackenzie River Valley
- 1.8°C warmer in Central and Eastern North.



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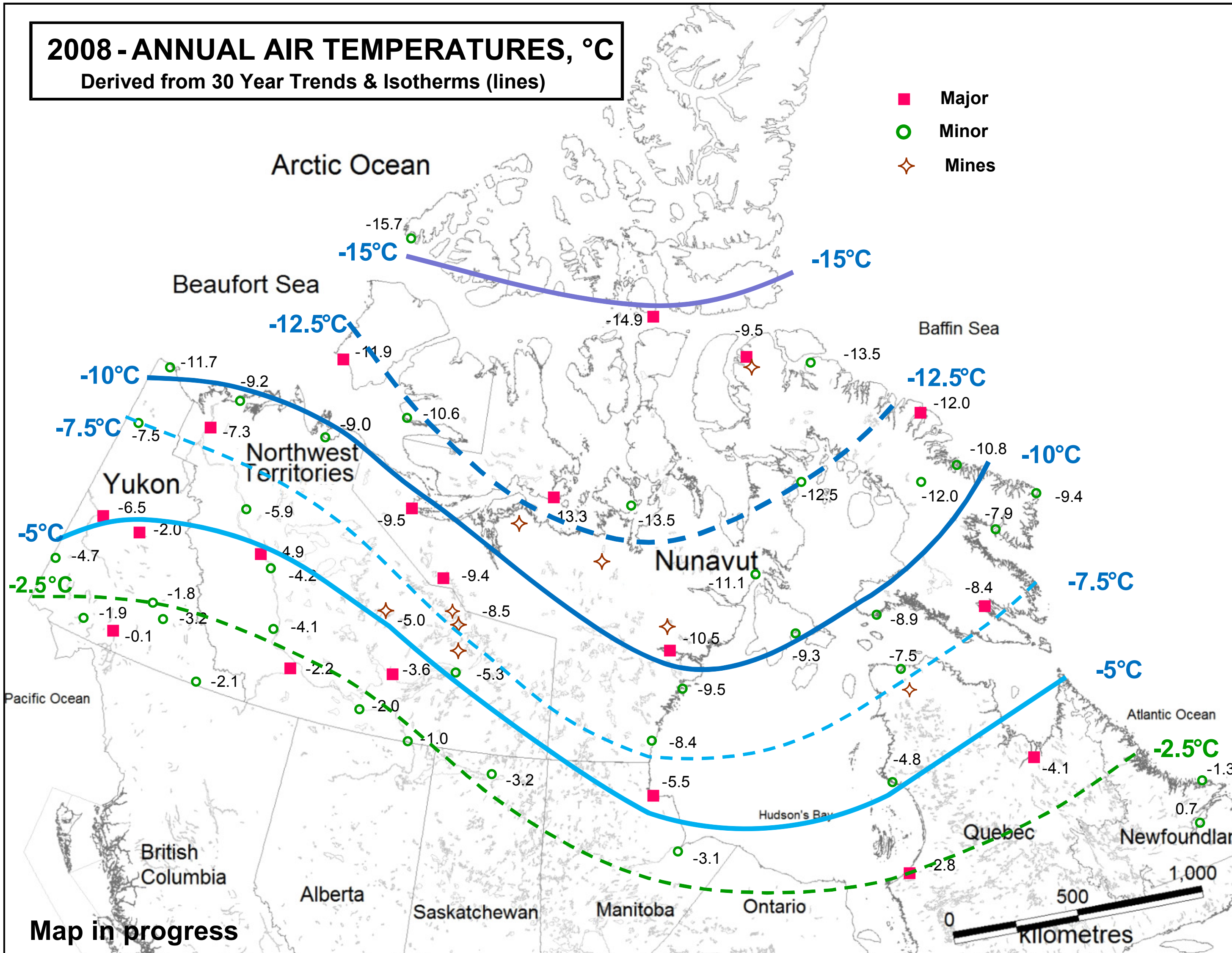
2008 Mean Annual Air Temperatures



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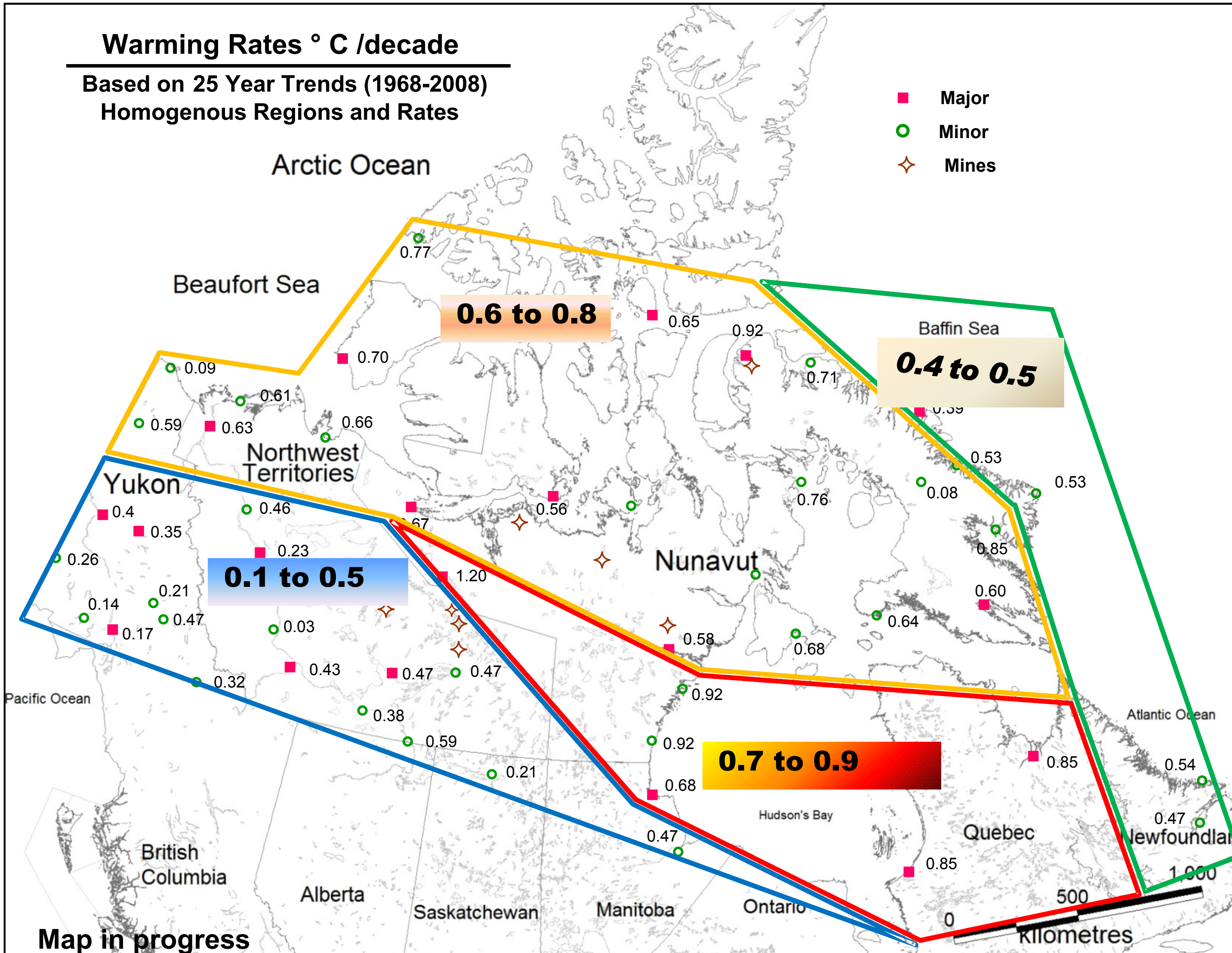
Homogenous Zones of Recent Climate Warming Rates



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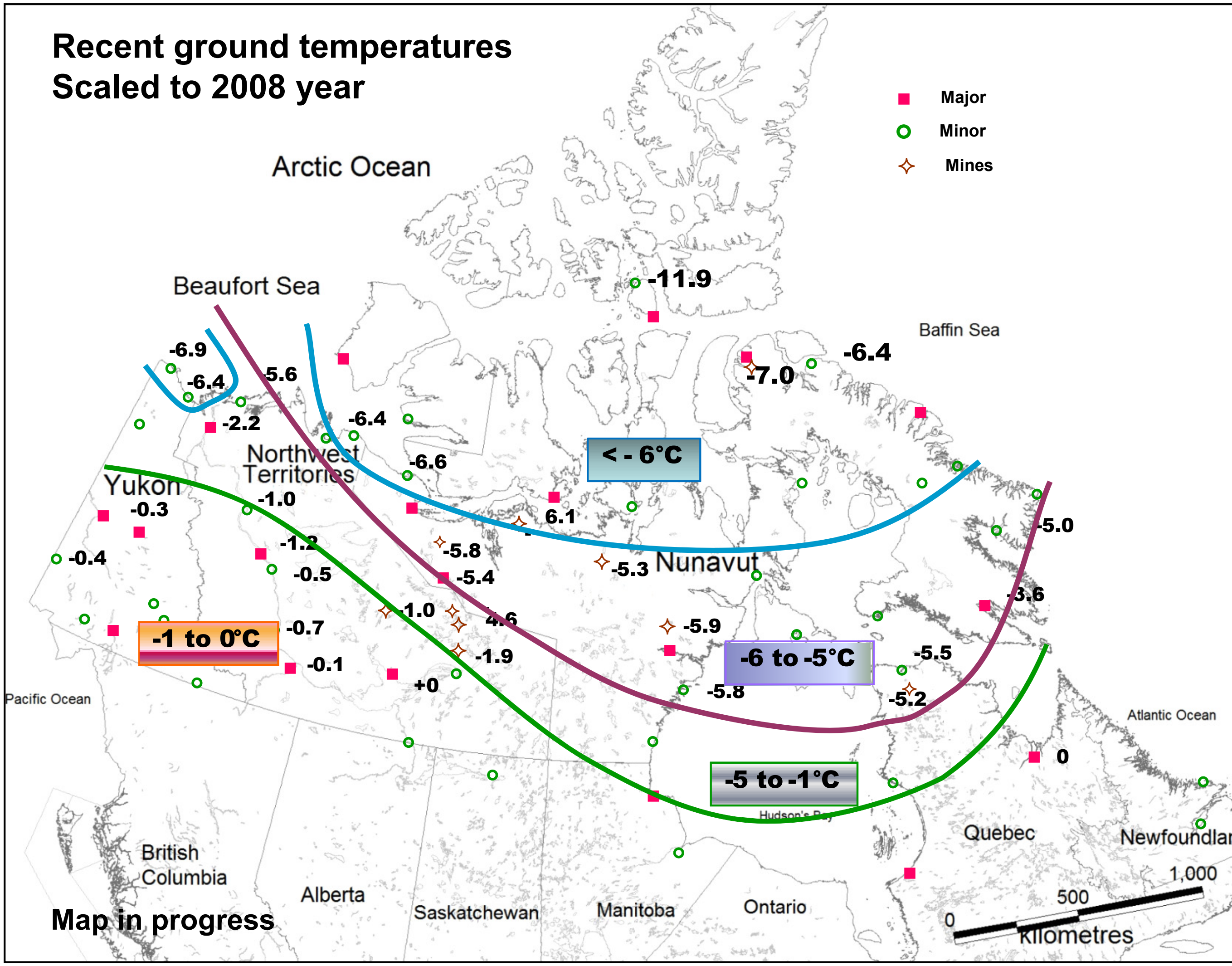
2008 Mean Annual Ground Temperatures

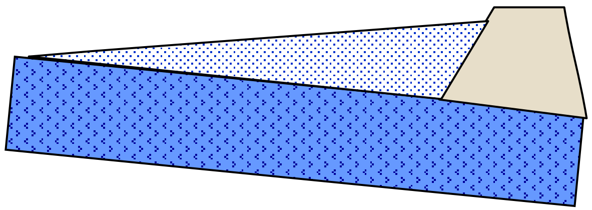


Climatic Warming Impact on Permafrost across Central North

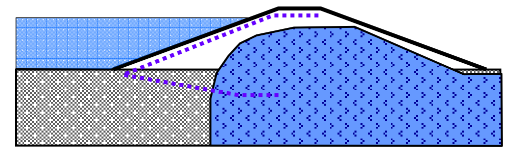
Present MAGT / Warming Rate
= Projected Years for Permafrost to begin to Thaw

In Range of 50 to 100 Years

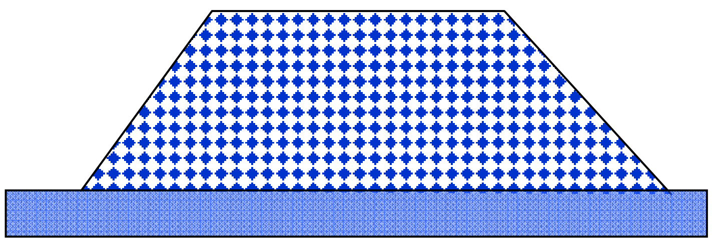
Mine Structures depending on Frozen Ground



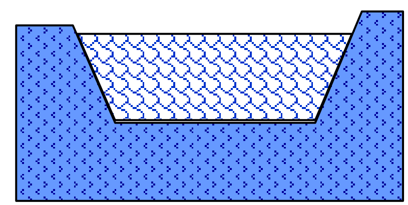
Tailings Facilities



Dams



Rock Embankments



Solid Waste Storage

Impact on Reclaimed Mine Components

Presently majority of mine components are frozen and on frozen ground

Long-term Impacts – Permafrost will likely thaw within 100 years

- Mine waste permafrost encapsulation not viable
- Physical stability of mine waste embankments and tailings containments endangered
- Seepage through thawing foundation beneath dams; unless kept artificially frozen

Erosion in Nature

In sedimentary rocks

In igneous rock, Iqaluit

Mackenzie River

Gully in sand

Erosion major Adversary to Mine Reclamation

Tailings dam failure

Tailings erosion

Crushed rock cover erosion

Soil cover slide & erosion

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Impact of Erosion

Results from recent workshops

- Erosion on the long-term inevitable
- Dry covers service life is 30 to 50 years
- Wet covers – continuous monitoring and maintenance

Reclamation – Long-term ?

- Guidelines state that reclamation is for the long-term;   but did not elaborate.
- 2007 Geoscience Forum Poll

Definition of Long-term:	Results form Poll
10 years	0
50 years	0
100 to 200 years	80%
Forever?	20%

Monitoring & Maintenance

- In reality, closure and reclamation plans address relatively short monitoring durations, about 7 to 20 years after closure.
- Several workshops concluded that monitoring & maintenance may be needed for long-term sustainability; degree depends on design and climate.

Conclusions

- Many larger closed mine sites in temperate climates are being continually monitored and maintained.
- Closed mine sites in the North with permafrost have extra challenges due to impact of climate warming, erosion and poor access.
- Guidelines require closure & rehabilitation designs to be for the long-term; should be designed for 100 years and longer.
- Need to minimize/eliminate monitoring & maintenance due to remoteness and to design beyond permafrost environment.

Some Design Measures for Long-term

- Design for permafrost absence.
- Segregate potential harmful rock and dispose in encapsulated spaces.
- Select sites and design disposal facilities to minimize stream and surface erosion.
- Design dumps, tailings containment and landfills with extra physical stability and massive erosion protection to slow rate of erosion, using ‘extra clean’ rock.
- Eliminate dams at closure.