



Permafrost Science Workshop

Characterization of permafrost and terrain conditions for informed decision making

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Workshop on State of the Science at ESS



Natural Resources
Canada

Ressources naturelles
Canada

Canada

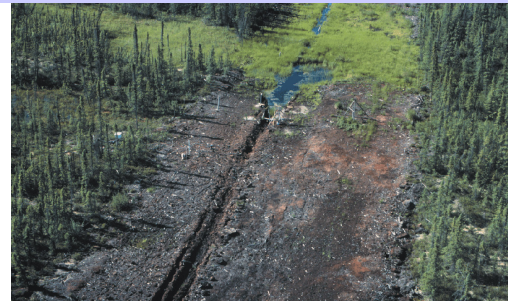
Research focuses on:

- What are the current permafrost conditions and the factors influencing spatial variability
- How do permafrost thermal conditions change in response to climate change and environmental disturbance and what are the impacts of these changes

Utilize observations of permafrost thermal conditions, soil conditions, environmental and climatic variables and analysis and modelling techniques to address these questions and provide essential information for:

- engineering design of northern infrastructure
- landuse planning
- assessment of environmental impacts associated with northern development and development of mitigation techniques
- assessment of impacts of climate change on natural and human systems

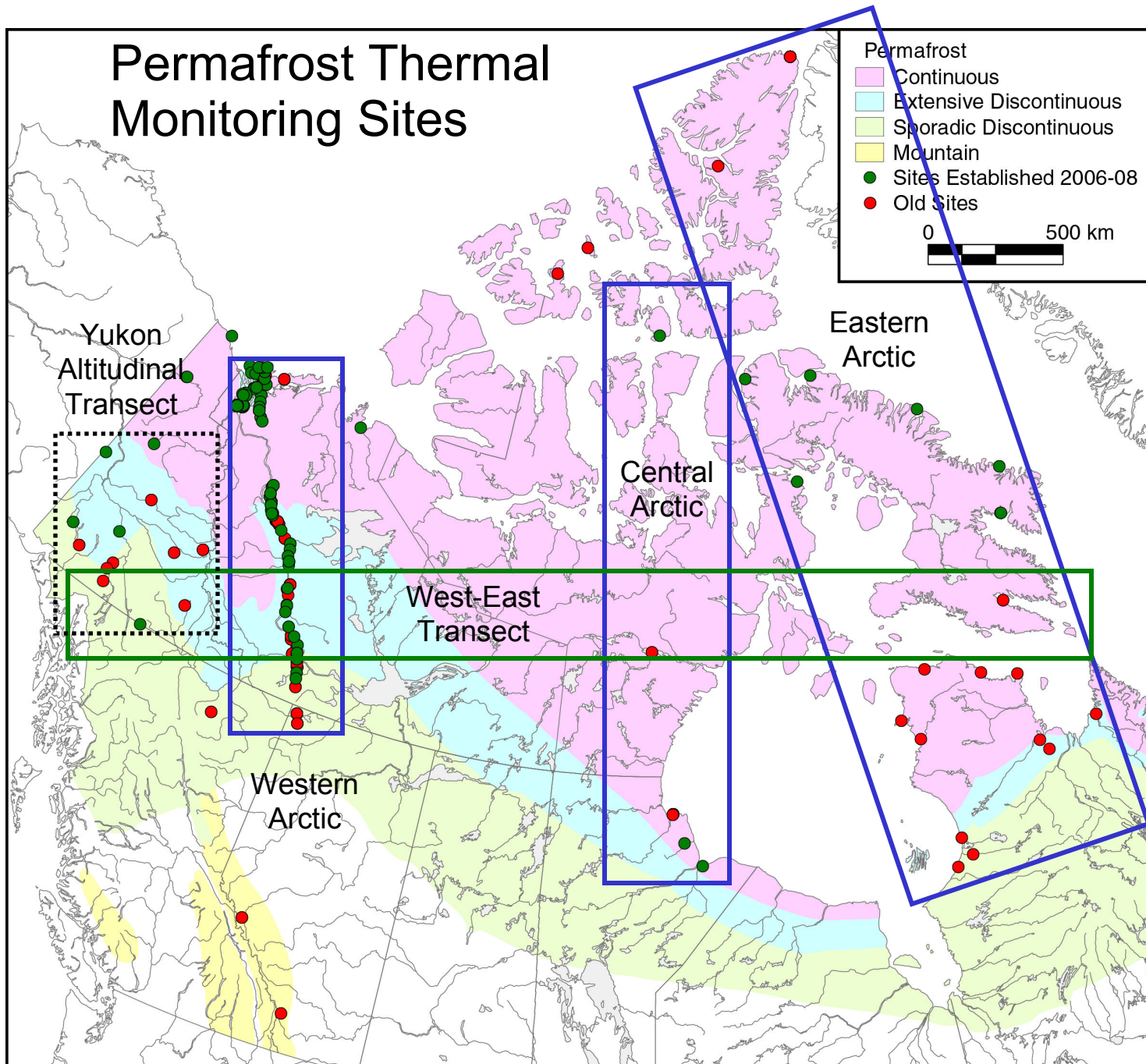
Thermokarst & surface settlement



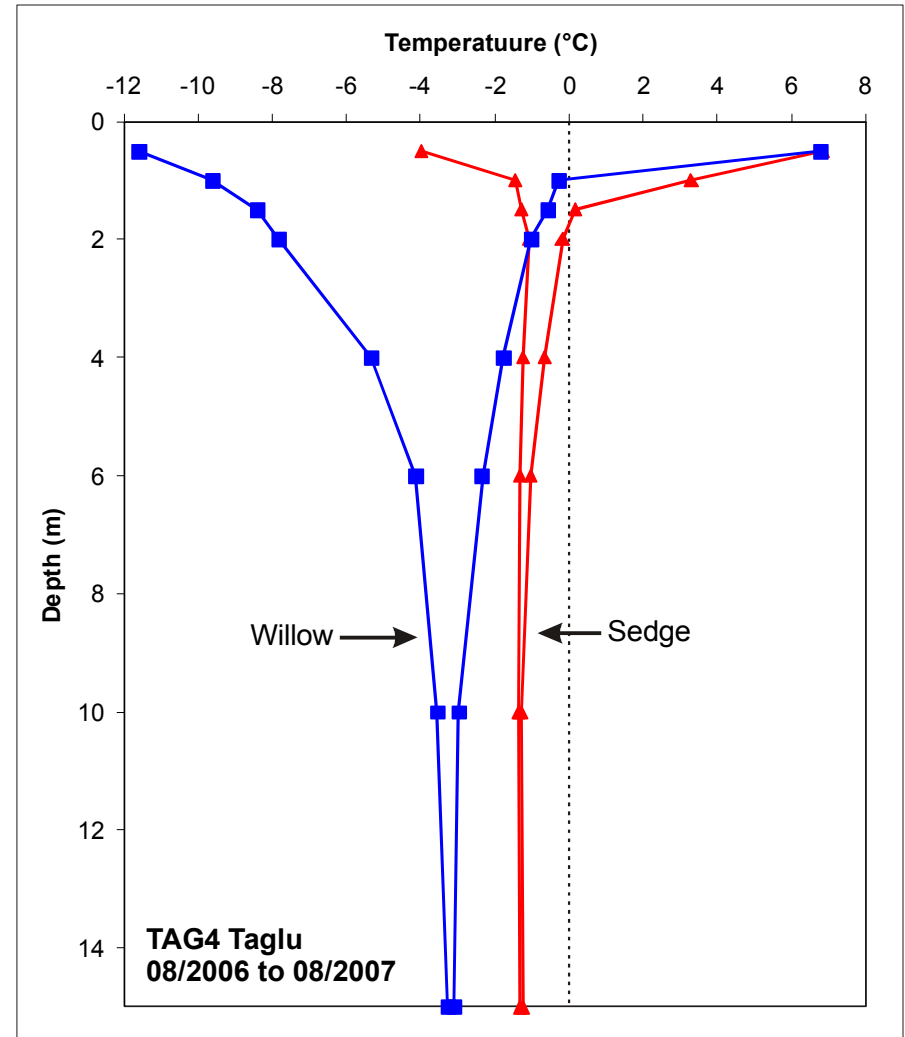
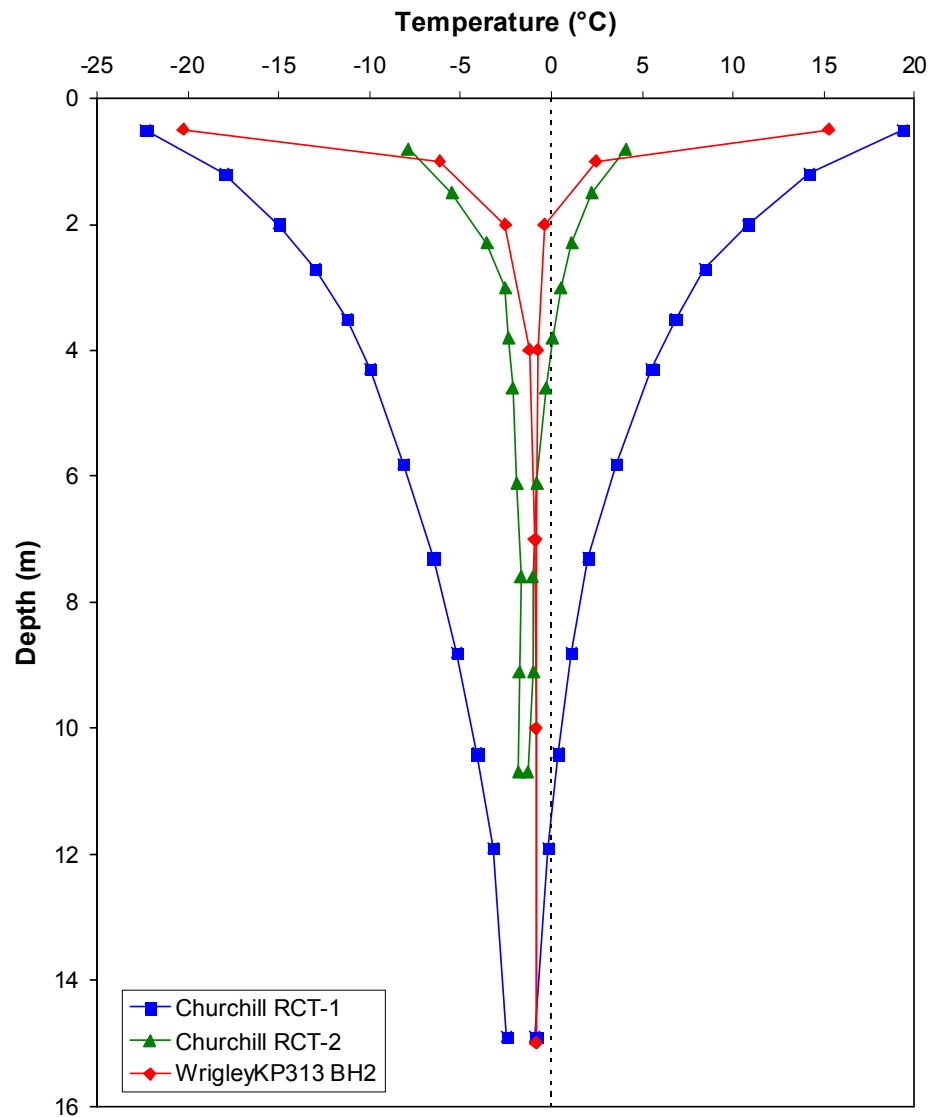
Ground instability



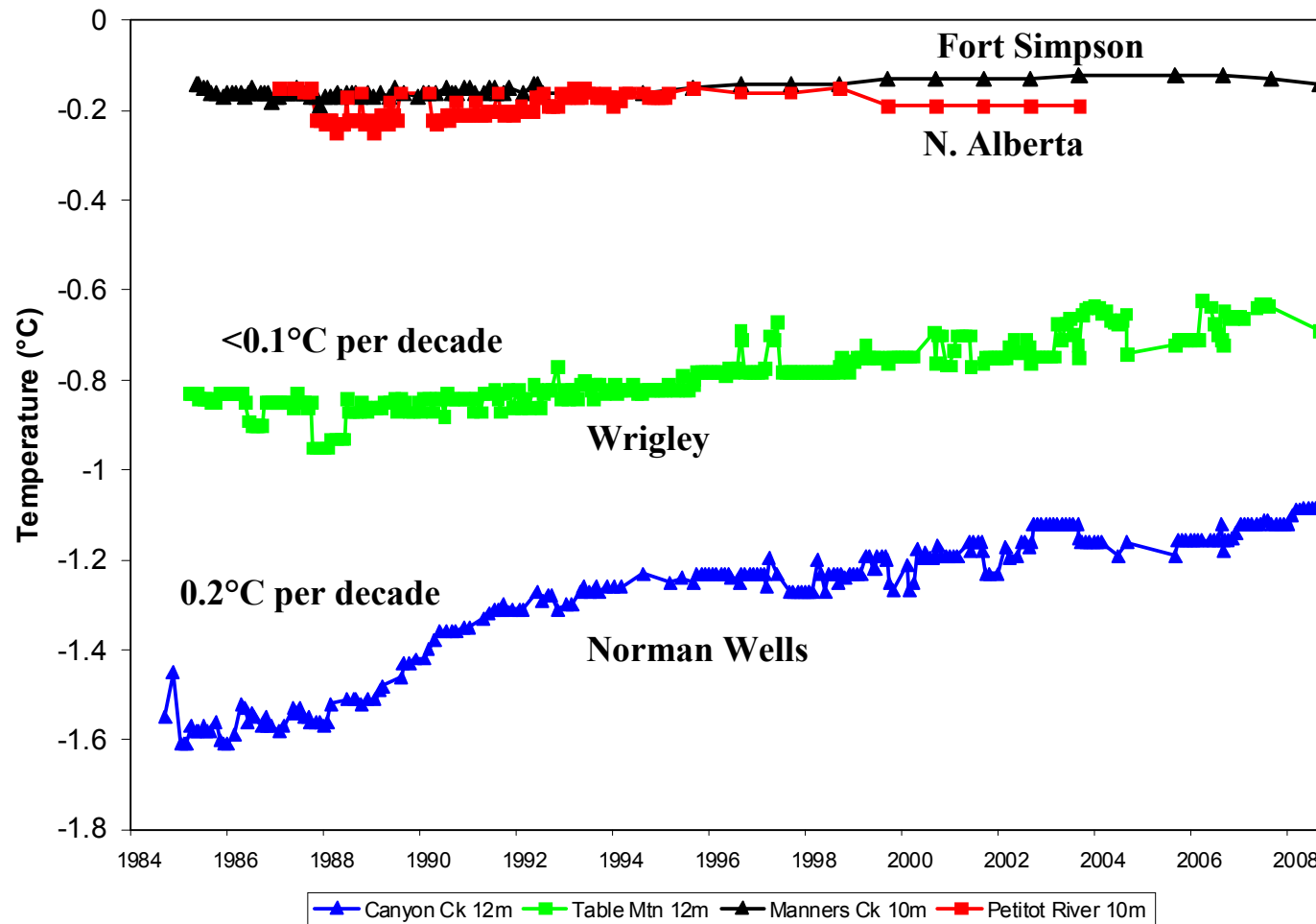
Permafrost Thermal Monitoring Sites

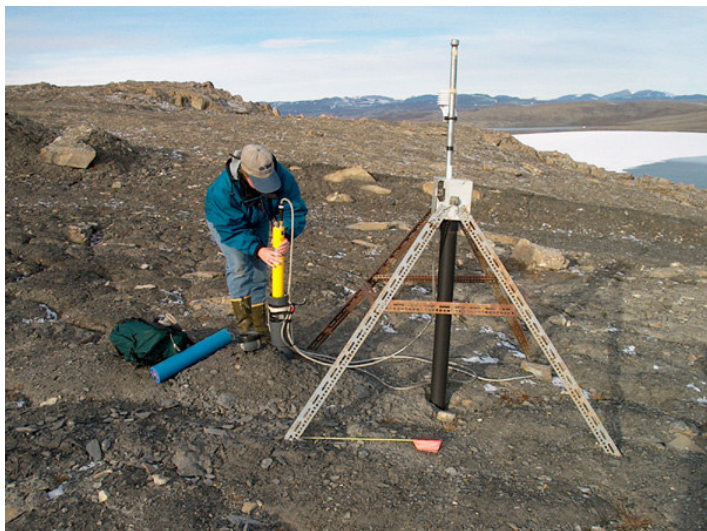


The ground thermal regime is influenced by local conditions



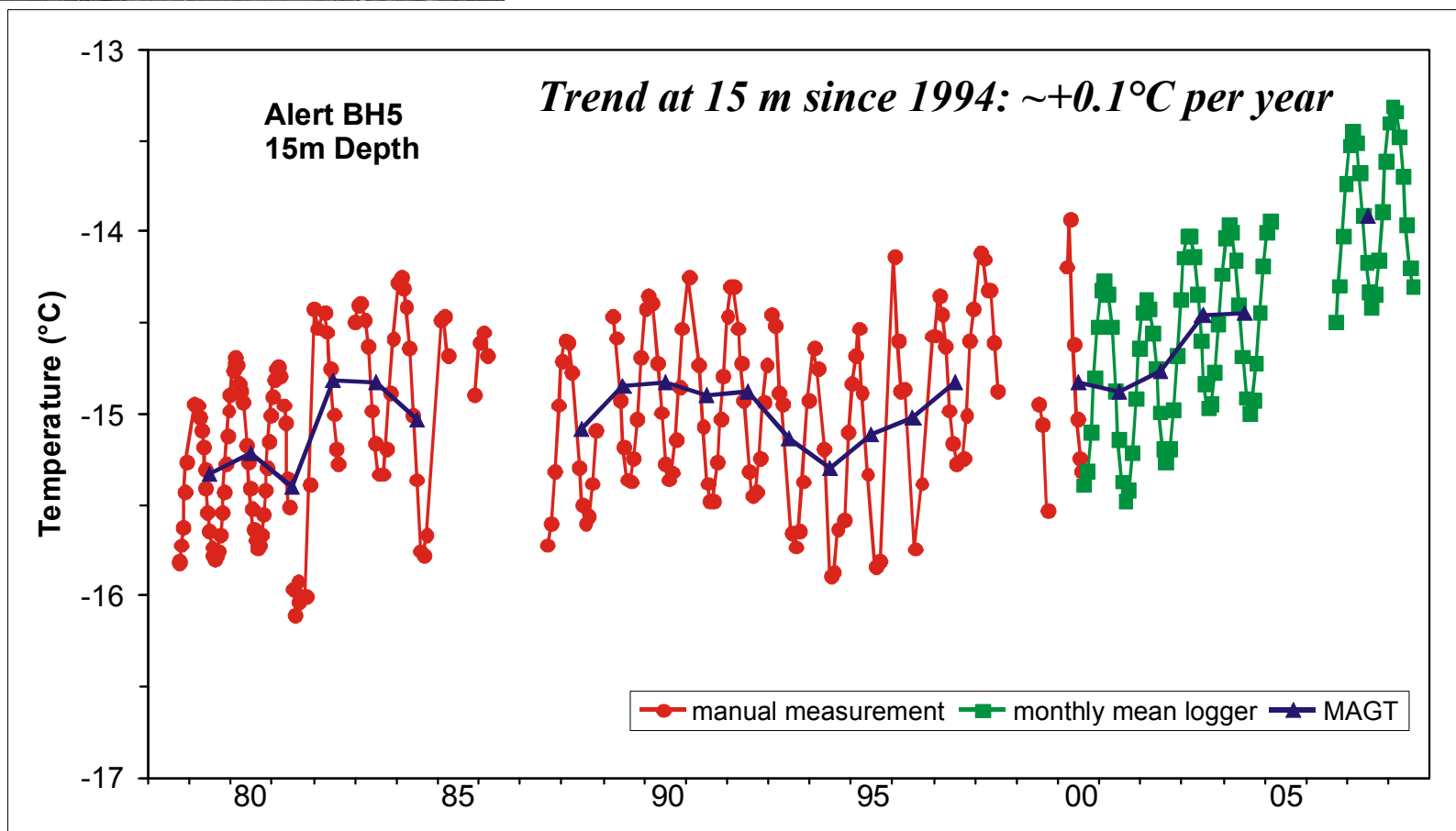
Trends in Permafrost Temperature Central and Southern Mackenzie Valley, 1984-2008

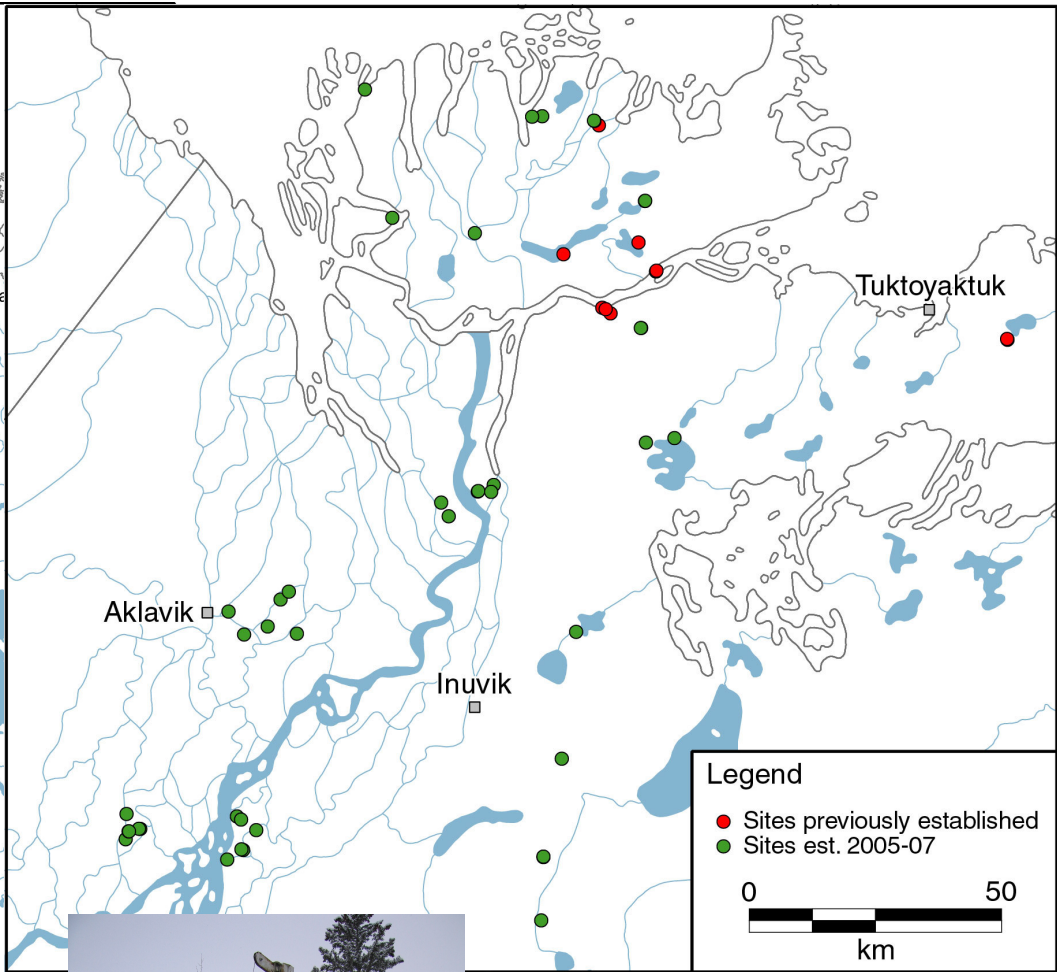
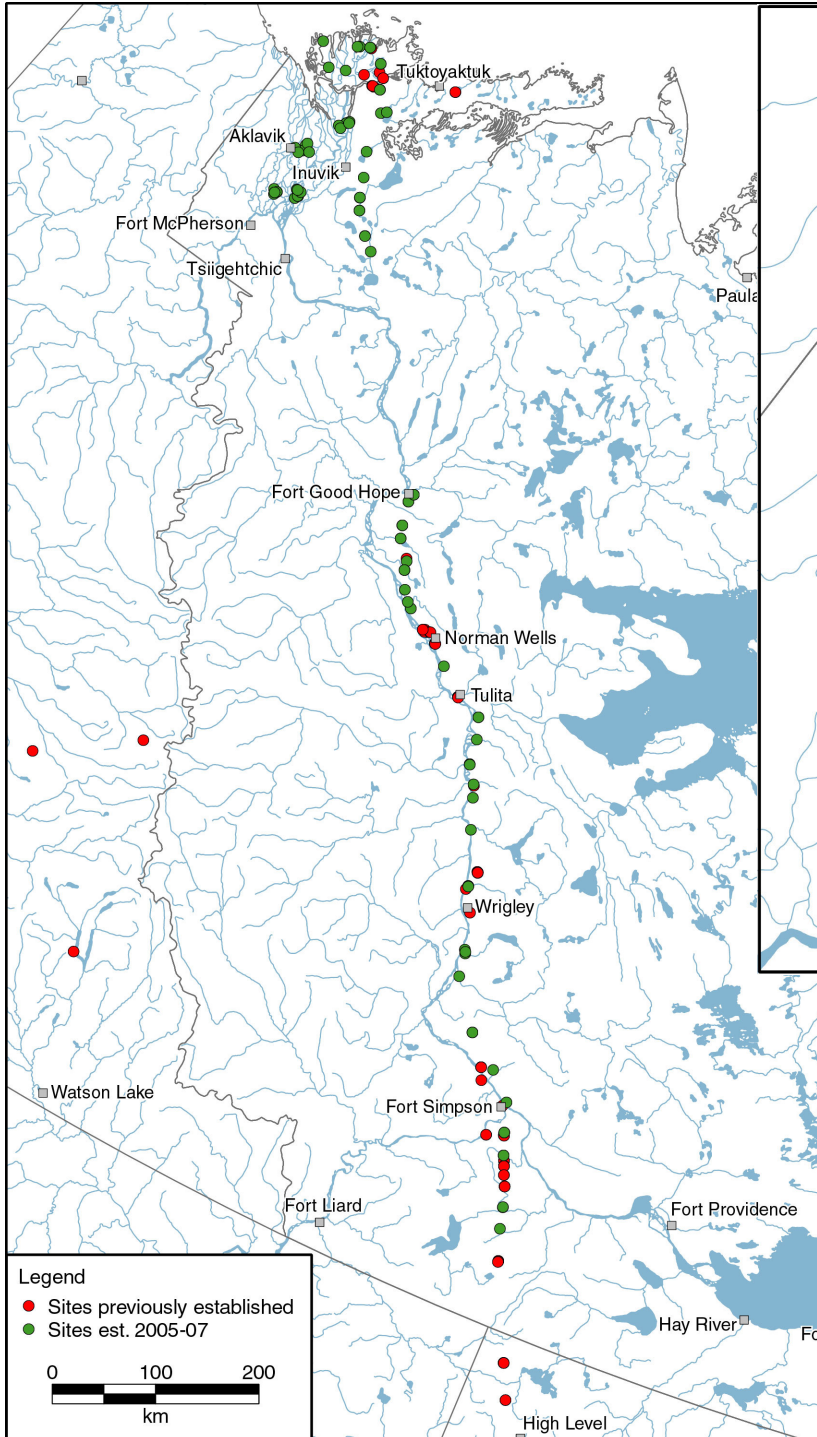




CFS Alert

Permafrost Temperature

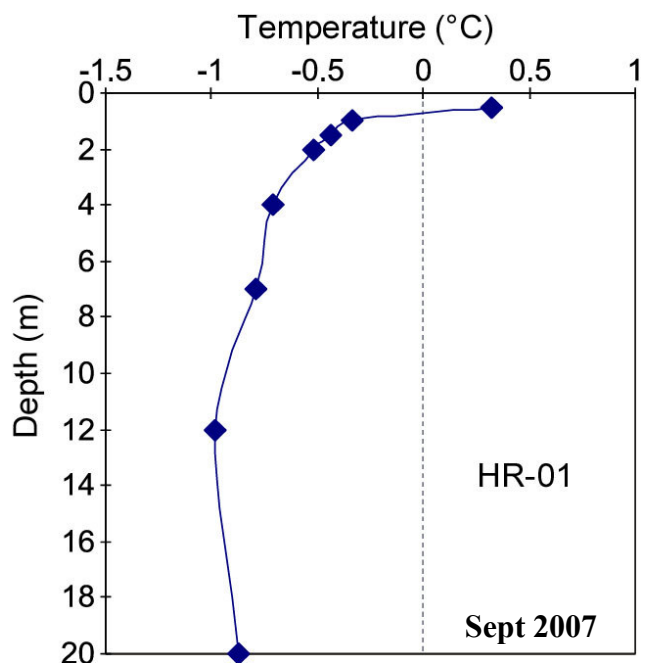




Environmental data collection – Mackenzie Valley

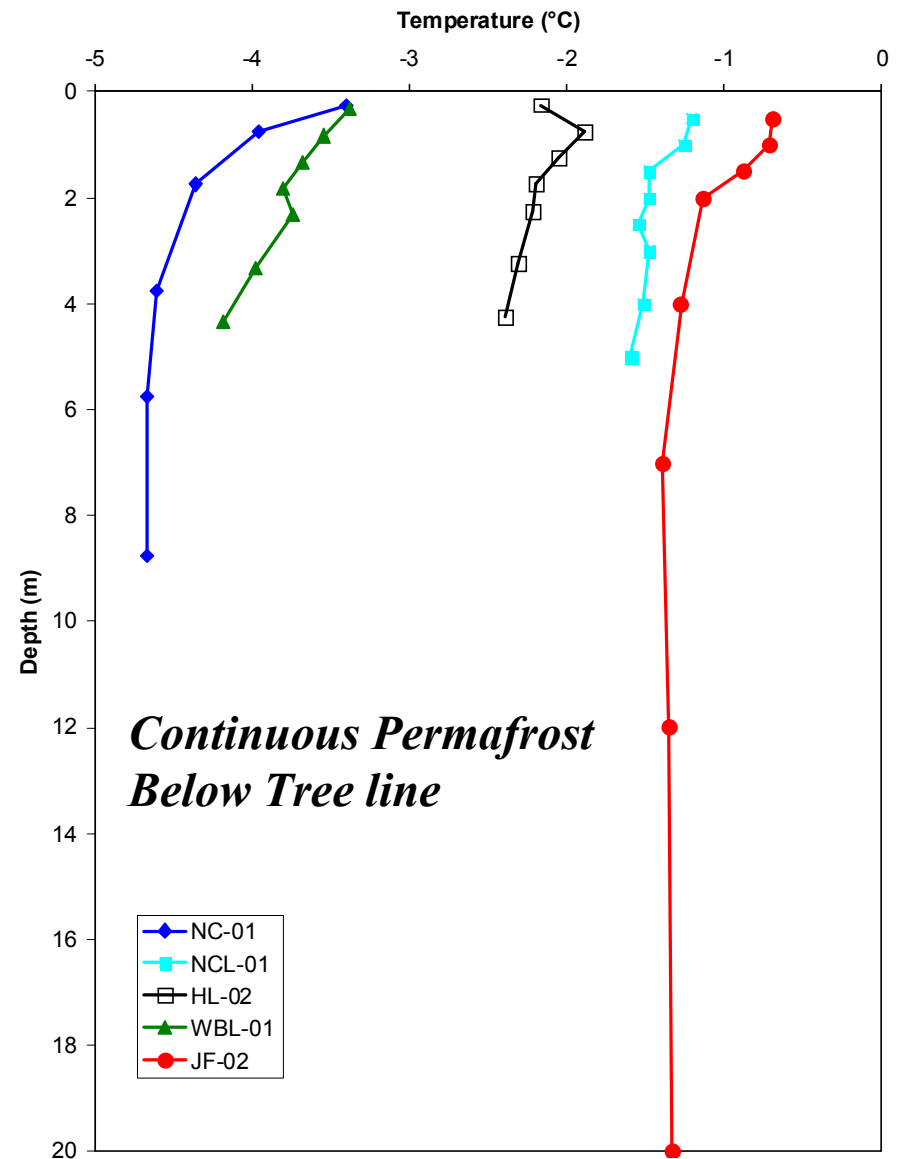
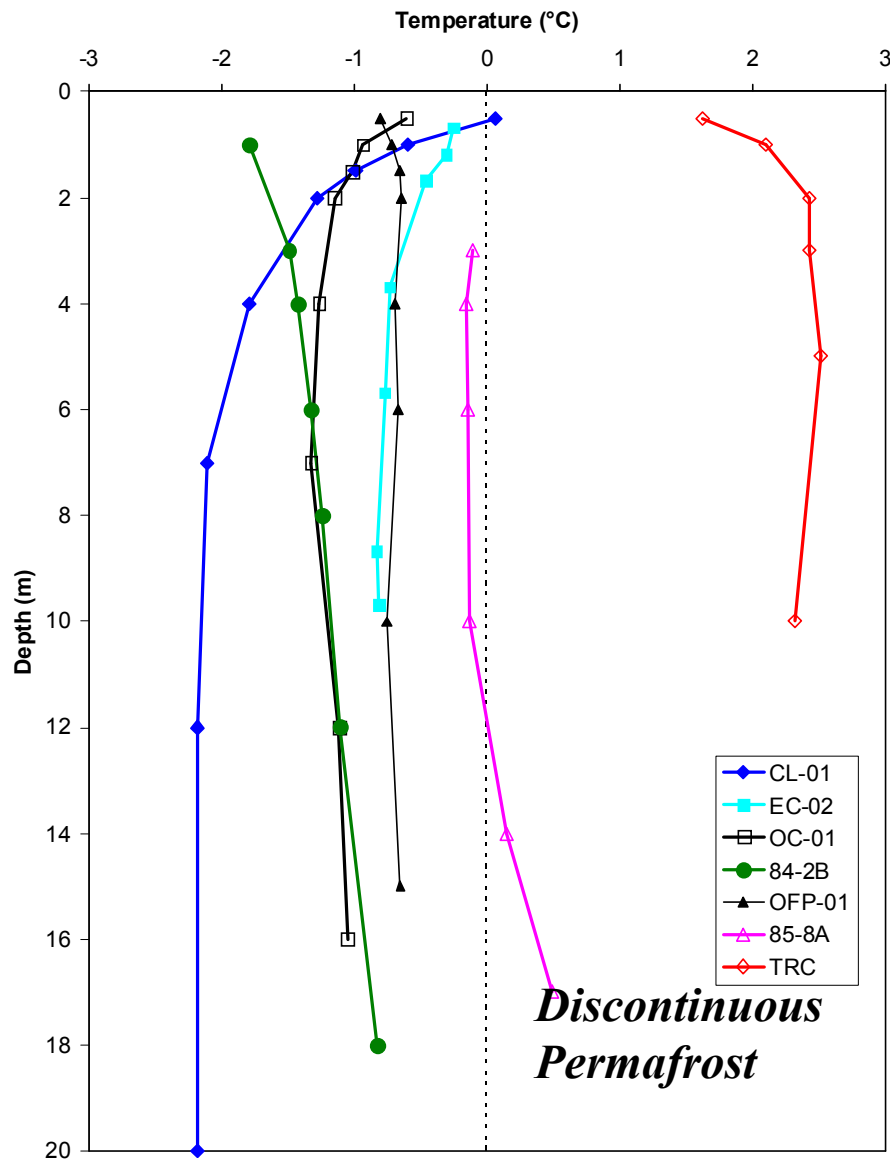


Borehole No: HR-01		Northing: 7283597		Easting: 553624		Zone: 9								
Borehole Depth: 21.3		Location: Hanna River 01				Date: 4-Mar-07								
Depth (m)	Soil Type	Soil Description	Ground Ice Description	Plastic	M.C.	Liquid	Bulk Density (kg/m ³)	Grain Size (%)						
								Clay	Silt	Sand	Gravel			
0		Peat: Roots, rootlets, wood chips, moss, fibrous, reddish brown.	Frozen - Vx up to 30% and Non											
1														
2		Clay and Ice: Layers of ice up to 5 cm thick spaced approximately 1 to 1.5 m apart.	Vx - up to 80%				1572.00							
3		Clay and Ice: High plastic.												
4														
5		Clay and Ice: Zones of ice up to 0.5 m thick.	Vx - 20 to 25%				107.10	1614.00						
6		Clay: Silty, dark grey.												
7			Vx - 50 to 80%											
8														
9														
10			Vx - 30 to 50%											
11														
12			Vx - 15 to 25%											
13														
							1675.00							



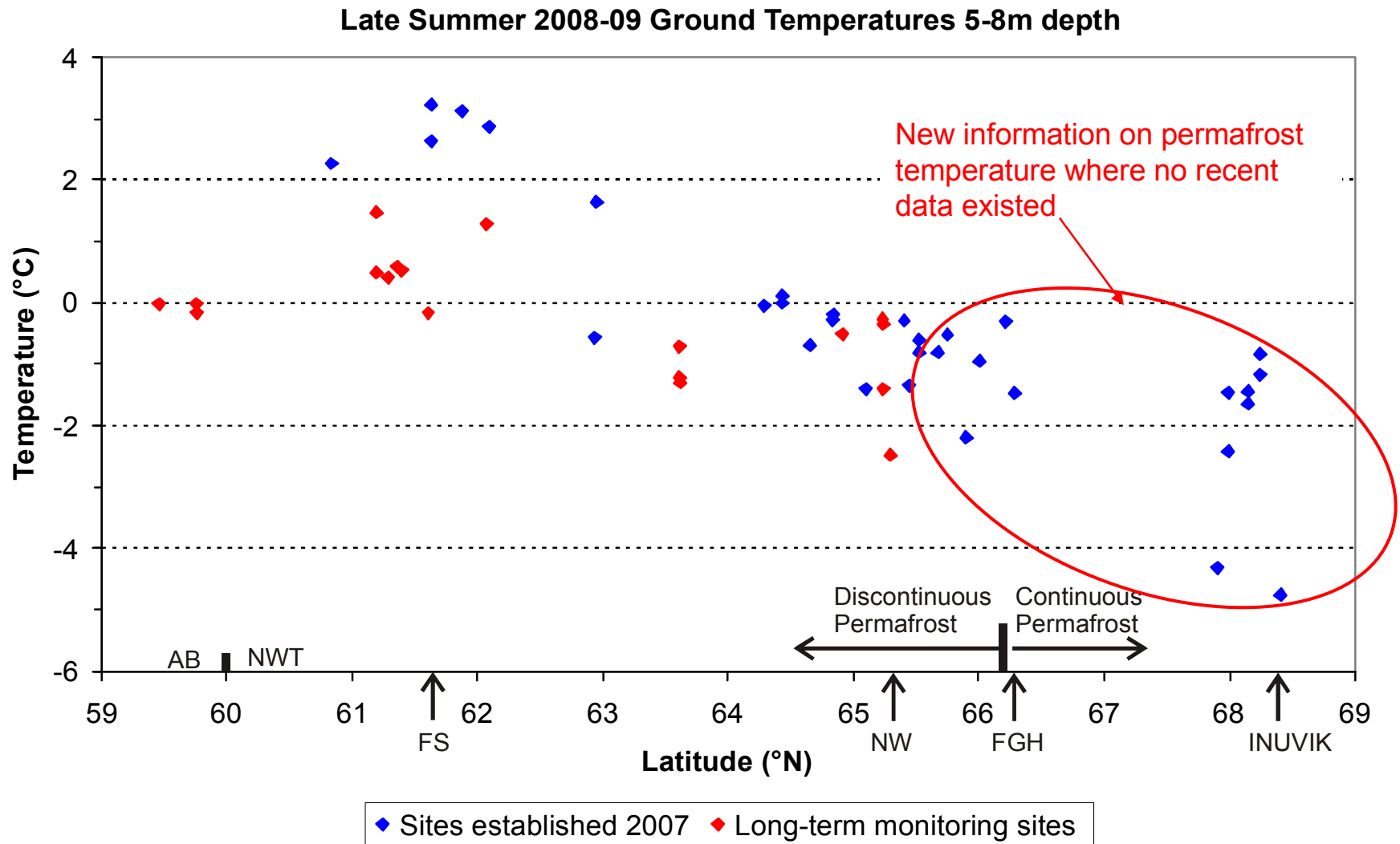
(From Smith et al. 2009)

Mean Annual Ground Temperature Mackenzie Valley 2007-2009

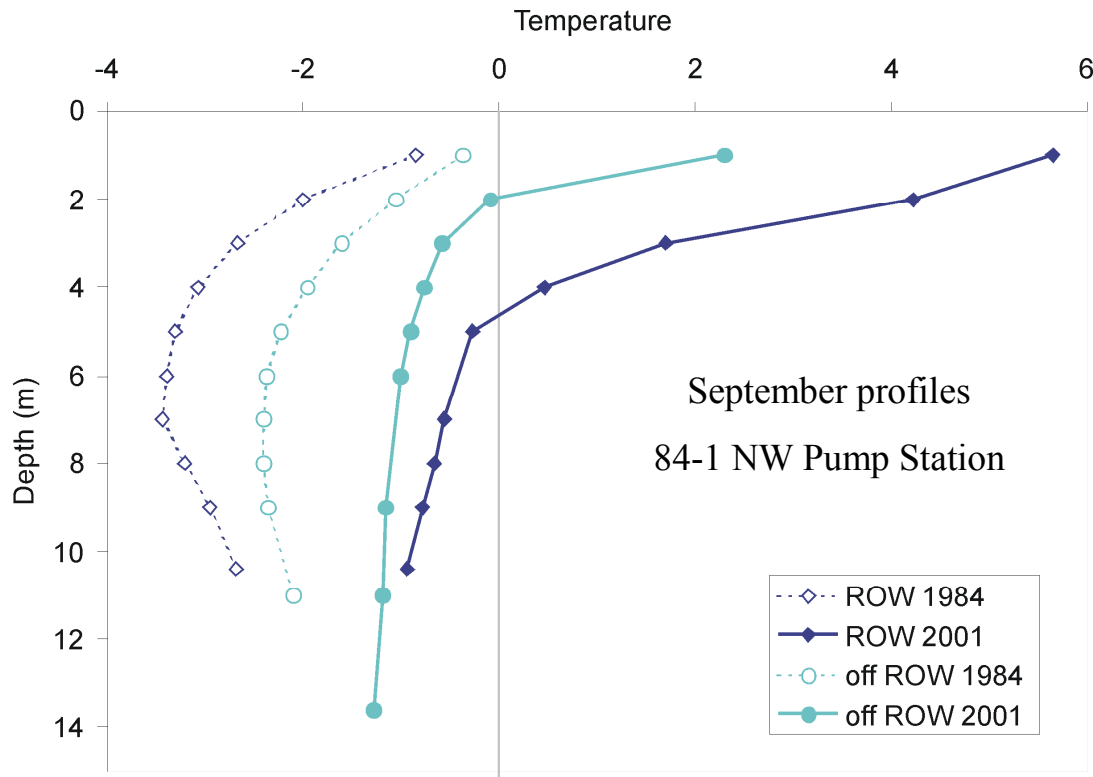


(from Smith et al., in prep)

Updated Thermal Regime – Mackenzie Corridor 2007-09



Impact of Environmental Disturbance



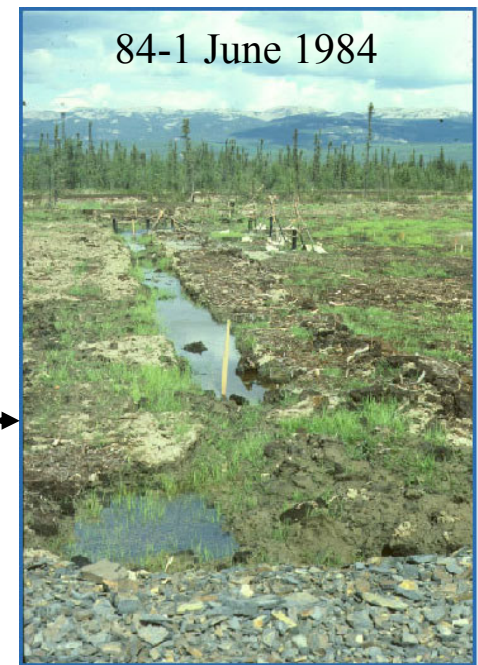
Comparison of on and off ROW sites, Norman Wells

Greater thaw penetration on ROW

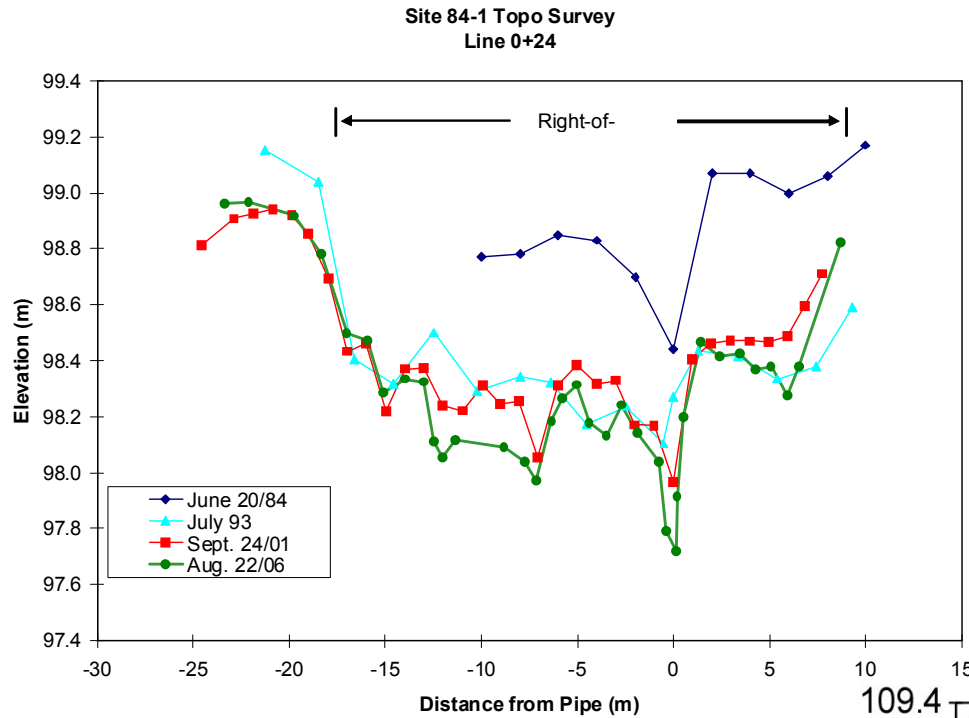
Greater increase in ground temperature on ROW



Thawing and settlement of ice-rich soil →



Surface Settlement

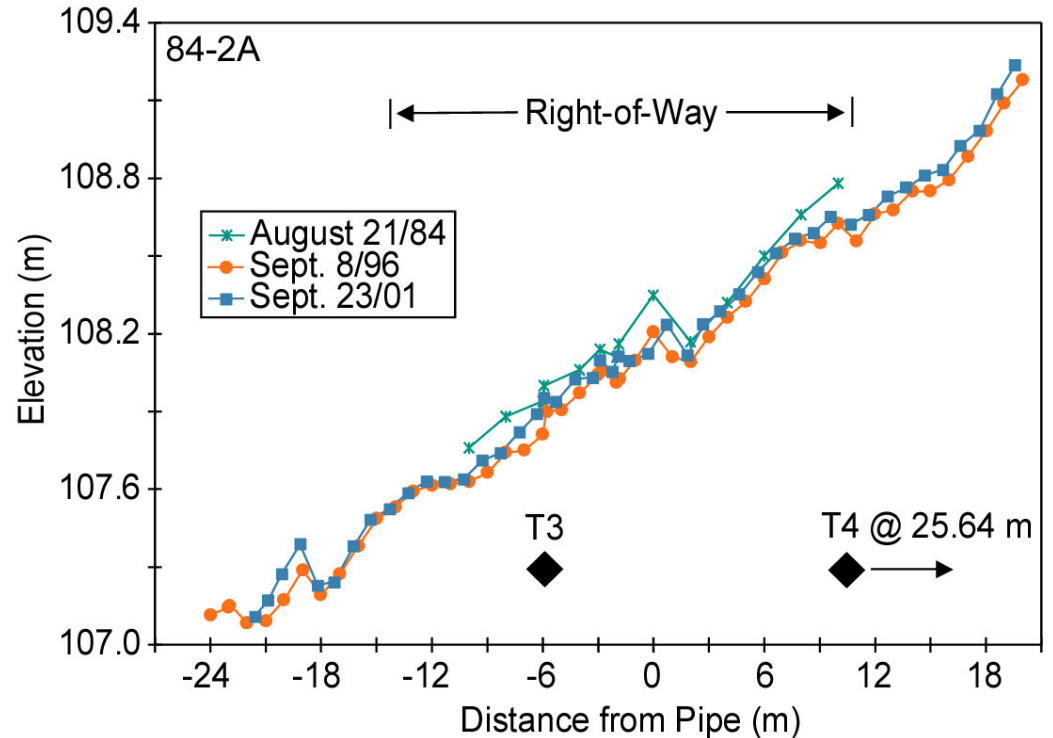


84-1, KP0.1

- Fine lacustrine silts and clays, 5-10% vis. ice
- 1984-2005 Active layer increase on ROW < 3m
- Thaw settlement up to 0.8m
- Total Thaw Strain = 20%

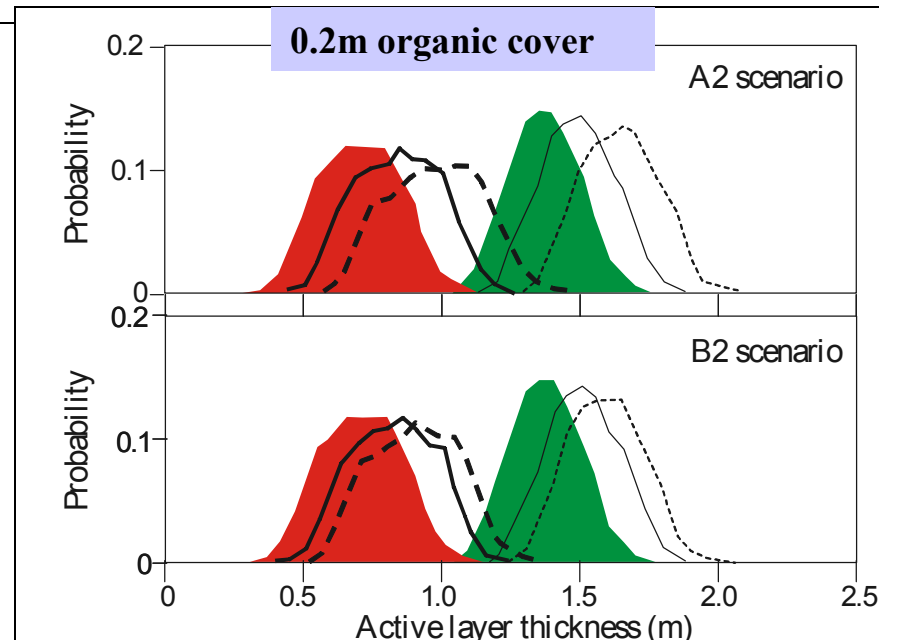
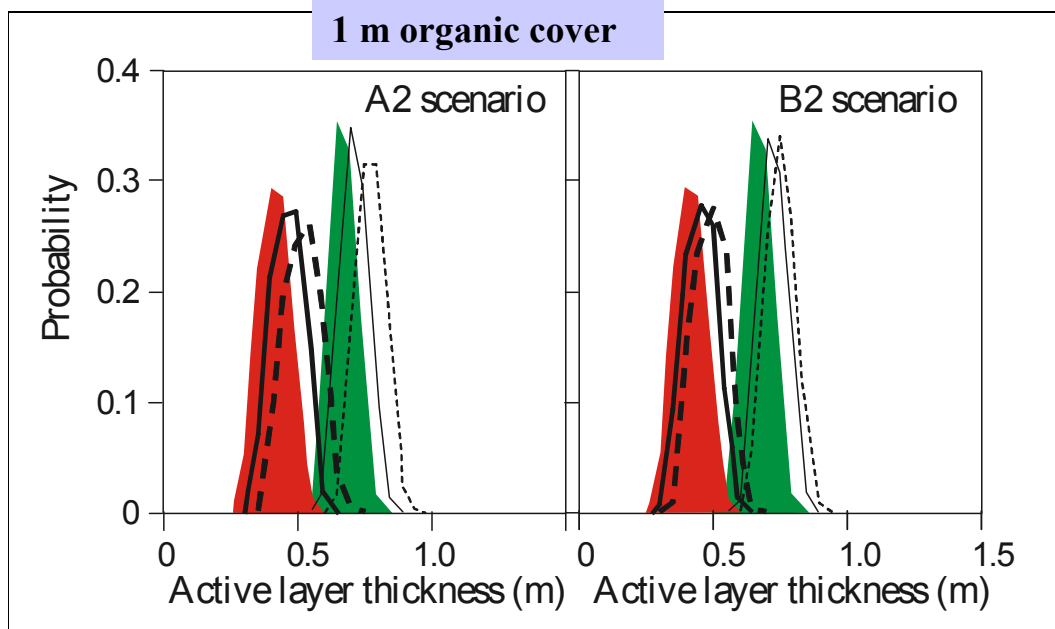
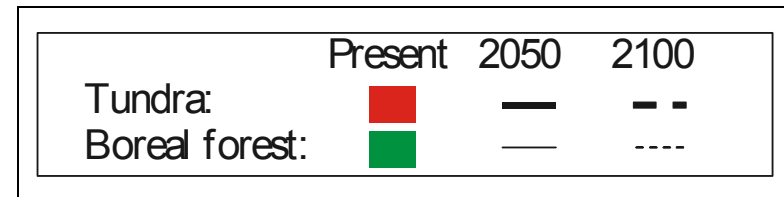
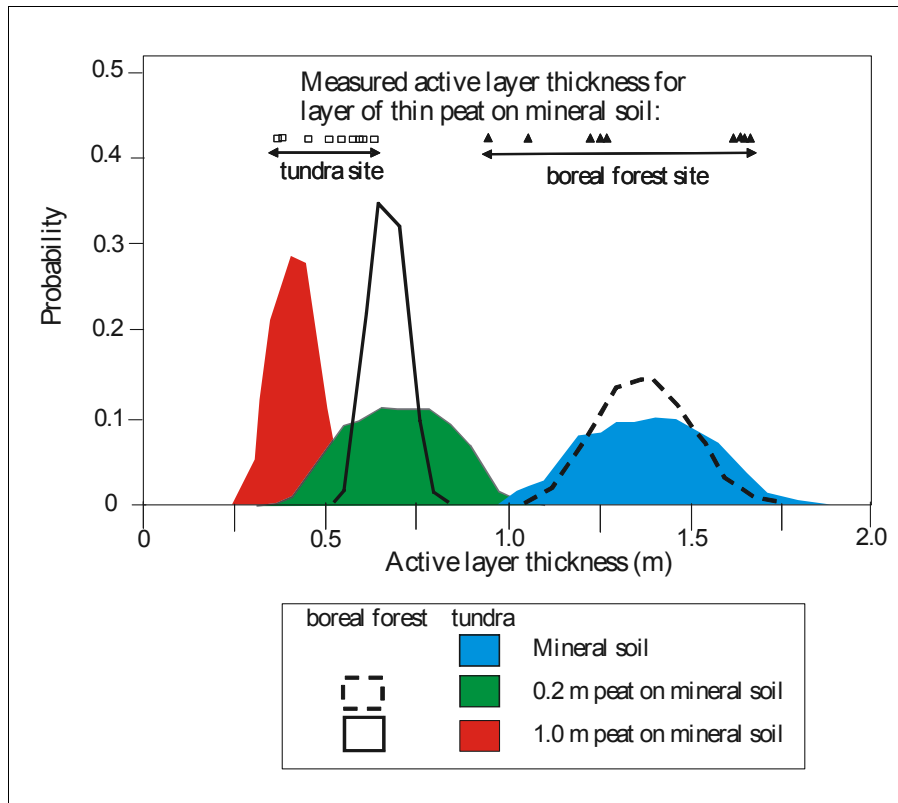
84-2A, KP19

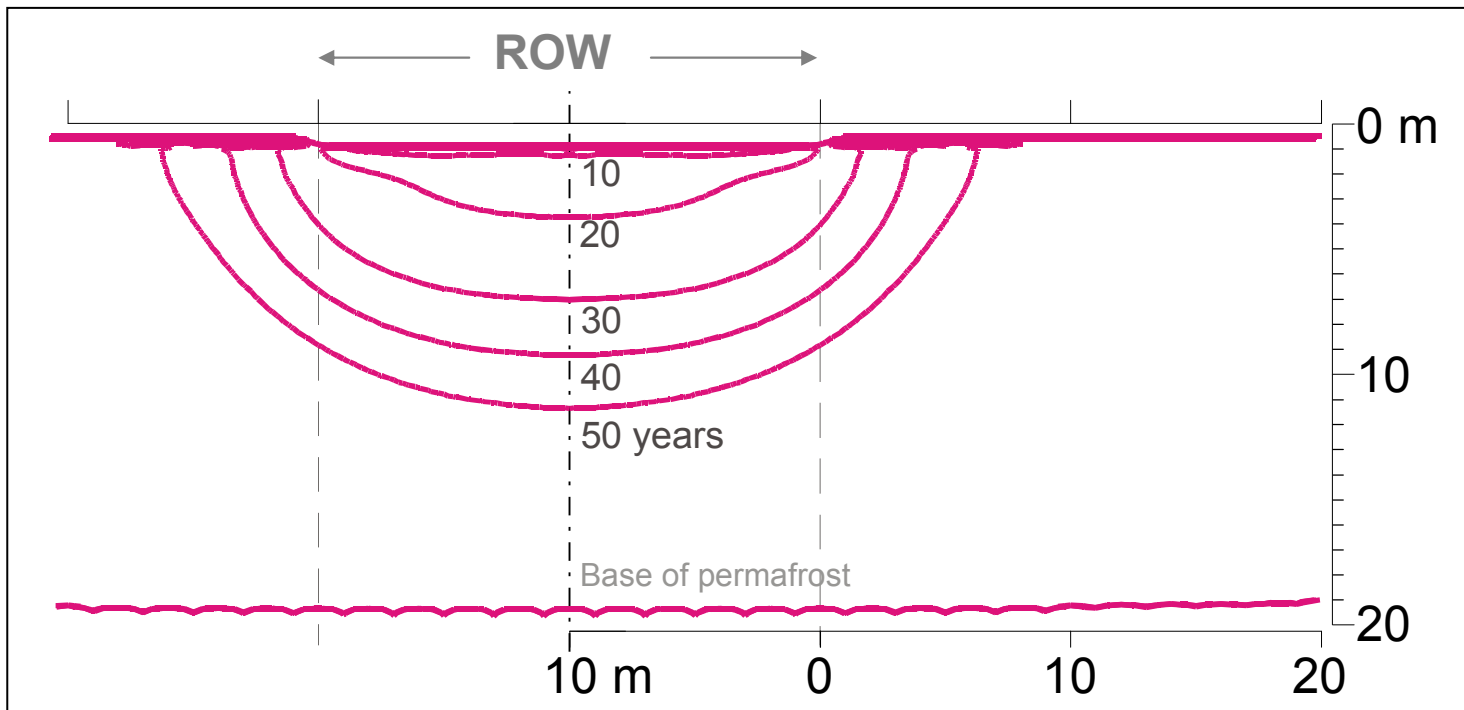
- Coarse till, no vis. ice
- 1984-2001 Active layer thickness increase >6m on ROW
- Thaw settlement <0.35m
- Thaw strain <10%



Application of warming scenarios and probability distribution of active layer thickness

(from Woo et al. (2007))



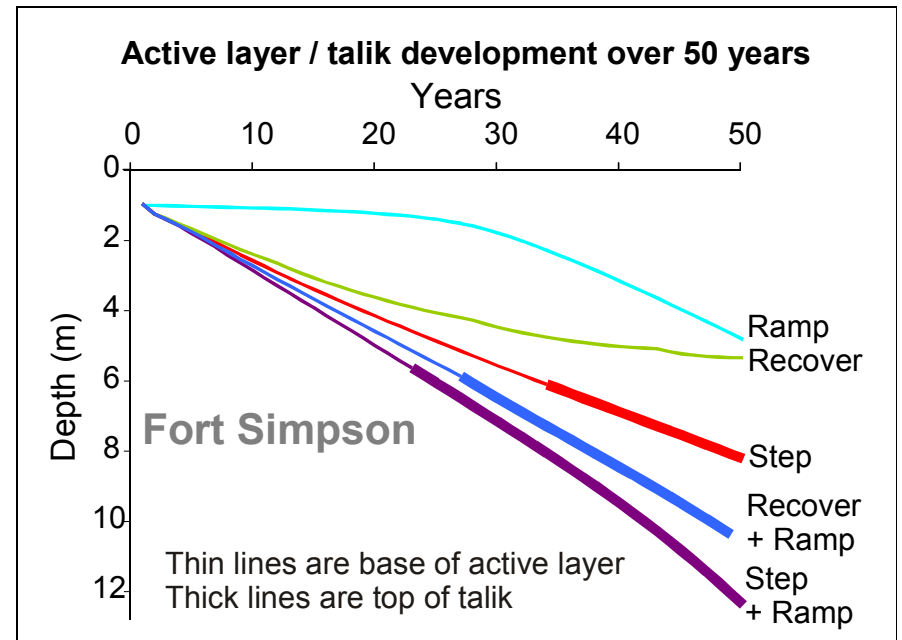


thaw of permafrost

Fort Simpson ROW Step
Disturbance + Climate Warming
Ramp

Attribution of changes in ground thermal condition

(From Smith and Riseborough, 2010)



Accomplishments

- **Comprehensive synthesis of permafrost thermal conditions and recent trends across Canadian north**
 - new information for poorly represented areas
 - improved baseline against which to measure change
 - national characterization of permafrost sensitivity to climate change
- **Improved understanding of impacts of infrastructure development on permafrost terrain**
 - attribution of causes of change
 - characterization of thaw sensitivity
- **Baseline geoscience knowledge supported informed decisions, environmental management and infrastructure design**
 - successful transfer of research results to regulatory-environmental assessment process for Mackenzie Gas Project and informed NRCan EA review
 - monitoring programs considered model for future environmental monitoring and management programs
- **Research results are key contributions to national and international climate change assessments**
- **National and international leadership and recognition**

Knowledge Gaps

- Significant areas where we have little information on permafrost thermal conditions and insufficient information on subsurface conditions (eg. ice content) to adequately characterize terrain sensitivity
 - e.g. potential mineral resource development areas
- Require improved understanding of interaction of processes in dynamic environments to better attribute causes of environmental change
 - e.g. Mackenzie Delta region
- Require improved understanding of feedbacks associated with changes in biophysical environment that accompany changes in permafrost conditions in order to reduce uncertainty in prediction of future conditions
 - changing ice/water content
 - interaction between hydrological, vegetation and ground thermal regime (discontinuous permafrost)
 - influence of surface settlement

Current Support and Partnerships

- Geological Survey of Canada, Natural Resources Canada
- GSC-Atlantic
- Polar Continental Shelf Project
- University of Ottawa
- Carleton University
- Northern Energy Development Initiative
- Panel on Energy Research and Development (PERD)
- Enbridge Pipelines
- Imperial Oil Resource Venture Limited
- Department of Indian and Northern Affairs
- Environment Canada
- Department of National Defence
- Parks Canada
- Government of Nunavut
- Yukon Geological Survey
- Federal IPY funding program