



UNIVERSITÉ  
LAVAL

## ARQULUK SYMPOSIUM

Research program  
in permafrost engineering



**GUY DORÉ** ing. PhD, Professor

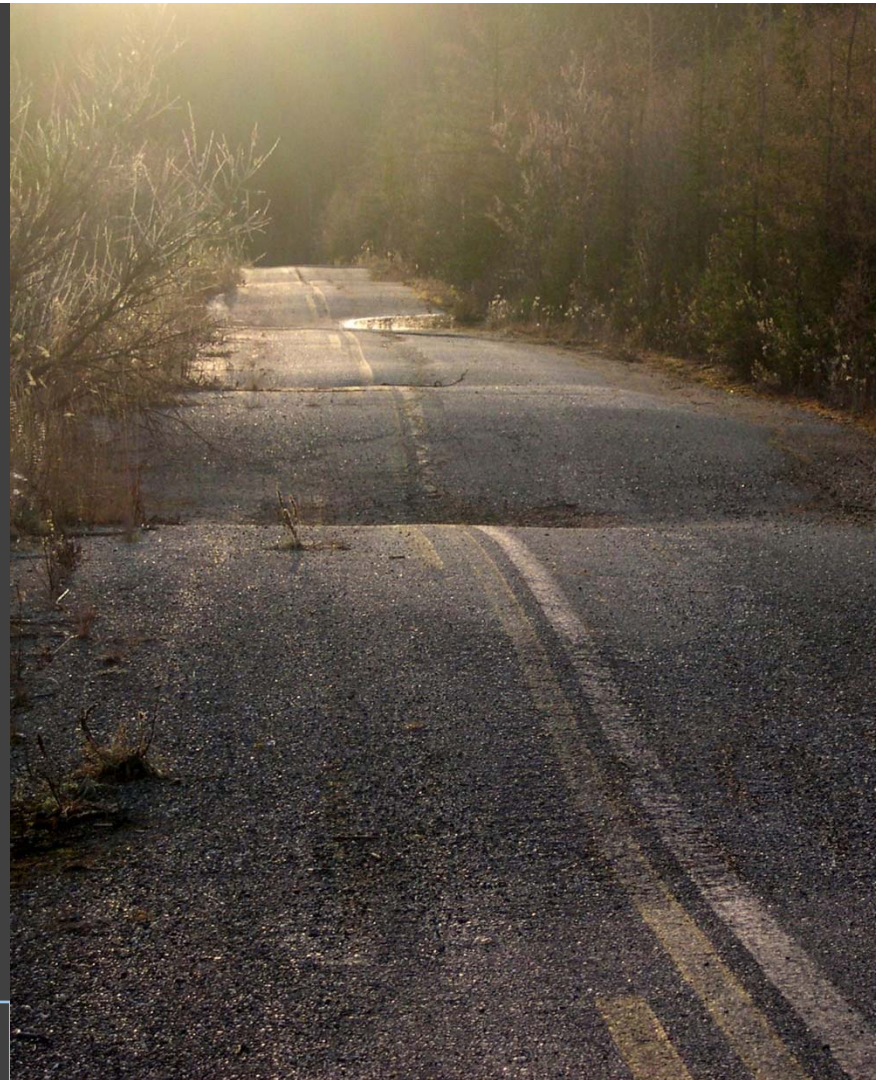
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Laval University, Quebec

Arquluk Symposium

Whitehorse, February 21st, 2018



# Today's program



Keynote presentation by Paul Murchison, YHPW – Transportation Engineering Branch

## Presentations:

- Projects of the Arquluk permafrost engineering program
- Northern Climate ExChange, Yukon Research Center  
Brian Horton, Fabrice Calmels and Louis-Philippe Roy
- Government of the Northwest Territories – The ITH project  
Dean Ahmet

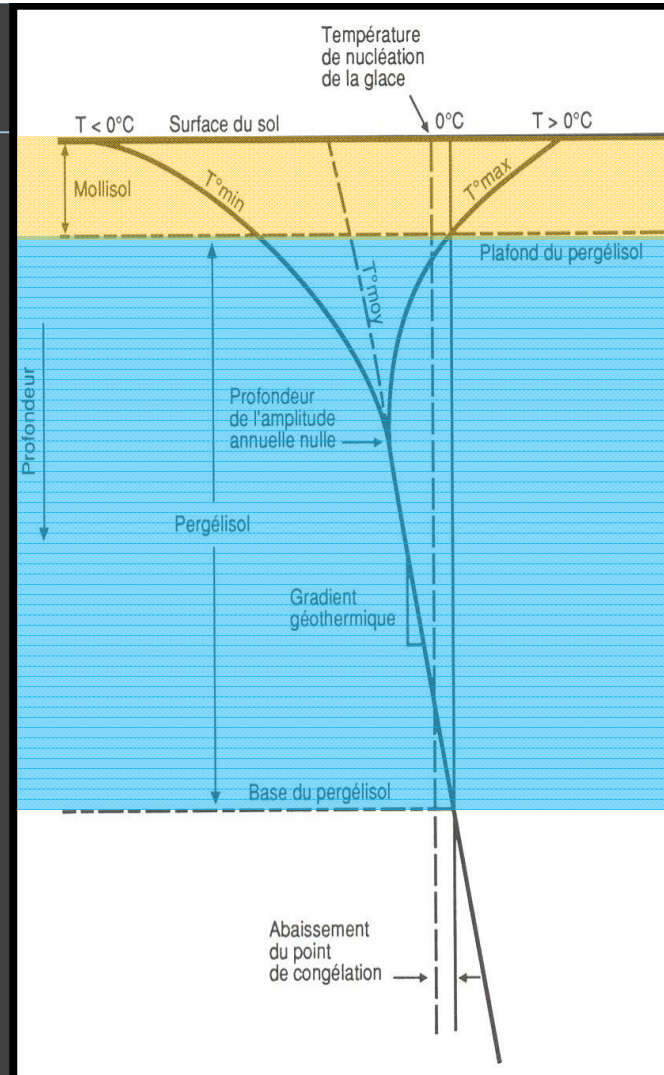
Breaks : 10am and 2:40pm

Lunch : 11:50am to 1pm

End at 5pm

# Intro permafrost

Ground with a temperature **lower** than **0°C** during an extended period (several years)



# Intro permafrost

## The challenge of permafrost engineering

- Permafrost is a complex physical system in fragile equilibrium with its environment (climate, surface characteristics)
- Permafrost can be ice-rich (sensitive)
  - Any surface disturbance will affect the thermal equilibrium of permafrost
  - Climate changes will also affect the equilibrium



Picture: Chris Burn

# Intro permafrost

## Examples of degradation



Differential settlement



Thermokarst



Thermal erosion



Creep of frozen soils

# Development of solutions in 5 steps

## Understand

- Problem assessment

## Identify solutions

- Review of the state of the art
- Development of preliminary concepts

## Refine

- Numerical simulations
- Laboratory modelling

## Experiment

- Full scale testing

## Apply

- Pilot projects

# Development of solutions in 5 steps

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# Understand: Problem assessment

> Site visits and documentation of distresses



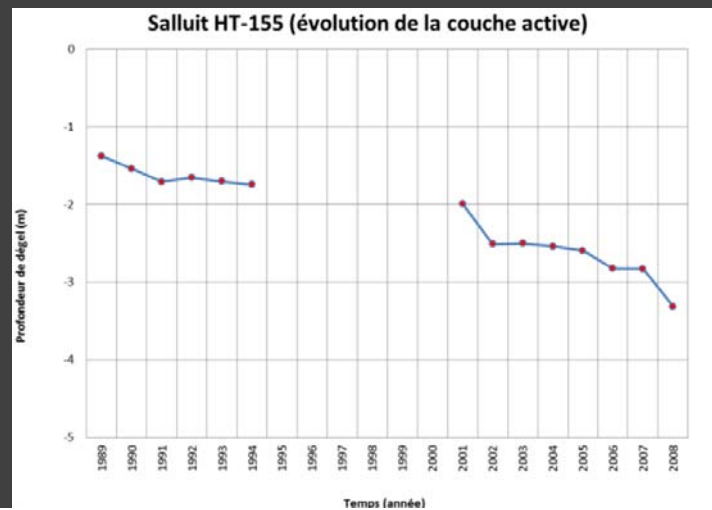
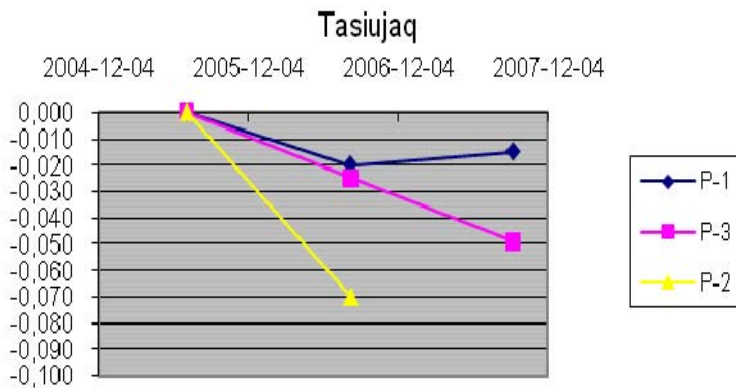




# Understand: Problem assessment

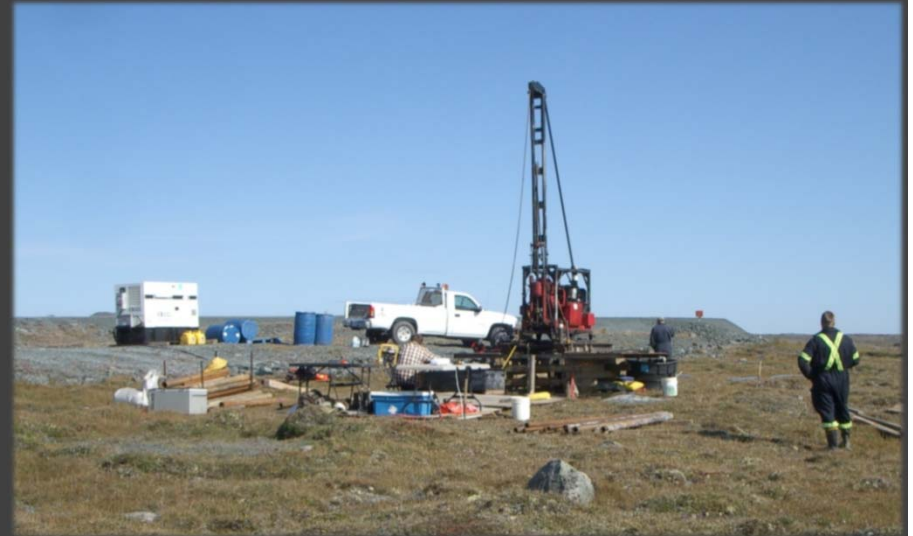
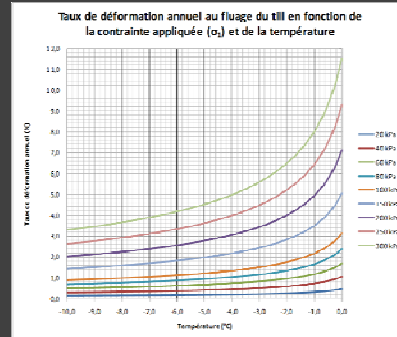
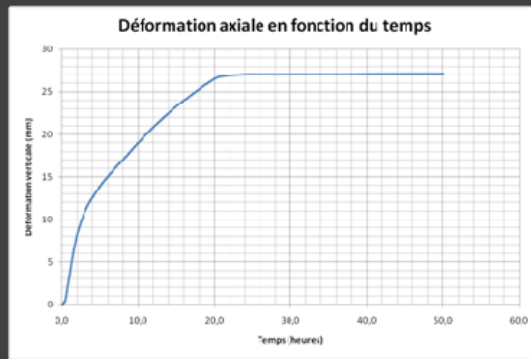
## > Monitoring

Several sites in Yukon  
and Nunavik (northern Quebec)



# Understand: Problem assessment

## > Geotechnical characterization of unstable sites



## Understand

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# Identification of potential solutions

- > Several methods developed in Alaska in past 50 years
- > Interesting related work done in China and Russia
- > Adaptation and further development required



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## Experiment

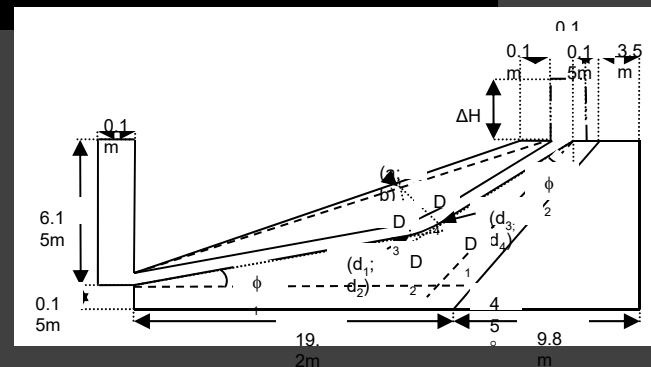
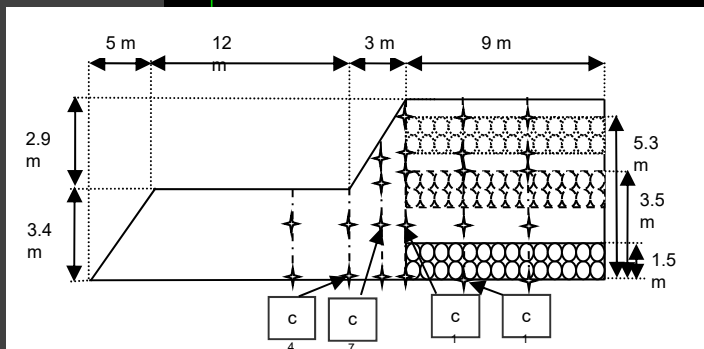
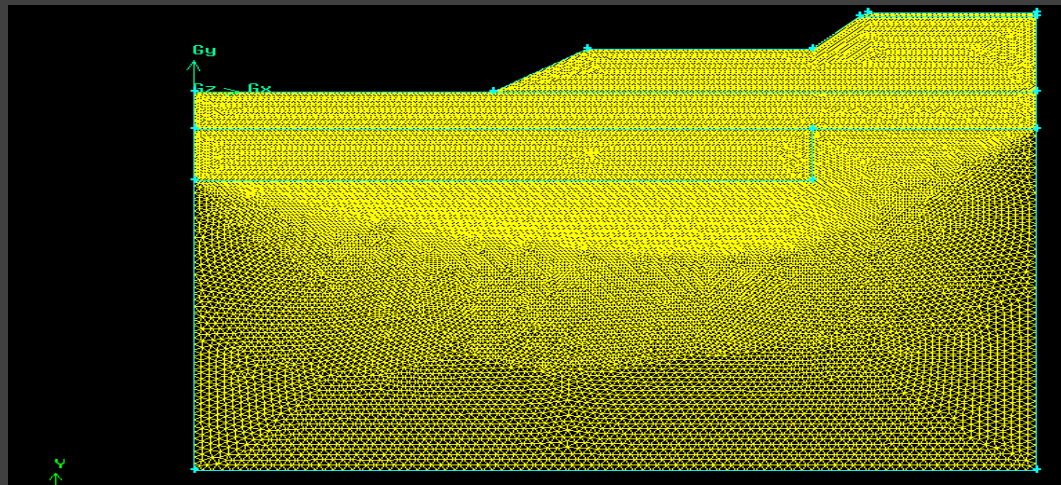
- Full scale testing

## Apply

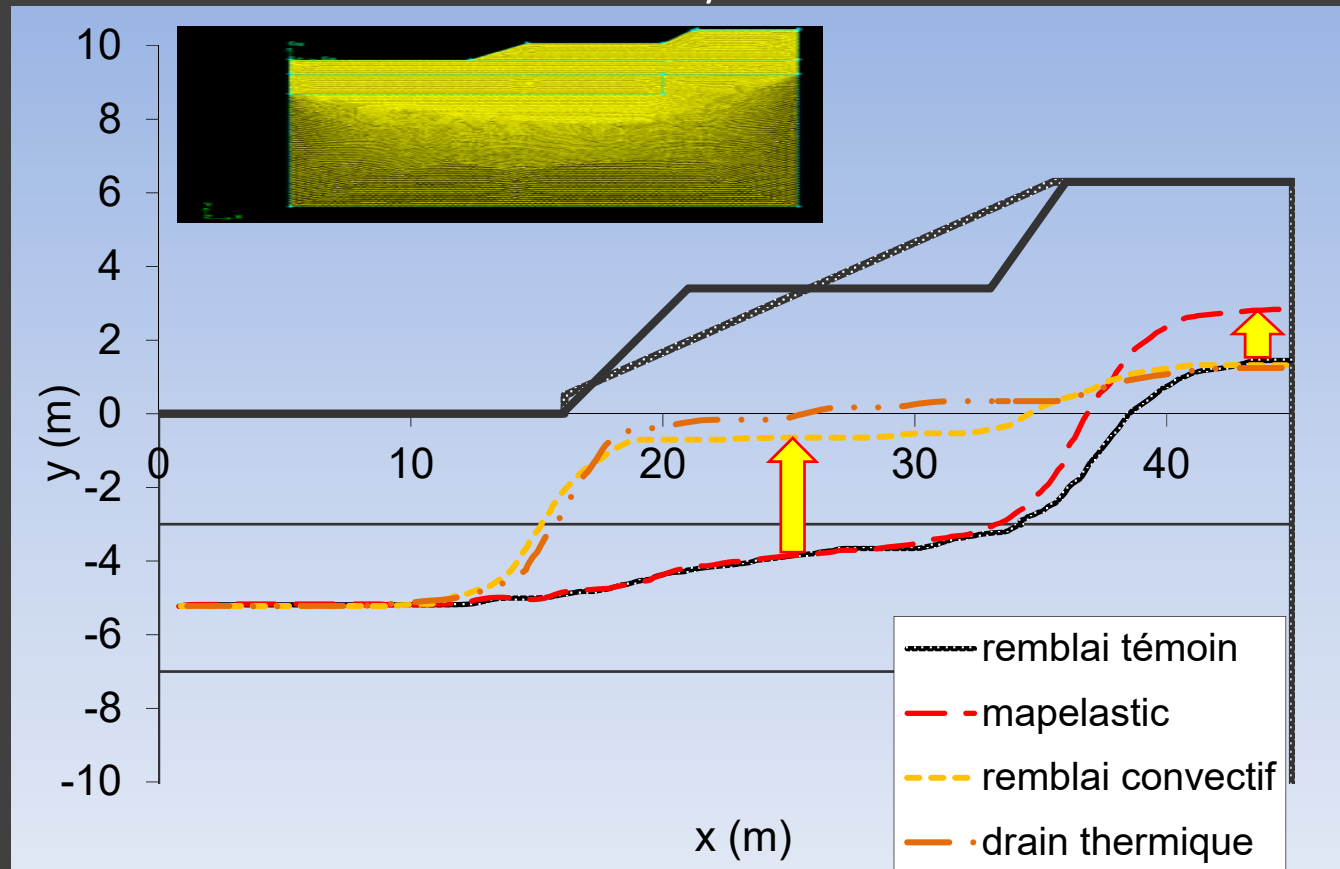
- Pilot projects

# Refine

## Optimization of design parameters by numerical simulations

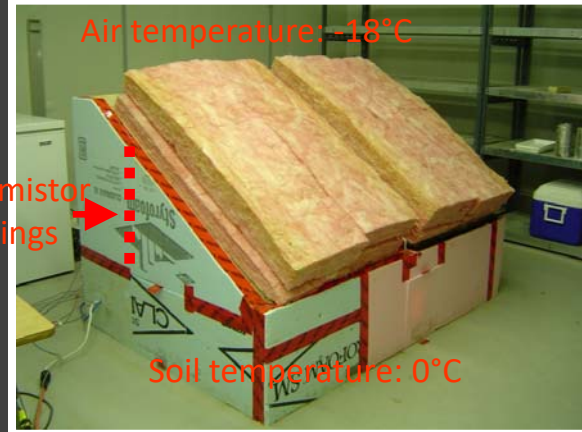
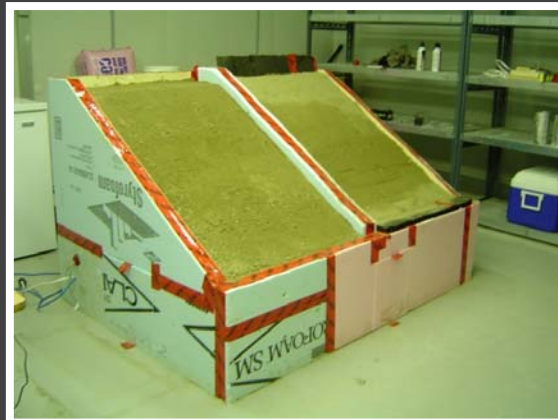
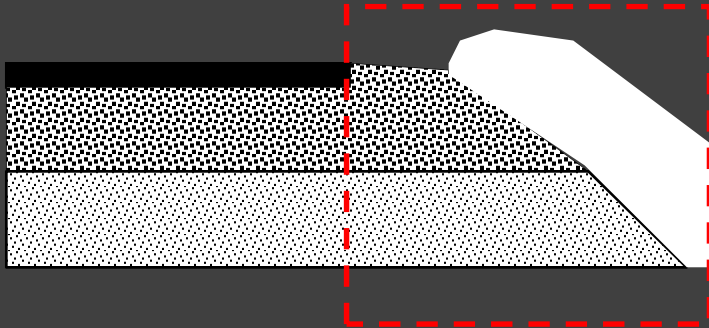


## Performance evaluation by numerical simulations





# Laboratory small-scale simulations



## Understand

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## Experiment

- Full scale testing

## Apply

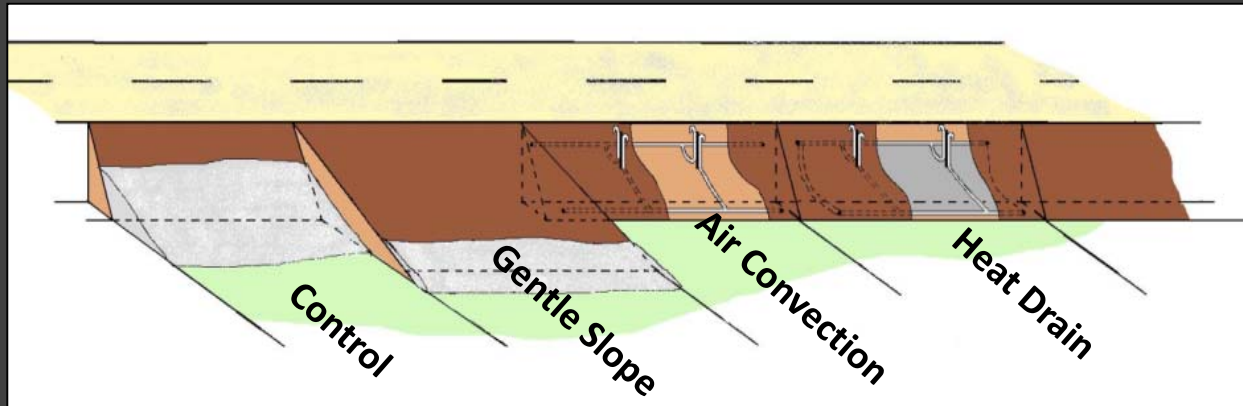
- Pilot projects

# Experimental projects

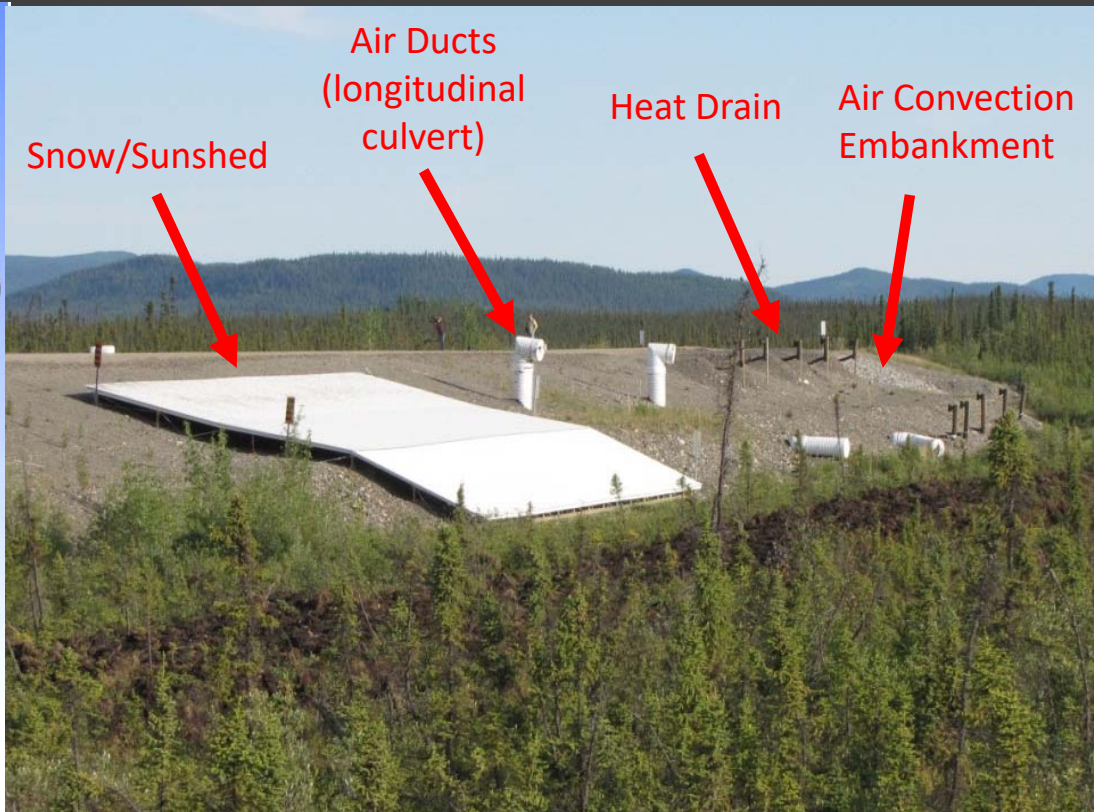
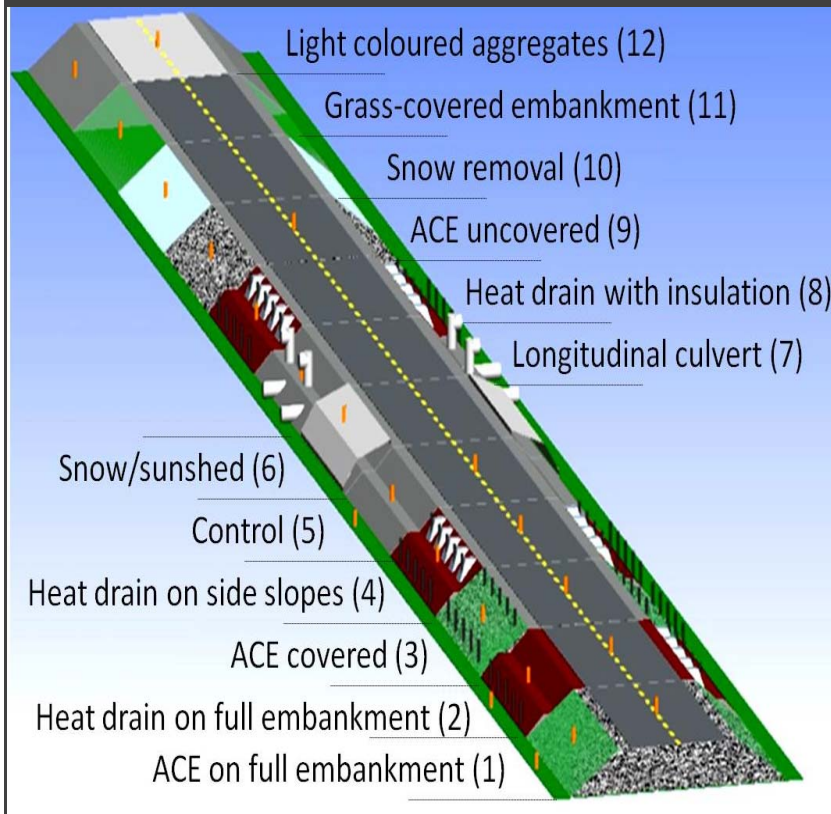
- > Assessment of feasibility
- > In-situ (full-scale) assessment of effectiveness
- > Preliminary assessment of cost effectiveness
- > Several test sites monitored:
  - Tasiujaq airstrip (4 test sections)
  - Beaver Creek (12 test sections)
  - Salluit test site on High Albedo Surface Treatment (3 test sections)



# Tasiujaq (northern Quebec) experimental test site



# Beaver Creek (Yukon) experimental test site



# Salluit (northern Quebec) experimental test site on High Albedo Surface Treatment



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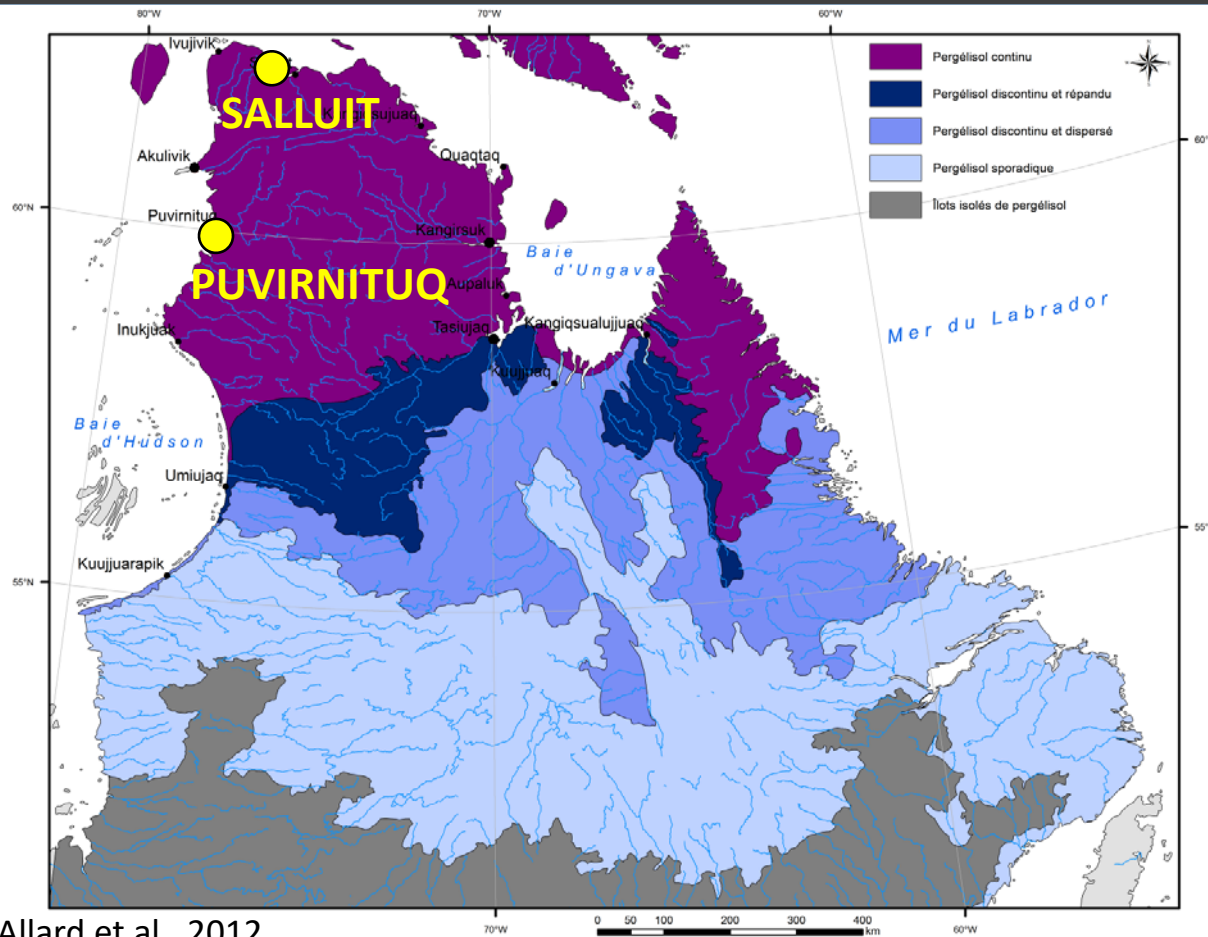
## Experiment

- Full scale testing

## Apply

- Pilot projects

# Adaptation projects in Nunavik – MTMDET

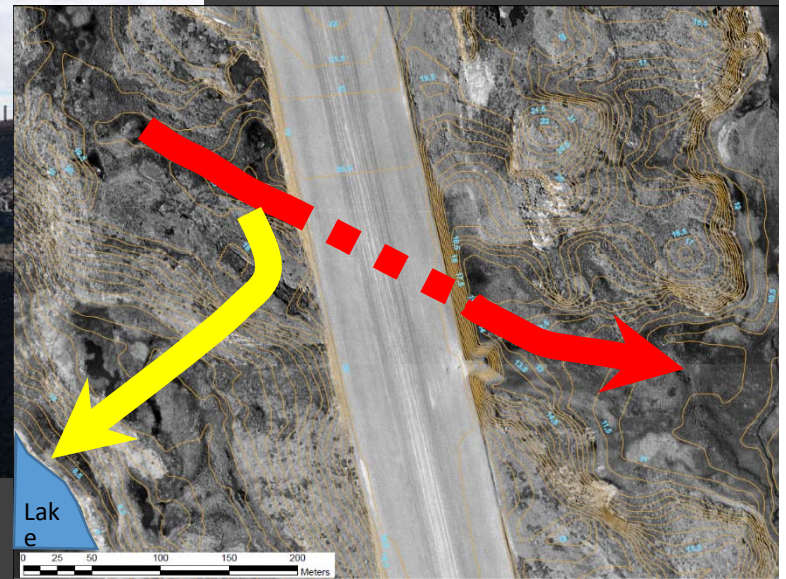


Allard et al., 2012



# Adaptation projects in Nunavik – MTMDET

## Stabilization project of Puvirnitug airstrip



# Adaptation projects in Nunavik – MTMDET

## Stabilization project of Salluit airport access road



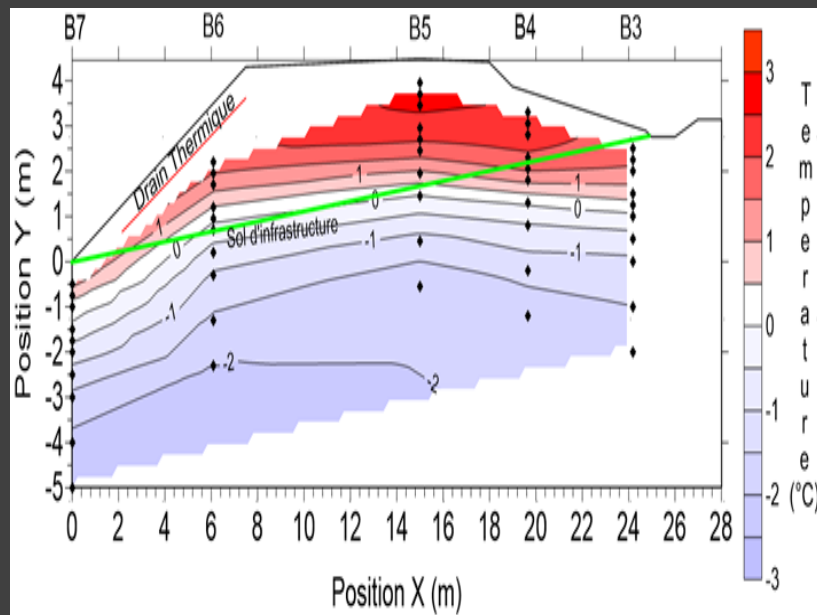
# Adaptation projects in Nunavik – MTMDET

## Stabilization project of Salluit airport access road



# Adaptation projects in Nunavik

## Monitoring the performance of protection systems



# Adaptation projects in Nunavik – MTMDET

Puvirnitug  
airstrip



8 years  
after  
adaptation

Airport access road  
Salluit



5 years  
after  
adaptation

No significant signs of degradation at both sites

# ARQULUK program



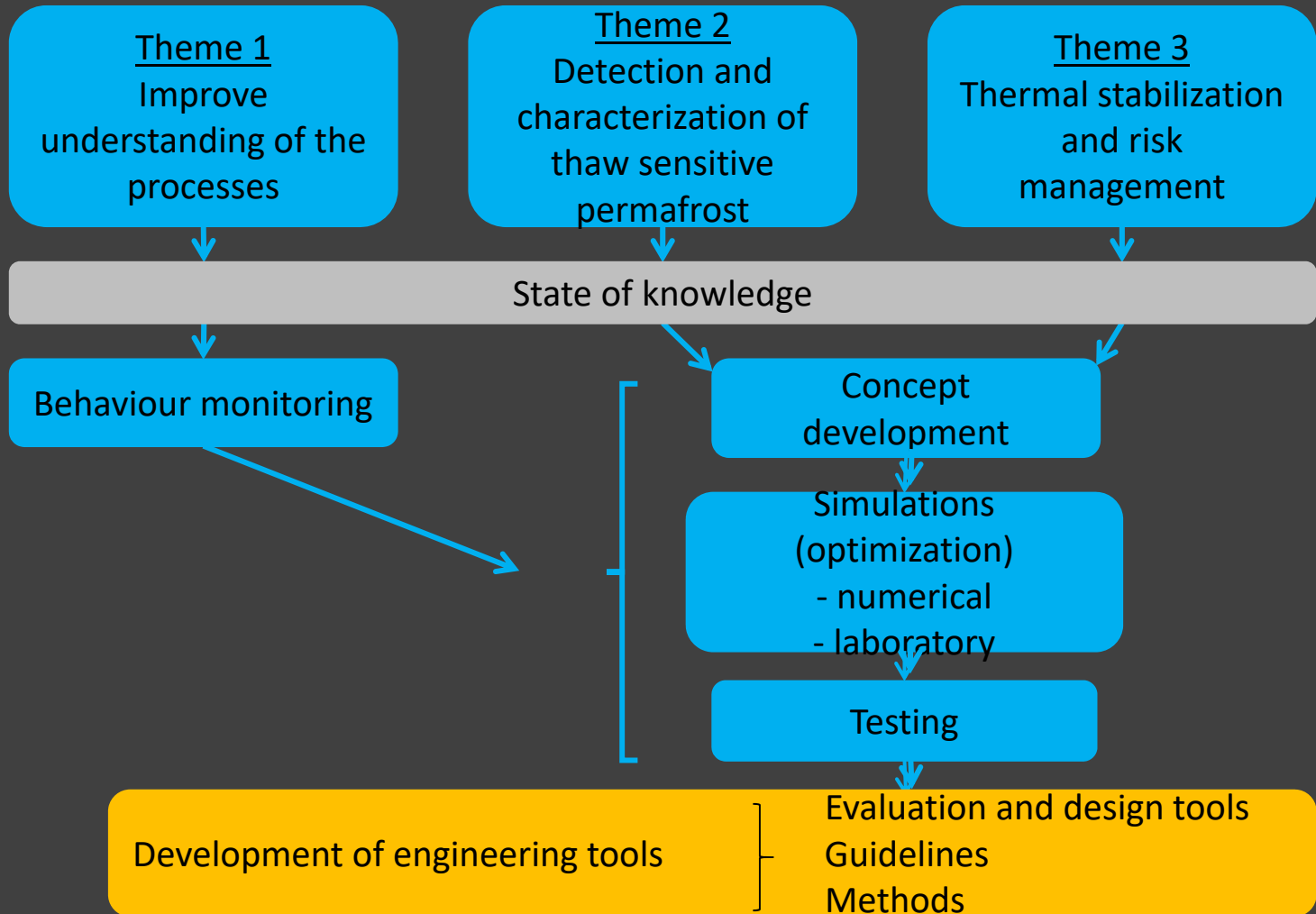
Cooperative Research and Development Program  
1 320 000\$ / 5 years (2012-2017)  
sponsored by NSERC and 12 partners (public and private)



Implication of program partners  
(meetings, project committees, products, expertise, services, etc, ...)

## GOAL

Improve current adaptive capacities  
by developing expertise  
on **thermal stabilization** of permafrost  
under transportation infrastructure





## Theme 1 – Improve understanding of processes

Monitoring of test sites

Development of engineering parameters

## Theme 2 – Detection and characterization of thaw sensitive permafrost

a. Geophysical method

b. Profiles analysis

c. In-situ oedometric tests

d. Mechanical behaviour of marginally frozen soils

## Theme 3 – Thermal stabilization and risk management

a. Thermal stabilization using high-albedo surfacing materials

b. Mitigation of disturbance caused by snow accumulation

c. Design of drainage systems

d. Risk analysis for linear infrastructure

e. Thermal stabilization using air convection systems



# ENJOY THE SYMPOSIUM!

