Development of design tools for convective mitigation techniques to preserve permafrost under northern transportation infrastructure

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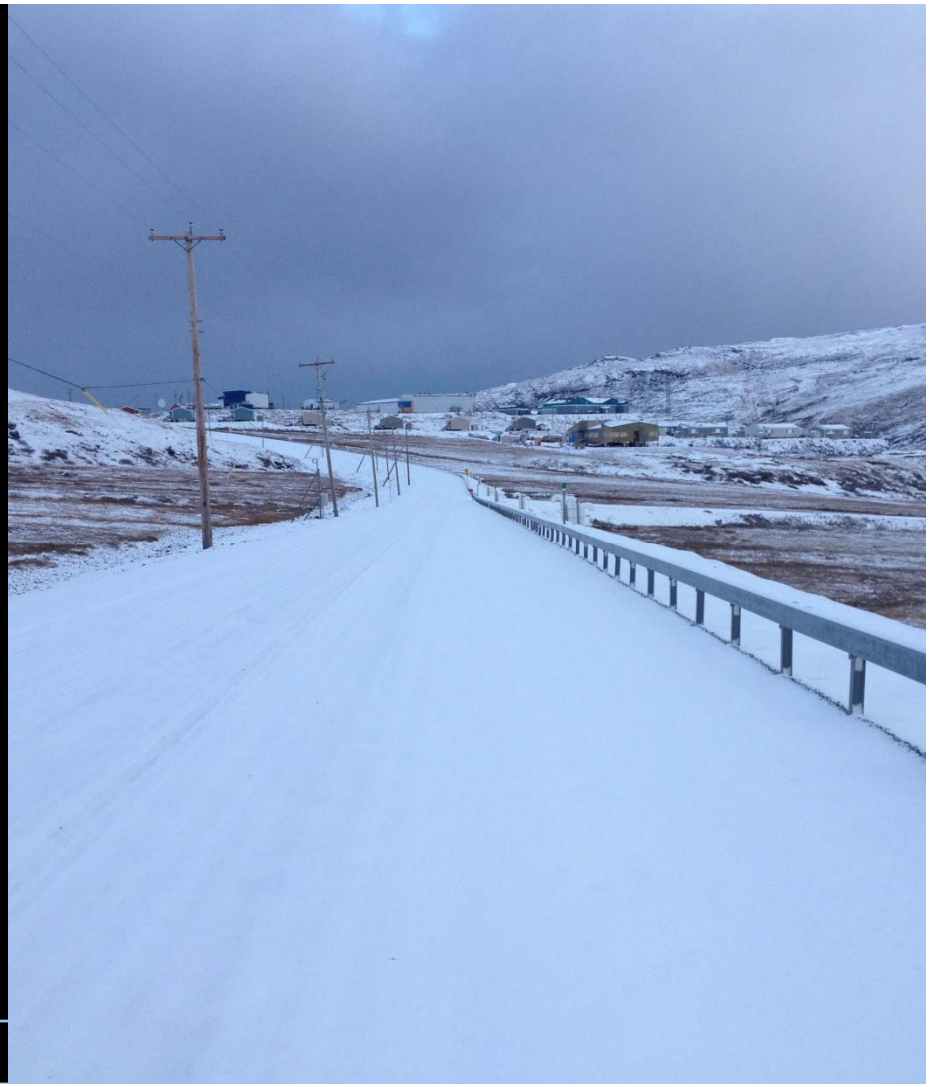
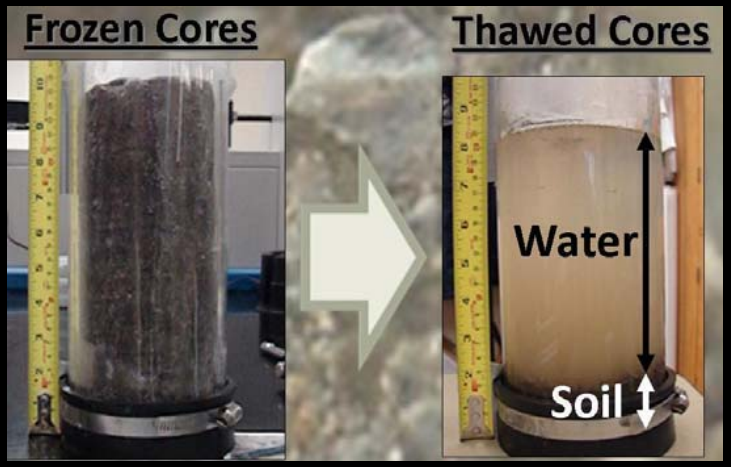


Introduction -> Permafrost and Embankment Degradation

Source: Fabrice Calmels, Yukon Research Centre



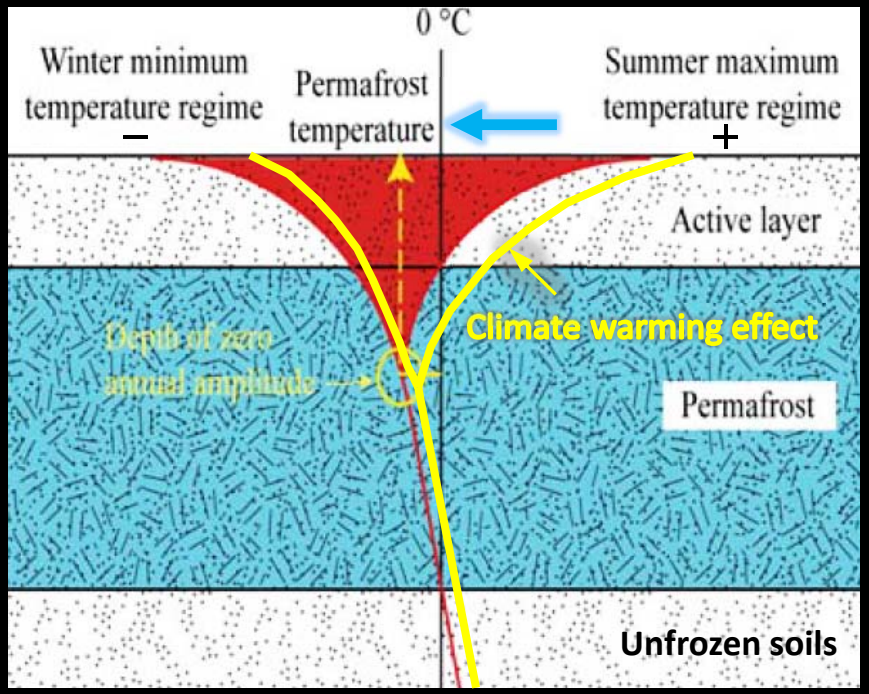
Introduction -> Permafrost and Embankment Degradation

Differential Settlement

Introduction -> Permafrost and Embankment Degradation

Embankment Spreading

Introduction -> Permafrost and Embankment Degradation



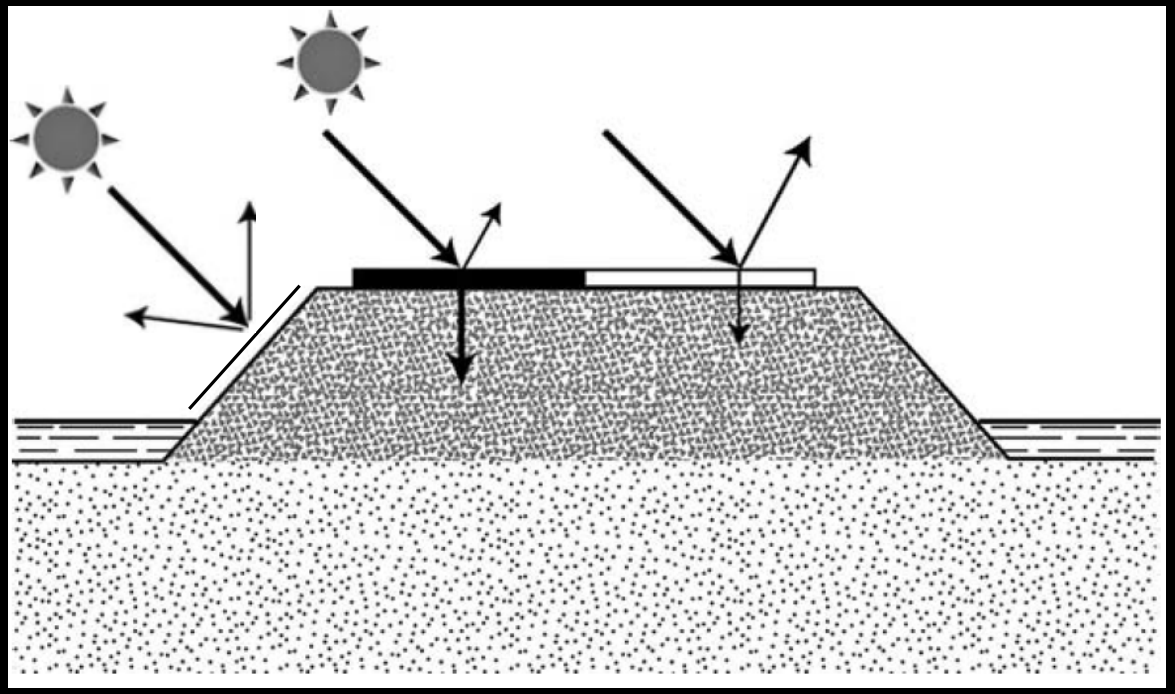
To protect permafrost :

- Prevent heat intake
- Extract heat from the ground

It is essential to keep permafrost frozen under transportation infrastructure

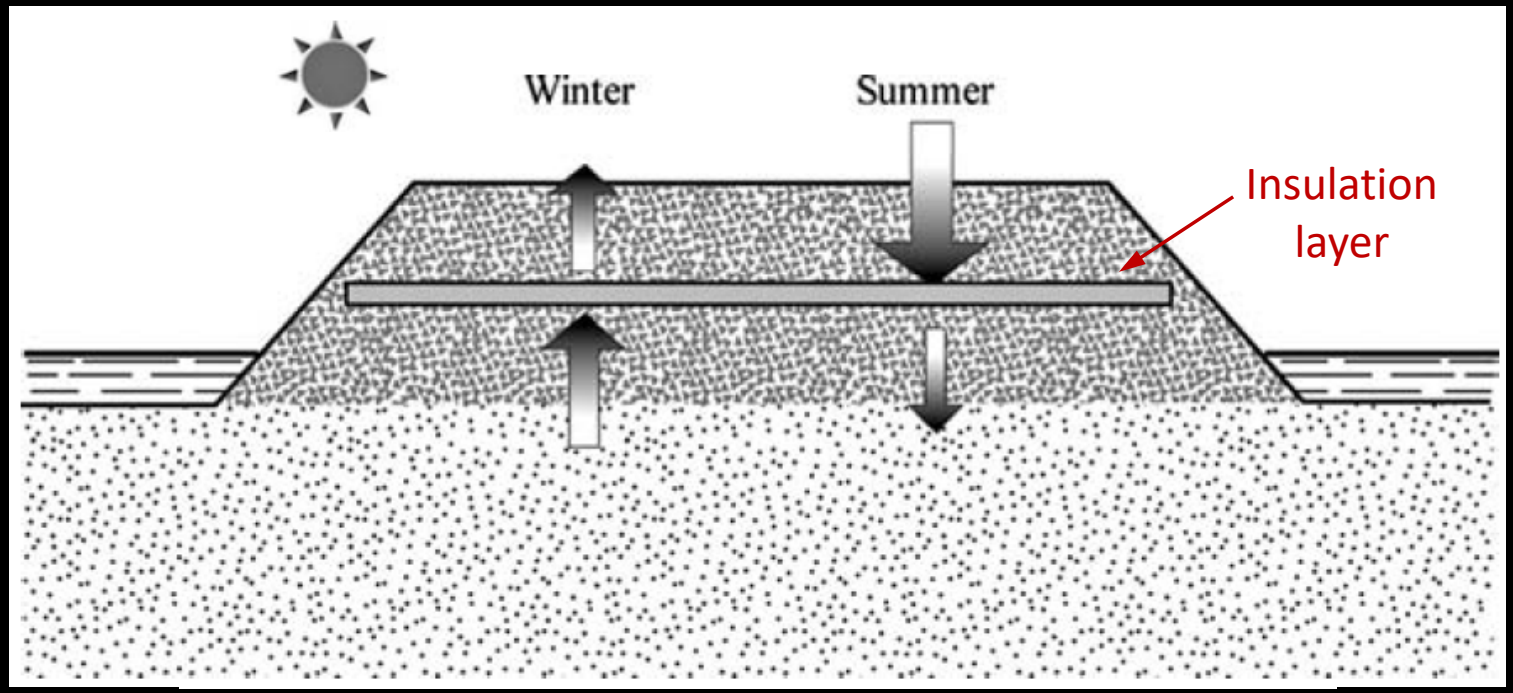
Introduction -> Heat Transfer

- Principle of preventing heat intake



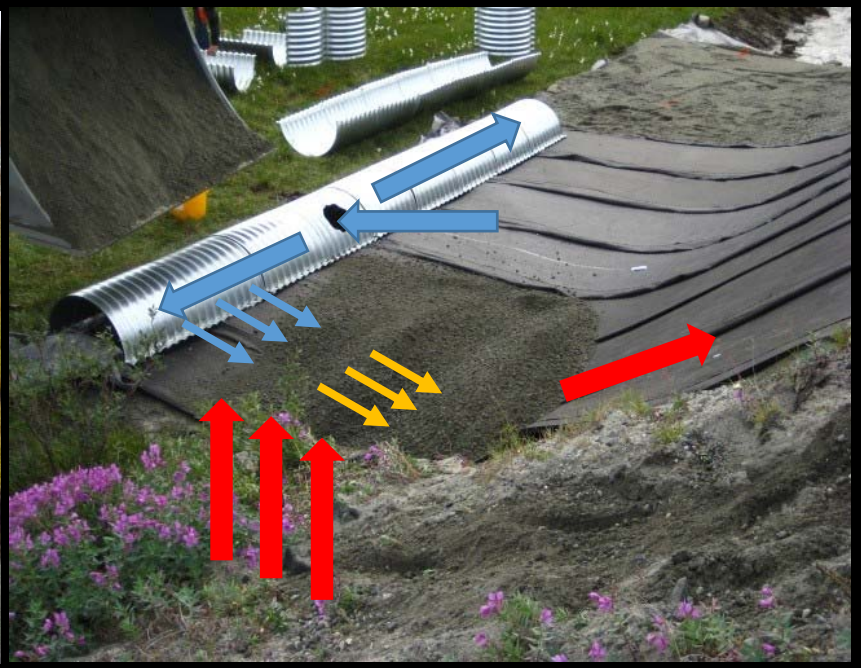
Introduction -> Heat Transfer

- Principle of preventing heat intake

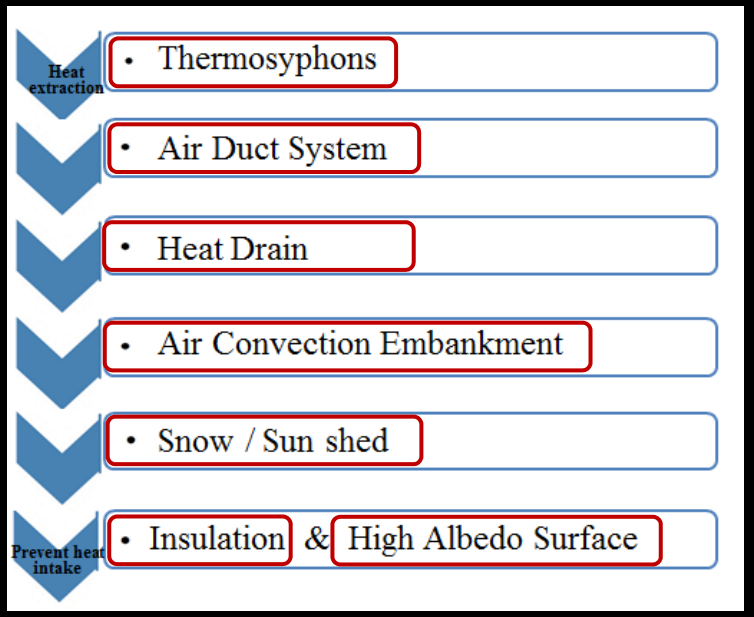


Introduction -> Heat Transfer

- Heat extraction – Heat Drain technique

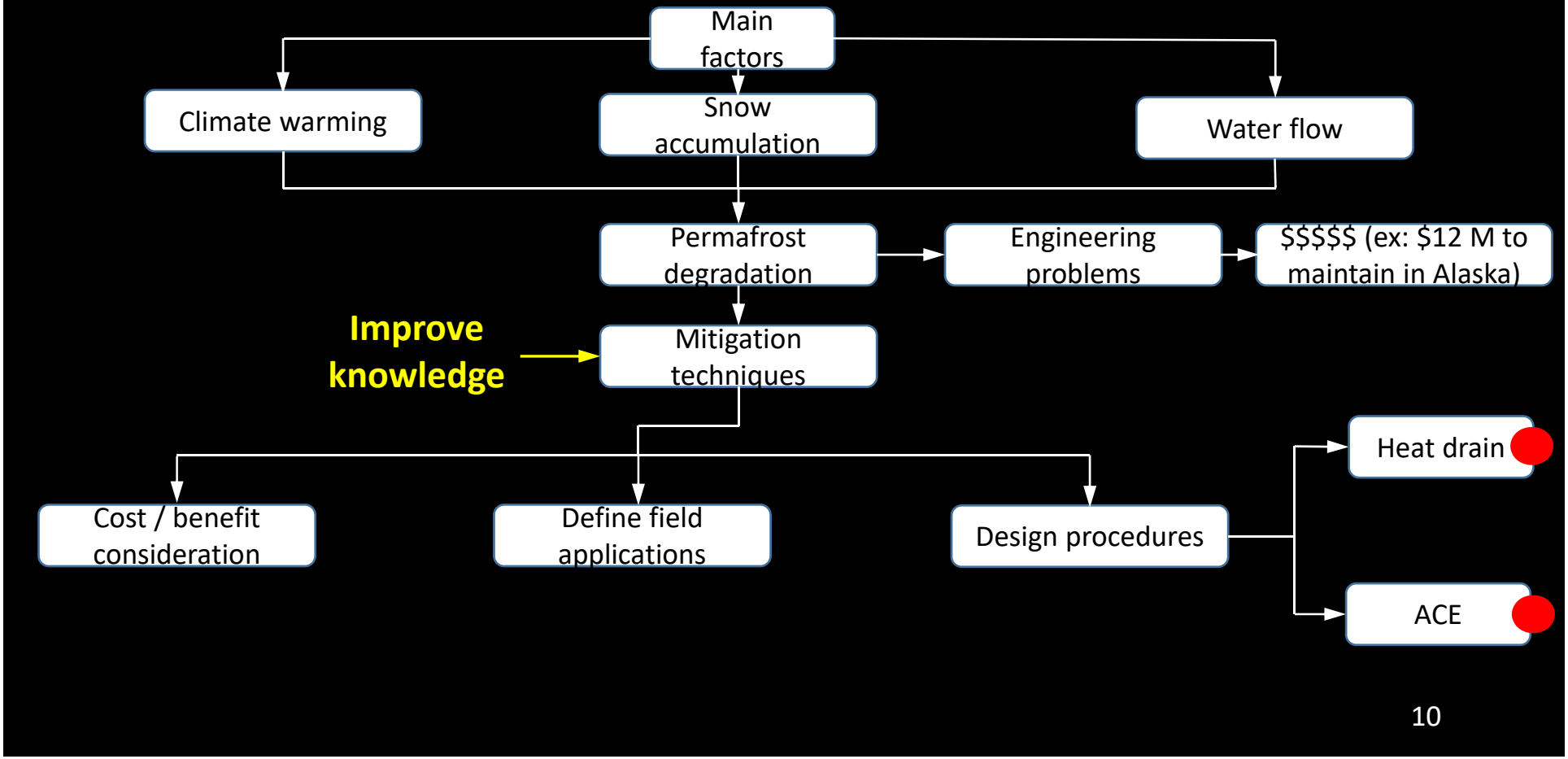


Introduction -> Mitigation Techniques



Source: Modified from Ferell, 2010

Research Project -> Improve Knowledge on Mitigation Techniques

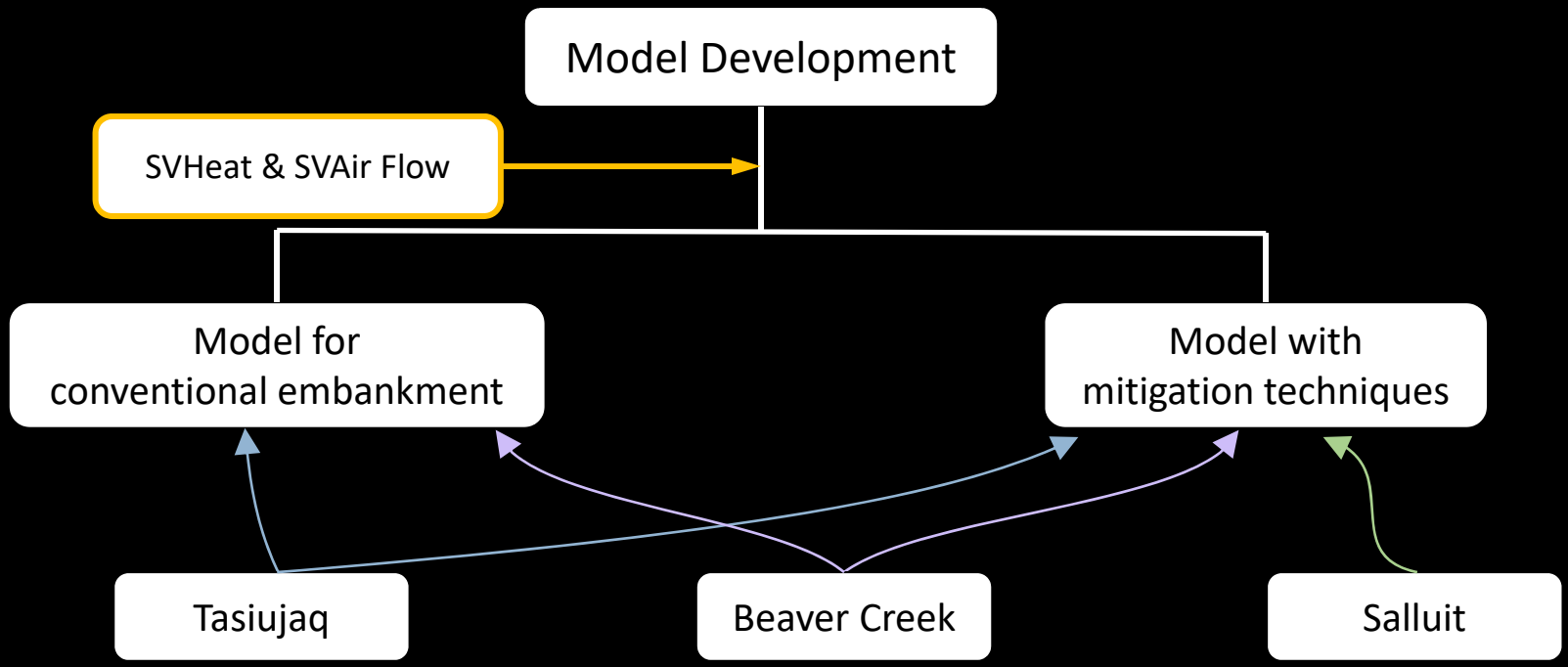


Project Goal

Develop optimized engineering tools to design air convective protection systems

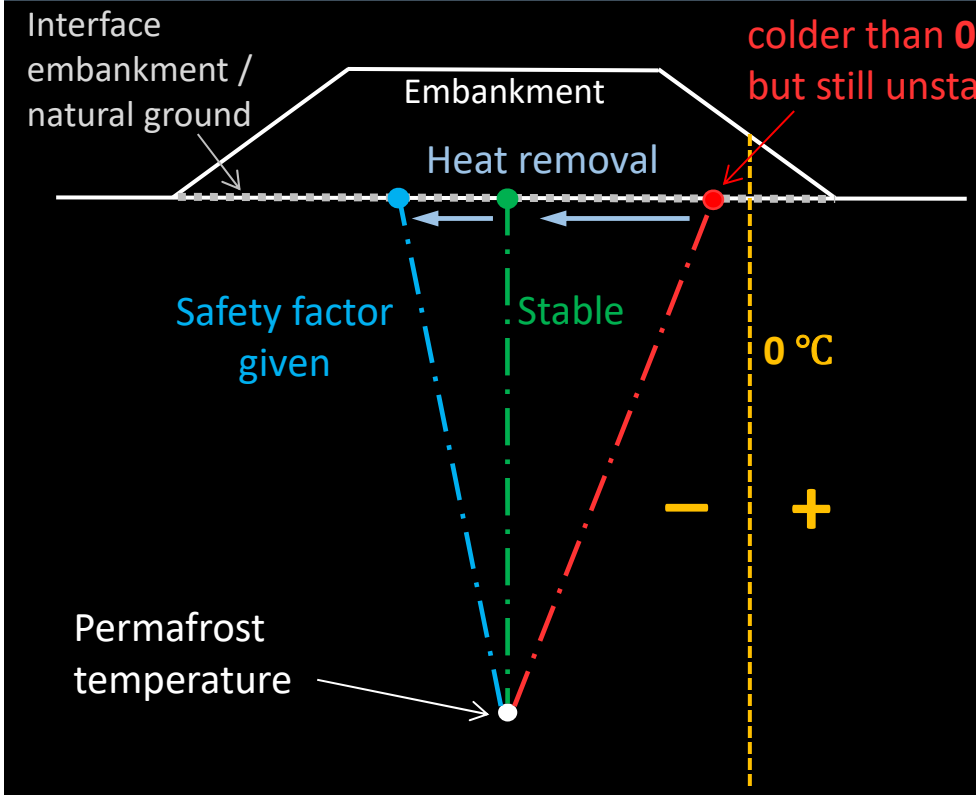
- Create a decision tool from existing techniques for the selection of an appropriate mitigation method that considers the local context and need
- Develop design procedures for convective mitigation techniques: heat drain and air convection embankment

Research Project -> Methodology

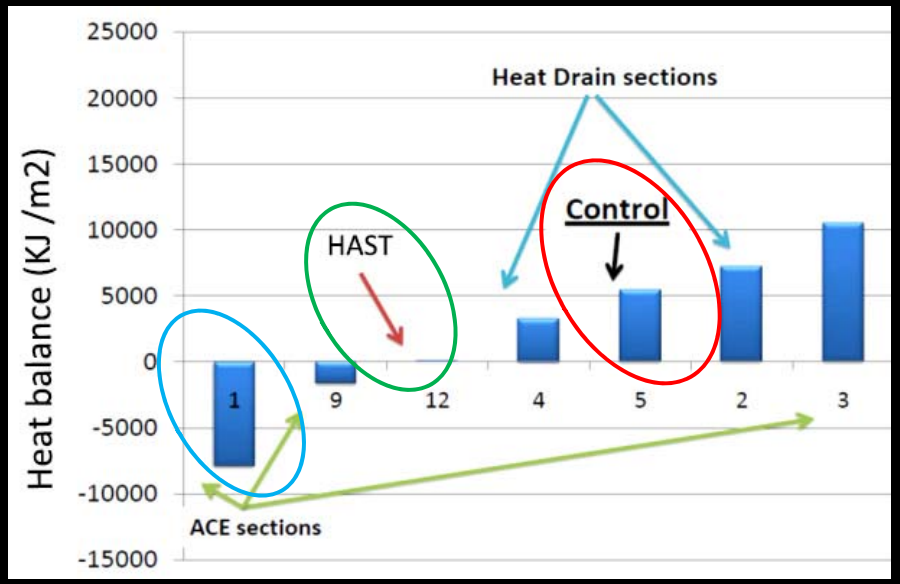


- One model examines permafrost degradation, the other examines the effectiveness of the mitigation methods
- 3 field sites available to validate models

Research Project -> Methodology



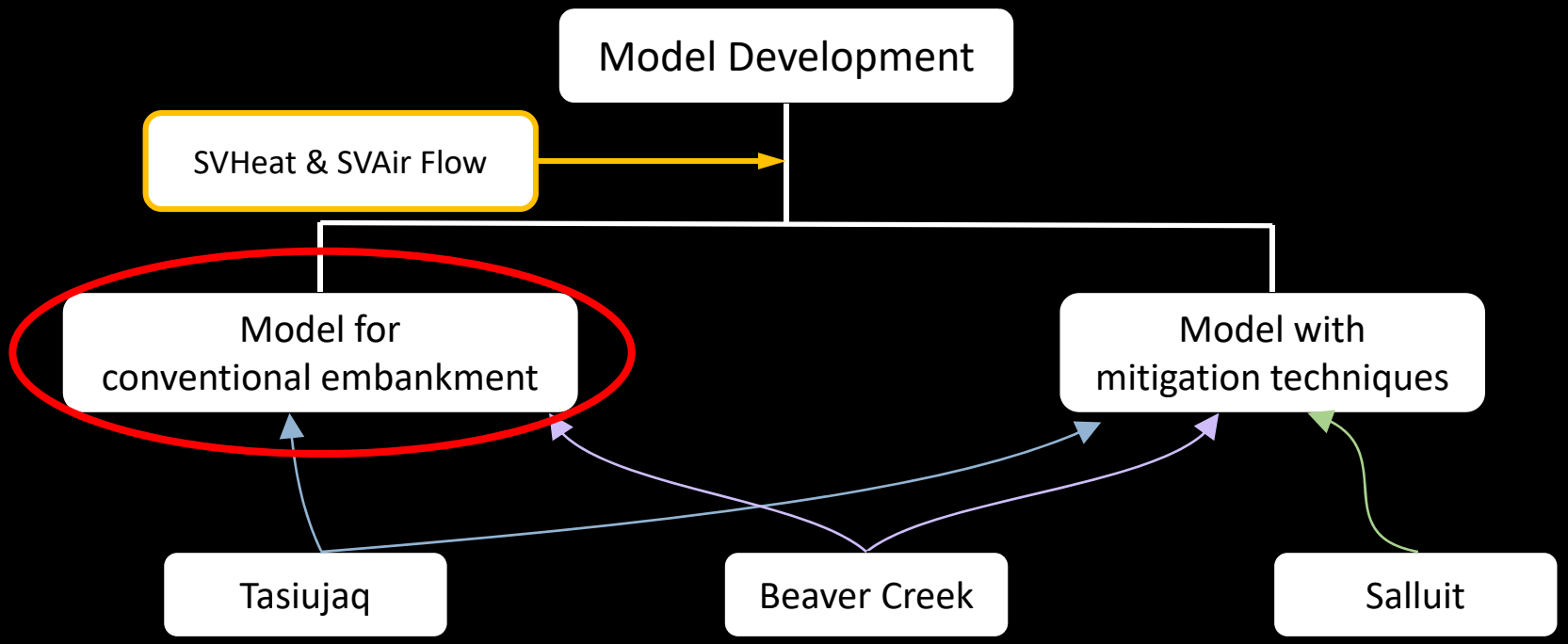
Difference between temperature of permafrost and temperature at 'embankment / natural ground' interface



Heat balance method will be used to :

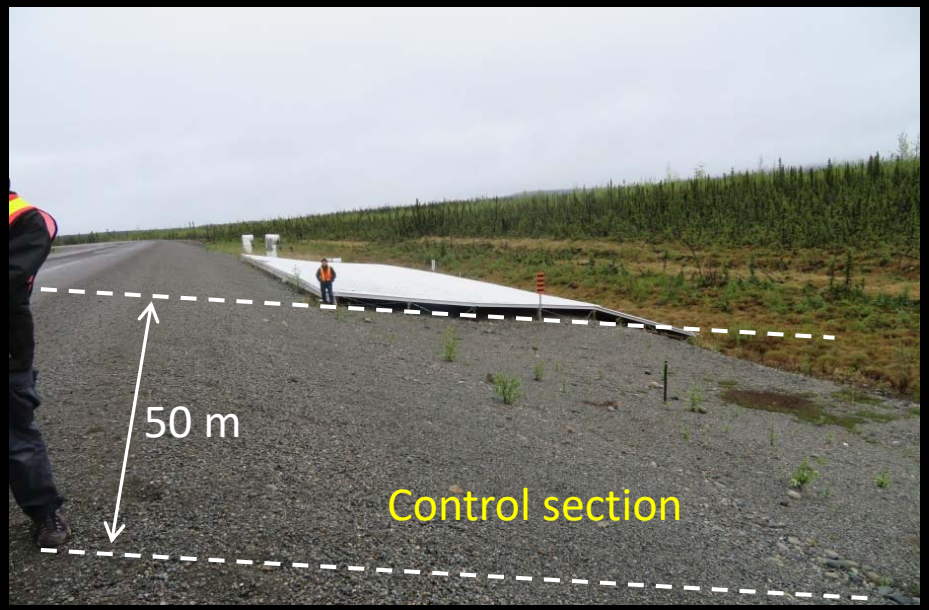
- validate models (field data)
- test heat extraction ability of mitigation techniques

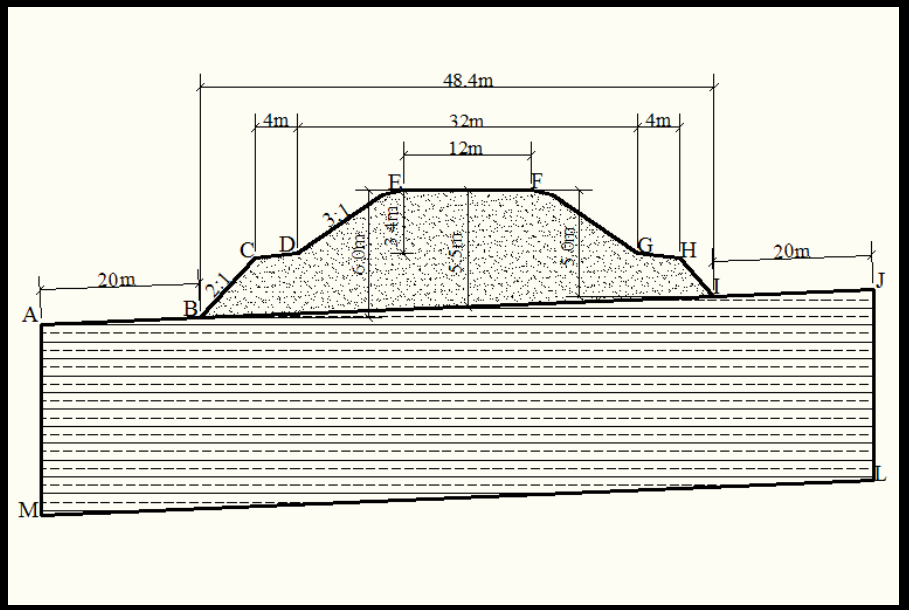
Research Project -> Methodology



Preliminary Outcomes -> Model development

Beaver Creek test site, Yukon

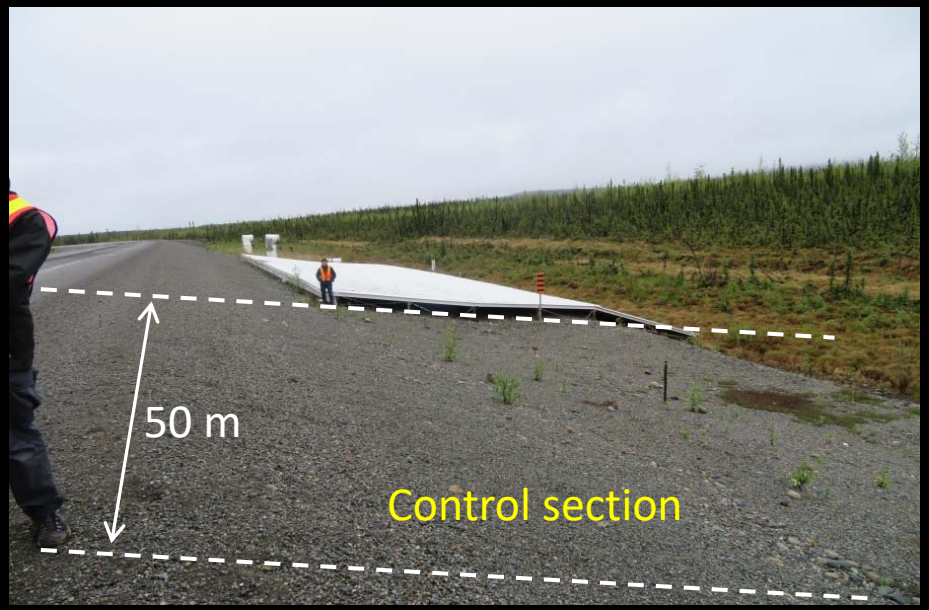


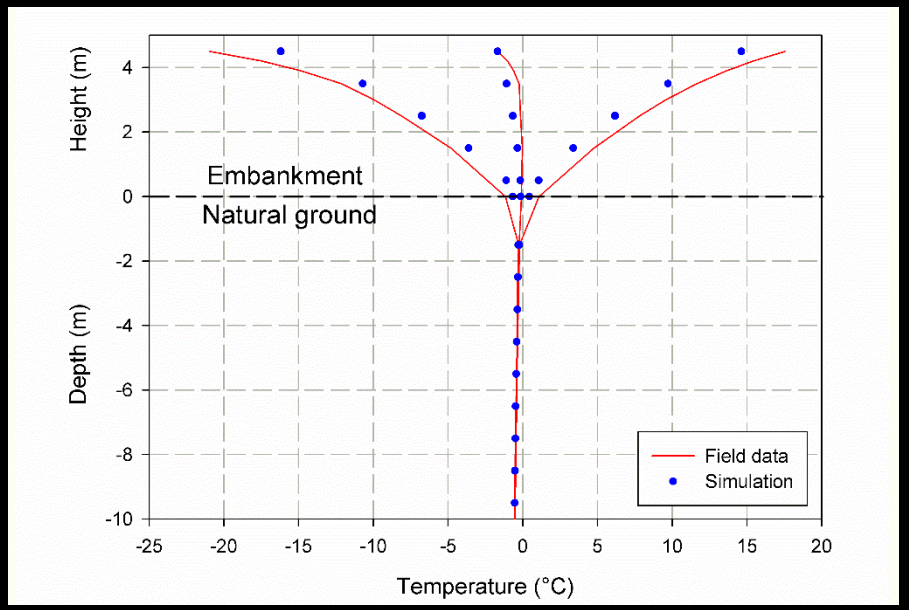


- A 2D thermal model was developed based on the control section at Beaver Creek, Yukon
- The thermal model was well calibrated by the field data along the centerline

Preliminary Outcomes -> Model development

Beaver Creek test site, Yukon





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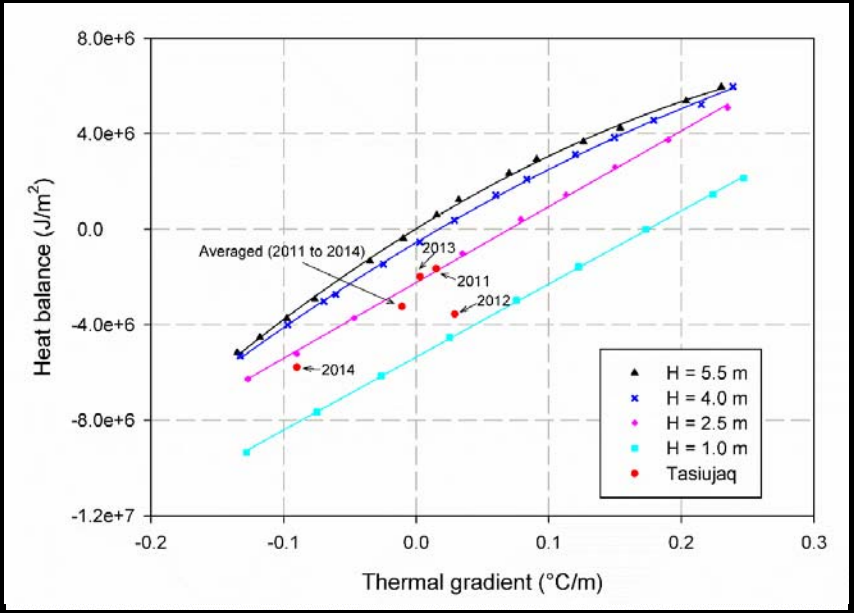
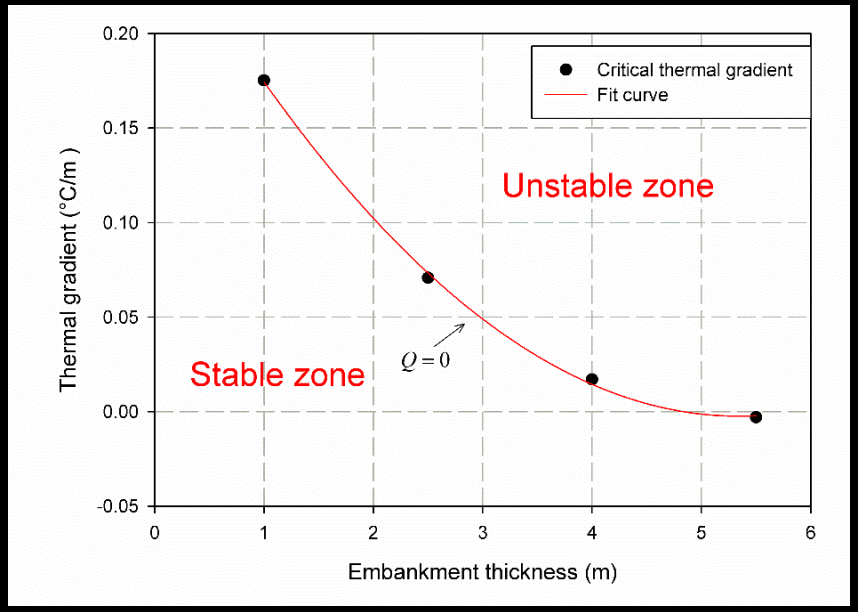
Preliminary Outcomes -> Heat balance



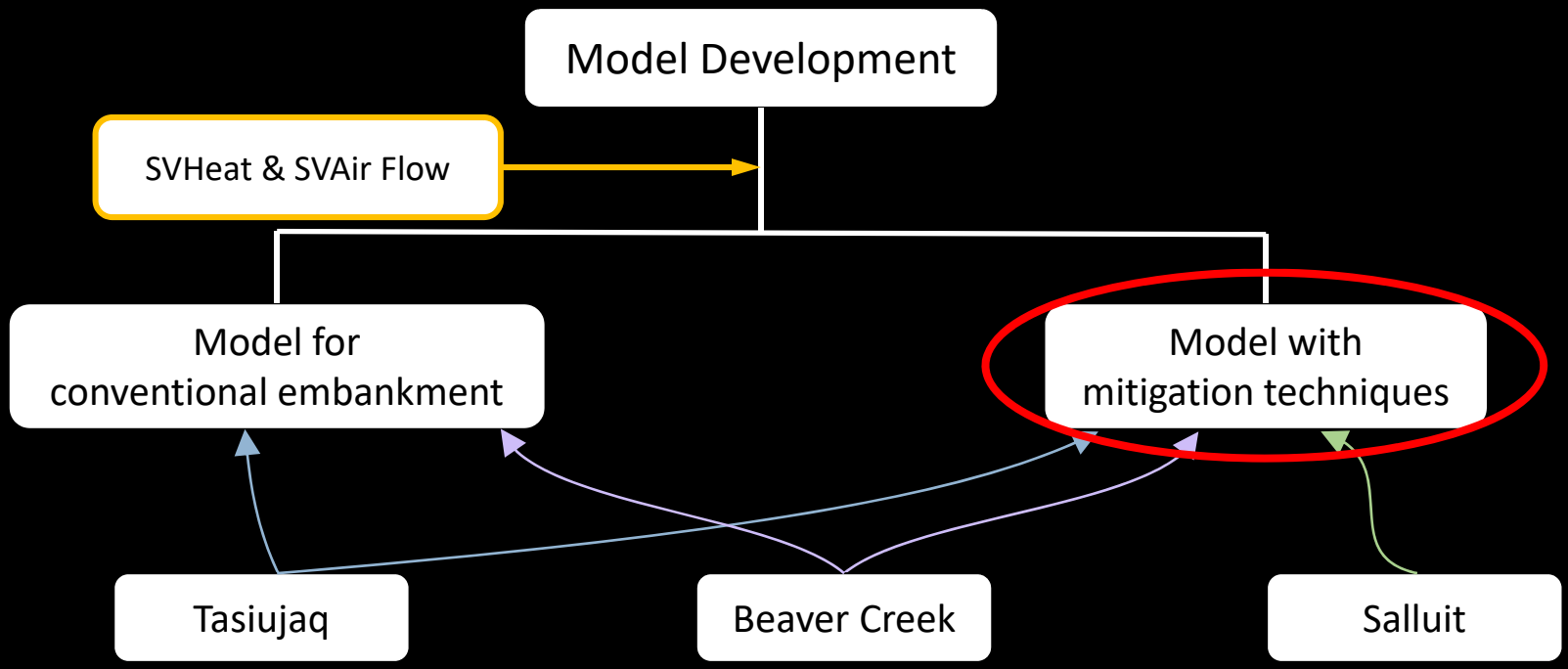
The chart of heat balance was obtained by sensitivity analysis

and validated with data from Tasiujaq site

(embankment thickness: 2.4 m)



The 2nd chart allows engineers to estimate the thermal stability of the infrastructure

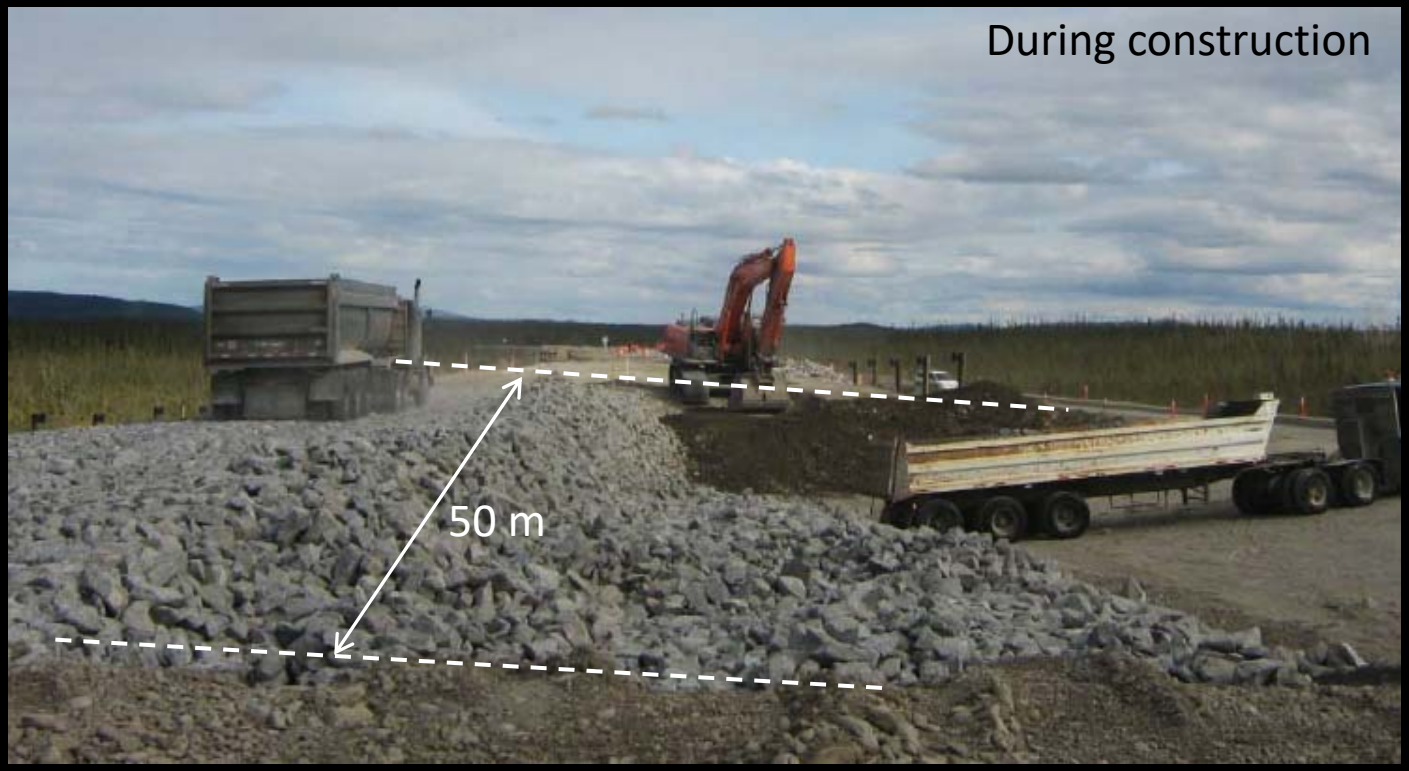

Model Development
SVHeat & SVAir Flow
Model for conventional embankment
Model with mitigation techniques
Tasiujaq
Beaver Creek
Salluit

Preliminary Outcomes -> Air convection embankment (ACE)

Beaver Creek test site, Yukon

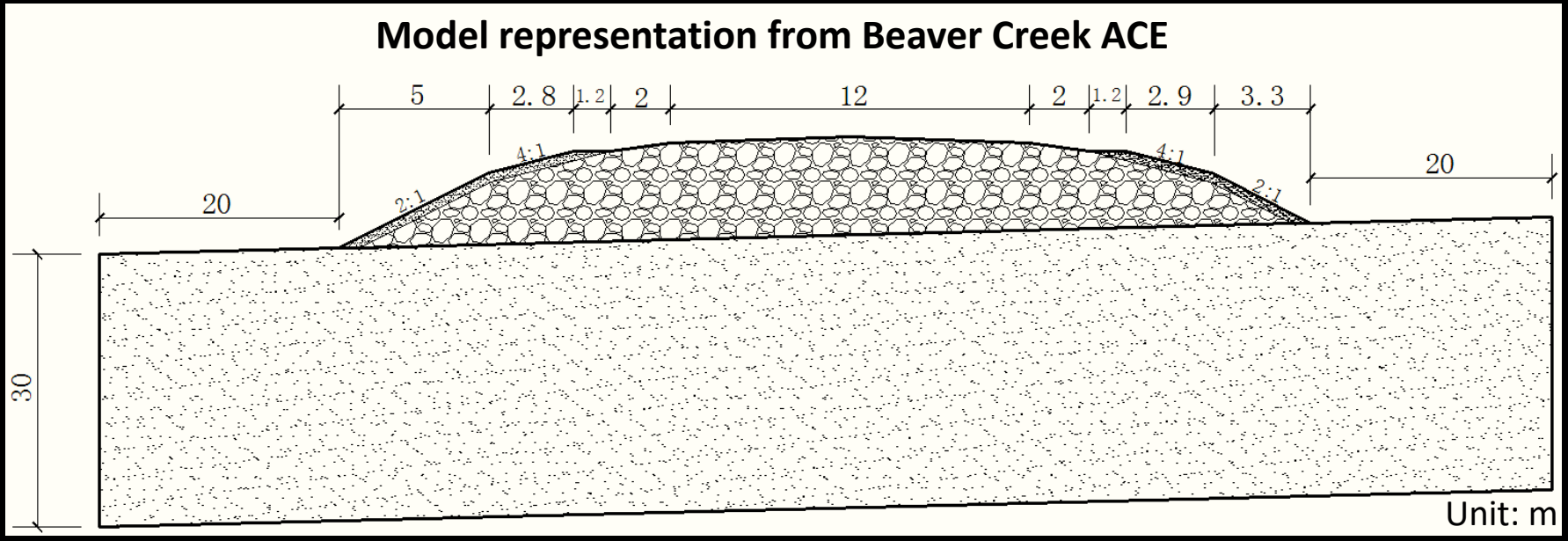
Preliminary Outcomes -> Air convection embankment (ACE)

Beaver Creek test site, Yukon



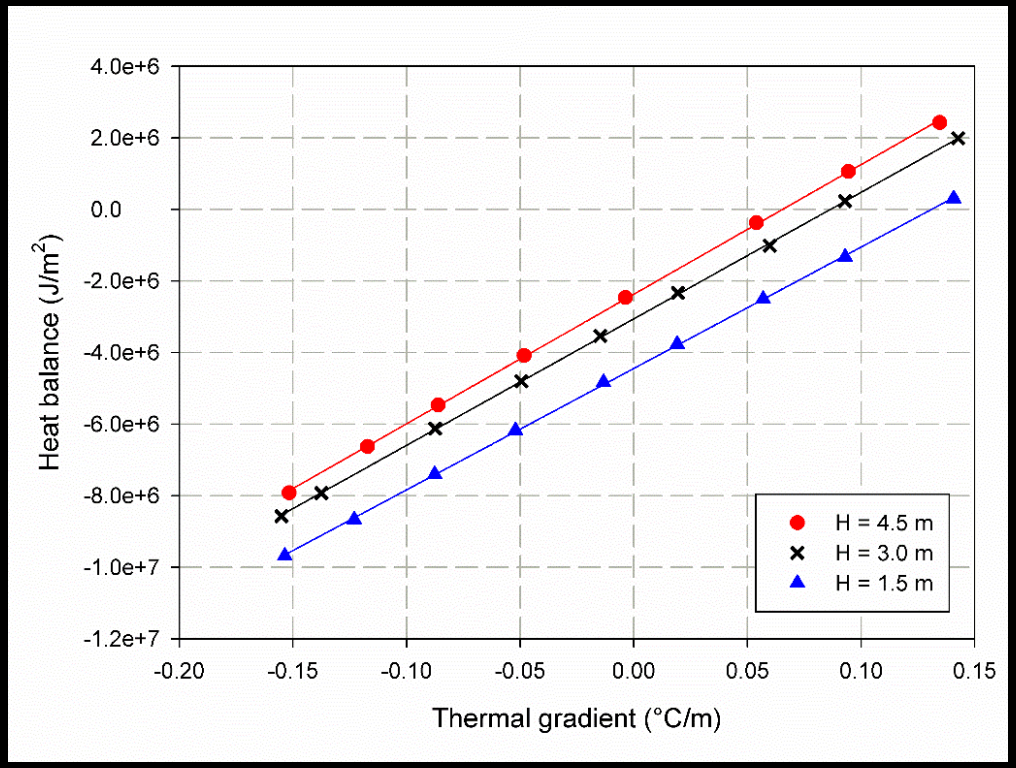
Preliminary Outcomes -> Air convection embankment (ACE)

Model representation from Beaver Creek ACE



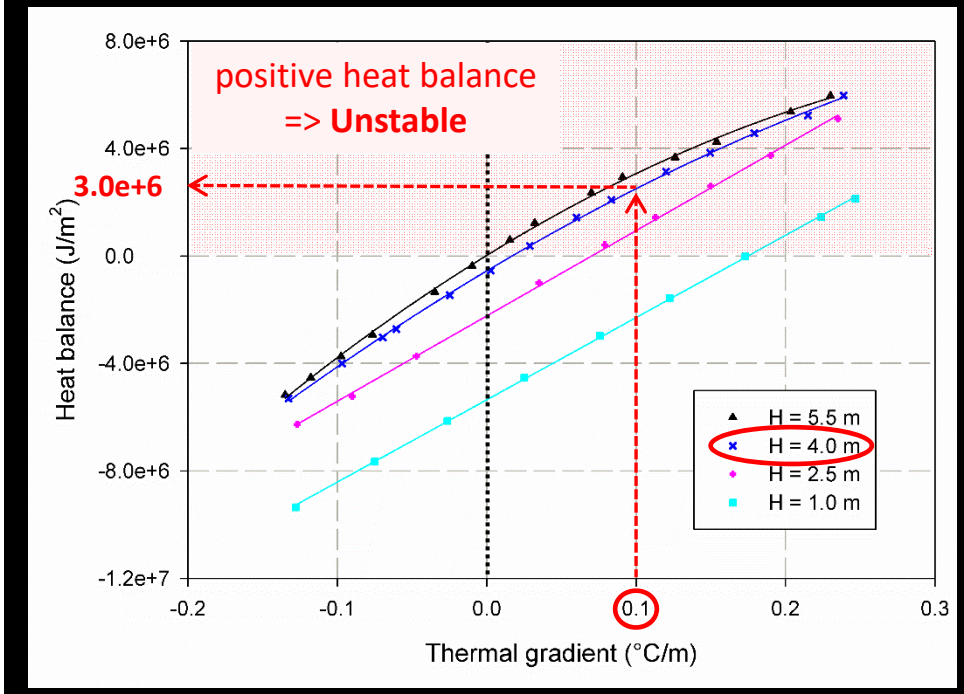
The thermal model was well calibrated

Preliminary Outcomes -> Air convection embankment (ACE)

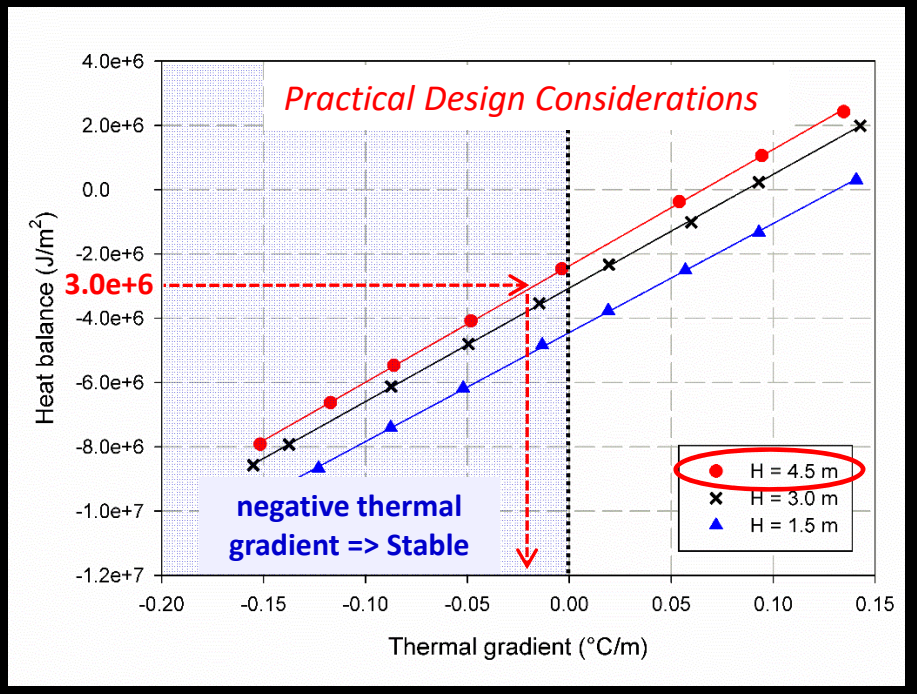


Preliminary Outcomes -> Air convection embankment (ACE)

Conventionnal embankment



ACE



Heat extraction ability = f (controlling parameters)

Conclusion

Important to:

- Define field of application of mitigation techniques
- Develop a method to select the appropriate mitigation techniques
- Propose design procedures for Heat Drain and Air Convection Embankment

Project schedule

- Modeling – on going
- Analysis of field data – on going
- Development of design criteria – starting soon

Arquluk
Permafrost engineering research program
Programme de recherche en ingénierie du pergélisol

THANK YOU

TO OUR PARTNERS

AND COLLABORATORS

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