

Pan-Territorial Permafrost Workshop Summary Report



Yukon
Government



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The Pan-Territorial Adaptation Partnership (PTAP) is a collaboration between the Governments of Nunavut, the Northwest Territories and Yukon. It is a concrete mechanism for identifying and realizing tangible climate change adaptation outcomes in the North. For more information on the Pan-Territorial Adaptation Partnership, the Pan-Territorial Permafrost Workshop, or any other climate change adaptation measures being undertaken, please visit our website at:

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EXECUTIVE SUMMARY

The 2013 Pan-Territorial Permafrost Workshop was held in Yellowknife, Northwest Territories (NWT) from November 5 to 7, 2013. The workshop was organized by the Pan-Territorial Adaptation Partnership, a collaboration between the Governments of Nunavut, NWT and Yukon. It brought together representatives of the three territorial governments, several provincial governments, the federal government, the Alaska state government, Aboriginal and community governments, universities, businesses and non-government organizations to discuss challenges associated with permafrost degradation in the North and propose solutions. In total, 210 delegates attended the workshop for some portion of the three-day event, either in person or via webcast.

The objectives of the workshop were to allow participants to share information, engage people from across many diverse sectors impacted by permafrost thaw and build personal linkages between, as well as within, these sectors. The workshop also served to identify relevant permafrost challenges, opportunities and accompanying actions to address these challenges and to use these opportunities.

Though presentations varied from person-to-person, the key take home message was the climate is changing in the North and, as a result, permafrost is thawing. The impacts of this thaw action are being observed and are affecting all areas of life in the North. This was illustrated by several presenters, who have seen negative effects on various infrastructure, geographic landscapes and traditional areas across the North. The costs of permafrost thaw are being felt in many sectors and are likely to increase as permafrost continues to warm and its distribution is reduced. In addition to the increased infrastructure costs of permafrost degradation, the human and ecological costs of climate change and related landscape changes are also increasing.

Participants and presenters also noted that though increasingly available technologies for monitoring, maintaining and even re-establishing permafrost exist, communication between the needs of community members and the scientific community is still lacking. Many attendees felt traditional knowledge was not being combined with scientific understanding to provide decision-makers with adequate information. Despite this, many noted the relationship was improving and events such as the workshop help to further establish relationships between the two groups. These thoughts, as well as other key messages that became apparent during the workshop, were identified and divided into eight emerging themes and challenges. These are outlined and discussed thoroughly within the document (pages 30-33). The emerging themes and challenges are also listed in the table of contents.

Throughout the workshop, presentations were provided in a format that was easy to understand and provided accessible information, including the use of maps, diagrams or 3D models. This helped to bring the technical language to a more accessible level for an audience who, in some instances, lacked a deep, scientific understanding of permafrost, climate change and associated engineering and monitoring techniques. In general, presentations of studies done with traditional knowledge-holders were made at a much more comprehensible level; as opposed to presentations made by technical and scientific knowledge-holders, which often delved too deeply into methodology and other technical matters.

The stated goals prior to the workshop were to “bring together front-line decision makers from Nunavut, NWT and Yukon, permafrost researchers and experts to share knowledge, form connections and look at possibilities for adaptation in the future”. While a hard metric to measure, based on the overall positive response from participants, the diverse attendees and the conversation generated between community members and permafrost experts, this workshop was successful at meeting this overall objective.

Pan-territorial momentum for climate change adaptation has been fostered through this workshop. It will be up to all stakeholders to keep this energy going. Future permafrost research, monitoring and thaw-mitigation measures will hopefully stem from the new and ongoing relationships established and maintained at this workshop. The government members of PTAP now have more information about permafrost impacts and have received valuable input into potential policy and project directions. This knowledge will help all three territories further their climate change adaptation programs and ensure adaptation is integrated into everyday decision making in the north.

The Pan-Territorial Adaptation Partnership is committed to hosting a climate change adaptation workshop every two years to develop networks and share information about programs, projects and funding opportunities. The meeting might not take the form of a large workshop but it will allow the outcomes of the 2013 Pan-Territorial Permafrost Workshop to be reflected on and properly evaluated.

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INTRODUCTION

Background

The 2013 Pan-Territorial Permafrost Workshop (PTPW or the Workshop) was held in Yellowknife, Northwest Territories (NWT) from November 5 to 7, 2013. The workshop was organized by the Pan-Territorial Adaptation Partnership (PTAP), a collaboration between the Governments of Yukon, NWT and Nunavut. PTAP is a way for the three territories to research and adapt to climate change in the North through a problem solving network of communities, academia, practitioners and funders.

A one-day short course on Arctic transportation was presented on Monday, November 4, 2013 to more than 30 transportation planners, managers and operational staff from Yukon, Northwest Territories, Nunavut, several provinces and Alaska. See appendix A for a list of course participants. Developed by the Transportation Association of Canada (TAC) and presented by consulting engineer Don Hayley, the short course followed the content of the 2010 *Guidelines for Development and Management of Transportation Infrastructure in Permafrost Regions*. The TAC guideline provides a compendium of best practices for the planning, design, construction, maintenance and abandonment of transportation infrastructure in regions with permafrost terrain. It is intended to be a practical easy-to-read guide for those directly involved in any aspect of the lifecycle of transportation structures in northern Canada. The short course consisted of four modules with opportunities for discussion and the exchange of ideas. These four modules focused on; reviewing infrastructure design that is unique to northern, permafrost rich terrain; the impact of northern infrastructure on topography, surficial geology, hydrology and frozen ground; best practices for engineering transportation infrastructure in permafrost regions; and an overview of road construction and maintenance practices specific to northern terrain, respectively.

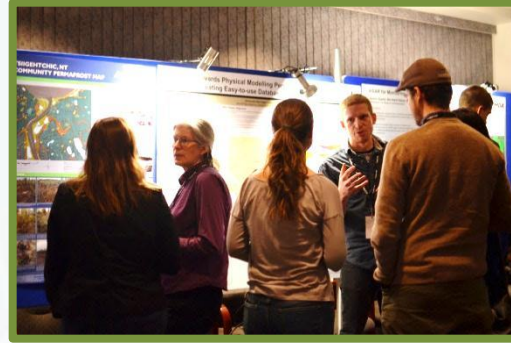
Workshop Objectives and Agenda

The goal of the PTPW was to bring together representatives of the three territorial governments, the federal government, universities, Aboriginal governments, community governments, business and non-governmental organizations to discuss common



permafrost challenges and propose solutions. The objectives of the workshop were to:

- share information;
- connect and build new linkages between decision makers and knowledge holders;
- engage across diverse sectors;
- ensure relevance to communities;
- identify relevant permafrost challenges; and
- identify actions to address these challenges.



The agenda focused on four themes: mapping and communities, building infrastructure, transportation and mining, oil and gas. Several presentations were made on each theme, followed by breakout discussion groups to identify the top challenges within each theme and to propose solutions. The first day of the workshop also included introduction to permafrost presentations; perspectives from the territorial PTAP representatives; videos and slideshows; and presentations on landscape changes and tools for adaptation. The workshop agenda is attached as appendix B.



Participation

143 delegates pre-registered for the workshop including delegates from Yukon, NWT, Nunavut, several provinces and the USA. See appendix C for a list of registered workshop delegates. A further 67 people registered at the door. All participants were invited to attend a wine and cheese reception at the Department of National Defense headquarters on Tuesday, November 5, where they could view research posters created by the workshop participants. The abstracts of these posters are available in appendix D of this report. A “Dinner Beneath the Northern Lights” was held at Aurora Village, a 30-minute drive from Yellowknife, on Wednesday, November 6. 108 people attended the dinner and enjoyed local entertainment and the keynote address by Sheila Watt-Cloutier, a Nobel Peace Prize nominee for her advocacy work on the effects of global climate change on human rights, particularly those of northerners.

Webcast

The workshop was webcast live to participants throughout North America. Throughout the workshop, the average number of computers logged onto the webcast was around 20, with as many as 33 during the first day. Many of the computers served more than one person. For example, at one point there were 13 people at one station and six at another. Participants joining by webcast included representatives of the Yukon Government, Associated Engineering Ltd, Environment Canada, the Alaska Department of Transportation and Public Facilities, the Nunavut Research Institute, MDA Corporation, the National Aeronautics and Space Administration (NASA) and others. Webcast participants were able to submit questions and had access to the breakout reporting and workshop evaluation cards.

WORKSHOP DAY ONE



Ministers' Welcoming Remarks

The NWT Minister of Environment and Natural Resources, the Honourable Michael Miltenberger and the NWT Minister of Municipal and Community Affairs, the Honourable Robert C. McLeod, provided opening remarks.

Minister Miltenberger thanked participants for coming to the workshop. He noted that the Government of the NWT (GNWT) is fully engaged in addressing the challenges of climate change and, in doing so, is committed to integrating western and traditional knowledge. He described examples of the effects of permafrost thaw in the NWT including changes to the landscape near Fort Simpson with associated hydrological and ecological effects, the sudden appearance of a large sinkhole in the Inuvik airport runway and massive slumping west of Aklavik. Minister Miltenberger emphasized the importance of understanding how to deal with the implications of degrading permafrost, a change that is occurring at an increasingly rapid pace on a circumpolar scale. He noted that the GNWT is committing funds to adaptation and mitigation and that he will carefully review the outcomes of the permafrost workshop.

Minister Robert C. McLeod welcomed participants and noted that half the landmass of Canada is susceptible to permafrost change. His Department has a Capital Asset Retrofit Fund program that helps northerners reduce greenhouse gases and save money on energy consumption. The Minister noted that permafrost degradation is affecting transportation infrastructure and housing in the north. He stated northerners must go beyond mitigation to adaptation with good building practices and collaboration and cooperation among jurisdictions. His hope was that the workshop would strengthen cooperation through networking, partnerships and sharing of information.

Presentations and Breakout Discussions

Day One of the workshop featured a series of presentations, videos and a slide show to introduce participants to the science of permafrost, landscape changes and tools which can be used to address the impacts of permafrost degradation. All speaker biographies are available in Appendix E and speaker guidelines are in Appendix F.

The presentations began with a tribute to a major Canadian pioneer in the field of permafrost research, Dr. Ross McKay. Dr. Chris Burn described Dr. McKay's long scientific career and fieldwork in the Arctic. In 2011, at age 95, Dr. McKay re-visited some of his original research stations in the Mackenzie Delta. Unfortunately he was unable to attend this workshop. Dr. Burn briefly summarized the lasting impact Dr. McKay has had on the field, leading permafrost research for decades and mentoring many of Canada's leading permafrost researchers, including Dr. Burn himself.

Introduction to Permafrost

The purpose of this portion of the workshop was to provide participants with an overview of permafrost, permafrost research and of the approaches and techniques for adaptation to the effects of permafrost degradation.

Title: The Impacts of Climate Change on Permafrost - Merging Science and Community Concerns

Presenter: *Michel Allard (Université Laval)*

Topic: An introduction to permafrost was provided including an explanation of what permafrost is where it is located in Canada, what drives its formation and thawing and the relationship between surficial geology and ground ice.

Case Study: Salluit, Nunavik

Key Findings/Take Away Messages:

- Permafrost is warming in many areas in Nunavik and thaw is widespread, causing significant effects to the landscape and infrastructure;
- Researchers should work collaboratively with communities and residents to support better local decision making through the application of a more thorough understanding of permafrost properties and processes.

Title: The World of Underground Ice in a Changing Climate

Presenter: *Steve Kokelj (NWT Geoscience Office)*

Topic: In the western Arctic, climate warming has caused permafrost temperatures to increase. This is causing the thawing of ice-rich permafrost on slopes, which is leading to thaw slumps.

Case Study: Dempster Highway and Mackenzie Delta

Key Findings/Take Away Messages:

- An acceleration of slump activity across northwestern Canada has occurred in concert with rising air and ground temperatures and the intensification of summer rainfall.
- Slump sensitive terrain characterizes over a hundred thousand square kilometers of northwestern Canada and has the potential to undergo intense alteration with climate change.

Title: Perspectives from Yukon, NWT and Nunavut

Presenters: *Johanna Smith, Stephan Roddick, Merran Smith, Brian Sieben, Colleen Healey (Governments of Yukon, NWT and Nunavut)*

Topic: Delegates were provided with an overview of the efforts and programs being undertaken by the territorial governments to mitigate and adapt to the effects climate change is having on permafrost.

Case Study: Yukon, NWT and Nunavut

Key Findings/Take Away Messages:

- In Yukon, communication initiatives and three permafrost related projects are being undertaken. The projects include examining how changes in temperature, precipitation, vegetation and permafrost thaw is impacting the timing, magnitude and seasonality of flow; the effects changing permafrost will have on agriculture; and changing permafrost conditions along the Yukon portion of the Alaska Highway.
- In the NWT, a permanent permafrost science position has been established in the Geoscience Office; a homeowner's guide to building on permafrost is being developed; and community permafrost mapping is being undertaken through the Center for Geomatics.
- In Nunavut, a Climate Change Adaptation Action Plan is being prepared (expected to be released in the spring of 2014); a terrain analysis program is being carried out in seven communities using InSAR; and the vulnerability of the mining industry to climate change is being assessed.
- Through the Pan-Territorial Adaptation Partnership, the three territories are working closely to share knowledge and address the shared challenges of permafrost thaw.



Title: Our Changing Homelands, Our Changing Lives

Presenter: *Norma Kassi (Arctic Institute of Community Based Research)*

Topic: Produced in partnership with the Vuntut Gwitchin First Nation (the "People of the Lakes"), the documentary film "Our Changing Homelands, Our Changing Lives" describes the alarming effects of climate change on the landscape of northern Yukon and on the lives of the Kassi family.

Case Study: Zelma Lake, Yukon

Key Findings/Take Away Messages:

- For generations the Kassi family has relied on the lakes and wetlands of Crow Flats for food and sustenance.
- When Zelma Lake was suddenly drained of its water because of permafrost thaw, the family's ways, culture, how they use the land and how they harvest the animals all changed dramatically.

Title: Living with Thawing Ground: Permafrost in Yellowknife, NWT

Presenter: *Stephen Wolfe (Natural Resources Canada)*

Topic: The annual average air temperature in Yellowknife has risen to above -3.3°C on a regular basis in the last decade, the generally accepted long-term air temperature threshold for sustaining permafrost. This has implications for Yellowknife's permafrost terrain, which is described as being thaw unstable.

Case Study: Yellowknife, NWT

Key Findings/Take Away Messages:

- Significant settlement or loss of strength may result from the thawing of thaw unstable terrain.
- Observations of seasonal ground surface subsidence using remote sensing reveal subsidence in developed areas of Yellowknife associated with thaw unstable terrain, suggesting the terrain is undergoing thaw settlement as permafrost degrades.
- Science, engineering and community planning need to be integrated when developing infrastructure, especially in areas of discontinuous and warming permafrost.

Title: Community-Based Monitoring of the Active Layer in the Yukon River Watershed

Presenters: *Jody Inkster and Brendan Mulligan (Yukon River Inter-Tribal Watershed Council)*

Topic: Since 2009 the Yukon River Inter-Tribal Watershed Council has been working with the United States Geological Survey and members of First Nations (Canada) and Native Tribes (Alaska) to monitor the active layer throughout the Yukon River watershed.

Case Study: Yukon River watershed

Key Findings/Take Away Messages:

- Community-based monitoring programs enable and empower community members to better understand the changes occurring in their traditional territories as a result of a warming climate.
- Community-based monitoring can also contribute to other studies. In this case, the data are integrated with the Circumpolar Active Layer Monitoring network and complements a large-scale water quality monitoring network in the Yukon River watershed.

Title: Impacts of Permafrost Thaw on Hydrology and Vegetation in the Taiga Plains

Presenter: *Jennifer Baltzer (Wilfred Laurier University)*

Topic: Much of the southern boreal region is underlain by discontinuous permafrost. As this permafrost thaws, the resulting changes in hydrological inputs and connectivity are expected to strongly influence the structure and composition of the region's peat plateaus and forest communities.

Case Study: Scotty Creek, NWT

Key Findings/Take Away Messages:

- Permafrost forms the physical foundation on which trees develop, forming tree-covered peat plateaus where trees contribute to permafrost maintenance and aggradation processes through reductions in radiation load and changes in snow accumulation.
- Thawing permafrost increases surface subsidence and slumping, increasing wetland extent and connectivity which in turn results in a decrease in forest cover. These changes have important implications for the ecological and hydrological functions of the boreal ecosystem with implications for wildlife, forest and water resources.

Title: Landscape and Adaptation: Linking Permafrost Performance with Climate Change

Presenters: *Chris Burn (Carleton University) and Douglas Esagok (Inuvik Hunters and Trappers Committee)*

Topic: A long-term partnership between scientists and the Esagok family to monitor near-surface ground temperatures at Herschel, Garry and Richards Islands has demonstrated the importance of active layer freeze back and topography on seasonal permafrost thawing.

Case Study: Herschel, Garry and Richards Islands of the Mackenzie Delta

Key Findings/Take Away Messages:

- Ground temperatures collected at Herschel, Garry and Richards Islands show that permafrost and active layer depth can be positively affected by increasing the duration of active-layer freeze back during the winter through attention to drainage and snow cover. These finding may be important for managing terrain effects near infrastructure.
- This work has demonstrated the importance of local community members being directly engaged with scientists in research and monitoring programs over the long term, such as Dr. Ross McKay's involvement with the Esagok family, which has been maintained through three generations.

“The identification of the importance of long term data and involvement by researchers over long periods stood out for me. This observation came from Douglas Esagok”
– Participant Comment

Tools for Adaptation

This portion of the workshop provided participants with an introduction to various remote sensing techniques used to identify the extent and characteristics of permafrost and to various tools used to mitigate the effects of permafrost degradation.

Title: 3vGeomatics: InSAR in the Arctic

Presenters: *Adrian McCardle and Jon Leighton (3vGeomatics)*

Topic: The role of remote sensing and in particular RADARSAT-2 and other radar satellite imagery, in monitoring permafrost changes in the Canadian Arctic.

Case Study: Ellesmere Island, Iqaluit, Kimmirut, Cambridge Bay and Tuktoyaktuk

Key Findings/Take Away Messages:

- RADARSAT-2 and other radar satellite imagery make it possible to reliably, accurately and cost-effectively monitor permafrost related ground displacement over large areas.
- These modern techniques can benefit community, transportation and resource development projects.

Title: Permafrost Technologies: Thermosyphons
Presenter: Brent Wall (*Achieve Engineering*)
Topic: Thermosyphons and their applications to preserve or re-establish permafrost.

Case Study: Not applicable

Key Findings/Take Away Messages:

- Thermosyphons are relatively simple and robust technologies which have been widely used to preserve or re-establish permafrost around and under buildings, storage tanks and other infrastructure.
- Thermosyphons are a versatile technology that can be used for ground freezing flat loop systems, thermopiles and freeze wall applications

“Products such as thermosyphons need to be better known for they are needed in communities.”

- Participant Comment

Title: Outreach Tools and Techniques: The Yukon Permafrost Network

Presenter: Sarah Laxton (*Yukon Geological Society*)

Topic: The Yukon Permafrost Network (YPN) website promotes communication and engagement related to permafrost issues across Yukon.

Case Study: Not applicable

Key Findings/Take Away Messages:

- Northern residents, First Nations, industry, government and academia all benefit from improved access to reliable permafrost information.
- The YPN provides an important range of communication and technical services, including basic information on permafrost, up-to-date maps and data, as well as YPN member contact information.

Title: Northern Infrastructure Standardization Initiative

Presenters: Mike Burns (*GNWT Public Works and Services*), Heather Auld (*Risk Sciences International*), Don Hayley (*Hayley Arctic Geoconsulting*), Antoni Lewkowicz (*University of Ottawa*) and Ken Johnson (*Stantec Consulting*)

Topic: The need to establish consistent and cohesive standards for the design, installation and maintenance of northern infrastructure is being met through the Northern Infrastructure Standardization Initiative (NISI), a program of the Canadian Standards Association.

Case Study: Numerous

Key Findings/Take Away Messages:

- Existing national standards frequently contain outdated or inaccurate information and generally do not adequately address the Northern realities of today. NISI is an important first step in establishing a sustainable process that will enable the unique circumstances of the North to be reflected in consistent and cohesive standards.
- Four new infrastructure standards are currently being developed: community drainage system planning; managing changing snow loads for buildings in the North; moderating the effects of permafrost degradation on existing structures; and thermosyphon supported foundations for new buildings in permafrost.

WORKSHOP DAY TWO



Mapping and Communities

A total of eight presentations were made on the Mapping and Communities theme that covered a variety of topics including: community hazard mapping; ground movement and permafrost temperature; permafrost and air temperature modeling; Electrical Resistivity Tomography; and tackling adaptation through partnerships. Breakout group discussions followed the eight presentations.

Title: Mapping Ground Movement and Permafrost Temperature: Case Studies from Nunavut and Nunavik

Presenter: *Anne-Marie LeBlanc (Geological Survey of Canada)*

Topic: Two methods have been successfully shown to provide useful geoscience information to support decision-making and climate change adaptation strategies: satellite radar data (InSAR), which is used to reveal ground surface movement and permafrost modeling, which can show variability in permafrost temperature over time and space.

Case Study: Pangnirtung and Iqaluit, Nunavut and Salluit, Nunavik

Key Findings/Take Away Messages:

- Case studies have demonstrated that the acquisition and analysis of InSAR data and use of mathematical models can assist in the assessment of spatial and temporal variability in permafrost temperature and thaw settlement at a regional or community scale.
- InSAR and model results must be interpreted in the context of field observations to accurately deduce possible causes of thaw settlement.

Title: Mapping Landscape Hazards in Yukon for Community Climate Change Adaptation Planning

Presenter: Bronwyn Benkert (*Northern Climate ExChange*)

Topic: Work is being conducted by the Northern Climate ExChange (part of the Yukon Research Centre at Yukon College), the Yukon Geological Survey, the universities of Montreal and Ottawa and several Yukon communities and First Nations to create ranked maps of landscape hazards in communities.

Case Study: Burwash Landing, Destruction Bay and Mayo, Yukon

Key Findings/Take Away Messages:

- By incorporating surficial geology, hydrology, permafrost characteristics and projections of future climate variability, landscape hazard maps can represent current and future conditions.
- These landscape hazard maps can serve as community adaptation planning tools, highlighting areas likely to change as a result of climate change, deepening understanding of permafrost dynamics and enabling improved planning and decision making.

Title: Permafrost Scenario and Mean Annual Air Temperature Modeling

Presenter: Philip Bonnaventure (*Queen's University*)

Topic: Air temperature changes are applied to a regional model of permafrost probability under equilibrium conditions in southern Yukon and northwestern British Columbia.

Case Study: Southern Yukon and northwestern British Columbia

Key Findings/Take Away Messages:

- Permafrost gain and loss under different air temperature scenarios is controlled by the surface lapse rate (SLR) (i.e. air temperature elevation gradient) which varies across the region below the treeline. With knowledge of the area SLRs, mean annual air temperature maps for various climate change scenarios can be created for future time periods.
- Topographic-corrected predictions for mountainous regions provide more information than those currently available and can be used as primary inputs for other modeling efforts.



Title: Electrical Resistivity Tomography as an Essential Tool to Investigate Sites in Discontinuous Permafrost

Presenter: Antoni Lewkowicz (*University of Ottawa*)

Topic: The benefits and limitations of using Electrical Resistivity Tomography (ERT) in investigating frozen ground conditions.

Case Study: Fort St. John, BC and various sites throughout Yukon

Key Findings/Take Away Messages:

- An ERT survey is a rapid, relatively inexpensive and useful noninvasive investigative tool.
- While it does not replace boreholes or direct ground temperature measurements, it can provide information on permafrost spatial variability that could otherwise only be obtained from multiple drill holes.

Title: Vulnerability to Permafrost Related Hazards in Jean Marie River First Nation, NWT

Presenters: *Fabrice Calmels (Northern Climate ExChange) and Margaret Ireland (Jean Marie River First Nation)*

Topic: The Jean Marie River First Nation (JMRFN) and its project partners combined and shared traditional, local and scientific knowledge to produce climate change vulnerability maps of traditional use areas near Jean Marie River.

Case Study: Jean Marie River, NWT

Key Findings/Take Away Messages:

- The vulnerability hazard map resulting from this project is tailored to the needs of the JMRFN community, is culturally oriented and, when overlain with spatial traditional land use information, brings a new, integrated perspective regarding climate change impacts on the JMRFN.
- This project represents a prototype for future surveys and mapping aimed at identifying and quantifying the impacts of permafrost degradation from a broader and more holistic viewpoint that combines western science and traditional and local knowledge.

Title: Planning Sustainable Nunatsiavut Communities from the Ground Up

Presenter: *Trevor Bell (Memorial University of Newfoundland)*

Topic: Community leaders in Nunatsiavut are forging an inter-departmental, multi-disciplinary team under the SakKijânginnatuk Nunalik (Sustainable Communities initiative) to inform best practices and provide guidance for community sustainability under changing climatic and environmental conditions.

Case Study: Nunatsiavut communities

Key Findings/Take Away Messages:

- The best practices were created were created using digital geographic information, Inuit knowledge and values and will serve to fill gaps in existing geoscientific databases, as well as assist local governments in making day-to-day land use and development decisions.

“I liked the idea of including Labrador/Nunavik and eastern Canada research that I didn’t know about” – Participant

Title: 4D Visioning for Climate Change Decision-Making in Clyde River, Nunavut

Presenter: *Ellen Pond (Pembina Institute)*

Topic: As part of a larger community planning initiative, the University of British Columbia worked with Ittaq in Clyde River to explore community land use planning and develop future planning scenarios using 4D visioning (i.e. extending the mapping to represent potential future scenarios in both time and space).

Case Study: Clyde River, Nunavut

Key Findings/Take Away Messages:

- 4D visioning is a useful tool to assist community members in ‘visualizing’ future landscape and community development scenarios and support community-based decision-making.
- Issues such as landscape hazards, housing, walkability and energy use need to be addressed in order to create useable land use plans.

Title: Tackling Adaptation through Partnerships

Presenter: Sara Brown (*NWT Association of Communities*)

Topic: The importance of working together to address climate change effects in the North.

Case Study: Not applicable

Key Findings/Take Away Messages:

- So much more can be accomplished by tapping into each other's strengths and skills and leveraging common opportunities.
- This partnership approach can be taken with government, private sector, researchers and other non-government organizations to introduce new perspectives, leverage strengths, share workload, avoid competing for resources and reduce duplication. In addition, funding organizations value partnerships, providing those involved in partnerships with access to additional funding possibilities.

Mapping and Communities Breakout Discussions

Following the Mapping and Communities presentations, workshop participants were divided into groups of 10 to 15 people, each led by a facilitator. Each group was asked to brainstorm the most significant permafrost-related issues in relation to Mapping and Communities and to record the top challenges, as decided by consensus. The groups were then asked to identify actions that would best address the top challenges. The results were subsequently reported back to the plenary group.

Appendix G contains the breakout discussion guidelines and appendix H contains the breakout group reporting cards.

The top three challenges related to Mapping and Communities, as identified by workshop participants, were information needs, community capacity and funding.

1. Information Needs

Participants identified a lack of coordination and communication, the need for better mapping and better management of data as major information challenges.

With respect to better coordination and communications, participants suggested:

- improving the integration of scientific data with field conditions by improving dialogue among researchers, land users and communities;
- engaging practitioners and community members by using local workshops and meetings to gather traditional knowledge and ground-proof collected data;



- making information more available and accessible to the public through on-line sources, single centralized data portals and creating user-friendly formats to share research and mapping results (e.g. audio files and videos) and;
- broadcasting success stories and lessons learned.

With respect to the need for better mapping, participants suggested:

- standardizing maps into useable and easily understood formats;
- increasing the use of remote sensing and other modern technologies to map large areas;
- making the maps more relevant to communities by conducting community needs assessments;
- creating maps that are relevant, actionable and adaptable and with the level of detail needed by the community or user and;
- ensuring better access to existing maps.

Participants suggested that the management of data could be improved through:

- better translation of pure science to applied science (i.e. real world situations);
- incorporating only verifiable and up-to-date information in maps and databases;
- establishing a location to amalgamate existing community and scientific data and;
- implementing consistent standards and protocols in the collection and analysis of data and production of maps.

2. Community Capacity

Participants identified the need for better knowledge of permafrost and emerging climate change challenges amongst community members and northern decision-makers and the need to improve capacity within communities to enable them to better work with researchers in documenting permafrost and landscape changes.

To help ensure better local knowledge of and involvement in, studies of permafrost and the emerging challenges, participants suggested:

- incorporating permafrost issues into the school curriculum;
- creating alternate communication strategies (e.g. comics, videos, social media);
- encouraging local participation by involving youth in all actions;
- creating a registry of locally available equipment and materials (e.g. drills and ATVs);
- conducting focus groups and meetings with Hunters and Trappers Associations (and their equivalents), elders, community councils and the local business community;
- ensuring the community has a stake and ownership in the initiative;
- identifying community champions and liaisons;
- mandating community involvement in all new mapping and research projects and;
- incorporating community involvement in funding applications.

“The emphasis on community involvement and cultural knowledge was very useful”

- Participant Comment

With respect to improving community capacity and the ability of community members to work with researchers it was suggested that:

- researchers and other professional organizations (i.e. engineers and consultants) and community members be actively encouraged to work alongside each other and;
- researchers work to secure a team of community participants, who can be trained to carry on the monitoring program in the absence of researchers.



3. Funding

Participants identified the lack of reliable long term funding for permafrost monitoring programs, the high cost of research, mapping and ground-proofing and the need for funding to move from maps to actionable items as major challenges.

Suggested actions included:

- identifying and establishing long term, sustainable and adequate funding;
- establishing focussed research priorities in the context of community and government needs;
- developing partnerships with government agencies, Aboriginal governments, businesses and communities;
- fundraising by submitting proposals for available grants and studies and;
- securing in-kind contributions from local, territorial and national businesses and organizations.

Building Infrastructure

Day Two continued with five presentations on the effects of permafrost on building infrastructure including effects of permafrost degradation on road stability and building foundations, ground temperature monitoring and developing a building assessment tool. The five presentations were followed by breakout discussions and reporting back to plenary.

Title: Recent Effects of Climate Change on Permafrost and Road Stability - Dempster Highway

Presenter: *Richard Trimble (EBA)*

Topic: Researchers, engineers and highway maintenance staff from EBA, GNWT, Yukon Government and Carleton University conducted a preliminary risk assessment of the Dempster Highway between Inuvik, NWT and Dawson City, Yukon, to identify locations where roadbed instability had occurred that required either emergency repairs or other non-routine effort.

Case Study: Dempster Highway, NWT and Nunavut

Key Findings/Take Away Messages:

- Evidence was collected that suggests climate change is contributing to Dempster Highway maintenance needs, beyond those of normal highway maintenance requirements.

- It is beneficial to have researchers and engineers work together with highway maintenance staff in conducting the preliminary risk assessment. This approach can yield significant advantages in gaining an integrated understanding of the issues and challenges related to permafrost degradation.

Title: Climatic Adaptations to Construction in Nunavut

Presenter: *John Watson (Nunavut Housing Corporation)*

Topic: Climate change and thawing permafrost is requiring the Nunavut Housing Corporation to review current building foundation designs and operations to develop and implement solutions that address the longer-term climate change challenges.

Case Study: Not applicable

Key Findings/Take Away Messages:

- The Nunavut Housing Corporation is improving its existing designs, operations and technologies in order to support affordable and sustainable housing development, identify economic solutions to adapt existing housing stock to the changing environment and better identify factors that will facilitate informed decisions in terms of future development.

Title: Climate Change Impact on the State of Permafrost at Inuvik, NWT

Presenter: *Ed Hoeve (EBA)*

Topic: Inuvik, because of its size and location, has been identified as being particularly vulnerable while the impact a warming climate may have within the developed area of the community has not been well defined.

Case Study: Inuvik, NWT

Key Findings/Take Away Messages:

- Initial data from ground temperature monitoring cables installed during the construction of the Western Arctic Research Centre in Inuvik during 2010 shows a heat flux from the ground surface downward, presumably as a result of warming air temperatures. This finding is consistent with other ground temperature observations and climate change predictions.
- One practical implication of this ground warming is that foundation pile embedment needs to be increased (i.e. piles need to be set deeper into the ground) so as to avoid future ice jacking.
- Installation of ground temperature monitoring cables in new infrastructure would enable changes in ground temperature to be identified and mitigated.

Title: Ground Temperature Monitoring in the NWT

Presenter: *Ed Cormier (GNWT Department of Public Works and Services)*

Topic: The GNWT Ground Temperature Monitoring Program has installed thermistors in eight locations in the Mackenzie River valley to assess the performance of thermosyphon foundations and to monitor the effects of thawing permafrost on the built environment.

Case Study: Inuvik, Fort Good Hope and Tulita, NWT

Key Findings/Take Away Messages:

- The GNWT intends to continue to install thermistors with data loggers during construction of new buildings and facilities throughout the Mackenzie River valley. The data collected would be made available upon request to government and non-governmental organizations.
- The foundations of existing buildings and facilities also need to be monitored where the risk of thawing permafrost threatens the integrity of the structure.

Title: Climate Change and Buildings: Developing a Building Assessment Triage Tool

Presenter: *Mark Porter (Associated Engineering)*

Topic: Assessing a building's risks to climate change currently requires specialized knowledge. The GNWT Risk Evaluation procedure is focused on providing non-technical personnel with a risk assessment tool to evaluate the vulnerability of buildings to damage by changes in permafrost and snow loading.

Case Study: 50 properties across the NWT

Key Findings/Take Away Messages:

- Through surveying more than 50 properties across the NWT, good and bad practices for building design, construction and operation are being documented in a best practices report.
- The survey is enabling weather and climate scenarios to be compared to building structure and capacity. A full building assessment would be triggered where the building scores badly.

Building Infrastructure Breakout Discussions

Following this series of presentations, workshop participants were again divided into groups of 10 to 15 people, each led by a facilitator. As before, each group identified the most significant permafrost-related issues in relation to Building Infrastructure and recorded its top challenges. The groups then identified actions that would best address the top challenges. The results were subsequently reported to the plenary group. The top three challenges, as identified by workshop participants were design; maintenance; and capacity and training in communities.

1. Design

Participants identified the need for proper site selection, better design and planning and the need to acquire and share data regarding the effects of climate change on building design as major issues.

With respect to proper site selection, participants suggested:

- conducting mapping and literature reviews prior to originating the design work;
- early community consultations with a collaborative and cooperative approach;
- informed land use planning;
- adequate budgeting for site investigation and preparation and;
- ensuring foundations are designed for actual site conditions.

Regarding better design and planning, suggestions included:

- having standardized hazard mapping for all communities incorporated into community plans;
- ensuring good building practices are stipulated in contractor selection standards;
- increased weighting of northern expertise and climate change/permafrost design options in proponent selection;
- ensuring lessons learned from past mistakes and successes are incorporated into planning and design through extended accountabilities (such as extended warranty);
- establishing northern best management practice guidelines on design, construction and maintenance;
- incorporating foundation monitoring systems into building design;
- sharing of borehole and other geotechnical data;
- taking a risk-based approach to infrastructure design;
- incorporating local knowledge into initial building design;
- avoiding repetition of efforts and;
- publicizing case studies.



Regarding the need to acquire and share design data, participants suggested:

- creation of a Centre for Northern Building Innovation;
- developing a central location or database for sharing easy-to-use information with decision-makers including planners, builders and designers;
- improving access to privately held data from climate and other monitoring (e.g. mining and other resource companies);
- undertaking surficial mapping in key corridor areas instead of map sheet areas;
- supporting central points for knowledge/data gathering (e.g. northern colleges);
- promoting collaborations with similar projects and;
- supporting knowledge transmission and relationship building.

2. Maintenance

Participants identified foundation instability and drainage, insufficient post-construction maintenance and monitoring and lack of capacity and training in communities as major issues.

Regarding foundation instability and drainage, participants suggested:

- using the best available technologies to renovate or to replace foundation systems where necessary;
- identifying remedial options for existing buildings before maintenance is required;
- minimizing risk by building away from existing hazard areas (e.g. building on bedrock);
- keeping designs simple to facilitate local maintenance and adjustments to existing building foundations;

- having construction associations implement registration and standards for members and;
- having specific cold and permafrost region training for engineers required by legislation and advocated for by communities.

Regarding insufficient maintenance and monitoring post-construction, suggestions included:

- maintaining ditches, site drainage and ensuring proper snow management;
- increased communication and coordination among agencies responsible for infrastructure design, construction and maintenance;
- fostering a culture of maintenance including keeping good maintenance records;
- full life-cycle costing incorporated in building design;
- regular and rigorous inspections (e.g. by using a score card system) and;
- installing automatic sensors to monitor and alarm foundation shifts.

Regarding capacity and training in communities, suggestions included:

- investing in local people and training by educating local maintenance crews;
- developing permafrost foundation training manuals and operational procedures;
- having northern colleges deliver training in communities in northern construction, maintenance and building monitoring tools, techniques and procedures;
- creating and delivering a building maintenance guide and training program for building owners and managers and;
- having a designated person in communities, or regions, employed to monitor foundations.

“[There is a] need for research on how to preserve and maintain existing infrastructure before it becomes too costly; requires government priorities based on safety”

- Participant Comment

3. Cost

Participants identified the cost of design, maintenance and upgrading structures as a significant barrier.

Suggested actions for costing included:

- better coordination of projects across departments and organizations;
- sharing of experiences around research, tools and projects (duplicate successes while avoiding repeated failures);
- taking advantage of longer shipping seasons through better collaboration and bulk buying;
- incorporating full life-cycle costing into decision-making (i.e. paying more now in order not to pay so much later) and;
- sharing of specialized equipment within and between communities.

WORKSHOP DAY 3



Transportation

Day Three began with six presentations on the theme of the effects of permafrost degradation on transportation. Topics included developing a forensic analysis system for transportation infrastructure, highway mapping and vulnerability and airport construction. Presentations were followed by breakout discussions and reporting back to plenary.

Title: Developing a Climate and Infrastructure Forensic Analysis System for Northern Transportation

Presenters: *Simon Eng (Risk Sciences International) and Alison Perrin (Northern Climate Exchange)*

Topic: The GNWT is working collaboratively with the Northern Climate Exchange and the transportation and mining sectors to consolidate and identify gaps in existing knowledge and develop products that enable better transfer of snow and permafrost data and information to industry decision-makers.

Case Study: Not applicable

Key Findings/Take Away Messages:

- An Infrastructure Forensic Analysis System was created to respond to needs and address gaps identified by practitioners.
- Recommendations on future courses of action include gathering additional relevant data, expanding the data geographically and integrating climate change considerations into mining and transportation projects and planning.

Title: Mapping the Bumps in the Road: Permafrost and the North Alaska Highway, Yukon

Presenters: *Fabrice Calmels and Bronwyn Benkert (Northern Climate Exchange)*

Topic: Permafrost under the Alaska Highway is susceptible to thaw in response to climate warming. The project combined geophysical data, geotechnical reports, highway maintenance records and air photos to examine the thaw sensitivity of permafrost under the northern portion of the Highway.

Case Study: Northern 200 kilometers of the Alaska Highway

Key Findings/Take Away Messages:

- Surficial geology and periglacial landforms and features related to permafrost occurrence were used to develop a map of the susceptibility of permafrost to thaw along the highway.
- Results of the project will help Highways and Public Works develop targeted, efficient and effective permafrost adaptation policies and highway engineering designs and maintenance plans.

Title: ARQULUK Program: Preservation of Canada's Northern Transportation Infrastructures

Presenter: *Julie Malenfant-Lepage (Université Laval)*

Topic: The Arquluk Research Program aims to improve transportation adaptive capacities by improving knowledge of permafrost degradation and its effect on transportation infrastructures; identifying and characterizing thaw sensitive soils; and developing adaptation techniques for transportation infrastructure built on unstable permafrost.

Case Study: Yukon and Nunavik

Key Findings/Take Away Messages:

- Six research projects have been assigned to researchers with four additional projects planned for 2014. Results will be made available as soon as possible.

Title: Iqaluit International Airport Improvement Project

Presenter: *John Hawkins (Government of Nunavut)*

Topic: The Iqaluit Airport is experiencing challenges from thawing permafrost (i.e. the runway and associated roadways are becoming increasingly unstable due to cracks forming). The infrastructure at the Airport is undergoing complete replacement and reconstruction through a program that will incorporate the best available permafrost knowledge and appropriate adaptation measures.

Case Study: Iqaluit International Airport

Key Findings/ Take Away Messages:

- Because this project will be a Public-Private Partnership (P3), less risk is assigned to the government and more flexibility can be incorporated into the design and implementation of the project.
- The new airport facilities will use permafrost-related technologies including thermosyphons in the building design and operation and permafrost monitors under the apron and runway.

Title: Permafrost – Infrastructure Research: Great Slave Region, NWT

Presenter: *Stephen Wolfe (Natural Resources Canada)*

Topic: Research is being conducted on permafrost conditions in climatically-sensitive permafrost terrain in the Great Slave Region through the Transportation Risk in the Arctic to Climate Sensitivity (TRACS) Program, a collaborative network between the GNWT, Government of Canada, industry and Carleton University.

Case Study: Great Slave Region, NWT

Key Findings/ Take Away Messages:

- The presentation highlighted several components of TRACS including: surficial materials mapping and identification of ice-rich terrain for infrastructure route selection; ground subsidence identification from satellite radar (InSAR) and LIDAR in relation to existing highway infrastructure; and distribution and return frequency of overland ice build-up in relation to winter road routings.
- An overview of datasets related to permafrost research in the region was also provided.



Title: NWT Highway 3 - Climate Change Vulnerability Assessment

Presenter: *Lukas Arenson (BGC Engineering Incorporated)*

Topic: Engineers Canada, through its Public Infrastructure Engineering Vulnerability Committee (PIEVC), has developed a protocol to assist in the systematic evaluation of risks to roads and highways related to changing climate parameters. The results of an evaluation of Highway 3, as well as the challenges and limitations related to the use of the PIEVC protocol, were presented.

Case Study: Highway 3 between Yellowknife and Behchoko, NWT

Key Findings/ Take Away Messages:

- Although the Department of Transportation has reported that ongoing maintenance and repair needs are much higher than originally anticipated, the evaluation indicates that no immediate road-bed remedial action is warranted, but the collection of baseline information and documentation of maintenance and repair activities should continue.
- Uncertainties in highway foundation conditions (i.e. ground ice conditions) can have a significant impact on the overall risk evaluation.

Transportation Breakout Discussions

As before, workshop participants were divided into small groups and tasked with identifying the most significant permafrost-related issues in relation to transportation, recording the top challenges and identifying actions that could be taken to best address these challenges. Results of the breakout session were subsequently reported to the plenary group.

The top four transportation challenges, as identified by workshop participants, were infrastructure design, cost, safety and maintenance.

1. Design

Participants identified major design issues to be; the need to improve route and highway design, build effective and sustainable partnerships and employ best practices in construct of infrastructure.

Regarding better route and highway design, suggestions included:

- better integration and sharing of scientific knowledge and data during the planning process;
- developing shared understandings of knowledge and data requirements to better inform planning and construction;
- incorporating projections of future climate change into structure design;
- better route and drainage planning (e.g. avoiding highway proximity to creeks) and;
- better design through the use of geotextiles, insulating materials and appropriate quantities and qualities of granular fill materials.

Regarding effective and sustainable partnerships, suggestions included:

- increasing community engagement with planners, engineers and road builders starting at the pre-design stage;
- local apprenticeship opportunities for community resident and;
- increased site visits and data collection involving local residents.



Regarding best practices for constructing transportation infrastructure, participants suggested:

- Incorporating climate change scenarios into early planning;
- incorporating climate change sensitive area issues into design and siting considerations;
- more local sourcing of building materials and labour;
- better monitoring of embankment and road stability, settlement and erosion through the use of LIDAR sensors and remote sensing techniques;
- using gravel for surface coverings rather than asphalt as gravel can be graded to temporarily address safety issues around frost heaving and surface settlement;
- better culvert design and;
- incorporating wind direction into airstrip design.

2. Cost

Participants identified inadequately resourced planning, design, construction and maintenance as the major cost issue.

Participants suggested:

- exploring privatization and private-public partnerships;
- increased budgets;
- better route selection and design in order to lower costs of construction and maintenance;
- incorporation of preventative measures by an initial design above design requirements;
- full life-cycle cost accounting and efficient use of limited resources;
- changing contracting procedures from cost-based to qualification-based to enable greater opportunities to choose better design and construction methods;
- greater reliance on operations and maintenance personnel to identify efficiency opportunities;
- adhering to best management and construction practices and ensuring that they are reviewed regularly and kept up-to-date,
- utilizing only high quality building and granular materials;
- better control of heavy loads on highways and;
- avoiding winter road damage and allowing winter roads to recover from damage by limiting traffic.



3. Safety Issues

Participants identified human safety as being an important issue.

They suggested a need for:

- increased signage for bumps and slumps and a sign hierarchy based on risks (e.g. colour coding);
- having ready access to temporary bridges in the event of a washout and;
- increased road networks so that one highway does not receive all the travel.

“[What I liked most about the workshop was] Being able to receive and give new or better ideas on dealing with global warming, i.e., extreme weather and how it’s going to affect roads and buildings (all infrastructure)”

- Participant Comment

4. Maintenance

Another challenge identified by participants was the need to address existing ailing transportation infrastructure and minimizing future maintenance needs.

Regarding dealing with existing maintenance issues, participants suggested:

- obtaining real time data (e.g. using remote sensing techniques) for the early detection of areas in need of repair;
- better training for local maintainers and operators and;
- the development of new and innovative planning solutions – not being restricted by old ideas and plans.

Regarding minimizing future maintenance needs, suggestions included:

- more preventative maintenance and annual repairs;
- reducing lag times by ensuring a supply of necessary materials and equipment is available in northern communities and;
- better management of public expectations.

Mining, Oil and Gas

The final theme, Mining, Oil and Gas, included presentations on encapsulating oil and gas drilling waste in permafrost, the Giant Mine Remediation Project and permafrost research to support northern hydrocarbon development and transportation. Presentations were followed by breakout discussions.

Title: Permafrost and Drilling Mud Sumps

Presenter: Steve Kokelj (*NWT Geoscience Office*)

Topic: Sumps in the Mackenzie Delta region were designed to fully encapsulate drilling wastes within permafrost, but subsidence of many sump covers suggests that the wastes are no longer frozen.

Case Study: Mackenzie Delta Region, NWT

Key Findings/Take Away Messages:

- Research indicates that human disturbance in stimulating the “shrub - snow cover - ground warming feedback” process is an important factor affecting the stability of drilling waste sumps in low-Arctic permafrost terrain. Removal of shrubs to expose mineral soils can rapidly decrease ground temperatures of historical sumps and lead to the re-establishment of permafrost.



Title: Giant Mine Remediation Project – Arsenic Trioxide Management

Presenter: *Peter Mikes (SRK Consulting)*

Topic: To prevent the release of arsenic into the groundwater around the Giant Mine site, the Government of Canada's current remediation plan calls for the arsenic trioxide dust and the rock around each underground storage chamber and stope, to be frozen using an active freezing system to initially cool the rock and dust and passive freezing to keep it frozen over the long term.

Case Study: Giant Mine, NWT

Key Findings/Take Away Messages:

- A full-scale optimization study was constructed at the mine site in 2010 to test freezing methods and performance at one of the dust storage areas.
- An overview of the decision-making process that led to the selection of the “frozen block method” was provided along with preliminary results of the full-scale optimization study and an outline of how study results are being used to assist the full-scale design. The optimization study is going well, with frozen ground conditions being established more quickly than initially anticipated.

Title: Permafrost Research to Support Northern Hydrocarbon Development and Transportation

Presenter: *Sharon Smith (Geological Survey of Canada)*

Topic: A collaborative industry-government permafrost terrain research and monitoring program associated with the Interprovincial Pipeline Limited Norman Wells to Zama oil pipeline investigated the effects of pipeline construction and operation on permafrost terrain and the additional impact of climate change.

Case Study: Mackenzie Valley, NWT

Key Findings/Take Away Messages:

- Observational data and modeling studies can lead to a better understanding of terrain response to pipeline construction and operation and the performance of impact mitigation measures.
- The Norman Wells pipeline monitoring project demonstrates that effective monitoring programs are essential for the assessment of environmental effects from northern development projects and the impacts climate change may be having on infrastructure. The results of these studies can support the design of other infrastructure projects.

Mining, Oil and Gas Breakout Discussions

As before, workshop participants were divided into small groups and asked to identify the most significant permafrost-related issues regarding mining, oil and gas. They were asked to identify the top challenges and actions that could be taken to best address the latter challenges. The results were subsequently reported to the plenary group.

The top three challenges, as identified by workshop participants, were planning and design, managing environmental consequences and community engagement.

1. Planning and Design

Participants identified better access to planning and design information and planning in a holistic context as major planning and design issues.

Suggested actions for better access to information included:

- recognizing and acknowledging knowledge gaps;
- ensuring adequate baseline data is available;
- developing better hydrological models;
- insisting on higher levels of permafrost understanding for engineers and geoscientists and;
- developing permafrost-related design and construction standards and guidelines.

Regarding planning in a holistic context, suggestions included:

- instituting a multi-disciplinary approach to project planning and implementation;
- having a neutral third party or organization responsible for impact monitoring;
- incorporating permafrost, water and other risk considerations early in the planning process;
- ensuring project planning includes closure and restoration consideration;
- undertaking rigorous risk assessments throughout the life of the project;
- a commitment to long-term monitoring and;
- full consideration of any unique location-specific risks to operations.

2. Environmental Consequences

Participants identified preventative actions, waste management planning and the need for monitoring and adaptation as major issues pertaining to environmental consequences.

Solutions identified by participants for preventative actions included:

- taking a proactive approach to researching site-specific interactions between operations and permafrost, especially with regard to chemicals in drilling fluids and other compounds that could interact with permafrost;
- creating and testing robust contingency and remediation plans in the event of failure or accident and routinely reviewing these plans;
- planning for effective site remediation at the outset by reducing the amount of waste generated and by incorporating remediation plans into operations from the outset;
- developing and implementing best management practices and standards based on experience elsewhere and local conditions;
- exploring alternative energy sources;
- avoiding mechanical solutions where possible (because mechanical solutions tend to fail over time);
- requiring resource companies to monitor permafrost conditions around their operations;
- using an adaptive management decision triage tool;

- creating an effective industry-funded remediation fund;
- adopting a cradle to grave waste management approach and;
- ensuring a rigorous environmental assessment process is in place to assess and address potential impacts on human health and the environment.

Regarding waste management, solutions included:

- continued research into waste treatment and storage under various changing climate, hydrological and geological scenarios;
- finding new and innovative ways to stabilize, treat and dispose of hazardous substances;
- better waste management planning, including the requirement that operators demonstrate the effectiveness of their restoration plans and processes and;
- decreased reliance on permafrost for the permanent storage and stabilization of waste.

Solutions identified for monitoring and adaptation included:

- adapting to changing circumstances by using best practices and techniques; and
- increased understanding of permafrost distribution within arctic and boreal regions aided by remote sensing technology, community monitoring and field research.

3. Community Engagement

Participants identified ensuring public participation in understanding safety and long-term issues and limited opportunities for the transfer of knowledge as being issues.

Participants suggested:

- using science to demonstrate the validity of traditional knowledge;
- greater consideration of local and traditional knowledge, values and interests in development and remediation planning;
- improving information sharing between the local community and researchers;
- providing data in an easy-to-read format, like fact sheets, to meaningfully engage the public and other stakeholders on mining, oil and gas issues, such as safety and environmental issues;
- creating easy-to-read fact sheets and public awareness materials to increase the understanding of mining, oil and gas safety and long-term environmental issues;
- creating and maintaining a single accessible public registry or steward of information;
- taking better advantage of opportunities to transfer knowledge from experts to the public; and
- mandating developers to make their data and information available.

COMMUNICATION TOOLS AND TECHNIQUES

Given the importance of effective communications regarding permafrost degradation and the challenges associated with communicating technical issues to a variety of audiences, a panel discussion on communication tools and techniques was held with Douglas Esagok, Billy Archie, Ellen Pond, Bronwyn Benkert, Norma Kassi and Margaret Ireland participating. Each described communication issues from his or her personal perspective and proposed possible solutions.

Douglas Esagok talked about the importance of researchers developing long-term relationships with local people. In his family, three generations have worked with one researcher, Dr. Ross McKay. He stressed the need for researchers to report back to communities and the need to train community-based monitors.



Billy Archie talked about the climate and landscape changes local people have observed since the 1970's in his home community of Aklavik. He provided examples such as river banks collapsing, freeze-up occurring later and ocean waters becoming warmer. He would like to see local people presenting information to scientists to inform them of what is happening in the communities.

Ellen Pond advised researchers to present material to community people in reverse of their normal presentations - by talking about the results first and then the methodology. She said a lot of important work is being done and scientists need to let communities as well as policy makers know the significance and implications of that work. She said there is a tremendous story in the north that needs to be told to people in southern Canada and around the world.

Bronwyn Benkert said the scientific community needs to simplify its messages because policy makers need key messages, not details. Another challenge is that researchers are doing similar work across the north and need to find a way to share it with each other. She stated that researchers need to gain community trust, put a human face to science, create buy-in by knowing who the audience is, find new and innovative ways to communicate and get youth involved by visiting schools and taking young people into the field.

Norma Kassi emphasized the importance of researchers involving communities in their projects from the outset and building capacity among the youth. She said community members need to hear the results of research before they learn about it through the media. Her suggestions for stronger communications included the following: hiring local people to assist with research; using visual representations and plain language; instituting research agreements with communities, particularly when using traditional knowledge; government-to-government meetings; community meetings with the researcher attending and local staff presenting; inviting local experts to meetings; talking with students; using local radio stations; using translation; and leaving contact information for follow-up questions.

Margaret Ireland said that a lot of information is put on websites, which young people can access but that older people still need oral communication. Community members also like to put a face to the person providing the information. A few years ago she worked on a project where scientists and young people worked together at a lake for a week. In the evenings they would share what they had learned and get to know each other. She suggested that researchers contact communities to see if they have a local or regional Scientific Knowledge Policy. She also asked researchers to keep in mind that scientific terms are often very difficult to understand and translate.

WORKSHOP CLOSING REMARKS

Communication panel members, co-facilitators and participants from the floor made a few closing remarks. A participant noted that he had learned a lot about permafrost and that he hoped the talent in the room stays in touch and meets again in a couple of years. One of the communication panel members talked about starting some research of his own on a simple, local solution to a problem in his community. Another participant noted that some communities are being overwhelmed with researchers while others could use more help. Perhaps a way can be found to match community concerns with researchers. Comments were made about the importance of building relationships, respecting the residents of the land researchers are working in and having a community liaison person to represent the project. One Communication panel member said the overlying theme is water; researchers need to focus on retaining clean water.

If future workshops are held, it was suggested that communities be fully involved in setting an agenda that responds to northern priorities. More youth presence would be welcome as many youth have been involved in research programs. A panel member suggested that community leaders be specifically invited to attend future gatherings and be charged with sharing information when they return home.

On behalf of the Pan-Territorial Adaptation Partnership, Colleen Healey closed the workshop by thanking everyone for their participation and enthusiasm throughout the week. She specifically recognized Don Hayley for leading the short course on transportation, the many presenters who spoke over the three days and the major workshop partners – Aboriginal Affairs and Northern Development Canada and the Canadian Northern Economic Development Agency. She also thanked the NWT Department of Transportation for sponsoring the short course and the NWT and Nunavut Association of Professional Engineers and Geoscientists (NAPEG), Risk Sciences International and MDA for their funding support (see appendix J for a list of sponsors).

Finally, participants were encouraged to complete workshop evaluation forms (see appendix I). A separate report summarizes the results of the evaluations and is available on the workshop website (www.northernadaptation.com).



EMERGING THEMES AND CHALLENGES

Permafrost is warming and is increasingly susceptible to thaw

The majority of presentations highlighted the link between climate change and the degradation of permafrost being observed throughout Northern Canada and Alaska. **There is no argument that the average ambient air temperature in areas with permafrost has increased over the last half century and as a result, permafrost is degrading and thawing.**

The presentation by Chris Burn and Douglas Esagok showed a strong link in the increasingly warm climate of the high-north and the permafrost thaw. Steve Kokelj also emphasized the importance that permafrost has in shaping the North's landscape and how its decay results in ground slumping, which is being observed with increasing frequency. Steve Wolfe's presentation, which hit close to home for many, looked at how changes in Yellowknife's climate, in combination with some instances of poor infrastructure design, has resulted in many examples of the impacts of permafrost thaw on buildings and roads in the community.

The sustained thawing of continuous and discontinuous permafrost emphasizes the need for science, engineering and community planning to work towards better design, construction and maintenance to preserve our diminishing permafrost landscapes and safeguard our communities, infrastructure and landscapes.

"[The best part of the workshop was] The public from other departments presenting with actual experience from the land and from communities; they have seen the actual changes taking place"

- Participant Comment

Landscapes, ecosystems, lifestyles and infrastructure are being impacted by thawing permafrost

Permafrost degradation and thaw, related to increasingly warming climates, **has already begun affecting the lives of northerners by impacting the land around them.** Presentations such as the film "Our Changing Homelands, Our Changing Lives" by Norma Kassi and her family and Jennifer Baltzer's examination of the changes in permafrost rich, boreal forest ecosystems stressed the environmental impacts of permafrost thaw. Norma's video focused on the damage these environmental changes have on the people using their traditional land. Jennifer's research investigated how these changes impact our wildlife, forest and water resources.

Many of the presentations dealing with infrastructure, transportation and mining, oil and gas outlined the increased costs of building, designing and maintaining infrastructure in permafrost landscapes. Presenters advocated for project managers and decision makers to review their policies and procedures relating to all areas of design and construction when dealing with permafrost. Matters such as the need for proper site selection, realistic capital, operations and maintenance budgets, appropriate training and expertise and the need to implement new information and technical advances were all mentioned as necessities in building long-term infrastructure within permafrost rich areas.

Pragmatism was evident throughout the workshop, as many presentations and discussions acknowledged and emphasized the financial costs related to the effects of permafrost degradation, which are likely to increase and the need for appropriate cost/benefit analysis when planning any measures to alleviate permafrost impacts on infrastructure.

Traditional knowledge, science and engineering need to be better integrated

The recognition that traditional knowledge, as well as local knowledge, need to be better integrated with science and engineering, was a theme throughout the workshop. From both the scientific community, which stressed the use of traditional knowledge to provide a more thorough understanding and offered excellent examples of existing partnerships between researchers and First Nations, Inuit and local communities, which emphasized the mutual benefit of using traditional knowledge and offered ideas on how to better access these resources from communities. In the cases of collaborative monitoring and planning programs, the use of community resources and traditional knowledge have enabled local decision makers to better understand and plan for changes taking place in their communities and traditional territories.

One of the many challenges noted during the three days of discussions, **the need to integrate local and traditional knowledge into decisions and ensure community engagement** was most frequently identified by participants. While there was a general recognition that collaboration, cooperation and communication have improved in recent years; participants noted the continuing need to form long term partnerships with community members and organizations, to integrate local and traditional knowledge with western scientific information and to make information on permafrost readily and easily available to the public.



Modern technologies make it possible to detect and to a lesser degree predict, permafrost and landscape changes

Modern remote sensing technology and techniques are making it easier to detect the presence (or absence) of permafrost. Several presenters, including Antoni Lewkowicz, Adrien McCardle and Jon Leighton, presented on methods to detect and map permafrost, such as electrical resistivity tomography for small areas and RADARSAT-2 or other satellite imagery for large scale maps. While these presentations focused on detecting and mapping permafrost, other areas of research looked at combining this knowledge with computer models to predict changes in the permafrost of an area over time. Philip Bonnaventure provided a detailed look at how this is done. Ellen Pond, Fabrice Calmels and Margaret Ireland presented case studies of these maps being used effectively within communities.

Despite the usefulness of these technologies, workshop participants noted reliable long term funding for permafrost monitoring programs, the high cost of research, mapping and ground-truthing and the need to move from monitoring to actionable items remain major challenges. Participants also noted the need to integrate the use of these modern techniques with traditional and local knowledge to ensure studies benefit from all sources of knowledge, the results are sound and relevant to community decision makers and decisions incorporate the best available information and reflect local priorities.

Modern tools make it possible to monitor, maintain and re-establish permafrost but are costly and require additional technical capacity

Several presentations described technologies and techniques routinely used to **maintain or re-establish permafrost conditions**. Brent Wall described how thermosyphon technology is relatively simple, robust and in common use around buildings, storage tanks, parking lots and other infrastructure. Ed Hoeve outlined the use of ground temperature monitoring cables, or thermisters, in Inuvik, NWT. Ed Cormier confirmed the GNWT intends to continue installing thermisters, thermosyphons and other technologies during construction of new buildings and facilities where the risk of permafrost degradation threatens the integrity of the structure. Peter Mikes explained how the Government of Canada intends to use active and passive freezing to re-encapsulate arsenic trioxide dust in underground stopes and vaults at the Giant mine site.

Workshop participants emphasized the need for adequate planning, design, construction and maintenance, qualified and trained local maintenance staff, reliable long term funding and a thorough understanding of the environmental consequences of relying upon the use of these technologies and techniques.

Permafrost-related impact prediction and risk assessment is improving but can be costly and require additional capacity

Assessing the risk to infrastructure from thawing permafrost currently requires specialized knowledge and skills. Due to these limitations, several presenters described their work on developing methods for risk assessment tools to assist non-technical personnel. Mark Porter's presentation focused on a tool for evaluating a building's vulnerability to changes in permafrost and snow loading. Simon Eng and Alison Perrin presented on research in regards to mining and transportation infrastructure. Lucas Arenson described Engineers Canada's newly designed protocol to assist in the evaluation of risks to roads and highways due to climate change.

Workshop participants noted the challenges and costs associated with relying upon consultants and government agencies to perform the required assessments. They suggested **investing in local people through partnerships**, reinforcing the message of several of the presentations, such as those by Sara Brown and Fabrice Calmel and Margaret Ireland and **developing maintenance guides and training programs**, such as those Sara Laxton had presented, as the best ways to ensure knowledge and skills are locally available to assess risks and to undertake the maintenance of buildings and infrastructure.

Hazard maps and development standards are fundamental to better decision making

The identification and mapping of landscape hazards is a critical step in identifying areas that are susceptible to climate change. Such mapping enables a deeper understanding of permafrost dynamics and improved planning and decision making. The explanation of mapping and risk assessment methods by several presenters helped the audience understand the need for such resources when planning communities, highways or buildings.

With respect to development standards, several presenters emphasized **existing national standards generally do not adequately address the Northern realities** of today. A panel presentation by the Northern Infrastructure Standardization Initiative, outlined the intent of the Canadian Standards Association to establish consistent and cohesive standards for the design, installation and maintenance of northern infrastructure.

Participants welcomed the ongoing development of hazard mapping and northern standards but reiterated the need for better coordination and communication; ensuring hazard maps and standards are accessible and relevant to community needs and improving the consistency and sharing of data and other information.

Communication continues to be a challenge but is improving

The importance of **working together to address climate change effects in the North** was another underlying theme that emerged from the workshop. Several presentations focused on the benefits of partnerships, such as increased capacity and increased availability to skill and expertise. The addition of new perspectives, sharing of the workload, reduction of competition over limited resources and reduction of the chance of duplication, results in increased efficiency for all studies undertaken by partnerships.

“I found it very effective with fair amount of people in their expertise in each different angle; I think we now just need to communicate more to the local community public”

- Participant Comment

Several presenters, including Sarah Laxton and Ellen Pond, provided examples of beneficial partnerships between communities, First Nations and Inuit, industry, government and academia. These presentations focused on the Yukon Permafrost Network website and the 4D visioning of the community of Clyde River, respectively. Both projects have incorporated community members and resulted in products that are **better understood by the communities** and benefited from **increased local support**.

Participants noted the dialogue among researchers, land users and communities is generally improving. The development of long-term partnerships between researchers and locals, the involvement of communities and youth in research projects and the presentation of simplified results to community members were identified as ways to ensure communication continues to improve. The final panel presentation of the workshop focused on methods to engage communities and encourage the transfer of local and traditional knowledge to interested parties.

NEXT STEPS

The Governments of Yukon, NWT and Nunavut listened very carefully over the span of the three days and were pleased with the emerging themes that came out of the Workshop. Each agency will have different priorities but it is encouraging to see many of the major issues are already being addressed by a number of partners and that people were keen to collaborate on moving forward. The three governments have taken these themes and will work to incorporate them into future planning. We encourage everyone else to do the same and to work together on prioritizing action.

There was good conversation around the need for greater community participation in permafrost research. We agree that transferring knowledge both ways, between community and researcher, is incredibly valuable to both partners. This continues to be one of PTAP's greatest priorities and we are striving to ensure all future projects have a strong community component. We encourage researchers to continue to work with the communities where research is being conducted and for communities to be clear in communicating their needs to researchers.

“The workshop was the best gathering of scientists, experts, engineers and regional stakeholders facing the impacts of climate warming and permafrost I ever attended”

- Participant Comment

One of the most useful comments heard over the three days was “when is the next workshop?”. We agree that there is strong momentum right now, which needs to continue, whether through formal meetings, such as this workshop, or informal working groups, knowledge sharing meetings and online forums. The Pan-Territorial Adaptation Partnership is committed to hosting a climate change adaptation workshop every two years to develop networks and share information about programs, projects and funding opportunities. Since the next meeting will likely focus on a different climate change issue, we encourage participants to keep the permafrost dialogue going and to continue to share and partner on projects that address changes to permafrost. **Perhaps most importantly, is to share the knowledge gained from this workshop with other members of your universities, communities and social networks, spreading information on climate change adaptation and the impacts of permafrost degradation.** PTAP's slogan is “Moving forward together on climate change adaptation in Canada's North”; so let's keep it going!

Appendices

- A Short Course Registrants
- B Agenda
- C Workshop Delegates
- D Poster Abstracts
- E Speaker Biographies
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- H Reporting Cards
- I Workshop Evaluation Form
- J Workshop Sponsors

Appendix A

Short Course Registrants

Short Course Registrant	Organization
Dennis Althouse	GNWT Municipal and Community Affairs
Terry Brookes	GNWT Department of Transportation - Airports
Heather Brooks	Université Laval
Fabrice Calmels	Northern Climate Exchange Yukon Research Centre
Conor Costigan	EBA, A Tetra Tech Company
Greg Cousineau	GNWT Department of Transportation
Mark Cronk	GNWT Department of Transportation - Airports
Pietro de Bastiani	GNWT Department of Transportation
Stephan Gruber	Carleton University
Richard Guy	Guy Architects
Muhammad Idrees	Yukon Highways and Public Works
Sudhir Jha	GNWT Municipal and Community Affairs
Tom Johnson	NWTAA
Brian Kinzie	GNWT Department of Transportation - Airports
Olivia Lee	GNWT Municipal and Community Affairs
Jorn Meier	Tr'ondëk Hwëch'in First Nation
Jalil Mustafa	EBA, A Tetra Tech Company
Kathy Palko	Transport Canada
Allison Perrin	Northern Climate Exchange Yukon Research Centre
Louis-Philippe Roy	Northern Climate Exchange Yukon Research Centre
Tim Schaap	EBA, A Tetra Tech Company
Allen Sebastian	Associated Engineering
Garry Snyder	GNWT Department of Transportation - North Slave
Jennifer Waugh	GNWT Department of Transportation - Airports
Christopher Stevens	SRK Consulting

Appendix B
Agenda



	Monday Nov 4	Tuesday Nov 5	Wednesday Nov 6	Thursday Nov 7
8:00	Short course on Arctic Transportation (Transport Canada's Working Group)	Breakfast	Breakfast	Breakfast
9:00		8:30 Introductions & Overview Opening and Welcoming Remarks	8:30 Overview of Day #2 8:45 Mapping and Communities (20 min. each) <ul style="list-style-type: none"> Mapping ground movement and permafrost temperature Landscape Hazard Mapping in YT for communities Permafrost scenario & air temperature modeling Electronic Resistivity Tomography 	8:30 Overview of Day #3 8:45 Transportation (20 min. each) <ul style="list-style-type: none"> Developing an Infrastructure Forensic Analysis System for the northern transportation sector Alaska Highway permafrost mapping ARQULUK program: Preservation of Canada's northern transportation infrastructure
10:00		9:15 Introduction to Permafrost. <ul style="list-style-type: none"> Two 25 minute presentations with 5 minutes of questions. 	10:05 Health Break	10:05 Health Break
11:00		10:30 Perspectives from the Yukon, NWT and Nunavut Presentations from three representatives of the Territories.	10:30 Mapping and Communities (20 min. each) <ul style="list-style-type: none"> Permafrost Vulnerability assessment in Jean Marie River First Nation (30 minutes) Mapping and Community Planning in Nunatsiavut Hazard Mapping & 4D visualization in Clyde River Adaptation and Permafrost: tackling challenges through partnerships 	10:00 Transportation (20 min. each) <ul style="list-style-type: none"> Iqaluit Airport Infrastructure Research: Great Slave Region Climate change vulnerability assessment: Highway 3
12:00		11:10: Traditional Knowledge Video (45 minutes) for video and questions.	12:00 Lunch Catered at Explorer Hotel	12:00 Lunch Catered at Explorer Hotel
1:00		12:00 Lunch Catered at Explorer Hotel	1:00 Breakout Discussion and Reporting 30 minutes breakout followed by 30 minutes reporting	1:00 Mining, Oil and Gas (20 min. each) <ul style="list-style-type: none"> Exploration waste in permafrost Giant Mine Frozen Block Remediation Permafrost Research to Support Northern Hydrocarbon Development and Transportation
2:00		1:30 Slide Show of Yellowknife Permafrost (30 minutes)	2:00 Building Infrastructure (20 min. each) <ul style="list-style-type: none"> Recent Effects of Climate Change on Permafrost and Road Stability Building infrastructure in NU Climate Change Impacts on the State of Permafrost in Inuvik, NWT 	2:00 Breakout Discussion and Reporting 30 minutes breakout followed by 30 minutes reporting
3:00		1:30 Landscape Changes (20 min. each) <ul style="list-style-type: none"> Community-based monitoring of the active layer in the Yukon River watershed Permafrost thaw impacts on hydrology and vegetation in the Taiga Plains Landscape change and adaptation: linking permafrost performance with climate change 	3:00 Health Break	3:00 Health Break
4:00		2:45 Health Break	3:20 Building Infrastructure (20 min. each) <ul style="list-style-type: none"> Geotechnical Site investigation guidelines for building Foundation Building Risk Evaluation and Climate Change 	3:30 Outreach Tools and Techniques – 10 minute panel presentation and facilitated panel discussion with Yukon, NWT and NU reps.
5:00		3:00 Tools for Adaptation (20 min. each) <ul style="list-style-type: none"> Remote Sensing in the Arctic Thermosyphons The Yukon Permafrost Network Northern Infrastructure Standards initiative (50 minutes) 	4:00 Breakout Discussion and Reporting 30 minutes breakout followed by 30 minutes reporting	4:30 Closing Comments/Wrap-up
6:00	5:00 Day Wrap-up and Prepare Next Day	5:00 Day Wrap-up and Prepare Next Day		
7:00	6:00 Wine and Cheese Reception (Department of National Defense Mess Hall): A relaxing atmosphere to socialize and peruse colleagues' research initiatives through the concurrent poster session.	6:00 Dinner Beneath the Northern Lights (Aurora Village): An evening of cultural experiences, fine Northern cuisine and phenomenal company.		
	7:00 Public Presentation - Northern Heritage Museum			

Appendix C
Workshop Delegates

Delegate	Organization	Location
Jesse Ajayi	Government of Nunavut	Kugluktuk, NU
Michel Allard	Centre d'études nordiques, Université Laval	Québec, QC
Dennis Althouse	Municipal and Community Affairs GNWT	Yellowknife, NWT
Lukas Arenson	BGC Engineering Inc.	Vancouver, BC
Duncan Armfield	Stantec	Yellowknife, NWT
Iqbal Arshad	Municipal and Community Affairs GNWT	Yellowknife, NWT
Heather Auld	Risk Sciences International	
Colin Avey	Centre for Geomatics GNWT	Yellowknife, NWT
Jennifer Baltzer	Wilfrid Laurier University	Waterloo, ON
Larry Baran	Community Government of Whati	Whati, NWT
Nicole Becker	Tr'ondek Hwech'in	Dawson, YK
Trevor Bell	Memorial University of Newfoundland	St. John's, NL
Bronwyn Benkert	Northern Climate ExChange Yukon College	Whitehorse, YK
Alexandre Bevington	University of Ottawa	Whitehorse, YK
Philip Bonnaventure	Queen's University / University of Ottawa	Ottawa, ON
Mark Braiter	Canadian Standards Association	Mississauga, ON
Sara Brown	NWT Association of Communities	Yellowknife, NWT
Chris Burn	Carleton University	Ottawa, ON
Michael Burns	Public Works and Services GNWT	Yellowknife, NWT
Jennifer Busier	MDA Corporation	
Fabrice Calmels	Northern Climate Exchange Yukon College	Whitehorse, YK
Sandi Chan	Nunavut Climate Change Centre	Iqaluit, NU
Bill Chapple	Department of Transportation GNWT	Yellowknife, NWT
Robert Chapple	Community and Government Services GN	Kugluktuk, NU
Lona Collins	Bottomline Event Planners	Yellowknife, NWT
Fred Collins	Public Works and Services GNWT	Yellowknife, NWT
Edward Cormier	Public Works & Services GNWT	Yellowknife, NWT
Greg Cousineau	Department of Transportation GNWT	Yellowknife, NWT
Mark Cronk	Department of Transportation GNWT	Yellowknife, NWT
Herb Danroth	Kluane First Nation	Burwash Landing, YK
Kam Davies	Agriculture Branch Government of Yukon	Whitehorse, YK
Pietro de Bastiani	Department of Transportation GNWT	Yellowknife, NWT
Ron Dennill	NWT Association of Communities	Yellowknife, NWT

Delegate	Organization	Location
Mark Dhillon	Associated Engineering Ltd.	Victoria, BC
Simon Eng	Risk Sciences International	Ottawa, ON
Jayson Eppler	MDA Systems	Richmond, BC
Douglas Esogak	Inuvik Hunters and Trappers Association	Inuvik, NWT
Vashti Etzel	Ross River Dena Council YESAA	Ross River, YK
Hillary Gladish	Yukon environmental Socio-Assessment Board	Whitehorse, YK
Jaime Goddard, P.Eng.	Williams Engineering Canada Inc.	Yellowknife, NWT
Janna Graham	CKLB Radio	Yellowknife, NWT
Katerine Grandmont	Geocryolab Université de Montréal	Montreal, QC
Kathleen Groenewegen	Environment and Natural Resources GNWT	Hay River, NWT
Stephan Gruber	Carleton University	Ottawa, ON
Michele Guy	Guy Syne Solutions Ltd	Yellowknife, NWT
Richard Guy	Guy Architects	Yellowknife, NWT
Linda Ham	Economic Development and Transportation NU	Iqaluit, NU
John Paul Handrigan	Transport Canada	Ottawa, ON
John Hawkins	Government of Nunavut	Iqaluit, NU
Don Hayley	Hayley Arctic Geoconsulting	Peachland, BC
Colleen Healey	Depart of Environment GN	Iqaluit, NU
Ed Hoeve	EBA A Tetra Tech Company	Yellowknife, NWT
Megan Holsapple	Environment and Natural Resources GNWT	Yellowknife, NWT
Sara Holzman	Department of Environment GN	Iqaluit, NU
Elizabeth Hoy	<i>National Aeronautics and Space Administration</i>	Greenbelt, Maryland
Muhammad Idrees	Highways and Public Works YTG	Whitehorse, YK
Jody Inkster	Yukon River Inter-Tribal Watershed Council	Whitehorse, YK
Jobie Inooya	Nunavut Housing Corporation	Iqaluit, NU
Margaret Ireland	Jean Marie River First Nation	Hay River, NWT
Randy Jacobs	Public Works and Services GNWT	Yellowknife, NWT
Sudhir Jha	Municipal and Community Affairs GNWT	Yellowknife, NWT
Ken Johnson	Stantec Engineering Ltd.	Edmonton, AB
Vicky Johnston	Environment Canada	Yellowknife, NWT
Margaret Kanayok	Hamlet of Ulukhaktok	Ulukhaktok, NWT
Norma Kassi	Arctic Institute of Community Based Research	Whitehorse, YK
John Ketchum	Northwest Territories Geoscience Office	Yellowknife, NWT
Lacia Kinnear	Northern Climate ExChange Yukon College	Whitehorse, YK

Delegate	Organization	Location
Brian Kinzie	Department of Transportation GNWT	Yellowknife, NWT
Steve Kokelj	Northwest Territories Geoscience Office	Yellowknife, NWT
Daniel Korver	Northwest Territories Housing Corporation	Yellowknife, NWT
Jerry Kruse	Selkirk RRC	McCabe Creek, YK
Abraham Kublu	Hamlet of Pond Inlet	Pond Inlet, NU
Kojo Kumi	Government of Nunavut	Iqaluit, NU
Robin Laboline	Community Government of Wekweeti	Wekweeti, NWT
Arlene Laudrum	SRK Consulting	Yellowknife, NWT
Beth Lavender	Natural Resources Canada	Ottawa, ON
Sarah Laxton	Yukon Geological Survey	Whitehorse, YK
Anne-Marie LeBlanc	Geological Survey of Canada	Ottawa, ON
Olivia Lee	Municipal and Community Affairs GNWT	Yellowknife, NWT
Jon Leighton	3v Geomatics	Vancouver, BC
Mickael Lemay	ArcticNet - CEN - U. Laval	St-Nicolas, Levis, QC
Chantel Lemieux	Université Laval	Québec, QC
Julie Lepage	Université Laval	Québec, QC
Toni Lewkowicz	University of Ottawa	Ottawa, ON
Ben Linaker	Environment and Natural Resources GNWT	Yellowknife, NWT
Panya Lipovsky	Yukon Geological Society	Whitehorse, YK
Tom Livingston	Williams Engineering Canada	Yellowknife, NWT
Denis Lord	L'Aquilon	Yellowknife, NWT
Ryan Lyle	Cementation Canada Ltd.	
David Malcolm	Malcolm & Associates	Yellowknife, NWT
Laura Malone	SRK Consulting	Yellowknife, NWT
Adrian McCardle	3v Geomatics	Vancouver, BC
Karen McKenna	CryoGeographic Consulting	Whitehorse, YK
Jorn Meier	Trâ€™ondëk Hwëchâ€™in First Nation	Dawson City, YK
Leslie Meier	Associated Engineering Ltd.	
Peter Mikes	SRK Consulting	Vancouver, BC
David Miller	Canadian Polar Commission	Yellowknife, NWT
Kelly Montgomery	Standards Council of Canada	Ottawa, ON
Lara Mountain	Ducks Unlimited Canada	Yellowknife, NWT
Brendan Mulligan	Yukon River Inter-Tribal Watershed Council	Whitehorse, YK
Jalil Mustafa	Tetra Tech EBA Inc.	Yellowknife, NWT

Delegate	Organization	Location
Kayham Nadji	Nadji Architects	Yellowknife, NWT
Lisa Nitsiza	Community Government of Whati	Whati, NWT
Aynslie Ogden	Government of Yukon	Whitehorse, YK
Kathy Palko	Transport Canada	Ottawa, ON
Alison Perrin	Northern Climate ExChange Yukon College	Whitehorse, YK
Ellen Pond	The Pembina Institute	Vancouver, BC
Mark Porter	Associated Engineering	Burnaby, BC
Scott Reid	Northwest Territories Housing Corporation	Yellowknife, NWT
Doug Ritchie	Yellowknives Dene First Nation	Yellowknife, NWT
John Ritchie	Gwich'in Tribal Council	Inuvik, NWT
Stephen Roddick	Climate Change Secretariat YTG	Whitehorse, YK
Louis-Philippe Roy	Northern Climate ExChange Yukon College	Whitehorse, YK
Mike Rudkin	Hamlet of Pond Inlet	Pond Inlet, NU
Tim Schaap	EBA, A Tetra Tech Company	Yellowknife, NWT
Steven Schwarz	Northwest Territories Centre for Geomatics	Yellowknife, NWT
Bill Shanks	Selkirk RRC	Pelly Crossing, YK
Jamal Shirley	Nunavut research Institute	Iqaluit, NT
Brian Sieben	Environment & Natural Resources GNWT	Yellowknife, NWT
Merran Smith	Climate Change Secretariat YTG	Whitehorse, YK
Johanna Smith	Climate Change Secretariat YTG	Whitehorse, YK
Lisa Smith	Environment and Natural Resources GNWT	Hay River, NWT
Sharon Smith	Geological Survey of Canada	Ottawa, ON
Marcella Snijders	Aboriginal Affairs and Northern Development	Yellowknife, NWT
Garry Snyder	Transportation GNWT	Yellowknife, NWT
Jim Sparling	Environment & Natural Resources GNWT	Yellowknife, NWT
Andrew Sprokkreeff	Nacho Nyak Dun First nation	Mayo, YK
Bruce Stebbing	Municipal and Community Affairs GNWT	Yellowknife, NWT
Paul Steenhof	CSA Group	Ottawa, ON
Christopher Stevens	SRK Consulting	Anchorage, AK
Yves Theriault	Aboriginal Affairs and Northern Development	Gatineau, QC
Richard Trimble	EBA, A Tetra Tech Company	Whitehorse, YK
Sjoerd Van der Wielen	Tlicho Government	Behchoko, NWT
Robert Van Dijken	Council of Yukon First Nations	Whitehorse, YK
Kari VanGeffen	Environment and Natural Resources GNWT	Yellowknife, NWT

Delegate	Organization	Location
Brent Wall	Arctic Foundations of Canada	Winnipeg, MB
John Watson	Nunavut Housing Corporation	Arviat, NU
Bill Watt	Arctic Foundations of Canada	Winnipeg, MB
Michael Westlake	Aboriginal Affairs and Northern Development	Gatineau, QC
Stephen Wolfe	Natural Resources Canada	Ottawa, ON
Vivienne WU	MDA	Vancouver, BC
Edward Yarmack	Arctic Foundations of Canada	Winnipeg, MB
Camilia Zoe-Chocolate	Dene Nation	Yellowknife, NWT

Appendix D

Poster Abstracts (in alphabetical order)

4D Visioning for Climate Change in Clyde River, Nunavut

Ellen Pond (Pembina Institute)

Using a participatory process, researchers at the Collaborative for Advanced Landscape Planning at UBC integrated landscape hazards, energy and quality of life into a set of future land use scenarios for the Hamlet of Clyde River, Nunavut. The UBC research team included David Flanders, Ellen Pond, Kristi Tatebe and Jia Cheng; the Ittaq community coordinator in Clyde River was Gordon Kautuk.

Arctic InSAR

Jon Leighton and Adrian McCardle (3V Geomatics)

This poster highlights the role of remote sensing for monitoring permafrost changes in the Canadian Arctic. The focus is on the role that RADARSAT-2 and other radar satellites can play in detecting and measuring permafrost related ground displacement. It is possible to monitor large areas with high accuracy, reliability and cost effectively. This can benefit communities, transportation corridors and resource development projects. Cases studies are presented from existing monitoring programs.

Building the Knowledge Foundation for Sustainable Climate-Adapted Nunatsiavut Communities

Trevor Bell (Memorial University)

Our Digital Information System for Communities project addresses the issue of inadequate building land in Nunatsiavut communities through the production of planning constraint maps that identify available, suitable areas for development. These maps combine existing community information with Inuit Knowledge and new geoscientific data, including permafrost and landscape hazards, in a georeferenced database to support community infrastructure planning and development decisions.

Community Permafrost Map for Tsiigehtchic, NWT

Rita Kors-Olthof (EBA)

EBA, A Tetra Tech Company, on behalf of Ecology North and the Government of the Northwest Territories, developed a community permafrost map for Tsiigehtchic, NWT. This desktop-level map is intended to help the community better understand the soils, rock and permafrost around them; provide a tool to assist land managers with land use and development; and provide a baseline reference for monitoring changes in the permafrost resulting from climate change and/or development.

Establishment of Community-Based Permafrost Monitoring Sites and Initial Ground Thermal Data in the Baffin Region of Nunavut

Anne-Marie LeBlanc (Geological Survey of Canada)

In 2008, the Geological Survey of Canada collaborated with northern communities and the Government of Nunavut to establish six permafrost monitoring sites in Baffin Region communities. The monitoring sites in Pangnirtung, Clyde River, Igloolik, Pond Inlet, Arctic Bay, and Resolute contribute to the thermal state of permafrost and enhance the permafrost monitoring network in the Eastern Canadian Arctic.

InSAR for Monitoring Permafrost: Preliminary Results over Yellowknife

Jason Eppler (MDA Corporation)

Satellite based Synthetic Aperture Radar Interferometry (InSAR) is a method for remotely measuring the deformation of both infrastructure (such as roads, buildings, airports) and natural terrain over extended areas of interest. It has potential to be a useful tool for monitoring existing and planned infrastructure in permafrost affected areas. Deformation results over the Yellowknife area are presented using RADARSAT-2 images obtained from 2009-2013.

Land-Use Planning in Nunavik

Tania Giberyen (University of Laval)

No abstract was provided.

Making Permafrost Modeling more Useful

Stephan Gruber (Carlton University)

Computer simulation of permafrost is often restricted by data availability, scaling issues, and uncertainty of parameters. This poster shows a simulation framework addressing these issues.

Mapping Coastal Erosion at Cape Bathurst, NWT using Landsat Satellite Imagery

Steven Schwarz (Government of the Northwest Territories)

The objective of this study was to map coastal erosion using Landsat satellite imagery from 1972 and 2010. Using GIS software, we measured the changes in the coastline over 38 years. Some areas of the coast line at Cape Bathurst experienced a loss of 360 meters, or approximately 9.5 meters per year of coastal erosion over 38 years.

Mapping the Potential Impacts of Permafrost Degradation on Land-Use Planning in Nunavik

Katerine Grandmont (University of Montreal)

No abstract was provided.

Northern Infrastructure Standardization Initiative

Michael Westlake (Aboriginal Affairs and Northern Development Canada)

The Northern Infrastructure Standardization Initiative (NISI) is an important first step in establishing a sustainable process to reflect the unique circumstances of the North in new or existing standards. NISI is led by Standards Council of Canada with support from Aboriginal Affairs and Northern Development Canada."

Observing Permafrost Thaw

Stephan Gruber (Carlton University)

When permafrost thaws, material properties such as ice and water content change, but temperature remains nearly constant. This poster shows how to complement temperature with new metrics. Here, dielectric spectroscopy provides a means to separately measure the evolution of ice and water content of soil in the laboratory and in plastic-cased boreholes.

Permafrost

Anne-Marie LeBlanc (Geological Survey of Canada)

Intended for a general audience, the poster provides information on permafrost and factors determining its existence, shows examples of ground ice and surface expressions, and briefly addresses the impacts of thawing permafrost.

Permafrost Characterization in Support of Northern Mine Development

Christopher Stevens (SRK Consulting)

Northern mines require a comprehensive evaluation of permafrost for baseline characterization and in support of mine design, operation, and closure. The response of permafrost to disturbance and its impact on the performance and safety of mine infrastructure is also important due to the changing regulatory, economic, and climatic environment of the north. We present an overview of permafrost characterization for northern mines.

Permafrost in Mountains Matters

Stephan Gruber (Carlton University)

A large proportion of permafrost, both globally and in Canada exists in mountain topography. This poster showcases European research relevant to Canada.

Salluit Permafrost Map and Community Participation

Michel Allard (University of Laval)

No abstract was provided.

Thermosyphons

Bill Watt (Arctic Foundations of Canada)

A photo series displaying the various applications of thermosyphon technologies, accompanied by an expert in thermosyphon design and application.

Using Simple Databases and Semi-Automated Calculations to Analyze Large Datasets

Alexandre Bevington (University of Ottawa)

This research aims to implement the Temperature at the Top of Permafrost (TTOP)-model of permafrost distribution for the Yukon. We are using climate and permafrost data from hundreds of sites throughout the Yukon. This poster explains our method and highlights the advantages and the challenges that we have/are facing.

Appendix E

Speaker Biographies (in alphabetical order)

Michel Allard - University of Laval

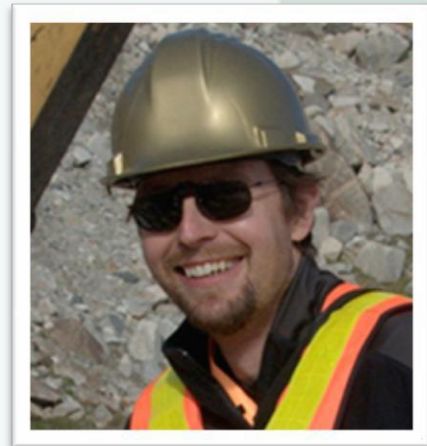
A professor in the Department of Geography of Laval University since 1975 and a researcher at Centre d'études nordiques, Michel Allard first is a geomorphologist, Quaternary geologist, ecologist and humanist at heart. He got involved in permafrost research and became an expert while working in Nunavik. With a team of graduate students and research professionals, he carries fundamental research projects on the physical processes of permafrost formation under past and current climates, on ground thermal regime and on the impacts of permafrost thawing both in the natural environment and under engineered infrastructures. From 1987 onwards, he involved himself in applied permafrost research through his work in the Nunavik airport construction program of the Government of Québec.



Over time, his activities were extended to the Inuit communities of Nunavik and Nunavut, doing studies in support of adaptation to climate change and construction of housing and infrastructures. One of his major current projects aims at developing tutorials for Inuit communities, colleges and high schools for learning the basics of permafrost science and engineering in order to build capacity in the North for decision making on land management and economic development.

Lukas Arenson - BGC Engineering Inc.

Lukas is a senior geotechnical engineer with BGC Engineering Inc. and has over ten years of experience, with specific interest and expertise in frozen soil mechanics and geothermal modelling. He has worked on linear infrastructure projects in Arctic permafrost and the stability of frozen slopes in the European Alps and the South American Andes. Additional work has concentrated on the thermo-mechanical processes of frozen and freezing soils at a microstructural level to better understand the hydraulic, strength and deformation properties of frozen soils with changing stress, temperature and salinity. He has taught permafrost engineering courses at universities and for industry, and authored several research papers on the strength of frozen soil, the stability of permafrost slopes, ice lens formation and frost heave. He is the current Chair of the Cold Regions Engineering Division of the Canadian Geotechnical Society, co-chair of the Permafrost Engineering Task Force of the International Permafrost Association and an Adjunct Professor at the Civil Engineering Department of the University of Manitoba. He was the recipient of the Troy L. Péwé award in 2003 and was awarded the Roger J. E. Brown Memorial Award from the Canadian Geotechnical Society in 2010 for his contributions to permafrost engineering research and to the cold regions engineering division.





Heather Auld - Risk Sciences International

Heather Auld is the Principal Climate Scientist with Risk Sciences International (RSI) and has 34 years of experience as a meteorologist, climatologist and climate change adaptation expert. She spent 32 of those years with Environment Canada, working in Edmonton, Vancouver, Toronto and Canadian Forces Trenton.

Heather has extensively researched and developed engineering climate and climate change design values for the National Building Code of Canada and is a climate change adaptation focal point for the Code. She has contributed to various CSA standards for buildings, electrical and communications structures and northern infrastructure, and is currently the lead to develop a new northern standard intended to risk manage changing snow loads on existing buildings. She contributed to an earlier CSA permafrost guideline and was the lead for a CSA standard on extreme rainfall intensities values (IDF). Heather has provided expert analyses and testimony

to several national weather disaster inquiries and developed an internationally recognized climate hazards web Portal to support disaster management planning. She has also served on expert teams with the World Meteorological Organization, UN Strategy for Disaster Risk Reduction, represented Canadian delegations to the UN Convention on Biological Diversity and served as a lead author with the Intergovernmental Panel on Climate Change.



Jennifer Baltzer - Wilfrid Laurier University

Jennifer Baltzer is a terrestrial ecologist and Canada Research Chair at Wilfrid Laurier University in Waterloo, Ontario.

Jennifer's northern research interests focus on the role of changing permafrost conditions on the structure and function of terrestrial ecosystems within the Taiga Plains Ecoregion of the Northwest Territories. She collaborates with hydrologists and remote sensors to provide an integrative understanding of these complex landscape changes. Jennifer works closely with the Government of the Northwest Territories through an ongoing Partnership between Laurier and the GNWT.

Trevor Bell - Memorial University of Newfoundland

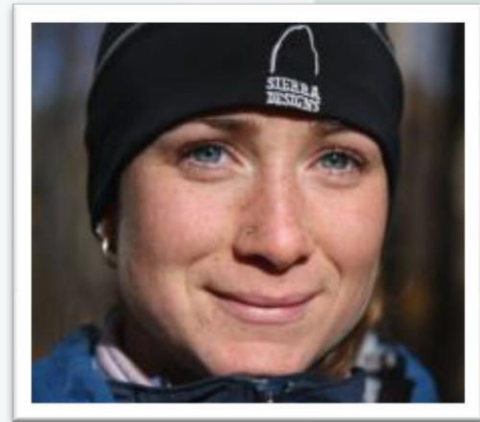
Trevor Bell is Professor of Geography and Archaeology at Memorial University of Newfoundland. His area of expertise is landscape history from a variety of perspectives, including geological evolution, climate change impacts and human adaptation and his approach is strongly interdisciplinary and collaborative, involving a range of disciplines in the earth, life, and social sciences. He has 30 years of field experience in Arctic and subarctic environments and for the past decade has worked closely with communities on co-designed research projects. One such project is the

Nunatsiavut Government-led SakKijânginnatuk Nunalik, a broad integrated research program that aims to inform best practices and provide guidance for community sustainability in coastal subarctic environments.



Bronwyn Benkert - Northern Climate ExChange

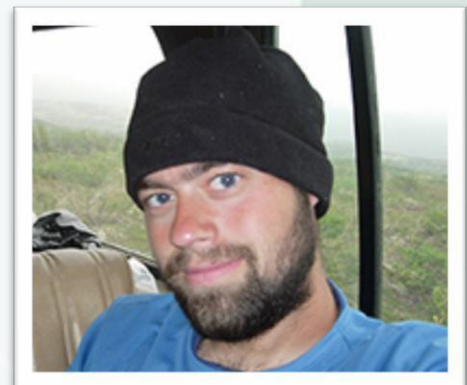
Bronwyn's PhD research focused on using water isotope tracers to characterize the present and past hydrology of the lakes in the Slave River Delta, NWT, to address local concerns about observations of change and to anticipate potential future changes in response to climate variability. She has been involved in similar research in northern Alberta's Peace-Athabasca Delta and the Old Crow Flats. Bronwyn now works with the Northern Climate ExChange, part of the Yukon Research Centre at Yukon College, as the research project coordinator. Currently she's coordinating projects related to the impacts of climate change on permafrost in Yukon.



Philip P. Bonnaventure - Queen's University

At the broadest scale my research interests focus on the use of geomatic modeling in environmental systems at different scales of time and space. Specifically, I am interested in using geomorphic data collected in high arctic and mountain systems to understand the evolution of terrestrial and fluvial landscapes in the past, present and into the future. My current research focuses on two distinctive projects, which examine terrain in the Yukon and Melville Island, Nunavut. These projects investigate and model current, past and future spatial

distributions of permafrost as well as examining the link between permafrost thaw and budgets of water, sediment, salts and carbon through the distribution mechanism of hydrological processes. My aim is to expand the scales of my research both temporally and spatially in order to include the modelling and evolution of northern landscapes as the climate of the north changes in the future.



Sara Brown - Northwest Territories Association of Communities



Having been raised in Yellowknife, although school and work have taken her to various locations in the south, Sara has always considered herself a Northerner and she keeps getting drawn back. Starting out in construction and consulting, Sara took her first job as a Municipal Engineer in Iqaluit almost 20 years ago. Sara has dealt with the varied issues facing communities as a Manager of Engineering, Director of Public Works and SAO with a number of communities throughout Ontario, Alberta, Nunavut and the NWT. Sara is now CEO of the Northwest Territories Association of Communities. With Climate Change a major issue for communities in the NWT, Sara has stayed active on that file by advocating on behalf of

communities as well as actively participating in solutions such as co-chairing the technical committee for the development of a suite of northern infrastructure climate change standards.



Chris Burn - Carleton University

Chris Burn is Professor of Geography at Carleton University. He has been studying permafrost in the Yukon and western Arctic since 1981. His interests concern several aspects of the permafrost environment, but most recently has been working on the response of permafrost to climate change. He has maintained long-term observations that were started by Dr Ross Mackay at both Garry Island and the Illisarvik experimental drained lake site on Richards Island in the Mackenzie delta area. He has completed several projects at Herschel Island, most recently the publication of a multi-disciplinary book about the natural and cultural history of Qikiqtaryuk. This book has 43 co-authors, half of whom live in Yukon or NWT.



Fabrice Calmels - Northern Climate ExChange

Fabrice is a geosciences and engineering specialist. His work is devoted to the impact of climate and environmental change on Canadian Landscape, communities, and infrastructures. Fabrice worked in most of the Northern Communities of Nunavik, Quebec, in the communities of Mayo and Dawson City, Yukon, and more recently in Jean Marie River, NWT. He is currently working on a survey of the Alaska Highway, YT, as an associate researcher. His objectives are to assess the impact of climate change on the highway, and to develop adaptation strategies.

Ed Cormier - GNWT Department of Public Works and Services

Ed is the Senior Architectural/Structural Officer with GNWT Public Works. He began his own practice in Toronto after working in the offices of Shore Tilber Herschel Erwin and Peters until he was principal partner with EC Design Architects until 2007. He then took up projects in Abu Dabi, United Arab Emirates until 2009 when he came to Yellowknife. He has worked on a number of projects for the GNWT in all areas of the Northwest Territories.

Simon Eng - Risk Sciences International

Simon Eng has nearly 5 years of experience working in climate and weather services, with a focus on extreme and severe weather events and climate impacts on the built environment. He has combined degrees in Civil Engineering and Meteorology. While obtaining his bachelor's degree in Civil Engineering, he worked various summer student positions at Environment Canada, including work for the Weather History Project (associated with the Canadian Weather Trivia Calendar), severe summer weather forecast assistant (including work on post-storm damage assessment), and finally researcher at Adaptation and Impacts Research Division (AIRD). Following graduation, Simon enrolled in the Certificate in Meteorology program at York University, completing his certificate in December 2011. During this time, he continued to work as a researcher at AIRD. Since the early spring of 2011, Simon has taken up the hobby of storm chasing, most notably including a trip to the United States in 2012, where he witnessed first-hand multiple severe weather events, including several tornadoes. He also conducts his own historical research on severe weather as a hobby. Since the summer of 2012, Simon has worked as a climate analyst and researcher for Risk Sciences International.



Douglas Esagok - Inuvik Hunters and Trappers Committee

Douglas Esagok is a director of the Inuvik HTC. He is a hunter who has lived in the Mackenzie Delta area the whole of his life, and has travelled extensively and frequently throughout the Delta and along the Yukon North Slope. Since the late 1990s he has accompanied Chris Burn and Steve Kokelj during their fieldwork, and this summer marked his 17th season of field research with them. His observations have initiated many research projects by these scientists and by others, because his vision combines a sharp focus on the behavior of the environment with an appreciation of how things are changing in the western Arctic.





John Hawkins - Government of Nunavut

John Hawkins has been involved with the transportation system in Nunavut since the early 1990's. He is the former Director of Transportation Policy and Planning for the Government of Nunavut. Currently, as Director of the Iqaluit International Airport Division, he is heavily involved in a major project to rebuild the airport under a Private-Public-Partnership (P3) agreement.

Don Hayley - Hayley Arctic Geoconsulting

Don Hayley is a Consulting Engineer with a focus solely on arctic regions. He was a senior principal of EBA Engineering Consultants for 45 years, retiring as Director of Arctic Resource Development in 2013. He has continued part-time practice with EBA and on technical review boards for several operating northern mines. He is active on Committees for Transport Canada and the CSA that address challenges associated with northern roads and buildings. He has applied his technical knowledge across the entire northern



hemisphere from Alaska to Siberia. Don is a registered Professional Engineer in three provinces and all three northern territories. He was appointed a Fellow of the Engineering Institute of Canada in 2002 and received the Julian C. Smith Medal from the EIC for contributions to the development of Canada in 2005. He received the Roger Brown Medal for his contributions to Permafrost Science and Engineering from the Canadian Geotechnical Society in 1991 and was a member of the Executive of the International Permafrost Association from 2003 to 2008.

Mr. Ed Hoeve - EBA, A Tetra Tech Company



Ed is a senior geotechnical engineer with 30 years of Northern experience, the last 24 of those gained based in EBA Engineering Consultant Ltd.'s Yellowknife office, working on projects throughout the Northwest Territories and Nunavut. He is thoroughly familiar with the practical constraints on foundation and earthworks design and construction in the north. An area of specialization in this regard is geotechnical engineering in permafrost. For about the last 10 years, this has necessitated consideration of potential climate change impacts on new and existing infrastructure. He has experience with projects focusing specifically on this issue, but the state of the practice has advanced so that consideration of potential impacts of climate change is an integral component of routine projects.

Jody Inkster - Yukon River Inter-Tribal Watershed Council

Jody Inkster is an Environmental Scientist for the Yukon River Inter-Tribal Watershed Council. She has family history in Yukon River watershed, but more specifically has ties to Pelly River headwaters. Jody is a Kaska citizen of Ross River Dena Council and belongs to the wolf clan. She has a paternal connection to the Tahltan Nation and her Tahltan name is Thickee. Jody was born in Faro, Yukon and grew up in many communities throughout Yukon and British Columbia, but she finds her home in Whitehorse. In 2009, she obtained her diploma in Renewable Resources Management from Yukon College and has several years of experience working in the environmental sector, including a past position with Water Survey of Canada. She is a proud Yukoner and loves the work she has contributed to, in preserving and protecting the Yukon River watershed.



Margaret Ireland – Jean Marie River First Nation

Margaret was born and raised in Jean Marie River. After moving back to the community in 1997, she has sat on numerous boards, did short contracts with Jean Marie River First Nation (JMRFN) and other indigenous organizations and eventually went to work for Imperial Oil and then JMRFN. She is now JMR District Education Authority.

Working for a small first nation with limited human resources, a person has to wear many hats. Currently with the possibility of another pipeline and oil and gas exploration, JMRFN find itself having to respond to inquiries of industry, increased demand that requires leaders to have to deal with more sophisticated issues, pressures for land development and requirements for communities to negotiate complex issues. She works very closely with the elders' council. She deeply appreciates their vast environmental knowledge which offers great insights. She is deeply committed to preserving and revitalizing the traditional history, knowledge and skills of the Dene people that are now jeopardized by the impact of climate change on their traditional lands.

Ken Johnson – Stantec Consulting Ltd.

Ken Johnson is a senior planner and environmental engineer with Stantec Consulting in Edmonton, Alberta. For the past 25 years Ken has been involved in a wide variety of water and sanitation projects throughout the Canadian north, from Iqaluit, Nunavut, to Beaver Creek, Yukon to Ulukhaktok (Holman), NWT. Ken is a widely published expert on water and sanitation projects through the Northern Territories Water and Waste Association Journal, Western Canada Water Magazine and various conferences associated with northern water and sanitation infrastructure. In his current volunteer role as Chair of the Canadian Standards Association subcommittee on Drainage Planning, Design, Construction and Maintenance in Northern Communities, Ken is the lead technical expert on a committee of planners, engineers, and other technical resources working to develop a comprehensive standard for community drainage in the Canadian far north.

Norma Kassi - Arctic Institute of Community Based Research

Norma Kassi was raised and educated in Old Crow, Yukon; she is Vuntut Gwitchin and a member of the Wolf Clan. It was in Old Crow flats where she gained her traditional, scientific and ecological knowledge through her parents, grandparents and the land itself. Norma has been involved in Yukon politics since 1985, represented the Gwich'in Nation as their spokesperson in the fight to protect the Porcupine caribou herd and has been the recipient of many awards for her work, including the National Wildlife Federation's Conservation and Achievement Award, and the Goldman Prize in 2002, one of the world's highest profile awards for Conservation. In 2007 Norma co-founded the Arctic Institute of Community-Based Research in 2007 where she is engaged in Community Based Health Research, particularly with Indigenous communities.

Steve Kokelj - NWT Geoscience Office



Steve Kokelj is a permafrost scientist with the NWT Geoscience Office, GNWT Department of Industry Tourism and Investment. For over ten years he has lived in Yellowknife and conducted permafrost research in the NWT. His studies have contributed to understanding permafrost conditions in the western Arctic and North Slave regions, and the impacts of permafrost thaw on infrastructure, and terrestrial and aquatic systems. He has been recognized for an ongoing commitment to communication of results to northern residents, to agencies involved in environmental assessment and regulation, and to the scientific community. Steve led several multidisciplinary projects and provides a northern scientific perspective and a liaison role between the researchers, northern communities, project proponents and regulators.

Sarah Laxton - Yukon Geological Survey



Sarah Laxton is the Outreach Geologist for the Yukon Geological Survey. She maintains the Yukon Permafrost Network website and has participated in the INAC funded Infrastructure Vulnerability to Permafrost Degradation project from 2009-2011. Currently, she is collaborating with the Northern Climate Exchange and partners on the AANDC funded Geoscience mapping for climate change adaptation planning project.

Anne-Marie LeBlanc - Geological Survey of Canada

Anne-Marie is a geological engineer and a permafrost research scientist at the Geological Survey of Canada (GSC - Natural Resources Canada). Her research conducted in northern Quebec and Nunavut dealt with the characterization of thermal, mechanical and physical properties of permafrost by geotechnical and geophysical methods. Her interest also includes the interaction between climate and permafrost through numerical modeling for climate change community and transportation infrastructure assessment, and the application and validation of remote sensing for ground surface movement. She was involved in the Nunavut Landscape Hazard Mapping Project in the communities of Pangnirtung and Iqaluit. Currently, she is leading a GSC activity in collaboration with the Centre d'études Nordiques at the Iqaluit airport to understand permafrost processes and assess the impacts of climate change.



Jon Leighton - 3v Geomatics

Jon Leighton is an experienced geospatial scientist and Radar data analyst. He is equally happy indoors, using remotely sensed Radar data to infer ground motion at the millimeter scale, and outdoors, planning and executing fieldwork across Canada's arctic communities. Prior to his InSAR and GPS based PhD, Jon conducted geodetic survey tasks all over the world with the British Army. Jon is currently involved in three separate projects involving seventeen different Arctic communities. The common theme amongst these projects is the use of Interferometric Synthetic Aperture Radar (InSAR) observations to measure ground motion caused by melting permafrost.



Antoni Lewkowicz - University of Ottawa

Toni Lewkowicz is a Professor in the Department of Geography at the University of Ottawa. He has been a permafrost researcher for more than 35 years, working in the Canadian High Arctic, the Mackenzie Valley and Delta, the Yukon, Labrador, northern Norway, Svalbard and Antarctica. In the past decade, his major interests have been in the distribution and characteristics of permafrost and the impacts of climate and other environmental changes. He is collaborating with the Yukon Research Centre on project to map hazards associated with projected changes in permafrost for Yukon communities. He was editor for 6 years of *Permafrost and Periglacial Processes*, the premier international journal in the field, and is currently President of the International Permafrost Association.





Julie Malenfant-Lepage (Université Laval)

Julie Malenfant Lepage has done her master thesis at the Department of Civil and Water Engineering of Laval University, in Quebec City. Her research aimed at experimenting mitigation techniques to reduce the effects of permafrost degradation on transportation infrastructures on the Alaska Highway, in Yukon Territory. She started her PhD in 2013 on the management of surface water and groundwater flow for transportation infrastructures in permafrost environment.



Adrian McCardle - 3v Geomatics

After working in the remote sensing industry internationally for 10 years, Adrian McCardle founded 3v Geomatics in July 2007 to develop a business through expanding applications of SAR and InSAR technology for the commercial and public sectors. After over 5 years, 3vG has successfully completed projects in some of the most difficult environments around the world. Adrian and 3vG have been applying new processing techniques for monitoring permafrost related displacement across Yukon, NWT, Nunavut and Labrador. Varying conditions across the Canadian North have required major modifications to existing monitoring methods. 3vG remain focused on moving R&D initiatives to real solutions in the Arctic.



Peter Mikes - SRK Consulting

Peter Mikes is a Senior Consultant in the Geo-Environmental Engineering division of SRK Consulting in Vancouver, BC, and specializes in mine closure work with an emphasis in geotechnical and frozen ground engineering. Peter has been involved in the Giant Mine Remediation Project for the past six years, focusing on the analysis and evaluation of the freeze optimization study, in support of the design of the project's "Frozen Block" method for managing underground arsenic dust.

Brendan Mulligan - Yukon River Inter-Tribal Watershed Council

Brendan is a hydrogeologist, geological engineer, and a committed advocate of community development and empowerment through scientific training and education. He is currently working as Environmental Scientist for the Yukon River Inter-Tribal Watershed Council (YRITWC) in Whitehorse, Yukon. Brendan brings to the organization a decade of experience working on water issues with Indigenous people across the Americas (in Canada, U.S.A., Guatemala, Honduras, El Salvador and Bolivia). The YRITWC consists of 70 First Nations and Tribes, dedicated to the protection and preservation of the Yukon River Watershed. One of the YRITWC's initiatives is their "Active Layer Network", which is building the capacity of First Nations in Yukon and tribes in Alaska to monitor permafrost degradation in their traditional territories.



Alison Perrin - Northern Climate ExChange

Alison leads the Climate Change Information and Mainstreaming program at the Northern Climate ExChange in the Yukon Research Centre, where she provides support and expertise to decision and policy makers to assist them with integrating climate change considerations in project, planning, and decision-making processes. Her professional experience includes project management, ecological monitoring, community-based research, adaptation research and communications for both government and non-governmental organizations. Alison completed her Master of Arts in Environmental Education and Communications from Royal Roads University where she focused on experiential education and environmental ethics.

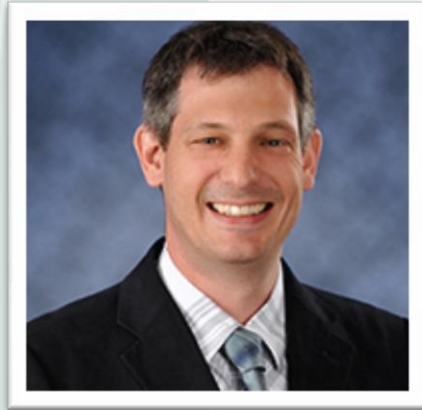


Ellen Pond - Pembina Institute

Ellen specializes in the development of community-based climate change solutions, including spatial planning, visual communications, and public process facilitation. She has designed and evaluated citizen engagement strategies for adaptation, energy and land use planning and is currently supporting the NWTAC in a project to mainstream adaptation into community planning. In prior work with the Collaborative for Advanced Landscape Planning, UBC, Ellen worked on a 'Visualizing Climate Change' project that integrated hazards, energy and quality of life into planning scenarios for the Hamlet of Clyde River, Nunavut. Ellen also teaches as a Sessional Lecturer in the Landscape Architecture program at the University of British Columbia.



Mark Porter - Associated Engineering



Mark is a Senior Engineer and Manager at Associated Engineering looking after a team of building structural and mechanical engineers. He is currently the Lead Engineer undertaking a vulnerability risk assessment of GNWT owned building stock with respect to changes in snow loading and permafrost. To date he and his team have surveyed over 50 buildings and the work continues. Mark chairs the APEGBC climate change advisory panel and is an active manager of the sustainability committee. He is a designated Structural Engineer and a Fellow of the Institution of Structural Engineers with over 15 years of experience as a structural designer. He has worked on numerous projects across Canada including the Northwest Territories and the Yukon.

Sharon Smith - Geological Survey of Canada



Sharon is a permafrost research scientist at the Geological Survey of Canada. She leads research activities investigating the response of permafrost to climate change and environmental disturbance associated with northern development. Much of her recent work has focused on the Mackenzie corridor and the Alaska Highway corridor including enhancement of permafrost monitoring networks and regional baseline permafrost information. She led an International Polar Year synthesis of permafrost variability and change and has contributed to several national and international assessments (e.g. IPCC) and the Canadian Standards Association guideline for permafrost, infrastructure and climate change

adaptation. She provides permafrost expertise for government reviews of environmental assessments for northern development projects such as base metal and diamond mines and the Mackenzie Gas Project.

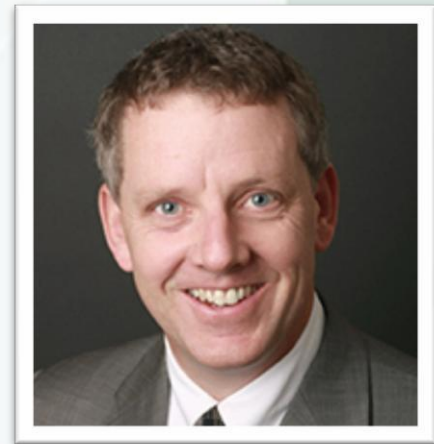
Richard Trimble - EBA, A Tetra Tech Company



Richard Trimble is a Principal Consultant with EBA, A Tetra Tech Company in Whitehorse, Yukon. He has worked for EBA for 36 years, and opened EBA's Whitehorse Office in 1981. Richard has extensive practical experience in permafrost foundation design, and mitigating the effects of permafrost thaw on buildings, towers, roads, airports and other structures. He has worked across northern North America from Prudhoe Bay to the eastern shore of Baffin Island, and across all of the Arctic Islands up to Grise Fiord, NT. He currently lives in Whitehorse with his wife Ella, and they have three adult daughters

Brent Wall - Achieve Engineering Inc.

Brent is the President and CEO of Achieve Engineering Inc. Brent has 30-years of engineering experience in Industrial and Commercial projects throughout Canada. Achieve Engineering is a specialty mechanical engineering firm based in Winnipeg, Manitoba. Our engineers have been designing and troubleshooting mechanical systems across Canada's Arctic for over 15-years. Achieve Engineering is the engineer of record for Arctic Foundations of Canada Inc. We oversee the design of thermosyphon ground freezing systems. We are an active member of the CSA Technical Committee for the upcoming CSA standard on thermosyphons.



John Watson - Nunavut Housing Corporation

John worked 30 years with the Nova Scotia Department of Transportation as a Civil Engineering Technician / Technologist in the Materials Laboratory where he worked on all aspects of highway construction from sub surface investigations and soil mechanics to concrete and bituminous asphalt mix designs. In 2000 John moved to Kugaaruk, Nunavut and worked as Maintenance Manager at the Local Housing Organization and assisted with technical aspects of the road and bridge construction to the Barrow Lake DEW Line site. In spring 2002 he moved to Pond Inlet, Nunavut where John worked as the Baffin Regional Maintenance Administrator for Public Works coordinating all maintenance on Government of Nunavut buildings and infrastructure for the Baffin region. In the fall of 2003 John transferred to Project Management where he was responsible for several projects to enhance or replace Municipal Service Facilities including office buildings, a new school project and the New Arctic Bay Airport. In the fall of 2010 John moved to Arviat, Nunavut and started work with Nunavut Housing Corporation (NHC) as the Manager, Territorial Maintenance.



Sheila Watt-Cloutier - World Leader on Global Climate Change and Human Rights

Nobel Peace Prize nominee Sheila Watt-Cloutier is in the business of transforming public opinion into public policy. Experienced in working with global decision makers for over a decade, Watt-Cloutier offers a new model for 21st century leadership. She speaks with passion and urgency on the issues of today—the environment, the economy, foreign policy, global health, and sustainability—not as separate concerns, but as a deeply interconnected whole. At a time when people are seeking solutions, direction, and a sense of hope, this global leader provides a big picture of where we are and where we're headed.



In 2007, Watt-Cloutier was nominated for the Nobel Peace Prize for her advocacy work in showing the impact of global climate change on human rights—especially in the Arctic, where it is felt more immediately, and more dramatically, than anywhere else in the world. Watt-Cloutier is also an Officer of the Order of Canada. She is also the recipient of the Aboriginal Achievement Award, the UN Champion of the Earth Award, and the Norwegian Sophie Prize. From 1995-2002, she was elected the Canadian President of the Inuit Circumpolar Council (ICC). She was later elected in 2002 to become the International Chair of the ICC, representing the 155,000 Inuit from Canada, Greenland, Alaska and Russia; she held this post until 2006.

Stephen Wolfe - Natural Resources Canada



Dr. Wolfe is a research scientist at Natural Resources Canada with expertise in geomorphology. He leads a Geological Survey of Canada project on Northern land-based infrastructure risks to climate change, and heads TRACS (Transportation Risk in the Arctic to Climatic Sensitivity). His present research interests include landscape risks to northern transportation infrastructure, detecting present and historical change in permafrost and landscape conditions, permafrost-ecological relations within “warm” discontinuous permafrost. He is an adjunct professor in the Department of Geography and Environmental Studies, Carleton University, and participates in national and international

societies, journal and funding review boards, and as an expert reviewer of Environmental Impacts Statements. He has published more than 50 articles on the topics of climate change impacts to geomorphic processes in Canada on the topics of permafrost, drought, wind erosion (and wind energy) and coastal processes.

Appendix F

Speaker Guidelines

Permafrost Workshop Speaker Guidelines

Thank you for your interest in presenting at the Permafrost Workshop this coming November 5-7th 2013. The main questions we'd like to be addressed in presentations are listed below. Please keep in mind, not all of them are relevant to individual presentations:

- How does your study contribute to permafrost knowledge in the North?
- What are the gaps in permafrost research in your sector and how can we address them?
- What is the role of communities in your work, to date and in future?
- How can we encourage knowledge transfer between research and decision-making and ensure that the communities' research needs are being met?
- What is needed in order for you to make better decisions related to permafrost in your job? (I.e: what kind of research needs to be done? How do you want this information given to you? How would you like to be engaged in permafrost research projects?)

Speaker Guidelines

Sessions are based on broad themes/sectors. Presenters will present in a panel format, which will include short question and answer periods. Presentations should be 15 minutes in length with an additional minute for introduction by the facilitator and 4 minutes for question and answers at the end of the presentation. The following is suggested for breaking up the time:

- Introduction by the facilitator (30 seconds-1min)
 - Context and case study overview (10 min)
 - Lessons learned / key recommendations— specifically address how the results of your work can be applied in the context of adaptation (5 min)
 - Question and answer period (4 min)
- **Please limit your presentation to 15 minutes.** This strict rule will ensure that the workshop meets its objectives and flows smoothly
 - Keep presented material to an understandable level for all audiences, including non-technical municipal staff, Elders, and general community members – focus on key messages, not the technical details

Allow time for people to have a chance to ask questions and make comments. The success of the workshop relies on the opportunity for open discussion prompted by effective, well-planned and accessible talks from invited presenters. The broad audience needs to be able to clearly follow presentations to contribute to the discussion.

Please note:

- Laptop with PowerPoint, including full audio will be available for presentations
- Your presentation will be filmed and webcasted and may be available as part of a communication distribution plan following the workshop
 - An electronic version of your presentation will be required for webcasting and for inclusion in the final workshop report
- **You will be asked to submit, by October 23th, a non-technical abstract, as well as a bio and a photo, which will be posted on the website. For examples, please visit:**
www.permafrostworkshop2013.ca/Program/Speakers.aspx

If you have any questions regarding posters please contact Lona Collins from Bottomline at 867-766-3865 or lona_bottomline@theedge.com

Appendix G

Break-Out Discussion Guidelines

Permafrost Workshop Breakout Discussion Guidelines

Four session themes will be explored during Day 2 and Day 3 of the 2013 Pan-territorial Permafrost Workshop: Mapping and Communities; Building Infrastructure; Transportation; and Mining, Oil and Gas. Each thematic session will include presentations followed by a one-hour Breakout discussion. This Guideline is intended to assist the Breakout session facilitators. It sets out the methodology which will be followed, and the questions which will be explored, during each Breakout session.

Methodology

Each Breakout group will be comprised of a maximum of 15 participants. A session facilitator will be assigned to each group and, where possible, a recorder. Session facilitators will be responsible for guiding their assigned Breakout group through the session questions, noting major areas of discussion and consensus, and completing the provided 'reporting cards'. The workshop facilitators (Emery Paquin and David Livingstone) will meet with session facilitators and recorders before the initial Wednesday Breakout session to ensure that respective roles and responsibilities are clearly understood.

Each Breakout group will be asked to identify and discuss major permafrost-related challenges related to each session theme and the priority actions that should be undertaken to best address each challenge. The specific questions will be:

1. What are the most significant permafrost-related challenges related to ... (i.e. Mapping and Communities)? Of these challenges, which are the top two?
2. What actions could be taken which would best enable the top two challenges to be addressed? Of these possible actions, what are the top five for each challenge?

As an example, a group might identify 'lack of local information on permafrost' as a key challenge. The actions to be undertaken may include better permafrost sensitivity and vulnerability mapping, establishment of a community Elders group, access to a centralized database of permafrost information, better communication between visiting researchers and the community, etc. Breakout groups will be asked to identify the top two key challenges and the top five recommended actions for each challenge.

Each Breakout group will be provided with a flip chart and two 'reporting cards' at the beginning of each session. The 'reporting cards' will be pre-printed and are intended to assist the group in focusing discussions on its two most significant challenges and subsequent actions. At the conclusion of the discussions, the workshop facilitators will assemble the 'reporting cards' into major themes and post them on a wall inside the conference room. A brief 10-15 minute oral report on the challenges and actions will then be made to Plenary by Paquin and Livingstone.

Workshop participants will be invited to review the posted responses and groupings throughout the remainder of the workshop and, using provided coloured dots, to rank the challenges and the recommended actions.

At the conclusion of the workshop, the responses, groupings and rankings will be used by the workshop facilitators and conference organizers to identify, organize and prioritize the challenges and actions identified through the Breakout sessions. The flipcharts will be used to ensure all relevant discussions and recommendations are summarized in the final workshop report.

Appendix H

Reporting Cards



SESSION: MAPPING AND COMMUNITIES

What are the most significant permafrost-related issues related to Mapping and Communities?
Of these challenges, which are the top two?

What actions could be taken which would best enable the top two challenges to be addressed?
Of these actions, which are the top five for each challenge?

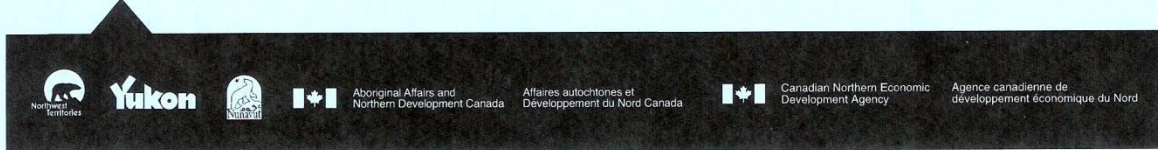
1.

2.

3.

4.

5.



SESSION: BUILDING INFRASTRUCTURE

What are the most significant permafrost-related issues related to Building Infrastructure?
Of these challenges, which are the top two?

What actions could be taken which would best enable the top two challenges to be addressed?
Of these actions, which are the top five for each challenge?

1.

2.

3.

4.

5.



SESSION: TRANSPORTATION

What are the most significant permafrost-related issues related to Transportation?
Of these challenges, which are the top two?

What actions could be taken which would best enable the top two challenges to be addressed?
Of these actions, which are the top five for each challenge?

1.

2.

3.

4.

5.



SESSION: MINING, OIL AND GAS

What are the most significant permafrost-related issues related to Mining, Oil and Gas?
Of these challenges, which are the top two?

What actions could be taken which would best enable the top two challenges to be addressed?
Of these actions, which are the top five for each challenge?

1.

2.

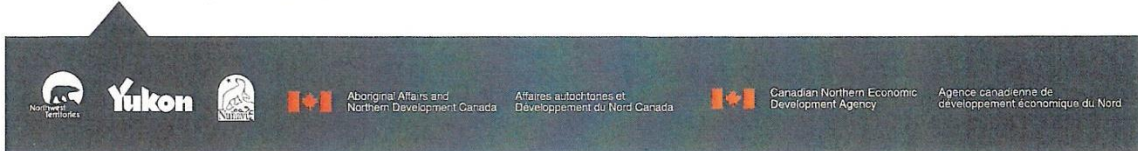
3.

4.

5.

Appendix I

Workshop Evaluation Form



Please take a few minutes to fill out the rating form and answer the questions below. Your comments and recommendations are very important in assisting the workshop organizers to determine the effectiveness of this workshop and the design of possible future workshops.

Should you prefer to fill out the evaluation form at a later date or wish to email it to workshop organizers, the form can be found on the workshop website at www.panterritorialadaptation.ca.

Workshop and Plenary Session Preparation	Poor	Fair	Good	Excellent	Comment
Workshop agenda					
Workshop length					
Workshop timing (early November)					
Information provided prior to the workshop					
Information provided during the workshop					
Opportunity to ask questions following presentations					
Knowledge of presenters					
Opportunity to interact with presenters and other participants during breaks					
Workshop location and physical lay-out					
Breakout Sessions	Poor	Fair	Good	Excellent	Comment
Length of break-out sessions					
Opportunity to interact with other Participants during the break-out sessions					
Layout of break-out sessions					
Overall effectiveness of break-out sessions					
Overall	Poor	Fair	Good	Excellent	Comment
Did the workshop meet your expectations?					
Will the workshop be useful to you in your work?					
Were the facilitators effective?					
Would you attend another workshop of this kind?					
If you were a webcast participant, did you feel included in the workshop?					



GENERAL COMMENTS

1. What did you like most about this workshop? Were there particularly memorable or important statements or presentations that stood out for you?
2. What did you like least about this workshop? Was there anything that made it particularly difficult for you to participate effectively?
3. What recommendations would you make to the workshop organizers with regards to improving future workshops?
4. Do you feel that your key issues and challenges were addressed or was something significant missed?
5. Do you feel that the workshop was effective in transferring knowledge about permafrost challenges and potential solutions to decision-makers and other affected organizations and individuals? If not, what could be done to improve communications?

Optional (for possible follow-up by organizers)

Name: _____ Organization: _____

I allow you to use quotes from my evaluation form in workshop reporting material

Thank you!

Appendix J

Workshop Sponsors

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