weathering change

newsletter of **the northern climate exchange** fall 2002

The effects of warmer winters in the NWT: an indication of future trends?

GOVERNMENT OF NORTHWEST TERRITORIES, DEPARTMENT OF TRANSPORTATION, TRANSPORTATION PLANNING DIVISION

The entire land, air, and marine based transportation system is reliant on many variables that are influenced by the effects of climate change, such as air temperature, precipitation, visibility, ice on rivers and lakes, snow cover thickness and length of season, and the characteristics of permafrost. As northern transportation infrastructure relies on the properties of frozen ground materials for stability, climate change could degrade the performance of the transportation system. If the impacts of the recent warmer winters are an indication of future trends, it will become imperative to assess and adapt to climate change impacts in the Northwest Territories (NWT).

The impacts of warmer winters over the last few years are already being realized in the Northwest Territories

GNWT PHOTO

Tension cracks caused by slumping Ingraham Trail, NWT

Potential impacts of climate change, some of which have been observed in the past years, include the shortening of the season for heavy pack ice, which will lead to thinner ice, earlier spring break-up, and longer ice-free periods on oceans, lakes, and rivers. There will likely be more precipitation, especially in fall and winter. Snow seasons will be shorter, but the build-up of snow could result in heavier spring flooding along many northern rivers.

The slow melting of the permafrost layer, in addition to the pooling of melt water, could further reduce ground stability. These impacts are already being recognized in the NWT after just a few years with warmer winter temperatures. This climatic warming has resulted in the shortening of the land transportation season in the North and increased road construction and maintenance costs. As the following examples of the impacts of warmer winters indicate, further warming may have a devastating effect on transportation infrastructure.

SHORTENING OF THE ICE ROAD SEASON

A later fall freeze-up and earlier spring thaw have already affected the length of the ice road and ice bridge season in the NWT. As the data for the Mackenzie River Crossing Ice Road on page 3 shows, the average opening date for light traffic has shifted from December 12 to January 4 since 1996. This is a profound change in the length of season, given the fact that the average opening date remained relatively unchanged, between

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CLIMATE CHANGE AND TRANSPORTATION IN NORTHERN CANADA

A note from the editor

Climate change is already having an impact on northern transportation systems, and if current models prove correct further dramatic changes could happen. This issue of *Weathering Change* examines some of the impacts that climate change is having on our northern transportation systems.

DIAND PHOTO

Washout on the South Canol Road

The North has always faced unique transportation challenges. First Nation peoples have traveled the lands and waters of the North for tens of thousands of years and developed innovative, regionally appropriate technologies to undertake their journeys. Early explorers and traders used our extensive river systems to expand the frontiers of sovereignty and commerce. In the Yukon, the Klondike Gold Rush brought railway transportation, carriage trails, and steamboats. In the 1920s and '30s, aviation pioneers transported prospectors to increasingly remote areas of the North. World War II brought the construction of the Alaska Highway and a number of northern airstrips. The federal government's Roads to Resources programs resulted in the construction of the Dempster Highway and other northern highways.

Remote northern communities currently rely on ice roads for the transportation of essential goods. For decades northern transportation companies have used a winter road system to supply remote mines. The reliance on winter roads is increasing as diamond-mining projects come on stream and oil exploration continues.

We hope that this issue will provide you with some background information on the current state of knowledge and provoke discussion on what further research needs to be done.

Bob Van Dyke

weathering change

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Canada

Manitoba Northern Transportation and Climate Change Impacts and Adaptation Workshop

This workshop will address the climate change impacts affecting transportation and utility infrastructure in northern Manitoba. Information about observed climate conditions, impacts on infrastructure and communities, identifying adaptation needs and strategies, and establishing a network of contacts for exchanging information will take place.

LOCATION: Winnipeg, Manitoba
DATE: Winter 2002-03 (TBD)
CONTACT: Terry Zdan
Manitoba Transportation and Government Services
PHONE: (204) 945-2631
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Climate change impacts and adaptation calls for letters of interest

The Climate Change Impacts and Adaptation Program provides funding for targeted research and activities that will contribute to a better understanding of Canada's vulnerabilities to climate change and provide information necessary for the development of adaptation strategies.

SCHEDULE FOR CALLS FOR LETTERS OF INTEREST

Transportation	September 2002
Coastal zone	November 2002

For more information on the calls for letters of interest, visit Natural Resources Canada's website at: http://adaptation.nrcan.gc.ca/splash_call_for_proposals.asp.

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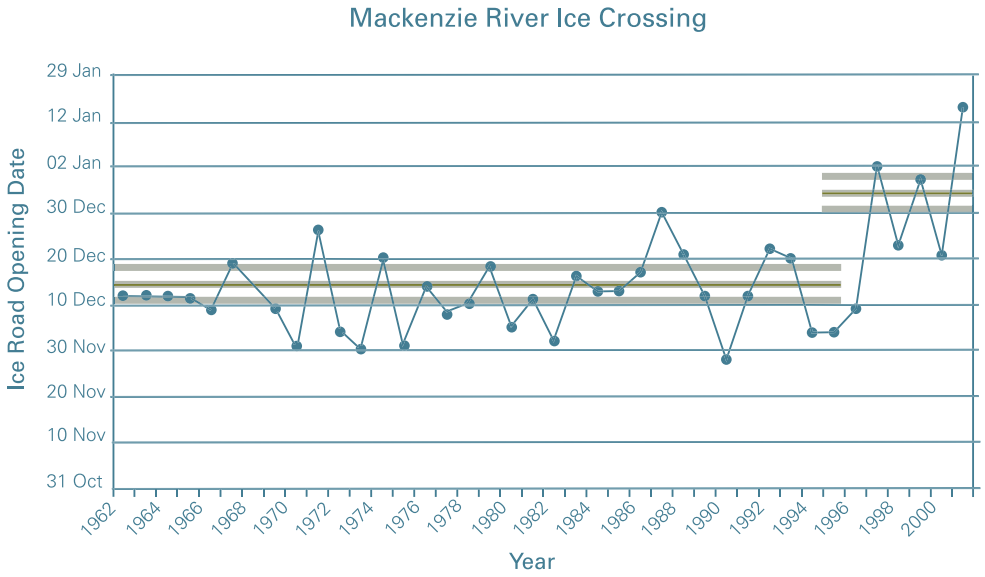

Average opening dates, light traffic, Mackenzie River Ice Road GNWT GRAPH

December 8 and December 19, from 1962 to 1996. The late freeze-up can be attributed, at least in part, to a warmer ambient surface air temperature.

PERMAFROST DEGRADATION AND ROAD SURFACE INSTABILITY

The recent warmer winter temperatures have also accelerated permafrost degradation, which has been evidenced by the rapid deterioration of road surfaces and increased need for road maintenance in the NWT. A section of the Ingraham Trail, Highway 4, just outside of Yellowknife, provides an example of the effects of permafrost degradation. In 1999, this section of highway was realigned, moving traffic off of this section of road. The now unmaintained surface grade has sloughed by as much as 1.5 m in areas, and the banks have quickly eroded due to the melting of the permafrost layer and the subsequent pooling of melt water—all of which has occurred within the last three years.

Wash-out, Yellowknife Highway 3, NWT GNWT PHOTO

INCREASED PRECIPITATION AND FLOODING

A washout of Yellowknife Highway 3 (see photo), which occurred this spring, demonstrates the profound affect that increased snow pack and precipitation may have on the northern transportation system. This washout restricted highway access for over a week until temporary fixes could be put in place.

INCREASED CONSTRUCTION AND MAINTENANCE COSTS

The NWT Department of Transportation (DOT) is adapting to climate change and its effects on permafrost with evolving construction techniques. DOT is currently reconstructing an area approximately 100 m long by 30 m wide to stabilize a section of runway at the Yellowknife Airport, which has a long history of recurring settlements and surface depressions. The settlements have resulted from the thawing of permafrost under the runway.

After excavating the runway to a total depth of four metres, including one metre into the permafrost, 100 mm of rigid high-density foam insulation is being placed before backfilling the excavation with layers of sand, a geotechnical liner, crushed rock, and compacted granular sub-base and base materials. The runway will be resurfaced with 100 mm of hot-mix asphalt concrete.

INCREASED NEED FOR RESEARCH

The Department of Transportation will continue to monitor and assess the impacts of climate change on our transportation infrastructure. With warming winter temperatures, new construction and design techniques must be adapted to reflect the increased instability of the permafrost regime on which our roads, highways, and runways depend. To address the need for improved engineering and design practices, DOT is hosting a two-day conference, Permafrost: Impacts on Infrastructure and Applied Engineering, on October 21 and 22 in Yellowknife. As well, a half-day workshop, Winter and Ice Road Construction and Operation Practices, will be conducted on October 23. If you wish to participate in the conference or workshop or require more information, contact Jayleen Philps, Transportation Planner, Department of Transportation, at Jayleen_Philps@gov.nt.ca or by fax, (867) 920-2565.

Shipping in the Canadian Arctic: possible climate change scenarios

JOHN FALKINGHAM, CHIEF OF OPERATIONS, CANADIAN ICE SERVICE
DR. HUMFREY MELLING, INSTITUTE OF OCEAN SCIENCES
KATHERINE J. WILSON, APPLIED SCIENCE DIVISION, CANADIAN ICE SERVICE

By now, most of you have heard the predictions from Global Climate Models (GCMs) that warn, if warming trends continue, that by 2050 sea ice in the Canadian Arctic will no longer be present during summer months (Flato and Boer, 2000). This scenario has brought forth much discussion concerning expected increases in marine transportation in Canadian Arctic regions. The Northwest Passage (NWP) lies in the middle of the Canadian Arctic and is a shortcut between Europe and Asia that is 9,000 km shorter than the Panama Canal route and 17,000 km shorter than the route around Cape Horn, (Falkingham et al., 2001).

The ever-present sea ice has made this shortcut virtually inaccessible, but a future with less sea ice would mean an increase of shipping traffic through this passage. This, combined with the ability to finally access and exploit large natural-gas reserves within the Canadian Arctic (Melling, 2002), will cause significant impacts on our Arctic environment and its people.

There is observational evidence consistent with GCMs that the amount of ice has decreased during 1971 to 1998 in all the areas of the Canadian Arctic (Falkingham et al., 2001). Military and shipping interests are currently working on future impacts and adaptation strategies based on this scenario of ice-free summers. Yet this is only one of several other possible climate change scenarios for the Canadian Arctic. The Canadian Ice Service (CIS), as part of its mandate, has monitored ice conditions in the Canadian Arctic for over 40 years.

Drawing on work by Canadian scientists and our long experience in providing ice information, we would like to present some other very possible climate change scenarios that will need to be addressed when planning future impacts and adaptation strategies for shipping in the Canadian Arctic.

The lack of solar radiation during winter months in the Arctic means that there will always be at least a winter ice cover; therefore, year-round shipping will not be possible. Moreover, ice conditions have always been extremely variable, with light ice years interspersed with heavy ice years. Thus, marine users cannot assume consistent ice-free summers and should still expect occasional heavy ice years.

Pack ice in the Arctic Ocean can circulate around the North Pole for several decades (Colony and Thorndike, 1984), continuing to thicken by freezing to as much as 3 to 4 m (Flato and Brown, 1996). As this ice bumps up against the coastlines of Canada, it is broken and heavily ridged, reaching an average thickness of 8 m (Bourke and Garret, 1997) and a maximum of nearly 50 m (H. Melling, pers. comm. 2002). Normally, old ice occasionally drifts into the channels of the Canadian Arctic Archipelago, freezing across the narrow passages to create a barrier between the Arctic Ocean and the NWP. The old, thick, land-locked ice of the northern Canadian Arctic Archipelago can remain in place for several years.

In 1998, the warmest year on record in the Canadian Arctic, regions of land-locked ice in the Archipelago broke free. This also happened early in the 1960s and has occurred at roughly decadal intervals since. The collapse of these barriers has allowed very thick, old ice from the Arctic Ocean to drift through the Arctic Islands in subsequent years (Jeffers et al., 2000; Wilson 2001).

Evidence of prior incursions of old ice into the NWP has also been found through the analysis of historical data from the Canadian Ice Service (Falkingham et al., 2002) and other

Ship traversing ice ENVIRONMENT CANADA

contributors this issue

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sources (Melling, 2002). The increased incidence of warm summers anticipated with climate warming may cause the ice in the Canadian Arctic Archipelago to break up more frequently and earlier (Melling, 2002). This change will permit old ice to drift more rapidly from the Arctic Ocean into the Northwest Passage, thereby increasing the rate of supply to and thickness of ice within the Northwest Passage. Old ice is extremely strong and dangerous to all ships, even ice breakers, and the increase of this ice in the NWP will result in increased hazards to the marine environment and its users.

Winds and ocean currents can drive sea ice against coastlines and into narrow channels, creating high-pressure zones capable of crushing ships and creating barriers to navigational passageways. Some of these "choke points" are impassible, and icebreaker assistance is usually required. Even in a generally ice-free Arctic, small amounts of sea ice could collect at these choke points to create local congested areas. Possible incursions of old ice from the Arctic Ocean will also mean that choke points will continue and become more hazardous with the increased presence of thick, old ice.

The most publicized climate change scenario, that of an ice-free Arctic summer by 2050, may lead many into a false sense of optimism regarding the ease of future shipping in the Canadian Arctic. After 2050, there will still be summers of occasional heavy ice conditions, choke points blocking routes within the Northwest Passage, and navigational danger. Ships may attempt to travel faster than is prudent through what may appear to be an ice-free passage. Even small pieces of old ice can rip holes into hulls of ships, thereby risking human safety, cargoes, and the environment.

Ice piling up on shore

ENVIRONMENT CANADA

It is important to remember that with our present, imperfect ability to predict future impacts on Arctic sea ice, there are a number of plausible scenarios for the impact of climate change on marine areas of Arctic Canada. These must be acknowledged when planning future impacts and adaptation strategies for shipping in the Canadian North.

For more information call client services at 1-800-767-2885 or email cis-scg.client@ec.gc.ca.

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Permafrost and infrastructure in Alaska: where is climate change taking us?

WALTER B. PARKER, CHAIRMAN, ARCTIC COUNCIL CIRCUMPOLAR INFRASTRUCTURE TASK FORCE

A great deal of information on sea ice has been available to the Arctic Climate Impact Assessment as a result of submarine cruises beneath the Arctic icepack since 1958, including scientific-oriented cruises from 1995 to 1999 (Project SCICEX).

A recent publication by the U.S. Arctic Research Commission (*The Arctic Ocean and Climate Change: A Scenario for the U.S. Navy*, July 2000) predicted that by mid-century temperatures in the Arctic region will increase by 1 – 2˚ C in summer, 7 – 8˚ C in autumn, 8 – 9˚ C in winter, and about 5˚ C in spring. Variation runs at 1 – 2˚ C in summer and 5 – 6˚ C in winter.

In winter the entire Arctic Basin will be ice-covered, while model studies suggest that summer ice extent will decrease by roughly 30% and ice volume by roughly 40%. More conservative estimates set the decrease in ice extent at 15%, with the decrease in ice volume remaining at 40%, which means there will be more thin first-year ice. Obviously, we are due for some major changes in the next five decades.

Unfortunately, there is not the same depth of information in recent years on permafrost change. Permafrost research peaked in the early 1970s during the planning and engineering of the above-ground portions of the massive Trans-Alaska Pipeline project. This research was built on the intensive work that accompanied development of the Distant Early Warning (DEW) Line in the United States and Canada from 1948 until 1970.

The completion of the pipeline and the shutdown of much of the DEW Line after the collapse of the Soviet Union resulted in a shift in priorities among those responsible for permafrost research—namely, in the United States, the U.S. Army Corps of Engineers Cold Regions Laboratory, and the U.S. Geological Survey. Similar shifts in research priorities related to permafrost occurred in Canada and the Russian Federation. As a result, much of our engineering practice is based upon the relatively cold decades of the 1940s, 1950s, and 1960s.

The U.S. Arctic Research Commission recognized the need for a substantial increase in research to upgrade engineering practices so that permafrost can serve as a terrestrial marker comparable to the model use of sea ice. The commission established a seven-person task force in September 2001 to report on the problem and make recommendations for needed research. The first report is due out in the fall of 2002.

The need to recognize the effects of relatively rapid permafrost change on infrastructure has received a good deal of attention recently. At its September 2001 meeting in Uhlan Bhator, Mongolia, the International Permafrost Association focused strongly on the impacts of permafrost change. In January 2000, the University of Alaska Anchorage sponsored a workshop called The Warming World, Effects on the Alaska Infrastructure. In March 2001, Yukon College and the Northern Climate ExChange sponsored the Circumpolar Climate Change Summit in Whitehorse.

The results of the these discussions, as they relate to Alaskan infrastructure in permafrost-affected areas, are synthesized below and represent the author's interpretation of what he heard and read.

Of Alaska's 265 communities, 166 are affected by permafrost. The greater part are located in areas of discontinuous permafrost. Alaska has 12,800 miles (20,480 km) of roads, but only 30% are paved. Seventy-eight percent of its highways are in areas of continuous or discontinuous permafrost. It was necessary to raise more than half (420 miles/672 km) of the Trans Alaska Pipeline off the ground because of permafrost. The majority of Alaska's 285 publicly owned airports and 3,000 airstrips will be affected by changes in permafrost.

The effects of permafrost will not be limited to subsidence under structures. Increased erosion due to liquifaction and flooding will also be major factors. Many scientists and engineers believe that only areas of discontinuous, warm permafrost will be strongly affected and that areas of continuous, cold permafrost will be relatively free of problems. However, this view overlooks the warming-induced increase in the depth of the active layer.

Increased flooding, which is predicted in most climate change models, will have a major effect since all but a handful of communities in permafrost-affected areas are located on rivers or the seacoast.

In order to prepare for these changes it is necessary to establish many more monitoring sites, both for borehole measurements of deep permafrost and for measuring changes in the active layer. This will provide some of the information necessary to fine-tune the Arctic Climate Impact Assessment and to predict the budgets necessary to maintain communities in their present locations or to move them. Community movement is already a hot political topic in Alaska.

The Arctic Climate Impact Assessment (ACIA) has been presented several times to the eight nations of the Arctic Council and to the 29 members of the Northern Forum. Senior Arctic officials have asked the Circumpolar Infrastructure Task Force to proceed with programs to ensure transportation and telecommunications services to the small communities of the Arctic in the next several decades. Increased information on permafrost will become more and more important in the next half century.

For more information on the ACIA see their web site at: www.acia.uaf.edu/

Roads at risk: assessing potential impact on winter roads

KAREN BERGMAN, POLICY ANALYST, TRANSPORT CANADA, PRAIRIE AND NORTHERN REGION

Many remote communities and industry in the prairie provinces and the territories rely on winter roads for ground transportation. Warming temperatures and changing precipitation patterns affect the building and operating of these roads and can have significant economic impact. For example, warmer than usual temperatures in northern Manitoba during the winter of 1997-98 precluded the building of winter roads that year. The Manitoba government spent $15 to $16 million flying in supplies to communities normally served by winter roads.

Over 5,000 km of winter roads are built each year in Prairie and Northern Region.

Winter roads are built and maintained seasonally by provincial and territorial governments to resupply communities with, for example, fuel and dry goods; to bring in construction material for the next building season; and for travel between communities. Industry also builds and maintains winter roads to explore for and extract oil, gas, and minerals. For example, in the Northwest Territories, the diamond mine owners in that area share the cost of operating an annual winter road to bring in building materials, heavy equipment, fuel, etc. needed to build and operate the new and developing diamond mines in the area.

Over 5,000 km of winter roads are built each year in Prairie and Northern Region. These roads are in place as far south as 51 degrees latitude and as far north as the Arctic Circle. Opening dates can be as early as November. Closing dates can be as late as April in the most northerly areas. These "operating windows" are sometimes maintained despite warmer temperatures by using costly winter road engineering techniques. For example, in recent years the Government of the Northwest Territories has built permanent crossings where the Mackenzie Valley winter road crosses streams.

Winter roads are currently a less expensive alternative to building and maintaining all-season roads or relying exclusively on air transportation. However, the winter road systems in at least some areas are at risk should warmer temperatures increase building and operating costs to a point where they are economically unviable for government and industry.

YUKON GOV'T PHOTO

Road construction in a permafrost area

Climate Change. Are you doing your bit?

***Tip**: Increasing temperatures can cause areas of discontinous permafrost to melt, affecting buildings and roads. Check out the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) website for more information on impacts and adaptation: http://www.taiga.net/c-ciarn-north/*

For more tips from the NCE's Bob and Dog Mackenzie go to www.taiga.net/nce/doyourbit.html

ExChanging VIEWS

Towards sustainable transportation

TERRY ZDAN

Sustainable development is about social, economic, and environmental well-being. Transportation is a vital element of well-being.

Most Canadians have access to extensive transportation systems, and some industries' economic viability depends on these services. Less developed countries and some parts of Canada do not have the same level of service. These global and regional disparities need to be addressed in a sustainable transportation system.

Current transportation depends on the combustion of fossil fuels. In Canada, about 25% of the country's greenhouse gas (GHG) emissions are generated in the transportation sector, and demand is increasing. Our transportation system's dependency on non-renewable fuels is a threat to our environmental well-being.

Increasing evidence links fine particulate matter with respiratory and cardiovascular disease. Much of that pollution comes from the combustion of transportation fossil fuels. Our transportation system's emissions are a threat to our social well-being.

The impact of climate change on transportation is particularly pronounced in northern regions. Some areas face significant challenges in maintaining road, rail, and airfield infrastructure due to warm winter weather, increased freeze-thaw cycles, and intense rain/flood events.

Adaptation strategies for addressing these impacts tend towards technical fixes to repair or avoid damage. Adaptation strategies that focus on social aspects are needed.

An alternative approach to sustainable transportation is to define what a new system might look like. How might it be non-polluting? How might it be benign to human health? How might it be economically efficient?

In a technical analogy, one major automotive manufacturer developed a new concept vehicle based on what a car would be like if invented in 2002, with all the available and emerging technology, rather than a century earlier. The result is a very different "vehicle."

The issue of transportation and climate change challenges us to identify socially, economically, and environmentally acceptable ways to reduce transportation GHG emissions. It also challenges governments and public institutions to take risks and make difficult decisions—for our well-being.

NOTE: The views expressed in this commentary are those of the author and not necessarily those of Manitoba Transportation and Government Services or the Government of Manitoba.

Current Government of Canada initiatives on climate change and transportation

KATHLEEN NADEAU, SENIOR ANALYST, TRANSPORT CANADA
WARREN BELL, PRESIDENT, RAINCOAST RESOURCES INC.

The Government of Canada is currently undertaking a range of projects on climate change impacts in the transportation sector—including a research update, a national stakeholder workshop, and funding for new research. The research update will summarize work done since the 1997 Canada Country Study and is being prepared for release later this fall as part of a larger report on impacts and adaptation in key sectors in Canada.

The research update will summarize recent work in a number of areas relevant to the North, work that is providing a better understanding of climate change and the options for addressing risk and taking advantage of opportunities. Some of the key areas include topics addressed in this newsletter: changes to arctic ice and the implications for shipping; the impact of permafrost degradation on roads, rail lines, and airports; and the effect of warmer winters on winter and ice roads.

Transport Canada is also planning a national workshop on transportation and climate change impacts and adaptation, likely in late 2002. The workshop will bring together experts and stakeholders from transportation sectors across the country to review the most recent research, discuss issues, share perspectives, and help identify where further work is needed to ensure Canadians have the information and tools they need to adapt to climate change. For information on the workshop, contact Kathleen Nadeau, Senior Analyst, Transport Canada, Tel. (613) 991-2403 Email: nadeauk@tc.gc.ca.

The workshop will also help identify promising areas for future research. A proposal call for research on transportation will be issued later this year under the Government of Canada's Climate Change Impacts and Adaptation Program. This program funds research to improve our knowledge of the risks and benefits posed by climate change and to build the foundation for appropriate adaptation decisions. More information on the program and the call for proposals is available at http://adaptation.nrcan.gc.ca/home.asp.