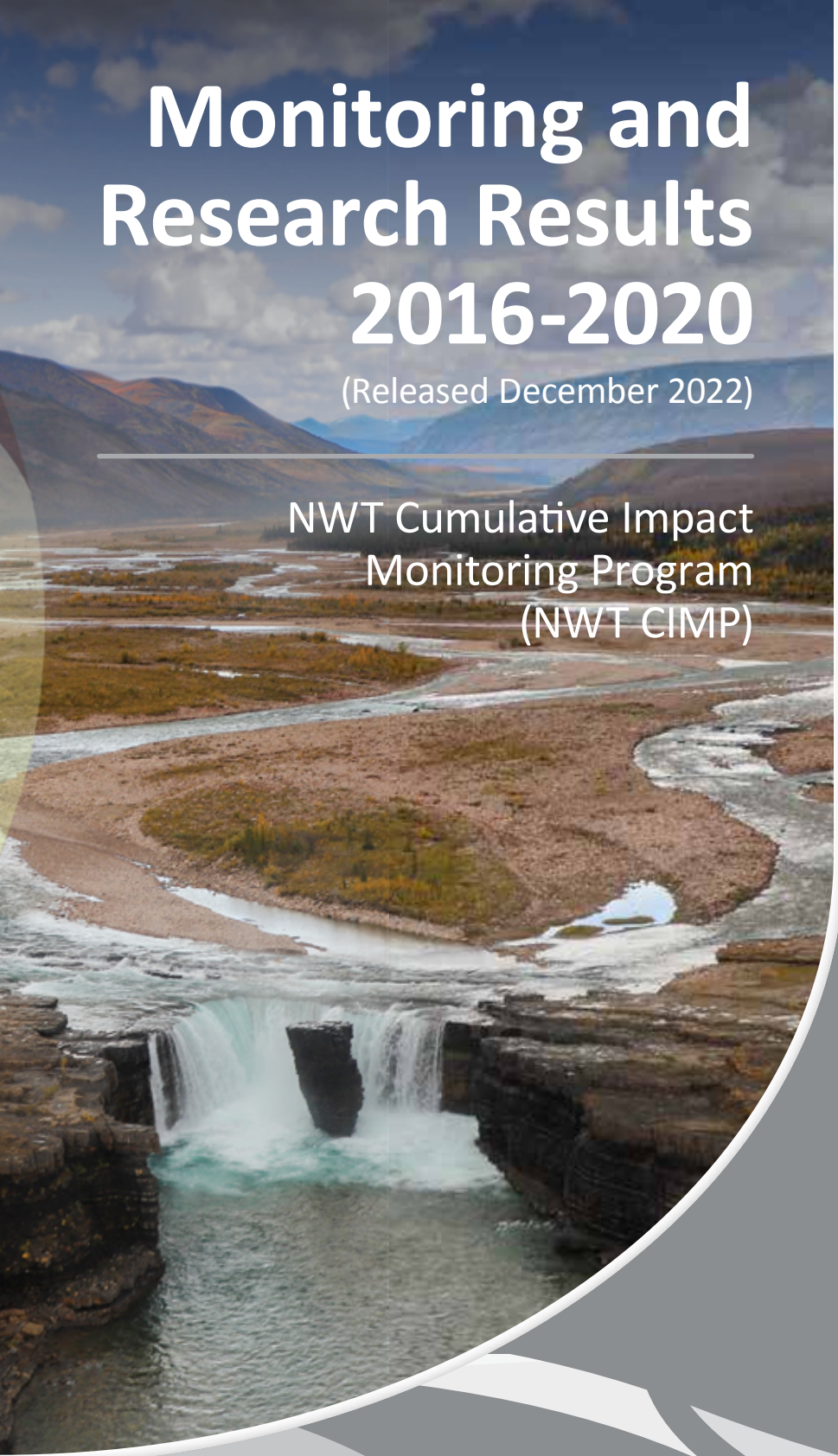


Monitoring and Research Results 2016-2020

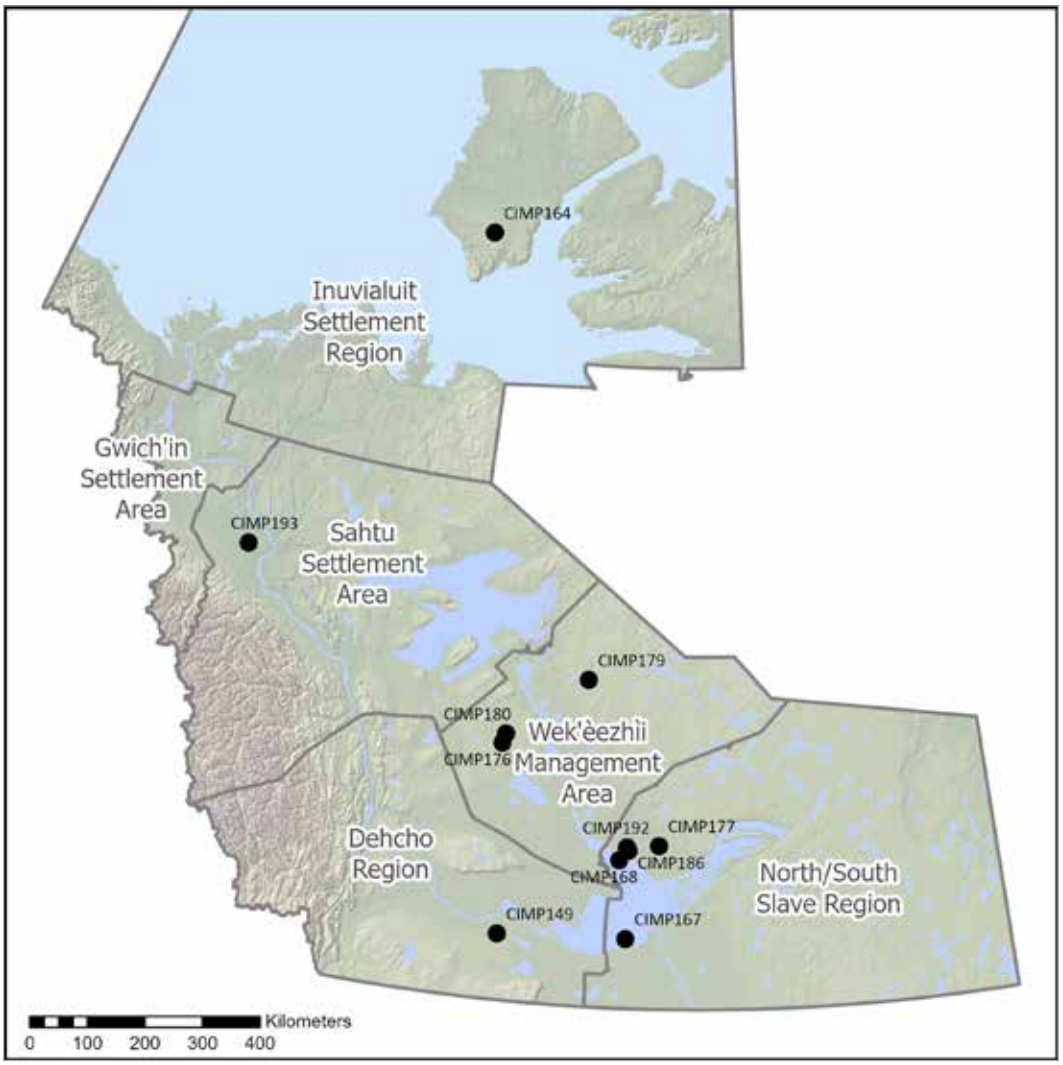
(Released December 2022)

NWT Cumulative Impact Monitoring Program (NWT CIMP)

WATER

Government of
Northwest Territories

NWT CIMP-funded water projects in the NWT



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December 2022

About the Northwest Territories Cumulative Impact Monitoring Program (NWT CIMP)

The Northwest Territories Cumulative Impact Monitoring Program (NWT CIMP) is a source of environmental monitoring and research in the NWT. The program coordinates, conducts and funds the collection, analysis and reporting of information related to environmental conditions. Its main purpose is to better support resource management decision-making and the wise use of our resources by furthering our understanding of cumulative impacts and environmental trends. Based on the priorities of environmental regulators, co-management boards, and Indigenous governments and Indigenous organizations, the program has focused on caribou, water, and fish since 2011.

NWT CIMP strives to place research and monitoring results in the hands of those who need it to make decisions. As such, we are focused on reporting back to communities and to environmental regulators who can use the information to manage the land and water. This booklet of caribou monitoring, and research is one way in which the program shares results. Other means include community presentations by researchers, regional results workshops, peer-reviewed publications, and online through the NWT Discovery Portal.

NWT CIMP annually funds approximately 30 projects, providing $1.7 million to research and monitoring of cumulative impacts in the Northwest Territories. This publication provides high level summaries of the results from the boreal and barren ground caribou research and monitoring projects that were funded in 2016-2020 (see map on facing page).

For more information on the program, visit **www.nwtcimp.ca**. For NWT CIMP project results, visit **nwtdiscoveryportal.enr.gov.nt.ca** or email the principal investigator directly.

Contents

CIMP193

Years funded: 3

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP193" or read the 22nd issue of the NWT Environmental Research Bulletin (NERB), available online at www.nwtcimp.ca.

Understanding changes in aquatic ecosystem health and water quality in the Fort Good Hope – Ramparts Area

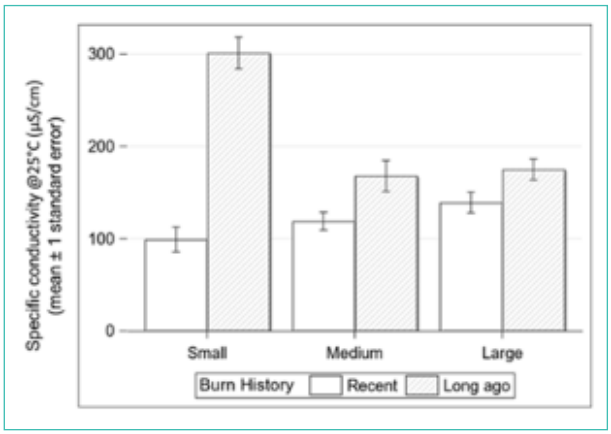
Purpose

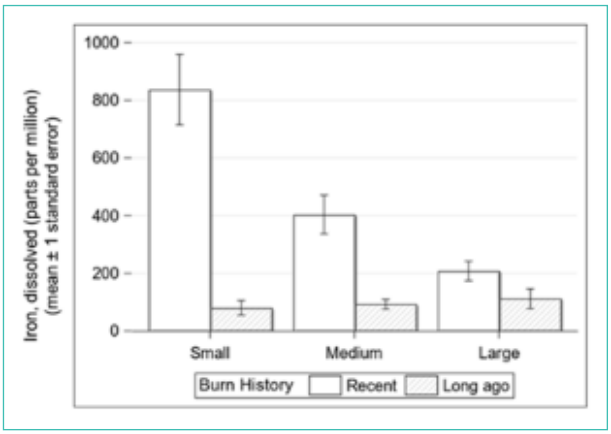
How forest fires affect the water quality of wetlands in the Sahtú region is not well understood. This project began in response to questions from community members in Fort Good Hope about local water quality. The main objective is to establish a wetlands and water quality monitoring and research program that provides insights about potential consequences of environmental change. The program will improve the effectiveness of water conservation and management in the Sahtú Settlement Area by helping regulators make more informed decisions regarding water permits.

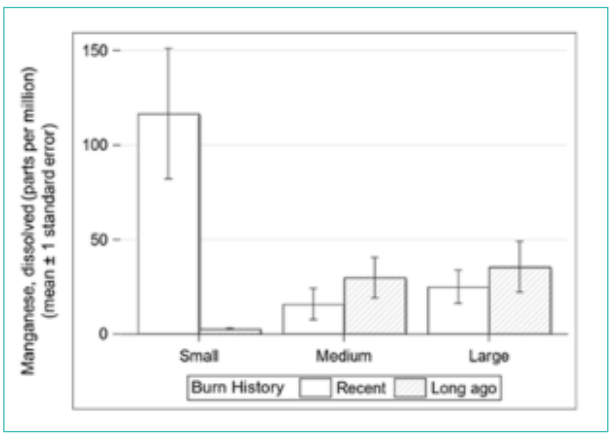
Environment and Climate Change Canada has been working with community members to study the water quality of important wetland ecosystems in the protected area of Ts'ude Niline Tuyeta (Ramparts Wetlands), near Rádeyı̨lı̨kóé (Fort Good Hope). The many diverse wetlands of the Sahtú region are highly valued for their unique ecological and cultural significance. Monitoring will teach us about wetland water quality, and it will help us make informed decisions about water management in Ts'ude Niline Tuyeta.

Key Findings

- Levels of toxic metals (including cadmium, lead and mercury) were very low in all wetlands, and in most cases were not detected.
- Wetlands in the recently burned sites had lower conductivity, lower dissolved organic carbon, higher chlorophyll-a, and different nutrient levels, compared to long-ago burned or not-burned sites. Many of these impacts from fire were strongest in smaller wetlands.







Water chemistry was distinct in recently burned areas. For conductivity, dissolved iron and dissolved magnesium. Changes related to fire were greater on small ponds.

How does this project help to understand cumulative impacts?

The project's sampling protocols and future potential locations could be used for long-term community-based monitoring of wetlands by Rádeyɣlɣkóé Guardians. Sediment core data can be used to help identify historical changes in water quality related to forest fires.

CIMP149

Years funded: 7

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP149".

Community-based monitoring in the Tathlina watershed

Purpose

This project was a continuation of a previous project "Investigating the cumulative impacts of environmental change and human activity in the Tathlina watershed" (2012-2015). The purpose of this project was to conduct community-based water quality monitoring in the Tathlina watershed while building environmental monitoring capacity in the community of Kakisa.

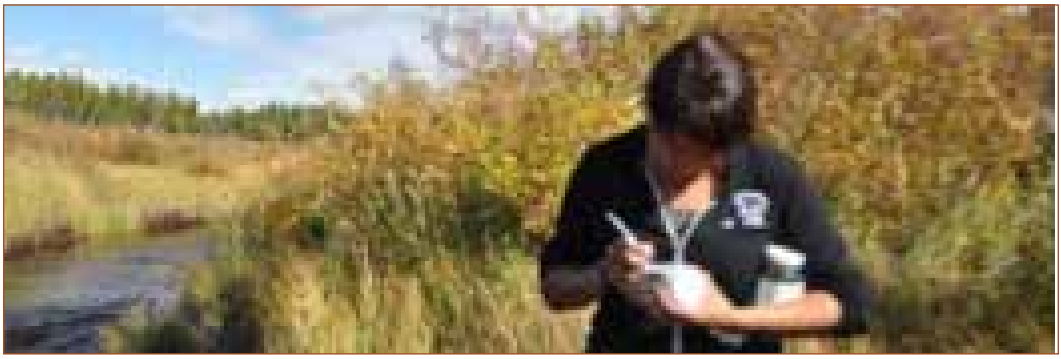
Water samples were collected at five sites within the Tathlina watershed including Upper Kakisa River, Western Cameron River, Tathlina Lake, Eastern Cameron River, and Kakisa River at Kakisa, and tested for various water quality parameters. Also, YSI multiparameter sondes were used to measure various physical parameters. All sites were downstream of the Cameron Hills Oil and Gas development. Water quality data from the project was uploaded in the Mackenzie DataStream.

Key Findings

- Considerable data was collected and demonstrated that water quality was good and did not exceed federal water quality guidelines.
- Multiple community members received environmental monitoring training with one community member becoming proficient in project management, coordinating logistics for field trips and collecting field data.

How does this project help to understand cumulative impacts?

The information collected can help address community concerns about water quality. This information can also be used to help make decisions about water quality in the NWT.



Melaine Simba (KTFN) performing field work.

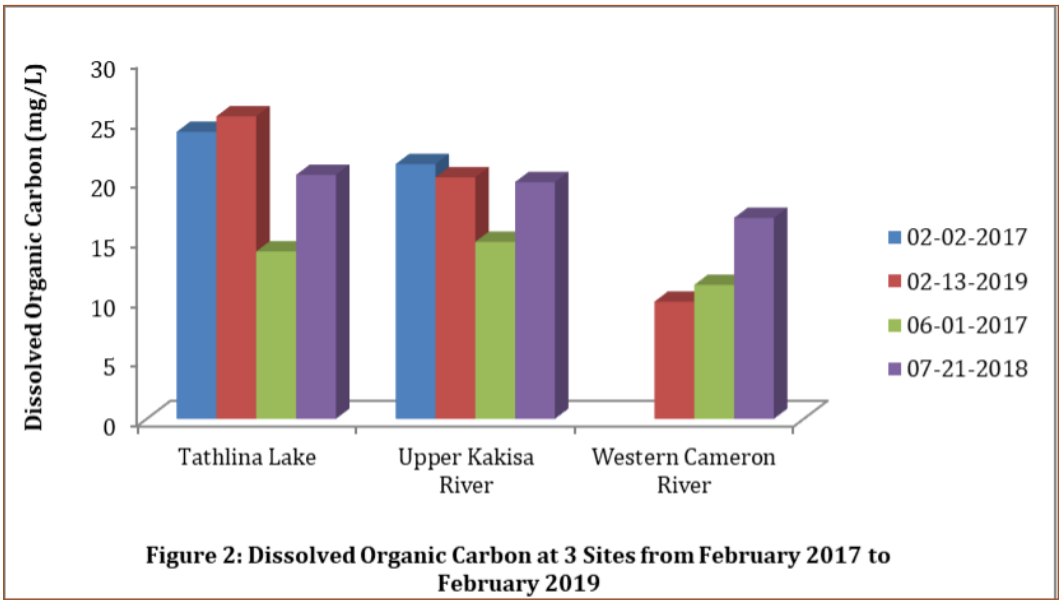


Figure 2: Dissolved Organic Carbon at 3 Sites from February 2017 to February 2019

Dissolved organic carbon at 3 sites from February 2017 to February 2019.

CIMP168

Years funded: 3

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP168".

Understanding the regional variability in soil geochemistry in an area impacted by legacy industrial activity

Purpose

Previous studies on water and lake sediments in the Yellowknife area have provided evidence that historic roaster emissions from activities at Giant and Con Mines impacted areas beyond the mine leases.

However, little information about the impact on soil had been collected beyond the lease boundaries. This project investigated concentrations of arsenic and other elements in soils around Yellowknife to identify whether arsenic in soils is from a natural geologic source or from past industrial activities and to provide a better understanding of the connections between terrestrial and aquatic systems in the area.

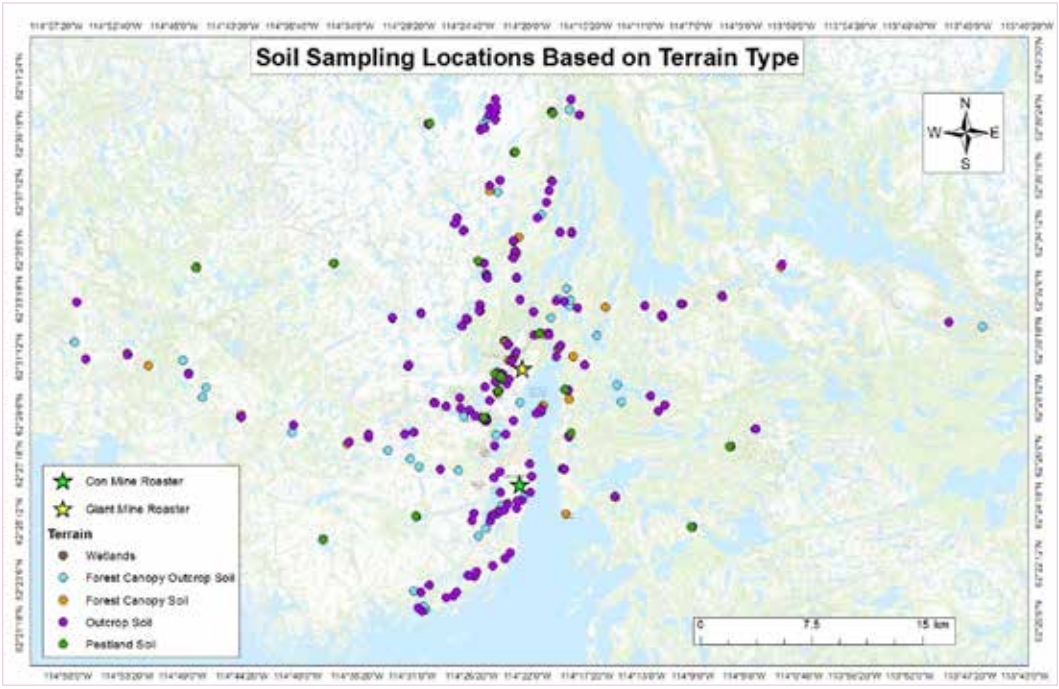
Over 400 soil samples were collected from undisturbed locations within 30 kilometers of Yellowknife over two years. Sampling targeted four distinct terrain units, including outcrop soils, forest canopy soils, forest canopy outcrop soils and peatland soils, in the Public Health Layer, top 5 cm of soil.

Key Findings

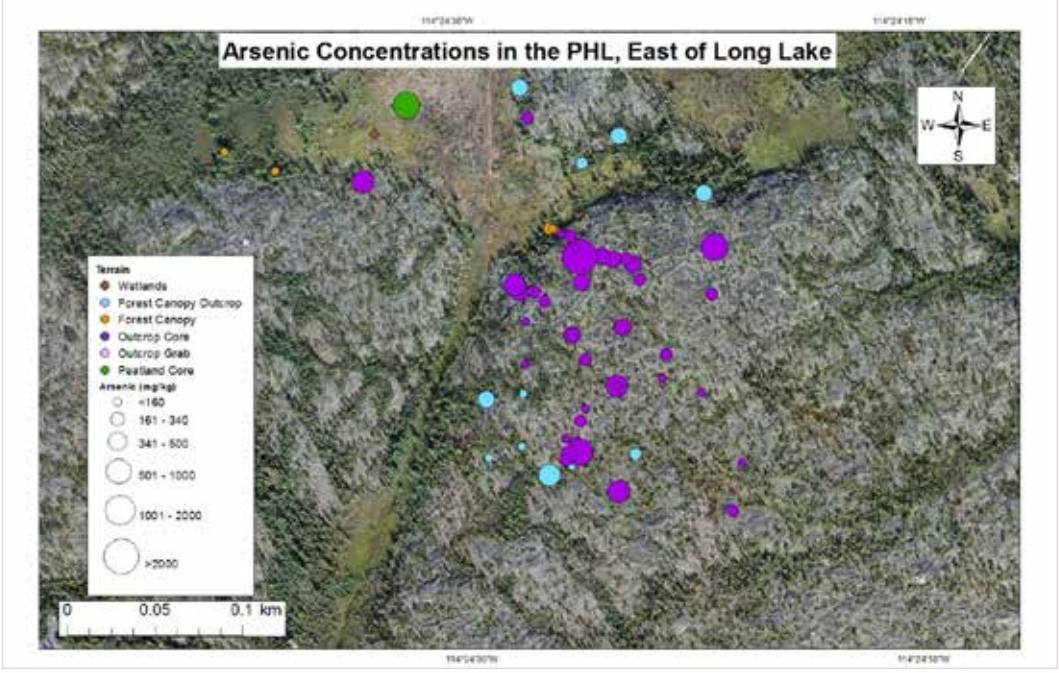
- Arsenic concentrations are highly variable at the local scale, and even between field duplicates. This is likely due to the uneven distribution of arsenic-rich minerals in the soil.
- Distance and direction from former ore roasters, soil depth, elevation and terrain type all influence total arsenic concentration.
- As of May 2018, 87 of the soil samples were examined for arsenic speciation and 70 of these samples were found to contain arsenic trioxide, indicative of roaster stack emissions.

How does this project help to understand cumulative impacts?

Information on regional soil geochemistry is important in understanding the cumulative influences of human actions on the environment. These soil data, coupled with ongoing related research on lake sediment and water chemistry in the region, is needed for decision-making. Regional soil geochemistry information is a critical link between these terrestrial and aquatic systems.



Soil sampling locations from field collections in 2015 and 2016 coded by terrain.



Terrain units vary locally and the arsenic concentrations vary those terrain units. PHL is the Public Health Layer, the top 5 cm of soil. For more information, please see GNWT Public Health Advice (www.hss.gov.nt.ca/en/newsroom/arsenic-lake-water-around-yellowknife)

CIMP192

Years funded: 3

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP192".

A multidisciplinary investigation of recovery in Yellowknife area lakes from 50 years of arsenic pollution: What are the factors inhibiting recovery and the biological consequences?

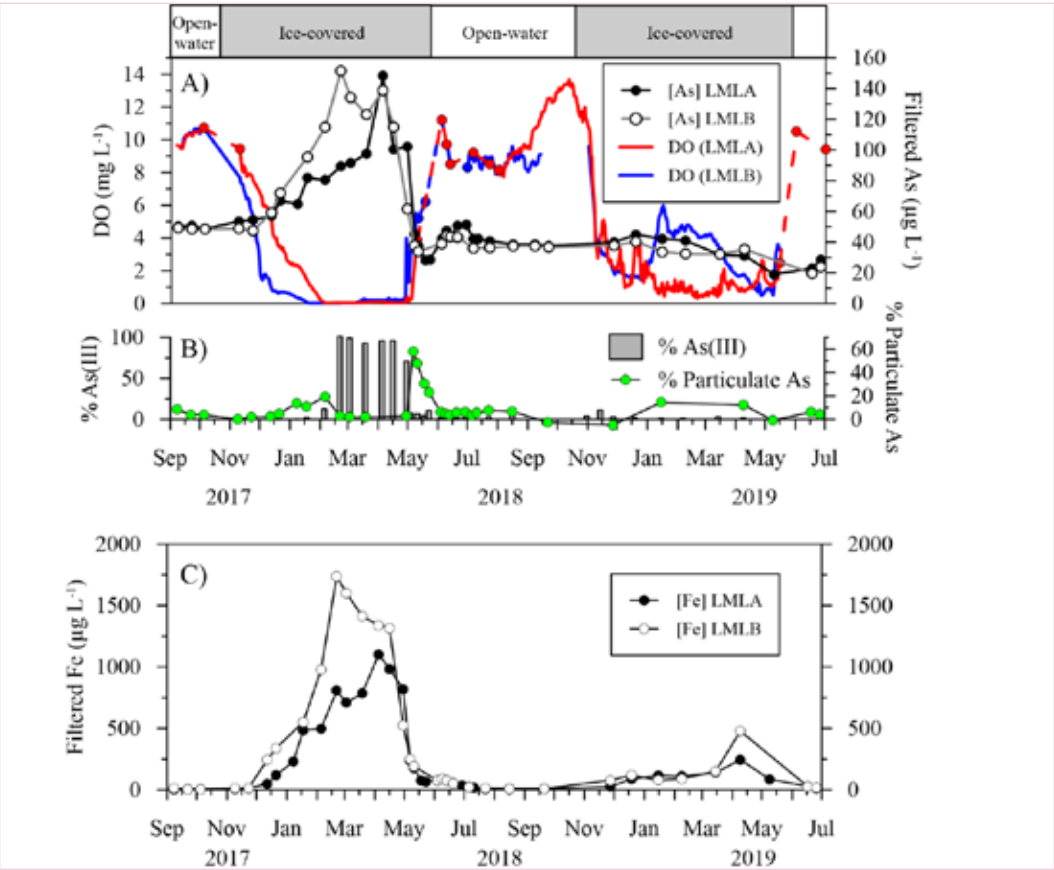
Purpose

This project investigated the movement and location of legacy arsenic in the Baker Creek watershed that was heavily impacted by mining emissions from 1948-1999, to help understand the timing and relative importance of arsenic fluxes across the landscape.

A model was developed of the changes in arsenic, iron, and sulphur under the ice in Lower Martin Lake, a shallow subarctic lake. The model includes measurements of arsenic fluctuations between sediments and overlying water, in and out of the lake, and the terrestrial loading of arsenic being washed into the lake from the surrounding catchment.

Key Findings

- Winter remobilization of arsenic from lake sediments to overlying surface water leads to higher under ice concentrations of arsenic in shallow lakes. This may be delaying recovery of shallow lakes in the region from legacy mining impacts.
- Changing winter hydrology can alter arsenic cycling under ice. Increased connectivity and delivery of oxygen under ice can suppress the upward diffusion of arsenic from contaminated sediments.
- Short-term experiments showed that As (III), arsenite, in surface waters is rapidly oxidized to arsenate As (V), a less harmful form of arsenic, by sunlight.



Time-series of A) total filtered As and dissolved oxygen (DO); and C) total filtered Fe at two locations in Lower Martin Lake, September 2017 to July 2019. Water concentrations represent the depth-integrated mean of 3-4 sampling intervals within the water column. DO was measured continuously 1m above the sediment boundary, except for the periods represented by red and blue circles connected with dashed lines, which indicate discrete measurements and interpolated DO levels between measurements. The middle panel B) represents the proportion of total inorganic As as As(III) at the mid-water column sampling depth and the proportion of total As in the particulate fraction at Lower Martin Lake.

Michael Gilday holding a sediment core sample.
(Credit: M. Palmer)

How does this project help NWT decision-makers and communities?

This project is providing important information on the upstream loading of arsenic to the Giant Mine site, with project data being integrated into the Giant Mine water quality model used by the Giant Mine Remediation Team and the Mackenzie Valley Land and Water Board. It has also been provided to the Office of the Chief Public Health Officer and integrated into the public health advisory regarding arsenic in local lakes.

CIMP164

Years funded: 6

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP164" or read the 27th issue of the NWT Environmental Research Bulletin (NERB), available online at www.nwtcimp.ca.

Tracking landscape change and cumulative environmental impacts using remote sensing

Purpose

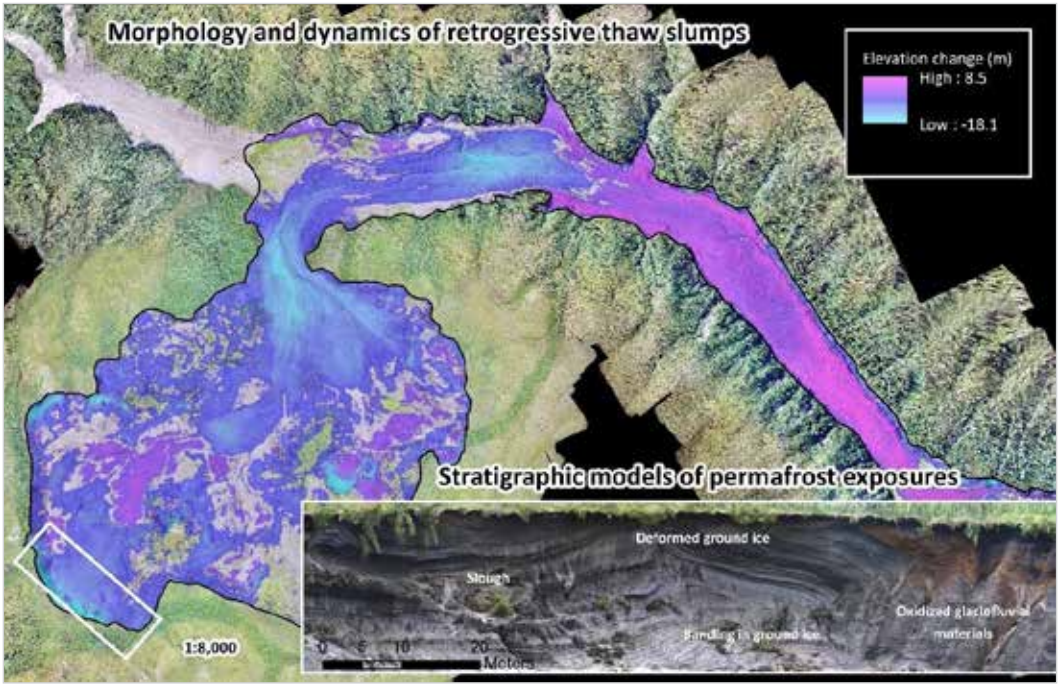
Permafrost influences most of the NWT and provides a foundation for ecosystems and infrastructure. Climate warming is causing permafrost thaw, and areas underlain by ice-rich ground are most sensitive to future changes. The main purpose of the project was to better understand landscape change and its impacts on terrestrial and aquatic environments in the NWT. New remote sensing methods were coupled with geomorphic mapping to delineate landscape disturbances resulting from permafrost thaw, and remote sensing and GIS techniques were developed to link these effects to hydrological networks. Field-based mapping and monitoring provided opportunities to validate results and engage local partners in field investigations and knowledge generation.

Our main project objectives were to improve monitoring and understanding of changes to terrestrial and aquatic environments across the NWT, and to use remote sensing tools, analytical techniques and expert interpretation to develop broad-scale mapping syntheses.

Key Findings

- Standardizing permafrost mapping protocols can guide future research and monitoring initiatives and can ensure that information generated in different regions is comparable.
- Integrating permafrost feature inventories with statistical modelling is an ideal method to identify thaw-sensitive terrain as susceptibility models can inform risk assessments and decision making, support community geohazard mapping, and improve public safety and environmental management.
- Developing hydrological frameworks for linking terrestrial disturbance with aquatic systems is required to understand the cumulative effects of natural and anthropogenic impacts on water resources, and to inform mapping and water quality monitoring programs.

Thaw slump in the Gwich'in Settlement Area.



Example of terrain models and orthomosaic time series that reveal the annual dynamics of retrogressive thaw slumps. The annual net erosion of the example slump was 0.39 × 106 m3 (approximately 1040 swimming pools (25 m) of material). Inset shows example of stratigraphic 3D model of thaw slump headwall that can be used to delineate ground-ice bodies and stratigraphic unconformities.

How does this project help to understand cumulative impacts?

Project results are a key data layer to understanding cumulative impacts in the NWT in areas being affected by climate change and have had a direct influence on infrastructure planning. For example, these results informed regulatory decisions and mitigation planning along the Inuvik-to-Tuktoyaktuk and Dempster highways. These results continue to influence environmental management decisions along both highways and the data layers are incorporated into the Inventory of Landscape Change Webviewer.

CIMP167

Years funded: 3

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP167".

Changes in dissolved organic carbon quality and quantity: Implications for aquatic ecosystems and drinking water quality for northern communities

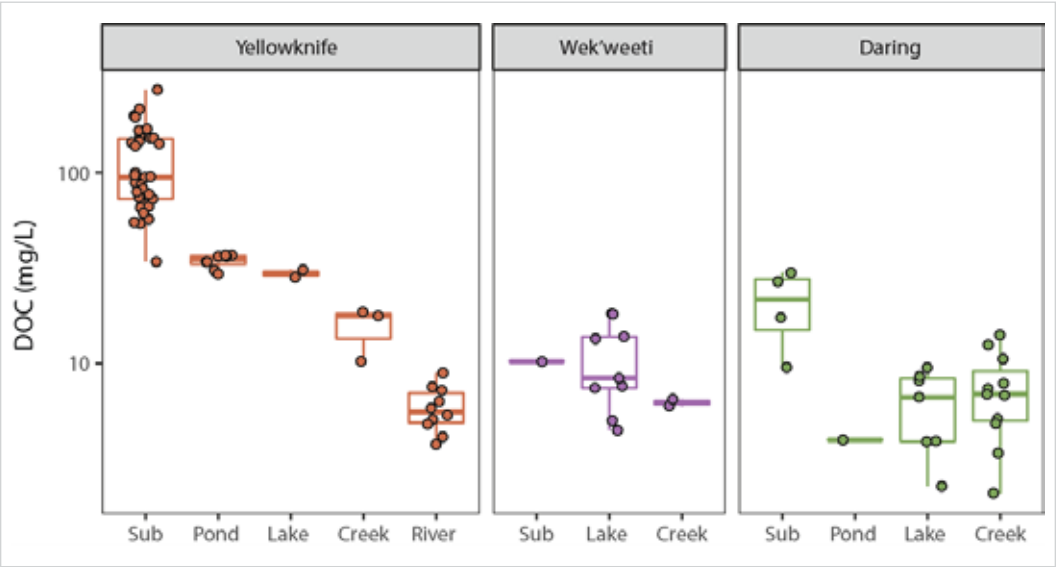
Purpose

A warming climate has the potential to release dissolved organic carbon (DOC) stored in permafrost into the surrounding environment, with possible impacts to aquatic health. One of the implications of higher levels of DOC in water is potential changes to drinking water treatment. The purpose of this three-year project was to understand how a warming climate could influence DOC quantity and quality in the NWT.

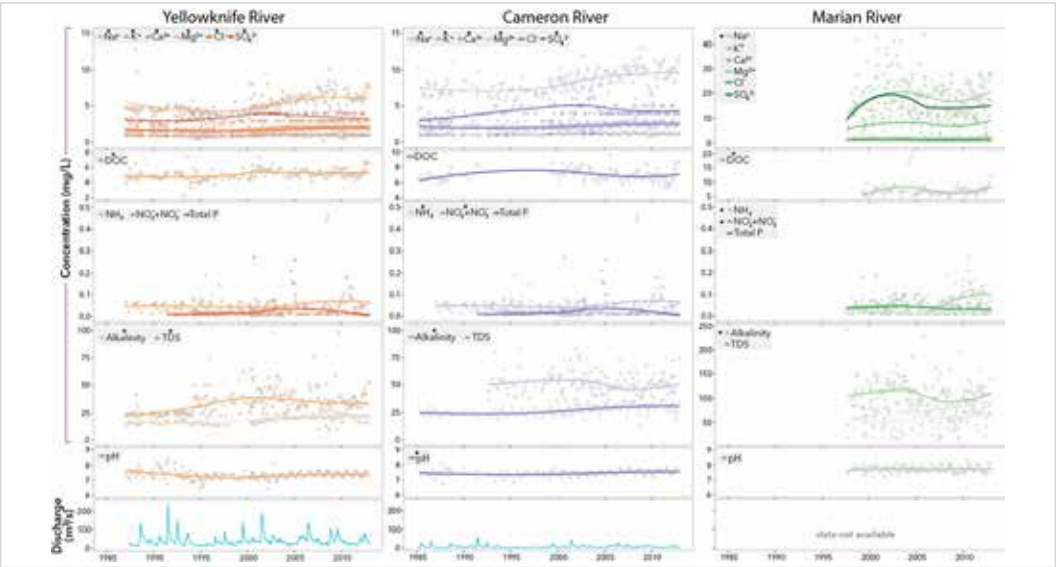
Water was collected from lakes, ponds, creeks and subsurface peat water at three sites along a latitudinal gradient from Yellowknife to Wekweètì and Daring Lake. Baseline DOC conditions were analyzed using long-term geochemical records of the Yellowknife, Cameron and Marian rivers.

Key Findings

- DOC quality is as important as DOC quantity when determining its reactivity within northern environments.
- Subsurface environments across the NWT contain high concentrations of large, humic, aromatic DOC that have the potential to impact drinking water quality and aquatic health.
- Sunlight and microbial degradation drive DOC fate. These drivers can influence how DOC reacts with some drinking water treatment methods.
- Comparison of long-term river water chemistry data from the Yellowknife, Cameron, and Marian rivers with contemporary measurements illustrates a dynamic baseline and may represent the response of northern watersheds to a changing climate and permafrost degradation.
- Simple and cost-effective methods of monitoring of DOC quality produce similar results to more expensive and complex characterization methods.



Dissolved organic carbon (DOC) concentration for different hydrological environments from Yellowknife (2013-2016), Wekweètì (2015, 2016), and Daring Lake (2016). Graphical columns have a random scatter to provide a better view of all data points. "Sub" represents samples taken in subsurface environments, sampled using piezometers.



Concentrations of major ions (Na+, K+, Ca2+, Mg2+, Cl-, SO42-), nutrients (DOC, NH3+, NO2-+NO3-, Total P), alkalinity, total dissolved solids (TDS), and pH for the Yellowknife, Cameron, and Marian rivers over time. The bottom graph depicts hydrological discharge of the Yellowknife and Cameron rivers (no data available for the Marian River). Significant monotonic trends are denoted by a star (*) above the significant parameter in the legend of each graph. Lines represent a locally-weighted scatter plot smoothing using non-parametric regressions (LOESS).

How does this project help to understand cumulative impacts?

This project contributes baseline information on both nutrients and DOC quantity and quality from different spatial and temporal scales. As temperatures increase and permafrost continues to melt, the DOC in northern waters will increase. Understanding baseline levels of DOC is important for water treatment and permitting development.

CIMP176

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP176" or read the 19th issue of the NWT Environmental Research Bulletin (NERB), available online at www.nwtcimp.ca.

Assessing regulators' information needs to make decisions regarding cumulative effects under the *Mackenzie Valley Resource Management Act*

Purpose

This project's purpose was to determine: (i) the information needs of northern decision-makers to make decisions about cumulative effects on water quality in the Mackenzie Valley, and (ii) how information about cumulative effects is provided through existing monitoring programs.

Key Findings

- Both proponent- and government-led monitoring are required to effectively understand and manage cumulative effects, but these programs must be mutually supportive. Defining responsibilities at the project and regional levels, and improvements in collaboration and leadership for cumulative effects assessment, are imperative to ensuring that cumulative effects are consistently and appropriately considered as part of project reviews and regulatory decisions.
- Improving alignment of monitoring efforts across programs and scales is essential. This requires a suite of indicators or parameters that are useful for understanding cumulative effects, which can trigger more intense monitoring actions, and support regulatory decisions at the project scale. It is the responsibility of governments, in collaboration with scientists, to provide guidance on what is sufficient to support regulatory decisions whilst supporting longer-term cumulative effects monitoring strategies.
- Monitoring data must be available for end users and in a format that is accessible. This may be a limited set of data, designed specifically to aid cumulative effects understanding, whilst protecting the sensitivity of proprietary information. This will only be achieved through clear regulatory requirements for data sharing and access, accompanied by clear articulation of the benefits of open data.

(Credit: L. Arnold)

- Often missing from project reviews and monitoring data is the interpretation of data for decision-makers such that they can understand the significance of cumulative change within the context of the project decision at hand. A broader set of information, inclusive of social and cultural values and Traditional knowledge, is needed to understand cumulative effects and to inform decision-making about biophysical impacts.
- There must be conceptual guidance for cumulative effects, such that the role of monitoring is clear. An overarching model for cumulative effects must, at a minimum, identify the types of cumulative effects questions to be asked, guide and provide knowledge from the hypotheses tested, and ensure timely and meaningful output to support regulatory decisions at the project scale. The information generated through coordinated monitoring and assessment programs is of value only if there is an agreed-up framework to support data collection and its subsequent analysis and interpretation.

How does this project help to understand cumulative impacts?

Given these findings, it is recommended that: (i) monitoring efforts be better coordinated across industry and government, (ii) community input is required to interpret the significance of monitoring results, and (iii) an overarching framework is required to guide cumulative impact assessment, monitoring and interpretation. This will provide regulators with the necessary information for informed decision-making and will allow for better management of cumulative effects. NWT CIMP is currently developing such a framework.

CIMP177

Years funded: 2

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP177" or read the 20th issue of the NWT Environmental Research Bulletin (NERB), available online at www.nwtcimp.ca.

The influence of forest fires on metal deposition to lakes and peatlands in the North Slave Region, NWT

Purpose

Wildland fire can introduce metals into aquatic habitats through residual ash and fine particles, which can travel long distances through the air. In 2016 the project sampled surface water and sediments from the bottom of 10 lakes and peat from five bogs, at various distances from the 2014-15 forest fires. The project tested the samples for metal concentrations and charcoal particles. The project examined whether fire events, indicated by large amounts of charcoal particles in layers of sediment or peat cores, influenced the concentrations of total metals found.

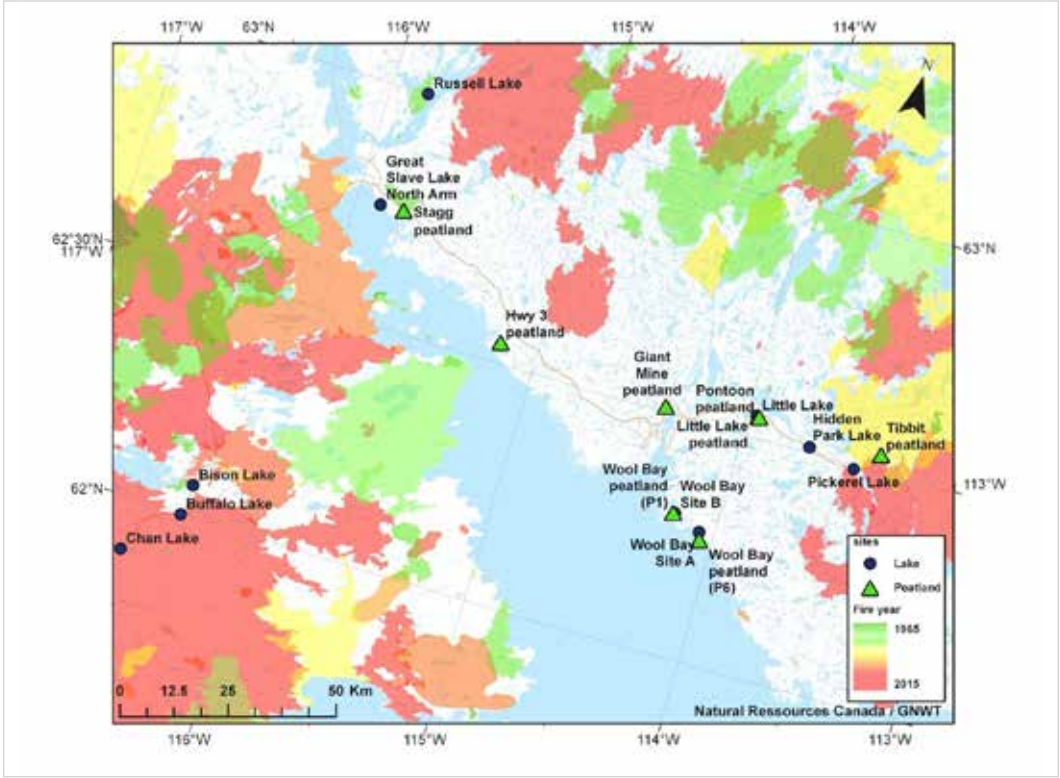
Key Findings

- The ash deposited from a single fire delivered insignificant metal concentrations.
- Metal concentrations (cadmium, lead and mercury) in water and sediment from all sampled lakes were below Canadian Council of Ministers of the Environment (CCME) guidelines for protection of the aquatic environment.
- Arsenic concentrations in sediments were in some cases higher, but likely due to pre-existing historic accumulation.

How does this project help to understand cumulative impacts?

Peat bogs receive metals only from the atmospheric deposition and as a result, these environmental archives can be used to estimate rates of metal deposition over time. With further analysis, the peat cores will provide information on the relative importance of metal deposition from mining emissions compared to deposition from forest fire emissions. This analysis will advance our understanding of the cumulative impacts of human activities and natural processes on metal deposition in the North Slave region.

A peat core sample taken from a study site in the North Slave Region in 2016.



Lake and peatland study sites that were sampled in the North Slave Region in 2016, including the delineation of areas influenced by forest fires over the last 50 years.

CIMP179

Years funded: 1

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP179".

Empirical modelling for improved streamflow forecasting in the Snare River basin, NWT

Purpose

The objective of this one-year project was to improve our understanding of stream flow in the Snare River, a watershed that is representative of other North Slave watersheds and is important for local power generation. A specific objective was to test the effectiveness of an annual, end-of-winter snow survey that has been used by resource managers for many years to predict stream flow in the following spring and summer.

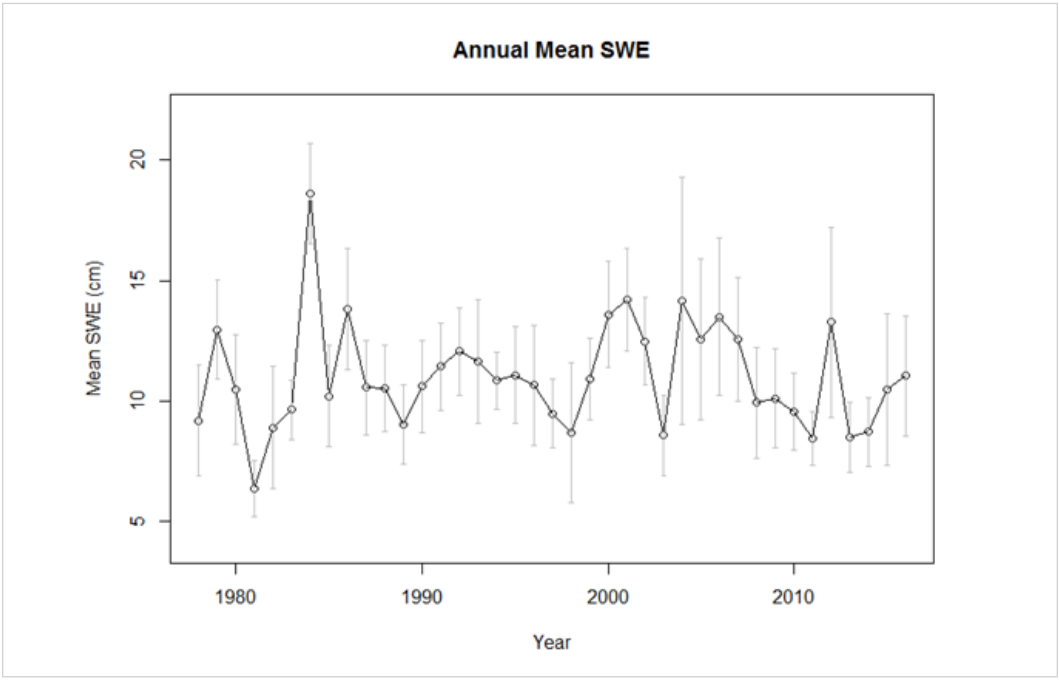
Key Findings

- There is a critical need to improve streamflow forecasting ability for the Snare River hydroelectric system, but current predictive tools do not adequately represent Snare streamflow response to climatological variables.
- Characterization of precipitation inputs into the ~13,700 km^2 Snare River basin is particularly challenging and prone to large errors, including the annual end-of-winter snow survey.
- Improved quantification of precipitation inputs to the Snare system, will be required to improve short-to-medium term hydrologic forecasting.

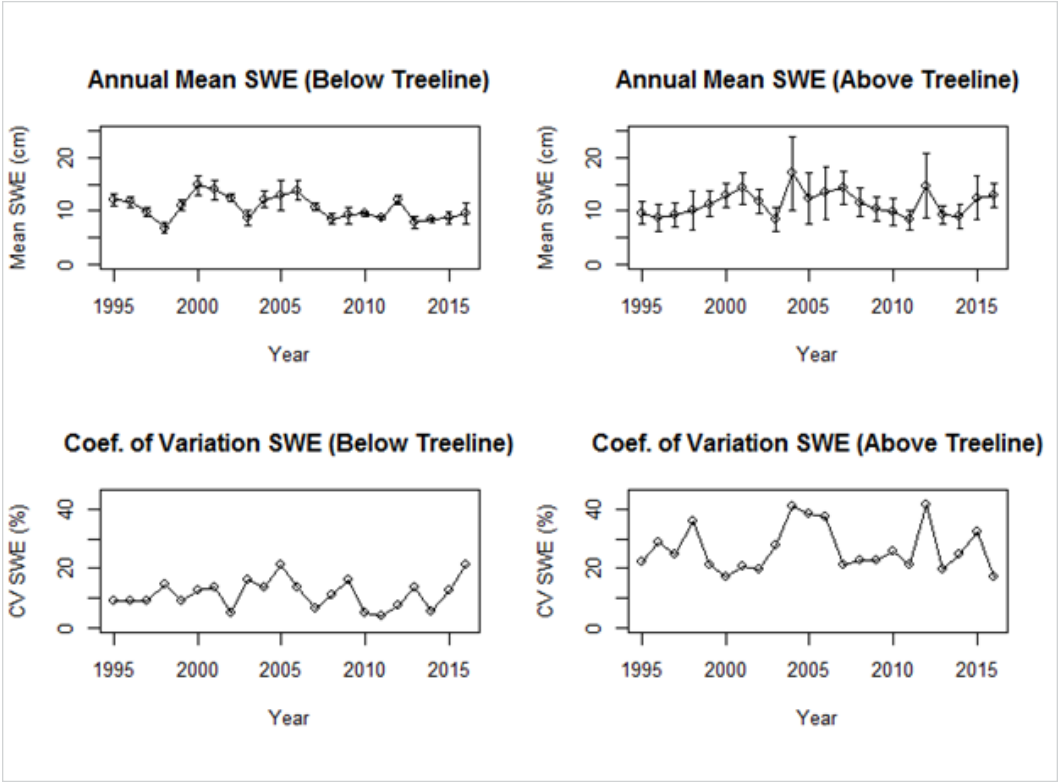
How does this project help to understand cumulative impacts?

Mike Palmer and Shawne Kokelj conducting snow surveys in the Snare River basin, March 2016. (Credit: M. Richardson)

The preliminary results presented by this project have clear and important implications for future-decision making by the Northwest Territories Power Corporation. We are generating new information on historical, end of winter snow distribution across the Snare River basin and associated sources of uncertainty. These uncertainties propagate directly into short- and medium-term streamflow forecasts and hence power generating potential, since the spring snowpack is a dominant source of spring and summer runoff in subarctic environments. ENR continues to support the expanded snow survey and has encouraged and adopted additional measurements at all sites.



Mean annual snow water equivalent (SWE) and 1 SD error bars, 1978-2015, estimated from Indigenous and Northern Affairs Canada (INAC) and Northwest Territories Power Corp (NTPC) snow survey records.



Mean annual SWE (top panels) in the Snare River basin for sites below (left) and above (right) treeline. Error bars represent 1SD and are expressed as coeffcients of variation in the bottom panels. These plots only show data from 1995-2015 when the record was more complete.

CIMP180

Years funded: 1

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP180".

The impact of wildfire on diverse aquatic ecosystems of the NWT

Purpose

During the summer of 2014, southern NWT experienced an unprecedented high wildfire season. This one-year study aimed to quantify the immediate effects of wildfire on southern NWT streams. Water quality samples were taken in the summer of 2015 and 2016 from 50 catchments across the Dehcho, Wek'èezhìı and North Slave regions, with a variety of landscape characteristics.

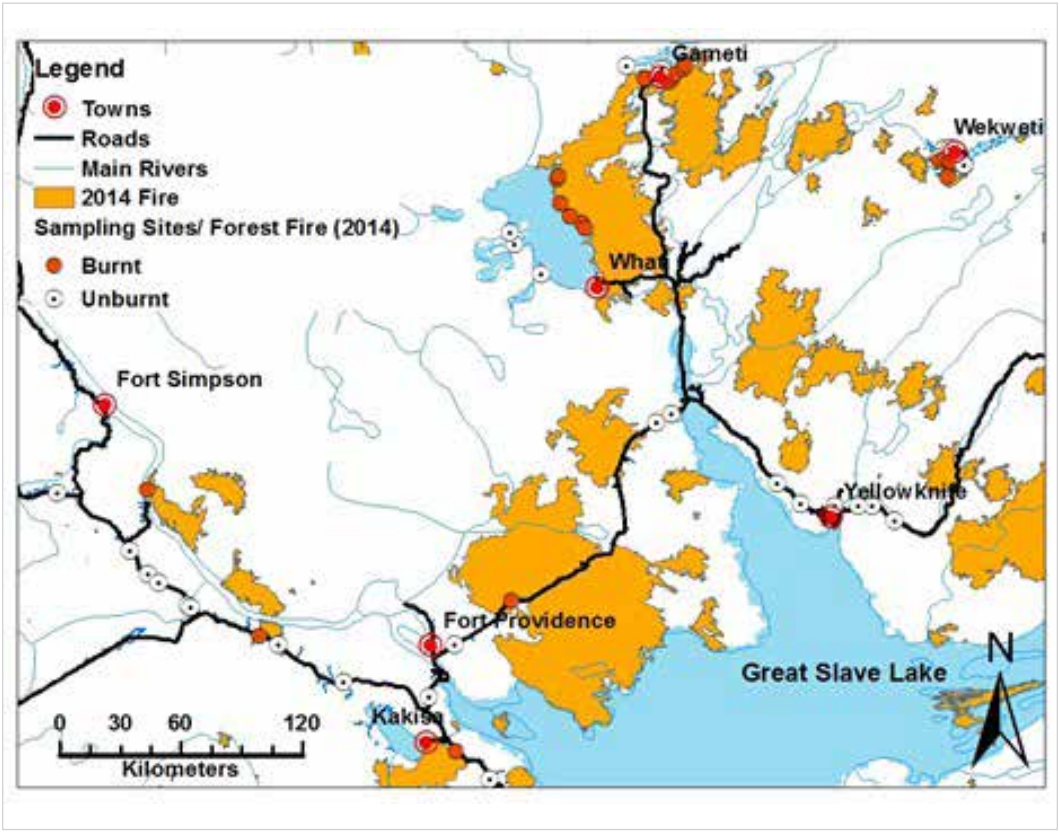
Key Findings

- The effects of wildfire on NWT stream chemistry are subtle, but with a large enough sample size can be teased apart from other, key landscape attributes using multivariate analyses.
- The effect of fire on stream water chemistry is most pronounced immediately after the fire event: (i.e., the first 'freshet' event post-fire).
- Further work may be needed to understand how streams respond to wildfire in their catchments in relatively wet years.

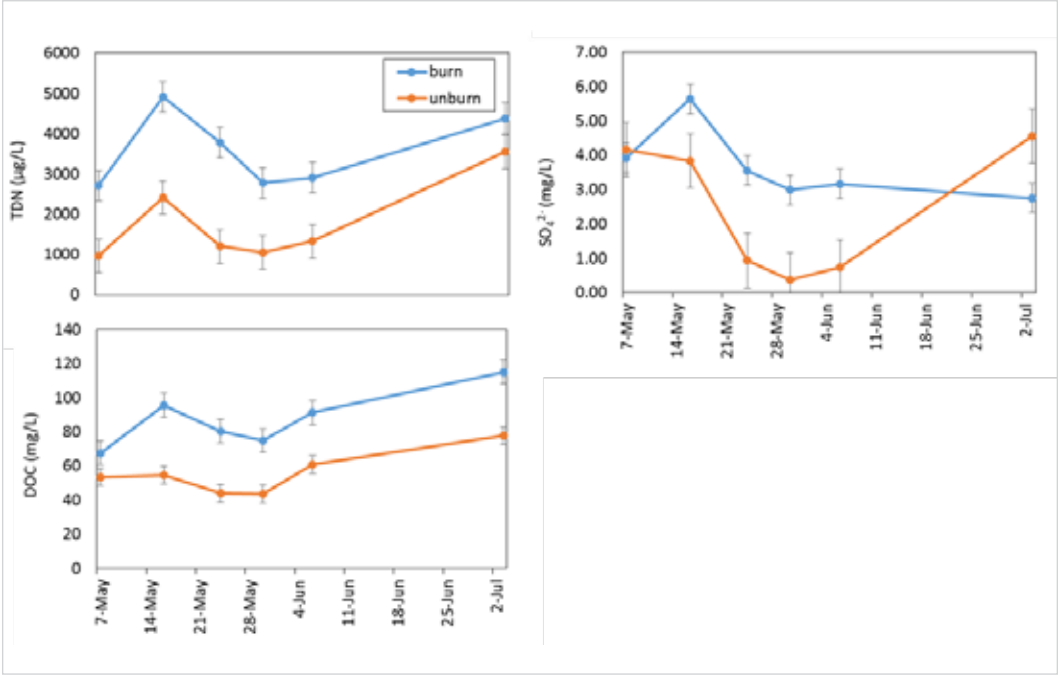
How does this project help to understand cumulative impacts?

This project's results advance the understanding of cumulative impacts in the NWT by assessing how co-occurring variation in landscape characteristics work together to affect stream water chemistry following a wildfire. In our analysis, wildfire emerges as just one of many drivers of stream water chemistry, and does not appear to have an over-riding effect on recipient stream systems, as little as one year post fire.

Measuring discharge in a wildfire-affect stream near Whatì, NT. (Credit: S. Tank)



A map showing the 50 sampling locations, overlain on the 2014 fire perimeters.



Measures of porewater chemistry averaged across multiple plots in burned (blue) and unburned (orange) areas of the Scotty Creek catchment. Measurements were conducted during the summer of 2016.

CIMP186

Years funded: 3

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Recommended Reading:
For additional information on this project please visit nwtdiscoveryportal.enr.gov.nt.ca and search "CIMP186" or read the 27th issue of the NWT Environmental Research Bulletin (NERB), available online at www.nwtcimp.ca.

Building a NWT Permafrost Database: Standardizing the reporting, archiving and dissemination of permafrost ground temperature and geohazard information.

Purpose

Permafrost underlies much of the landscape across the entire NWT. It consists of frozen earth materials and can be thought of as the glue that holds northern landscapes together. Rapid warming throughout the NWT is causing permafrost to thaw. Permafrost thaw is affecting northern ecosystems and is the main driver of changes to many northern aquatic ecosystems.

This project's purpose was to establish a way to compile and organize information on permafrost temperatures, ground ice conditions and maps that track landscape change so they can be accessed and used by researchers, planners and northern decision-makers. The project identified historical and ongoing ground temperature and geotechnical data collections, of which the metadata and raw data could be archived.

Key Findings

- Permafrost data from historical and ongoing projects was compiled and formatted according to the developed metadata templates; which can also be used for future projects.
- A total of 537 ground temperature datasets were acquired, which includes more than 22 million ground temperature data points. A database is currently being developed and will be made publicly available when complete.
- The project is working to develop similar reporting protocols and data recovery activities for ground ice information and permafrost disturbances.

Permafrost thaw slump. (Credit: Steve Kokelj)

How does this project help to understand cumulative impacts?

Knowledge of permafrost conditions is an essential component of northern research, environmental monitoring, resource development projects, as well as infrastructure design and performance monitoring.

The project's compiled datasets represent a wealth of knowledge on permafrost conditions that can be used to track change and inform decision-making.

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