NWT COMMUNITY-BASED WATER MONITORING

10-YEAR SUMMARY REPORT

2025

PROGRAMME COMMUNAUTAIRE DE SURVEILLANCE DE LA QUALITÉ DE L'EAU DES TNO

RAPPORT D'ÉTAPE À 10 ANS

2025

Government of Northwest Territories
Gouvernement des Territoires du Nord-Ouest

Executive Summary

Stemming from *Northern Voices, Northern Waters: the NWT Water Stewardship Strategy* (2010), the NWT Community-Based Water Quality Monitoring (CBM) program was initiated in 2012 for communities to have greater involvement in water monitoring and ensure results would be meaningful to community members. The CBM Program fosters water stewardship and informed decision-making. This report summarizes the main findings and recommendations of the 10-year review and technical report.

For over 10 years, community members have worked with technical and scientific staff from the GNWT's Department of Environment and Climate Change (ECC) to monitor water quality across the NWT. This kind of long-term monitoring is critical for understanding current water quality conditions and detecting change over time.

Community partnerships are central to the CBM program. Community members determine where to monitor water quality near their communities and conduct the monitoring themselves or with ECC staff. ECC plays a coordinating and supporting role by providing training and assistance to community monitors, enabling them to collect water samples, analyze water quality data, and report results back to the communities.

Monitoring is regularly conducted at 36 sites (10 mainstem Mackenzie River sites, 19 tributary sites, and 7 lake sites). The number of sites sampled varies slightly from year to year based on priorities, logistics, environmental, and safety constraints.

The CBM program collects data on a variety of parameters, including metals, ions, nutrients, bacteria, chlorophyll, dissolved oxygen, pH, conductivity, turbidity, hydrocarbons, hardness, and temperature. Water quality data are collected from water samples taken in the field then analyzed at laboratories for analysis (grab samples), by using instruments left in the water which record water quality parameters over time (YSI sondes), or by samplers that are sensitive to certain hydrocarbons that are left in the water and later analysed at a laboratory (polyethylene membrane devices, PMDs).

Water quality data are compared to established guidelines such as the Canadian Council of Ministers of the Environment (CCME) *Canadian Water Quality Guidelines for the Protection of Aquatic Life.* The CBM program collects data on over 90 parameters. However, guidelines only exist for 28 of these parameters. The most common substances to exceed guidelines were total metals (such as aluminum, cadmium, copper, iron, lead, and mercury), all of which are naturally present in the water and usually attached to soil suspended in the water that cannot be absorbed by fish or other aquatic life.

The results from the 10-year CBM review (2012-2021) were compared to the results of the previous 5-year CBM review (2012 to 2016) and showed the importance of gathering long-term data. Trends emerged in the 10-year review that were not apparent in the 5-year review, and some trends apparent in the 5-year review were no longer apparent in the 10-year review. Initial review of aluminum and lithium, for example, were seen to be increasing across the region in the 5-year review; however, analysis of the 10-year dataset (2012-2021) showed aluminum and lithium were no longer increasing at most sample sites.

Analysis of the 10-year data set indicated increasing trends in sulphate, chloride, and dissolved lithium for the Slave River. Geologic formations can naturally release sulfate and lithium into surface waters, especially in regions with mineral deposits. Lower water levels can concentrate existing salts in water bodies, leading to higher measured concentrations of sulfate, chloride, and other dissolved ions.

There were decreasing trends for dissolved organic carbon for both the Slave and Mackenzie rivers, and seasonal changes can influence dissolved organic carbon (DOC) levels. Changes in temperature and precipitation patterns can influence vegetation and microbial communities, potentially leading to shifts in DOC levels.

The 10-year review found no evidence that human landscape disturbance or industrial activity is impacting water quality in the NWT portion of the Mackenzie River basin. The review showed that water quality across the basin is largely influenced by:

- Where the water is (for example, lake, mainstem, tributary, or delta),
- The geology of tributary watersheds feeding into waterbodies, and
- Permafrost thawing and slumping.

For specific localized issues, such as investigating the potential effects of a spill, sewage lagoon or landfill, targeted studies would be a better approach rather than the broader system-level monitoring provided by the CBM program.

Overall, the results indicate that the CBM program is functioning effectively and producing reliable data thanks to the dedicated efforts of GNWT technicians, scientists, and community monitors who provide valuable insights into water quality.

Sommaire

Lancé en 2012, le Programme communautaire de surveillance de la qualité de l'eau des TNO a comme fondement le document intitulé « La voix du Nord, les eaux du Nord: Stratégie sur la gestion des eaux des Territoires du Nord-Ouest » (2010) et a pour but de permettre aux collectivités de participer de manière accrue à la surveillance des eaux et de garantir que les résultats en découlant leur soient pertinents. Le programme favorise ainsi la gestion des eaux et la prise de décisions éclairées. Le présent rapport résume les conclusions et recommandations principales de l'examen décennal effectué et du rapport technique.

Pendant plus de 10 ans, les membres des collectivités ont travaillé avec le personnel technique et scientifique du ministère de l'Environnement et du Changement climatique (MECC) pour surveiller la qualité de l'eau partout aux TNO. Cette surveillance à long terme est essentielle pour que nous comprenions les conditions actuelles relatives à la qualité de l'eau et pour que nous puissions détecter des changements au fil du temps.

Les partenariats avec les collectivités sont intrinsèques au programme communautaire de surveillance de la qualité de l'eau. Les membres des collectivités déterminent eux-mêmes le lieu de prélèvement d'échantillons près de leur collectivité, et choisissent de le faire eux-mêmes ou avec le personnel du MECC. Le ministère apporte du soutien et coordonne le tout, fournissant aux collectivités de la formation et de l'accompagnement pour la collecte d'échantillons, l'analyse de la qualité de l'eau et la transmission des résultats.

Le suivi de la qualité est régulièrement effectué au niveau de 36 sites (10 dans l'axe fluvial du fleuve Mackenzie, 19 dans des affluents et 7 dans des lacs). Le nombre de sites de prélèvement des échantillons varie d'une année à l'autre selon les priorités ainsi que les contraintes logistiques, environnementales et liées à la sécurité.

Le but du programme communautaire de surveillance est de collecter des données relatives divers paramètres, dont les métaux, les ions, les nutriments, les bactéries, la chlorophylle, l'oxygène dissout, le pH, la conductivité, la turbidité, les hydrocarbures, la dureté et la température. Les données concernant la qualité de l'eau sont tirées d'échantillons qui sont collectés sur le terrain et qui sont ensuite analysés en laboratoire (échantillons instantanés), à l'aide d'instruments laissés dans l'eau qui mesurent les paramètres de qualité de l'eau au fil du temps (sondes YSI) ou encore au moyen d'échantillonneurs sensibles à certains hydrocarbures qui sont laissés dans l'eau, puis analysés en laboratoire (dispositifs à membrane en polyéthylène).

Les données sur la qualité de l'eau sont comparées à des lignes directrices établies, comme les Recommandations canadiennes pour la qualité des eaux : protection de la vie aquatique du Conseil canadien des ministres de l'Environnement (CCME). Le programme communautaire de surveillance collecte des données sur plus de 90 paramètres. Cependant, des lignes directrices n'existent que pour 28 d'entre eux. Les substances qui dépassent le plus fréquemment ces lignes directrices sont les métaux totaux (tels que l'aluminium, le cadmium, le cuivre, le fer, le plomb et le mercure), qui sont naturellement présents dans l'eau, généralement attachés au sol ou en suspension et qui ne peuvent être absorbés par les poissons ou d'autres organismes aquatiques.

Les résultats de l’examen décennal (2012-2021) du programme communautaire de surveillance ont été comparés aux résultats de l’examen quinquennal précédent (2012-2016), et nous avons pu constater l’importance de la collecte de données à long terme. L’examen décennal a fait ressortir des tendances qui n’étaient pas apparentes dans l’examen quinquennal, tandis que certaines tendances mises en lumière dans l’examen quinquennal n’étaient plus significatives dans le contexte de l’examen décennal. Par exemple, l’évaluation initiale des teneurs en aluminium et en lithium démontrait leur augmentation dans la région lors de l’examen quinquennal. Cependant, l’analyse de l’ensemble des données sur dix ans (2012-2021) a révélé que l’aluminium et le lithium n’étaient plus en hausse au niveau de la majorité des sites.

L’analyse de l’ensemble des données sur 10 ans a indiqué une tendance à la hausse pour la présence des sulfates, des chlorures et du lithium dissous dans la rivière des Esclaves. Les formations géologiques peuvent naturellement libérer des sulfates et du lithium dans les eaux de surface, en particulier dans les régions où se trouvent des gisements de minéraux. Des niveaux d’eau plus bas peuvent entraîner une concentration des sels existants dans les masses d’eau, ce qui se traduit par des concentrations mesurées plus élevées de sulfates, de chlorures et d’autres ions dissous.

Des tendances à la baisse ont été observées pour le carbone organique dissous (COD) dans la rivière des Esclaves et le fleuve du Mackenzie. Les variations saisonnières peuvent influencer les niveaux de COD, dans la mesure où les changements de température et de précipitations peuvent influer sur la végétation et les communautés microbiennes, ce qui peut faire fluctuer les niveaux de COD.

L’examen décennal n’a révélé aucune preuve selon laquelle les perturbations du paysage par l’humain ou l’activité industrielle auraient une incidence sur la qualité de l’eau dans la portion ténoise du bassin du fleuve Mackenzie. L’examen a mis en lumière ce qui influence grandement la qualité de l’eau dans l’ensemble du bassin :

- L’emplacement de l’eau (par exemple dans un lac, un axe fluvial, un affluent ou un delta);
- La géologie des bassins versants des affluents s’écoulant dans les plans d’eau;
- Le dégel et l’affaiblissement du pergélisol.

S’il s’agit de répondre à des questions spécifiques et localisées, telles que l’étude des effets potentiels d’un déversement, d’un bassin d’épuration ou d’un site d’enfouissement, il serait préférable de réaliser des études ciblées plutôt que d’effectuer une surveillance à plus grande échelle du système dans le cadre programme communautaire de surveillance.

Dans l’ensemble, les résultats indiquent que le programme communautaire de surveillance fonctionne efficacement et produit des données fiables grâce aux efforts dévoués des techniciens et scientifiques du gouvernement des Territoires du Nord-Ouest et des observateurs locaux, qui fournissent des renseignements précieux concernant la qualité de l’eau.

Contents

What is the NWT Community-Based Water Quality Monitoring Program?

Indigenous governments and Indigenous organizations in the Northwest Territories (NWT) began working with territorial and federal governments in 2008 to develop a water stewardship strategy. *Northern Voices, Northern Waters: The NWT Water Stewardship Strategy* was released in 2010 and underlined the need for NWT residents to be more involved in and knowledgeable about water stewardship.

The NWT Community-Based Water Quality Monitoring (CBM) program was initiated by the Government of the Northwest Territories (GNWT) in 2012 to foster water stewardship through informed decision-making. The program was initiated to encourage communities to be more actively involved in water monitoring and ensure that the results are meaningful to community members. Over the last decade, community members have collaborated with technical staff from the GNWT's Department of Environment and Climate Change (ECC) to monitor water quality at up to 62 sites across the NWT; currently, monitoring continues at approximately 40 sites.

The following questions from community members guided the design of the CBM program:

- Is the water healthy?
- Can we drink the water?
- Is the quality of the water changing?
- Are fish safe to eat?
- Is the water different than when you occasionally take samples?

Community partnerships are key to the CBM program. Community members help determine where to monitor water quality near their communities, identify where capacity exists, and conduct the monitoring themselves or with ECC staff. ECC plays a coordinating and supporting role within the program by providing ongoing training, equipment, and assistance to community monitors to collect water samples, analyzing water quality data, and reporting results back to the communities.

A 5-year review of the program was conducted in 2017. An assessment was conducted with program partners to determine if any changes were required to improve the identification of water quality trends during the 2012-2016 sampling period. Several recommendations were made:

- Ensure standardized sampling procedures, number and types of parameters measured, and consistent sampling frequency across sites and years,
- Remove sites deemed challenging or unsafe to access,
- Use field measurements to supplement data, and
- Maintain a 5-year cycle for reviewing and reporting the program's results.

In 2022, a 10-year review was initiated for the CBM program, with similar goals to the 5-year review. A technical report was also prepared to analyze the first 10 years of data. This 10-year summary report compiles the main findings and recommendations from the 10-year review and technical report, effectively communicating this information to the community. All CBM data are available on Mackenzie DataStream (mackenziedatastream.ca).

How the CBM Program Works

Since the CBM program was initiated in 2012, 62 water quality sites have been monitored within the Mackenzie River Watershed. Of the 62 monitoring sites (16 mainstem Mackenzie River sites, 32 tributary sites, and 14 lake sites), monitoring continued at ~36 sites in 2021 (10 mainstem Mackenzie River sites, 19 tributary sites, and seven lake sites). The discontinued sites were removed due to challenging access or safety concerns. The CBM monitoring sites are shown in the map below (*Figure 1*). The number of sites sampled varies slightly from year to year, based on priorities, as well as logistical, environmental, and safety constraints. Monitoring is conducted at each site three to four times during the open-water season (from June to October) each year.

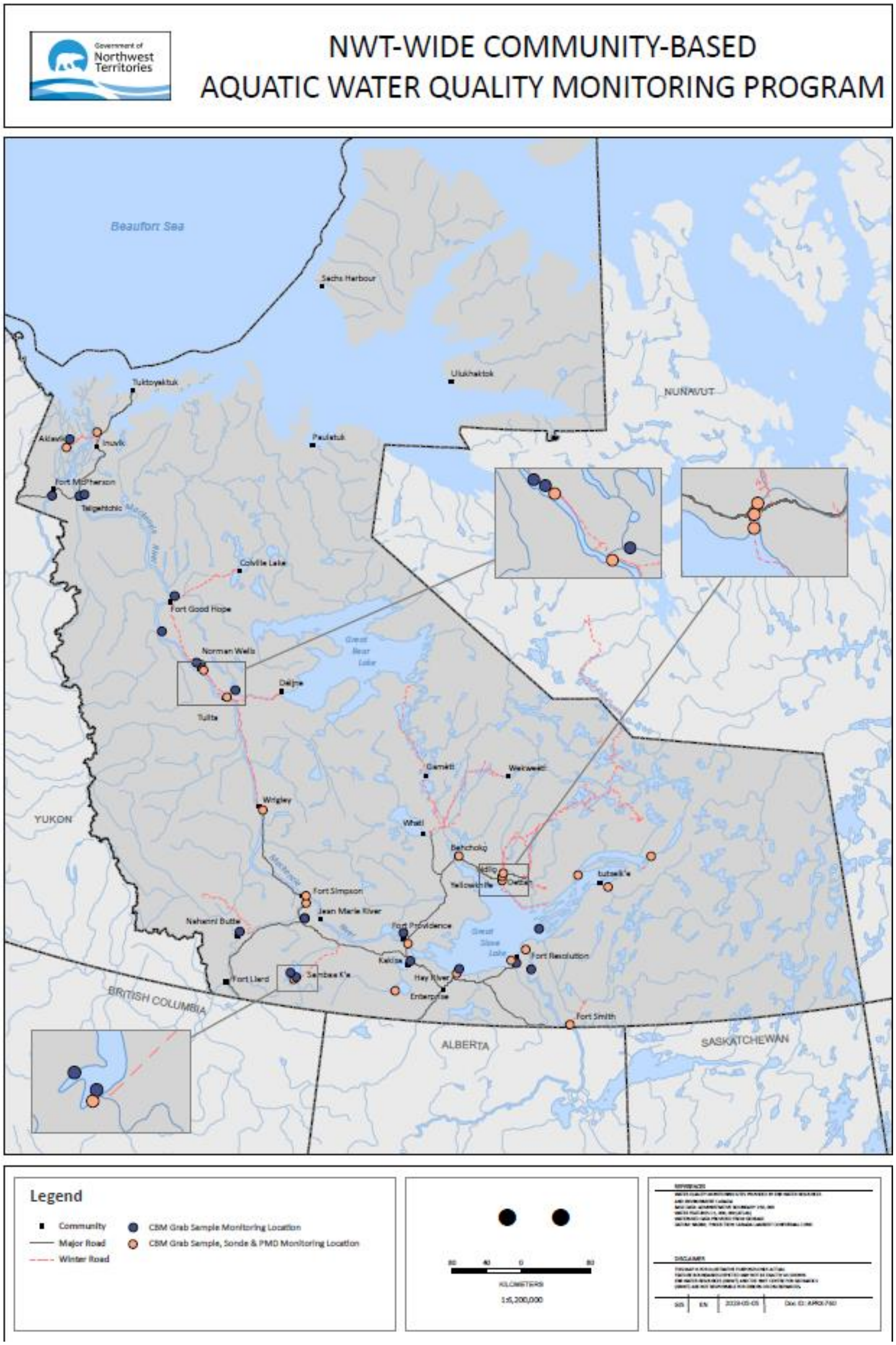


Figure 1: Community-based water quality monitoring locations across the NWT

How Do We Sample Water Quality?

The CBM program uses three types of equipment to sample water quality:

Surface water grab samples

Surface water grab samples provide a detailed snapshot of water quality conditions. To collect a grab sample, community monitors fill special bottles with water from the lake or river surface (*Figure 2*). These bottles are then sent to a laboratory for analysis. Over 90 different substances are measured in grab samples, including metals, ions, and nutrients. Since the amount of a substance in water can change over time, it is useful to take more than one grab sample each year. In the CBM program, grab samples were collected approximately once a month during the open water season each year.

Figure 2: Catherine Graydon and Laura Krutko, ECC Water Monitoring and Stewardship Coordinators, collecting surface grab samples at the Sans Sault CBM site in Norman Wells.

Data Sondes

Sondes are water quality monitoring equipment that collect data continuously (*Figure 3*). They can be placed in the water for long periods (for example, the entire summer). Every 2 hours, the sonde automatically takes measurements of specific parameters, including temperature, pH, turbidity, dissolved oxygen, conductivity, and chlorophyll a. Data are downloaded when the sonde is removed from the water. Sondes are useful for collecting information on how water quality changes over time, for example, in relation to storms or daily temperature fluctuations.

Figure 3: ECC's Jayden Grandjambe, Laura Krutko, and Ka'a'gee Tu First Nation's Melaine Simba retrieve a sonde from the Kakisa River, a major tributary of the Mackenzie River, where it has been continuously recording water quality data throughout the summer.

Polyethylene membrane device (PMD)

Hydrocarbons are pollutants of concern. However, due to their low concentrations, they are difficult to detect using regular water sampling methods, such as grab samples. Specialized monitoring methods are used. Polyethylene membrane devices (PMD; *Figure 4*) are placed in water for a specified period and gradually absorb hydrocarbons over time. The GNWT, in partnership with Environment and Climate Change Canada, deployed PMDs at monitoring sites for approximately 30 days at a time during each summer and then analyzed the collected data.

Figure 4. Deploying a polyethylene membrane device (PMD) into the water for 15-30 days during the summer. PMDs absorb polycyclic aromatic compounds (PACs) over time. Polycyclic aromatic hydrocarbons (PAHs) are at such low levels that they would be undetectable using regular water sampling methods.

Factors that affect water quality in the NWT

Many factors, both human and natural, can influence water quality. Human activity can change water quality, for example, through the discharge of treated sewage or industrial effluent. Natural processes can also affect water quality, such as runoff from rainfall or snowmelt, decomposition of organic matter, and weathering of rock.

The immense size of the Mackenzie River Basin means that natural conditions, and in turn water quality, vary substantially across the watershed. However, results show that a few key factors are the main drivers of water quality in the Mackenzie River Watershed: water source, rate of flow, turbidity and climate change.

Water Source Affects Water Quality

Many of the differences in water quality of the Mackenzie River are due to the influence of rivers and creeks that flow into the river as it travels from the outlet of Great Slave Lake to the Arctic Ocean. The water quality of these rivers and creeks is influenced in turn by the geological features surrounding them.

In the CBM study area, three primary geological landforms significantly impact water quality. The Mackenzie, Selwyn, and Cassiar Mountains lie west of the Mackenzie River. Their bedrock is composed of minerals, including dolomite and limestone, which are broken down relatively easily by the elements—water, ice, and wind—a process known as weathering. These mountains also contain large amounts of glacial till, a rocky material deposited by glaciers during the last Ice Age. In contrast, the Precambrian Canadian Shield, composed of granite bedrock, is less prone to weathering. This means that lakes and rivers flowing from the surrounding mountains receive more mineral-rich runoff containing higher levels of suspended sediments than those flowing from the Shield portions of the study area.

Figure 5: East Arm of the Great Slave Lake, 2024.

Rate of Flow Affects Water Quality

In calm, low-flow waters, such as lakes, dirt particles tend to sink to the bottom because they are denser than water. In fast-flowing water, the force of the water stirs up dirt from the river or lakebed, causing it to remain suspended or mixed throughout the water at all depths, resulting in cloudy or turbid water.

Turbidity and Metals

When turbidity levels are high, the levels of many metals, such as aluminum, copper, and iron, are also elevated because these substances readily attach to suspended particles of dirt. This pattern is visible along the main stem of the Mackenzie River (*Figure 12*). For example, aluminum concentrations rose sharply at Wrigley, which is downstream of where the Liard River meets the Mackenzie, reflecting the influx of highly turbid water from the Liard River.

Climate Change Can Affect Water Quality

One of the biggest impacts of climate change in the NWT is the gradual thawing of permafrost. Permafrost is ground that is at or below 0 degrees for at least two consecutive years. As the ground warms, permafrost thaws and releases dirt that may contain substances such as metals, nutrients, or salts. Rainwater flowing across the land picks up this dirt and washes it into rivers and lakes.

Permafrost thawing also makes the ground less stable. It can lead to “thaw slumps” (a type of mudslide) that release large amounts of sand, soil, and rock, along with associated substances such as metals and nutrients, into Arctic and sub-Arctic streams, rivers, and lakes.

Numerous significant thaw slumps have developed in recent decades in the Peel Plateau area of northwestern NWT. Analysis of CBM data (*Figure 10*) revealed that the highest levels of turbidity and associated metals were observed at sites within the Peel River system, particularly in the Vittrekwa River. Nutrient concentrations (phosphorus and nitrogen) were also elevated in this region. These findings suggest that permafrost thawing and slumping are having a significant impact on water quality in this region of the NWT.

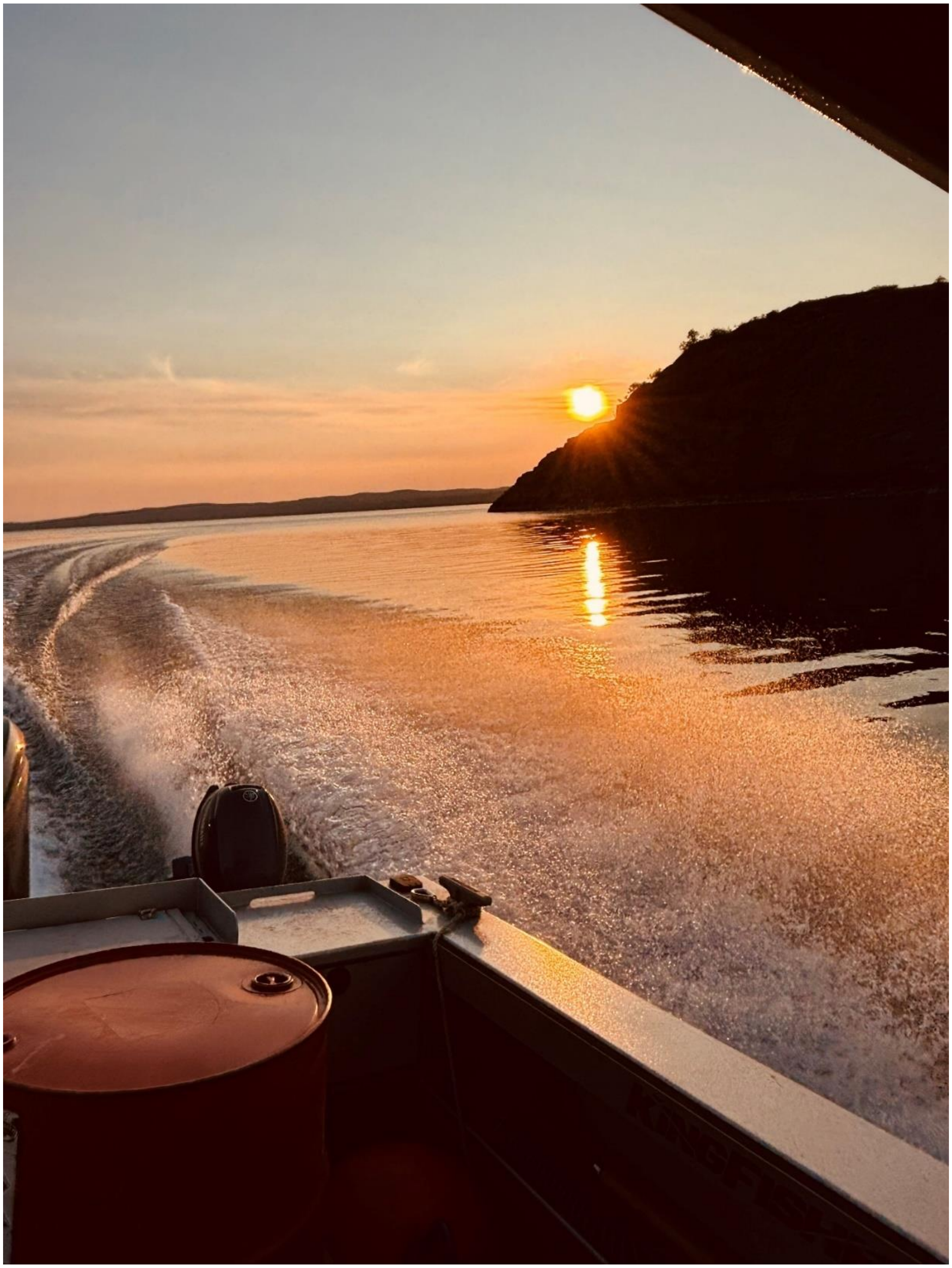


Figure 6: Utsingi Point is the water gateway to the Thaidene Nëné Indigenous Protected Area. The CBM program has monitoring stations in this area (2024).

Monitoring Sites

To analyze water quality, data from 62 sites (Table 1) were organized into eight groups based on sites that were close together or represent distinct areas in the NWT:

Group	CBM Sites
Great Slave Lake and Tributary Sites (17)	• Behchokǫ̀ at Franks Channel/Up Stream from Bridge • Yellowknife at Yellowknife River/Upstream from Bridge • Kakisa at Kakisa River • Fort Resolution at Slave River/ Big Eddy • Fort Resolution – Little Buffalo • Fort Smith at Slave River/ Rapids • Hay River at Hay River/ Upstream of West Channel • Hay River at Mouth of Hay River/ Great Slave Lake • Yellowknife at Yellowknife Bay- Dettah/Great Slave Lake • Yellowknife at Yellowknife Bay- Ndilǫ/Great Slave Lake • Łutsel K'e at Snowdrift River • Łutsel K’e Bay • Łutsel K’e Thaltheilei Narrows • Fort Resolution at Resolution Bay/ Great Slave Lake • Fort Resolution- Mixing Zone • Fort Resolution- Culture Camp • Great Slave Lake- Drybones Bay
Headwaters of the Mackenzie (3)	• Fort Providence at Mackenzie River/Downstream of Boat Launch • Fort Providence at Mackenzie River/Upstream of Bridge • Fort Providence at Mackenzie River/upstream of Ferry
Sambaa K’e (5)	• Sambaa K’e at Island River/Mouth • Sambaa K’e at Samba K’e • Sambaa K’e at Samba K’e West Channel • Sambaa K’e at Island River 1/Upstream of Winter Road • Sambaa K’e at Island River 2/ Below Winter Road
Liard River Confluence (6)	• Fort Simpson at Liard River / Upstream of Ferry • Fort Simpson at Mackenzie River / Upstream of Liard River Mouth • Jean Marie at Jean Marie River / Downstream of HWY • Jean Marie at Jean Marie River / Upstream of HWY Work Site • Nahanni Butte at Nahanni Butte River / Upstream • Wrigley at Mackenzie River
Tulita Sites (5)	• Tulita at Bog Creek / Mouth • Tulita at Great Bear River • Tulita at Mackay Creek / Mouth • Tulita at Slater Creek / Mouth • Tulita at Mackenzie River
Norman Wells Sites (5)	• Norman Wells at Mackenzie River / Downstream at Radar Island • Norman Wells at Mackenzie River / Upstream • Norman Wells Mid Channel

	• Norman Wells at Bosworth Creek / Under Upstream Bridge • Norman Wells at Bosworth Creek / Under Downstream Bridge
Sans Sault Rapids and Fort Good Hope (4)	• Sans Sault Rapids between Norman Wells and Fort Good Hope / • Mackenzie River • Carcajou River at Mouth by Sans Sault Rapids • Fort Good Hope at Mackenzie River / Ramparts • Fort Good Hope at Rabbit Skin River
Mackenzie Delta and Peel River Sites (7)	• Fort McPherson at Vittrekwa River • Fort McPherson at Frog Creek / Upstream of Dempster Highway • Fort McPherson at Peel River • Aklavik at Mackenzie River Delta / Peel Channel • Tsiigehtchic at Arctic Red River • Tsiigehtchic at Mackenzie River • Inuvik at Mackenzie River Delta / East Channel

Table 1: CBM Regional Site Groups

Overall results

Water quality in the first section of the Mackenzie River, as it flows past Fort Providence, is similar to that of Great Slave Lake, generally clear with low turbidity and low levels of metals, nutrients, and other substances. Water quality remains constant until the Liard River flows out of the mountainous terrain into the Mackenzie River from the south at Fort Simpson. It is here that the largest and most significant differences in mainstem water quality were observed upon analysis of 10 years of CBM data.

The water quality in the Liard River differs significantly from that of the Mackenzie River. Most noticeably, the Liard River is very turbid and appears muddy, resembling chocolate milk. The difference in water quality between the two rivers is evident from space, as satellite images (Figure 7) reveal the muddy, brown waters of the Liard flowing into the clear waters of the Mackenzie River. The influence of the Liard River is so significant that the Mackenzie River downstream of the Liard appears muddy as it flows north from Fort Simpson.

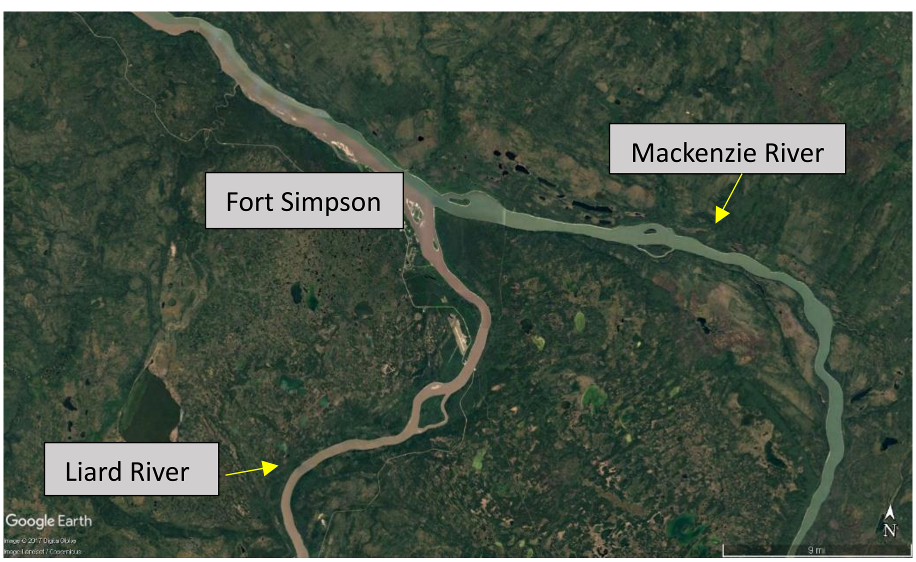


Figure 7: Muddy water of the Liard River meets the relatively clear water of the Mackenzie River. Image courtesy Google Earth.

Why is the Liard River so muddy? Like other rivers flowing from mountains in the west and southwest of the Mackenzie River, the Liard flows through lands with a lot of loose soil and relatively soft rocks that weather easily and quickly.

In comparison, rivers that flow into the Mackenzie River from the east, such as the Great Bear River at Tulita, tend to be more apparent. These rivers originate from regions on the Canadian Shield, where rocks are harder and do not easily release materials, such as metals, when water flows over them.

This satellite image (Figure 8) shows what happens when turbid water of the Slave River enters Great Slave Lake at Fort Resolution. Close to the eastern shore of the lake, mud and dirt from the Slave River flowing through the Taiga plains are still suspended in the water, making it look muddy. But as the water in the lake slowly flows west towards its outlet at the Mackenzie River, the dirt settles to the bottom. By the time the water has reached the midpoint of the lake, the water appears much clearer.

Figure 8: Muddy water from the Slave River enters Great Slave Lake at Fort Resolution. Image courtesy Google Earth.

Most of the Mackenzie River is deep and fast-flowing. As shown in Figure 9, turbidity levels increase sharply after Fort Simpson and remain high until Tsiigehtchic. As the water moves into the Mackenzie Delta, it spreads out into many shallow channels, slowing down and allowing dirt to settle. Turbidity levels were thus much lower at Inuvik.

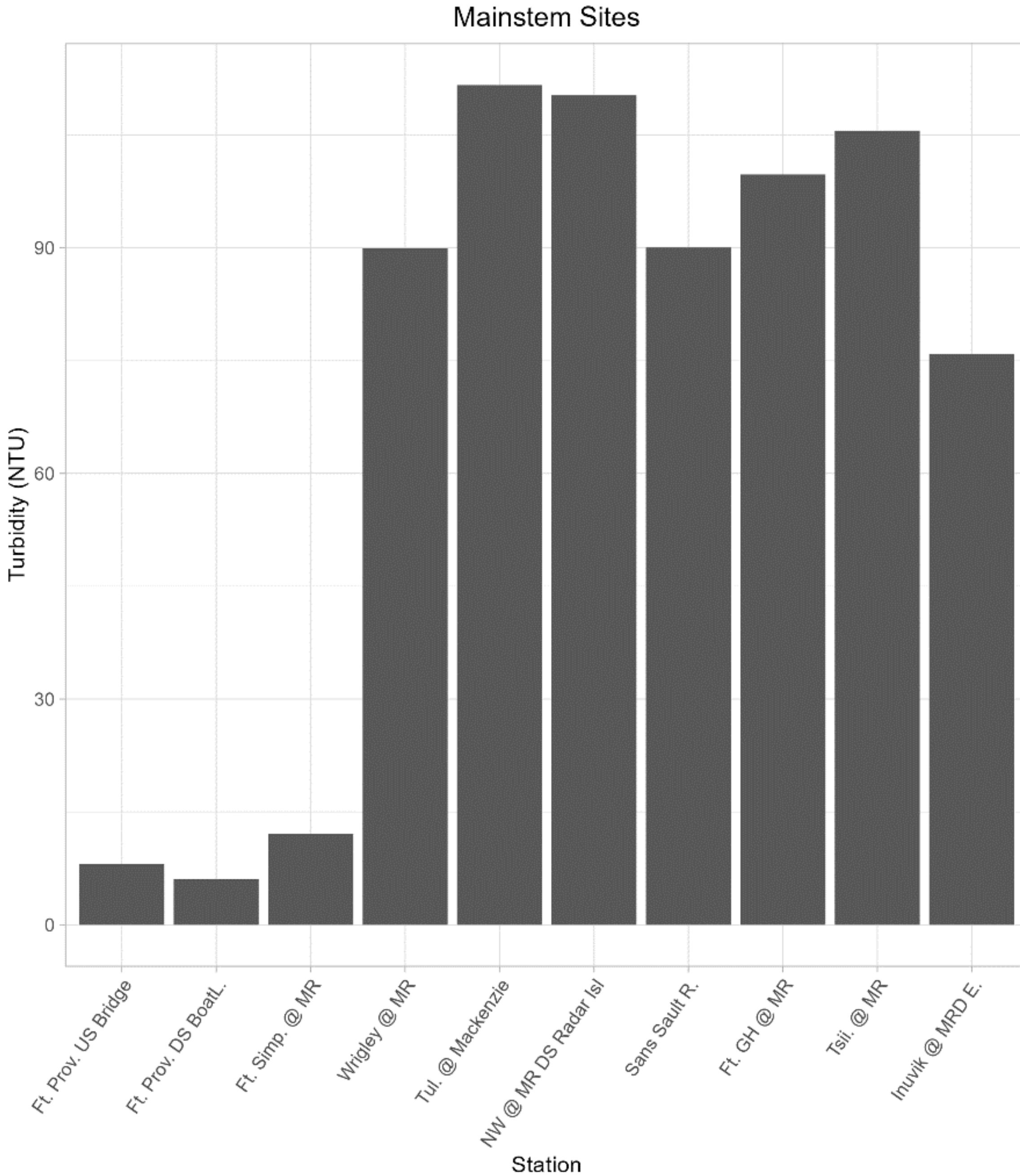


Figure 9: Data show an increase in turbidity along Mackenzie River. On the left of the graph are the relatively clear water inputs, then the increase from the muddy water input from the Liard River and other river systems originating from the mountains west of the Mackenzie River. Data from 2012-2021. (US= upstream, DS = downstream, MR = Mackenzie River, NW = Norman Wells, Ft. GH = Ft. Good Hope, Tul = Tulita, Tsii = Tsiigehtchic, MRD E = Mackenzie River Delta East).

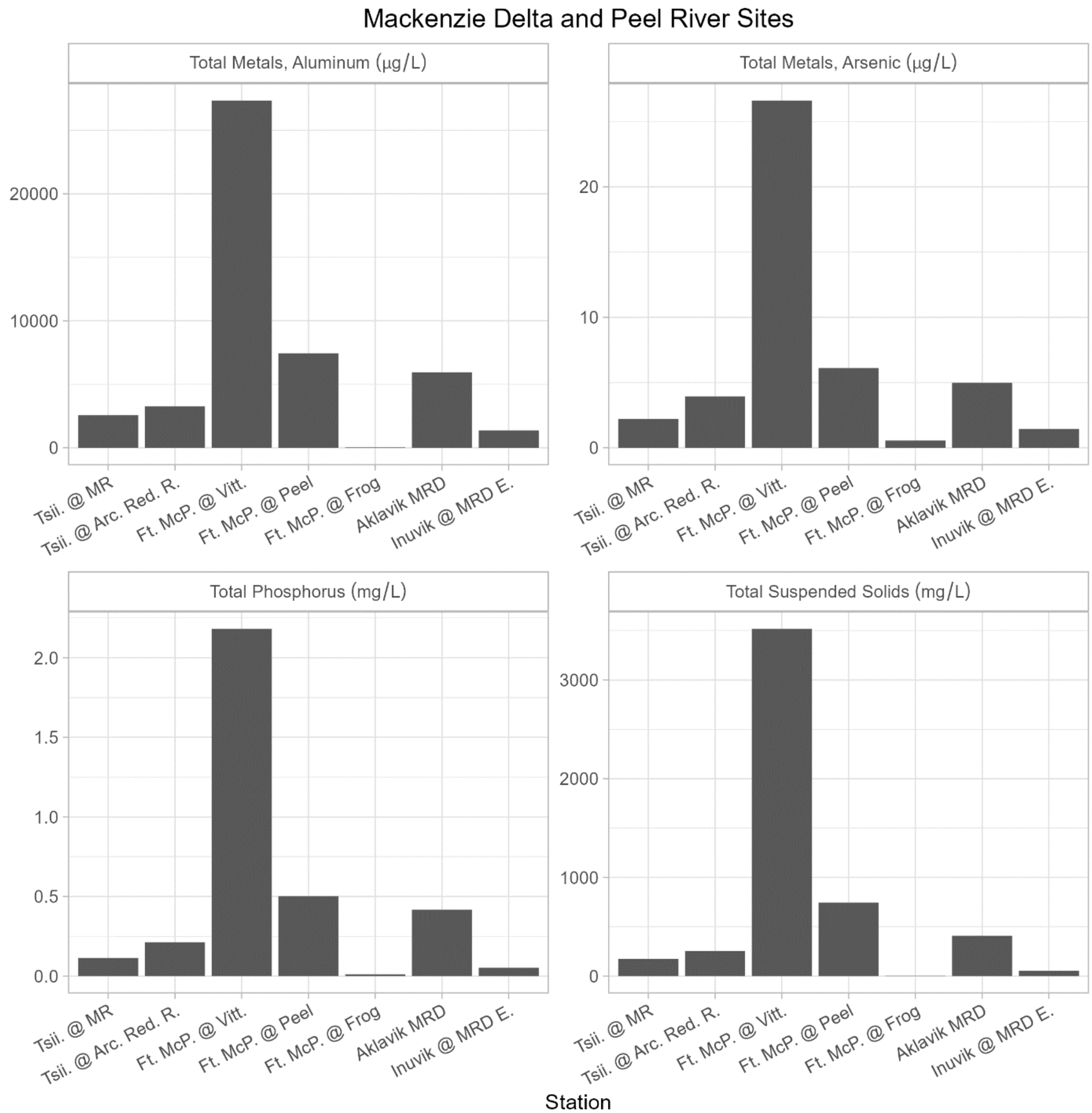


Figure 10: Data showing the influence of permafrost slumping on the Peel Plateau, particularly the Vittrekwa River (Ft. McP. @ Vitt.), is affecting water quality in the Mackenzie River. Data from 2012-2021. (MR = Mackenzie River, Arc. Red. R = Arctic Red River, Ft. McPh = Ft. McPherson, Vitt = Vittrewka River, Frog = Frog Creek, Tsii = Tsiigehtchic, MRD E = Mackenzie River Delta East).

Figure 11: Permafrost slumping in the Peel Plateau represents a significant source of sediment, resulting in increased turbidity in receiving waters. Image credit: Andrea Czarnecki (GNWT).

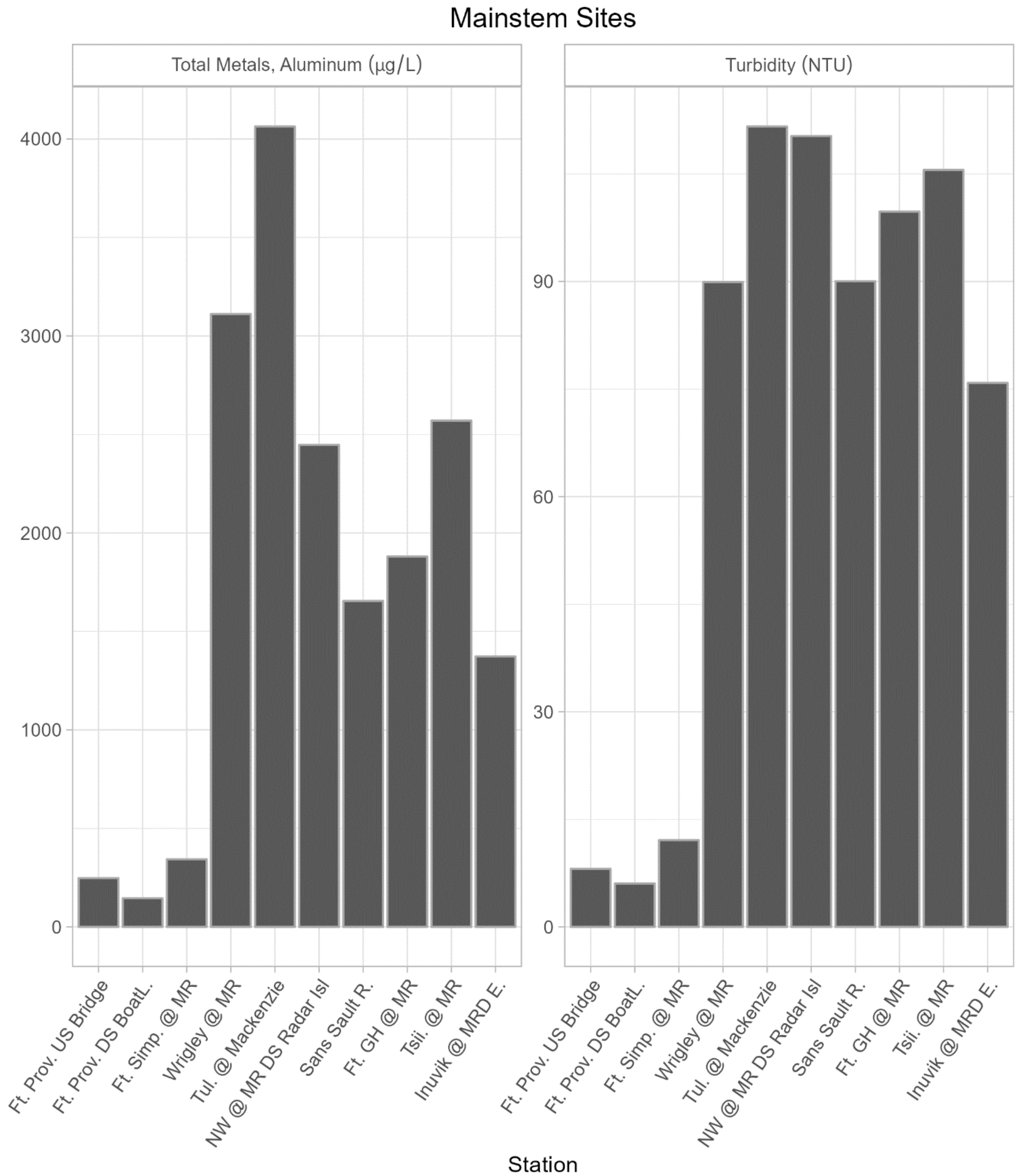


Figure 12: Metals bond to suspended sediments (dirt) in the water. This relationship is evident when looking at aluminum and turbidity as measured on the Mackenzie River, where higher levels start after Fort Simpson with the influx of muddy waters flowing from the mountains. Data from 2012-2021. (US= upstream, DS = downstream, MR = Mackenzie River, NW = Norman Wells, Ft. GH = Ft. Good Hope, Tul = Tulita, Tsii = Tsiigehtchic, MRD E = Mackenzie River Delta East).

Most metals measured in the CBM program were in particulate form, attached to dirt, and thus unlikely to pose a threat to fish and other animals. Figure 13 shows aluminum as a representative metal. The blue dotted lines represent guideline concentrations for dissolved and total aluminum, respectively.

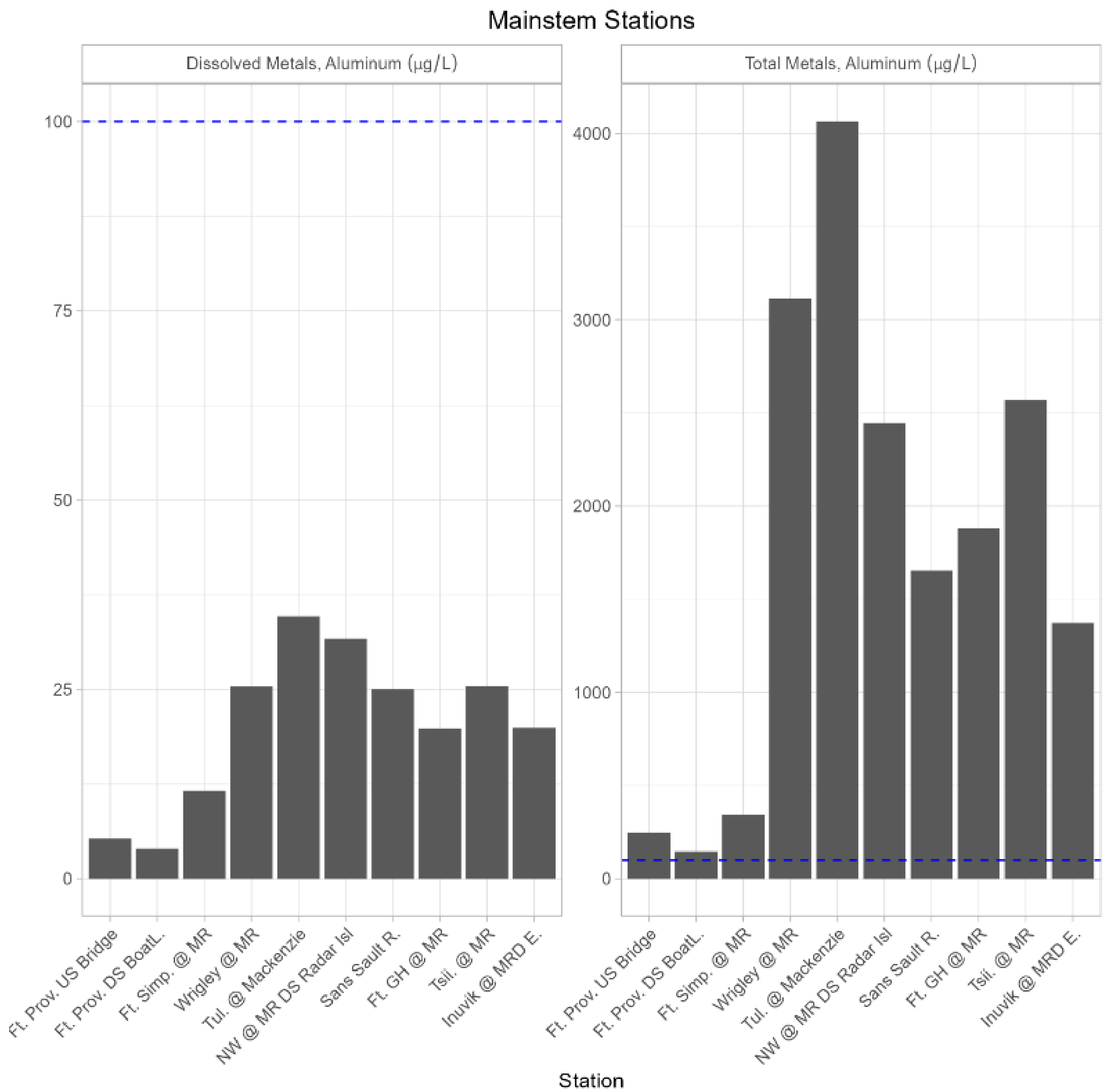


Figure 13: Most metals measured in the CBM program were in particulate form (attached to sediment or "dirt") and are unlikely to pose a threat to fish and other animals. Here, aluminum is shown as a representative metal. The blue dotted lines represent guideline concentrations for dissolved and total aluminum, respectively. Data from 2012-2021. (US= upstream, DS = downstream, MR = Mackenzie River, NW = Norman Wells, Ft. GH = Ft. Good Hope, Tul = Tulita, Tsii = Tsiigehtchic, MRD E = Mackenzie River Delta East).

Hydrocarbons

To address knowledge gaps about hydrocarbons in the NWT, GNWT staff collaborated with Environment and Climate Change Canada to investigate the relative abundance and concentrations of hydrocarbons across space and time (2012-2021) in the Mackenzie River Basin. The analysis revealed no effects from fire or industrial activity on hydrocarbon concentrations, indicating that hydrocarbons in the Mackenzie River are currently at ultra-low levels.

Water Quality Results by Region

Figure 14: ECC Staff and Community Staff collaboratively collecting water samples for the CBM Program, 2023

Great Slave Lake Area

From 2012 and 2021, a total of 17 sites were monitored on the Great Slave Lake and its tributaries (Figure 15).

Figure 15: Community-based monitoring program water sampling sites (open triangle or orange square) on Great Slave Lake and the surrounding area

What is Water Quality Like Here?

- Water entering the lake from the Hay River was significantly different from that of other tributary waters. The data show high levels of conductivity, total dissolved solids, dissolved organic carbon, and total organic carbon. Unlike the other rivers, the Hay River flows through areas with extensive wetlands that drain through rich, fertile soil.
- Dissolved oxygen levels were frequently below guidelines in the Hay River, likely influenced by surrounding wetlands that contain high amounts of organic matter, which consumes oxygen when it is broken down.
- Several metals that attach to dirt (aluminum, copper, iron, lead, and mercury) exceeded CCME guidelines at least once in rivers feeding into the lake.
- Within Great Slave Lake, higher conductivity, turbidity, and total metal concentrations were measured in Resolution Bay (*Figure 16*), near the mouth of the Slave River, compared to areas to the North (in Yellowknife Bay) and East (near Łutsel K'e). This highlights the influence of the Slave River on the southern part of the lake.

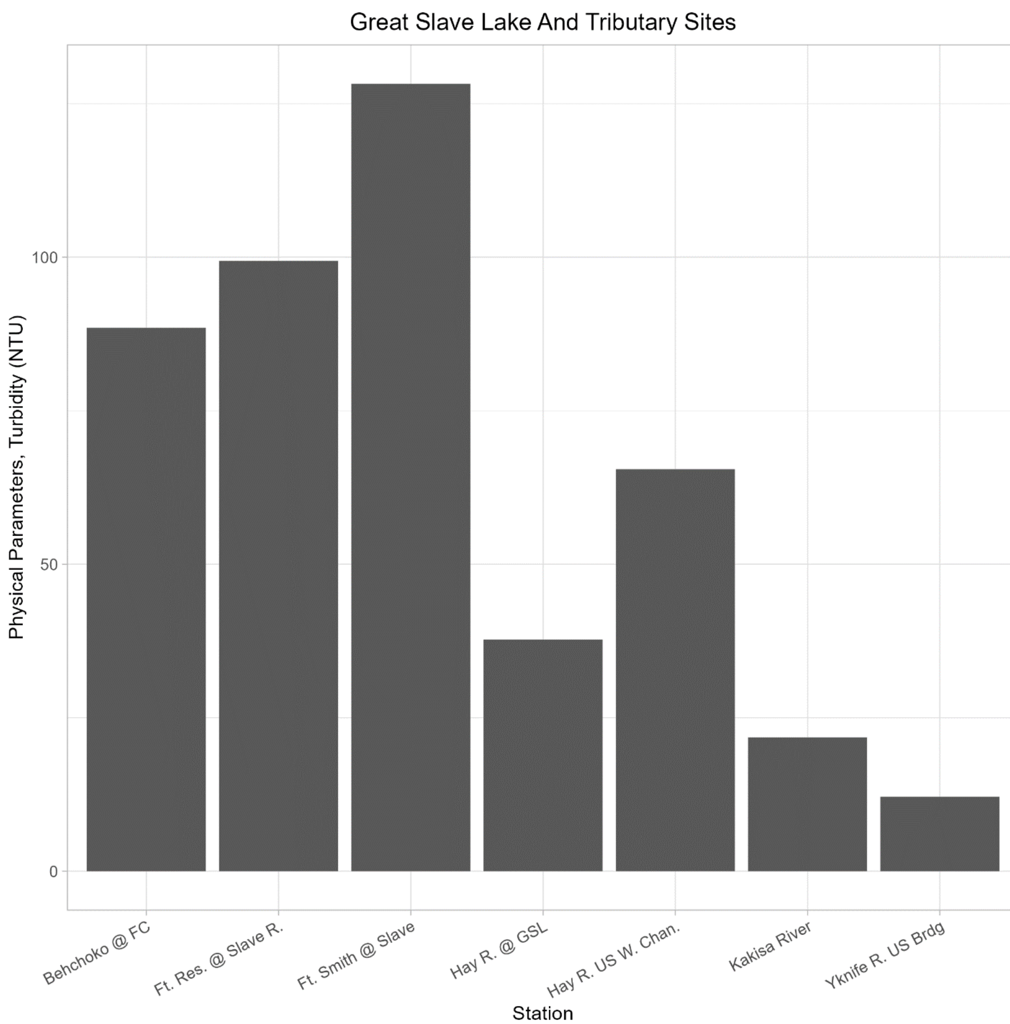


Figure 16: Turbidity is measured in and around Great Slave Lake by the CBM program. This graph shows that the lake is clear, and turbidity levels are highest at river outlets. Data from 2012-2021. (US= upstream, GSL = Great Slave Lake, W Chan = West Channel, Yknife = Yellowknife).

Headwaters of the Mackenzie

Three sites were monitored: downstream of the boat launch and upstream of the bridge in Fort Providence, at the Mackenzie River, and at Fort Simpson, upstream of where the Liard River meets the Mackenzie River (*Figure 17*). The headwaters receive water mainly from Great Slave Lake and several small rivers, including the Kakisa and Trout rivers.

What is Water Quality Like Here?

- Water quality was generally clear, with low amounts of total metals and nutrients.
- There were few exceedances of guidelines for total metals and dissolved oxygen, compared to downstream sites.

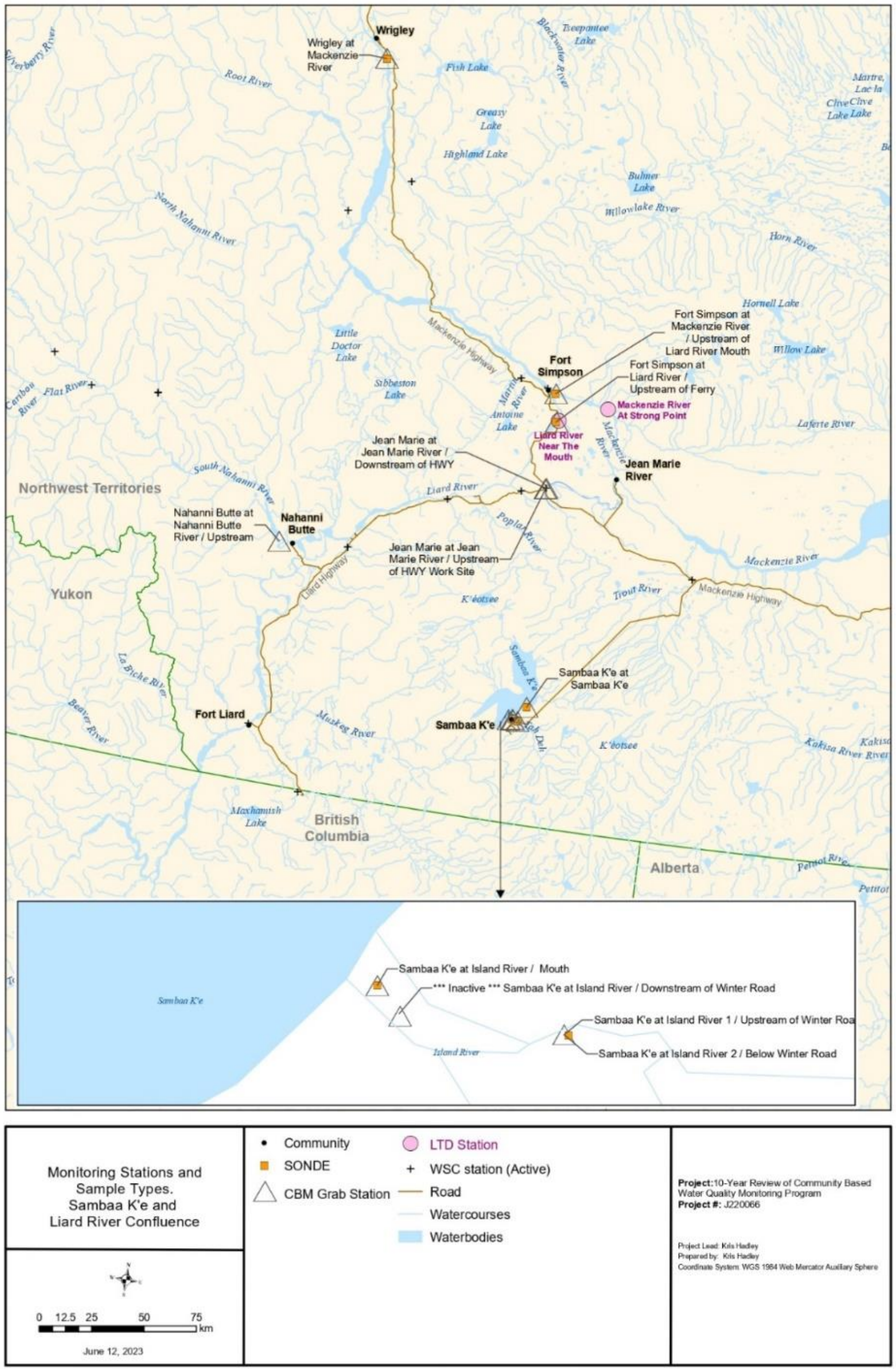


Figure 17: CBM program water sampling sites (open triangle or orange square) sites around Sambaa K'e and the Liard River.

Liard River Confluence

Six sites were monitored: one on each of the Mackenzie and Liard rivers upstream of the confluence, one downstream at Wrigley, and at tributary sites on the Jean Marie and Nahanni Butte rivers.

What is Water Quality Like Here?

- Water quality differed upstream and downstream of where the Liard meets the Mackenzie. The Liard carries large amounts of sediment, which mix with the less turbid waters of the Mackenzie, resulting in elevated sediment levels. This sediment combines with the less turbid waters of the Mackenzie, resulting in elevated levels of nutrients, total metals, and turbidity immediately downstream at Wrigley. The satellite image (*Figure 18*) shows muddy waters from the Liard entering the Mackenzie.

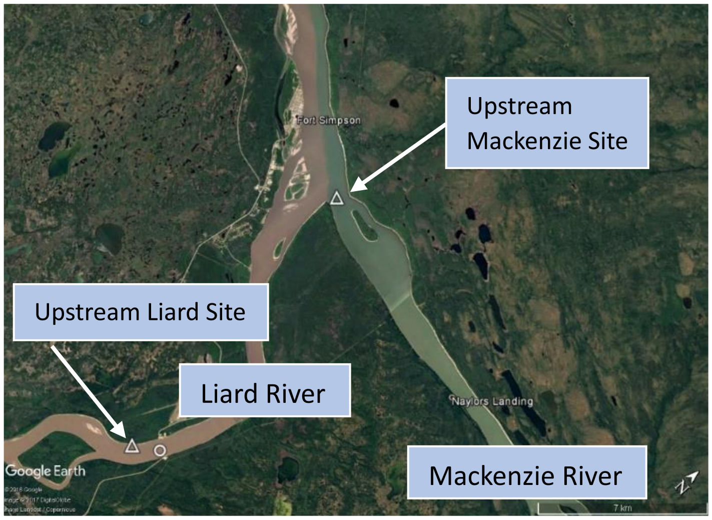


Figure 18: The Liard River meeting the Mackenzie River. Image courtesy Google Earth.

- Another satellite image reveals that the water from the Liard is not thoroughly mixed with the water from the Mackenzie at the Wrigley sampling site (*Figure 19*), located downstream of the confluence. The east bank appears relatively clear, compared to the west bank, where the water is muddy brown. This likely contributed to Wrigley's water quality being more like that of the Liard River upstream site than to other sites on the Mackenzie River.

Figure 19: A satellite image shows the Mackenzie River downstream of Wrigley. Image courtesy Google Earth.

- Guideline exceedances were common for total metals, especially at the Wrigley and Liard River sites, due to metals sticking to dirt in the water (*Figure 20*).

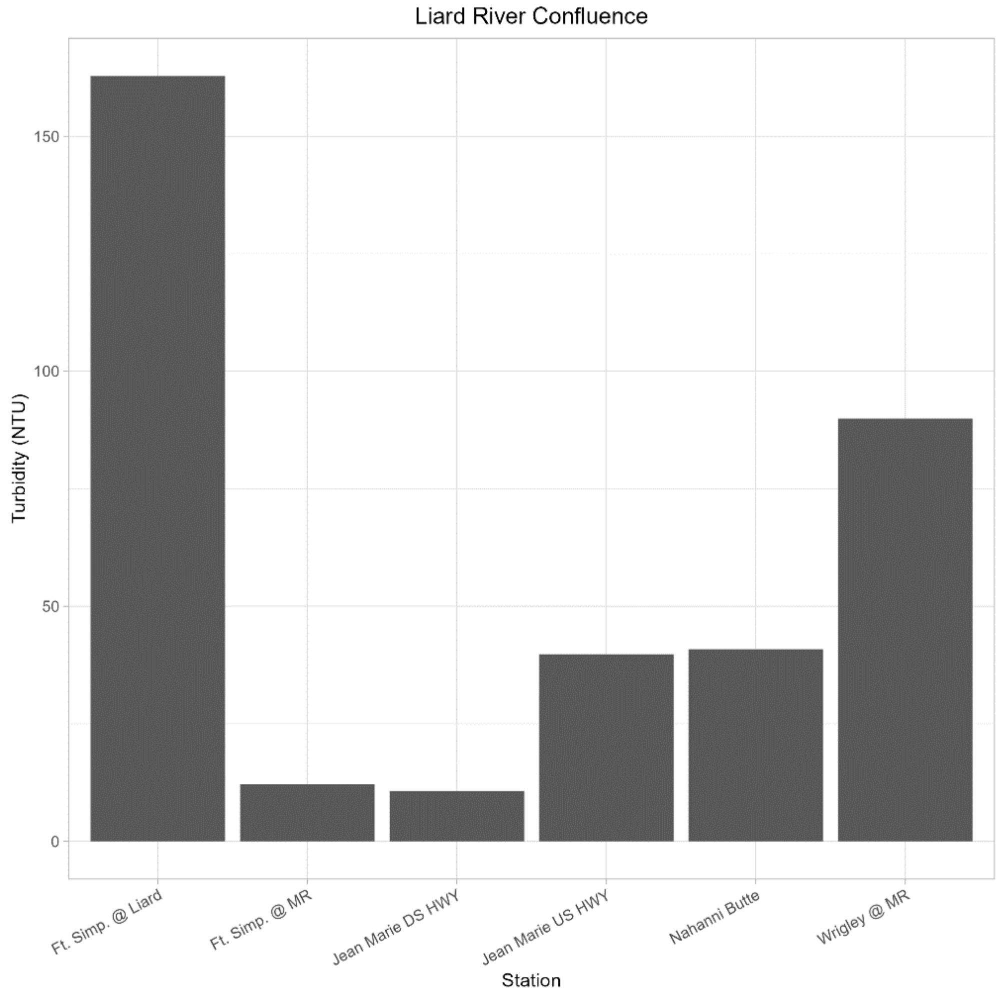


Figure 20: Turbidity as measured on the Liard and Mackenzie rivers by the Community-Based Monitoring program. The influence of the muddy Liard River water on increased turbidity in the Mackenzie River is evident. Data from 2012-2021. (US= upstream, DS = downstream, MR = Mackenzie River).

Tulita

Water quality was monitored at a single mainstem site, upstream of the community, and at five sites on Bog Creek, Great Bear River, Mackay Creek, and Slater Creek, near where these tributaries meet the Mackenzie (*Figure 21*).

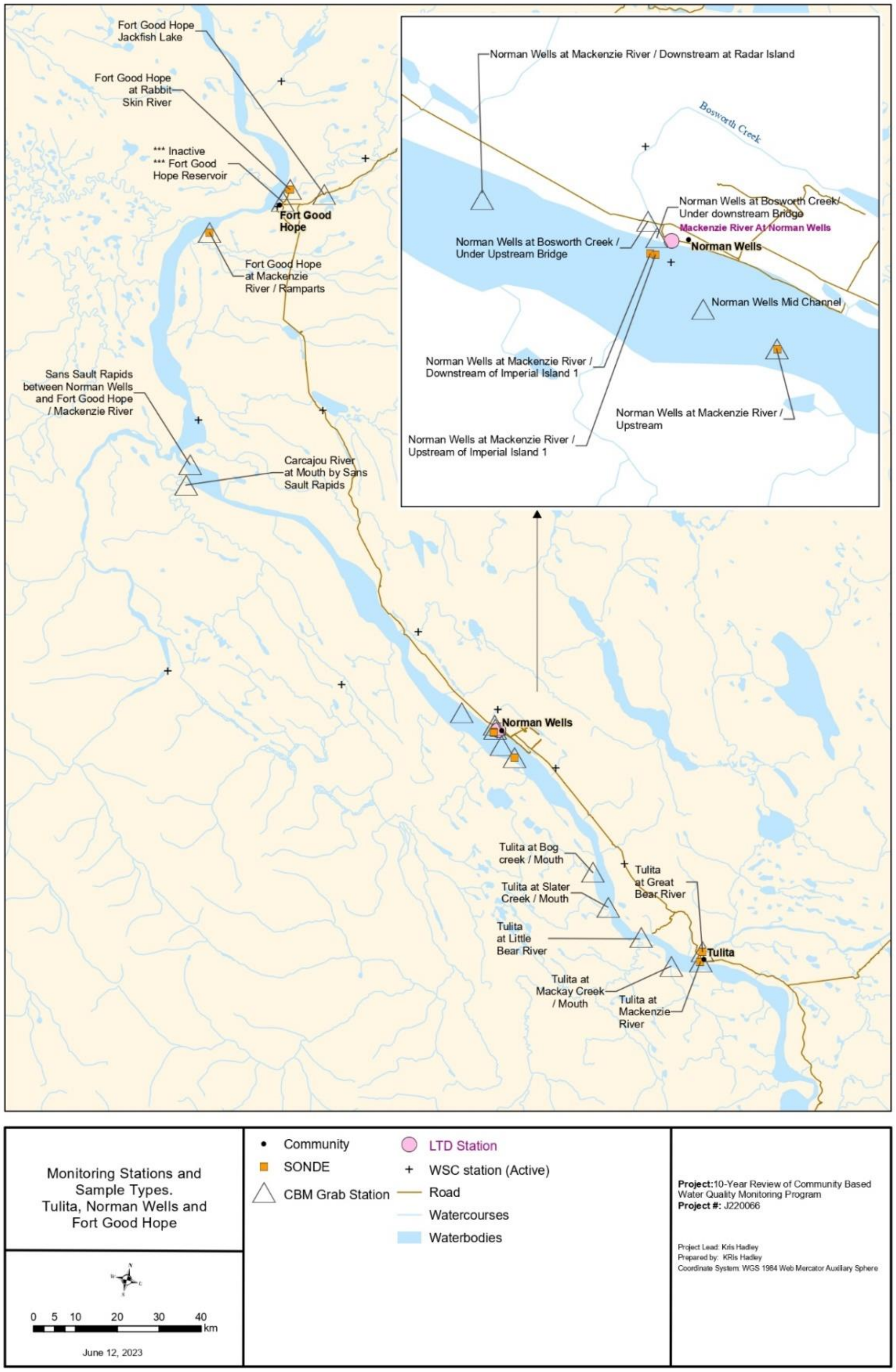


Figure 21: CBM program water sampling sites (open triangle or orange square) around Tulita, Norman Wells and Fort Good Hope.

What is Water Quality Like Here?

- Water quality at the Mackenzie River site near Tulita was similar to other sites along the river between Wrigley and Inuvik.
- Water quality was highly variable across the tributaries feeding into the Mackenzie River around Tulita, likely due to different local conditions in these creeks and rivers.
- The Great Bear River flows from Great Bear Lake, where the waters are clear and have low levels of nutrients and metals, similar to those found in Great Slave Lake (Figure 22).
- In comparison, Bog Creek, Mackay Creek, and Slater Creek are very turbid because their origins are in the western mountains.
- Exceedances of CCME guidelines occurred frequently for several substances at the mainstem site and most tributary sites, except at the Great Bear River.
- Substances that most often had exceedances included total aluminum, cadmium, copper, iron, and lead. These metals tend to attach to dirt and are usually found in higher concentrations in turbid waters.

Figure 22: Satellite imagery courtesy Google Earth showing the Great Bear River entering the Mackenzie River at Tulita.

Norman Wells

Five sites were monitored around the community of Norman Wells: three along the Mackenzie River and two on Bosworth Creek, which drains into the river (*Figure 21*).

What is Water Quality Like Here?

- Water quality along the Mackenzie River, near Norman Wells, was similar to that of other sites along the river between Wrigley and Inuvik.
- Despite significant oil and gas development in the region, no differences were found in water quality between Mackenzie River sites upstream, midstream, and downstream of oil and gas facilities.
- Water from Bosworth Creek had higher conductivity, lower turbidity (*Figure 21*), and lower levels of nutrients and total metals than water from the Mackenzie River.
- Water samples frequently exceeded CCME guidelines for several total metals, including aluminum, cadmium, iron, lead, and mercury, due to increased sediment and these metals binding to soil particles.

Sans Sault Rapids and Fort Good Hope

Water quality was monitored at four sites in the Sans Sault and Fort Good Hope regions. Two sites along the Mackenzie River (one near the San Sault Rapids and one site at Fort Good Hope), a site on the Carcajou River (which flows into the Mackenzie upstream of the San Sault Rapids) and a site at the Rabbit Skin River (which flows into the Mackenzie downstream of Fort Good Hope) (*Figure 23*).

What is Water Quality Like Here?

- Water quality at San Sault Rapids and Fort Good Hope was similar to that of other locations along the Mackenzie River. San Sault Rapids and Fort Good Hope experienced similar conditions to those elsewhere along the Mackenzie River, between Wrigley and Inuvik.
- Like other rivers that flow into the Mackenzie River from the western mountains, the Carcajou River had elevated turbidity, nutrients, major ions (such as salts) and metals.
- Rabbit Skin River, which originates in the east, had lower turbidity, metal, and nutrient levels than the Carcajou.
- Several total metals occasionally exceeded CCME guidelines during the monitoring period, including aluminum, cadmium, copper, iron, and lead.

Mackenzie Delta and Peel River

Seven water quality sites were monitored in the region of the Mackenzie Delta and Peel River. Two sites were upstream of the Delta at Tsiigehtchic (one on the Mackenzie River and one on the Arctic Red River), two sites were in the Delta at Inuvik and Aklavik, and three sites were on the Peel River and its tributaries (Frog Creek and Vittrewka River) near Fort McPherson (*Figure 23*).

Figure 23: CBM program water sampling sites (open triangle or orange square) in the Mackenzie Delta.

What is Water Quality Like Here?

- Water quality in this region was strongly influenced by permafrost slumping. The large-scale thawing of frozen ground can lead to sudden drastic increases in turbidity, sediment, nutrients, and metals in affected waters.
- Most rivers in this region were very turbid, with elevated amounts of salts, nutrients, and metals. Levels of several substances, including total aluminum, copper, iron, and total suspended solids, were significantly higher than in any other part of the Mackenzie River Watershed.
- High turbidity was measured at locations where massive permafrost slumping has occurred, including Fort McPherson at Peel River, Fort McPherson at Vittrekwa, and Aklavik on the Mackenzie River Delta.
- In contrast, Frog Creek, which has experienced less slumping, did not have extremes in turbidity and associated metals and nutrients.
- Several total metal parameters exceeded CCME guidelines in water samples here (including aluminum, cadmium, copper, iron, and lead), likely linked to the extreme episodes of soil and sediment being washed into rivers due to slumping (*Figure 24*)

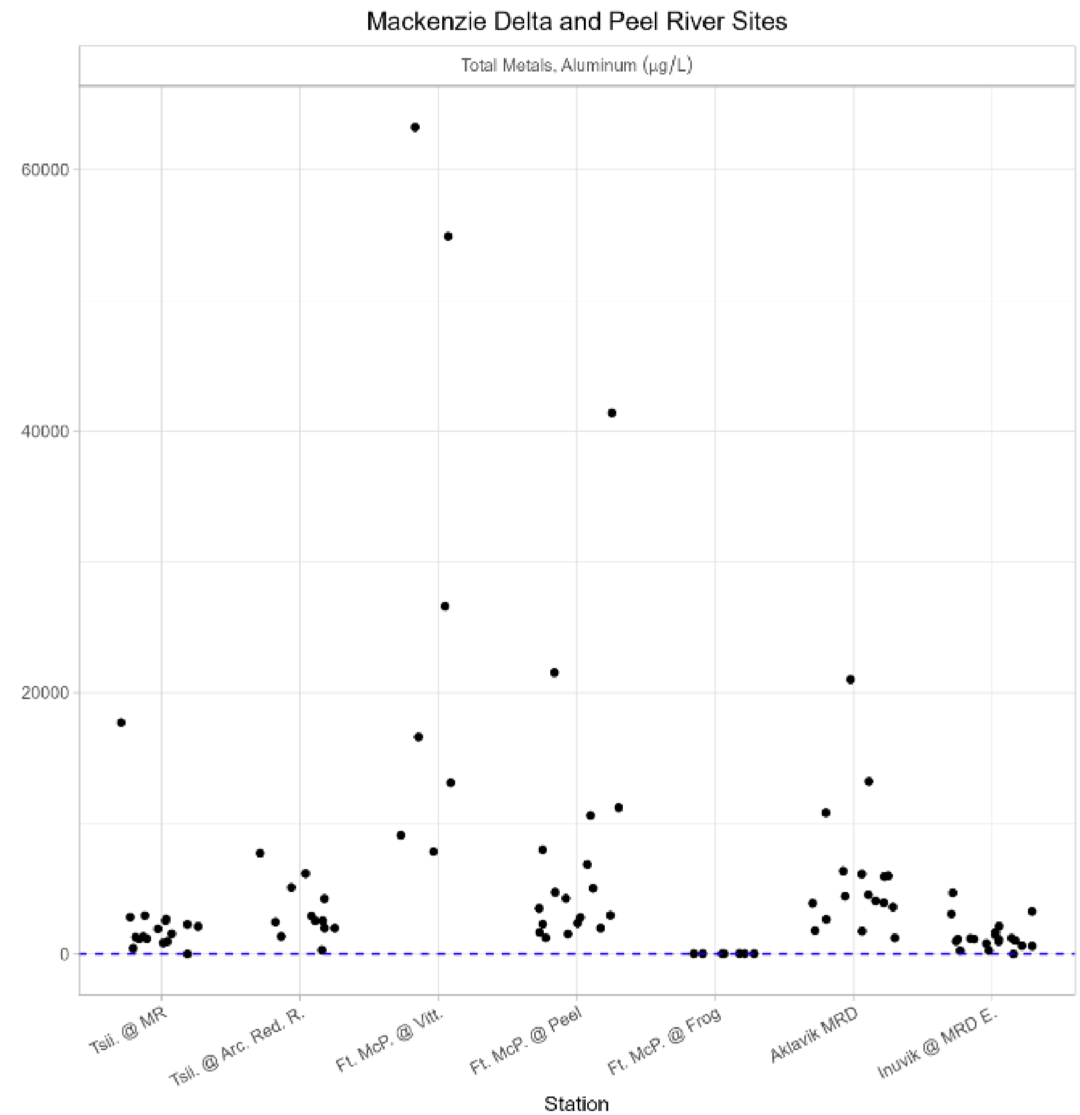


Figure 24: Aluminum measured at Mackenzie Delta sites of the CBM program. Here, total aluminum is shown as a representative metal, with the blue dashed line representing guideline concentrations. The increase is due to sediment inputs, likely from permafrost slumping on the Peel Plateau. Data from 2012-2021. (MR = Mackenzie River, Arc. Red. R = Arctic Red River, Ft. McPh = Ft. McPherson, Vitt = Vittrewka River, Frog = Frog Creek, Tsii = Tsiigehtchic, MRD E = Mackenzie River Delta East).

- The high levels of turbidity and metals measured in waters affected by slumping are significantly higher than those observed elsewhere in the watershed. Impacts on fish and wildlife in the region are unknown. Metals associated with suspended dirt particles are usually tightly bound to this dirt and are not readily taken up by fish and wildlife. However, high levels of dirt in water may still have negative impacts on fish and wildlife.

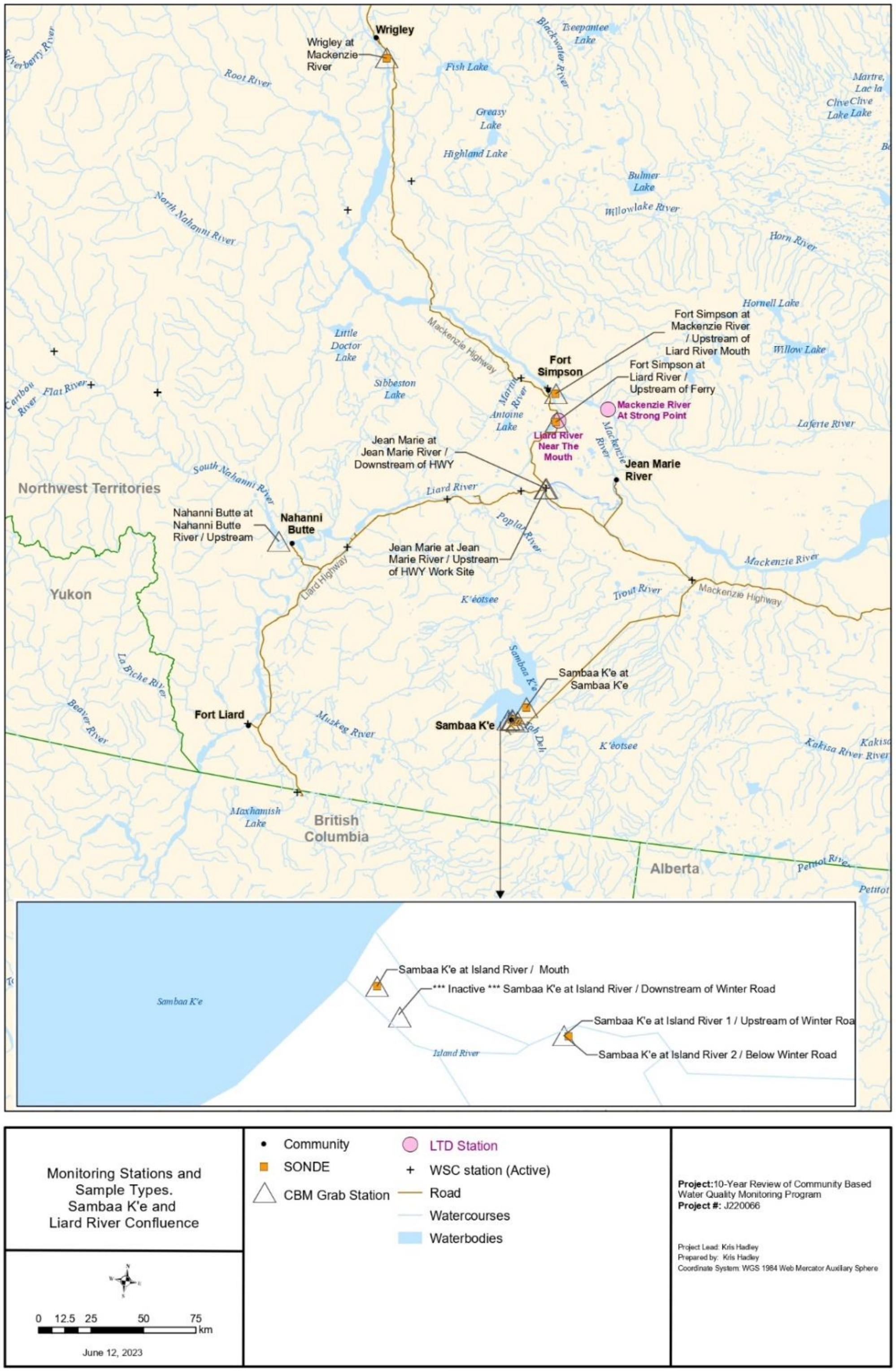


Figure 25: CBM program water sampling sites (open triangle or orange square) around Sambaa K'e

Sambaa K'e Lake

Five sites were monitored in Sambaa K'e – three at the mouth of the Island River, one in the western channel, and one in the central basin of the lake (*Figure 25*).

What is Water Quality Like Here?

- The water quality in the lake was similar to that of Great Slave Lake, characterized by low turbidity, low nutrient levels, and few substances exceeding guideline values.
- Within the lake, the waters at the mouth of the Island River had slightly higher turbidity, nutrients, and major ions than the other two sites, which were farther away from the river's influence.

Summary of Water Quality Findings

Three main patterns were apparent in the water quality results across the regions, all of which were driven by the underlying geology and natural features of the watershed.

The first pattern is linked to the Mackenzie and Selwyn mountains. Water samples collected from the Peel River, the Mackenzie River Delta downstream of the Peel, and the Nahanni Butte River were all highly turbid. They had elevated levels of total metals and total phosphorus. These rivers all originate in the Mackenzie and Selwyn mountains, where rock weathering releases mineral-rich runoff to waterways. The Peel and Nahanni Butte also travel through areas prone to permafrost slumping, which can result in occasional extreme sediment inputs.

The second pattern is linked to the Taiga Plains and similar ecozones east of the Mackenzie River. Water samples from the Hay River and Tulita tributaries (Bog, Slater, and Mackay creeks) had high levels of dissolved solids, nutrients, and dissolved organic carbon. The numerous wetlands in the area contributed to elevated levels of organic matter in the Hay River.

The third pattern is linked to the Canadian Shield. Water samples collected from sites located on the Shield, such as Great Slave Lake, had low levels of major ions (salts, including sodium, potassium, and chloride), as well as dissolved organic carbon. The Shield has thin soils and granite bedrock that weathers very slowly, resulting in runoff that is low in mineral and organic content.

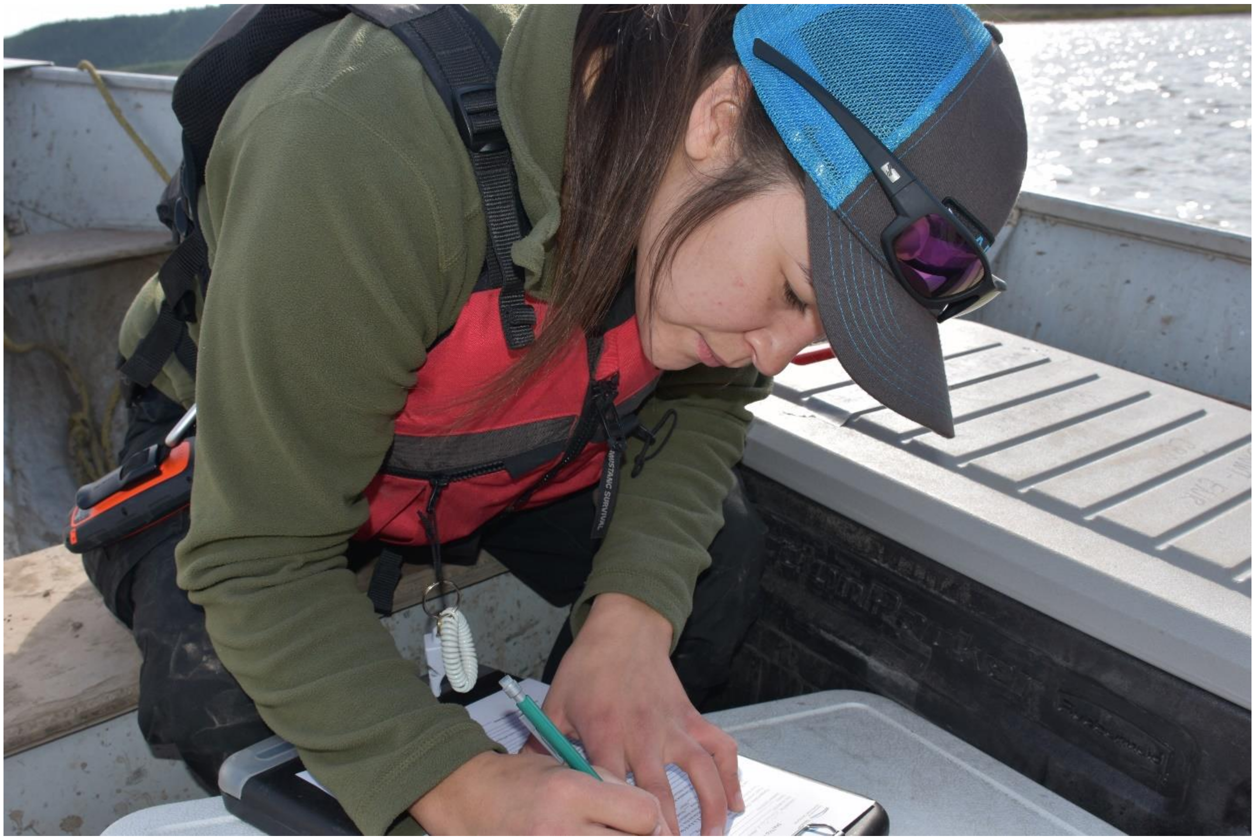


Figure 26. Catherine Graydon, a GNWT Water Monitoring and Stewardship Coordinator, records field notes, 2022.

Data Sonde Results

Water quality can change dramatically over hours or days in response to short-term events, like daily temperature variations and local storms. Grab samples, which are collected monthly, cannot capture this variation, but data sondes, which take measurements every two hours, can be used to track changes over time.

For example, during the 2017 review of the CBM Program, concerns were raised that dissolved oxygen levels were low at several locations based on grab sample data. However, it was not possible to determine the severity of the reduced oxygen concentrations or their duration. Data sonde sampling has filled in these gaps, revealing that dissolved oxygen levels in the Mackenzie River and its tributaries in Great Slave Lake did not drop below guidelines for the protection of aquatic life during the adult life stages during the monitoring period.

Water Quality Changes Over Time

Communities in the NWT portion of the Mackenzie River Watershed have expressed concern with how water quality changes over time in the region. This review of the first 10 years of the CBM Program allows us to address this question.

When examining water quality trends, it is essential to consider that as more data becomes available, our confidence in the results increases. In other words, the larger the number of samples, the more confident we can be that the observed trends accurately represent what is happening in the environment. The more samples we have, the more confident we can be that the observed trends accurately represent what is happening in the environment. While 10 years of monitoring data may seem like a lot, it is a relatively short period on an environmental timescale and may not capture the full range of factors affecting water quality, nor the natural variation in water quality that occurs over time.

Comparing the results from the 10-year CBM review with those from the 5-year CBM review highlights the importance of collecting additional data. For example, the 5-year review found that two dissolved metals, aluminum and lithium, were rising across the region (based on data from 2012 to 2016). Additionally, aluminum and lithium were rising across the area during the same period. Re-analysis with five additional years of data (2012-2021) indicated that these metals were not increasing at most sites. Similarly, increases in sulphate levels found in the 5-year review downstream of Norman Wells were no longer apparent in the 10-year review; however, they continued to be evident in the Peel River, as sampled at Fort McPherson.

Analysis of the 2012-2021 data set indicated increasing trends in sulfate, chloride, and dissolved lithium for the Slave River. There were decreasing trends for dissolved organic carbon for both the Slave and Mackenzie rivers.

How is the CBM Program Doing?

The CBM program fosters water stewardship through informed decision-making. The program was initiated to encourage communities to participate more actively in water monitoring and ensure that the results are meaningful to community members. The 10-year review found that, overall, the program is doing well in meeting its objectives. In particular, the CBM program:

- is tailored to address community concerns,
- has widespread geographic coverage in the Mackenzie River Watershed, focused around 21 communities,
- is designed to allow comparison at multiple spatial scales, from local creeks up to the entire watershed,
- is designed to allow comparison at multiple timescales, from hours (data sondes) to months (grab samples) to years (long-term trend assessment),
- provides a comprehensive assessment of water quality by monitoring over 90 parameters, which include dissolved and total metals, major ions, nutrients, chlorophyll, and physical measurements (such as water temperature, pH, and dissolved oxygen), and
- has a 5-year reporting and review cycle, which allows enough data to accumulate for meaningful analysis of change over time and space.

The CBM program was compared to federal water quality monitoring programs carried out at nearby locations across the Mackenzie River Watershed. Generally, similar patterns and trends were observed. Some differences were observed, but these are likely explained by variations in monitoring design between programs, such as the timing and frequency of sample collection. Federal programs have also been in operation for much longer and have accumulated significantly more data.

Most community concerns about water quality have been addressed in the first 10 years of sampling, or may be addressed in future sampling, as indicated in the table below.

Table 2. Community Questions Answered by CBM

Community Concern	Answers/Evidence provided by the CBM to address question
General	
Has there been change in the water over time and seasons?	The dataset cannot address seasonality due to the sampling regime.
	Temporal trends reveal 10-year changes in certain parameters; however, many of the 5-year trends are no longer statistically significant, underscoring the importance of maintaining a long-term record. As the dataset grows, changes in trend assessments with new data will be less likely to occur.
Development and Land Use Change	
Are there contaminants that can affect the health of fish and wildlife in the water?	In general, water quality guidelines for the protection of aquatic life were only exceeded by total metals associated with high suspended solids.
	Exceedances of livestock guidelines, used as a proxy to determine potential impacts on wildlife, were very rare, suggesting minimal risk to wildlife.
	PMD analysis is provided in a stand-alone report.
Are stressors from climate change affecting water quality?	Water quality data in the Peel River system indicate climate change impacts, which have manifested as permafrost thawing and slumping, accompanied by increases in total suspended sediments and associated metals.
Local	
What is the water chemistry in the various watersheds contributing to the Mackenzie River around Tulita?	Spatial analysis of the Tulita site suggests significant variability in the water quality of the various inputs to the Mackenzie River.
How does water quality compare between upstream	A comparison of the Fort Smith and Resolution Bay sites did not indicate significant differences in water quality between upstream and downstream locations in the Slave River.

and downstream locations on the Slave River?	Additional analysis, including merging the Slave River long-term data (ECCC) with CBM data, which may be challenging, would be necessary to assess water quality in the Slave River further.
Is permafrost slumping impacting water quality?	Data collected by the CBM program (total suspended sediments, major ions, and metals) coupled with recent scientific literature from studies in the region suggest that slumping may be one of the most significant drivers of water quality change in the area. The CBM data confirm the observations reported in the literature.
	Sonde data suggest frequent significant increases in turbidity; however, without a special study, these results cannot be directly attributed to permafrost slumping.
What is the water chemistry in the various watersheds contributing to the Peel River (including from differing geomorphological influences)?	Spatial analysis of the Peel and Mackenzie Delta sites characterized the water quality in the region, but there were limited data for the tributaries contributing to the Peel River, specifically Frog Creek and Vittrekwa. Inputs of total suspended sediments from numerous mega-slumps, which have been linked to the thawing of permafrost, are a major geomorphological influence on water quality. The individual contributions of the rivers and creeks in the Peel River system are outside the scope of this dataset.
What is the difference in water chemistry, and metals between Mackenzie Tributaries and the main river stem?	Water quality and metal levels are influenced by geological differences. For example, tributaries which flow from the western mountains tend to display much higher variability in suspended solids and associated parameters (e.g., metals), and bedrock geology influences the concentrations of total dissolved solids and major ions in different watersheds.

Figure 27 CBM program participants come together at a workshop to receive training and exchange knowledge (2022).

Recommendations

Overall, the CBM program's sampling methods and frequency create meaningful results and compare well to other programs. Since 2016, data management has undergone significant improvements with the implementation of an internal database (Lodestar) and a publicly available online data portal (Mackenzie DataStream).

The 10-year review made several recommendations to improve the CBM program:

It is recommended that the data analysis approach be reviewed and adapted at regular, approximately 5-year reporting intervals to accommodate the increasing size of the dataset, evolving conditions in the watershed, such as climate change and development pressures, and newly emerging community concerns.

Water quality regulations and standards can vary regionally and may need to be adapted to the specific characteristics in question. For instance, the acceptable limits for wastewater runoff from a lagoon area may differ from limits set for a dump site. A general program would not account for this diversity, whereas site-specific studies allow for better alignment with local regulations and more relevant policy recommendations.

Water quality is highly dependent on the unique characteristics of each site, including factors such as:

- Geography (e.g., proximity to water bodies, topography, drainage patterns)
- Hydrology (e.g., groundwater flow, surface water interaction)

- Climate (e.g., rainfall patterns, temperature)
- Human activities (e.g., industrial use, waste management practices)

The CBM program could add more sites in areas experiencing permafrost slumping, such as the Root, North Nahanni, Redstone, Keele and Mountain rivers. However, all these rivers are far from any communities, which can make access challenging.

CBM program objectives may simplify complex environmental interactions, leading to inaccurate or generalized assessments of the impact on water quality. By conducting individual studies for each incident, lagoon or dump, researchers can gather more precise data on water quality parameters (e.g., pH, turbidity, concentration of specific pollutants) and make more accurate predictions of environmental impacts.

Conclusions

The first 10 years of the CBM program have shown that water quality across the NWT's portion of the Mackenzie River Watershed is largely influenced by:

- Where the water is (for example, lake, mainstem, tributary, or delta),
- The geology of tributary watersheds feeding into waterbodies, and
- Permafrost thawing and slumping.

The headwaters of the Mackenzie are fed by clear waters from Great Slave Lake, but farther downstream the river becomes turbid where it meets the Liard River, which carries high amounts of dirt. Tributaries that originate in the western mountains, such as the Liard, are rich in dirt and associated metals because the rocks that make up these mountains are easily broken down by the elements through weathering.

Water quality in the Hay River is influenced by the many wetlands contributing dirt and organic material to the waterway. Climate warming appears to be affecting water quality in some regions through the thawing of permafrost, which causes the ground to collapse into surrounding lakes and rivers.

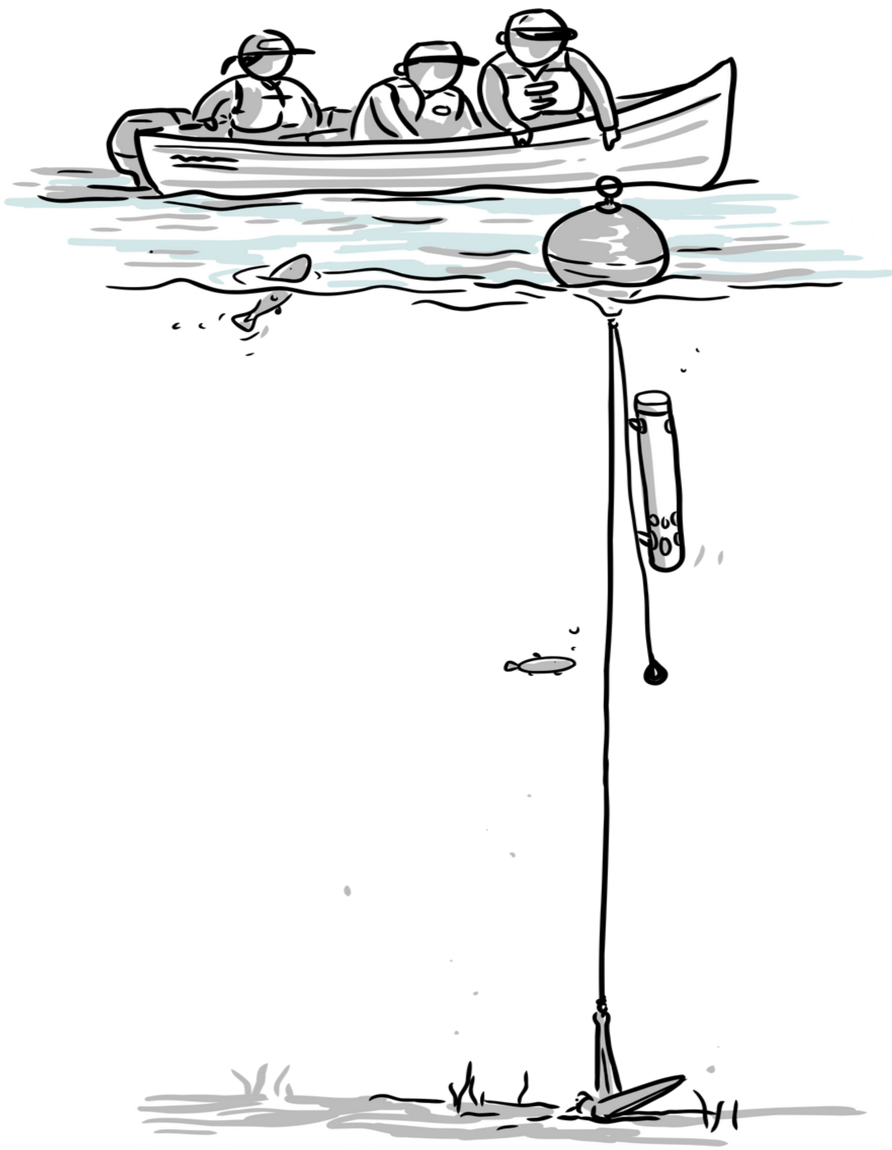
Samples collected from turbid tributaries and downstream sections of the Mackenzie River often exceeded guidelines for protecting aquatic life, particularly for total metals and dissolved oxygen. Since turbidity is a natural feature of these waterways, resident fish are likely adapted to these conditions. Extreme levels of turbidity measured in the Peel River system, however, are likely caused by permafrost slumping, a relatively new phenomenon that fish and wildlife may not be adapted to in this region.

To address knowledge gaps about hydrocarbons in the NWT, GNWT staff collaborated with Environment and Climate Change Canada to investigate the relative abundance and concentrations of hydrocarbons across space and time (2012-2021) in the Mackenzie River basin. The analysis determined that levels of hydrocarbons are ultra-low in the NWT.

Overall, the results suggest that the CBM program is effective and consistently generates reliable and meaningful data. The 10-year CBM review found no indication that human disturbance or industrial activity is affecting water quality across the region. Community monitors continue to work collaboratively and diligently with GNWT technicians and scientists to maintain this valuable CBM long-term water quality monitoring network, benefiting all residents of the NWT.

All CBM data are available on Mackenzie DataStream (mackenziedatastream.ca).

Figure 28: CBM monitors and GNWT staff in Kakisa (Melaine, George, and Sadie Simba, Jayden Grandjambe, Laura Krutko, and Sarah Chapman, 2023).



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