Integrating Indigenous Knowledge into a Community Contaminant and Climate Change Monitoring Program

Tr'ondëk Hwëch'in First Nation Community Report

2013

Prepared by the Yukon River Inter-Tribal Watershed Council

ONE PEOPLE-ONE RIVER

Yukon River Inter-Tribal Watershed Council

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Acknowledgments

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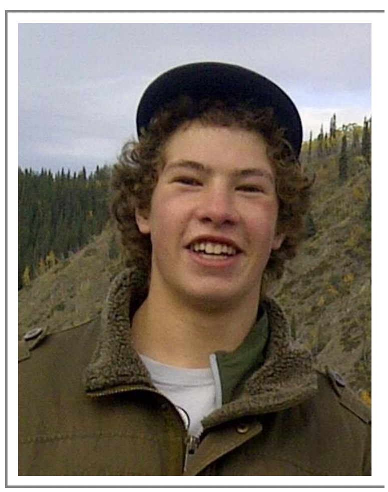

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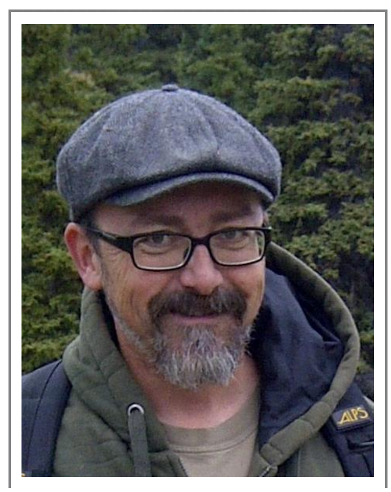

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Introduction

This report details the results of the Yukon River Inter-Tribal Watershed Council's community-based research project "Integrating Indigenous Knowledge and Public Health Concerns into a Community Contaminant and Climate Change Monitoring Program" conducted with Tr'ondëk Hwëch'in First Nation.

Climate change and environmental degradation pose significant threats to Arctic and Sub-Arctic freshwater systems and their Indigenous inhabitants. Scientific studies indicate that these regions are among the first to experience the impacts of climate change (Serreze et al. 2000; ACIA 2005; Hinzman 2005; IPCC 2007). Indigenous peoples whose subsistence livelihoods rely on the lands and waters within their traditional territories are closely connected to their local geography and consequently, they are among the first to feel the effects of climate change (Berkes, Folke, and Gadgil 1995; Nyong, Adesina, and Osman Elasha 2007; Turner and Clifton 2009). Furthermore, environmental degradation other than climate change also has significant implications for subsistence livelihoods. Contaminants transported from local and long-range sources are known to impact traditional food systems in the Arctic and Sub-Arctic (Kuhnlein and Chan 2003). The Indigenous inhabitants of the Yukon River Basin have identified the impacts of climate change and environmental degradation to the Yukon River and its tributaries as major threats to their lives and livelihoods.

During open floor discussions at the Yukon River Inter-Tribal Watershed Council's (YRITWC) Summit in August of 2011, First Nations discussed concerns about their health risks, unpredictable

Text Box 1. What is the Yukon River Inter-Tribal Watershed Council?

The Yukon River Inter-Tribal Watershed Council is a treaty-based Indigenous grassroots organization consisting of 70 First Nations and Tribes, dedicated to the protection and preservation of the Yukon River Basin.[1]

events of climate change, and exposure to contaminants. First Nations called on the YRITWC staff to assist them with conducting community-based research to assess and monitor climate change and contaminants within their traditional territories (See Figure 1).

Figure 1 Map of the Yukon River Basin

Text Box 2 What Is Traditional Knowledge?

”Traditional knowledge is a constantly evolving body of information, which originated generations ago and is built upon daily; therefore it must be understood that any definition of traditional knowledge will not be static and must be given room to expand and change, as Tr’ondëk Hwëch’in grows and evolves” (Tr’ondëk Hwëch’in First Nation 2012, 2).

Traditional Knowledge, also referred to as Indigenous Knowledge, is defined as “a cumulative body of knowledge and beliefs handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Further, TEK is an attribute of societies with historical continuity in resource use practices; by and large these are non-industrial…, many of them indigenous or tribal” (Berkes 2008: 7).

This project integrates Indigenous Knowledge of the environment into a community contaminant-monitoring program (i.e., heavy metals, hydrocarbons, nutrients, and bacteria) for five Yukon First Nations. The main question that this project aimed to answer was two-fold:

1. What concerns do First Nations have regarding climate change, public health, and contaminants?
2. What are the baseline levels of contaminants within these communities?

During this project, the YRITWC worked with the First Nations of Selkirk, Tr’ondëk Hwëch’in, Kluane, White River and Carcross/Tagish in developing their research project and increasing scientific capacity of First Nation members. This report details the results of the research conducted in Tr’ondëk Hwëch’in First Nation.

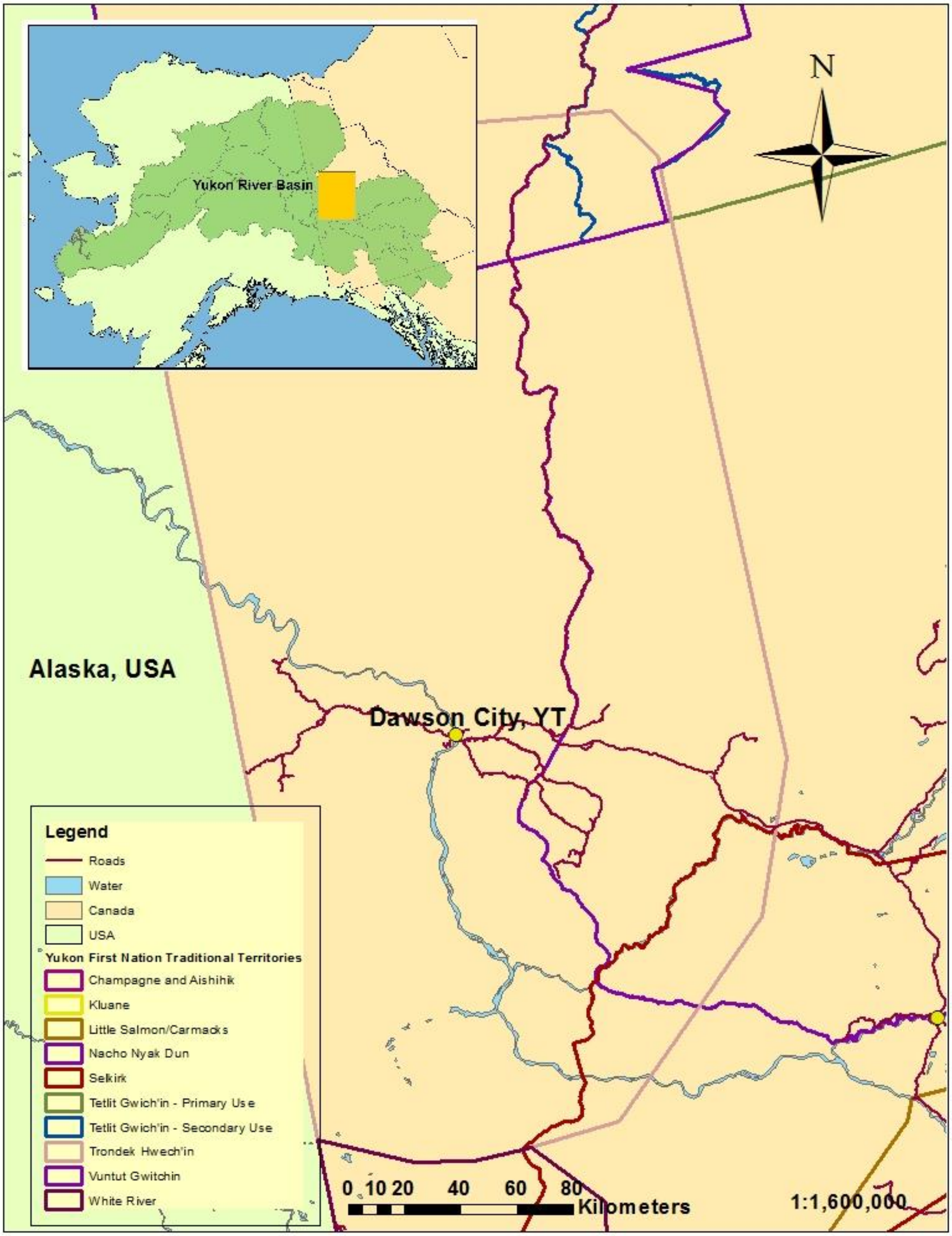
Community Context

The Indigenous people of Dawson City are known as the Tr'ondëk Hwëch'in First Nation. The Tr'ondëk Hwëch'in are part of the Hän nation. The Hän language is part of the Athapaskan language group. The Tr'ondëk Hwëch'in people have relied heavily on salmon from the Yukon River. They also hunted large game including moose and caribou. They moved according to the seasons as they engaged in these subsistence livelihoods (Government of Canada 2004).

The Tr'ondëk Hwëch'in faced massive social changes over the past century. During the Klondike Gold Rush, the Tr'ondëk Hwëch'in relocated to Moosehide, located five kilometres down river from Dawson. Today, they continue to rely heavily on subsistence livelihoods. The Tr'ondëk Hwëch'in signed their land claims and self-governance agreements in 1998 (Government of Canada 2004). The current THFN Citizenship includes approximately 1,000 descendants of Hän-speaking people,[1] approximately 40 percent of who reside in other parts of the Yukon or elsewhere of Canada (Government of Canada 2004).

[1] http://www.trondek.ca/aboutus.php

Figure 2 Map Tr'ondëk Hwëch'in First Nation Traditional Territory



Research Design

This project is characterized by a community-based participatory approach. Community-Based Participatory Research (CBPR) is, first and foremost, designed to meet the needs of local communities: "In contrast to more traditional investigator-driven research, CBPR begins with an issue selected by, or of real importance to, the community, and involves community members and other stakeholders throughout the research process, including its culmination in education and action for social change" (Minkler and Wallerstein 2011, 1–2). This project also has a multidisciplinary research design, meaning that it uses methods from both the social and biophysical sciences to examine First Nation concerns related to the impacts of contaminants and climate change on water.

In the summer and fall of 2012, the YRITWC research team conducted interviews and a focus group with members of THFN. Semi-structured interviews were conducted with key stakeholders to gather in depth information on the importance of water for the community as well as concerns about changes in water resources as a consequence of either contamination or climate change. Fifteen interviews were conducted in total. Nine out of fifteen community members were Elders. The remaining six participants were middle-aged community members. Four of the participants were THFN staff. Interview participants were asked to describe the importance of water to their community and any changes in water resources they observed within their traditional territory. Interview participant's observations of change contributed to the identification of water quality sites of concern.

A focus group was held at the Tr'ondëk Hwëch'in Community Support Centre on September 11th, 2012. Seven people attended the focus group. Three of the focus group participants also completed an interview. Therefore, a total of nineteen individuals participated in this research.

During the focus group the YRITWC used a participatory mapping exercise (Donovan et al. 2009) as a primary means for gathering data. Where possible, focus group participants identified, mapped and discussed sources of contamination and the associated impacts on water resources. Using ArcGIS, a map of the THFN traditional territory was projected on a screen and focus group participants took turns identifying sites of concern on the map. A laser pointer was used to indicate the exact location. Sites of concern were recorded as points in ArcGIS 10, a spatial mapping program. A note taker recorded the site descriptions provided by participants including the suspected source of contamination. A total of 26 sites of concern were identified.

The YRITWC had funds available to sample at five sites. During the focus group, the YRITWC used a voting process to prioritize the top five sites of concern. Each of the focus group participants was provided ten stickers and was directed to place the stickers on their areas of greatest concern. Participants could put more than one sticker next to a given site name. The names of all sites were written on a piece of paper and participants placed stickers next to the sites they felt should be prioritized for water sampling.

The next step of the research process was to collect water samples from each of the five prioritized sites. Water sampling was conducted between August and October of 2012. YRITWC environmental technicians conducted water sampling with help from the youth intern and staff from the THFN Natural Resources Department.

The research was designed in accordance with the Tr’ondëk Hwëch’in Traditional Knowledge Policy allowing us to provide research data to the THFN Archive for future use. Research data will not be released without the consent of the individuals involved. Copies of all interview data were returned to the THFN Heritage Department for this purpose. The YRITWC consider this an important step in the research process as it allows First Nations to maintain traditional knowledge for their own use. This community research report allows the YRITWC research team to return the results of this research to the community in a usable format.

Youth Capacity Building

Youth capacity building is another important aspect of the project. In each community, the YRITWC worked with one youth intern, identified by the First Nation as between the ages of 16-25. The youth were an important addition to the research team. Each of the youth received training in water quality sampling and in some cases permafrost monitoring. The youth interns assisted with focus groups and helped YRITWC's environmental technicians with water sampling. Their in-depth knowledge about the community and surrounding area was invaluable to the project. Tyler Rear was the THFN intern.

Results and Analysis

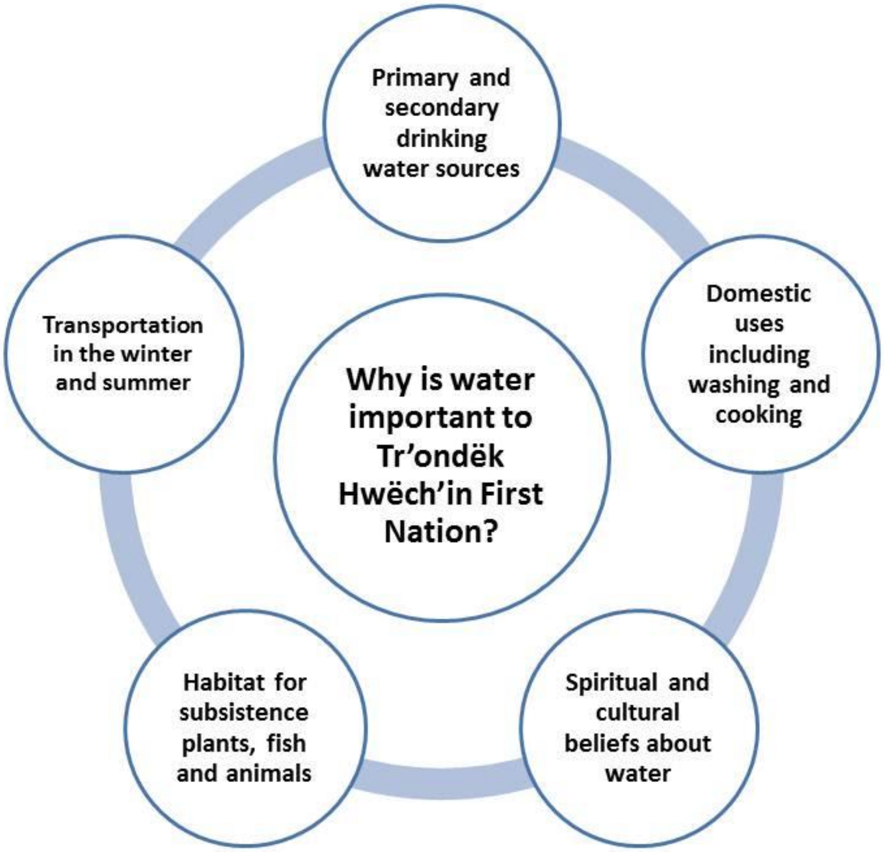
The Importance of Water to Tr'ondëk Hwëch'in First Nation

Water is important to the people of Tr'ondëk Hwëch'in First Nation for many reasons. Interview participants were asked to answer the question '*Why is Water Important to Your Community?*' Their responses reveal that water is essential to all aspects of life or as one interview participant put it,

> [m]y people have lived on the Yukon for millennia, thousands and thousands of years and we are going to continue to do so. Nothing is going to change that. We are going to do what we have to protect the Yukon River and the salmon that live in it, spawn in it, and that's where we are as Tr'ondëk Hwëch'in.

During the research project, many uses of water were identified (Figure 4). Water is used as drinking water. Primary and secondary sources of drinking water are used. Primary sources include delivered water from the water treatment centre and some private wells. Secondary drinking water sources include water from the Klondike River, various creeks and springs and occasionally from the Yukon River.

Figure 3 Why is water important to Tr'ondëk Hwëch'in First Nation?



The main sources of water that community members spoke about were Moosehide Creek, in the village of Moosehide and Wolf Creek, located on the Dempster Highway. The Tr'ondëk Hwëch'in Heritage Department often goes to Wolf Creek to collect water for Elders. Many THFN Elders stated that they prefer water from secondary sources to treated water, which tastes of chlorine. Other THFN community members stated that they often used these other sources when they are out on the land or at camp. Water also provides important habitat for a diversity of fish and wildlife. Rivers such as the Klondike and Yukon are also used as a transportation corridor both in times of open and frozen water. The uses identified above make it easy to see why water is integral to all aspects of subsistence livelihoods, which are central to First Nation culture and identity.

Documenting the importance of water is fundamental to establishing a community climate change and contaminants monitoring program for two reasons: 1) It allows us to understand how changes in water resources are impacting people 2) Cultural connections to water are also the inspiration for protecting water resources. The following section details the concerns that were raised about water quality and contaminants during the research process.

> "People have a hard time today, actually, to find good drinking water. I know people, they go up the Dempster. They call it Wolf Creek and they get pure drinking water and you could taste the difference between that water and the town water that we have here." (THFN Community Member)

Observations of Changes in Water Resources

The purpose of this project was to understand the impacts of contaminants and climate change on water and public health for Yukon First Nations. The following sections detail community water quality concerns and the results of baseline contaminant monitoring completed during the project and describe community observations of climate impacts

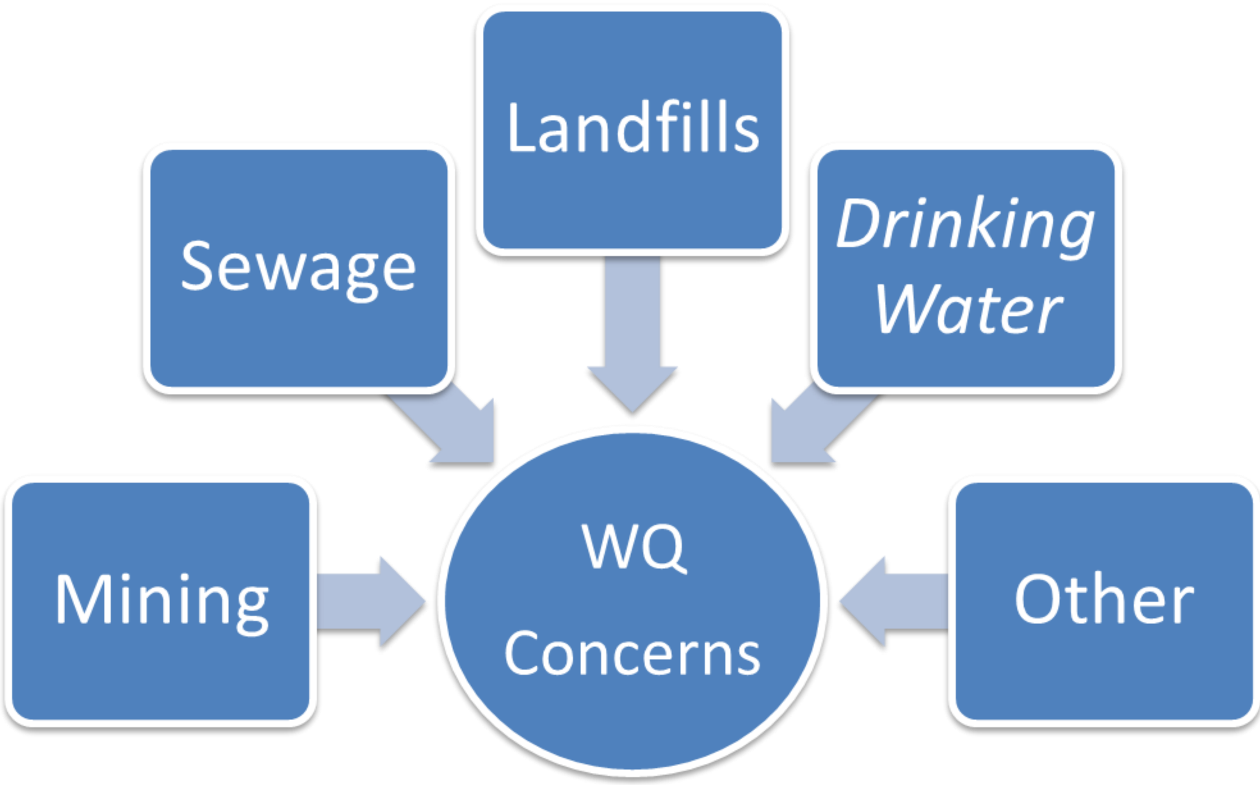
Community Water Quality and Quantity Concerns

THFN community members described a number of concerns about water quality and quantity during interviews and the focus group. Their concerns included the impacts of mining, sewage, landfills and other land uses. In some cases, maintaining existing water quality was identified as a priority in areas important for subsistence fishing and hunting or as sources of drinking water (See Figure 4).

> "There's mining, all along the river here, right to Whitehorse. All the rivers run into the Yukon. It's all mining. Waste, toxic stuff from all the mines. Oil, gas, leach mining, poison stuff, all flows into here. As long as they are mining it all runs in. I don't know how you get rid of it. You've got to have good plans. Filter it. I guess they do that, but I don't know if they do enough." (THFN Community Member)

The specific sites associated with these concerns are identified on the contaminants map that was created during the focus group (See Figure 5 to 7). Twenty-six sites in total were identified. Sites identified during interviews were subsequently added to the map. Detailed descriptions of these sites were recorded (See Appendix A).[2]

Figure 4 Types of Concerns Regarding Water Quality in THFN



[2] The sites of concern identified during the course of this research should not be considered an exhaustive list.

Figure 5 Participatory Contaminants Map in the Tr'ondëk Hwëch'in Traditional Territory

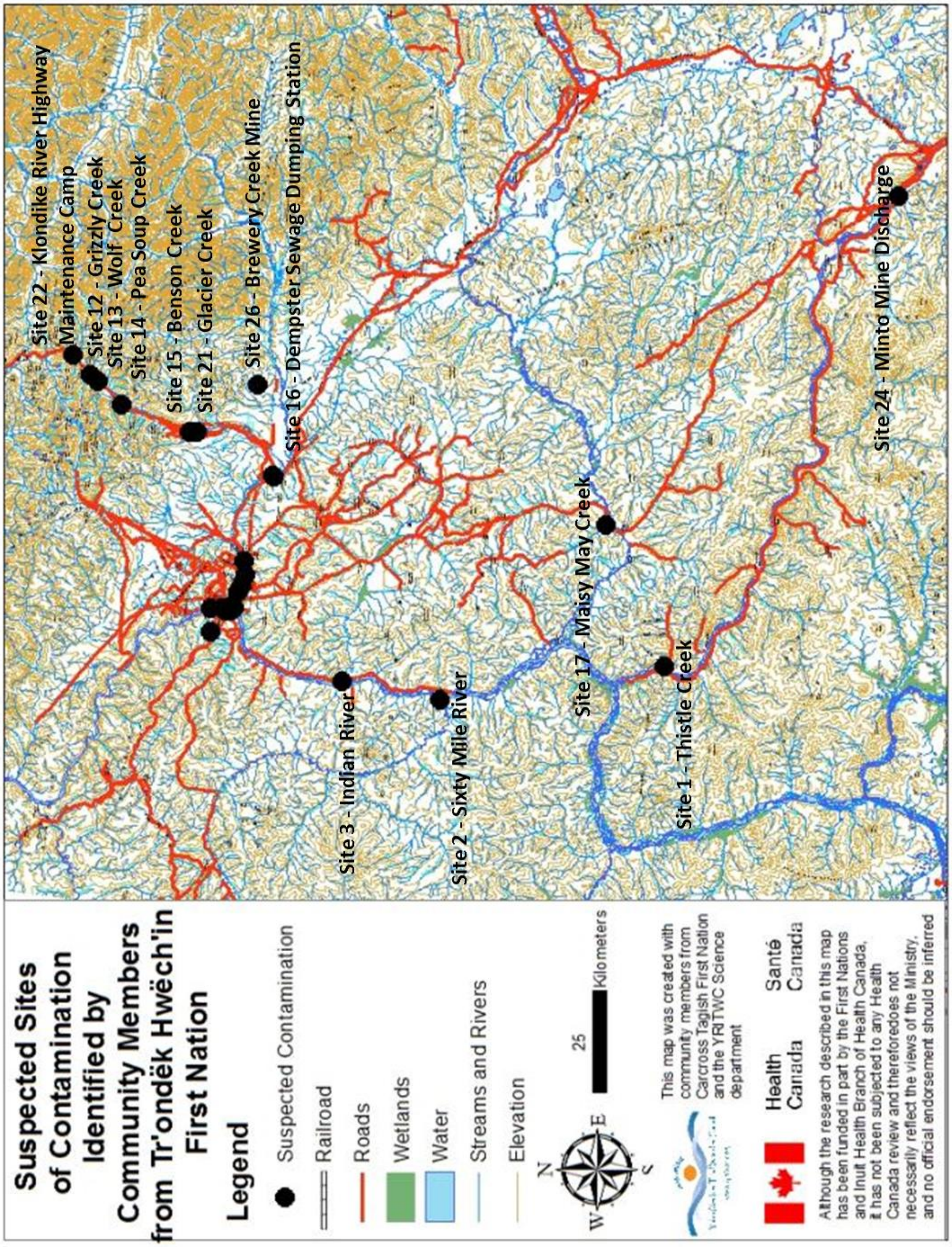


Figure 6 Water Quality Sites Identified near Dawson

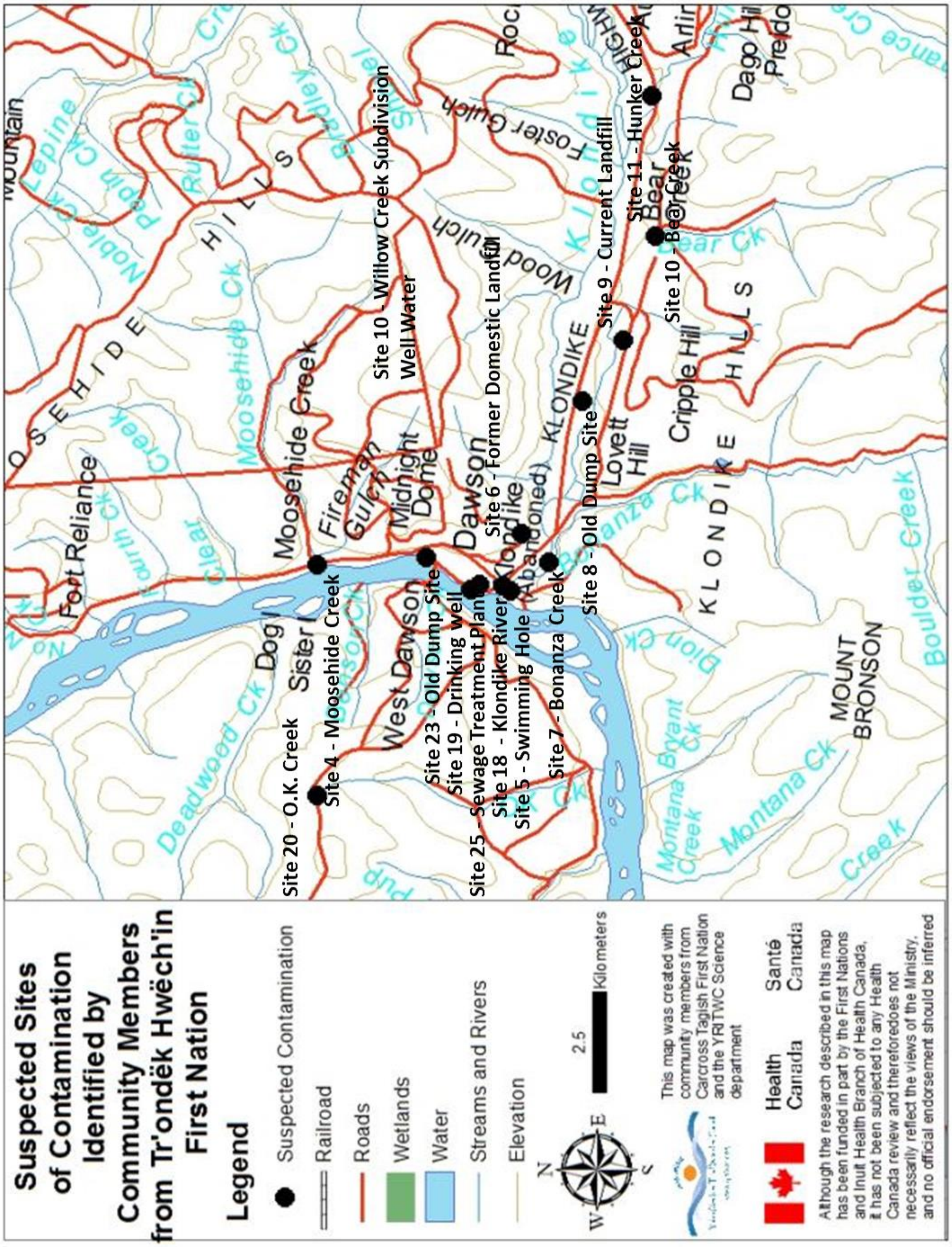
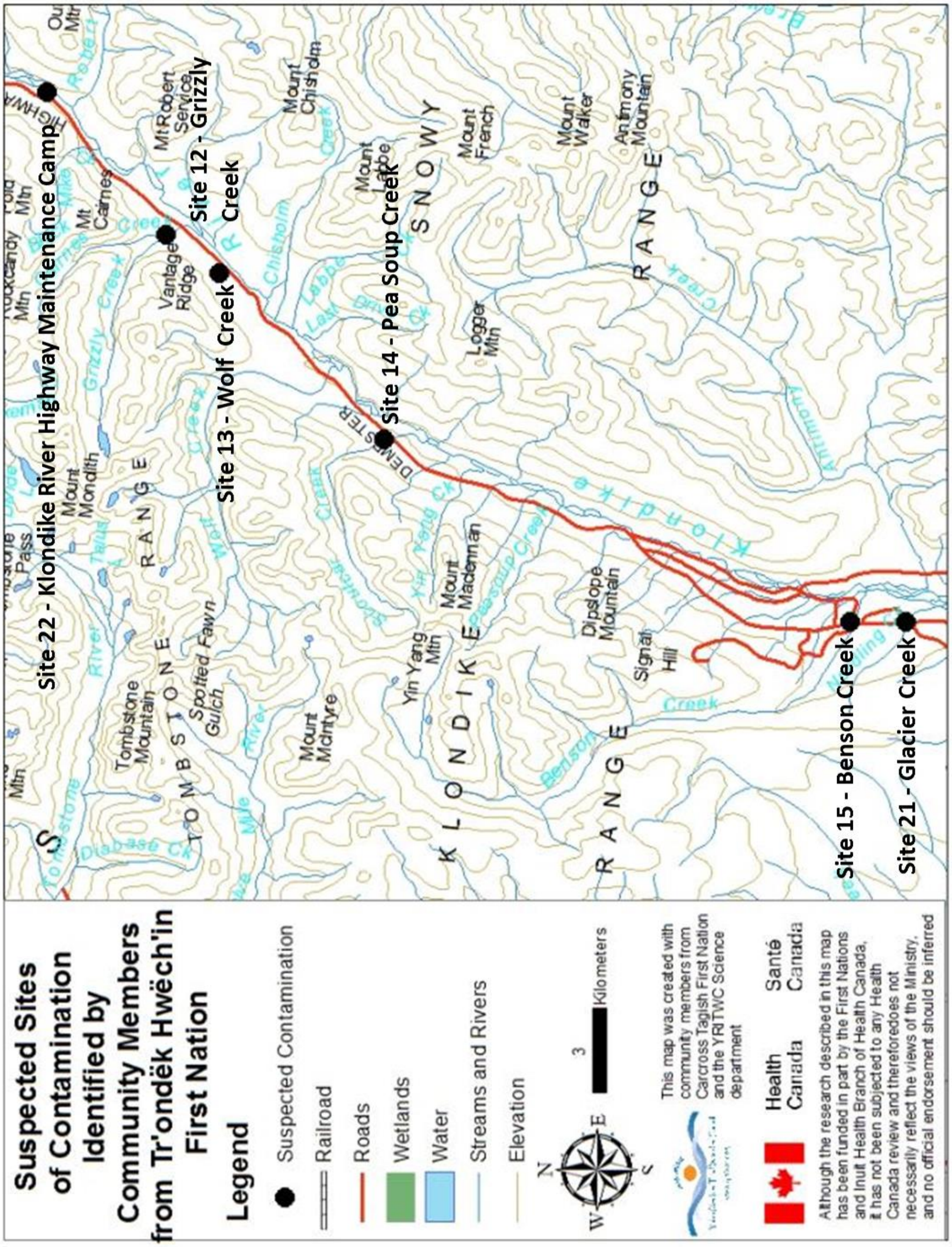


Figure 7 Water Quality Sites in Tombstone Territorial Park



Results of Water Quality Contaminants Monitoring

Water Quality Parameters and Physical Tests

Water was tested for a variety of parameters. A suite of metals, nutrients, bacteria, and hydrocarbons were analyzed at ALS Environmental Laboratory. The Yukon River Inter-Tribal Watershed Council, Indigenous Observation Network (including C/TFN), and US Geological Survey's Water Quality Monitoring Program are working together to collect baseline water quality samples for each of the sites identified by this project. For each sample collected, analysis was performed for the following dissolved parameters: major ions (alkalinity, chloride, sulphate, calcium, magnesium, sodium and potassium), some trace metals, nutrients (ammonium and nitrate), dissolved organic carbon, and stable water isotopes (deuterium and oxygen-19). Temperature, pH, and dissolved oxygen were measured in the field at each site. The following section provides a description of the water quality parameters mentioned above.

Metals

A suite of 19 metals was analyzed for this project. These metals are often naturally occurring; however, the Canadian Guidelines for Drinking Water Health Canada (2012b) indicates that the concentration of dissolved metals can be elevated by sewage effluent, mining effluent, landfill run-off, soil erosion, weathering of rocks, industrial waste, leachates from plumbing materials, air emissions, and irrigation. There is no evidence that the metals aluminium, calcium, sodium, iron, magnesium, manganese, selenium, and zinc have adverse health effects (*Ibid.*). Guidelines have been developed to ensure treated drinking water with no offensive taste, as consumers may seek alternative sources that are less safe.

Major Ions (Anions and Cations)

Major anions include alkalinity, chloride (Cl), and sulphate (SO_4). Major cations include sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), and some trace metals. Major ions come mostly from natural (geologic) sources and make up most of what is dissolved in water.

Alkalinity is a measure of the water's ability to buffer or balance acid-producing substances. Carbonates, bicarbonates, hydroxides, borates, silicates, phosphates, and some organic substances are represented by alkalinity. It is affected by the bedrock, soils and vegetation (EMAN-North 2005, 3–14).

Chloride is a useful parameter because it behaves conservatively; that is, it tends not to participate in chemical reactions and so the amount going into a river and the coming out tend to be equal. Chloride concentrations can be used to determine the origin of a water sample and to track long-term trends.

Sulphate is also a nutrient; and some bacteria known as sulphate-reducing bacteria thrive from sulphate consumption. These bacteria reduce sulphate to hydrogen sulphate and this also reduces available oxygen in water. These bacteria can change mercury's chemical form and render it toxic to birds, mammals, and fish (Schuster and Toohey 2012).

Potassium is important because it is a nutrient for aquatic life.

Bacteria

The bacteria samples were collected for total coliform and *Escherichia coli* (*E. coli*). Coliform bacteria are a group of rod-shaped bacteria commonly found in the environment. Fecal coliform bacteria are found in intestines of mammals and humans. Total coliform bacteria are not likely to cause illness, but their presence indicates that a water supply may be vulnerable to contamination by more harmful microorganisms. *E. coli* are the only member of the total coliform group of bacteria that is found only in the intestines of mammals and humans. The presence of *E. coli* in water indicates recent fecal contamination and may indicate the possible presence of disease-causing pathogens like bacteria, viruses, and parasites. Although most strains of *E. coli* bacteria are harmless, certain strains may cause illness. These bacteria are known to grow well in warm temperatures. Fecal coliform bacteria often cause bladder and kidney infection or intestinal inflammation. When *E. coli* bacteria move outside of the intestine they cause disease with symptoms that include stomach cramps, diarrhea, nausea, and vomiting. Boiling drinking water will kill microorganisms but not viruses (Health Canada 2012b).

Hydrocarbons

Hydrocarbons sampled included Volatile Organic Compound (VOC) (e.g. gasoline), Polycyclic Aromatic Hydrocarbons (PAH) (e.g. creosote), Light Extractable Petroleum Hydrocarbons (LEPH) and Heavy Extractable Petroleum Hydrocarbons (HEPH) (e.g. diesels, greases, waxes, lubricating oils, and hydraulic oils).

VOCs are organic compounds containing one or more carbon atoms that have high vapour pressures and evaporate quickly to the atmosphere. VOC emissions result from natural and man-made sources and examples would be from vegetation, forest fires, and animals. Man-made sources in Canada are from the transportation sector, the use of solvents and solvent containing products, and industrial sources (Environment Canada 2010).

PAHs are emitted into the environment from both natural and human sources. Examples would be from forest fires, aluminum smelters, creosote, metallurgical and coking plants, and deposition of atmospheric PAHS. PAHs are relatively non-volatile and of low solubility in water and are mostly absorbed to particulate matter and can be transported and degrade over time. PAHs degrade very slowly in sediments, an important environmental sink for PAHs (Health Canada 2007).

LEPHs are a group of hydrocarbons that contains petroleum hydrocarbons with a carbon range of C10-19 with the exception of some PAHs in the same weight range. The Contaminated Sites Regulations explain HEPH contain a carbon range of C19-32 (Yukon Government 2011).

Nutrients

Nutrients include, among other elements, nitrogen (N) and phosphorous (P). Both of these nutrients are important for aquatic life. In excess these nutrients can alter water quality by reducing oxygen in the water from the increase of algae growth. Sewage effluent and agriculture can increase nutrient levels. Most nutrients test will look for total oxidized nitrogen (NO2 + NO3) because NO2 is toxic to fish and is known to contribute to the overgrowth of algae. Nitrate (NO_3) is a nutrient and too much can cause algae blooms and contribute to the depletion of available oxygen in water for aquatic life. Ammonium (NH4) is also measured because in high concentrations it can be toxic to fish and other animals (YRITWC 2012, 44).

Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) is the first available nutrient in the food chain. This nutrient is not a health concern on its own; however, it can attract heavy metals such as mercury and cadmium. When these metals increase in concentration by moving up the food chain they become toxic for wildlife and humans. Arctic rivers are generally low in DOC but levels are higher with surrounding wetlands (YRITWC 2012, 44).

Stable Water Isotopes

The stable isotopes of water, deuterium or hydrogen-2 (H2) and oxygen-18 (O18) are measured to determine a water sample's "signature" or "fingerprint". They can be used to trace the origin and movement of a water sample. Groundwater has a different signature than rainwater. Lake water has a different signature than glacial melt water (YRITWC 2012, 44).

Field pH

The measure of pH is of the basic and acidic nature of a solution and varies with the amount of hydrogen ions present in water. Aquatic life tends to thrive in a particular range of pH values and this depends on their stage of life and environment. If their living environment fluctuates outside of that range they could die or become ill. A pH range of 6.0 to 9.0 provides a healthy environment for freshwater fish and invertebrates (YRITWC 2012, 43).

Dissolved Oxygen

Dissolved Oxygen (DO) is the amount of available oxygen in the water. Oxygen gets into water by aeration (rapid water movement), diffusions from the air, and as a product of photosynthesis. A high level of dissolved oxygen in drinking water is good because it makes the water taste better; however, high levels of dissolved oxygen can speed up corrosion of water pipes. If the concentration levels of total dissolved gas in water go over 110% it can be harmful to aquatic life. Fish and aquatic invertebrates can experience 'gas bubble disease' and die. The amount of DO that an aquatic organism needs is dependent on the species of the animal, the water temperatures, the animal's physical state, and the pollutants present in the water. At higher temperatures fish use more oxygen because their metabolic rate increases. Research suggests that 4 - 5 mg/L is the minimum amount of DO that can support a large and diverse fish population. Good fish habitat generally averages around 9 mg/L of DO. Fish die when DO levels fall below 3 mg/L (YRITWC 2012, 43).

Conductance

Conductance refers to the ability of a water sample to conduct electricity. Electrical current is transported by the ions that are present in the water. All of the dissolved solids in water are either negatively charged ions (anions, discussed above) or positively charged ions (cations, similarly discussed above). The total concentration of ions dissolved in water is commonly called total dissolved solids (TDS). The conductance of water generally increases as the number of ions increases; therefore a higher conductivity reading means that there are more anions and cations present in the water and therefore a higher TDS (YRITWC 2012, 43).

Total Dissolved Solids (TDS)

Total dissolved solids are not known to cause any human health problems, but are more likely to have aesthetic influences; they can contribute to the corrosion of water pipes. Elevated TDS can cause drinking water to taste unpleasant and look murky in appearance. Water becomes saline at extremely high levels of TDS; therefore, water is not recommended for drinking when the TDS reads above 500 mg/L or when specific conductance is above 750 uS/cm. Occasionally high levels of TDS cause gastrointestinal irritations.

Location of Water Quality Sampling

Community members and THFN government officials selected five water quality sites throughout the THFN traditional territory. Table 1 provides background information for these samples, including their location and the types of contaminants for which they were sampled.

Samples were collected from Grizzly Creek, Wolf Creek, Hunker Creek, Bonanza Creek, and Tr'ochëk Pond, a swimming pond near Dawson. Several types of samples were sent to the ALS Environmental laboratory in Whitehorse, Yukon. Hydrocarbon samples were collected for petroleum contamination concerns at Hunker and Bonanza Creeks. Bacteriological and nutrient samples were collected for drinking, sewage and landfill concerns in Grizzly Creek, Wolf Creek and the swimming pond. Metal samples were collected for mining effluent concerns in Hunker and Bonanza Creeks and at Wolf Creek as it is a source of drinking water. Additional samples, (YRITWC kits) were sent to the United States Geological Survey (USGS) in Boulder, Colorado. These kits include: major ions, metals, nutrients, dissolved organic carbon, and stable water isotopes. The YRITWC sampling protocols were used to collect surface water by a grab sample technique. The YRITWC will follow-up with THFN when additional USGS data is made available.

Table 1 Tr'ondëk Hwëch'in First Nation Water Quality Sites Sampled

Site Name	Site ID	GPS Coordinates	ALS Samples	Analysis	YRITWC Kits (Y/N)	Suspected Contaminants	Date
Grizzly Creek	THFN01	64.40790, -138.30675	Nutrients, *E. coli,* Total Coliform	*E. coli* and Total by Colilert (Health). N+N-VA. P-T-COL-VA. PO4-DO-COL-VA.	Y	sewage	Sept. 12, 2012
Wolf Creek	THFN02	64.35679, -138.409471	Total Metals, Nutrients, *E. coli,* Total Coliform	BTEX+VPH+MTBE. LEPH/HEPH+VA. MET-TOT-DW-VA, Total Metals in water. *E. coli* and Total by Colilert (Health). N+N-VA. P-T-COL-VA. PO4-DO-COL-VA.	Y	sewage & petroleum	Sept. 12, 2012
Hunker Creek	THFN03	64.02990, -139.17856	Total Metals, Hydrocarbons	Total Metals in water. BTEX+VPH+MTBE. LEPH/HEPH+VA. MET-TOT-DW-VA	Y	mining effluent & petroleum	Sept. 13, 2012
Swimming Pond near Dawson	THFN04	64.04972, -139.43982	Nutrients, *E. coli,* Total Coliform	*E. coli* and Total by Colilert (Health). N+N-VA. P-T-COL-VA. PO4-DO-COL-VA.	Y	sewage	Sept. 13, 2012
Bonanza Creek	THFN05	64.031139, -139.38910	Total Metals, Hydrocarbons	Total Metals in water. BTEX+VPH+MTBE. LEPH/HEPH+VA. MET-TOT-DW-VA	Y	mining effluent & petroleum	Sept. 13, 2012
		Total			**5**		

Analysis of Water Quality Samples

Generally, the YRITWC found the water quality to be within aquatic, recreational, and drinking water standards and guidelines. However, sampling at these sites occurred with respect to the suspected contaminants (i.e., if hydrocarbons were suspected, samples were analyzed for hydrocarbons not nutrients). Therefore, these sites may have other sources of contamination. Additional samples are needed to determine trends and to have a robust baseline to help identify physical and chemical changes.

Several water quality guidelines and standards were applied to determine a threat of contamination in drinking water, recreational water, and aquatic habitat. Caution is needed when applying guidelines and standards for water quality analysis, as there may be additional factors to consider, such as dilution, pH, or water hardness. Drinking water standards are referenced for the sole purpose of consumption in its raw state. There are no standards for raw drinking water as there needs to be a form of water treatment used for a standard to apply.

The guidelines and standards applied are Guidelines for Canadian Drinking Water Quality (GCDWQ/CCME DW)[3], Guidelines for Canadian Recreational Water

[3] Health Canada publishes the Guidelines for Canadian Drinking Water Quality and they are developed by a committee of Federal-Provincial-Territorial governments (Health Canada 2012). This guideline has set out Maximum Acceptable Concentrations (MAC) in drinking water for microbiological, chemical, and radiological contaminants. Also physical characteristics of drinking water, such as taste and odour have standards set to avoid consumers from seeking unreliable alternatives. Although Canadian drinking water supplies are generally of excellent quality, is it natural for water from these sources to contain elements of all of the substances they come in contact with. These can include minerals, silt, vegetation, fertilizers, and agricultural run-off. Most of these substances are not harmful to human health; some of them make be dangerous to vulnerable populations including children and the elderly. The Health Canada Drinking Water

Quality (GCRWQ),[4] Canadian Environmental Quality Guidelines (CEQG/CCME AW),[5] and Yukon Government Contaminated Sites Regulations (YCSR).[6] A committee of scientists, experts, and government establish standards and guidelines to help determine maximum acceptable concentrations of water contaminants. No samples exceeded recreational water guidelines (See Table 2).

Grizzly Creek

Grizzly Creek at kilometre 58.8 on the Dempster Highway was sampled for nutrients and bacteria. Samples for hydrocarbon, VOCs, and PAHs were not collected at this site. Grizzly Creek had five coliform organisms present in the 100 mL sample (See Figure 15).

Wolf Creek

Wolf Creek at kilometre 49.8 on the Dempster Highway was sampled for total metals, nutrients, and bacteria. Samples for hydrocarbons, VOCs, and PAHs were not collected at this site. Metal and nutrient concentrations, when detected, did not exceed the relevant standards. Wolf Creek had five coliform organisms present in the 100 mL sample (See Figure 15).

Guideless provide parameters that all drinking water systems to seek to meet or exceed in order to provide safe drinking water (Health Canada 2012b).

[4] The objective of Health Canada's Guidelines for Canadian Recreational Water Quality is the protection of public health. These guidelines outline current scientific knowledge of health and safety issues related to the recreational use of water. These mainly include “the risk of infection from contact with pathogenic microorganisms, and illness or injury as a result of physical or chemical properties of the water” (Health Canada 2012a).

[5] The Canadian Environmental Quality Guidelines are nationally recognized science-based goals for environmental quality. They are defined as “numerical concentrations or narrative statements that are recommended as levels that should result in negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of ecosystems and the designated resource uses they support” (CCME 2013).

[6] The Yukon Government’s Contaminated Sites Regulations (YCSR) establishes standards for drinking water, aquatic life, irrigation, and livestock. These standards ensure water is suitable for direct use and is clean enough to protect water uses on adjacent properties (Yukon Government 2012).

Hunker Creek

Hunker Creek was sampled along the North Klondike Highway for hydrocarbons, VOCs, PAHs, and total metals. Table 2 highlights the parameters that exceeded drinking water standards (i.e., aluminum, manganese and iron). Table 3 highlights the parameters that exceeded aquatic guidelines and standards. Aluminum concentrations exceeded the YCSR drinking water standard (See Figure 14). Manganese concentrations exceeded the YCSR standard and the Canadian Guidelines for drinking water (See Figure 13). Iron concentrations exceeded the YCSR drinking water standard and the Canadian Guidelines for aquatic and drinking water (See Figure 12). Hydrocarbons, VOCs or PAHs were not detected at Hunker Creek.

Swimming Pond

Tr'ochëk pond, the swimming pond near the confluence of Klondike River and Yukon River, was sampled for nutrients and bacteria. *E. coli* was not detected but 201 total coliform organisms were detected in a 100 mL sample (See Table 2 and Figure 15). The Canadian Guidelines for recreational water have no standard set for total coliform bacteria. There is a standard for safe pH levels for swimming from 5.0 to 9.0. Numerical values have not been established for oil and grease in recreational waters. Oil, grease or petrochemicals should not be detectable by sight or odour.

Bonanza Creek

Bonanza Creek was sampled at about 1.5 kilometres on Bonanza Creek Road for hydrocarbons, VOCs, PAHs, and total metals. Manganese concentrations exceeded the YCSR standard and the Canadian Guidelines for drinking water (See Figure 12). Iron concentrations exceeded the YCSR drinking water standard and the Canadian Guidelines for aquatic and drinking water (See Figure 11). Hydrocarbons, VOCs, and PAHs were not detected at Bonanza Creek.

Table 2 Parameters Exceed Drinking and Recreational Water Guidelines and Standards

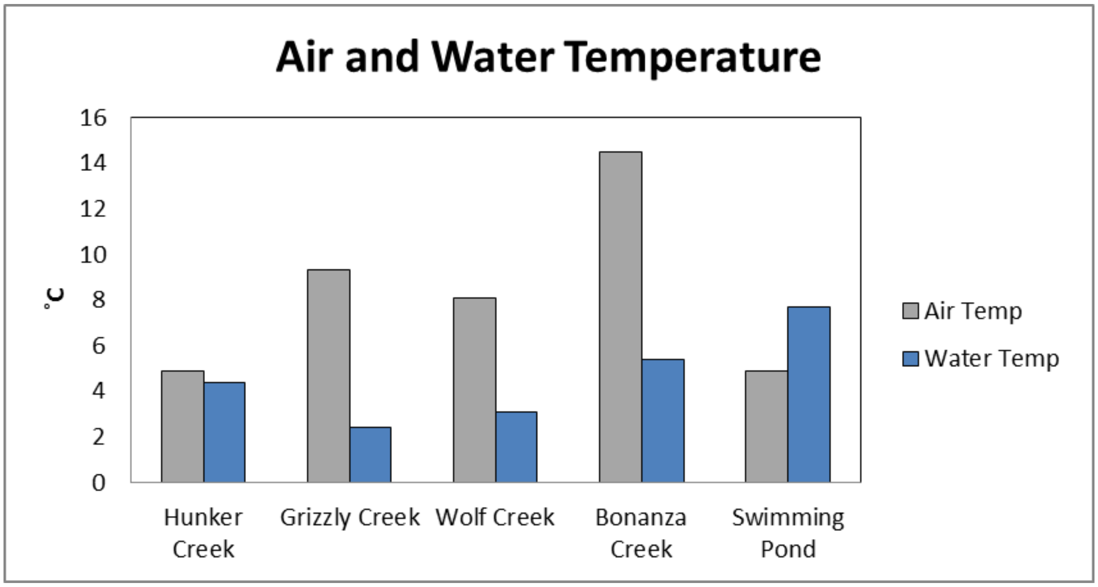
Surface Water Body	Site	Water Quality Parameters that Exceed YCSR DW Standards	Water Quality Parameters that Exceed CCME DW Guidelines	Water Quality Parameters that Exceed GCRWQ
Grizzly Creek	THFN01	No	No	No
Wolf Creek	THFN02	No	No	No
Hunker Creek	THFN03	Fe, Mn, Al	Fe, Mn	No
Swimming Pond	THFN04	-	Total Coliform Bacteria	No
Bonanza Creek	THFN05	Fe, Mn	Fe, Mn	No

Table 3 Parameters Exceed Aquatic Life Water Guidelines and Standards

Surface Water Body	Site	Hydrocarbon, Volatile Organic Compounds, PAH	Water Quality Parameters that Exceed YCSR AW Standards	Water Quality Parameters that Exceed CCME AW Guidelines
Grizzly Creek	THFN01	-	No	No
Wolf Creek	THFN02	-	No	No
Hunker Creek	THFN03	No	Fe, Cu	Fe
Swimming Pond	THFN04	-	No	No
Bonanza Creek	THFN05	No	Fe, Cu	Fe

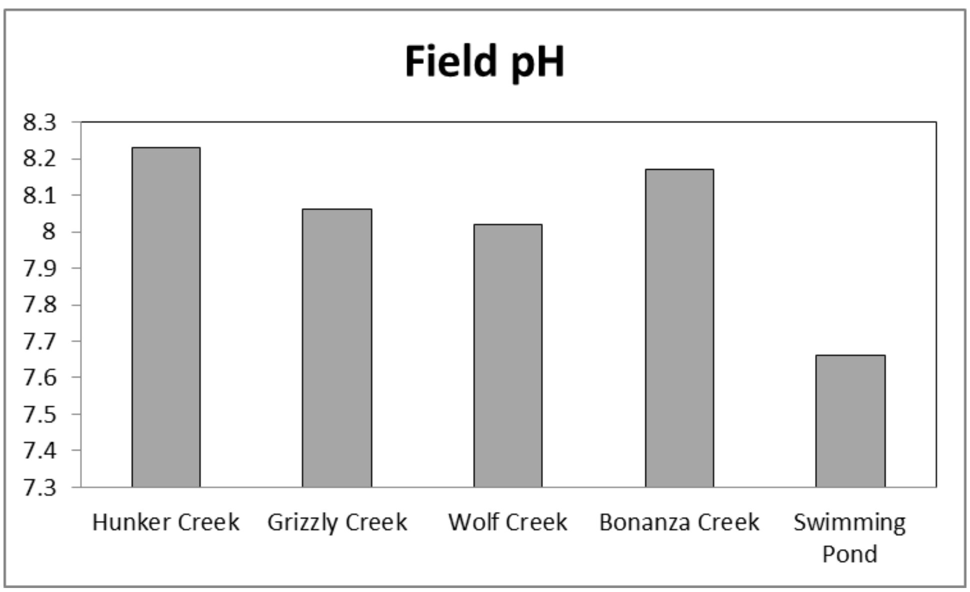
Field measurements of air and water temperatures are compared across all sites in Figure 8:

Figure 8 Air and Water Temperature



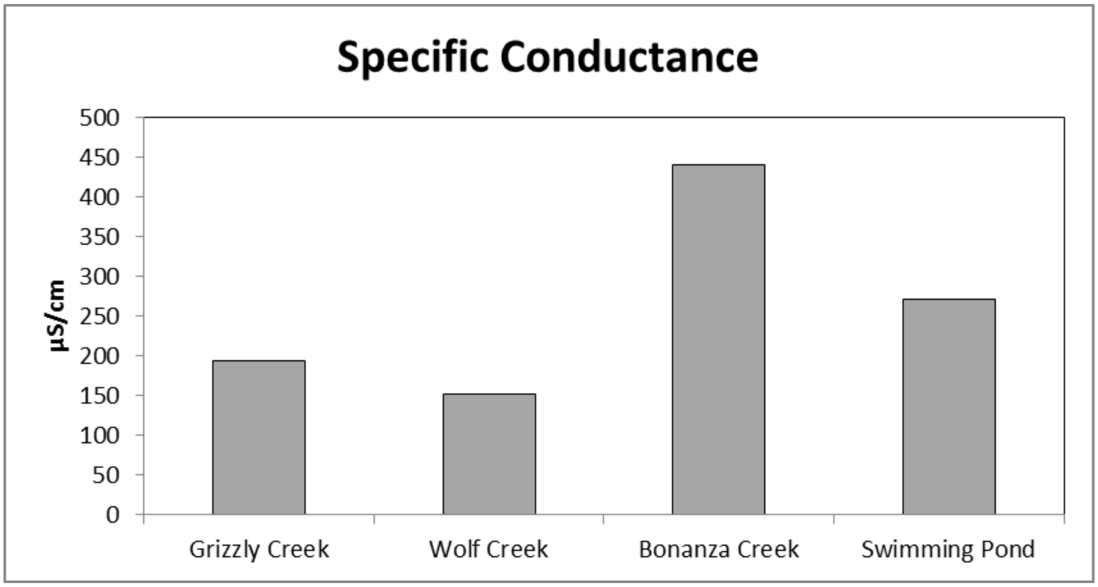
The pH field readings are in normal ranges for aquatic life, recreational water, and drinking water (See Figure 9). All of the samples collected were slightly basic (as opposed to acidic or neutral). Waters within the Yukon River watershed have similar pH values.

Figure 9 Field pH



Specific conductance was analyzed at the USGS lab for all sites (See Figure 9).

Figure 10 Specific Conductance



Dissolved oxygen levels were within aquatic life standards (See Figure 11). The Canadian water quality guideline for the protection of aquatic life recommends a minimum concentration for DO in fresh water of 5.5 mg/L.

Figure 11 Dissolved Oxygen

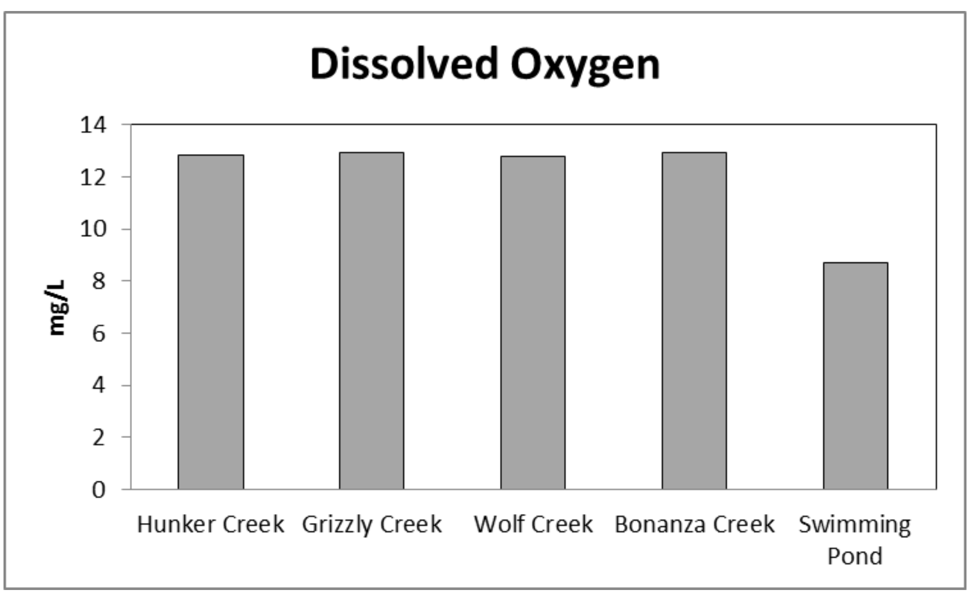


Figure 12 Iron Concentrations

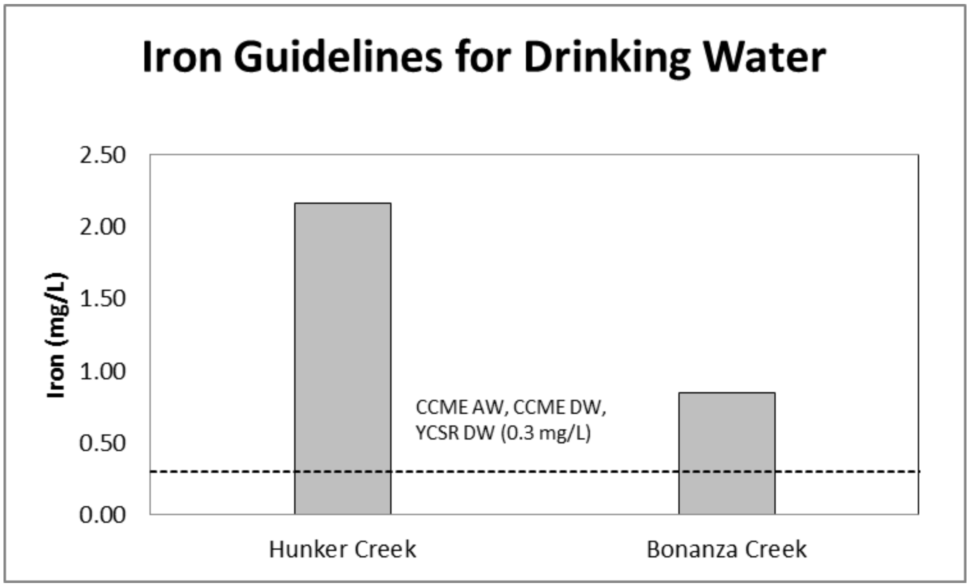


Figure 13 Manganese Concentration Exceed Drinking Water Guidelines

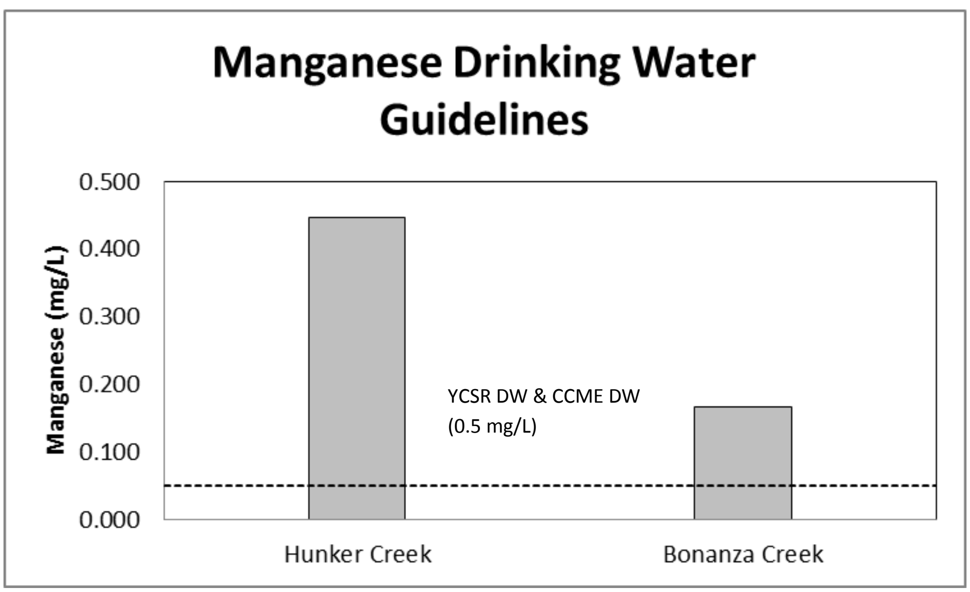


Figure 14 Aluminum Concentrations Exceed Drinking Water Guidelines

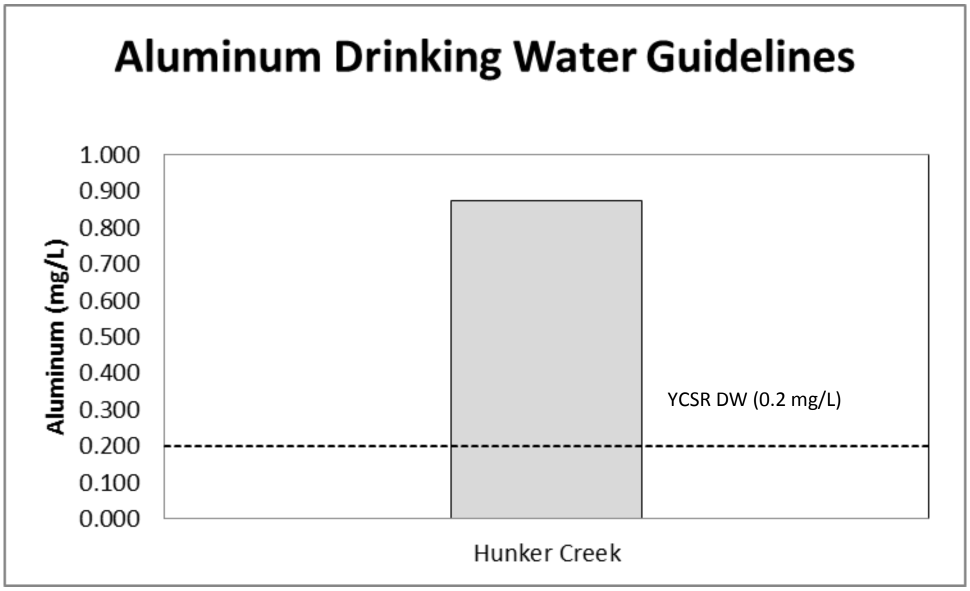
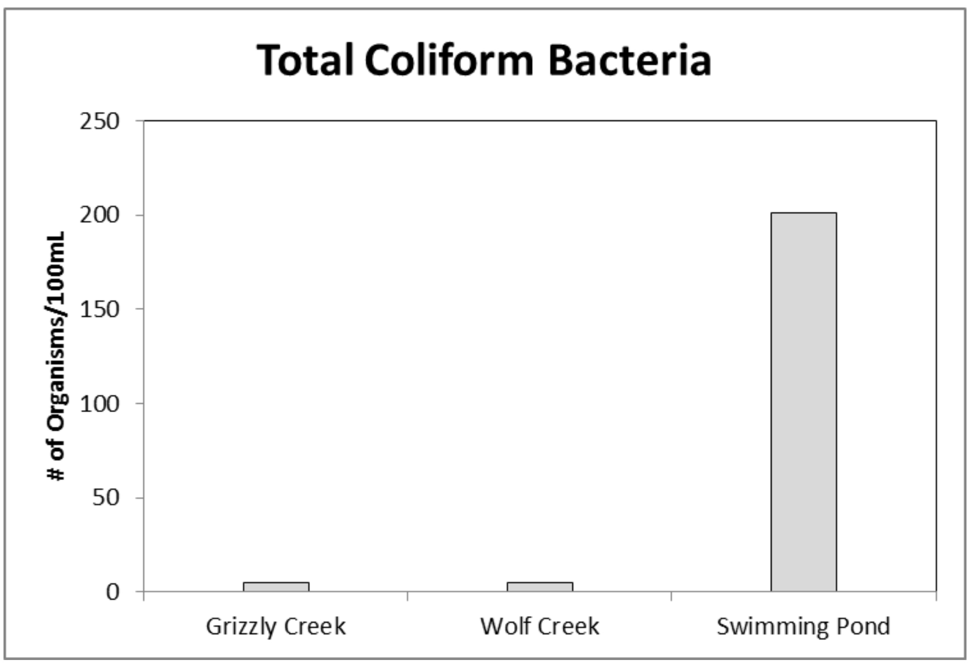


Figure 15 Total Coliform Bacteria Count



Interpretation of Results

While some of these samples showed elevated levels of specific metals and bacteria, this year's sampling did not suggest any major contamination occurring within the selected water bodies. Within this report, we compare results from the selected water bodies to four different sets of Canadian water quality standards: Drinking Water Quality, Recreational Water Quality, Environmental Quality and Contaminated Sites Regulations. Each of these standards was designed for different uses of water resources. The Drinking Water Quality standards are the strictest and only applied to treated water (i.e., filtered, chlorinated, etc.). However, we wanted to compare these untreated water bodies to Drinking Water standards because of their use as drinking water sources. Natural water bodies generally contain a wide variety of bacteria, nutrients, and metals that varies depending upon the geology, human and wildlife populations within the water body's watershed. Bacteria results (*E. coli* and Total Coliform) are just as likely to come from wildlife as they from humans. Within this study, we could determine the source (human vs. wildlife). Therefore, the results from this year's sampling do not show any significant results of contamination.

However, this year's results only provide a very small amount of data (one sample at one point in time) with respect to the selected water bodies. We hope that future funding will allow YRITWC and THFN to monitor these sites throughout the open water season for two more years. Sampling throughout the open water season will give a much clearer picture about any risk of contamination. If increased and continued sampling continues to support the results found in this report, then this data becomes a valuable set of baseline monitoring data which THFN can continue to reference for many years in the future. At the very least, this data will allow THFN and the YRITWC to assess changes over the years to come.

Take home points from the Water Quality Analyses:

1. Much more sampling needs to occur to confirm or rule out any risk of contamination. The YRITWC and THFN have submitted proposals to fund water quality sampling for Year 2 of this project.

Observations of Climate Change

During interviews and focus groups, participants were asked if they had observed any changes in the environment that may be attributed to climate change. These observations included changes in the weather, water levels, permafrost, river and lake ice regimes, plants, fish and wildlife and others. Observations of Climate Change in the Tr'ondëk Hwëch'in First Nation Traditional Territory are summarized in Table 4. Observations are also illustrated by the quotes provided in the textboxes contained within this section. Many of these observations are consistent with observations of climate change elsewhere in the Arctic and Sub-Arctic (ACIA 2005; Environment Yukon 2011). Each of these observations provides important information regarding the impacts that climate change is having on the environment and the people who call this region home. In combination

"In the weather, there's climate change and it's getting warmer and they always talk about when they were growing up it was never windy here and now it's windy. And it's warmer. We just don't get the cold winters that they used to get when my parents were around and their parents. It used to go to 50, 60 below for long periods of time. We never see that anymore. We may get 40 below for a few days, but that's it." (THFN Community Member)

"We have longer periods of high water and right now the water is not as low as it normally gets. Just looking at the river a couple of days ago and you can see that it's not dropped as much as it normally does. And the high water is staying a lot longer than it normally does, which means that there is a lot of runoff. There seems to be more flooding in various areas." (THFN Community Member)

"Moose are very slow this year. They are not running yet. They are not moving. There's still lots of time for them. I figure, it get a little cooler, colder and that's when they start moving. It's too warm, it's too warm." (THFN Community Member)

"The river is taking a much longer time to freeze-up. It's not as thick as it used to be where it freezes. Usually in areas where there's a hot spring under the water, those are staying, they are much wider than normal during freeze-up and I notice that all along the river. I spend a lot of time driving on the highway from here to Whitehorse and I notice in different areas on the river, like Stewart, Pelly, Carmacks are all taking a lot longer to freeze-up than normal, along with the Yukon River." (THFN Community Member)

with concerns about the impacts of contaminants on water and results from water quality sampling, observations of climate change are important in understanding overall environmental change and the affects these changes may be having on community members. The documented observations of climate change provide a basis for further research on the interactions between contaminants and climate change in specific aspects of the environment. The observations documented in this report could also be useful to the community as they seek to respond to climate change. This could include the development of community-based adaptation and mitigation programs.

Table 4 Observations of Climate Change in the White River Traditional Territory

Type of Change Observed	Examples of Change
Weather	• Warmer temperatures in the winter • Colder temperatures in summers • Increased rain in the summer • More winds
Water Levels	• Increased water levels in lakes and streams
Permafrost	• Permafrost thaw • Increased erosion
River and Lake Ice	• Reduced ice thickness • Later freeze-up • Earlier break-up
Plants	• Increased shrubs and grasses
Fish & Animals	• Reduced salmon runs • Moose are rutting later
Other	• Spruce rust

Study Limitations

This project was limited by several factors. Time limitations impacted the project in two major ways. First, in high latitude regions, water sampling must take place within a four-month field season. The YRITWC was only able to take one water sample per site. The ability to take multiple samples throughout the season could have given us a more complete picture of what is occurring with water quality. Second, time limitations also impacted the ability to integrate interview data into decision-making about water sampling. The YRITWC spent one week in each community. In general, the focus group was conducted at the beginning of the week in order to allow time for sampling to be completed in the following two days. Interviews were conducted at the same time as sampling. Often new information came to light that should have been incorporated into the water quality sampling plan. In the future, it would be useful to conduct interviews before focus groups are conducted.

The contaminants monitoring conducted during this project was limited to water quality sampling. As contaminated sites were identified, it became apparent that surface water was not always the appropriate sampling medium. Soils samples also would have been useful in identifying contaminations.

Conclusion and Next Steps

The purpose of this project was to initiate a community contaminant and climate change monitoring program. The preceding report documents the steps taken during the project to accomplish this task:

- **Documented the importance of water to THFN, which is a necessary first step for situating a community-based contaminants monitoring program.** Understanding the importance of water is fundamental to establishing a community climate change and contaminants monitoring program for two reasons: 1) It allows us to understand how changes in water resources are impacting people 2) Cultural connections to water are also the inspiration for protecting water resources;

- **Identified and mapped the sites of concern to community members.** The contaminant maps produced during this project document community concerns regarding the impact of contaminants on water resources in their traditional territory. While we were able to take water samples at ten of these sites, the maps can act as a resource for the community as they seek to further develop their water quality monitoring program;

- **Conducted water quality sampling at five sites**. While some of these samples showed elevated levels of specific metals and bacteria, this year's sampling did not suggest any major contamination occurring within the selected water bodies. Further sampling is required. This year's results only provide a very small amount of data (one sample at one point in time) with respect to the selected water bodies.

Next Step: Identify sources of funding to conduct water quality monitoring of these sites for at least two years. Sampling throughout the open water season will give a much clearer picture about any risk of contamination. Continued sampling would allow for the establishment of a valuable set of baseline monitoring data which could be used as a reference for many years to come and allow for the assessment of changes over the years to come;

- **Documented observations of climate change.** Observations of climate change provide a basis for further research on the interactions between contaminants and climate change in specific aspects of the environment.

  Next Step: The observations documented in this report could also be useful to the community as they seek to respond to the impacts of climate change in their traditional territory. This could include the development of community-based adaptation and mitigation programs.

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Appendix A - Description of Community Identified Water Quality Sites of Concern

Site #*	**Name**	**Suspected Contaminant**	**Description**
1	Thistle Creek	Mining	White gold exploration. This site is too far to reach during the Health Canada Research. Suggestion came to do a healing journey along the Yukon River to visit this site.
2	Sixty Mile River	Mining	Placer mining. This site is too far to reach during the Health Canada Research. Suggestion came to do a healing journey along the White River to visit these sites
3	Indian River	Mining	Placer mining. This site is too far to reach during the Health Canada Research. Suggestion came to do a healing journey along the Yukon River to visit this site.
4	Moosehide Creek	No specific concern	Drinking water source. Last tested in 1998. Is in continual use and is considered good water by those who use it.
5	Swimming Pond	Bacteria, Nutrients	Pond popularly used for swimming by locals. Concerns about water quality. Fecal coliform, *E. coli* and others.
6	Former Domestic Landfill	Heavy Metals, Hydrocarbons	Former landfill was used for domestic waste. There is no surface water source near here. It is a concern, but would be difficult to test for without soil or ground water samples.
7	Bonanza Creek	Mining, Hydrocarbons	Creek drainage has been mined extensively. It is a tributary of the Klondike River. Concerns about mining impacts include dumping used oil as it is difficult to properly dispose of here. One Elder said that in 1987 she used to fish grayling from this creek and it was clear. The appearance of the creek has changed. It now has a rusted colour.
8	Old Dump Site	Heavy Metals, Hydrocarbons	Scrap metal dump.
9	Current Landfill	Heavy Metals, Hydrocarbons, Bacteria, Nutrients	Team would have to look for a creek nearby to test.

10	Bear Creek	Heavy Metals, Hydrocarbons	Gold mine processing.
11	Hunker Creek	Heavy Metals, Hydrocarbons, Bacteria, Nutrients	This drainage has been mined extensively. Concerns about the impact on fish habitat. People fish for grayling in this stream.
12	Grizzly Creek	Sewage	Drinking water source. Camping at Grizzly Lake. Concerns about the impacts of overflowing outhouses and campers on water quality.
13	Wolf Creek	No specific concern	Drinking water source. Interviews identify this creek as one of the most important secondary drinking water sources for the members of THFN. People travel here to get water for themselves and for Elders, who prefer the creek water to the treated drinking water available in town.
14	Pea Soup Creek	No specific concern	Drinking water source.
15	Benson Creek	No specific concern	Drinking water source.
16	Dempster Sewage Dumping Station	Sewage. Hydrocarbons	Concern about influence sewage from dumping station and fuel spills on nearby drinking water source (spring water)
17	Maisy May Creek	Hydrocarbons	Oils pill of 10,000 litres occurred here several decades ago. It is not certain to what extent the spill might still be an influence.
18	Klondike River at Yukon River	Mining, Hydrocarbons	The Klondike River Drainage has been mined extensively throughout the last century. In addition to concerns about the impact of mining on specific tributaries, a concern was raised about the total effect of mining on the Klondike. The Klondike and its tributaries are important salmon habitat and fewer juvenile salmon have been found there recently. Also noted that it is more difficult to detect contaminants in this river, as opposed to smaller tributaries due to dilution.
19	Drinking Water Well	No specific concern	Groundwater, potential influence from Klondike River. Tested regularly.
20	O.K. Creek	Hydrocarbons	Land Treatment Facility, used to treat hydrocarbons contaminated soils. Treated centre is located 530 metres from creek.

21	Glacier Creek	Erosion	Drinking water source. You can see permafrost slumping, erosion. Concern about the impacts of climate on water quality
22	Klondike River Road Maintenance Camp on Dempster Highway	Hydrocarbons	Fuel spill occurred here at the site of the maintenance camp and may have influenced the Klondike River. Soil and groundwater remediation currently underway.
23	Old Dumpsite	Sewage, Heavy Metals, Hydrocarbons	Garbage used to be dumped directly into the Yukon River. It would be deposited on the bank of the river and then a machine would push it in. This was estimated to have taken place in the 50s and 60s and before then. People are concerned that there may still be barrels and machinery at the bottom of the Yukon River near this site. Moosehide is located downstream from here. People used to drink the water straight from the river, and would also fish there. Concerns were raised about the impacts of these contaminants on people's present health.
24	Minto Mine Discharge	Heavy Metals, Sediments	Concerned about the influence of Minto Mine located upstream in the river system from Dawson.
25	Sewage Treatment Plant	No specific concern	
26	Brewery Creek Mine	Mining	Concerns about the influence of heap leaching on nearby water. The land around this area represent important moose habitat.

*The sites of concern identified during the course of this research should not be considered an exhaustive list.

Appendix B – Pictures of Water Quality Sites Sampled

Figure 16 Grizzly Creek

Figure 17 Wolf Creek

Figure 18 Hunker Creek

Figure 19 Swimming Pond near Dawson

Figure 20 Bonanza Creek

Appendix C – Useful Resources

1. Yukon Water: Here, you'll find information about Yukon's water resources. There is information about how water is used, managed and monitored (http://yukonwater.ca/-). The following is a listing of reference material from the yukonwater site:

Climate Change

- Mayo Region Climate Change Action Plan (PDF 2.3 MB)
- Climate Change Adaptation and Water Governance Report. (PDF 1.2 MB)
- Summary of: Compendium of Yukon Climate Change Science: 2003-2011 (PDF 4.1 MB)
- Compendium of Yukon Climate Change Science: 2003-2011 (PDF 2.3 MB)
- Hydrology of the Bennett Lake Watershed: Contemporary Conditions and Potential Impacts of Climate Change (PDF 4.01 MB)
- Yukon Water: An Assessment of Climate Change Vulnerabilities 2011 (PDF 10MB)
- Yukon Water: A Summary of Climate Change Vulnerabilities 2011 (PDF 3.1MB)
- Yukon Government Climate Change Action Plan (PDF 2.2 MB)
- Climate Change and Water Intergovernmental Panel on Climate Change Technical Paper VI (PDF 7.11 MB)
- Arctic Climate Impact Assessment (PDF, 1.62 MB)
- United States Environmental Protection Agency National Water Strategy: Response to Climate Change (PDF, 11.4 MB)

Groundwater

- Yukon Wide Long-Term Groundwater Monitoring Program, Community of Whitehorse Wells, 2001-2010 Monitoring Data Analysis (PDF 276 KB)

Water Monitoring

- Yukon Snow Survey & Water Supply Forecast

The Yukon Snow Survey Bulletin and Water Supply Forecast is prepared and issued by Environment Yukon's Water Resources Branch three times annually after March 1, April 1, and May 1. The bulletin provides a summary of winter meteorological and stream flow conditions for Yukon, as well as current snow depth and snow water equivalent observations for 56 locations.

http://www.env.gov.yk.ca/monitoringenvironment/snow_survey.php-)

2. The Fresh Water Quality Monitoring & Surveillance Division focuses on regular monitoring, surveillance and reporting on fresh water quality, and aquatic ecosystem status and trends.

   http://waterquality.ec.gc.ca/-

3. The Water Survey of Canada (WSC) is the national authority responsible for the collection, interpretation and dissemination of standardized water resource data and information in Canada. In partnership with the provinces, territories and other agencies, WSC operates over 2500 active hydrometric gauges across the country. http://www.ec.gc.ca/rhc-wsc/-

4. Environment impacts analysis; Contaminated sites monitoring; Assess and remediate Yukon Government contaminated sites.

   http://www.env.gov.yk.ca/branches/environmental_programs.php-

5. Kwanlin Dun First Nation, Department of Heritage, Lands & Resources. Conduct continuous monthly seasonal water sampling at Michie Creek, southeast of Whitehorse.

   http://www.kwanlindun.com/-

6. Ta'an Kwäch'än Council, Department of Lands, Resources and Heritage. Conduct seasonal continuous and continuous water chemistry sampling at sites within traditional TKC territory, on Takhini River, Flat Creek, Laurier Creek and Lake Laberge.

   http://www.taan.ca/-

7. Water Resources Branch: Water-related strategic planning, policy development and implementation; Regional water quality/quantity monitoring and research; Provision of expert technical advice regionally and nationally; Enforcement and compliance of the *Waters Act* and water licences; Administration of water security deposits; Share responsibility for managing Yukon waters with five other Yukon Government departments including: **Health & Social Services** (drinking water & private sewage disposal), **Highways & Public Works** (water & sewage provision in unincorporated communities), **Energy, Mines & Resources** (regulate placer mining activities), **Executive Council Office, Water Board Secretariat** (water licensing process), **Community Services** (project management services for community infrastructure).

   http://www.emr.gov.yk.ca/csi/index.html-

8. Health & Social Services monitors drinking water in town sites including Old Crow, Dawson City, Keno City, Mayo, Pelly Crossing (Selkirk First Nation), Carmacks (Little Salmon Carmacks First Nation), Faro, Ross River, Whitehorse, Haines Junction, Burwash (Kluane First Nation), Carcross Tagish, and Watson Lake. Sampling types include microbiological and water chemistry.

   http://www.hss.gov.yk.ca/environmental_drinkingwater.php-

9. The **Yukon Water Board** is an independent administrative tribunal established under theWaters Act . The Board is responsible for the issuance of water use licences for the use of water and/or the deposit of waste into water.

   http://www.yukonwaterboard.ca/-

10. YESAB was established under the *Yukon Environmental and Socio-economic Assessment Act* (YESAA), which came into full force November 28, 2005. YESAB is committed to delivering an assessment process that works well for all Yukoners as well as all stakeholders. YESAB's goal is to ensure the assessment process under YESAA is the best possible arrangement for all interests. http://www.yesab.ca/index.html-

11. Summary of Yukon water wells. Most current report dating May 11, 2006.

    http://www.env.gov.yk.ca/pdf/YukonWaterWellsSummary.pdf-

12. Reference Condition Approach Bioassessment of Yukon River Basin Placer Mining Streams Sampled in 2006. http://www.geology.gov.yk.ca/pdf/MPERG_2007_2.pdf

13. Yukon Water Resources Hydrometric Program Historical Summary 1975 – 2004. http://www.env.gov.yk.ca/pdf/hydrometricmanual2005.pdf

Appendix D – Water Quality Data

Sample ID	THFN01	THFN02	THFN03	THFN04	THFN05
Site Name	Grizzly Creek	Wolf Creek	Hunker Creek	Swimming Pond	Bonanza Creek
Site Coordinates (DD)	64.40790, -138.30675	64.35679, -138.40971	64.02990, -139.17856	64.04972, -139.43982	64.031139, -139.38910
Date Sampled	12-SEP-12	12-SEP-12	13-SEP-12	13-SEP-12	12-SEP-12
Time Sampled	11:56	18:18	11:05	10:48	15:04
Matrix	Water	Water	Water	Water	Water
Physical Tests					
Hardness (as CaCO3 in mg/L)	-	75.6	431	-	294
pH	8.06	8.02	8.23	7.66	8.17
Air Temp. (°C)	9.3	8.1	4.9	4.9	14.5
Water Temp. (°C)	2.4	3.1	4.4	7.7	5.4
Dissolved Oxygen (mg/L)	12.93	12.76	12.82	8.71	12.95
Total Metals (mg/L)					
Aluminum (Al)	-	<0.010	0.875	-	0.040
Antimony (Sb)	-	<0.00050	<0.00050	-	<0.00050
Arsenic (As)	-	0.00076	0.00549	-	0.00510
Barium (Ba)	-	0.048	0.159	-	0.062
Boron (B)	-	<0.10	<0.10	-	<0.10
Cadmium (Cd)	-	<0.00020	<0.00020	-	<0.00020
Calcium (Ca)	-	23.1	104	-	79.1
Chromium (Cr)	-	<0.0020	<0.0020	-	<0.0020
Copper (Cu)	-	<0.0010	0.0047	-	0.0018

Iron (Fe)	-	<0.030	2.16	-	0.850
Lead (Pb)	-	<0.00050	0.00337	-	<0.00050
Magnesium (Mg)	-	4.39	41.6	-	23.6
Manganese (Mn)	-	<0.0020	0.446	-	0.167
Mercury (Hg)	-	<0.00020	<0.00020		<0.00020
Potassium (K)	-	0.22	3.00	-	1.80
Selenium (Se)	-	<0.0010	<0.0010	-	<0.0010
Sodium (Na)	-	<2.0	10.5	-	7.1
Uranium (U)	-	0.00065	0.0122	-	0.00630
Zinc (Zn)	-	<0.050	<0.050		<0.050
Volatile Organic Compounds (mg/L)					
Benzene	-	-	<0.00050	-	<0.00050
Ethylbenzene	-	-	<0.00050	-	<0.00050
Methyl t-butyl ether (MTBE)	-	-	<0.00050	-	<0.00050
Styrene	-	-	<0.00050	-	<0.00050
Toluene	-	-	<0.00050	-	<0.00050
ortho-Xylene	-	-	<0.00050	-	<0.00050
meta- & para-Xylene	-	-	<0.00050	-	<0.00050
Xylenes	-	-	<0.00075	-	<0.00075
Surrogate: 4-Bromofluorobenzene (SS) %	-	-	82.0	-	80.8
Surrogate: 1,4-Difluorobenzene (SS) %	-	-	85.2	-	85.2
Hydrocarbons (mg/L)					
EPH10-19	-	-	<0.25	-	<0.25
EPH19-32	-	-	<0.25	-	<0.25
LEPH	-	-	<0.25	-	<0.25

HEPH	-	-	<0.25	-	<0.25
Volatile Hydrocarbons (VH6-10)	-	-	<0.10	-	<0.10
VPH (C6-C10)	-	-	<0.10	-	<0.10
Surrogate: 3,4-Dichlorotoluene (SS) %	-	-	84.5	-	82.9
Polycyclic Aromatic Hydrocarbons (mg/L)					
Acenaphthene	-	-	<0.000050	-	<0.000050
Acenaphthylene	-	-	<0.000050	-	<0.000050
Acridine	-	-	<0.000050	-	<0.000050
Anthracene	-	-	<0.000050	-	<0.000050
Benz(a)anthracene	-	-	<0.000050	-	<0.000050
Benzo(a)pyrene	-	-	<0.000010	-	<0.000010
Benzo(b)fluoranthene	-	-	<0.000050	-	<0.000050
Benzo(g,h,i)perylene	-	-	<0.000050	-	<0.000050
Benzo(k)fluoranthene	-	-	<0.000050	-	<0.000050
Chrysene	-	-	<0.000050	-	<0.000050
Dibenz(a,h)anthracene	-	-	<0.000050	-	<0.000050
Fluoranthene	-	-	<0.000050	-	<0.000050
Fluorene	-	-	<0.000050	-	<0.000050
Indeno(1,2,3-c,d)pyrene	-	-	<0.000050	-	<0.000050
Naphthalene	-	-	<0.000050	-	<0.000050
Phenanthrene	-	-	<0.000050	-	<0.000050
Pyrene	-	-	<0.000050	-	<0.000050
Quinoline	-	-	<0.000050	-	<0.000050
Surrogate: Acenaphthene d10 %	-	-	89.4	-	95.0
Surrogate: Acridine d9 %	-	-	93.4	-	97.7

Surrogate: Chrysene d12 %	-	-	89.9	-	92.2
Surrogate: Naphthalene d8 %	-	-	88.4	-	95.4
Surrogate: Phenanthrene d10 %	-	-	92.5	-	96.2
Anions and Nutrients					
Nitrate and Nitrite (as N)	0.0562	1.35	-	<0.0051	-
Nitrate (as N)	0.0562	1.35	-	<0.0050	-
Nitrite (as N)	<0.0010	<0.10	-	<0.0010	-
Orthophosphate-Dissolved (as P)	<0.0010	<0.0010	-	<0.0010	-
Phosphorus (P)-Total	<0.0020	<0.0020	-	0.0048	-
Bacteriological Tests					
E. coli	<1	<1	-	<1	-
Coliform Bacteria - Total	5	5	-	201	-
Cation (ueq/L)					
Al 396.153	2.120	2.503	4.442	243.3259	-0.196
Ba 455.403	39.555	45.692	79.457	388.8776	68.432
Ca 317.933	26.657	20.817	94.546	76.77329	36.131
Cu 224.700	1.847	1.817	3.193	-3.24425	1.664
Fe 259.939	-0.917	1.316	14.672	480.1596	0.438
K-ax 766.490	0.155	0.146	2.330	1.84842	0.424
Mg 279.077	6.033	4.388	43.335	24.31511	11.848
Mn 257.310	0.320	0.171	408.753	168.9117	1.301
Na 589.592 <50	0.661	1.009	10.813	5.701175	2.357
Ni 231.604	-0.842	-2.480	-7.462	0.836361	-2.780
S 180.669	16.655	12.329	72.746	49.76814	19.164
SiO2 251.609	4.436	5.559	7.119	7.073873	3.519
Sr 407.771	164.043	134.076	995.961	907.2908	244.534

Zn 213.857	10.179	8.882	16.727	287.4587	13.675
Dissolved Organic Carbon					
UV A@254nm (whole)	0.0122	0.0145	0.2443	0.0456	0.2293
Avg DOC [ppm]	11.25	0.77	11.25	3.19	9.18
SUVA	2.17	1.89	2.17	1.43	2.50
Alkalinity (ueq/L)	928.237	748.967	4478.032	1744.075	2892.728
Conductivity	-	-	-	298	580
Dissolved Oxygen					
SC	194.7	151.8	n/a	271.2	440.9
DO mg/L	12.93	12.76	12.82	8.71	12.95
DO %	94.4	95	98.1	71.8	102.5

At or below instrument Detection Limit