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

White River First Nation Community Report

2013

Prepared by the Yukon River Inter-Tribal Watershed Council

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Acknowledgments

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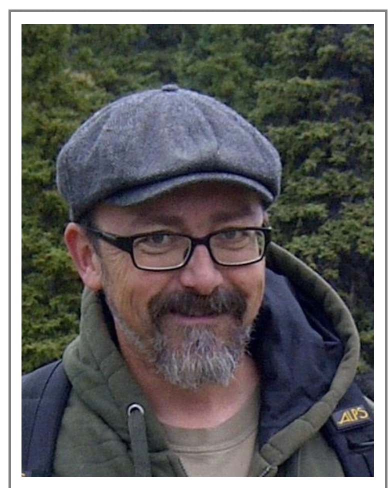

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Introduction

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 White River First Nation in 2012.

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 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).

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]

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 White River First Nation.

Figure 1 Map of the Yukon River Basin

Text Box 2 What Is Traditional Knowledge?

Indigenous knowledge of the environment, also referred to as Traditional Ecological Knowledge (TEK), 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; …many of them indigenous or tribal" (Berkes 2008: 7).

"The knowledge held by White River First Nation. Traditional Knowledge is specific to place, usually transmitted orally, and rooted in the experience of multiple generations. It is determined by our Aboriginal community land, environment, region culture and language. Traditional knowledge is usually described by Aboriginal peoples as holistic, involving body, mind, feelings, and spirit. Knowledge may be expressed in symbols, arts, ceremonial and everyday practices, narratives and, especially, in relationships. The word tradition is not necessarily synonymous with old.

Traditional knowledge is held collectively by all members of a community, although some members may have particular responsibility for its transmission. It includes preserved knowledge created by, and received from, past generations and innovations and new knowledge transmitted to subsequent generations. In international or scholarly discourse, the terms traditional knowledge and Indigenous knowledge or sometimes used interchangeably" (WRFN).

Community Context

WRFN is comprised of both Upper Tanana and Northern Tutchone people. The administrative headquarters for White River First Nation are located in Beaver Creek, YT (See Figure 2). The Department of Indian Affairs grouped the Upper Tanana people with the Southern Tutchone people of Kluane First Nation. In 1991, White River First Nation separated from Kluane First Nation to form a separate First Nation. [1]

The Upper Tanana people followed a subsistence way of life, hunting, fishing, and trapping. The Upper Tanana language belongs to the Athabascan language group. The people of White River are related to the Upper Tanana peoples of Alaska, including Northway. The Upper Tanana traditional territory extends well into the interior of Alaska. Beaver Creek was not the original Village site. Prior to the construction of the Alaska Highway in 1942, the Upper Tanana people were located at Snag and Scottie Creek (Government of Canada 2004). Beaver Creek, YT is the current administrative headquarters for WRFN. The current population of WRFN is approximated at 220 people (Government of Canada 2004). WRFN has not signed a First Nation Final Agreement and Self-Government Agreement.[2]

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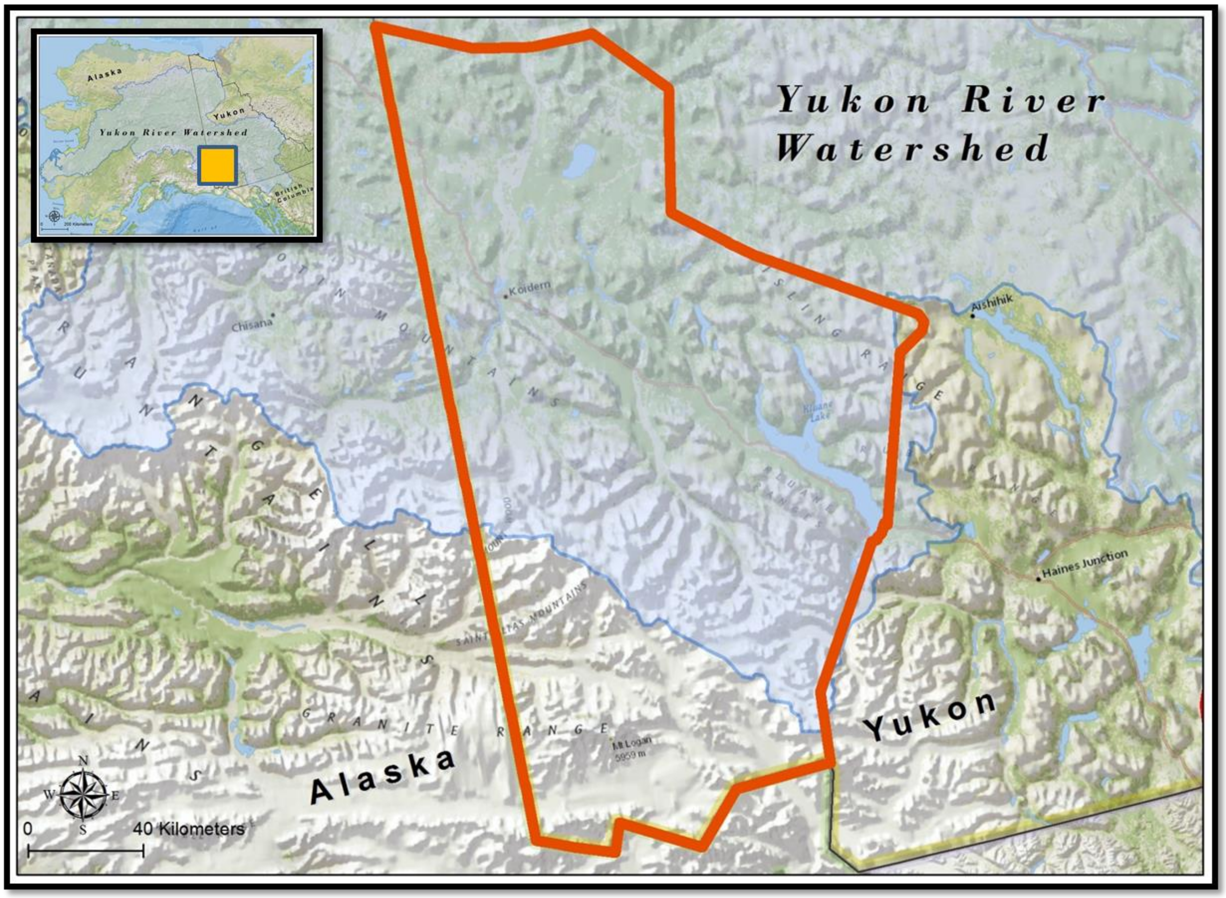
[1] http://www.cyfn.ca/ournationswrfn?noCache=339:1352336936
[2] http://www.cyfn.ca/ournationswrfn?noCache=339:1352336936

Figure 2 Map White River 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 WRFN. 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. Nine interviews were conducted in total. Four out of nine community members were Elders. The remaining five participants were middle-aged community members. 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 White River First Nation Wellness Centre on August 28th, 2012. Eight people attended the focus group. One of the focus group participants also completed an interview. Therefore, a total of sixteen individuals participated in this research.

During the focus group, the YRITWC research team used on 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 WRFN 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 16 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 ten 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 our Health Canada Youth Intern. The purpose of this report is to return the results of this research to the WRFN in a usable format.

In addition to the water quality monitoring, data from the Active Layer Network (ALN) site was collected, with support from the Youth Intern.[3] In areas with permafrost, the active layer is the surface layer that freezes in the winter and thaws in the summer ("Permafrost (geology) -- Britannica Online Encyclopedia" 2013). The ALN site is located about ten kilometres south of Beaver Creek. Within the $50m^2$ grid, one hundred depth measurements of the active layer were collected. This data is collected on an annual basis. Data was also retrieved from the soil climate station, which monitors air temperature, soil temperature and soil moisture. This grid was installed in 2010 and subsequent visits occur during peak thaw in late August to early September. This data is used to monitor the freeze and thaw trends of the active layer as an indicator of climatic change.

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

[3] https://sites.google.com/a/yritwc.org/active-layer-network/

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 the YRITWC environmental technicians with water sampling. Their in depth knowledge about the community and surrounding area was invaluable to the project. Glenn Stephen Jr. was the WRFN Youth Intern (See Project Team Profile).

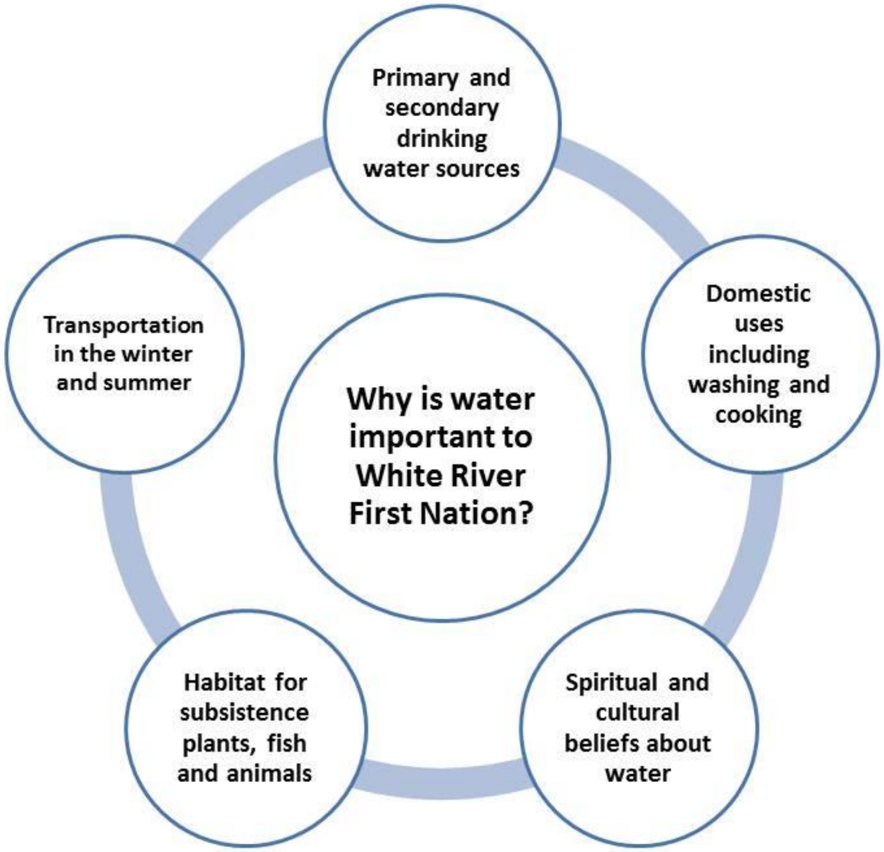
Results and Analysis

The Importance of Water to White River First Nation

Water is important to the people of White River 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 important to all aspects of life or as one interview participant put it, "[w]ater to me is more precious than gold and silver. It's the lifeline of this country. There wouldn't be anything in this world if we didn't have water. Nothing, complete nothing."

During the research project, many uses of water were identified (Figure 3). 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 creeks and springs. These secondary water sources are used by some WRFN Elders as their preferred drinking water source. Other WRFN community members cite using these other sources when they are out on the land or at camp.

Figure 3 Why is water important to White River First Nation?



Water also provides important habitat for a diversity of fish and other animals. The uses identified above makes it easy to see why water is integral to all aspects of subsistence livelihoods, which are central to First Nation culture.

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.

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 Concerns

WRFN community members described a number of water quality concerns during interviews and the focus group. These concerns included the impacts of mining, sewage, landfills, especially those resulting from the historic construction of the Alaska Highway by the US Army road camps and other historic land uses such as the impacts of the Haines to Fairbanks Military Pipeline,[4] on the waters within their traditional territories (See Figure 4). In some cases, maintaining existing water quality was identified as a priority in areas important for subsistence fishing and hunting.

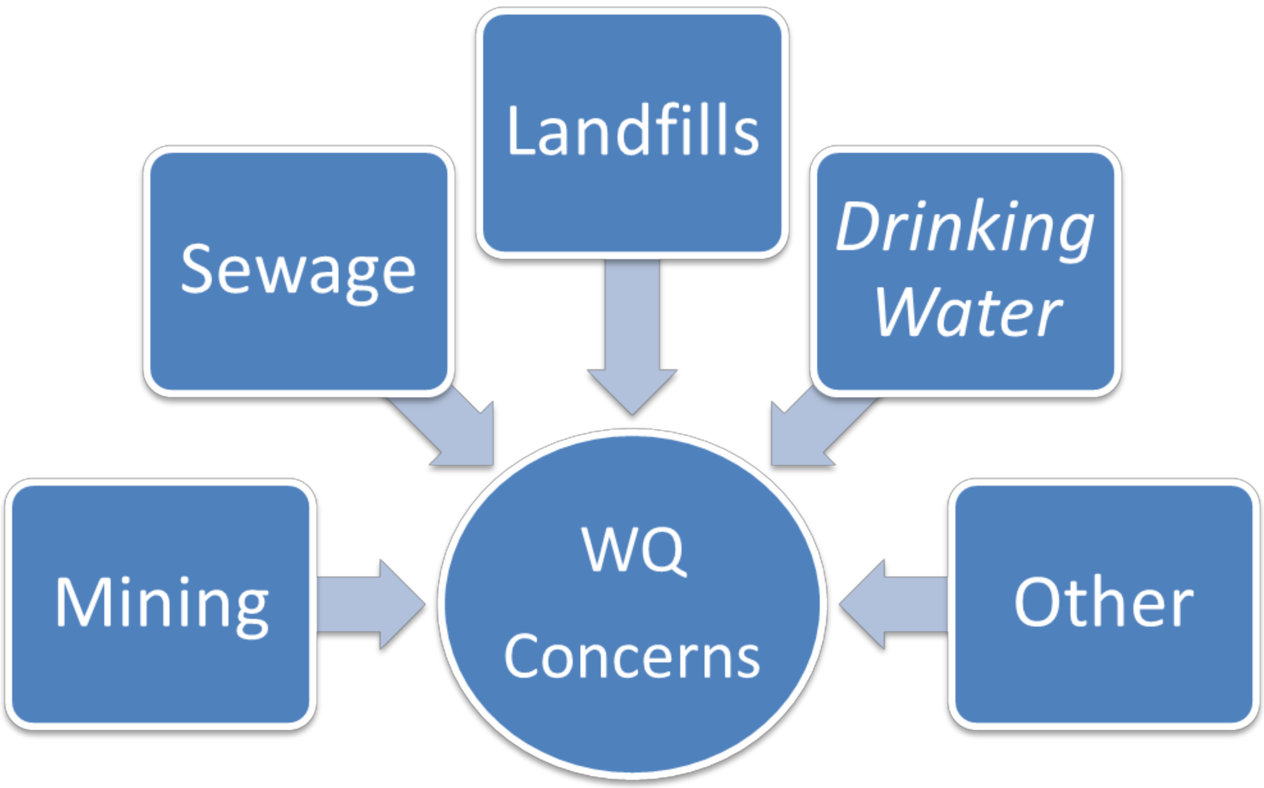
> "Sewage gets pumped out every year. The sewage lagoon is located the other side of mile 1202. The lagoon is in a marshy area. They should put it in a different location and find alternative ways to recycle sewage." (WRFN Community Member)

> "I think mainly the concern of contaminants is when the Army went through we don't exactly know where they buried everything. Even when I was talking with my late dad, he was talking about, there was so many people and so many equipment he wonder if they break down what happens to them when they broke down like all the way from Donjek River. I would have a concern for that. You would see spots where they used to have big camps. It's just mainly just brush growing up and you could tell there are just remnants that used to be a camp before. We do a lot of fishing, a lot of hunting, and a lot of berry picking out on the land... we are wondering if it's safe." (WRFN Community Member)

[4] http://sheldonmuseum.org/hainespipeline.htm

The specific sites associated with these concerns are identified on the contaminants map that was created during the focus group (See Figure 5 to 6). Sites identified during interviews were subsequently added to the map. A total of 16 sites of concern were identified. Sites identified during interviews were subsequently added to the map. Detailed descriptions of these sites were recorded (See Appendix A).[5]

Figure 4 WRFN Concerns Regarding Contaminants and Water Quality



[5] 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 WRFN Traditional Territory

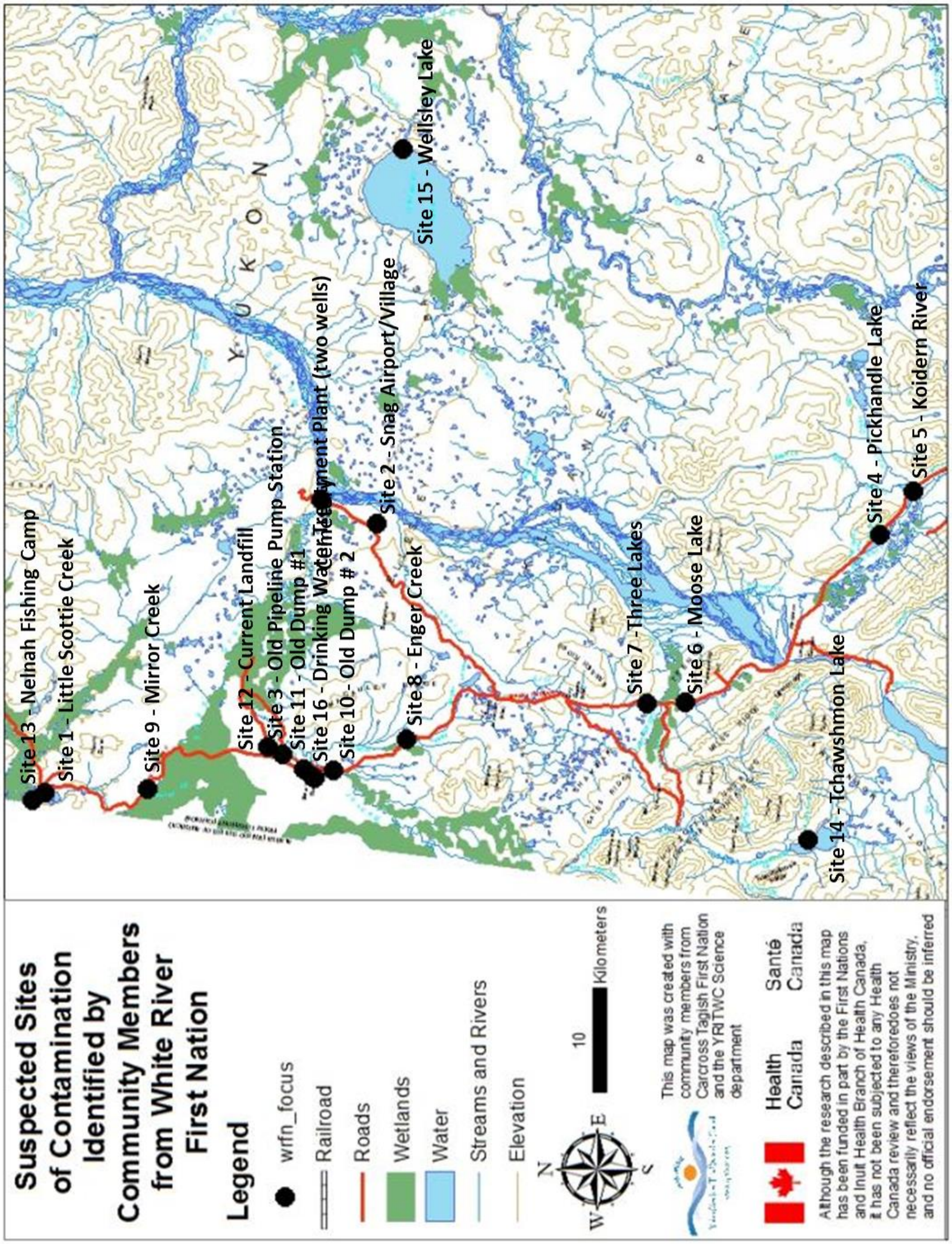
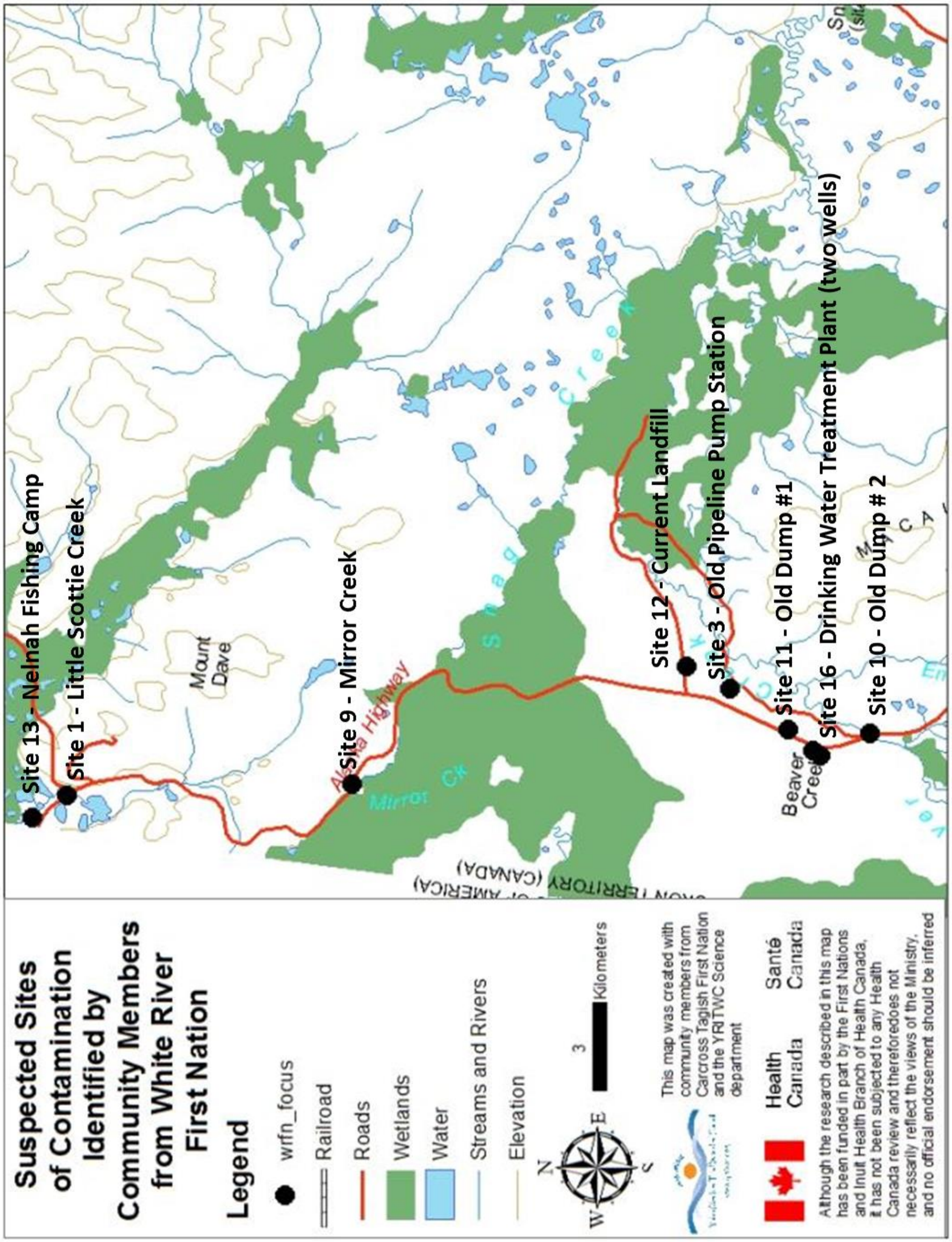


Figure 6. Water Quality Sites Identified Between Beaver Creek and the Alaska, US Border



The Health Canada grant provided YRITWC with funding to conduct water sampling at five of the sites that were identified during the research process. A voting process was used to prioritize a total of five water quality sites. Water was sampled for Hydrocarbons and YRITWC kits.

Results of Water Quality Contaminants Monitoring

Water sampling was conducted at five sites. The results of water quality sampling are displayed in Table 1.

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 work 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 aluminum, 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 is 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 et al. 2012).

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

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 WRFN government officials selected five water quality sites throughout the WRFN traditional territory. The YRITWC was responsible for sampling these sites. Table 1 provides background information for these samples, including their location and the types of contaminants for which they were sampled.

Pickhandle Lake, a recreational site located along the Alaska Highway (km 1802), was sampled for petroleum. This area was a traditional fish camp but it is now primarily used as a rest stop. Gasoline run-off from parked vehicles was observed at the time of sampling. A larger corridor between the parking area and the lake may limit fuel run-off directly flowing into the lake. The sample was taken on the downstream side of the recreational site.

At the United States and Canadian international border, the Nelnah Fishing Camp (Ts'oogot Gaay Lake) was sampled for hydrocarbons. Nelnah Fish Camp is a traditional fish camp used by WRFN and there are concerns of contamination from highway construction. This lake is highly valuable for cultural and harvesting practices for WRFN. Previously a beaver dam was blasted because of the rising water levels and bank erosion.

Little Scottie Creek was sampled above and below the Alaska Highway for hydrocarbons. Community members mentioned to the research team that the discharge of Little Scottie Creek has decreased over time ("it is drying up"). This creek had traditionally been used for fishing.

Mirror Creek was also sampled above and below the Alaska Highway for hydrocarbons. This creek is known for grayling fishing. Beavers have major influences on this creek: at least two dams were observed in the creek.

Koidern River was sampled above and below the Alaska Highway for hydrocarbons. A former US Army base was established along the river during the initial highway construction. Several old structures remain including metal scraps and barrels. An old cement floor remains and there are community concerns with buried fuel barrels. This area is prime habitat for beavers with evidence of trails and tree clippings. Also Koidern River is used for fishing.

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 will follow-up with WRFN when additional USGS data is made available.

Table 1 White River First Nation Water Quality Sites Sampled

Site Name	Site ID	GPS Coordinates	ALS Samples	Analysis	YRITWC Kits (Y/N)	Suspected Contaminants	Date
Pickhandle Lake	WRFN03	61.92035, -140.30145	Metals, Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SF	**Y**	Pullout rest-stop. Outhouse. Hydrocarbons. Fuel draining into lake from vehicles.	Aug. 29, 2012
Nelnah Fishing Camp - Lake Site	WRFN04	62.61652, -140.99608	Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SFB	**Y**	No specific contaminant.	Aug. 30, 2012
Little Scottie Creek above	WRFN05	62.60364, -140.97702	Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SF.	N	No specific contaminant.	Aug. 30, 2012
Little Scottie Creek below	WRFN06	62.60700, -140.97610	Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SF.	**Y**	Hydrocarbons, Agent Orange	Aug. 30, 2012
Mirror Creek above	WRFN07	62.49335, -140.86060	Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SF.	N	Hydrocarbons.	Aug. 30, 2012

Mirror Creek below	WRFN08	62.49392, -140.85968	Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SF.	**Y**	Hydrocarbons.	Aug. 30, 2012
Koidern River above	WRFN09	61.89782, -140.21950	Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SF.	N	Army Hwy Construction Camp. Possible buried oil fuel barrels. Hydrocarbons.	Aug. 30, 2012
Koidern River below	WRFN10	61.89754, -140.22241	Hydrocarbons	BTEX+VPH+MTBE+Styrene in water GCMS/FID. LEPH & HEPH CSR by SF.	**Y**	Army Hwy Construction Camp. Possible buried oil fuel barrels. Hydrocarbons.	Aug. 30, 2012
				Total	**5**		

Analysis of Water Quality Samples

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 used to determine a threat of contamination in drinking water, recreational water, and aquatic habitat. Caution is needed when applying guidelines and standards to water quality analyses 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 (CCME DW)[6], Guidelines for Canadian Recreational Water Quality (GCRWQ),[7] Canadian Environmental Quality Guidelines (CCME AW),[8] and Yukon

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

[7] 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

Government Contaminated Sites Regulations (YCSR).[9] A committee of scientists, experts, and government establish standards and guidelines to help determine maximum acceptable concentrations of water contaminants.

The water samples collected were sent to two laboratories, ALS Environmental and United States Geological Survey (USGS). At all five sites, hydrocarbon samples were collected and sent to ALS Environmental. Additional samples were collected and sent to the USGS laboratory in Boulder, Colorado. All sites were collected by a grab method of surface water.

Field measurements of air and water temperatures are compared across all sites in Figure 7:

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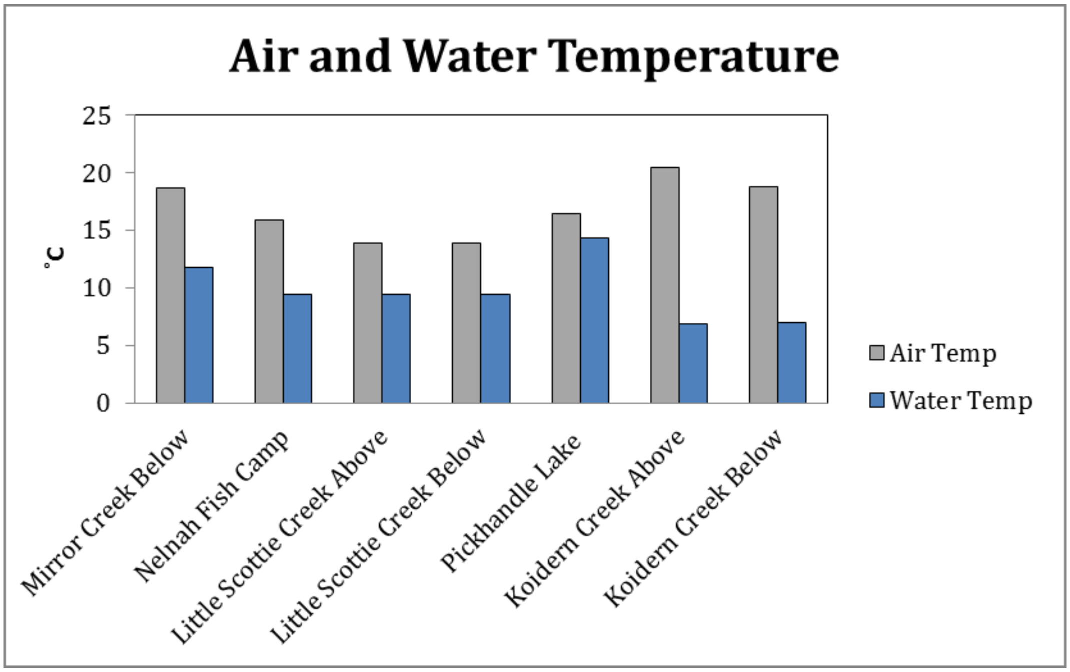
from contact with pathogenic microorganisms, and illness or injury as a result of physical or chemical properties of the water" (Health Canada 2012a).

[8] 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).

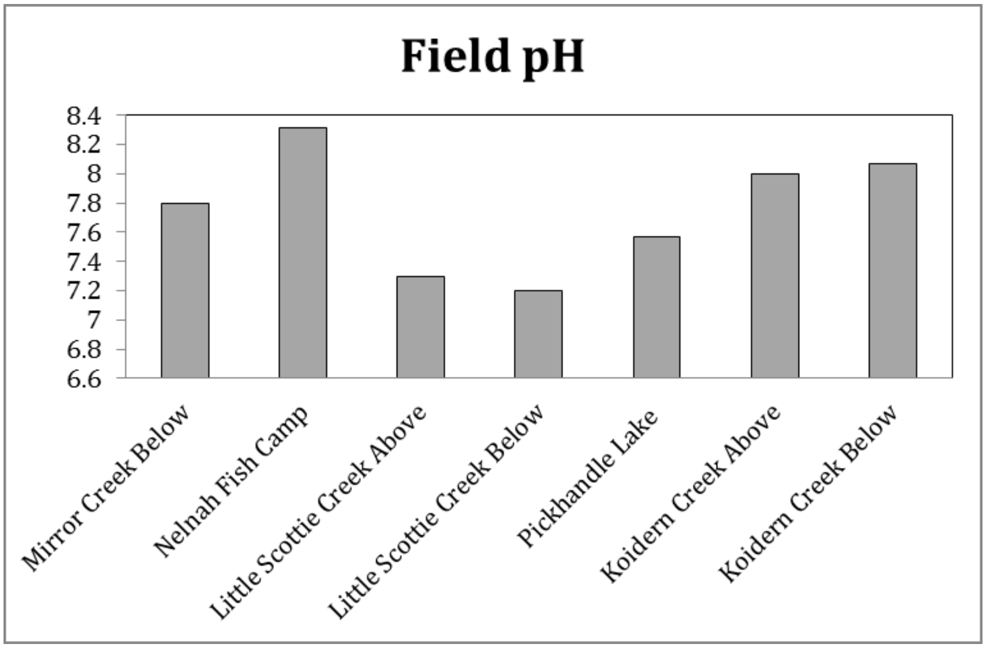
[9] The Yukon Government's Contaminated Sites Regulations (CSR) establishes standards for drinking water, aquatic life, irrigation, and livestock. These standards ensure water is suitable for direct use and is clean enough to protect water uses on adjacent properties (Yukon Government 2012).

Figure 7 Air and Water Temperature



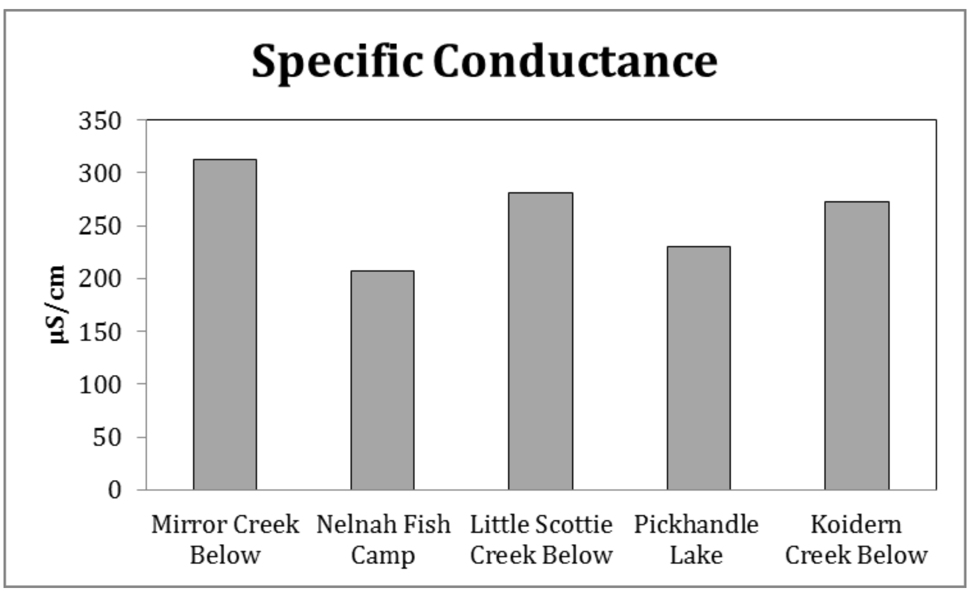
The pH field readings are in normal ranges for aquatic life, recreational water, and drinking water (See Figure 8). All of the samples collected were slightly basic (as opposed to acidic or neutral). Waters within the Yukon River watershed have similar pH values.

Figure 8 Field pH



Specific conductance was analyzed at the USGS lab for all sites except for above samples at Mirror, Little Scottie, and Koidern River (See Figure 9).

Figure 9 Specific Conductance



Dissolved oxygen levels for Koidern River and Ts'oogot Gaay Lake (Nelnah Fishing Camp) are within aquatic life standards (See Figure 10). The Canadian guidelines of water quality for the protection of aquatic life recommends a minimum concentration for DO in fresh water of 5.5 mg/L. Mirror Creek, Little Scottie Creek, and Pickhandle Lake are all below the Canadian guidelines. The below site on Little Scottie Creek could possibly be an outlier.

Figure 10 Dissolved Oxygen

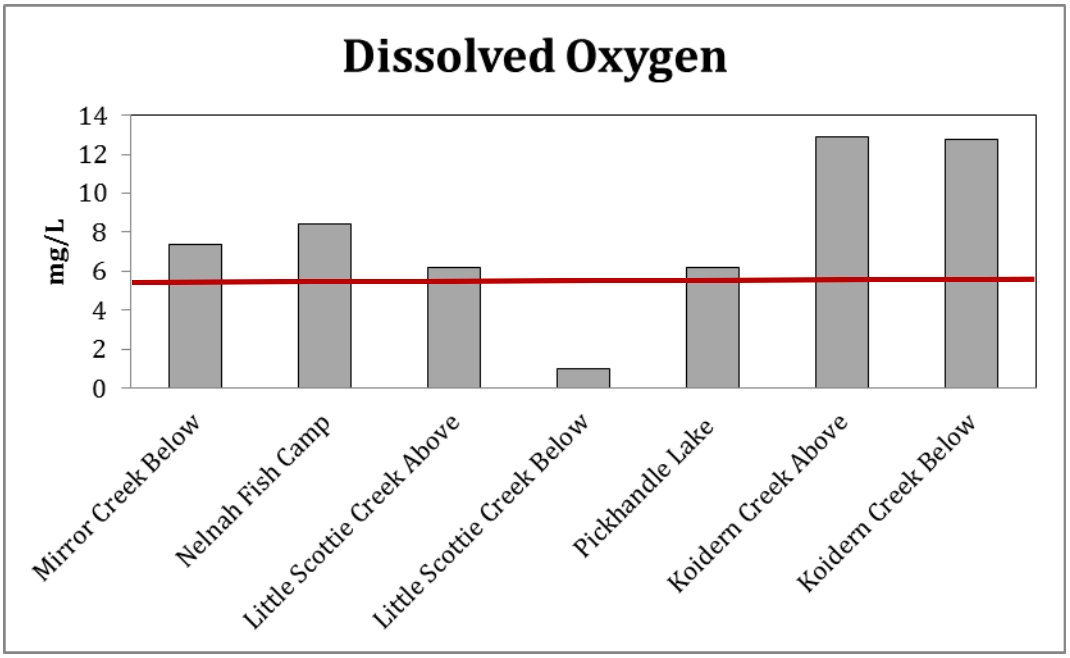


Table 2 identifies substances that exceed drinking water and recreational standards and guidelines. Collectively, hydrocarbons were not detected. Table 2 and 3 reflect ALS data and not USGS data.

Table 2 Substances Exceed Drinking and Recreational Guidelines and Standards

Surface Water Body	Site	Water Quality Parameters that Exceed YCSR DW Standards	Water Quality Parameters that Exceed CCME DW	Water Quality Parameters that Exceed GCRWQ
Pickhandle Lake	WRFN03	No	No	No
Nelnah Lake	WRFN04	No	No	No
Little Scottie Creek Above	WRFN05	No	No	No
Little Scottie Creek Below	WRFN06	No	No	No
Mirror Creek Above	WRFN07	No	No	No
Mirror Creek Below	WRFN08	No	No	No
Koidern River Above	WRFN09	No	No	No
Koidern River Below	WRFN10	No	No	No

Table 3 summarizes the parameters exceeding aquatic life standards.

Table 3 Substances Exceeding Aquatic Life Guidelines and Standards

Surface Water Body	Site	Water Quality Parameters that Exceed YCSR AW Standards	Water Quality Parameters that Exceed CCME AW Guidelines
Pickhandle Lake	WRFN03	No	No
Nelnah Lake	WRFN04	No	No
Little Scottie Creek Above	WRFN05	No	No
Little Scottie Creek Below	WRFN06	No	No
Mirror Creek Above	WRFN07	No	No
Mirror Creek Below	WRFN08	No	No
Koidern River Above	WRFN09	No	No
Koidern River Below	WRFN10	No	No

Raw drinking water sites were not identified and no *E. coli* or other biological samples were collected. Volatile organic compounds were not detectable within the detection limits used in the analysis.

Interpretation of Results

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 apply to treated water (i.e., filtered, chlorinated, etc.). However, we wanted to compare these untreated water bodies to Drinking Water standards due to their use as secondary or traditional drinking water sources. Natural water bodies generally contain a wide variety of bacteria, nutrients, and metals that varies depending on 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 not determine the source (human vs. wildlife). Therefore, the results from this year's sampling do not show any significant results of contamination.

"The permafrost is melting. One time there were big lakes and now there are small lakes. Where one time I used to go hunting with canoe, right now I could walk across." (WRFN Community Member)

"There are no blueberries this year. There are a lot of cranberries. There might have been too much rain for blueberries." (WRFN Community Member)

"The winters are not as cold as they used to be. For about a month and a half a year we used to have 40 to 60 F below. That's normal around here. You don't see that anymore. In these past few winters, we get 40 [below], oh about, four and if we are lucky maybe five days." (WRFN Community Member)

"The ice, it doesn't freeze up as much. It will freeze, but it's just the top, which means that the creek is dangerous because it's so thin ice. I used to travel those lakes with dog team and snow machines in the winter. We know the lakes that are not really safe to travel on because they have soft spots on." (WRFN Community Member)

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 WRFN 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 WRFN can continue to reference for many years in the future. At the very least, this data will allow WRFN 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 WRFN 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, river and lake ice regimes, plants, fish and animals and others. These observations of climate change in the White River 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 information regarding the impacts that climate change is having on the environment and the people who call this region home. In combination with concerns about the impacts of contaminants on water and results from water quality sampling, observations of the impacts of climate change are important in understanding overall environmental change and the impacts these changes may be having on community members. Further research on the interactions between contaminants and climate change in specific aspects of the environment are required.

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

Type of Change Observed	Examples of Change
Weather	• Warmer temperatures • Increased snow
Water Levels	• Lower water levels in lakes • Lower water levels in Beaver Creek and Snag Creek
Permafrost	• Permafrost thawing and was linked to lower water levels in lakes
River and Lake Ice	• Reduced ice thickness • Later freeze-up • Break-up is occurring faster than it used to
Plants	• Different plants that don't belong here, i.e., algae on the lakes • Blueberry crops were poor
Other	• Decrease in bees

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 research team were only able to take one water sample per site. The logistics of sampling over the large geographic area of the Yukon Territory further reduced the time available for fieldwork. 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 our 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. Soil samples also would have been useful in identifying contamination.

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 WRFN, 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**. 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 Contaminants	Site Description
1	Little Scottie Creek	Hydrocarbons, Agent Orange	There was a historic spill on the pipeline near the near Little Scottie Creek, at the Alaska-Yukon border. This creek flows into Little John Lake. Agent orange was used along the pipeline (1950's & 60's). There also used to be a road camp there when the Highway was being constructed, located where the Highway crosses the creek. This are is used for berry picking, fishing and water fowl hunting.
2	Snag Airport/Village	Hydrocarbons, PCBs	It is thought that at Snag Airport/Village PCBs (Polychlorinated biphenyls) were used. Participants also informed that a remediation project was conducted at Snag Airport a couple of years ago. There are still houses there, but no one lives there now. There is a graveyard. People continue to hunt this area for moose and grouse. There are a number of creeks in the area.
3	Old Pipeline Pump Station	Hydrocarbons	Old pipeline pumping station from the 1940s. There are old drums and holding tanks located there that could affect water quality.
4	Pickhandle Lake	Hydrocarbons/Fish Habitat	There is a fish camp there currently. This area is important for subsistence harvesting and is referred to as a food basket. The US Army was there during the construction of the Alaska Highway. Pickhandle Lake is located 40 minutes south of Beaver Creek.
5	Koidern River	Hydrocarbons	Location of an old US Army road camp, from the time of the construction of the Alaska Pipeline. Koidern River was sampled, above and below the camp. The area is important for fishing and moose hunting. There is a steamer found in the Koidern River.
6	Moose Lake	No specific concern/Habitat	Very important for moose hunting and fishing. It is a big lake and it provides important habitat. It would be good to have a baseline site on this lake.

7	Three Lakes	No specific concern/Habitat	Very important for moose hunting and fishing. No known contaminants, but a baseline sample would be valuable. The area is important for people's overall health.
8	Enger Creek	No specific concern/Habitat	Important fishing area. People fish for grayling there. Area of possible gold prospecting. Located ten minutes north of Beaver Creek.
9	Mirror Creek	Hydrocarbons	Used to fish for grayling and was a drinking water source before drinking wells. Large Beaver dam on creek. There is a cabin near the pull-off with the no trespassing sign.
10	Old Dump # 2	Leaching, Metals, Hydrocarbons etc.	Site of a former dump. It was not used after the 1960s. There are many things buried in there.
11	Current Landfill	Leaching, Metals, Hydrocarbons etc.	Built in the 1970s or 80s.
12	Old Dump # 1	Leaching, Metals, Hydrocarbons etc.	Site of former dump. It stopped being used in the 1960s when the current landfill came into use.
13	Nelnah Fishing Camp (Mile 1220)	Hydrocarbons	Located on Ts'oogot Gaay Lake. Concerns about hydrocarbon contaminants. Located along the Alaskan border. Important area for fishing. Nelnah's fish camp is located here.
14	Tchawshmon Lake	No specific concern/Habitat	Tchawshmon Lake is very important for moose hunting and fishing for trout. It was also the site of a former village, pre 1940s.
15	Wellsle Lake	No specific concern/Habitat	Important for fishing, ice fishing, resort located there.
16	Drinking Treatment Plant	No specific concern.	There is a new water treatment plant (2008). A number of houses still have private wells. The drinking water is tested daily and weekly. Water for water treatment plant is being drawn from 40 metre deep wells.

*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 11 Pickhandle Lake

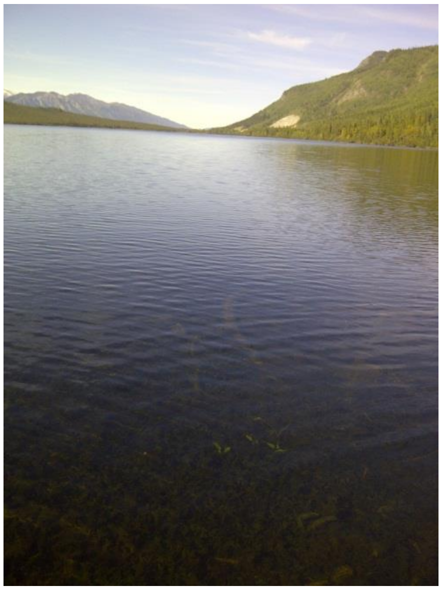


Figure 12 Nelnah Fishing Camp/Ts'oogot Gaay Lake

Figure 13 Little Scottie Creek Above

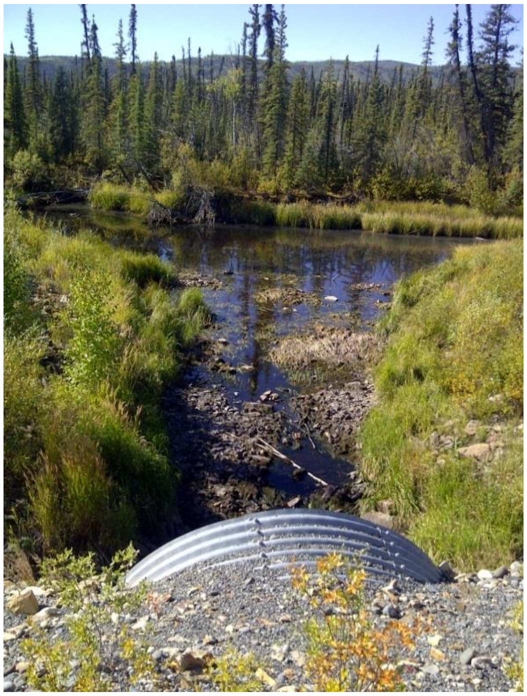


Figure 14 Little Scottie Creek Below

Figure 15 Mirror Creek Above

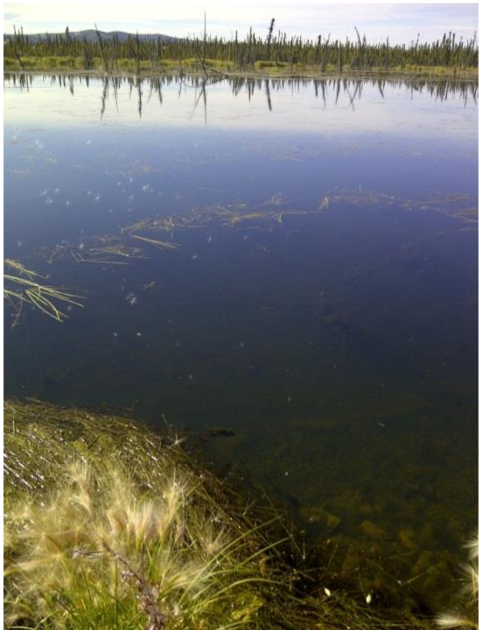


Figure 16 Mirror Creek Below

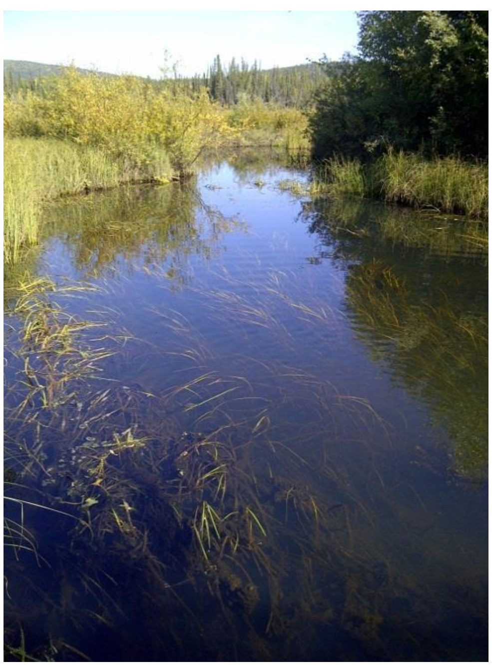
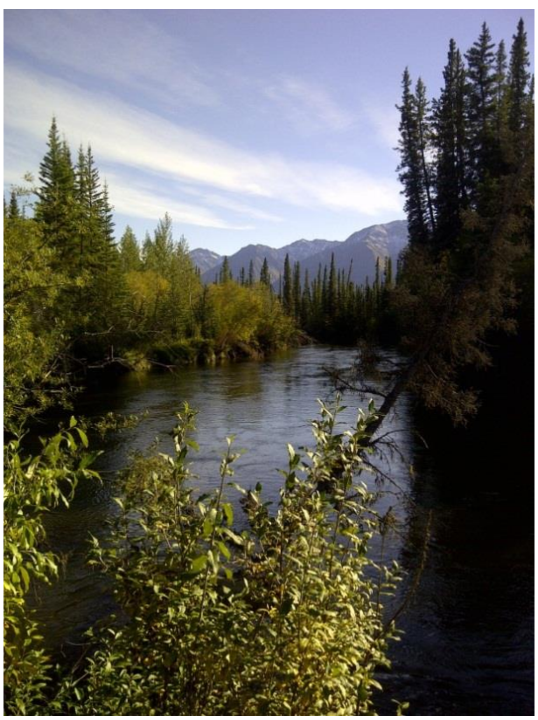


Figure 17 Koidern River Above

Figure 18 Koidern River Below



Appendix C – Beaver Creek ALN

Figure 19 Beaver Creek Active Layer Network Site

Glenn Stephen Jr. is maintaining the temperature and moisture data logger.

Appendix C – Useful Resources

1. Yukon Water- http://yukonwater.ca/- Here, you'll find information about Yukon's water resources. There is information about how water is used, managed and monitored. 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

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

3. http://waterquality.ec.gc.ca/- The Fresh Water Quality Monitoring & Surveillance Division focuses on regular monitoring, surveillance and reporting on fresh water quality, and aquatic ecosystem status and trends.
4. http://www.ec.gc.ca/rhc-wsc/-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.
5. http://www.env.gov.yk.ca/branches/environmental_programs.php- Environment impacts analysis; Contaminated sites monitoring; Assess and remediate Yukon Government contaminated sites.
6. http://www.kwanlindun.com/- Kwanlin Dun First Nation, Department of Heritage, Lands & Resources. Conduct continuous monthly seasonal water sampling at Michie Creek, southeast of Whitehorse.
7. http://www.taan.ca/- 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.
8. http://www.emr.gov.yk.ca/csi/index.html- 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).
9. http://www.hss.gov.yk.ca/environmental_drinkingwater.php- 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.

10. http://www.yukonwaterboard.ca/- 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.
11. http://www.yesab.ca/index.html- 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.
12. http://www.env.gov.yk.ca/pdf/YukonWaterWellsSummary.pdf- Summary of Yukon water wells. Most current report dating May 11, 2006.
13. 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
14. 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	WRFN03	WRFN04	WRFN05	WRFN06	WRFN07	WRFN08	WRFN09	WRFN10
Site Name	Pickhandle Lake	Nelnah Fish Camp	Little Scottie Creek Above	Little Scottie Creek Below	Mirror Creek Above	Mirror Creek Below	Koidern River Above	Koidern River Below
Site Coordinates	61.92035, -140.30145	62.61652, -140.99608	62.60664, -140.97702	62.60700, -140.97610	62.49335, -140.86060	62.49392, -140.85968	61.89782, -140.21950	61.89754, -140.22241
Date Sampled	29-AUG-12	30-AUG-12	30-AUG-12	30-AUG-12	30-AUG-12	30-AUG-12	30-AUG-12	30-AUG-12
Time Sampled	13:53	13:09	13:45	14:09	15:50	16:05	18:05	18:33
Matrix	Water	Water	Water	Water	Water	Water	Water	Water
Field pH	7.57	8.31	7.30	7.20	7.67	7.8	8.00	8.07
Air Temp. (°C)	16.4	15.9	13.9	13.9	18.7	18.7	20.4	18.8
Water Temp. (°C)	14.3	9.4	9.4	9.5	11.1	11.8	6.9	7
Dissolved Oxygen (mg/L)	6.21	8.45	6.16	-	7.33	7.36	12.89	12.77
Volatile Organic Compounds (mg/L)								
Benzene	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Ethylbenzene	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Methyl t-butyl ether (MTBE)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Styrene	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
ortho-Xylene	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
meta- & para-Xylene	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Xylenes	<0.00075	<0.00075	<0.00075	<0.00075	<0.00075	<0.00075	<0.00075	<0.00075
Surrogate: 4-Bromofluorobenzene (SS) %	91.2	88.0	90.4	93.8	89.2	84.8	92.8	88.8
Surrogate: 1,4-Difluorobenzene (SS) %	99.0	98.5	99.8	99.9	99.2	98.3	100.5	100.4

Hydrocarbons (mg/L)								
EPH10-19	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
EPH19-32	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
LEPH	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
HEPH	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Volatile Hydrocarbons (VH6-10)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
VPH (C6-C10)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Surrogate: 3,4-Dichlorotoluene (SS) %	111.4	110.7	100.1	111.9	103.7	97.8	115.2	108.2
Polycyclic Aromatic Hydrocarbons (mg/L)								
Acenaphthene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Acenaphthylene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Acridine	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Anthracene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benz(a)anthracene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benzo(a)pyrene	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Benzo(b)fluoranthene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benzo(g,h,i)perylene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Benzo(k)fluoranthene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Chrysene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Dibenz(a,h)anthracene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Fluoranthene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Fluorene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Indeno(1,2,3-c,d)pyrene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Naphthalene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Phenanthrene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Pyrene	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Quinoline	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Surrogate: Acenaphthene d10	90.5	89.3	99.0	114.2	113.0	89.6	90.6	92.1
Surrogate: Acridine d9 (%)	92.6	90.2	93.1	116.2	111.3	124.9	114.4	120.4
Surrogate: Chrysene d12 (%)	85.8	85.4	95.3	105.3	104.3	90.2	88.1	103.3
Surrogate: Naphthalene d8 (%)	89.3	88.5	97.1	113.5	111.7	89.2	101.5	102.6

Surrogate: Phenanthrene d10 (%)	94.8	95.0	103.6	117.8	117.7	108.7	102.9	109.8
Cation (ueq/L)								
Al 396.153	2.188	7.022		14.827		2.207		27.988
Ba 455.403	45.308	230.710		27.884		119.666		29.554
Ca 317.933	32.482	27.282		38.643		47.466		43.095
Cu 224.700	1.859	1.103		2.023		2.744		4.534
Fe 259.939	9.483	279.583		1621.278		94.367		63.142
K-ax 766.490	1.930	0.508		0.823		0.870		0.988
Mg 279.077	15.005	9.596		11.719		8.246		8.691
Mn 257.310	5.720	25.814		423.412		42.691		18.538
Na 589.592 <50	5.824	5.462		4.039		3.905		2.578
Ni 231.604	-0.487	1.241		-0.560		-2.396		0.667
S 180.669	11.849	2.492		4.819		9.964		13.956
SiO2 251.609	0.796	0.823		6.443		8.678		9.099
Sr 407.771	176.296	147.270		185.698		257.952		182.364
Zn 213.857	18.542	13.534		18.202		39.660		12.583
Dissolved Organic Carbon								
UV A@254nm (whole)	0.1791	0.8997	-	0.9788	-	0.1246	-	0.2657
Avg DOC [ppm]	11.08	27.97	-	19.52	-	0.1246	-	8.25
SUVA	1.62	3.22	-	5.02	-	3.08	-	3.22
Alkalinity ueq/L	2385.016	2027.985	-	2572.529	-	2787.991	-	2156.304
Conductivity	307	218	-	282	-	325	-	288
Dissolved Oxygen								
SC	229.8	206.8	-	281.1	-	313.2	-	272.1
DO mg/L	6.21	8.45	-	0.98	-	7.36	-	12.77
DO %	60.8	73.8	-	8.5	-	62.1	-	105.1

At or below instrument Detection Limit

Relative Percent Difference > 10%

Average from Duplicate