

2009

Yukon River Condition Summary

Prepared jointly by:

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Alaska Monitoring and Assessment Program;

Yukon River Inter-Tribal Watershed Council; and
University of Alaska Anchorage, Alaska Natural Heritage Program

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Executive Summary

The purpose of the field study was to conduct a water quality and habitat assessment of the Yukon River main-stem. The Yukon River Inter-Tribal Watershed Council and the Alaska Department of Environmental Conservation conducted the synoptic survey using protocols consistent with National Rivers and Streams Assessment protocols and the United States Geological Survey Techniques of Water Resource Investigations Book 9 standards. In situ, Secchi disk transparency, water chemistry, sediment enzymes, chlorophyll-a, benthic macroinvertebrate assemblage, fish tissue chemistry, physical habitat assessment, fecal indicators, and site characteristics were evaluated at each station. The survey was designed to provide representative condition to compare against future surveys, and help build State and Tribal capacity for monitoring and assessing its waters. The Yukon River is a dynamic, high velocity system that supports a relatively pristine ecosystem and multiple uses. Overall results do not indicate water quality, sediment, biological, or habitat concerns.

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The document can be downloaded at the following URL:

<http://www.dec.alaska.gov/water/wqsar/monitoring/2009YukonRiver.htm>

Disclaimer

Note that the design supports probability based estimates of the percent area of the target population surveyed for particular ecological condition. However, this design does not provide for detailed assessments of ecological conditions for individual sites.

Acknowledgments

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1.0 Introduction

Through a culture of collaboration, a 600 mile synoptic survey of the Yukon River main-stem between Fort Yukon and Kaltag, Alaska was accomplished during the summer of 2009. The survey was completed during a two week field campaign from July 5th through July 18th. The collaboration involved partnerships between the Yukon River Inter-Tribal Watershed Council (YRITWC), State of Alaska Department of Environmental Conservation (DEC), Environmental Protection Agency's National Rivers and Streams Assessment Program (NRSA), United States Geological Survey (USGS), Council of Athabascan Tribal Governments (CATG), Koyukuk National Wildlife Refuge (KNWR), and the University of Alaska Anchorage Alaska Natural Heritage (AKNHP) program (Figure 1).



Figure 1. Three teams work simultaneously to complete the survey. Left: The water quality team was from the YRITWC; Middle: The upper reach team was made up from the CATG, AKNHP and DEC; Right: The lower reach team was from the KNWR and AKNHP.

Yukon means “great river” in Gwich’in. The river is believed to be the human migration route to North America, it also served as the transportation route for the Klondike Gold Rush. Although the Yukon River has a history of pollution from gold mining, military activities, unregulated dumps, and wastewater discharges recent environmental studies describe a relatively intact ecosystem. Climate change and the effects from thawing permafrost and glacial runoff are the main stressors to the Yukon River (Richter-Menge, et al., 2009).

Before the year 2001 there was no comprehensive hydrological dataset for the Yukon River Basin. The USGS conducted the first comprehensive examination of water quality in the Yukon Basin between 2000 and 2005. YRITWC worked directly with USGS, using a Community Participatory Approach, to streamline the USGS study and protocol in an effort to make a smooth transition to future YRITWC led studies from 2005 to 2009. The partnership between the DEC, YRITWC, and USGS was a direct result of USGS and YRITWC's existing partnership and the previous work by DEC in the basin. Results from the nine years of baseline, the 2007 Healing Journey profile, and the 2006 DEC Tanana River survey showed that the Tanana-Yukon River confluence has a significant influence on water chemistry of the Yukon main-stem.

The underlying methodology we applied used a unique approach to large scale data collection. A melding of protocols, from the NRSA protocol and a Community Participatory Research approach was used to implement the survey. The EPA Quality Assurance Project Plan and Field Manual were followed. Additionally, USGS samples were taken following protocols consistent with the USGS Techniques of Water-Resources Investigations Book 9 Standard and are outlined in the YRITWC Quality Assurance Project Plan. The foundation of the methodology was to create verifiable data that can be used by community, science and regulators alike. This report outlines the survey design, observed results and a discussion of the results.

The YRITWC built on previously established relationships to engage the communities directly with information and training resources; while DEC used their previous relationship with AKNHP to conduct large scale habitat assessment. Community members learned how to conduct scientific field campaigns through on-site experiential training and public outreach was conducted through public service announcements about the survey. The public service announcements were aired across the region in English, Gwich'in and Cup'ik.

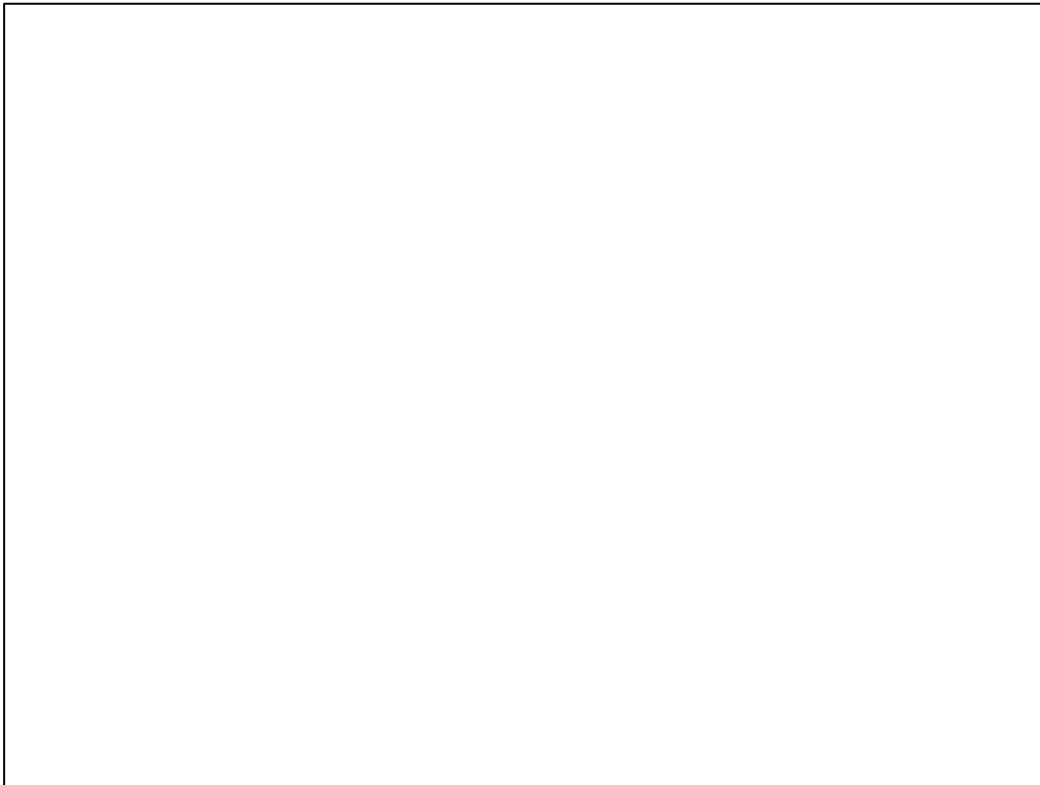


Figure 2. The Yukon River experienced severe flooding in the spring of 2009. Above average ice formations and snow packs combined with unseasonably warm spring temperatures caused rapid melting and large ice flow movement downstream. Water levels were very high and ice choked the river; several communities along the Yukon River experienced catastrophic flooding. By July, most of the debris had been swept away but trees were still falling into the river due to undercut banks caused by the flooding and ice scouring.

2.0 Characteristics of the Yukon River

2.1 Physical setting

The Yukon River is the largest free flowing river in the world (Nilsson et al., 2005) and the 4th largest river basin in North America. While climate change is having a drastic and rapid effect on ecosystems around the globe, the most dramatic effects are being displayed in the Arctic and Sub-Arctic (Arctic Climate Impact Assessment, 2004; National Academy of Sciences, 2010). The climates in these regions also present many challenges to the acquisition of long-term (or short-term) data sets. The watershed, which consists of the main-stem Yukon River and all tributaries, covers a vast portion of Alaska and the Yukon Territory in Canada. Temperatures across the watershed on average will range from over 30° Celsius in the summer to temperatures lower than 40° below Celsius in the winter.

The Yukon River Basin is approximately 330,000 mi² in area and 1,980 miles in length. It has an annual discharge of over 200,000 ft² per second at its mouth (Brabets, 2000). The River is characterized by annual winter freeze-ups and summer thaws. It supports various activities including residential development, subsistence lifestyles, mining, tourism, and military activity. Nearly all the people in the basin depend to varying degrees on fish and game resources for livelihood and subsistence use. The Yukon River Basin can be divided into five distinct physiographic descriptions: (1) rolling topography and gentles slopes, (2) low mountains-generally rolling, (3) plains and lowlands, (4) moderately high rugged mountains, (5) and extremely high rugged mountains (figure 3). The Yukon Basin is split between two countries: the United States and Canada. Our survey focused on the Alaskan side with work beginning in the Yukon-Tanana Upland region and ending in the Nowitna Lowland region.

Figure 3. Physiographic regions of the Yukon River Basin (Brabets 2000).

There are four distinct regions within our survey area:

Yukon-Tanana Upland-rounded even topped ridges, flat-alluvium floored streams, no glaciers presents, discontinuous permafrost present.

Tanana-Kuskokwim Lowland-broad depression, drained by the Tanana River, thaw lakes presents, braided glacial streams, permafrost covers entire area.

Yukon Flats-marshy lake dotted flats, gently sloping outwash fans to broad gentle outwash fans are contributing tributaries, flat flood plains, braided meandering course, many sloughs.

Nowitna Lowland- rolling silt-covered tableland, drained by the Yukon River in the northern boundary, confluence of the Yukon River and Tanana River in eastern part.

Tanana-Kuskokwim Lowland-broad depression, drained by the Tanana River, thaw lakes presents, braided glacial streams, permafrost covers entire area.

2.2 Biological setting

The Yukon Basin has a relatively intact ecosystem with high-quality habitat for birds, mammals, fish, invertebrates and one amphibian. Thousands of lakes, ponds, sloughs, wetlands, and river and stream miles provide habitat. White spruce, paper birch, and quaking aspen forests, willow and alder thickets, grasslands, meadows and alpine tundra round out the potential habitats. In the Yukon Flats National Wildlife Refuge an estimated 1.5 million ducks breed annually. Bird, mammal and fish species checklists have been completed for the National Wildlife Refuges in the Basin, but no comprehensive list of invertebrates has been completed. More than 150 bird species, 40 mammal, and 18 fish species can be found within the Basin. The one amphibian, the wood frog, is able to survive by increasing glucose in its cells, the glucose acts as antifreeze allowing the frog to survive the winters.

The Yukon River has one of the longest salmon runs in history. Chinook, coho and chum salmon return each year to spawning streams in Alaska and Canada. Yukon River salmon must build up large fat reserves for their long journeys. Because of this they prized for their rich and oily meat. Salmon are an important subsistence resource for villages along the river and are traditionally dried, smoked and frozen. Subsistence, recreation, and commercial fisheries are actively managed by the Alaska Department of Fish and Game as well as several national and international treaties.



Figure 4. Fish wheels can be found along the Yukon River and provide a means of subsistence harvest. A Federal Disaster Declaration was in place for commercial Chinook fisheries' in 2008 and 2009. Addition subsistence restrictions were in place in 2009.

2.3 Human Influence

Within Alaska, the Yukon Basin is comprised of Cup'ik, Yup'ik, Koyukon and Gwich'in Athabascan Tribal Nations consisting of 62 Tribal communities, over 11% of all Tribes in the entire United States. The population of the entire watershed is approximately 119,000 people, with roughly 88% living in the Fairbanks area. The Fairbanks North Star Borough and the Fairbanks Census area is approximately 32,106 mi². The remaining 13,318 people live in the Yukon-Koyukuk and the Wade Hampton Census Areas. These areas combined cover 162,585 mi², with roughly 83% of the population being Indigenous people (US Department of Commerce, 2010). A skeletal road system traverses the state and many of the Indigenous communities in the region are very remote with no access to the primary road system. They rely on travel via airplanes, riverboats, dog teams and snow-machines. The river and surrounding lands provide over 50% of the Indigenous peoples' food and nutrition in the form of fish, moose, caribou, berries, mountain sheep, rabbit, beaver, ducks, goose and other animals; making sustainable management and appropriately implemented adaptation strategies exponentially important.

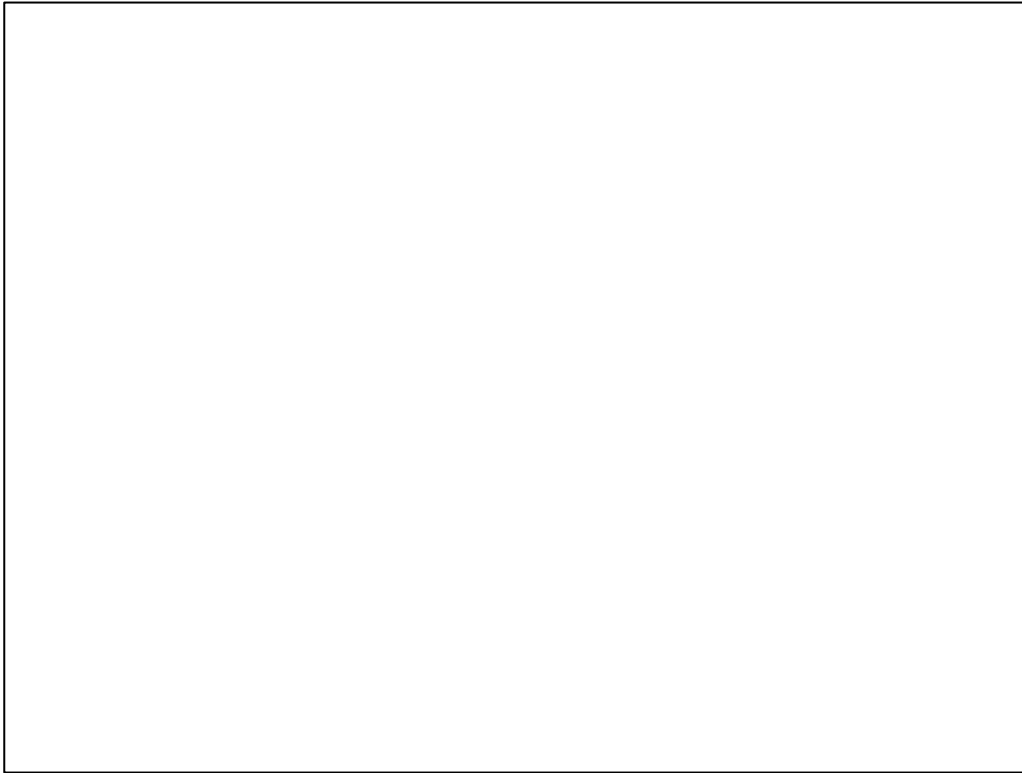


Figure 5. A moose navigates the river.

3.0 Survey Summary

3.1 Survey Design

Our survey is part of EPA's 2008-2009 National Rivers and Streams Assessment and designed to evaluate stress on the aquatic condition, which can occur as people use the landscape. Their actions can produce effects through chemical, physical, or biological changes in the environment. The list of stressors selected for this survey is not intended to be all inclusive; budgets, logistics, or the lack of agreed upon methods for evaluating stressors limited our selection. In-situ and laboratory parameters were assessed as indicators of stress based on direct measures in the river or adjacent riparian areas. This report highlights only a select few; others are available in Appendices A through F. The majority of results indicate little to no change throughout the reach surveyed, and fall within expected natural conditions

This study was completed in a synoptic fashion. A synoptic study is a short-term investigation of water quality during selected seasonal periods or hydrologic conditions. Studies of this nature provide improved spatial resolution, compared with fixed-site data, for critical water-quality conditions during selected seasonal periods or hydrologic conditions. They also evaluate the spatial distribution of selected water-quality conditions in relation to causative factors, such as land uses and other contaminant sources.

In order to accomplish the survey three crews worked simultaneously. The survey occurred during the first two weeks of July 2009. YRITWC technicians sampled water quality and performed outreach along the entire reach. Two crews made up from ADEC, ENRI, BLM, NWR, and the YRITWC sampled physical habitat, biological specimens, and additional water quality parameters. One crew focused on the upper reach starting in Fort Yukon and worked downriver to Tanana. The second crew focused on the lower reach from Tanana to Kaltag.

3.2 Site Selection

Site selection was determined using a stratified systematic sample design. The sample points were confined to the main-stem Yukon River, 25 samples above and 25 below the Tanana confluence (Figure 6). Physical habitat transects composed of 11 shoreline sites centered about each water sampling site, approximately 1.0 to 1.5 river miles apart. Five-hundred and fifty physical habitat sites were sampled along the entire reach, 225 above the Tanana confluence, and 225 below. The first five sites of each transect were located on the right side of the river, upon crossing the river a grab sample of water was collected mid channel before the remaining six sites were sampled on the left side of the river.

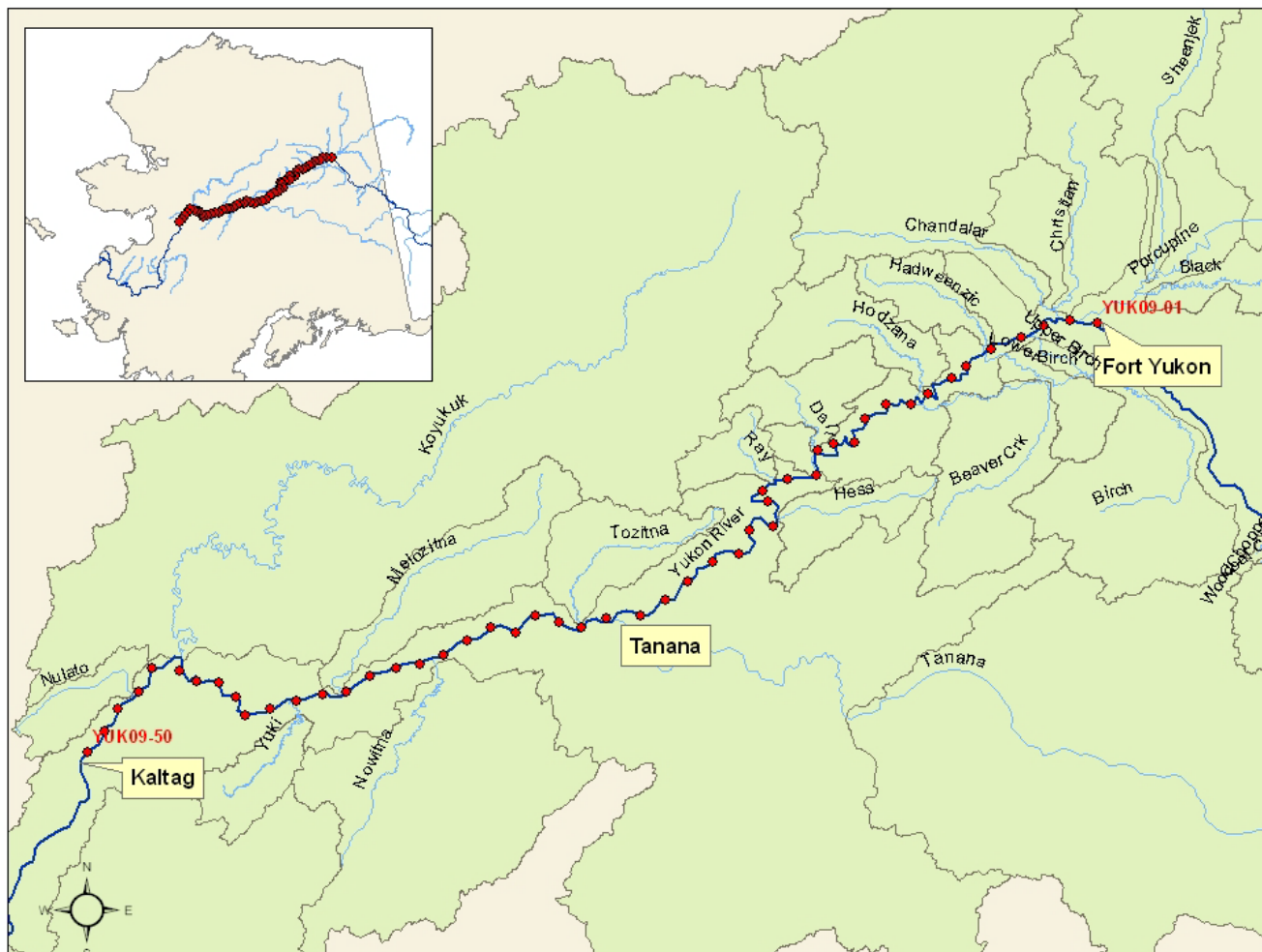


Figure 6. During the 2009 Yukon River Survey 50 sites were surveyed from Fort Yukon to Kaltag, AK.

3.3 Water Chemistry

In-situ and laboratory results were evaluated due to concerns about the extent to which they may be impacting the river biota. A few parameters are highlighted below; the majority of measurements were consistent with natural variability and expected conditions throughout the reach. Temperature increased in a downstream direction, while dissolved oxygen was unrelated to longitudinal position (Figure 7). Total suspended solids also increased in a downstream direction, with highest readings found after the confluence of the Tanana River (Figure 8). All water chemistry parameters are summarized below in Table 1.

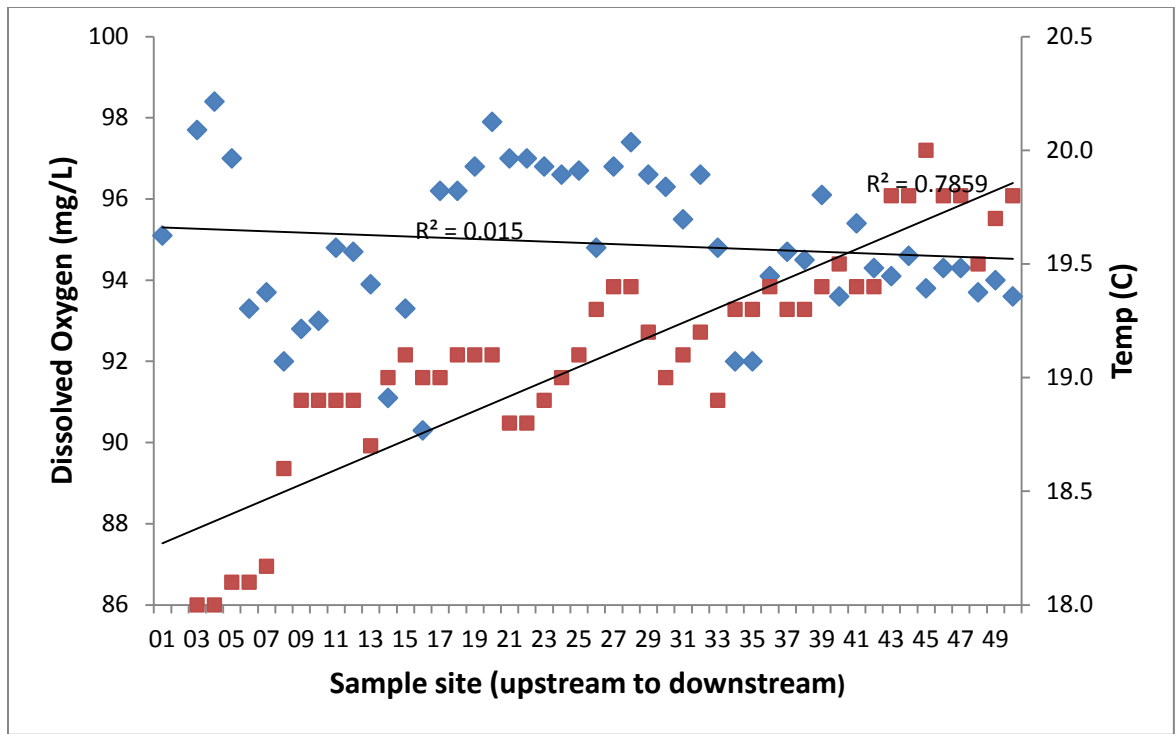


Figure 7. Longitudinal pattern of dissolved oxygen and temperature in surface water column samples.

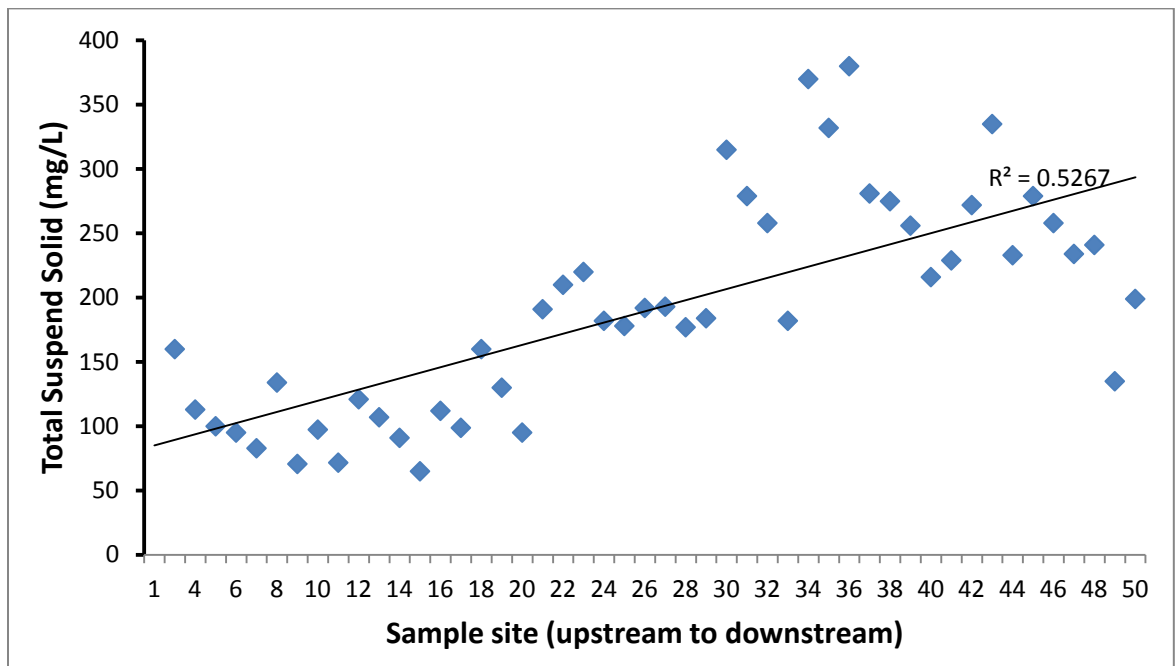


Figure 8. Longitudinal pattern of total suspended solids in surface water column samples.

Table 1. Summary of water quality parameters throughout the reach surveyed. Samples were analyzed in-situ with a portable YSI 556 Multi-Probe Sensor or collected and field preserved for laboratory analysis.

	Minimum	25th Percentile	75th Percentile	Maximum	Mean	Standard Deviation
pH	7.24	7.93	8.13	8.85	8.05	0.302
SpCond (uS/cm)	191	223	232	238	226	7.63
Cond (uS/cm)	163	197	207	212	201	8.36
ODO%	90.3	93.7	96.6	98.4	94.9	1.85
ODO Conc	8.37	8.60	8.93	9.31	8.79	0.214
TDS (g/L)	0.124	0.145	0.151	0.154	0.147	0.005
Turbidity+ (NTU)	1.1	6.1	14.8	1619.6	199.6	493.8
TSS (mg/L)	65	113	252	380	191	84
TOC (mg/L)	4.2	4.7	5.2	6.9	5.0	0.49
DOC (mg/L)	4.6	5.1	5.3	6.0	5.2	0.24
TP (mg/L)	0.0529	0.0761	0.1245	0.2400	0.1089	0.0438
NitrateN (mg/L)	0.18	1.44	1.89	2.27	1.57	0.49
NO3 (ueq/L)	41.9	42.9	44.6	54.6	44.4	2.50
NH4 (ueq/L)	0.9	1.2	3.0	9.9	3.4	3.3
SO4 (ueq/L)	711.1	751.0	810.1	898.5	784.1	43.5
Cl (ueq/L)	14.5	16.3	25.8	37.4	22.3	6.27
K (ueq/L)	23.4	27.4	34.2	41.7	30.9	4.19
Mg (ueq/L)	695.4	726.8	741.4	856.4	735.3	22.93
Na (ueq/L)	94.0	104.2	118.9	138.6	112.1	9.54
Ca (ueq/L)	1479.1	1584.5	1621.5	1684.5	1597.3	36.492
UV (@254)	0.155	0.178	0.190	0.227	0.186	0.014
SUVA	3.0	3.4	3.7	4.4	3.6	0.28
2-H (per mil)	-170.1	-168.6	-166.8	-162.9	-167.6	1.447
O-18 (per mil)	-21.4	-21.1	-20.6	-20.2	-20.8	0.321

3.4 Sediment enzymes

Benthic organisms are influenced by the physical and chemical properties of sediments they are in contact with. Current research suggests sediment enzymes can be used to assess water body eutrophic condition (Koster, M et al., 1997), assess the responses of microbial assemblages to environmental conditions (Foreman et al., 1998), and serve as a functional indicator of key ecosystem processes (NRSA Field Manual 2008). EPA included these indicators nationally as a research question and has since published a scientific article describing their findings. Analytical tests included dissolved inorganic nitrogen, total nitrogen, ammonia, dissolved inorganic carbon, total carbon and total phosphorus. Results from EPA's study indicate sediment enzymes may be used to assess regional impacts of climate change or anthropogenic disturbances on a large scale. (Hill et al., 2012).

3.5 Littoral Substrate

Our habitat measurements allowed an extensive suite of habitat metrics to be calculated (Angradi et al, 2006). For this report we present only the percent areal cover of fine substrate (i.e., particles <0.06 mm) and % sand and fine substrate (i.e., particles <2 mm) in the littoral zone as these metrics varied substantially across the survey reach and because substrate composition is an important feature of diatom, macroinvertebrate, and fish habitat. Longitudinal

plots of these substrate metrics indicated different trends below and above the Tanana River, so we divided the data sets and analyzed data from above and below the Tanana separately. Above the Tanana, % fines was unrelated to longitudinal position and averaged 25% ($\pm 15\%$) (Figure 9). Below the Tanana, % fines increased in a downstream direction, from 27% at Site 26 to 44% at Site 50, based on linear regression point estimates (Figure 9). Percent sand and fines was unrelated to longitudinal position below the Tanana and averaged 75% ($\pm 13\%$) (Figure 10). Above the Tanana, % sand and fines decreased in a downstream direction, from 70% at Site 1 to 44% at Site 25 (Figure 10).

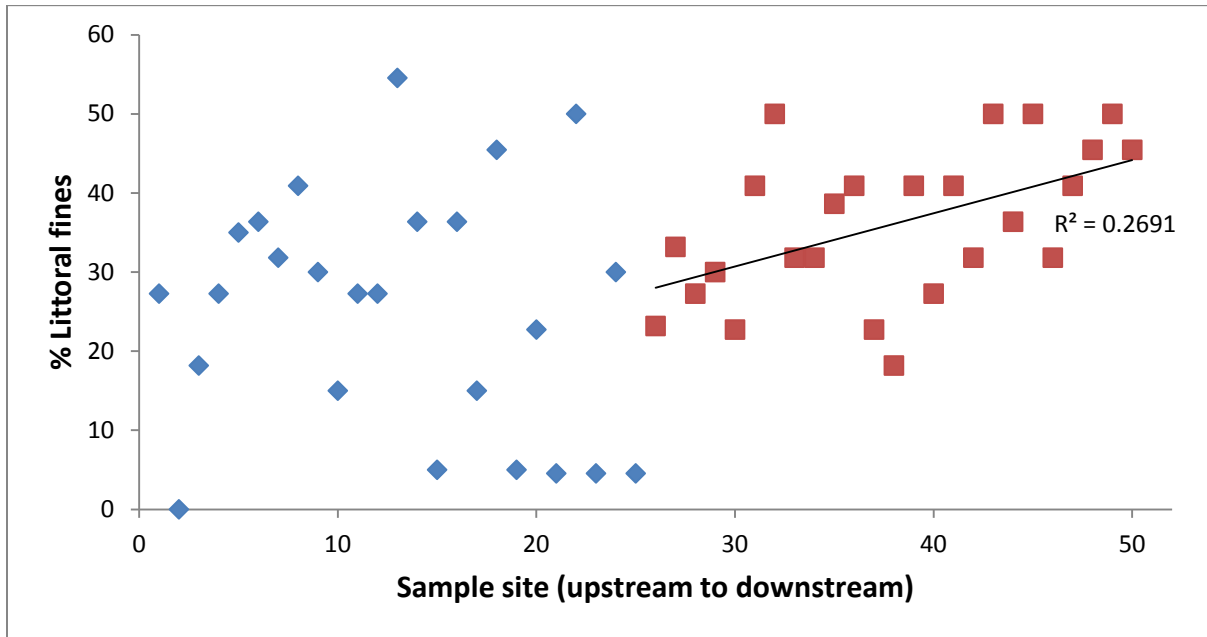


Figure 9. Longitudinal pattern in % fine substrate in the littoral zone.

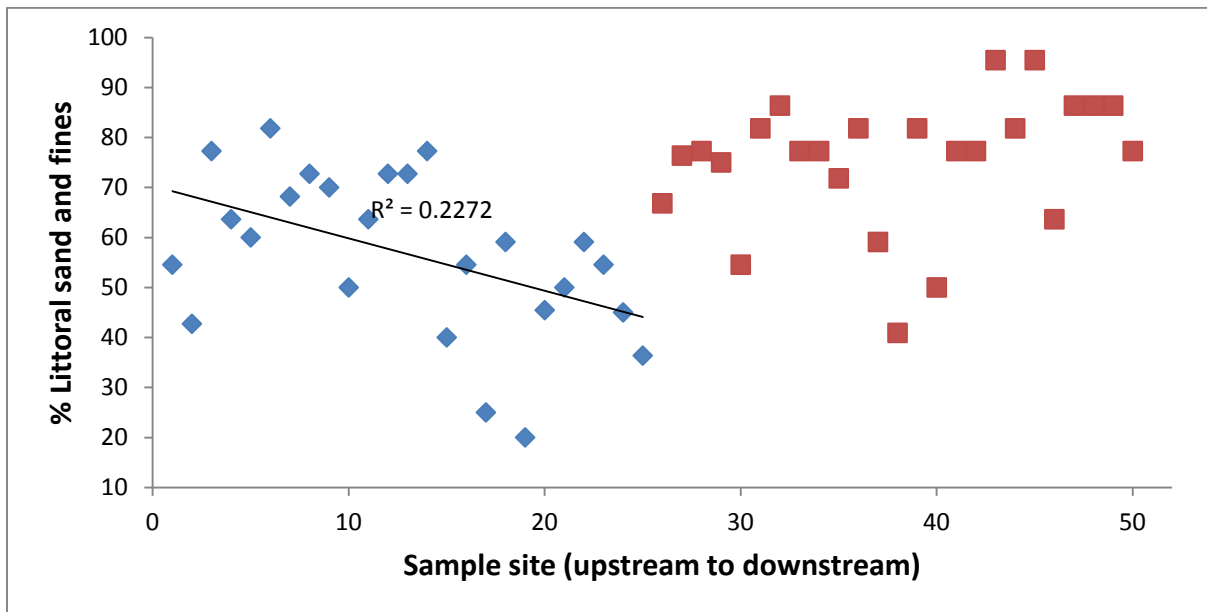


Figure 10. Longitudinal pattern in % sand and fine substrate in the littoral zone.

3.6 Macroinvertebrates

Benthic macroinvertebrates are an important component in riverine food webs, are relatively easy to collect, and are sensitive to a variety of environmental stressors (Barbour et al., 1999; Angradi et al., 2006). In this study we sampled macroinvertebrates using a D-frame net (500- μm mesh) from shoreline littoral habitat at each transect. Samples from the 11 transects comprising each sample reach were combined into a single composite sample. See Angradi et al. (2006) for more details on field sampling methodology. Laboratory protocols call for subsampling composite samples to a 500-organism fixed count (see USEPA 2008); however we identified all organisms found in the composite samples due to the relatively small number of organisms. We identified all macroinvertebrates to genus or lowest practical taxon using keys in Weiderholm (1983), Pennack (1989), Wiggins (1996), Thorpe and Covich (2001), Stewart and Oswood (2006), and Merritt et al. (2008).



Figure 11. Dan Bogan, AKNHP, collects macroinvertebrates using a D net.

The number of organisms identified from individual composite samples ranged from 4 to 413, for a total of 4862 in the 50 composite samples. We identified a total of 114 taxa; the vast majority of these were insects, although nematodes, annelids, arachnids, gastropods, and crustacean were also present (Appendix D). Over 90% of the organisms identified belonged to 3 taxonomic orders: Diptera (true flies), Tubificida (worms), and mayflies (Ephemeroptera). Using the macroinvertebrate community data, we calculated a number of metrics intended to reflect the biological condition at each site (see Barbour et al., 1999). These were the number of individuals, number of taxa (richness), proportional abundance of the dominant taxon (% dominant taxon), and the proportional abundance of the 5 numerically dominant taxonomic orders: % Diptera, % Tubificida, % mayflies, % stoneflies (Plecoptera), and % caddisflies (Trichoptera). Mayflies, stoneflies, and caddisflies are considered to be relatively intolerant to pollution (Barbour et al. 1999), so rarity or absence of these taxa could indicate poor habitat conditions.

The number of individual macroinvertebrates collected at each site was relatively low and highly variable, with a mean (\pm standard deviation) of 97 (\pm 88) (Appendix D). The low abundance is probably related to the inherently unstable substrates and naturally high suspended sediment load in this glacier-fed river. An equivalent amount of sampling effort in wadeable, clear water streams in Alaska would typically contain thousands of organisms (Rinella and Bogan, unpublished data). We identified an average of 17 (\pm 8) taxa at each site.

Macroinvertebrate samples were most frequently dominated by the worm Naididae (23 sites) and the mayfly *Pseudocloeon dardanum* (13 sites), and the dominant taxon comprised 38% ($\pm 17\%$) of the total community. Mayflies were surprisingly abundant, comprising 31% ($\pm 22\%$) of the total community. Stoneflies and caddisflies comprised 6.2% ($\pm 6.8\%$) and 1.8% (± 3.1), respectively. True flies and Tubificida were each major components of the macroinvertebrate community, comprising 30% ($\pm 21\%$) and 27% ($\pm 24\%$), respectively.

We used regression analysis to examine longitudinal changes in macroinvertebrate community structure over the survey reach. Of the above metrics, only % mayflies and % Tubificida correlated significantly ($\alpha = 0.05$) with longitudinal position. Mayflies comprised 43% of the macroinvertebrate community at the upstream end of the survey reach but only 20% at the downstream end, based on linear regression point estimates (Figure 12). Percent Tubificida, by contrast, increased in a downstream direction throughout the survey reach, comprising 14% of the macroinvertebrate community at the upstream end and 39% at the downstream end (Figure 13).

Samples from this survey yielded two mayfly taxa that have not previously been reported from Alaska. We collected *Pseudocloeon dardanum* at 42 of the 50 sampling sites, suggesting that this mayfly is widespread and abundant within the mainstem Yukon River. These records extend the known range of this mayfly to the northwest by about 1500 km. We also collected *Ametropus neavei* at three sites in the lower 200 km of the survey reach, extending its known range to the northwest by over 2000 km. A manuscript describing these and other new Alaskan aquatic insect records has been submitted for publication (Rinella et al. in review).

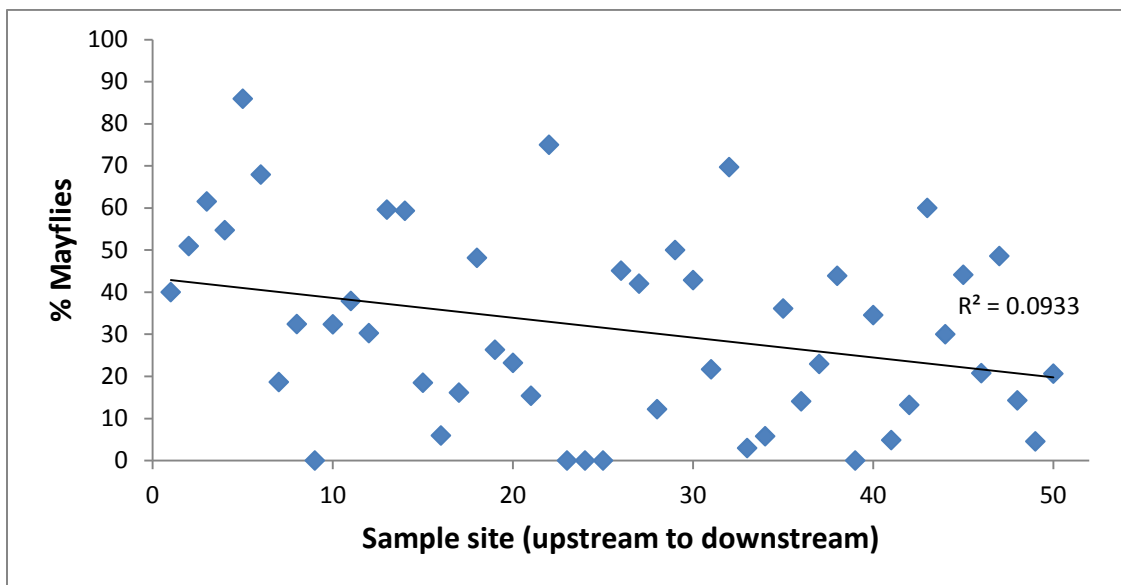


Figure 12. Longitudinal pattern in % of the macroinvertebrate community composed of mayflies.

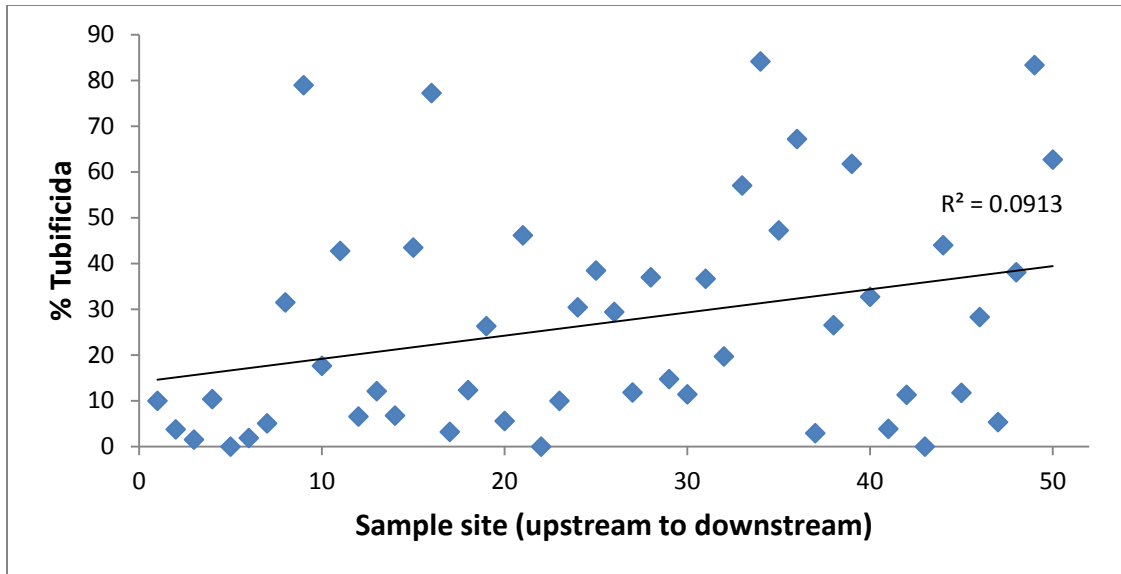


Figure 13. Longitudinal pattern in % of the macroinvertebrate community composed of Tubificida worms.

3.7 Diatoms

Benthic diatoms are a diverse group of single-celled algae encased in silica capsules. They are ubiquitous in aquatic habitats, where they serve as important primary producers. Diatom community composition is a valuable indicator of environmental conditions, including sedimentation, nutrient enrichment, metals, and other pollution sources (Van Dam et al., 1994; Stevenson and Bahls, 1999).

We sampled diatoms by scrubbing 25 cm² of the biofilm layer from hard substrates (i.e., wood, rock) in the littoral habitat at each transect. As for macroinvertebrates, we combined samples from the 11 transects comprising each sample reach into a single composite sample. We did not collect diatoms at 5 sites (14, 15, 18, 43, 48) due to a lack of hard substrates needed for sampling. See Angradi (2006) for more details on field sampling methodology. In the lab, diatom samples were cleaned, concentrated, and mounted on microscope slides.



Figure 14. Dan Rinella, AKNHP, scrubs woody debris for diatom collection.

We identified a fixed count of 600 diatom valves from each site (see USEPA 2007) to species or variety using keys in Patrick and Rimer (1975), Kramer and Lang-Bertalot (1986–1991), and Lang-Bertalot (1996).

We identified a total of 134 diatom taxa from the 50 sites. The three most numerous taxa – *Gomphonema productum*, *Achnantheidium minutissimum*, and *Diatoma tenuis* – together comprised half of all diatoms sampled (Appendix E). Over 80% of all diatoms belonged to the 10 most numerous taxa.

We calculated a number of metrics from each site's diatom community data. These included species richness and % dominant taxon as indicators of general biotic integrity. We used % motile individuals as a siltation index (Stevenson and Bahls, 1999). Motility, an adaptation possessed by a few genera, allows diatoms to crawl to the surface when buried by silt, and the proportion of motile diatoms can be high in streams with high silt loads (e.g., up to 83%; see Dickman 2005). Finally, we used Van Dam et al.'s (1994) ecological indicator values for pH, nitrogen uptake metabolism, oxygen requirements, and saprobity. Indicator values are assigned to each taxon based, respectively, on its preferred acidity/alkalinity, concentration of organically bound nitrogen, levels of dissolved oxygen saturation, and saprobic water quality class (see Van Dam et al., 1994). We expressed ecological indicator values as the community-wide weighted average for each sample.

Across the 50 sites we identified an average of 26 (± 5) diatom taxa. The community was frequently dominated by *Gomphonema productum* (24 sites) or *Achnantheidium minutissimum* (12 sites), with the dominant taxon comprising 27% ($\pm 9\%$) of the total community. Motile diatoms comprised 3% ($\pm 4\%$) of the community, which is surprisingly low given the Yukon River's high silt load. The pH index averaged 3.9 (± 0.24), indicating adaptation to neutral or alkaline conditions. The nitrogen uptake metabolism index averaged 2.0 (± 0.17), suggesting that elevated nitrogen levels are not required to sustain the diatom community. Finally, diatoms were adapted to moderate to high water quality, as indicated by the oxygen (1.9 ± 0.25) and saprobity (2.5 ± 0.19) indices.

We used regression analysis to look for longitudinal changes in diatom community structure over the survey reach. Of the metrics considered, only nitrogen uptake metabolism and saprobity correlated significantly ($\alpha = 0.05$) with longitudinal position (Figures 15 and 16). Both increased in a downstream direction, suggesting that downstream diatom communities were adapted to slightly higher levels of organic nitrogen, lower levels of dissolved oxygen, and higher biological oxygen demand (Van Dam et al., 1994). Interestingly, scores for both indices were flat or trending downward over the upper half of the survey reach (i.e., above the Tanana River) and clearly trending upward over the lower half of the survey reach (Figures 15 and 16).

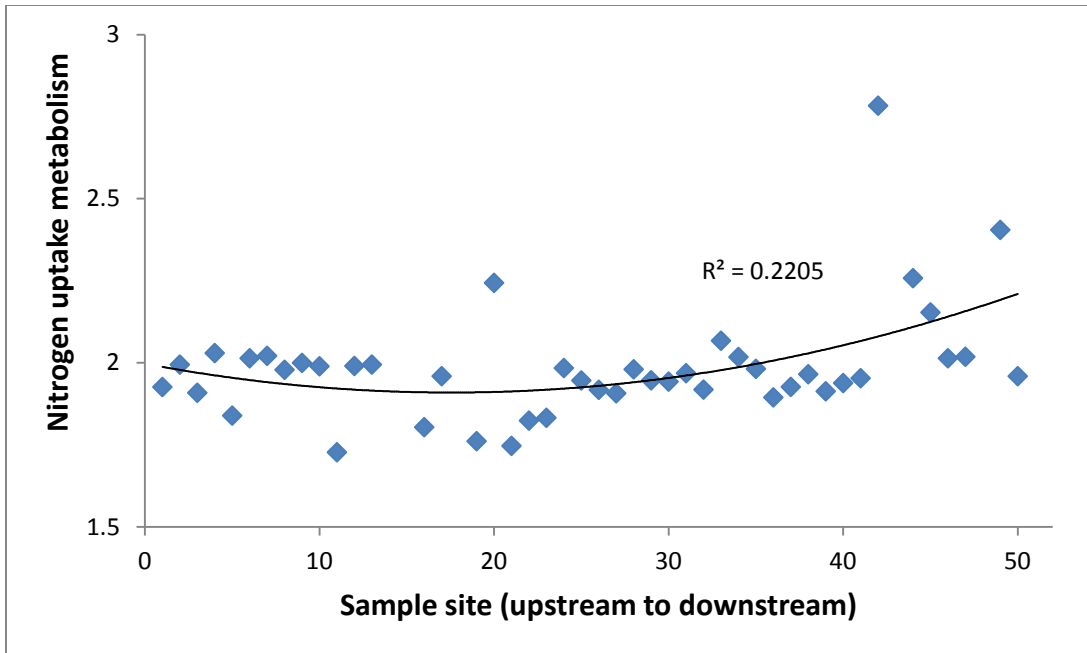


Figure 15. Longitudinal pattern in nitrogen uptake metabolism index scores for the diatom community.

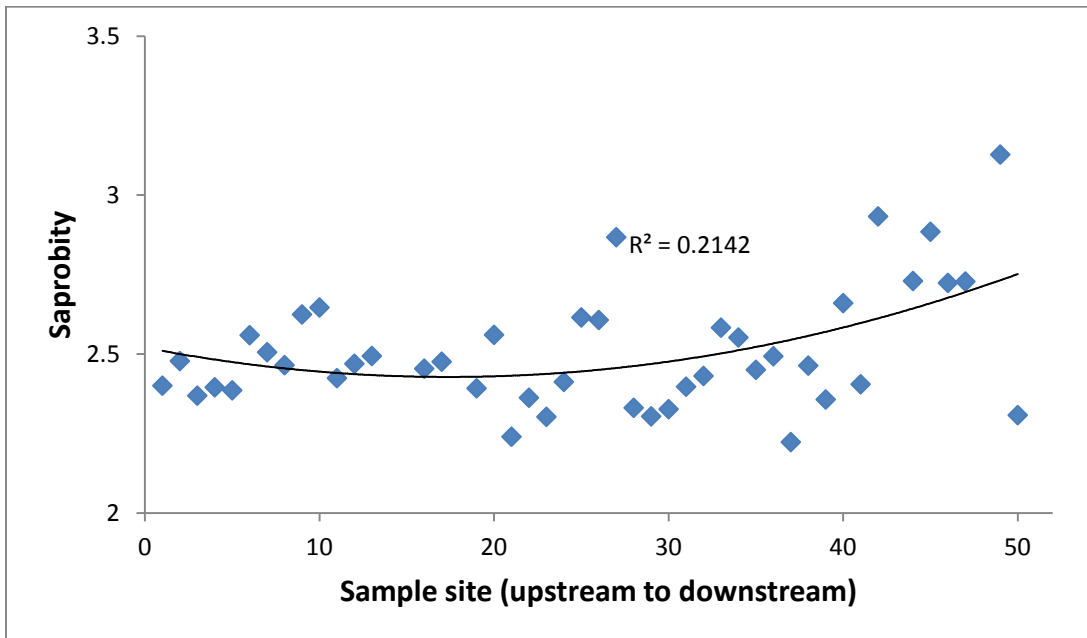


Figure 16. Longitudinal pattern in saprobity index scores for the diatom community.

3.8 Fish

A number of larval lamprey were collected in the macroinvertebrate samples. The specimens were too young to identify with existing keys, and genetic analysis was impossible because DNA was degraded by the methanol in the sample preservative. Based on known geographic distributions (Mecklenburg et al. 2002), the specimens are likely Arctic lamprey (*Lampetra camtschatica*), although Alaskan brook lamprey (*Lampetra alaskense*) and Pacific lamprey (*Lampetra tridentate*) are also possibilities. Samples contained from 0 to 9 lamprey, with an average of 1.7 (± 2) individuals (Appendix F). Lamprey abundance was not correlated with longitudinal position or substrate composition.

We intended to collect fish species for contaminant analysis during the survey, but poor or below average runs for Coho, Chum, and Chinook salmon prevented this (Yukon River Joint Technical Committee, 2010). The YRITWC instituted a fish for coffee exchange program and encouraged community members to participate. We were very pleased to received eight specimens in good condition during a year when subsistence fishing was extremely limited as well. Due to the low number of samples we did not perform any statistical analysis; instead, individual results are reported (Table 2).

Table 2. A total of eight fish tissue samples were donated to the survey. Below are individual specimen results.

Site ID	Species	Sample Type	As	Cd	Cu	Pb	Se	THg
YUK09-01	Northern Pike	skinless fillet	< 0.05	<0.01	<0.2	<0.05	0.47	0.53
YUK09-25	Chinook Salmon	small chunk	0.55	<0.01	0.59	<0.05	0.39	0.06
YUK09-37	Chum Salmon	small chunk	0.52	<0.01	0.51	<0.05	0.38	0.019
YUK09-37	Chum Salmon	small chunk	0.34	<0.01	0.39	<0.05	0.38	0.033
YUK09-37	Broad Whitefish	small chunk	< 0.05	<0.01	<0.2	<0.05	0.29	0.016
YUK09-42	Burbot	skinless fillet	0.96	<0.01	<0.2	<0.05	0.37	0.44
YUK09-45	Burbot	skinless fillet	0.22	<0.01	<0.2	<0.05	0.4	0.52
YUK09-45	Silver Salmon	skinless fillet	0.66	<0.01	0.82	<0.05	0.25	0.063

all concentrations in ppm (wet weight)

Fish tissue samples were analyzed for total mercury, THg. EPA's tissue-based water quality criteria is 0.300 ppm for methylmercury as concentration threshold that, if exceeded can potentially be harmful to human health. Using conservative guidelines and assuming all mercury is in the form of methylmercury, three samples have results that raise potential human health concerns.

3.9 Bacteria

Bacteria, *Enterococcus*, samples were collected at the last physical habitat transect for each site as an indicator of water quality health. The presence of *Enterococci bacteria* can indicate human or animal waste is entering the river. All samples results were reported as non-detects, meaning that no detectable level of bacteria forming colonies were found. This can result from sample degradation during storage, the inability to meet holding times or the lack of presence of *Enterococcus* species. All measures were taken to ensure the viability of the sample and meet holding times. The results are assumed to be accurate for our study period, but due to the variable nature of bacteria it should not be assumed as accurate for all locations or times along the Yukon River.



Figure 17. Smoke haze from wildfires upstream lingered along the river corridor. Hot, dry conditions during the summer of 2009 led to record wildfires. More than 1,662,000 acres burned in the Yukon Basin.

4.0 Discussion

The Yukon River or “Great River” is a large, dynamic river system that supports a relatively intact ecosystem. The river connects subsistence use communities throughout interior Alaska and Canada. Concerns with unregulated sewage, historic pollution, landfills containment issues, and climate change are a few of threats the river is experiencing.

In our survey, we sampled a total of 50 water quality and 550 physical habitat sites in an effort to characterize the condition of the Yukon River main stem. Our survey was designed to describe condition over a large geographic area and should not be used to characterize individual sites. Overall we found the results were consistent with natural variability and expected conditions throughout the reach. Results from water quality, sediment, and biological parameters sampled indicate naturally high water quality conditions, inherently unstable substrates, high suspended sediment loads, and sufficient nutrient levels to support biology.

The collaboration between partners in this survey was crucial to our success. Yukon River Inter-Tribal Watershed Council and the Council of Athabascan Governments knowledge of the river and surrounding communities were critical to this survey. Data gathered from this survey are available to governmental agencies, Native and Tribal organizations, general public, and other researchers. DEC utilizes data gathered on a large scale to help better understand the overall condition of Alaska’s water quality. This allows DEC and other resource managers to: report on the overall condition of Alaskan waters, a responsibility of the Clean Water Act; and use the information to make good decisions about our laws and regulations that protect the Nation’s most pristine water resources.

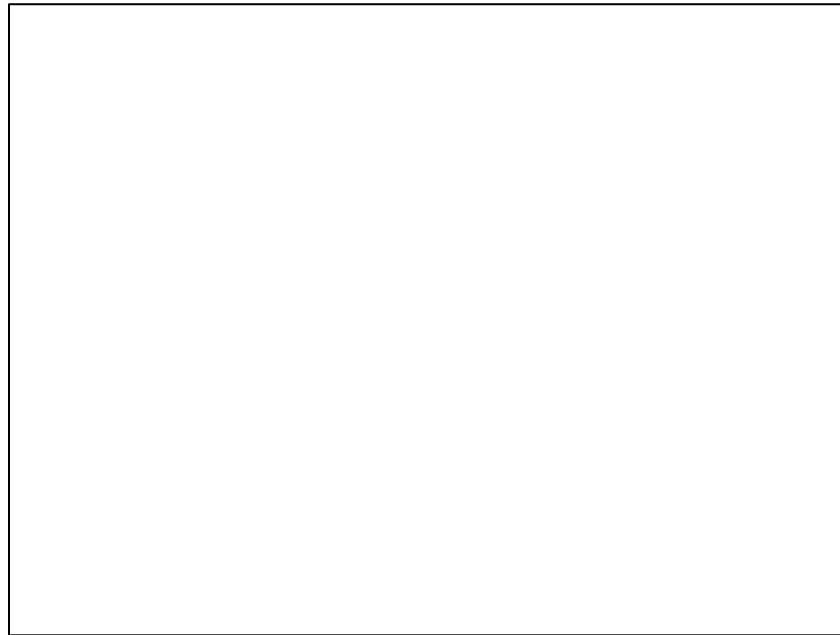


Figure 18. Sun setting on the Yukon River.

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Appendix A

Sample Location Data

<u>Site ID</u>	<u>WQ Sample Date</u>	<u>Habitat Sample Date</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Location Notes</u>
YUK09-01	7/5/2009	7/5/2009	66.559226	-145.286371	at Fort Yukon , in Yukon Flats NWR
YUK09-02	*	7/6/2009	66.592962	-145.655098	Porcupine and Chandalar Rivers enter
YUK09-03	7/6/2009	7/6/2009	66.582820	-146.024414	
YUK09-04	7/6/2009	7/7/2009	66.530971	-146.344269	
YUK09-05	7/6/2009	7/7/2009	66.487956	-146.762077	
YUK09-06	7/7/2009	7/7/2009	66.407010	-147.114360	
YUK09-07	7/7/2009	7/8/2009	66.349053	-147.336759	above Beaver, Beaver Creek enters
YUK09-08	7/7/2009	7/8/2009	66.281292	-147.671710	Hodzana River enters
YUK09-09	7/7/2009	7/9/2009	66.228257	-147.908202	
YUK09-10	7/7/2009	7/9/2009	66.245444	-148.245827	
YUK09-11	7/7/2009	7/9/2009	66.171622	-148.533504	
YUK09-12	7/7/2009	7/10/2009	66.051425	-148.711172	
YUK09-13	7/8/2009	7/10/2009	66.050901	-148.986491	
YUK09-14	7/8/2009	7/11/2009	66.024525	-149.205950	below Stevens Village
YUK09-15	7/8/2009	7/11/2009	65.890014	-149.237689	Dall River enters
YUK09-16	7/8/2009	7/11/2009	65.876857	-149.625981	Dalton Hwy bridge crossing
YUK09-17	7/8/2009	7/12/2009	65.825150	-149.963212	Ray River enters
YUK09-18	7/9/2009	7/12/2009	65.765872	-149.903083	leave Yukon Flats NWR
YUK09-19	7/9/2009	7/12/2009	65.627651	-149.857940	
YUK09-20	7/9/2009	7/13/2009	65.615169	-150.169981	
YUK09-21	7/10/2009	7/13/2009	65.484577	-150.319252	below Rampart
YUK09-22	7/10/2009	7/13/2009	65.451115	-150.674020	
YUK09-23	7/10/2009	7/14/2009	65.351958	-151.000508	
YUK09-24	7/10/2009	7/14/2009	65.260496	-151.307304	
YUK09-25	7/10/2009	7/14/2009	65.181306	-151.638604	Tanana River enters
YUK09-26	7/10/2009	7/6/2009	65.166660	-152.082071	at Tanana
YUK09-27	7/10/2009	7/7/2009	65.126852	-152.399102	Tozitna River enters
YUK09-28	7/10/2009	7/7/2009	65.155715	-152.685204	
YUK09-29	7/10/2009	7/8/2009	65.191303	-152.984282	enter Nowitna NWR
YUK09-30	7/10/2009	7/8/2009	65.100325	-153.235655	
YUK09-31	7/11/2009	7/9/2009	65.127634	-153.556231	
YUK09-32	7/11/2009	7/9/2009	65.057620	-153.868939	
YUK09-33	7/11/2009	7/10/2009	64.983432	-154.167590	Nowitna River enters
YUK09-34	7/11/2009	7/10/2009	64.933441	-154.473371	
YUK09-35	7/11/2009	7/11/2009	64.911284	-154.779447	
YUK09-36	7/11/2009	7/11/2009	64.864023	-155.107832	leave Nowitna NWR
YUK09-37	7/11/2009	7/12/2009	64.779407	-155.398869	above Ruby
YUK09-38	7/11/2009	7/12/2009	64.760238	-155.706283	Melozitna River enters
YUK09-39	7/11/2009	7/13/2009	64.719787	-156.035769	
YUK09-40	7/12/2009	7/13/2009	64.674823	-156.358109	

<u>Site ID</u>	<u>WQ Sample Date</u>	<u>Habitat Sample Date</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Location Notes</u>
YUK09-41	7/12/2009	7/14/2009	64.629663	-156.681662	
YUK09-42	7/12/2009	7/14/2009	64.729091	-156.808248	above Galena
YUK09-43	7/12/2009	7/15/2009	64.800999	-157.022651	enter Innoko NWR
YUK09-44	7/12/2009	7/15/2009	64.804200	-157.310361	
YUK09-45	7/12/2009	7/16/2009	64.856816	-157.539672	above Koyukuk
YUK09-46	7/12/2009	7/16/2009	64.859708	-157.893725	Koyukuk River enters
YUK09-47	7/12/2009	7/17/2009	64.728212	-158.046383	
YUK09-48	7/13/2009	7/17/2009	64.628962	-158.288870	below Nulato
YUK09-49	7/13/2009	7/18/2009	64.501833	-158.443512	
YUK09-50	7/13/2009	7/18/2009	64.384146	-158.627632	above Kaltag

* did not sample WQ, river current too strong

Datum: Nad 83

Appendix B

Water Chemistry Data

Site ID	DO; mg/L	Temp; C	pH	Conductivity; us/cm	Turbidity; NTU	NO3-N; mg/L	TDS; g/L	Air Temp; C
YUK09-01	9.5	17.6	7.61	210				
YUK09-03	9.3	18.0	8.15	214	20.1		1.390	26.8
YUK09-04	9.3	18.0	8.13	214	15.2	1.490	1.390	24.7
YUK09-05	9.2	18.1	8.25	236	8.3		0.153	
YUK09-06	8.8	18.1	8.89	220	12.5	1.670	0.143	
YUK09-07	8.8	18.2	8.46	225	19.1	1.672	0.146	22.6
YUK09-08	8.6	18.6	7.69	228	1609.6	0.242	0.147	27.4
YUK09-09	8.6	18.9	7.60	229	1619.6	0.181		28.2
YUK09-10	8.6	18.9	7.81	226	1616.1	0.222		25.5
YUK09-11	8.8	18.9	7.66	224	1616.0	0.183		25.0
YUK09-12	8.8	18.9	8.35	224	1618.8	1.434		24.7
YUK09-13	8.8	18.7	8.55	225	250.3	1.581	0.146	18.7
YUK09-14	8.4	19.0	8.93	227	650.9	1.665	0.147	
YUK09-15	8.6	19.1	8.54	223	346.2	1.494	0.145	22.1
YUK09-16	8.4	19.0	8.41	226	145.9	1.656	0.147	24.9
YUK09-17	8.9	19.0	8.59	222	5.0	1.767	0.144	18.9
YUK09-18	8.9	19.1	8.03	222	16.3	1.752	0.144	
YUK09-19	9.0	19.1	8.02	222	10.7	1.862	0.145	23.0
YUK09-20	9.1	19.1	7.93	222	6.1	1.816	0.145	17.1
YUK09-21	9.0	18.8	7.46	223	12.8	1.948	0.145	16.0
YUK09-22	9.0	18.8	8.00	223	1.8	2.094	0.145	
YUK09-23	9.0	18.9	8.01	223	5.0	2.105	0.145	20.3
YUK09-24	9.0	19.0	7.96	222	7.4	1.969	0.145	21.6
YUK09-25	8.9	19.1	7.95	223	12.5	2.231	0.145	22.0
YUK09-26	8.7	19.3	7.89	224	4.8	0.867	0.146	22.5
YUK09-27	8.9	19.4	7.90	224	1.1	1.277	0.145	21.8
YUK09-28	9.0	19.4	7.91	224	7.7	1.613	0.145	21.2
YUK09-29	8.9	19.2	7.95	230	8.7	1.517	0.149	21.4
YUK09-30	8.9	19.0	7.95	233	12.1	1.567	0.151	20.1
YUK09-31	8.8	19.1	8.54	233	7.0	2.271	0.151	19.9
YUK09-32	8.9	19.2	8.47	227	4.5	1.926	0.147	20.7
YUK09-33	8.8	18.9	8.37	238	13.7	1.896	0.154	19.6
YUK09-34	8.5	19.3	7.91	236	10.6	1.592	0.154	24.2
YUK09-35	8.5	19.3	7.98	237	11.2	1.438	0.154	24.2
YUK09-36	8.7	19.4	7.97	236	3.9	1.506	0.154	24.7
YUK09-37	8.7	19.3	8.00	232	7.0	1.591	0.151	26.4
YUK09-38	8.7	19.3	8.00	232	8.0	1.692	0.151	24.0
YUK09-39	8.8	19.4	8.02	227	8.4	1.890	0.148	18.4

Site ID	DO; mg/L	Temp; C	pH	Conductivity; us/cm	Turbidity; NTU	NO3-N; mg/L	TDS; g/L	Air Temp; C
YUK09-40	8.6	19.5	8.01	234	9.9	1.843	0.152	24.5
YUK09-41	8.8	19.4	8.01	231	13.3	2.010	0.150	25.9
YUK09-42	8.7	19.4	8.07	232	11.0	1.895	0.151	23.3
YUK09-43	8.6	19.8	7.98	233	8.5	1.286	0.151	28.1
YUK09-44	8.6	19.8	7.98	228	5.7	1.361	0.148	27.1
YUK09-45	8.5	20.0	7.97	231	6.7	1.464	0.150	27.9
YUK09-46	8.6	19.8	8.00	229	5.8	1.417	0.149	24.4
YUK09-47	8.6	19.8	7.93	232	2.3	1.902	0.151	25.3
YUK09-48	8.6	19.5	7.24	232	3.2	1.631	0.151	22.6
YUK09-49	8.6	19.7	7.77	227	5.8	2.182	0.147	25.0
YUK09-50	8.5	19.8	7.81	224	7.3	1.954	0.145	21.3

Data collected using a YSI 556 MPS by YRITWC

WQ Indicator	YUK09-01	YUK09-03	YUK09-04	YUK09-05	YUK09-06	YUK09-07	YUK09-08	YUK09-09	YUK09-10	YUK09-11	YUK09-12	YUK09-13	YUK09-14	YUK09-15	YUK09-16	YUK09-17	YUK09-18	YUK09-19	YUK09-20	YUK09-21	YUK09-22	YUK09-23	YUK09-24	YUK09-25
pH	7.74	8.13	8.13	8.24	8.85	8.45	7.69	7.58	7.8	7.62	8.35	8.55	8.53	8.54	8.4	8.59	8.03	8.02	7.93	7.96	7.98	8.01	7.96	7.95
pHmV (mV)	-79.5	-102	-101	-108	-135	-114	-74.5	-68.4	-80.3	-70.4	-109	-120	-119	-119	-112	-133	-104	-104	-99.4	-101	-102	-104	-101	-100
Salinity (ppt)	0.09	0.1	0.1	0.11	0.1	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
ORP (mV)	93	157	191	119	68	66	62	94	75	146	69	64	83	22	74	71	65	72	73	85	80	77	75	49
ODO%	95.1	97.7	98.4	97	93.3	93.7	92	92.8	93	94.8	94.7	93.9	91.1	93.3	90.3	96.2	96.2	96.8	97.9	97	97	96.8	96.6	96.7
ODO Conc (mg/L)	9.09	9.24	9.31	9.16	8.81	8.83	8.59	8.6	8.63	8.81	8.8	8.75	8.44	8.64	8.37	8.92	8.9	8.96	9.06	9.04	9.03	9	8.96	8.95
SpCond (uS/cm)	191	212	214	236	220	224	228	229	226	224	224	225	227	223	226	222	222	222	222	223	223	223	222	223
Cond (uS/cm)	163	184	185	204	191	195	200	203	200	198	197	198	201	197	200	197	197	197	197	196	197	197	197	197
TDS (g/L)	0.124	0.138	0.139	0.153	0.143	0.146	0.148	0.149	0.147	0.146	0.145	0.146	0.147	0.145	0.147	0.144	0.144	0.145	0.145	0.145	0.145	0.145	0.145	0.145
TSS (mg/L)		160	113	100	95.1	82.9	134	70.7	97.4	71.7	121	107	91	65	112	98.8	160	130	95.1	191	210	220	182	178
Turbidity+ (NTU)	20.1	22	15.2	8.3	12.5	19.1	1610	1620	1617	1617	1618	294.6	650.4	246.5	145.9	5	16.3	10.7	6.1	12.8	1.8	5	7.4	12.5
DOC (mg/L)	5.2	5.1	5.3	5	5.2	5.1	5	5.1	5.1	5.2	5.2	5.2	5.2	5.3	5.4	5.2	5.2	5.3	5.4	5.2	5.3	5.3	5.5	5.4
NitrateN (mg/L)	1.42	1.36	1.49	1.62	1.67	1.67	0.24	0.18	0.22	0.18	1.43	1.58	1.66	1.49	1.67	1.77	1.75	1.86	1.82	1.95	2.09	2.1	1.97	2.23
NitratemV (mV)	133.4	134.7	132.5	130.6	129.8	129.9	177.1	184.3	179.3	184	133.9	131.4	130.3	132.9	130.2	128.8	129.1	127.6	128.2	126.4	124.6	124.5	126.2	123.2
NH4 (ueq/L)	3.3	<0.9	1	<0.9	<0.9	2.4E	<0.9	<0.9		<0.9	<0.9	<0.9	2.2	5.3	<0.9	<0.9	<0.9	9.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
NO3 (ueq/L)	43.7	43.8	42.4	42.3	42.9	42.6	43.7	42.1		44.1	41.9	44.1	43.6	42.9	42.3	54.6	43	49.6	42.5	44.3	51.7	42.3	47	42.5
SO4 (ueq/L)	711.1	762.3	721.5	810.1	731.5	765.1	744.3	746.3		754	741.6	760.1	754.4	774.1	743.1	789.1	744.4	769.4	751.7	750.2	793.4	739.2	740.8	761.9
TP (mg/L)		0.066	0.204	0.089	0.105	0.095	0.053	0.073	0.076	0.076	0.067	0.156	0.084	0.062	0.072	0.067	0.074	0.094		0.075	0.083	0.093	0.073	0.077
TOC (mg/L)		4.2	4.4	4.5	4.4	4.4		4.8	4.5	4.6		4.6	4.9	4.6	4.9	5	4.7	5.8	4.8	6	4.9	4.9	5	5.1
Cl (ueq/L)	33	15.7	31.7	15.4	18	24.3	14.9	14.5		15.7	15.7	17.1	17.9	29.6	18.9	34.6	14.9	33	21	16.1	32.6	15.1	17.4	16
Na (ueq/L)	113.8	105.5	112.6	94	100.9	106	100.4	99.2		104	102	104.5	106.5	121.4	104.3	127.6	99.4	123.6	107.9	103.6	123.1	100.2	103.4	103.4
K (ueq/L)	28.7	28.2	28.6	23.4	27.5	26.8	26.5	25.3		26.3	25.9	28	26.9	32.7	26.6	31.1	26.5	33.6	27.8	29.1	31.4	26.3	30.5	26.8
Mg (ueq/L)	736.6	732.6	727.8	740.4	730.9	741.4	741.1	733.3		714.6	704.6	696.9	734.4	732.6	728.3	731.2	726.9	730.5	742.2	743	738.8	741.3	738.7	717.3
Ca (ueq/L)	1479	1508	1517	1685	1543	1589	1584	1582		1577	1571	1582	1586	1591	1568	1601	1569	1594	1598	1599	1615	1585	1585	1589
UV (@254)	0.177	0.186	0.181	0.156	0.174	0.178	0.176	0.182	0.194	0.19	0.174	0.182	0.178	0.189	0.181	0.18	0.189	0.179	0.187	0.177	0.181	0.175	0.198	0.169
SUVA	3.4	3.6	3.4	3.1	3.3	3.5	3.5	3.6	3.8	3.7	3.3	3.5	3.4	3.6	3.4	3.5	3.6	3.4	3.4	3.4	3.4	3.3	3.6	3.1
2-H (per mil)	-167	-167	-167	-170	-167	-168	-168	-170	-169	-168	-169	-169	-169	-169	-170	NA	-170	-170	-169	-168	-167	-168	-166	-169
std dev	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
O-18 (per mil)	-20.4	-20.2	-20.3	-21	-20.3	-20.7	-20.9	-21	-21.1	-21.1	-21.1	-21.1	-21.1	-21.3	-20.2	NA	-21	-21.1	-21.1	-21.1	-21	-20.9	-21.4	-20.8
std dev	0.2	0.2	0.15	0.15	0.15	0.2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.2	0.15

WQ Indicator	YUK09-26	YUK09-27	YUK09-28	YUK09-29	YUK09-30	YUK09-31	YUK09-32	YUK09-33	YUK09-34	YUK09-35	YUK09-36	YUK09-37	YUK09-38	YUK09-39	YUK09-40	YUK09-41	YUK09-42	YUK09-43	YUK09-44	YUK09-45	YUK09-46	YUK09-47	YUK09-48	YUK09-49	YUK09-50
pH	7.69	7.9	7.91	7.95	7.95	8.54	8.47	8.37	7.91	7.98	7.97	8	8	8.02	8.01	8.01	8.07	7.98	7.98	7.97	8	7.93	7.24	7.77	7.81
pHmV (mV)	-86.8	-97.9	-98.3	-100	-100	-128	-125	-119	-93.4	-97.1	-96.5	-98.1	-98.5	-99.4	-99	-99	-102	-97.3	-97.5	-96.9	-98.4	-94.6	-57.7	-87.2	-89.4
Salinity (ppt)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
ORP (mV)	35	42	48	56	50	74	73	76	39	35	44	50	52	56	66	63	45	20	37	40	49	55	76	69	71
ODO%	94.8	96.8	97.4	96.6	96.3	95.5	96.6	94.8	92	92	94.1	94.7	94.5	96.1	93.6	95.4	94.3	94.1	94.6	93.8	94.3	94.3	93.7	94	93.6
ODO Conc (mg/L)	8.74	8.91	8.96	8.92	8.93	8.84	8.93	8.81	8.48	8.48	8.66	8.74	8.7	8.85	8.6	8.77	8.67	8.58	8.64	8.53	8.6	8.6	8.61	8.6	8.54
SpCond (uS/cm)	224	224	224	230	233	233	227	238	236	237	236	232	232	227	234	231	232	233	228	231	229	232	232	227	224
Cond (uS/cm)	200	199	200	204	206	206	201	210	211	212	211	207	207	203	209	206	208	210	206	209	207	209	208	204	201
TDS (g/L)	0.146	0.145	0.145	0.149	0.151	0.151	0.147	0.154	0.154	0.154	0.154	0.151	0.151	0.148	0.152	0.15	0.151	0.151	0.148	0.15	0.149	0.151	0.151	0.147	0.145
TSS (mg/L)	192	193	177	184	315	279	258	182	370	332	380	281	275	256	216	229	272	335	233	279	258	234	241	135	199
Turbidity+ (NTU)	4.8	1.1	7.7	8.7	12.1	7	4.5	13.7	10.6	11.2	3.9	7	8	8.4	9.9	13.3	11	8.5	5.7	6.7	5.8	2.3	3.2	5.8	7.3
DOC (mg/L)	5.2	5.3	5.3	4.8	4.7	5.1	4.6	5.1	4.9	4.9	5	5.3	5.2	5	5	5.1		5.3	5.3	5.3	5.3	5.4	6	5.8	5.5
NitrateN (mg/L)	0.87	1.28	1.61	1.52	1.57	2.27	1.93	1.9	1.59	1.44	1.51	1.59	1.69	1.89	1.84	2.02	1.89	1.29	1.36	1.46	1.42	1.9	1.63	2.18	1.95
NitratemV (mV)	146.3	136.9	131.2	132.7	131.8	122.8	126.8	127.1	131.5	134	132.9	131.5	130.1	127.3	128	125.8	127.3	137	135.5	133.9	134.6	127.4	131	124	126.7
NH4 (ueq/L)	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	1.3	<0.9	0.9	1.2E	<0.9	<0.9	<0.9
NO3 (ueq/L)	45.6	42.4	42.1	43	43.3	43.1	42.8	45.2	47.6	44.6	43.5	45.2	44.8	43.4	48.9	44.1	43.9	46.2	44	44.4	44.4	44.1	44.7	44.2	44.1
SO4 (ueq/L)	744.3	751.3	754.9	793.8	819.9	791.7	753.8	817.1	794.5	819	840.1	798.4	821.4	888.5	825.1	793	824.4	872.8	833	778.8	785.5	807.7	898.5	863.8	805.4
TP (mg/L)	0.167	0.124	0.152	0.151	0.147	0.104	0.084	0.074	0.21	0.24	0.145	0.124	0.102		0.083	0.117	0.205	0.126	0.115	0.101	0.095	0.096	0.09	0.151	0.094
TOC (mg/L)	4.9	5.5	5.3	5.2	4.8		4.8	5.2	4.2	4.9	4.7	5.1		5.1	5.1	5.2	5	5.3	5.3	6.9	5.6	5.4	5.2	5.4	5.2
Cl (ueq/L)	16.2	16	16.3	22.1	24.1	20	17.6	37.4	26.2	27.9	23.6	21.3	24.5	21.3	25.5	23.1	23.6	23.5	28.5	26	29.5	29.3	17	22.4	25.8
Na (ueq/L)	105.1	103	109.8	114.4	118.4	118.5	104.7	138.6	127.2	123.1	118.3	114.4	121.7	113.6	126.8	117.7	118.9	119.5	120.5	116.9	120.1	113.6	111	107.7	110.7
K (ueq/L)	28.2	27.5	26.8	33.2	34.3	30.5	29.1	41.7	39.1	37.1	35.1	33.6	35.1	31.8	38	34.2	35	35.1	33.8	34.8	35.1	34.2	27.6	31.9	35.4
Mg (ueq/L)	712.3	695.4	736.9	745	743.2	737.6	729.6	752.3	756.6	755.1	750.3	743.4	726.3	705.3	749.3	741.4	740.5	737.5	727.3	725.1	723.1	715.6	856.4	758.8	724.3
Ca (ueq/L)	1594	1586	1585	1616	1622	1605	1579	1647	1651	1650	1635	1622	1634	1605	1644	1622	1623	1626	1607	1593	1585	1601	1634	1611	1600
UV (@254)	0.186	0.184	0.183	0.171	0.208	0.19	0.184	0.189	0.201	0.2	0.204	0.161	0.184	0.155	0.192	0.189		0.186	0.209	0.193	0.187	0.193	0.227	0.222	0.188
SUVA	3.6	3.5	3.5	3.6	4.4	3.7	4	3.7	4.1	4.1	4.1	3	3.5	3.1	3.8	3.7		3.5	3.9	3.6	3.5	3.5	3.8	3.8	3.4
2-H (per mil)	-168	-168	-168	-169	-169	-168	-168	-167	-165	-167	-167	-168	-167	-168	-165	-168	-167	-167	-167	-166	-166	-167	-163	-165	-165
std dev	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
O-18 (per mil)	-21.1	-21	-20.7	-21	-21.1	-21.2	-21.1	-20.8	-20.6	-20.7	-20.8	-20.9	-20.6	-20.7	-21.1	-20.9	-20.4	-20.3	-20.5	-20.6	-20.6	-20.7	-20.3	-20.5	-20.6
std dev	0.2	0.15	0.15	0.15	0.2	0.15	0.15	0.15	0.2	0.15	0.15	0.15	0.15	0.15	0.15	0.2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Appendix C

Littoral Substrate Data

Site ID	% Areal coverage of fine sediment (<0.06 mm) in the littoral zone	% Areal coverage of sand and fine sediment (<2 mm) in the littoral zone
YUK09-01	27	55
YUK09-02	0	43
YUK09-03	18	77
YUK09-04	27	64
YUK09-05	35	60
YUK09-06	36	82
YUK09-07	32	68
YUK09-08	41	73
YUK09-09	30	70
YUK09-10	15	50
YUK09-11	27	64
YUK09-12	27	73
YUK09-13	55	73
YUK09-14	36	77
YUK09-15	5	40
YUK09-16	36	55
YUK09-17	15	25
YUK09-18	45	59
YUK09-19	5	20
YUK09-20	23	45
YUK09-21	5	50
YUK09-22	50	59
YUK09-23	5	55
YUK09-24	30	45
YUK09-25	5	36
YUK09-26	23	67
YUK09-27	27	77
YUK09-28	30	75
YUK09-29	23	55
YUK09-30	41	82
YUK09-31	33	76
YUK09-32	27	50
YUK09-33	41	77
YUK09-34	32	77
YUK09-35	50	86
YUK09-36	32	77
YUK09-37	32	77
YUK09-38	39	72
YUK09-39	41	82
YUK09-40	23	59
YUK09-41	18	41
YUK09-42	41	82
YUK09-43	50	95
YUK09-44	36	82
YUK09-45	50	95
YUK09-46	32	64
YUK09-47	41	86
YUK09-48	45	86
YUK09-49	50	86
YUK09-50	45	77

Appendix D

Macroinvertebrate Data

Site ID	Number of individuals	Number of taxa	% Dominant taxon	% Mayfly	% Stonefly	% Caddisfly	% Diptera	% Tubificida
YUK09-01	30	12	23	40	30	0	20	10
YUK09-02	53	18	23	51	8	11	26	4
YUK09-03	65	16	23	62	9	2	26	2
YUK09-04	106	23	37	55	6	1	27	10
YUK09-05	64	12	45	86	5	0	6	0
YUK09-06	53	16	34	68	4	0	26	2
YUK09-07	413	38	56	19	2	0	73	5
YUK09-08	327	23	31	32	2	1	33	31
YUK09-09	38	5	39	0	0	0	13	79
YUK09-10	34	14	21	32	15	0	26	18
YUK09-11	124	15	43	38	3	1	15	43
YUK09-12	76	27	12	30	9	1	50	7
YUK09-13	99	19	47	60	16	1	10	12
YUK09-14	59	18	41	59	2	0	32	7
YUK09-15	184	21	38	18	4	1	33	43
YUK09-16	303	22	77	6	0	0	15	77
YUK09-17	31	15	29	16	23	3	48	3
YUK09-18	81	20	21	48	2	0	37	12
YUK09-19	19	7	26	26	26	0	16	26
YUK09-20	125	30	12	23	1	2	58	6
YUK09-21	13	8	46	15	0	8	31	46
YUK09-22	4	3	50	75	0	0	25	0
YUK09-23	20	8	30	0	0	0	90	10
YUK09-24	23	12	30	0	0	0	65	30
YUK09-25	13	5	38	0	15	0	46	38
YUK09-26	51	16	27	45	6	10	8	29
YUK09-27	169	32	17	42	8	4	31	12
YUK09-28	246	27	37	12	6	9	35	37
YUK09-29	122	16	25	50	11	4	16	15
YUK09-30	70	17	26	43	7	0	36	11
YUK09-31	60	20	33	22	5	2	28	37
YUK09-32	66	8	55	70	2	0	9	20
YUK09-33	135	20	54	3	3	1	24	57
YUK09-34	208	10	84	6	0	0	3	84
YUK09-35	36	9	47	36	3	0	14	47
YUK09-36	64	9	67	14	6	0	13	67
YUK09-37	170	39	19	23	9	2	61	3
YUK09-38	98	17	23	44	16	3	9	27
YUK09-39	68	10	62	0	0	0	35	62
YUK09-40	110	20	29	35	5	1	19	33
YUK09-41	103	25	49	5	3	2	85	4
YUK09-42	53	14	19	13	0	0	72	11
YUK09-43	25	10	44	60	8	0	20	0
YUK09-44	50	10	44	30	4	0	20	44
YUK09-45	34	15	32	44	6	3	29	12
YUK09-46	53	19	28	21	9	13	23	28
YUK09-47	280	34	16	49	8	1	35	5
YUK09-48	42	18	38	14	0	0	33	38
YUK09-49	66	8	83	5	0	3	6	83
YUK09-50	126	18	63	21	2	2	9	63

Taxon	Phylum	Class	Order	Family	Total abundance
Naididae	Annelida	Oligochaeta	Tubificida	Naididae	1351
Pseudocloeon dardanum	Arthropoda	Insecta	Ephemeroptera	Baetidae	568
Procladius	Arthropoda	Insecta	Diptera	Chironomidae	403
Heptageniidae	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	279
Metretopus	Arthropoda	Insecta	Ephemeroptera	Metretopodidae	278
Polypedilum	Arthropoda	Insecta	Diptera	Chironomidae	275
Monodiamesa	Arthropoda	Insecta	Diptera	Chironomidae	181
Ephemerellidae	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	101
Heptagenia	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	100
Isoperla decolorata	Arthropoda	Insecta	Plecoptera	Perlodidae	89
Enchytraeidae	Annelida	Oligochaeta	Tubificida	Enchytraeidae	82
Isoperla	Arthropoda	Insecta	Plecoptera	Perlodidae	79
Nematoda	Nematoda				79
Chironomidae	Arthropoda	Insecta	Diptera	Chironomidae	76
Micropsectra	Arthropoda	Insecta	Diptera	Chironomidae	57
Cyphomella	Arthropoda	Insecta	Diptera	Chironomidae	57
Brachycentrus	Arthropoda	Insecta	Trichoptera	Brachycentridae	57
Micropsectra/Tanytarsus	Arthropoda	Insecta	Diptera	Chironomidae	53
Paracladius	Arthropoda	Insecta	Diptera	Chironomidae	53
Perlodidae	Arthropoda	Insecta	Plecoptera	Perlodidae	46
Brillia	Arthropoda	Insecta	Diptera	Chironomidae	33
Stictochironomus	Arthropoda	Insecta	Diptera	Chironomidae	33
Hemerodromia	Arthropoda	Insecta	Diptera	Empididae	32
Chironominae	Arthropoda	Insecta	Diptera	Chironomidae	29
Thienemannimyia group	Arthropoda	Insecta	Diptera	Chironomidae	27
Paracladopelma	Arthropoda	Insecta	Diptera	Chironomidae	27
Culicoides	Arthropoda	Insecta	Diptera	Ceratopogonidae	21
Oligochaeta	Annelida	Oligochaeta			19
Orthocladinae	Arthropoda	Insecta	Diptera	Chironomidae	18
Ephemerella	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	17
Harnischia	Arthropoda	Insecta	Diptera	Chironomidae	15
Rhithrogena	Arthropoda	Insecta	Ephemeroptera	Heptageniidae	15
Metachela/Chelifera	Arthropoda	Insecta	Diptera	Empididae	13
Cladotanytarsus	Arthropoda	Insecta	Diptera	Chironomidae	13
Tanypodinae	Arthropoda	Insecta	Diptera	Chironomidae	12
Lebertia	Arthropoda	Arachnida	Hydrachnidia	Lebertiidae	12
Stempellinella	Arthropoda	Insecta	Diptera	Chironomidae	12
Arctopsyche	Arthropoda	Insecta	Trichoptera	Hydropsychidae	11
Trichoptera	Arthropoda	Insecta	Trichoptera		10
Baetidae	Arthropoda	Insecta	Ephemeroptera	Baetidae	10
Cricotopus/Orthocladius	Arthropoda	Insecta	Diptera	Chironomidae	9
Baetis	Arthropoda	Insecta	Ephemeroptera	Baetidae	9
Isoperla pinta	Arthropoda	Insecta	Plecoptera	Perlodidae	8

Taxon	Phylum	Class	Order	Family	Total abundance
Cryptotendipes	Arthropoda	Insecta	Diptera	Chironomidae	8
Chironomini	Arthropoda	Insecta	Diptera	Chironomidae	7
Chironomus	Arthropoda	Insecta	Diptera	Chironomidae	7
Chaoborus	Arthropoda	Insecta	Diptera	Chaoboridae	7
Empididae	Arthropoda	Insecta	Diptera	Empididae	7
Phaenopsectra	Arthropoda	Insecta	Diptera	Chironomidae	7
Potthastia	Arthropoda	Insecta	Diptera	Chironomidae	7
Stilocladius	Arthropoda	Insecta	Diptera	Chironomidae	7
Stagnicola	Mollusca	Gastropoda		Lymnaeidae	6
Ablabesmyia	Arthropoda	Insecta	Diptera	Chironomidae	6
Ametropus	Arthropoda	Insecta	Ephemeroptera	Ametropodidae	5
Krenosmittia	Arthropoda	Insecta	Diptera	Chironomidae	5
Lepidoptera	Arthropoda	Insecta	Lepidoptera		5
Suwallia	Arthropoda	Insecta	Plecoptera	Chloroperlidae	5
Simulium	Arthropoda	Insecta	Diptera	Simuliidae	5
Hydropsychidae	Arthropoda	Insecta	Trichoptera	Hydropsychidae	4
Demicryptochironomus	Arthropoda	Insecta	Diptera	Chironomidae	4
Procloeon	Arthropoda	Insecta	Ephemeroptera	Baetidae	4
Ephemeroptera	Arthropoda	Insecta	Ephemeroptera		4
Hydropsyche	Arthropoda	Insecta	Trichoptera	Hydropsychidae	4
Isoperla petersoni	Arthropoda	Insecta	Plecoptera	Perlodidae	4
Tanytarsus	Arthropoda	Insecta	Diptera	Chironomidae	4
Dolichopodidae	Arthropoda	Insecta	Diptera	Dolichopodidae	3
Isoperla longiseta	Arthropoda	Insecta	Plecoptera	Perlodidae	3
Pteronarcella	Arthropoda	Insecta	Plecoptera	Pteronarcyidae	3
Tvetenia	Arthropoda	Insecta	Diptera	Chironomidae	3
Paratrichocladius	Arthropoda	Insecta	Diptera	Chironomidae	3
Rhabdomastix	Arthropoda	Insecta	Diptera	Tipulidae	3
Ceratopogonidae	Arthropoda	Insecta	Diptera	Ceratopogonidae	2
Brachycercus	Arthropoda	Insecta	Ephemeroptera	Caenidae	2
Collembola	Arthropoda	Insecta	Collembola		2
Diptera	Arthropoda	Insecta	Diptera		2
Paraphaenocladius	Arthropoda	Insecta	Diptera	Chironomidae	2
Parametriocnemus	Arthropoda	Insecta	Diptera	Chironomidae	2
Nanocladius	Arthropoda	Insecta	Diptera	Chironomidae	2
Parakiefferiella	Arthropoda	Insecta	Diptera	Chironomidae	2
Hygrotus	Arthropoda	Insecta	Coleoptera	Dytiscidae	2
Heterotrissocladius	Arthropoda	Insecta	Diptera	Chironomidae	2
Hydrachnidia	Arthropoda	Arachnida	Hydrachnidia		1
Pteronarcys dorsata	Arthropoda	Insecta	Plecoptera	Pteronarcyidae	1
Hydroporinae	Arthropoda	Insecta	Coleoptera	Dytiscidae	1
Sperchon	Arthropoda	Arachnida	Hydrachnidia	Sperchonidae	1
Lipiniella	Arthropoda	Insecta	Diptera	Chironomidae	1

Taxon	Phylum	Class	Order	Family	Total abundance
Chrysomelidae	Arthropoda	Insecta	Coleoptera	Chrysomelidae	1
Stilobezzia	Arthropoda	Insecta	Diptera	Ceratopogonidae	1
Hyaella	Crustacea	Malacostraca	Amphipoda	Hyaellidae	1
Limnophyes	Arthropoda	Insecta	Diptera	Chironomidae	1
Isoperla katmaiensis	Arthropoda	Insecta	Plecoptera	Perlodidae	1
Limnephilidae	Arthropoda	Insecta	Trichoptera	Limnephilidae	1
Tipula	Arthropoda	Insecta	Diptera	Tipulidae	1
Triznaka	Arthropoda	Insecta	Plecoptera	Chloroperlidae	1
Arctoconopa	Arthropoda	Insecta	Diptera	Tipulidae	1
Valvata	Mollusca	Gastropoda		Valvatidae	1
Ceraclea	Arthropoda	Insecta	Trichoptera	Leptoceridae	1
Physidae	Mollusca	Gastropoda		Physidae	1
Euryhopsis	Arthropoda	Insecta	Diptera	Chironomidae	1
Gyrinus	Arthropoda	Insecta	Coleoptera	Gyrinidae	1
Paralauterborniella	Arthropoda	Insecta	Diptera	Chironomidae	1
Pentaneurini	Arthropoda	Insecta	Diptera	Chironomidae	1
Larsia	Arthropoda	Insecta	Diptera	Chironomidae	1
Ormosia	Arthropoda	Insecta	Diptera	Tipulidae	1
Psectrocladius	Arthropoda	Insecta	Diptera	Chironomidae	1
Dicrotendipes	Arthropoda	Insecta	Diptera	Chironomidae	1
Dytiscidae	Arthropoda	Insecta	Coleoptera	Dytiscidae	1
Plecoptera	Arthropoda	Insecta	Plecoptera		1
Probezzia	Arthropoda	Insecta	Diptera	Ceratopogonidae	1
Cricotopus	Arthropoda	Insecta	Diptera	Chironomidae	1
Corynoneura	Arthropoda	Insecta	Diptera	Chironomidae	1
Eukiefferiella	Arthropoda	Insecta	Diptera	Chironomidae	1
Coleoptera	Arthropoda	Insecta	Coleoptera		1
Isoperla sobria	Arthropoda	Insecta	Plecoptera	Perlodidae	1

Appendix E

Diatom Data

Site ID	Number of taxa	% Dominant taxon	% motile	pH index	Oxygen index	Nitrogen uptake metabolism index	Saprobity index
YUK09-01	27	36	0.7	3.6	1.8	1.9	2.4
YUK09-02	20	43	2.0	3.7	1.9	2.0	2.5
YUK09-03	28	25	1.2	4.1	1.7	1.9	2.4
YUK09-04	24	25	1.7	4.0	1.8	2.0	2.4
YUK09-05	22	36	1.0	3.7	1.6	1.8	2.4
YUK09-06	16	37	0.7	3.8	1.9	2.0	2.6
YUK09-07	27	31	1.3	3.8	1.9	2.0	2.5
YUK09-08	26	24	3.2	4.0	1.9	2.0	2.5
YUK09-09	25	19	1.7	4.1	2.1	2.0	2.6
YUK09-10	28	21	2.5	4.0	2.0	2.0	2.6
YUK09-11	25	16	1.7	4.0	1.9	1.7	2.4
YUK09-12	20	19	0.0	4.0	1.9	2.0	2.5
YUK09-13	23	25	0.0	3.9	1.8	2.0	2.5
YUK09-14*							
YUK09-15*							
YUK09-16	31	19	0.3	4.2	1.8	1.8	2.5
YUK09-17	19	21	0.0	4.3	1.9	2.0	2.5
YUK09-18*							
YUK09-19	34	16	1.7	4.2	1.8	1.8	2.4
YUK09-20	31	14	13.7	3.9	2.2	2.2	2.6
YUK09-21	22	17	1.8	3.9	1.7	1.7	2.2
YUK09-22	35	18	6.8	4.1	1.8	1.8	2.4
YUK09-23	27	28	1.3	4.3	1.6	1.8	2.3
YUK09-24	24	26	0.7	4.0	1.7	2.0	2.4
YUK09-25	26	21	0.7	4.0	1.9	1.9	2.6
YUK09-26	15	31	0.0	3.7	2.1	1.9	2.6
YUK09-27	27	33	4.3	4.1	2.3	1.9	2.9
YUK09-28	18	44	1.0	3.9	1.6	2.0	2.3
YUK09-29	22	41	2.0	3.7	1.6	1.9	2.3
YUK09-30	27	39	1.5	3.6	1.6	1.9	2.3
YUK09-31	34	26	2.3	3.9	1.9	2.0	2.4
YUK09-32	39	23	3.8	4.0	1.7	1.9	2.4
YUK09-33	25	19	1.0	4.0	2.0	2.1	2.6
YUK09-34	27	22	5.5	3.8	1.9	2.0	2.6
YUK09-35	25	27	0.5	3.8	1.8	2.0	2.5
YUK09-36	24	23	2.7	3.8	1.7	1.9	2.5
YUK09-37	23	54	0.8	4.8	1.5	1.9	2.2
YUK09-38	19	31	1.3	4.0	1.8	2.0	2.5
YUK09-39	32	24	1.3	4.2	1.8	1.9	2.4
YUK09-40	30	19	2.5	4.0	2.0	1.9	2.7
YUK09-41	25	40	1.0	3.6	1.8	2.0	2.4
YUK09-42	24	25	25.5	3.9	2.8	2.8	2.9
YUK09-43*							
YUK09-44	30	16	7.3	3.8	2.2	2.3	2.7
YUK09-45	31	16	6.3	4.0	2.4	2.2	2.9
YUK09-46	25	23	0.3	3.7	2.0	2.0	2.7
YUK09-47	25	25	1.3	3.8	2.1	2.0	2.7
YUK09-48*							
YUK09-49	25	29	2.0	3.8	2.4	2.4	3.1
YUK09-50	32	43	5.0	4.6	1.6	2.0	2.3

*Diatoms were not collected at some sites due to a lack of hard substrates required for sampling.

Diatom Taxon	Total abundance
<i>Gomphonema productum</i> (Grunow) Lange-Bertalot et Reichardt	5443
<i>Achnantheidium minutissimum</i> (Kützing) Czarnecki	4360
<i>Diatoma tenuis</i> Agardh	3838
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	2750
<i>Staurosirella pinnata</i> (Ehrenberg) Williams et Round	1382
<i>Navicula cryptocephala</i> Kützing	1356
<i>Fragilaria capucina</i> Desmazières	1041
<i>Staurosira construens</i> Ehrenberg	756
<i>Nitzschia palea</i> (Kützing) Smith	595
<i>Tabellaria flocculosa</i> (Roth) Kützing	569
<i>Hannaea arcus</i> (Ehrenberg) Patrick	407
<i>Encyonema silesiacum</i> (Bleisch in Rabenhorst) Mann	393
<i>Eucoconeis laevis</i> (Østrup) Lange-Bertalot	337
<i>Nitzschia acicularis</i> (Kützing) Smith	334
<i>Encyonema minutum</i> (Hilse) Mann	327
<i>Gomphonema micropus</i> Kützing	264
<i>Diatoma moniliformis</i> Kützing	244
<i>Meridion circulare</i> (Greville) Agardh	209
<i>Cocconeis placentula</i> Ehrenberg	200
<i>Reimeria sinuata</i> (Gregory) Kocielek et Stoermer	177
<i>Gomphonema olivaceum</i> (Lyngbye) Kützing	161
<i>Aulacoseira ambigua</i> (Grunow) Simonsen	153
<i>Luticola mutica</i> (Kützing) Mann	133
<i>Nitzschia dissipata</i> (Kützing) Grunow	113
<i>Diatoma mesodon</i> (Ehrenberg) Kützing	97
<i>Gomphonema parvulum</i> (Kützing) Kützing	86
<i>Craticula accomoda</i> (Hustedt) Mann	72
<i>Gomphonema sarcophagus</i> Gregory	63
<i>Surirella angusta</i> Kützing	41
<i>Eucoconeis flexella</i> (Kützing) Cleve	40
<i>Discostella pseudostelligera</i> (Hustedt) Houk et Klee	37
<i>Melosira varians</i> Agardh	35
<i>Brachysira neoexilis</i> Lange-Bertalot	33
<i>Eunotia praerupta</i> Ehrenberg	32
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow	31
<i>Cyclotella meneghiniana</i> Kützing	28
<i>Staurosirella leptostauron</i> (Ehrenberg) Williams et Round	26
<i>Planothidium frequentissimum</i> (Lange-Bertalot) Lange-Bertalot	26
<i>Sellaphora pupula</i> (Kützing) Mereschkowsky	25
<i>Eunotia bilunaris</i> (Ehrenberg) Mills	25
<i>Rosithidium pusillum</i> (Grunow) Round et Bukhtiyarova	25
<i>Psammothidium bioretii</i> (Germain) Bukhtiyarova et Round	25
<i>Nitzschia linearis</i> (Agardh) W. Smith	23

Diatom Taxon	Total abundance
<i>Amphora copulata</i> (Kützing) Schoeman et Archibald	23
<i>Discostella stelligera</i> (Hustedt) Houk et Klee	23
<i>Planothidium lanceolatum</i> (Brébisson ex Kützing) Lange-Bertalot	23
<i>Cyclotella tripartita</i> Håkansson	22
<i>Surirella brebissonii</i> Krammer et Lange-Bertalot	20
<i>Eunotia incisa</i> Smith ex Gregory	19
<i>Aulacoseira subarctica</i> (Müller) Haworth	18
<i>Neidium bisulcatum</i> (Lagerstedt) Cleve	18
<i>Navicula cryptotenella</i> Lange-Bertalot in Krammer et Lange-Bertalot	17
<i>Amphora inariensis</i> Krammer	17
<i>Nitzschia levidensis</i> (W. Smith) Grunow	16
<i>Cymbella cistula</i> (Ehrenberg) Kirchner	16
<i>Caloneis silicula</i> (Ehrenberg) Cleve	16
<i>Asterionella formosa</i> Hassal	16
<i>Navicula gregaria</i> Donkin	15
<i>Nitzschia perminuta</i> (Grunow) Peragallo	14
<i>Amphora pediculus</i> (Kützing) Grunow	14
<i>Cymbella naviculiformis</i> Auerswald ex Héribaud	14
<i>Amphipleura pellucida</i> (Kützing) Kützing	14
<i>Navicula lanceolata</i> (Agardh) Ehrenberg	12
<i>Denticula kuetzingii</i> Grunow	11
<i>Neidium ampliatus</i> (Ehrenberg) Krammer	11
<i>Luticola goeppertiana</i> (Bleisch) Mann	10
<i>Didymosphenia geminata</i> (Lyngb.) M. Schmidt	10
<i>Nitzschia filiformis</i> (Smith) Van Heurck	10
<i>Pinnularia borealis</i> Ehrenberg	10
<i>Cymbella gracilis</i> (Ehrenberg) Kützing	9
<i>Cyclotella michiganiana</i> Skvortzow	9
<i>Cocconeis neodiminuta</i> Krammer	9
<i>Cymbella caespitosa</i> Brun	8
<i>Gomphonema olivaceoides</i> Hustedt	8
<i>Eunotia paludosa</i> Grunow	8
<i>Cyclotella ocellata</i> Pantocsek	8
<i>Rosithidium petersennii</i> (Hustedt) Round et Bukhtiyarova	8
<i>Planothidium peragalli</i> Brun et Héribaud	7
<i>Rhoicosphenia abbreviata</i> (Agardh) Lange-Bertalot	6
<i>Planothidium oestrupii</i> (Cleve-Euler) Round et Bukhtiyarova	6
<i>Pinnularia microstauron</i> (Ehrenberg) Cleve	6
<i>Nitzschia tubicola</i> Grunow in Cleve et Grunow	6
<i>Navicula</i> spp.	6
<i>Meridion circulare</i> var. <i>constrictum</i> (Ralfs) Van Heurck	6
<i>Cymbella mexicana</i> (Ehrenberg) Cleve	6
<i>Diploneis elliptica</i> (Kützing) Cleve	6

Diatom Taxon	Total abundance
<i>Encyonopsis cesatii</i> (Rabenhorst) Krammer	6
<i>Frustulia vulgaris</i> (Thwaites) De Toni	6
<i>Pseudostaurosira parasitica</i> (Smith) Morales	5
<i>Rhopalodia gibba</i> (Ehrenberg) Müller	4
<i>Cyclostephanos dubius</i> (Fricke) Round	4
<i>Psammothidium subatomoides</i> (Hustedt) Bukhtiyarova et Round	4
<i>Chamaepinnularia soehrensensis</i> (Krasske) Lange-Bertalot et Krammer	4
<i>Karayevia clevei</i> (Grunow) Bukhtiyarova	4
<i>Nitzschia</i> spp.	4
<i>Cyclotella bodanica</i> fo. <i>lemanica</i> (Muller in Schroter; Muller in Chodat) Bachmann	4
<i>Hippodonta capitata</i> (Ehrenberg) Lange-Bertalot, Metzeltin et Witkowski	4
<i>Navicula radiosa</i> Kützing	4
<i>Stauroneis</i> spp.	4
<i>Pinnularia</i> spp.	4
<i>Planothidium haynaldii</i> (Schaarschmidt) Lange-Bertalot	4
<i>Pinnularia divergens</i> Smith	4
<i>Eucoconeis alpestris</i> (Brun) Lange-Bertalot	3
<i>Caloneis</i> spp.	2
<i>Craticula cuspidata</i> (Kützing) Mann	2
<i>Stauroneis anceps</i> Ehrenberg	2
<i>Surirella linearis</i> Smith	2
<i>Nitzschia amphibia</i> Grunow	2
<i>Caloneis bacillum</i> (Grunow) Cleve	2
<i>Planothidium joursacense</i> (Héribaud) Lange-Bertalot	2
<i>Pinnularia subcapitata</i> Gregory	2
<i>Frustulia rhomboides</i> (Ehrenberg) De Toni	2
<i>Aulacoseira crassipunctata</i> Krammer	2
<i>Fallacia pygmaea</i> (Kützing) Stickle et Mann	2
<i>Diatoma hyemalis</i> (Roth) Heiberg	2
<i>Discostella woltereckii</i> (Hustedt) Houk et Klee	2
<i>Gomphonema gracile</i> Ehrenberg emend. Van Heurck	2
<i>Achnanthes biasolettiana</i> (Kützing) Grunow	2
<i>Diploneis parma</i> Cleve	2
<i>Diploneis oblongella</i> (Naegeli ex Kützing) Ross	2
<i>Stauroneis prominula</i> (Grunow) Hustedt	2
<i>Tetracyclus glans</i> (Ehrenberg) Mills	2
<i>Navicula paramutica</i> Bock	2
<i>Gomphonema truncatum</i> Ehrenberg	2
<i>Navicula rhynchocephala</i> Kützing	2
<i>Encyonopsis descripta</i> (Hustedt) Krammer	2
<i>Cymbella mesiana</i> Cholnoky	2
<i>Gomphonema clavatum</i> Ehrenberg	2
<i>Eunotia bilunaris</i> var. <i>mucophila</i> Lange-Bertalot et Nörpel	2

Diatom Taxon	Total abundance
Cyclotella spp.	2
Encyonema reichardtii (Krammer) Mann	2
Cyclotella rossii Håkansson	2
Cymatopleura solea (Brébisson) Smith	2
Gomphonema spp.	2

Appendix F

Lamprey Data

Site ID	Number of larval lamprey	Site ID	Number of larval lamprey
YUK09-01	2	YUK09-26	2
YUK09-02	0	YUK09-27	1
YUK09-03	1	YUK09-28	3
YUK09-04	0	YUK09-29	2
YUK09-05	2	YUK09-30	1
YUK09-06	1	YUK09-31	0
YUK09-07	5	YUK09-32	8
YUK09-08	5	YUK09-33	0
YUK09-09	4	YUK09-34	0
YUK09-10	0	YUK09-35	0
YUK09-11	0	YUK09-36	3
YUK09-12	5	YUK09-37	0
YUK09-13	0	YUK09-38	0
YUK09-14	2	YUK09-39	2
YUK09-15	9	YUK09-40	2
YUK09-16	1	YUK09-41	1
YUK09-17	1	YUK09-42	0
YUK09-18	4	YUK09-43	4
YUK09-19	2	YUK09-44	2
YUK09-20	1	YUK09-45	1
YUK09-21	2	YUK09-46	0
YUK09-22	0	YUK09-47	0
YUK09-23	2	YUK09-48	2
YUK09-24	1	YUK09-49	0
YUK09-25	0	YUK09-50	3