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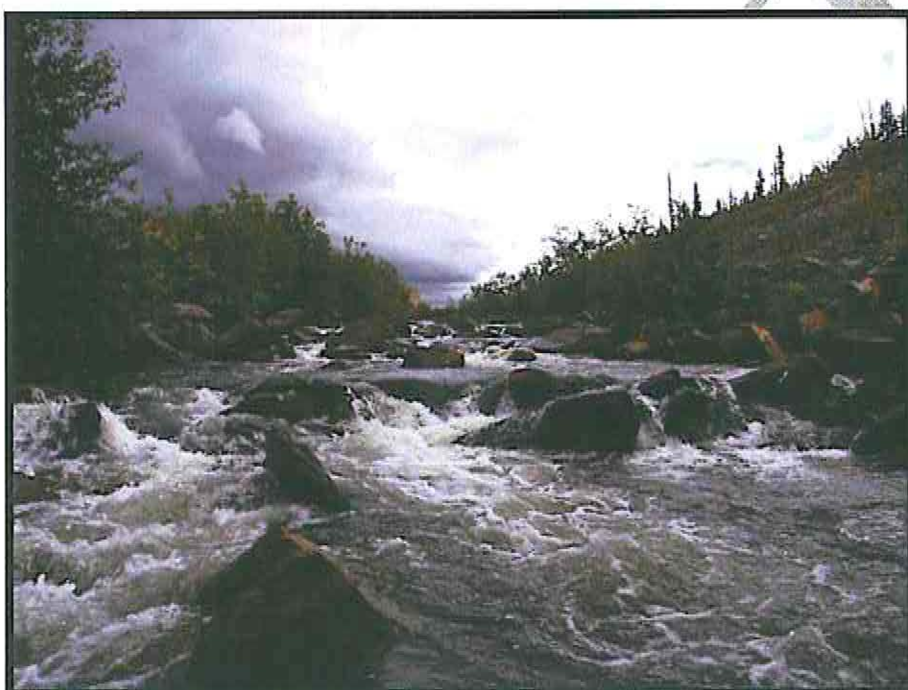
AQUATIC HABITAT CHARACTERIZATION OF THE NORTH FORK OF ROSE CREEK AND ROSE CREEK DIVERSION CHANNEL FARO MINE COMPLEX (2009)



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Aquatic Habitat Characterization of the North Fork of the Rose Creek and Rose Creek Diversion Channel Faro Mine Complex (2009)

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Cover Photo: Sampling site RD2 looking upstream.
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ABSTRACT

This report represents a summary of information collected during August and October of 2009 documenting the status of fish utilization and conditions of aquatic habitat in the North Fork of Rose Creek and the Rose Creek Diversion Channel associated with the Faro Mine Complex. Fieldwork included collections and analysis of periphyton, benthic organisms and fish as well as qualitative and quantitative assessments of aquatic and riparian habitats. Information in this report is intended to provide the basis for the development of a fish habitat compensation plan that is required as part of the proposed remediation activities that are expected to occur over a 15 year period. The report also serves to describe current environmental conditions at these locations.

Results show that the preponderance of periphyton and high densities of the diatom *Achnanthes minutissima* in the lower reaches of the North Fork of Rose Creek are indicative of a biotic response to heavy metal groundwater contamination. The CABIN site assessment results imply benthic communities at most sites in the Rose Creek Diversion Channel are potentially stressed and those in the lower reaches of the North Fork of Rose Creek are severely stressed. The study also confirms that Arctic grayling and slimy sculpin continue to utilize the North Fork of Rose Creek and the Rose Creek Diversion Channel. Other occasionally documented species include burbot, round whitefish and Chinook salmon. Aquatic habitat in the upper reaches of the North Fork of Rose Creek is relatively undisturbed while habitat and cover in the constructed Rose Creek Diversion Channel is constrained by the lack of natural stream processes, homogenous substrates and sparse riparian vegetation. Barriers that prevent upstream movements of fish in the upper Rose Creek drainage are believed to be exclusively associated with the road network at the Faro Mine Complex.

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INTRODUCTION

The Faro Mine Closure Project Management Team is currently finalizing the project description and environmental assessment for closure and remediation of the Faro Mine Complex. The remediation includes activities that will affect fish and fish habitat, especially in Rose Creek and in particular the North Fork of Rose Creek. It is anticipated that a 3.5 km section of the North Fork of Rose Creek will be reconstructed to prevent contaminated groundwater from entering into surface flows of this tributary. A section to the existing Rose Creek Diversion Channel (RCDC) will also be upgraded.

As a result of the proposed remediation work more detailed information is required about the current status of fish utilization and conditions of the aquatic habitat in the North Fork tributary and the RCDC, as well as the presence of barriers to the movements of fish in the upper Rose Creek drainage. The information gained from this project will serve as a basis to develop a fish habitat compensation plan under the requirement of the Fisheries Act for the harmful alteration, disruption or destruction of fish habitat (HADD). Compensation is defined in the Policy for the Management of Fish Habitat by the Federal Department of Fisheries and Oceans Canada as the replacement of natural habitat, increase in the productivity of existing habitat, or maintenance of fish production by artificial means in circumstances dictated by social and economic conditions, where mitigation techniques and other measures are not adequate to maintain habitats for Canada's fisheries resources (DFO 2010). It is anticipated that information contained in this report will also be used for a variety of purposes that may include mine closure planning, any proposed future environmental monitoring and other regulatory processes related to the remediation activities at the Faro Mine Complex.

OBJECTIVES

The objectives of this project are to investigate and report on fish habitat, fish utilization and fish passage in upper Rose Creek that will be affected by proposed closure and remediation activities. Specific objectives include:

i) Determine the fish utilization and aquatic habitat characteristics of the North Fork of Rose Creek between the confluence of the Faro Creek Diversion and the inlet of the Rose Creek Diversion Channel that is proposed for reconstruction.

ii) Determine the fish utilization and aquatic habitat characteristics of the Rose Creek Diversion Channel (RCDC).

iii) Identification of fish passage constraints and opportunities for improvements within those drainages of upper Rose Creek that are affected by infrastructure associated with the Faro Mine Complex.

STUDY AREA

Rose Creek watershed originates in the Anvil Range of the Yukon Plateau in the south-central Yukon near the town of Faro, about 200 km northeast of Whitehorse. The drainage basin is in Ross River Dena Traditional Territory. It lies within the Boreal Cordillera ecozone and is characterized by mountain ranges that contain numerous high peaks and extensive plateaus, and are separated by wide valleys and lowlands. Landscape features are primarily the result of past glacial activity, erosion and widespread deposits of glacial origin. Black spruce, trembling aspen, balsam poplar, and white birch are the most common forest types. At higher elevations, scrub birch and willow occur in subalpine sections with extensive landscapes of rolling alpine tundra characterized by sedge-dominated meadows, and lichen-colonized rock fields. The climate in this region is characterized as an interior subalpine type with long cold winters and summers that are brief and cool.

The Rose Creek watershed in the vicinity of the Faro Mine Complex contains numerous small tributaries and a few high elevation ponds and lakes (<50 ha.). Rose Creek constitutes a major portion of the Anvil Creek drainage basin. Surface waters originating in the Rose Creek basin flow into Anvil Creek and eventually flow into the Pelly River, a major tributary of the upper Yukon River basin. Information is limited about the distribution of freshwater fish species in much of the drainage outside of the mine site. Reported species within the proximate confines of the Faro Mine Complex include Arctic grayling, burbot, round whitefish, slimy sculpin and Chinook salmon (Sparling pers.com. 2009; Harder *et al* 1993).

METHODS

Selection of Study Sites

A total of 12 study sites, focusing on fish utilization and habitat characterization component of the study, were located within sections of upper Rose Creek that have been identified for remediation (Figure 1). Five of these study sites (RD1, RD2, RD3, RD4 and RD5) were equidistantly spaced and located in various habitats over the length of the RCDC. The RCDC is currently used to divert surface waters originating from the North and South Forks of Rose Creek around the tailings impoundment and is positioned against the valley wall on the south side of the valley. The RCDC is approximately 4.7 km in length. To characterize the two habitat types found in the channel, three 3 sites were chosen to represent the low gradient glide-run-pool type habitat (RD3, RD4 and RD5) and 2 sites were selected to represent the steeper gradient step-pools associated with the lower reaches of the channel (RD1 and RD2). Site RD2 was also in close proximity to a verified Chinook spawning redd that was discovered earlier in the season.

Another seven study sites (NF1-1, NF1-2, NF2-1, NF2-2, NF3-1, NF3-2 and NF3-3) were located along the North Fork of Rose Creek, a tributary drainage that flows from the north and joins the South Fork of Rose Creek just above the RCDC inlet. The lowest reach of the North Fork is highly altered from past mining activates. Conversely, the channels upstream of the Mine Access and Haul Road culverts are largely undisturbed. The stream length that was the focus of study in the North Fork tributary was approximately 4.3 km. Reaches in the north fork tributary were defined by two road crossings that served as reach breaks. The first reach (NF1) was a highly disturbed reach downstream of the mine Access Road culvert. Presently two channels convey surface flows in this reach. The first southern channel contains remnants of the original streambed and is connected with a series of 5 moderately sized manmade ponds. A second channel directs a portion of the North Fork surface flows away from the constructed ponds before eventually discharging into the South Fork of Rose Creek. The second reach (NF2) was defined as the section of channel between the Access Road culvert and the rock drain associated with the Haul Road. A third reach was the stream section between the Haul Road rock drain and the confluence with Faro Creek. At least 2 sampling sites were chosen within each of the three reaches for a combined total of seven sampling sites in the North Fork tributary of Rose Creek.

Channel Profiles and Discharge

To determine a cross section profile of the channel at each sampling site, a section of rebar was first anchored into the stream bank and placed well above the high water mark for use as a benchmark. Using a level, stadia and survey tape attached to the rebar and positioned across the stream (perpendicular to the flow), a bank or streambed elevation was recorded approximately every meter. Obvious high water marks and wetted edges of the stream were surveyed in as part of the cross section. Resulting data that was generated from each sampling site was entered into an Excel spreadsheet and plotted.

Instantaneous water discharge was measured at each site during both August and October sampling episodes. The exceptions were sites RD1 and RD4 where flow was measured only in August. The locations for each estimate was a relatively uniform cross section of the stream that was preferably a glide or run. A minimum of 10 individual depth and velocity measurements were taken across the width of the stream to estimate discharge at each site. A propeller driven Global Flow Probe was used to measure average water velocity by moving the probe up and down vertically in the water column for approximately 40 seconds. Resulting data from each site was entered into an Excel spreadsheet to calculate an estimate of instantaneous flow.

Periphyton Collection and Analysis

A fairly uniform substrate was located over the wetted width of the stream at each sampling site. Selected rocks were relatively flat and large enough to accommodate at least one scraping disc. Rocks were generally selected randomly. A minimum of 5 scraping discs was obtained at each site where algal densities were low. The exceptions were sites NF1-2, NF2-1 and NF2-2 where there was an obvious dense growth on the rocks and only 3 or 4 scraping discs were required. A combination of distilled water and a toothbrush were used to scrape periphyton off each rock using a cup of known area (80.1 cm^2). The water-algae mixture within the cup was transferred to a pre-labeled bottle using a "turkey" baster. Samples were preserved with at least 1 mL of Lugol's solution for each 250 ml sample. All periphyton collections were completed during the August sampling episode. Samples were shipped to an invertebrate taxonomist for identification and enumeration.

In the lab, each sample was allowed to settle after which an appropriate sample volume (usually 100 ml) was randomly removed. The sample was scanned on a slide at increasing powers of magnification to determine which species or genera were present. At least 10 random fields were counted until least a count of 100 was achieved for the dominant species. Data was enumerated to determine a total cell count (cells per mL). To calculate densities for a given species or genera within each sample, the following equation was used to derive a multiplying factor:

$$F = (A / r^2 \pi N)/V$$

F = multiplying factor

A = the area of the settling chamber

r = the radius of the field

N = the number of fields counted

V = the volume settled

Only diatoms were used for the calculation of various metrics that included taxonomic richness, Shannon-Weiner diversity index, density (cells per mL) and species dominance percentages.

Benthic Collection and Analysis

A 500μm mesh kick-net was used to sample benthic organisms at each site. The CABIN (Canadian Aquatic Biomonitoring Network) protocol for collection of benthic macroinvertebrates was followed. This required the placement of the kick net downstream of the collector, flat side of the net resting on the substrate of the stream. The collector walked backward, away from the net, kicking the substrate to disturb it to a depth of about 5 cm. For large boulders, the net is held downstream while brushing each boulder by foot. At each site the collector zig-zaged over the stream bottom from bank to bank in an upstream direction for 3 minutes. Generally, sections of stream chosen for sampling were those that were near riffle-pool transitions. All samples were collected during the August sampling episode. When sampling was completed, the net was washed with distilled water into a 250μm sieve and the residue was place into a 1-liter container and preserved using 10% formalin. Samples were shipped to a CABIN certified invertebrate taxonomist for identification and enumeration.

The CABIN (Canadian Aquatic Biomonitoring Network) protocol was also used for sorting, identification and enumeration of benthic macroinvertebrates. Each sample was first rinsed and elutriated to remove sand and gravel. The elutriate was checked for mollusks and trichopteran cases. The remaining organic component was examined to estimate densities. If the total number of invertebrates in the sample was estimated to be over 600 then the sample was subsampled using a Marchant Box subsampler. The sample was distributed in the Marchant box and cells were extracted one by one in a random way (using a random number table) until 325 invertebrates were counted. Ostracods, flatworms, pelagic crustaceans, terrestrial drop-ins were extracted and counted but did not count towards the total numbers. If 50 cells (of 100) were extracted and the total count was less than 300 then the whole sample would be sorted and identified. The invertebrates were identified to lowest level possible except for the phyla Nemata and the Oligochaete families. For quality assurance and control, three samples were resorted by a different sorter to test sorting efficiency. All three samples achieved a sorting efficiency of greater than 90%. Resulting benthic data was entered into the Environment Canada CABIN online database. Various metrics were calculated for each sample that included taxonomic richness, Shannon-Weiner diversity index, number of Ephemeroptera-Plecoptera-Tricoptera taxa (EPT) and species dominance expressed as a percentage.

Fish Collection

Fish sampling was conducted under a permit obtained from Fisheries and Oceans Canada. To establish fish presence during August and October at each site, three fish capture techniques were employed. These included electrofishing, minnow trapping and angling. Existing access roads associated with the Faro Mine Complex were the primary means of accessing sampling sites. ATV's were also used for several of the more remote sampling locations.

Electrofishing was the primary technique used to establish fish presence. The conductivity of the water was first noted to assist in the initial setup of the electroshocker. A minimum crew size of two people was used during each sampling episode. Captured fish were placed into a bucket filled with clean water. A tally of fish that were observed but avoided capture with the dipnet was also recorded. Voltage was adjusted to enable fish in the bucket to recover within 5 to 20 seconds. A standard waveform of between 300 to 500 volts and a 15% duty cycle was effectively used throughout the project. Between 600 and 1,200 seconds of shocking time was performed at each site.

Galvanized ¼ inch "Gee" type minnow traps, which were baited with suspended sacs of Yukon River salmon roe, were also utilized at each sampling site using methods described by the Yukon River Panel (2007). Minnow traps were set in various habitat types such as scour pools, side-channels, undercut banks or in woody debris that offered cover for fish. A total of 10 minnow traps were set for an overnight period at each sample site. Soak times were recorded for each trap. The exceptions were sites NF3-1, NF3-2, NF3-3, RD1 and RD4 during October where ice prohibited their use.

Angling was additionally used during August and October at all sites with the exception of site NF1-1, where the channel was too shallow due to low flow conditions. Angling employed the use of flies and small spinners. The time spent angling as well as the number of strikes and species captured were noted.

All captured fish during the project were measured for either a fork or total length (± 1 mm) and weight (± 0.1 gm). Weight was determined using a digital scale by first blotting excess water from the fish and then placing each fish into a container on the scale. A total length was recorded for burbot and slimy sculpin, and fork length for Arctic grayling. Fish were given time to recover in a bucket before being live-released away from the current near their site of capture.

Aquatic Habitat Characterization and Analysis

For the quantitative assessment of aquatic habitat, specifically in the North Fork tributary, three reaches (NF1, NF2 and N3) were walked to delineate the representative habitat types on maps. Habitat types included glide and run (combined), pool, rapid, riffle, side channel and open water pond. Stream lengths of each respective habitat type were tallied and multiplied by the average channel widths of the closest sampling site where habitat characterizations were completed. Surface areas for each open water pond were calculated by layering a polygon on an aerial photo and determining the area. For some of the longer stream reaches with a complex riffle, pool and run/glide sequences, percentages of each habitat type were estimated over a defined length of stream and partitioned.

For the habitat characterizations, all sites were surveyed during August. A 50 to 100 meter section of the stream was identified at each site. Various parameters were then measured using a combination of the CABIN (2010) field assessment protocols and the British Columbia Resource Inventory Committee (2001) standards for fish and fish habitat inventory. Each site was first geo-referenced with a hand held Garmin GPS (datum WGS 87). Attributes were determined from field measurements and included those related to site (date, time and length of stream surveyed), channel characteristics (channel and wetted widths, bankfull channel depth, residual pool depth, stage of flow and gradient), fish cover (abundance, cover types, bank characteristics, riparian vegetation and stage of development) and stream morphology (bed material, channel pattern, confinement, occurrence of bars and islands). Basic in situ water chemistry parameters (conductivity, pH and surface water temperature) were recorded with a digital thermometer and Oakton handheld meters. Digital photographs included upstream and downstream perspectives of each sampled site.

For the CABIN database and subsequent analysis comparing the project test sites to reference sites developed and used in Yukon Reference Model (CABIN 2010), several GIS metrics were calculated from the Canadian Land Cover Database. Calculated variables that were needed to run the modal included climate (maximum January temperature, rain and snow accumulations in June and January), basin area, basin perimeter, elevation, stream order, stream length, stream density and several landscape variables (Bailey pers. com. 2010). Landscape variables required the grouping of different cover types in the watershed that were determined from the Canadian Land Cover Database. Groupings included low shrubs (presumably *Betula nana*) and herbs to represent alpine landcover. Forest landcover was represented by dense, open and sparse coniferous and broadleaf vegetation that also included tall shrubs. Unregenerated forest was grouped as exposed land, rock and rubble. These variables and those determined from the stream habitat characterizations for each site were input into the CABIN database and used in the analysis. Using the analytical tools in CABIN, an assessment report was completed for each of the study sites. The final product of the assessment report was the determination of a site as being unstressed, potentially stressed, stressed or severely stressed.

For the barrier assessment in the drainages of upper Rose Creek, all road crossings associated with the Faro Mine Complex were inspected. Recorded information at each crossing included the culvert type, construction, length, slope, and maximum outlet drop. A velocity measurement was also made at those locations where culverts or habitat features could potentially be construed as a velocity barrier at high discharges.

RESULTS

Channel Profiles and Discharge

August and October sampling episodes were completed when stream flows were moderate to low respectfully, and well below the high water mark at all surveyed sites. The greatest decline in water surface elevation between August and October sampling episodes was at site NF1-2 of 11 cm. Of the three RCDC sites that were surveyed during both sampling episodes, the greatest decline in surface elevations was measured at site RD3 of 8 cm. With the exception of site NF1-1, the bulk of aquatic habitat at all sites in the study remained submerged during October, a period that was just before freeze-up. The greatest reduction in measured discharge between August and October was recorded at site NF1-1 with a decrease in flow by approximately 66 percent. Unfortunately, the benchmark at this location was destroyed that prohibited any temporal comparison.

The greatest discharge was recorded at site RD5 near in the RCDC of 2.67 CMS on August 27 (Figure 2). Average velocity within this uniform cross section was 0.44 meters per second with an average channel depth of 0.35 meters. Site RD5 was also the shallowest site in cross section compared to other sites in the RCDC (Appendix 1). Recorded discharges at site RD5 were generally higher (interesting – as this is the upper part of the RCDC) than those estimated for downstream sites during both the August and

October sampling episodes. The highest measured water column velocity in the RCDC was recorded in the highest gradient reach at site RD1 of 0.71 meters per second during August.

The greatest measured discharge of sampled sites in the North Fork tributary was recorded on August 26 at site NF3-1 of 1.92 CMS (Figure 2). Overall, other upstream and downstream sites were found to have lower discharges during both August and October sampling episodes. This was especially evident at site NF1-1 that receives only a small portion of the total flow of the North Fork tributary. The channel at this location was also the shallowest in cross section with an average depth of only 0.29 meters during August. Profiles of all sampling sites are presented in Appendix 1.

Periphyton

Identified periphyton included the following phyla: Bacillariophyceae (diatoms), Chlorophyta (green algae), Chrysophyta (golden algae), Cyanophyta (blue-green algae), Euglenophyta (flagellates) and Rhodophyta (red algae). The most diverse phylum in the collected samples was diatoms. The greatest taxonomic richness (number of taxa) of this group was 52 species identified at sites RD4 and RD5 (Table 1). The site with the fewest taxa was at NF3-3 with a total of 33 identified species. Species diversity ranged from a low of 0.39 at site RD2 to a high of 0.71 just upstream at site RD3. The highest densities of diatoms were documented at site NF1-2 of 6,043 cells per centimeter. Site NF3-3 had the lowest densities of diatoms with counts that were 2 orders of magnitude lower than most of the other study sites further downstream (do low densities indicate no impact?). The most dominant taxonomic genus of diatoms represented only 24.0 percent of the sample at site NF3-3 and 77.4 percent at site RD2. When combined, the two most dominant diatom genera ranged from 47.5 percent of the sample at site NF3-3 to 79.4 percent at site NF1-2. Densities of the *Achnanthes minutissima* were the highest at site NF1-2 (Figure 3). This species of diatom was found to be abundant at all sites except NF3-3 where it was found in very modest numbers. A summary of identified taxa and their relative abundance from sampled periphyton during August at each site are presented in Appendix 2. Any interpretation of what this all means?

Benthic Community

The taxonomic richness (number of taxa) in the August benthic samples collections ranged from a low of 9 species at site NF1-1 to a high of 19 species at NF3-1 (Table 2). With the exception of sites NF1-1 and NF1-2, all other sites were higher than the Yukon CABIN reference site mean of 11.4 species per site. Species diversity ranged from a low of 0.42 at site NF1-2 to 2.18 at site NF3-3. The mean diversity for the Yukon CABIN reference sites was 1.44. The highest number of EPT (Ephemerotera-Plecoptera-Tricoptera) taxa was associated with sites NF3-1 and NF3-3 where 12 species at each of these sites were collected. The lowest number of EPT taxa was 2 species at site NF1-1. The Yukon reference site average for the number of EPT taxa was 5.4 species per site. Percentages of the most dominant taxa ranged from a low of 26.1 percent at site NF3-3 to a high of 92.7 percent at site NF2-2. The two most dominant combined taxa ranged from 49.2 percent at site NF3-3 to 97.6 percent at site NF1-1. The Yukon reference site average for the most dominant and 2 most dominant groups were 52.1 percent and 70.9 percent, respectfully. A summary of identified benthic species and relative abundances of each from collected kick net samples during August for each sample site are presented in Appendix 2.

Results from the CABIN/BEAST analysis are presented in individual site assessment reports in Appendix 4. Potentially stressed sites were RD1, RD2, RD3 and RD4 in the RCDC. Site RD5 was concluded to be the only stressed site in the RCDC (is this site stressed because of physical conditions and not chemistry?). There were three severely stressed sites in the North Fork tributary and were associated with the lower reaches at sites NF1-1, NF1-2 and NF2-2. A stressed biological condition was concluded for NF2-1 and NF3-2. Site NF3-3 was considered to be potentially stressed and site NF3-1 was the only site in reference condition and considered unstressed biologically in the study. (Site references may be reversed in this sentence. NF3-3 is the reference location and NF3-1 would likely be "potentially stressed."

Fish Utilization

A total of three species of freshwater fish were captured during this survey. These included in descending catch frequency slimy sculpin (*Cottus cognatus*), Arctic grayling (*Thymallus arcticus*) and burbot (*Lota lota*). A single round whitefish was observed but not captured at site NF2-2 in August. Both slimy sculpin and Arctic grayling were captured at 9 of the 12 sampling sites in the study area (Table 3). Slimy sculpin were not captured at site RD1 in the RCDC, which was only sampled during August. Arctic grayling were not captured at site RD4 during the single sampling event in August or in August and October sampling episodes at site NF3-2.

Slimy sculpin fry were abundant at sites RD4 and RD5 in the RCDC. They were also abundant at sites NF1-1 and NF2-2 in the North Fork tributary. Slimy sculpin fry were represented in the catch at all sites except for site RD1. Captures of Arctic grayling fry were common only at site NF1-1 during October. Adult Arctic grayling were almost exclusively captured in August and were largely absent in October (Figure 4). Arctic grayling captures in October were almost exclusively fry and associated only with the North Fork tributary. Overall, all life history stages (fry to adult) of Arctic grayling were represented in catches above and below the Haul Road rock drain of the North Fork tributary.

Aquatic Habitat Characterization

North Fork of Rose Creek

Comparison of calculated areas and proportions of various aquatic habitat types determined for the three study reaches of the North Fork of Rose Creek are presented in Table 4. Overall, the three reaches represented about 4.3 km of stream habitat covering an area of about 5.26 ha. Reach NF3 above the Haul Road contained about 60 percent of the study area habitat associated with the North Fork tributary. The dominant habitat type were rapids that represented an area of about 15,670 m^2 or 30 percent of the aquatic habitat of the North Tributary. Open water pond habitat was also a major component representing a surface area of 13,295 m^2 or about 25 percent. Pools, riffles and runs or glides, which represent the best habitat type qualitatively for fish, when combined, represented about 43 percent or 2.3 ha of the aquatic habitat of the North Fork tributary.

Average channel widths ranged from 7.1 to 12.6 meters at sites in the North Fork tributary. Wetted widths ranged from 5.7 to 10.4 meters during the August survey when flows were moderate. The greatest average bankfull channel depth was measured at site NF1-2 of 1.6 meters. Residual pool depths ranged from 0.3 meters at sites NF1-1 and NF3-1 to 0.8 meters determined for site NF3-3. Stream gradients were generally below 1 percent at all sites except for NF2-1 where it was estimated to be at 2.4 percent. For the most part there were moderate amounts of fish habitat cover at nearly all sampled sites. The exception was site NF1-1 with only trace amounts and site NF3-2 where fish cover was abundant. The dominant cover types varied between sites but were confined to deep pools, boulders and undercut banks. Other cover types included (already listed in previous sentence), overhanging vegetation, small and large woody debris and instream vegetation that was mostly composed of moss and periphyton. Most sites contained either a few pieces or no observed large woody debris. All sample sites were directly open to sunlight with little in the way of crown closure. Bank steepness varied between sites and was either sloping or vertical. Shrubs were the dominant vegetative type of riparian vegetation at all sites. Substrates were mostly dominated by cobble at most sites. Gravels were common at sites NF1-1 and NF2-2. Boulders dominated the substrate at NF2-1. Generally, the north fork stream substrates were composed of cobbles and boulders. With the exception of site NF2-1, which had a cascade-pool configuration, all sites were characterized by a riffle-pool morphology. The channel patterns were either irregular or sinuous. Islands were rare and occasional at sites NF1-1, NF2-2 and NF3-2. Bars were observed at the majority of sites and were primarily composed of gravel. The stream channel throughout the study area of the North Fork tributary was generally confined.

Rose Creek Diversion Channel

Average channel widths ranged from 13.8 to 28.4 meters at sites in the RCDC (Table 6). Wetted widths ranged from 13.7 to 14.7 meters during the August survey when flows were moderate. At all sites the average bankfull channel depth was less than or equal to 1.5 meters. Residual pool depths ranged from 0.7 meters at site RD2 to over 1.0 meter at sites RD3, RD4 and RD5. Stream gradients were generally below 0.5 percent at the three most upstream sites: RD3, RD4 and RD5. Measured gradients at sites RD1 and RD2 were 5.5 and 5.0 percent, respectfully. Fish cover was abundant at sites RD1 and RD2. Cover for fish was only moderately abundant at sites RD3 and RD4. Site RD5 had limited quantities of habitat cover for fish. The dominant cover type were boulders at all sites in the RCDC. Other major cover types included deep pools and instream vegetation that was mostly moss and periphyton. Other cover types included small and large woody debris, and occasional patches of overhanging vegetation along the banks. Only site RD5 contained some representative pieces of large woody debris. All sample sites were directly open to sunlight with no crown closure. Bank steepness varied between sites and was either sloping or vertical. Shrubs were the dominant vegetative type of riparian vegetation at all sites and growth was sparse in many reaches. The dominant substrates in the RCDC were large pieces of bedrock and boulders. Cobble was also abundant at sites RD3, RD4 and RD5. A riffle-pool morphology was present at sites RD3 and RD4. Site RD5 was almost entirely an extended riffle. Sites RD1 and RD2 were characterized by having a cascade-pool morphology. The channel pattern throughout the RCDC was straight. There were no notable islands or bars. The stream channel throughout the RCDC was entrenched.

Upper Rose Creek Barrier Assessment

The upper Rose Creek barrier survey noted 4 complete and 1 partial barriers to the upstream movement of fish in the watershed portions associated with the Faro Mine Complex. All of the barriers were associated with road crossings of the North and South Forks of Rose Creek (Table 7, Figures 5 to 7).

DISCUSSION

North Fork of Rose Creek

Inspection of aquatic habitat in the lowest reach (NF1) of the North Fork of Rose Creek suggests the original stream channel has been heavily modified by past mining activities at the Faro Mine Complex. Currently, two channels convey portions of the flow of the creek. The dominant feature of the south channel is a series of connected ponds that were constructed to increase groundwater infiltration for a local well (Figure 5). Arctic grayling use the small riffles between these ponds as spawning habitat and the ponds offer suitable over-wintering habitat for fish due to their depth (Sparling pers. com. 2009). The outlet of the lowest pond reports into a several braided willow lined channels before finally discharging into the South Fork of Rose Creek. No barriers were observed that would prevent fish from accessing these ponds from the South Fork tributary. From observations at moderate and low flow periods, the north channel section accommodates a smaller percentage of the total flow of the creek. In this section the creek channel is boulder strewn and entrenched with a severely eroded lower reach presumably from past channel modifying flows (Figure 6). Site NF1-1 was situated in the eroded lower reaches of this channel. Catches of juvenile and adult fish at this location were few however the site was heavily utilized by Arctic grayling and slimy sculpin fry during October. Fish cover was relatively low and the CABIN assessment report concluded the site was severely stressed. Site NF1-2 was also situated in reach NF1 but just downstream of the mine Access Road culvert. This short section was just above the divergence of the two channels. Several Arctic grayling adults were observed or captured in the deeper pools located at this site during August. All life history stages of slimy sculpin were also captured at this site. This site had the highest densities of *Achnanthes minutissima*, a species that is believed to be a bioindicator of heavy metal pollution (Nakanishi *et al*). The CABIN site assessment suggests the stream is severely stressed at this location. (What reference stations were used for comparison and what metrics led you to conclude that they were appropriate reference stations.) The culverts just downstream of this site that convene flow into the south channel also represent a complete barrier to the upstream movement of fish. The large single culvert associated with the Access Road just upstream of this site is likely a partial barrier to movements of fish at higher flows.

Reach NF2, upstream of the mine Access Road culvert, is a single unmodified channel with a healthy riparian region. Some of the best pool-riffle habitat for adult Arctic grayling was located in the upper sections of this reach, primarily below the Haul Road rock drain that also served as the upstream reach break. The rock drain is believed to be a complete barrier to the upstream movement of fish. Flows at the downstream toe of the rock drain have been estimated to be 3 to 4 CMS (Campbell 1989). Modest numbers of the fish were captured at sampling site NF2-1. The stream at this location is an extended section of rapids. Site NF2-2 had reasonably good catches of both Arctic grayling and slimy sculpin, with the later fairly abundant in the rock rubble at the toe of the rock drain. The CABIN site assessment concluded that both sampled sites in this reach are either stressed or severely stressed despite the relatively good catches of fish. Densities of *Achnanthes minutissima* were also high at each sampled site and much higher compared to upstream sampling sites in reach NF3. Previous studies from field investigations indicated high levels of contaminants (S-wells) in close proximity to the North Fork of Rose Creek with a component of contaminated groundwater currently discharging into the creek (SRK Consulting 2009). The results of this study demonstrate that the lower reaches of the North Fork of Rose Creek are currently showing a strong biological response from groundwater contamination.

Reach NF3 was immediately upstream of the rock drain. This was the longest reach in the North Fork tributary study area (2.3 km) and rapids were the most common feature in this section of stream. Arctic grayling and slimy sculpin fry were moderately abundant at site NF3-1 inferring self-sustaining populations of these species upstream of the rock drain. With the exception of the inlet area of Faro Creek, where sediment deposits from erosional processes are readily apparent, the North Fork tributary above the rock drain is essentially undisturbed. Riparian zones were lush with willow and moose sign was common. In many sections riffle-glide-pool sequences and side channels provided excellent fish habitat between the steeper gradient sections characterized by rapids. Generally, fish cover was moderately abundant. The CABIN site assessment concluded that site NF3-1 was unstressed and in reference condition (this is the downstream site according to the map – is this correct? I would expect it to be more impacted and not to be in reference condition). The CABIN determination for sites NF3-2 and NF3-3 as being stressed and potentially stressed, respectfully, indicates some perturbation to the benthic community has occurred. None-the-less, site NF3-3 had the highest diversity of benthic organisms. It is interesting to note that in general, densities of *Achnanthes minutissima* and other periphyton types decreased with increasing distance upstream.

Rose Creek Diversion Channel

The Rose Creek Diversion Channel (RCDC) is an engineered channel designed to withstand a 1 in 500 year flood event (SRK Consulting 2009). As such, the channel does not contain some of the common habitat features one would find in a natural stream. There are no meanders, the substrates are homogenous, and there is little diversity in the types of fish cover that are present. Riparian vegetation is sparse and rooted vegetation is actively removed to maintain integrity of the banks. The RCDC is entrenched and the banks are generally steep sided. The majority of the RCDC consists of glides or runs and there are very few riffle-pool sequences. In previous studies the diversion channel around the tailings has been considered to have low rearing habitat potential and a moderate value for spawning, winter and summer habitat (Gartner Lee 2002; Harder 1993).

The two relatively short and fairly steep gradient sections (RD1 and RD2) consisted of a step-pool type of morphology that is constructed of large armor in the form of boulders and pieces of bedrock. Fish cover was abundant, consisting almost exclusively of interstitial spaces associated with the large substrate. Catches of Arctic grayling and slimy sculpin were modest at sites RD1 and RD2. Velocities at these locations were highly variable due to the turbulent nature of the flows. Despite the steepness of the gradient, it is believed that upstream fish passage is likely possible and potentially restricted only during high flows. Past evidence to support this conclusion are documented catches of juvenile Chinook salmon and the recovery of tagged Arctic grayling above the RCDC that presumably originated from below (Sparling pers. com. 2009). Further, a pair of Chinook salmon adults were discovered constructing a redd at site RD3 in August of 2009, having successfully negotiated the steeper gradient reaches of the RCDC (Sparling pers. com. 2009).

The lower gradient sections of the RCDC were surprisingly productive for slimy sculpin despite the habitat constraints associated with this engineered channel. All life history stages of this species were captured at sites RD3, RD4 and RD5. Slimy sculpin fry were commonly observed and especially abundant where periphyton growth was pronounced. Overall, Arctic grayling catches were few in the RCDC and is likely reflective of the low frequency of pool type habitat and other fish cover types. Burbot was the only other captured species in the RCDC at sites RD3 and RD4. Very few burbot were captured in the study indicating very low densities of this species.

The CABIN site assessments concluded all sites in the RCDC were potentially stressed with the exception of site RD5. Site RD5, located near the RCDC inlet, was concluded to be stressed and coincidently had the greatest densities of *Achnanthes minutissima*. While CABIN analysis is not capable of diagnosing any specific underlying cause, several factors have likely contributed including contributions of sediment from

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Sparling, P. 2009. White Mountain Consulting, P.O. Box 10140, Whitehorse, Yukon. Y1A 7A1 E-mail: psparling@gmail.com

Figure 1 Study sites associated with the Rose Creek Diversion and the North Fork tributary of Rose Creek.

0.5 0 1 2 km

SCALE 1 : 22,200

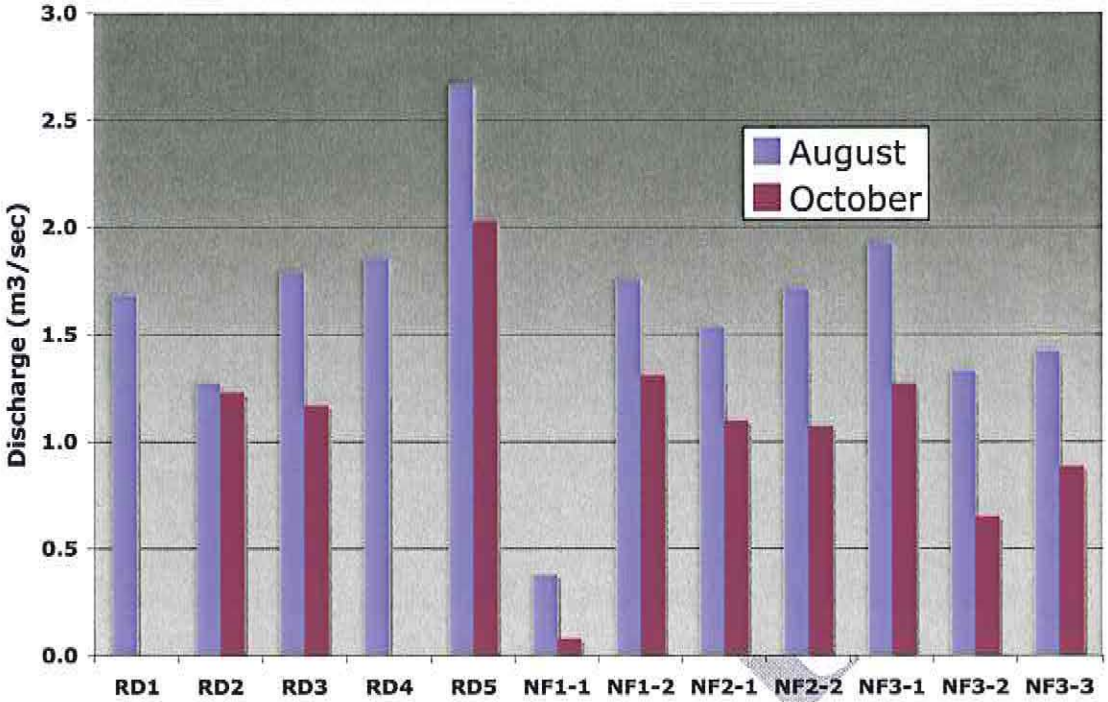


Figure 2 Measured discharges at Rose Creek sample sites during August and October at the Faro Mine Complex, 2009.

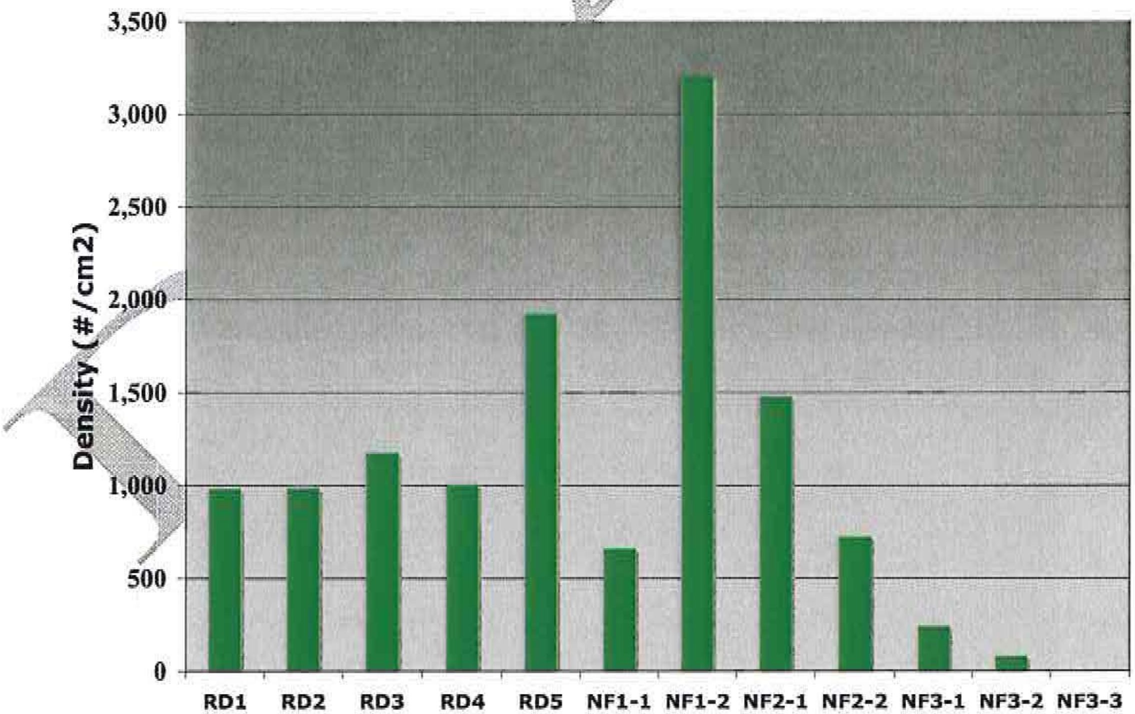


Figure 3 Comparison of densities of *Achnanthes minutissima* in periphyton samples collected at the Rose Creek study sites during August 2009.

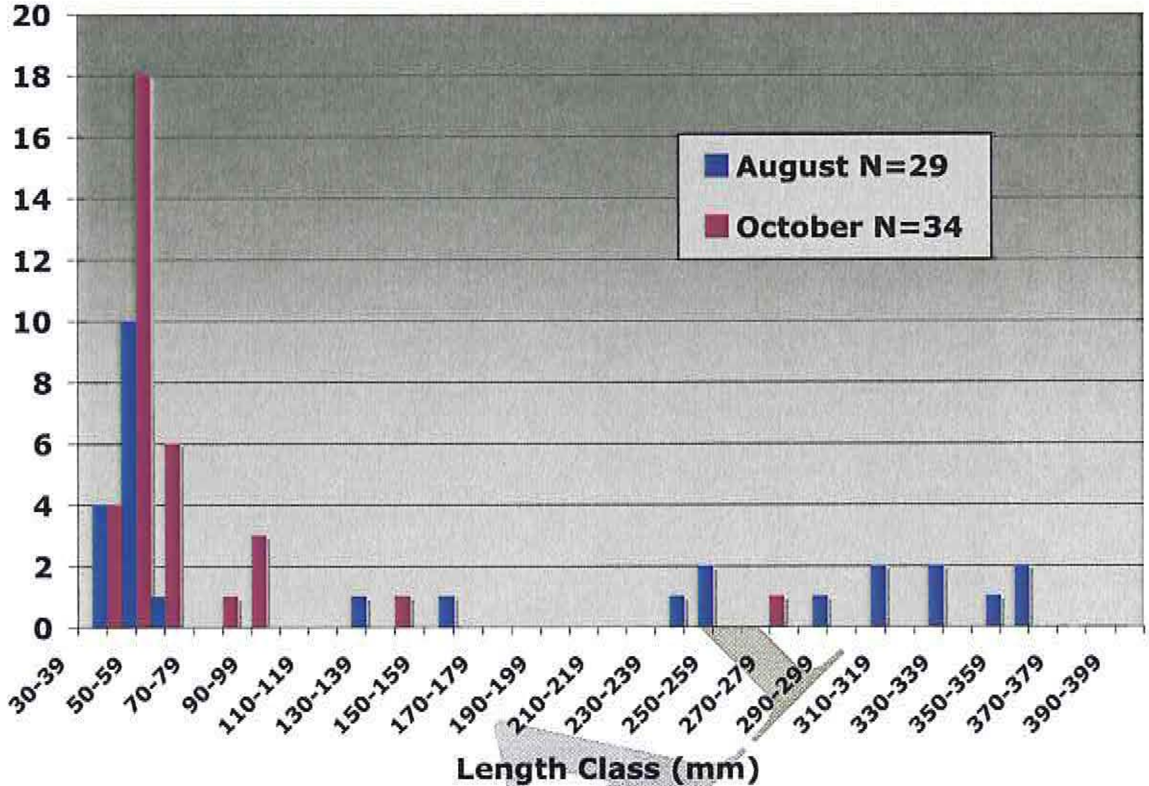


Figure 4 Comparison between August and October of capture sizes of Arctic grayling at the Rose Creek study sites during 2009.

Figure 5 Connected ponds associated with the south channel in reach NF1 of the North Fork of Rose Creek, August 2009.

Figure 6 North channel in reach NF1 associated with the North Fork of Rose Creek downstream of the Faro Mine Access Road, October 2009.

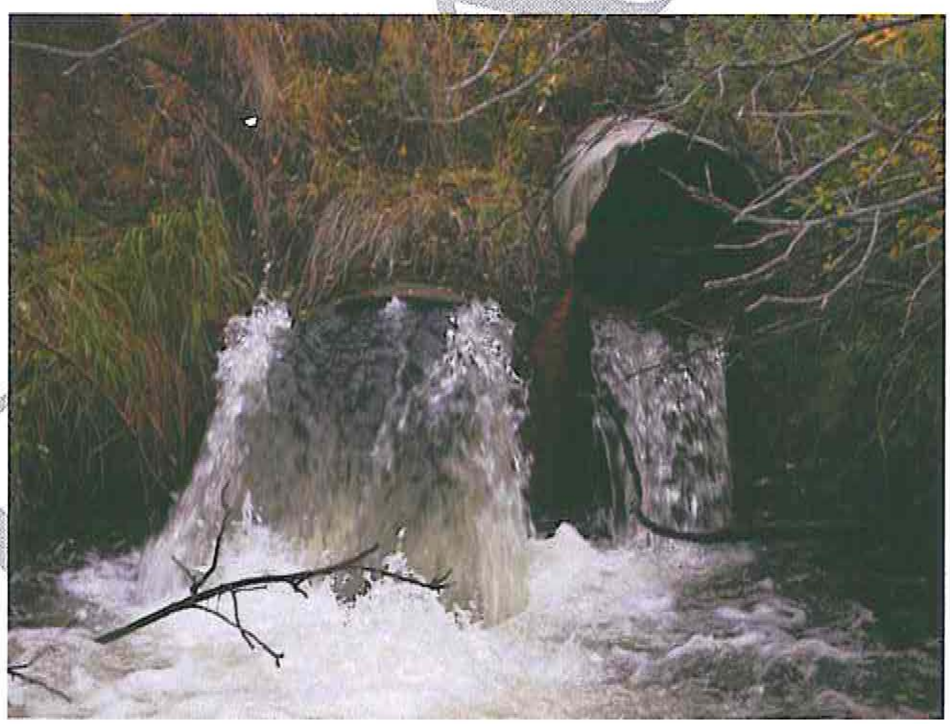


Figure 7 Culverts located upstream of the constructed ponds in reach NF1 of the North Fork of Rose Creek, August 2009.

Figure 8 Culvert located at the Access Road crossing of the South Fork of Rose Creek, August 2009.

Figure 9 Culverts located at the Haul Road crossing of the South Fork of Rose Creek, October 2009.

Table 1 Metrics derived from analysis of the diatom component of collected periphyton samples from the Rose Creek study sites during August 2009.

Parameter	RD1	RD2	RD3	RD4	RD5	NF1-1	NF1-2	NF2-1	NF2-2	NF3-1	NF3-2	NF3-3
Number of Discs	5	5	5	5	5	5	4	3	4	5	5	5
Total Number of Taxa Present	48	48	51	52	52	45	45	47	45	41	35	33
Shannon Weiner Diversity	0.57	0.39	0.71	0.69	0.66	0.61	0.49	0.58	0.65	0.52	0.63	0.67
Density (diatoms/cm^2)	2,036	1,364	2,642	2,211	4,002	1,450	6,043	5,439	2,639	485	258	35
% of Dominant Taxa	51.4	77.4	52.5	50.9	52.8	49.2	53.6	40.5	29.8	54.0	32.7	24.0
% of 2 Dominant Taxa	62.1	83.0	64.0	62.3	62.5	66.3	79.4	69.7	57.7	66.6	64.3	47.3

Table 2 Metrics derived from analysis of collected benthic samples at the Rose Creek study sites during August, 2009. All sites were treated as test sites for comparison to reference sites in the Yukon CABIN database.

Parameter	Reference Sites Mean	RD1	RD2	RD3	RD4	RD5	NF1-1	NF1-2	NF2-1	NF2-2	NF3-1	NF3-2	NF3-3
Total Number of Taxa Present	11.4	14	12	15	12	17	9	10	16	12	19	15	18
Shannon Weiner Diversity	1.44	0.86	0.66	1.23	1.11	1.56	0.43	0.42	0.79	0.43	1.94	1.56	2.18
EPT Taxa (number)	5.4	8	7	7	6	8	2	4	9	5	12	10	12
% of Dominant Taxa	52.1	81.3	86.7	68.2	69.0	59.7	90.0	92.5	84.4	92.7	39.7	55.1	26.1
% of 2 Dominant Taxa	70.9	87.4	91.7	80.5	83.1	69.1	97.6	94.6	89.1	94.2	61.0	70.7	49.2

Table 3 Comparison of total fish catches at Rose Creek study sites during August and October 2009.

SPECIES	SAMPLE PERIOD	SAMPLING LOCATION											
		RD1	RD2	RD3	RD4	RD5	NF1-1	NF1-2	NF2-1	NF2-2	NF3-1	NF3-2	NF3-3
Arctic grayling	August	5	2	1	0	1	8	4	3	4	1	0	0
	October	-	0	0	-	0	20	0	5	5	1	0	2
Burbot	August	0	0	1	1	0	0	0	0	0	0	0	0
	October	-	0	0	-	0	0	0	0	0	0	0	0
Slimy sculpin	August	0	1	33	52	51	11	38	2	21	26	20	19
	October	-	4	34	-	40	15	24	4	24	14	21	23

Table 4 Comparison of calculated areas and proportions of various aquatic habitat types derived for three study reaches associated with the North Fork of Rose Creek.

Parameter	Reach	Glide or Run	Pool	Rapid	Riffle	Side Channel	Open Water Pond	Total
Estimated Area (m^2)	NF1	1,442	1,029	2,337	986	685	7,486	13,965
	NF2	948	842	4,108	1,118	75	0	7,091
	NF3	4,971	4,169	9,225	7,132	194	5,809	31,500
	Combined	7,361	6,040	15,670	9,236	954	13,295	52,556
Proportion (%)	Combined	14.0	11.5	29.8	17.6	1.8	25.3	100

Table 5 Aquatic habitat characteristics determined at 7 study sites in the North Fork of Rose Creek during August 2009.

	Parameter	NF1-1	NF1-2	NF2-1	NF2-2	NF3-1	NF3-2	NF3-3
Site	Survey Date	Aug. 27, 2009	Aug. 28, 2009	Aug. 25, 2009	Aug. 26, 2009	Aug. 26, 2009	Aug. 27, 2009	Aug. 27, 2009
	Site Elevation (m)	1,054	1,070	1,077	1,085	1,099	1,110	1,120
	Site Survey Length (m)	80	50	60	70	100	70	60
Channel	Ave. Channel Width (m)	7.8	9.0	9.4	7.1	12.6	7.1	11.3
	Ave. Wetted Width (m)	6.1	7.4	6.9	6.0	10.4	5.7	6.7
	Ave. Bankfull Channel Depth (m)	1.0	1.6	0.9	1.4	0.9	1.4	1.3
	Ave. Residual Pool Depth (m)	0.3	0.7	0.4	0.6	0.3	0.6	0.8
	Stage	moderate	moderate	moderate	moderate	moderate	moderate	moderate
	Gradient (%)	0.3	0.4	2.4	0.7	0.9	0.7	0.4

	Parameter	NF1-1	NF1-2	NF2-1	NF2-2	NF3-1	NF3-2	NF3-3
Cover	Cover Abundance (%)	trace (<5)	moderate (5-20)	moderate (5-20)	moderate (5-20)	moderate (5-20)	abundant (>20)	moderate (5-20)
	Dominant Cover Type	boulders	deep pools	boulders	deep pools	boulders	undercut banks	deep pools
	Subdominant Cover Type	deep pools	boulders	deep pools, o/h vegetation	boulders, undercut banks	undercut banks	deep pools, boulders, large	undercut banks
	Other Cover Types Present	undercut banks and o/h	undercut banks, instream and	undercut banks, small woody	small and large woody debris,	small / large woody debris,	instream vegetation and	small and large woody debris,
	LWD Frequency	none	none	none	few	few	few	few
	Crown Closure (%)	0	0	0	0	0	0	0
	Left Bank Shape	sloping (<45°)	vertical (>45°)	sloping (<45°)	vertical (>45°)	sloping (<45°)	vertical (>45°)	sloping (<45°)
	Texture	cobble	boulder	boulder	fines	cobble	fines	cobble
	Riparian Vegetation	shrubs	shrubs	shrubs	shrubs	shrubs	shrubs	shrubs
	Riparian Stage	shrub/herb	initial	mature forest	mature forest	shrub/herb	mature forest	mature forest
	Right Bank Shape	vertical (>45°)	vertical (>45°)	vertical (>45°)	sloping (<45°)	vertical (>45°)	vertical (>45°)	vertical (>45°)
	Texture	cobble	cobble	boulder	fines	cobble	fines	fines
	Riparian Vegetation	shrubs	shrubs	shrubs	shrubs	shrubs	shrubs	shrubs
	Riparian Stage	initial	young forest	mature forest	mature forest	mature forest	mature forest	mature forest
	Instream Vegetation	none	moss	algae and moss	algae and moss	algae and moss	moss	none

	Parameter	NF1-1	NF1-2	NF2-1	NF2-2	NF3-1	NF3-2	NF3-3
Morphology	Dominant Bed Material	gravel	cobble	boulder	gravel	cobble	cobble	cobble
	Subdominant Bed Material	cobble	boulder	cobble	boulder	boulder	gravel	gravel
	D95 (cm)	60	50	44	80	60	33	20
	D (cm)	12	13	8	10	8	11	12
	Morphology	riffle-pool	riffle-pool	cascade-pool	riffle-pool	riffle-pool	riffle-pool	riffle-pool
	Pattern	irregular meanders	irregular meanders	sinuous	sinuous	sinuous	sinuous	sinuous
	Islands	occasional	none	none	occasional	occasional	none	none
	Bars	side	mid channel	none	side	none	side	side
	Confinement	confined	confined	confined	frequently confined	occasionally confined	frequently confined	frequently confined

Table 6 Aquatic habitat characteristics determined at 5 study sites in the Rose Creek Diversion Channel during August 2009.

	Parameter	RD1	RD2	RD3	RD4	RD5
Site	Survey Date	Aug. 30, 2009	Aug. 30, 2009	Aug. 29, 2009	Aug. 29, 2009	Aug. 28, 2009
	Site Elevation (m)	1,027	1,030	1,031	1,036	1,047
	Site Survey Length (m)	100	100	100	100	100
Channel	Ave. Channel Width (m)	16.5	16.0	28.4	13.8	18.1
	Ave. Wetted Width (m)	14.7	14.2	13.7	12.8	14.6
	Ave. Bankfull Channel Depth (m)	1.5	1.4	> 1.5	> 1.5	> 1.5
	Ave. Residual Pool Depth (m)	0.8	0.7	>1.0	>1.0	-
	Stage	moderate	moderate	moderate	moderate	moderate
	Gradient (%)	5.5	5.0	0.2	0.2	0.1
Cover	Cover Abundance (%)	abundant (>20)	abundant (>20)	moderate (5-20)	moderate (5-20)	trace (<5)
	Dominant Cover Type	boulders	boulders	boulders	boulders	boulders
	Subdominant Cover Type	deep pools	deep pools	deep pools	instream vegetation	instream vegetation
	Other Cover Types Present	small woody debris and overhanging vegetation	overhanging and instream vegetation	instream vegetation	small woody debris	overhanging vegetation and large woody debris
	LWD Frequency	none	none	none	none	few
	% Crown Closure	0	0	0	0	0

	Parameter	RD1	RD2	RD3	RD4	RD5
Cover	Left Bank Shape	vertical (>45°)	vertical (>45°)	sloping (<45°)	vertical (>45°)	sloping (<45°)
	Texture	rock	rock	boulders	rock	variable
	Riparian Vegetation	shrubs	shrubs	shrubs	shrubs	shrubs
	Riparian Stage	shrub/herb	shrub/herb	initial	initial	initial
	Right Bank Shape	vertical (>45°)	vertical (>45°)	sloping (<45°)	sloping (<45°)	sloping (<45°)
	Texture	rock	rock	boulders	boulders	variable
	Riparian Vegetation	shrubs	shrubs	shrubs	shrubs	shrubs
	Riparian Stage	shrub/herb	shrub/herb	initial	initial	pole-sapling
	Instream Vegetation	none	mosses	mosses	mosses	mosses
Morphology	Dominant Bed Material	large pieces of bedrock	large pieces of bedrock	angular boulders	boulder	gravel
	Subdominant Bed Material	boulder	boulder	cobble	cobble	cobble
	D95 (cm)	117	110	68	62	75
	D (cm)	17	17	9.4	5.5	4.5
	Morphology	cascade-pool	cascade-pool	riffle-pool	riffle-pool (few)	extended riffle
	Pattern	straight	straight	straight	straight	straight
	Islands	none	none	none	none	none
	Bars	none	none	none	none	none
	Confinement	entrenched	entrenched	entrenched	entrenched	entrenched

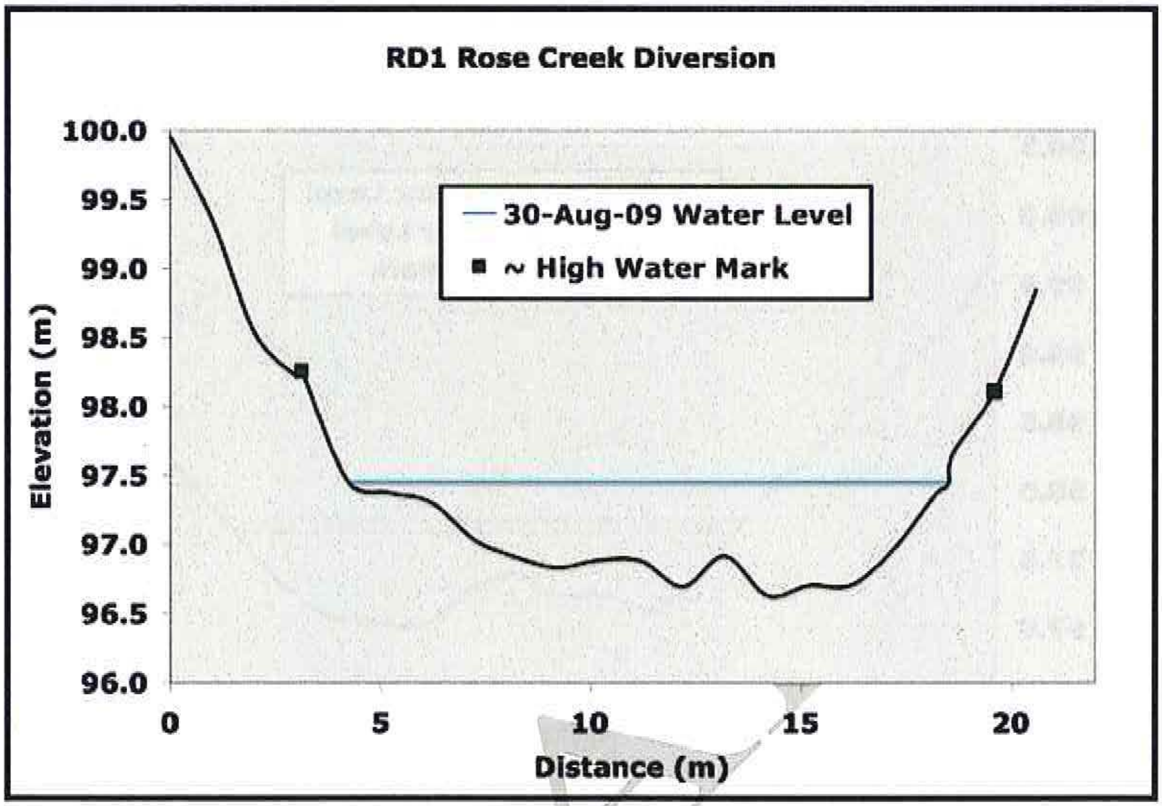
Table 7 Results from culvert assessments associated with various road crossings of Rose Creek tributary streams at the Faro Mine Complex, 2009.

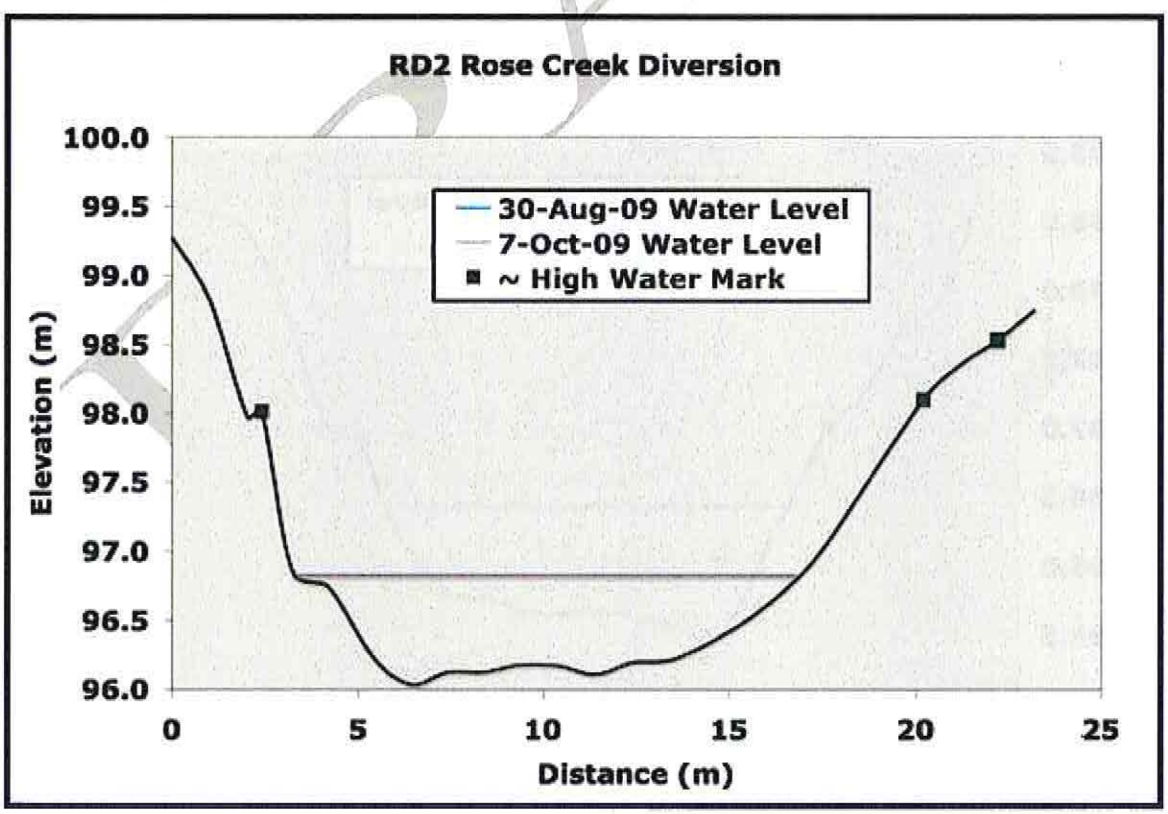
Parameter	Culvert(s) Location			
	Rose Creek North Fork Tributary u/s Constructed Ponds	Rose Creek North Tributary Access Road Crossing	Rose Creek South Tributary Access Road Crossing	Rose Creek South Tributary Haul Road Crossing
Survey Date	Aug. 31, 2009	Aug. 31, 2009	Aug. 31, 2009	Oct. 8, 2010
# of Culverts	2	1	1	2
Culvert(s) Length (m)	15.1	24.6	24.3	150 to 200
Culvert(s) Diameter	1 = 0.5 2 = 1.0	3.8	2.5	2
Construction	1 = round spiral 2 = cast iron	round multiplate	round multiplate	round spiral
Outlet Drop (m)	1 = 0.9 2 = 0.5*	0	1.25	2
Slope (%)	1 = 3.9 2 = 1.7	1.8	3.8	n/a
Velocity (m/s)	n/a	1.73	2.6	n/a
Downstream Pool Depth (m)	1.4	~2.0	1.5	1.0
Stream Length Upstream (km)	72.2	72.0	12.7	12.2
Determination	Complete barrier to upstream movement of fish	Partial barrier to upstream movement of fish	Complete barrier to upstream movement of fish	Complete barrier to upstream movement of fish

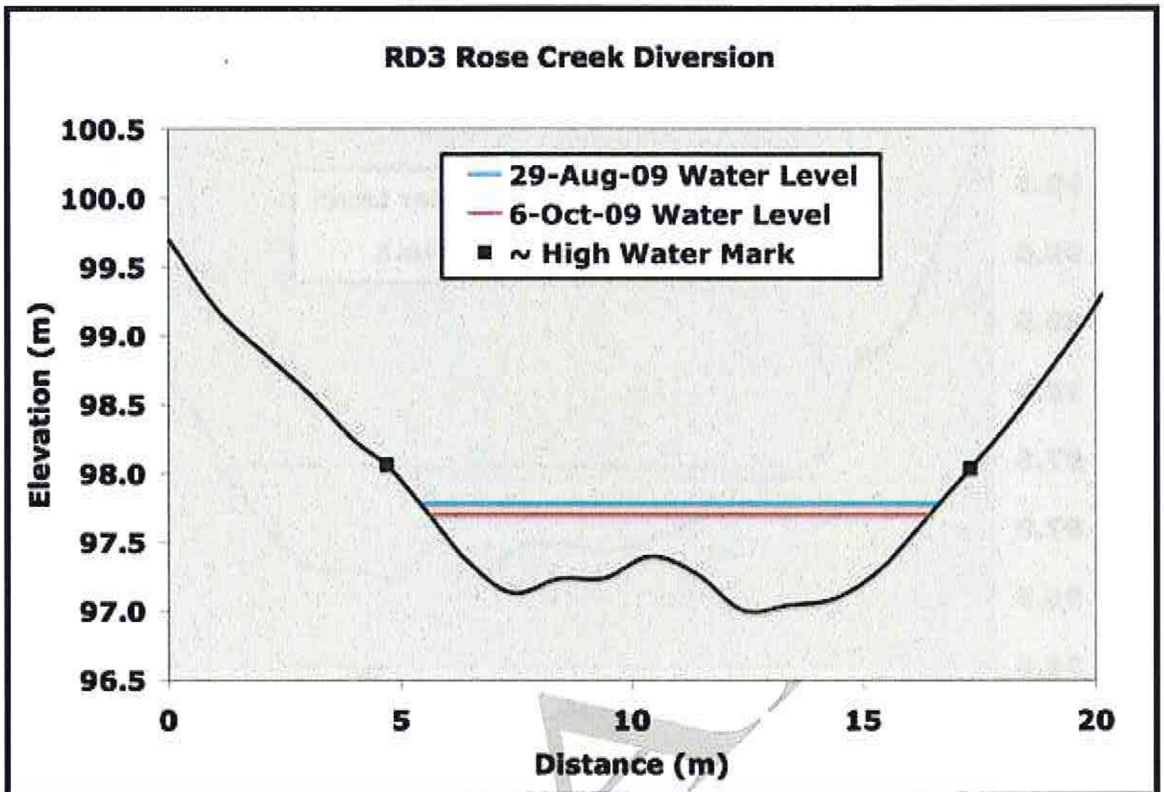
* Outlet drop measured from top of steel plate that was wielded to the downstream end of the cast iron culvert.

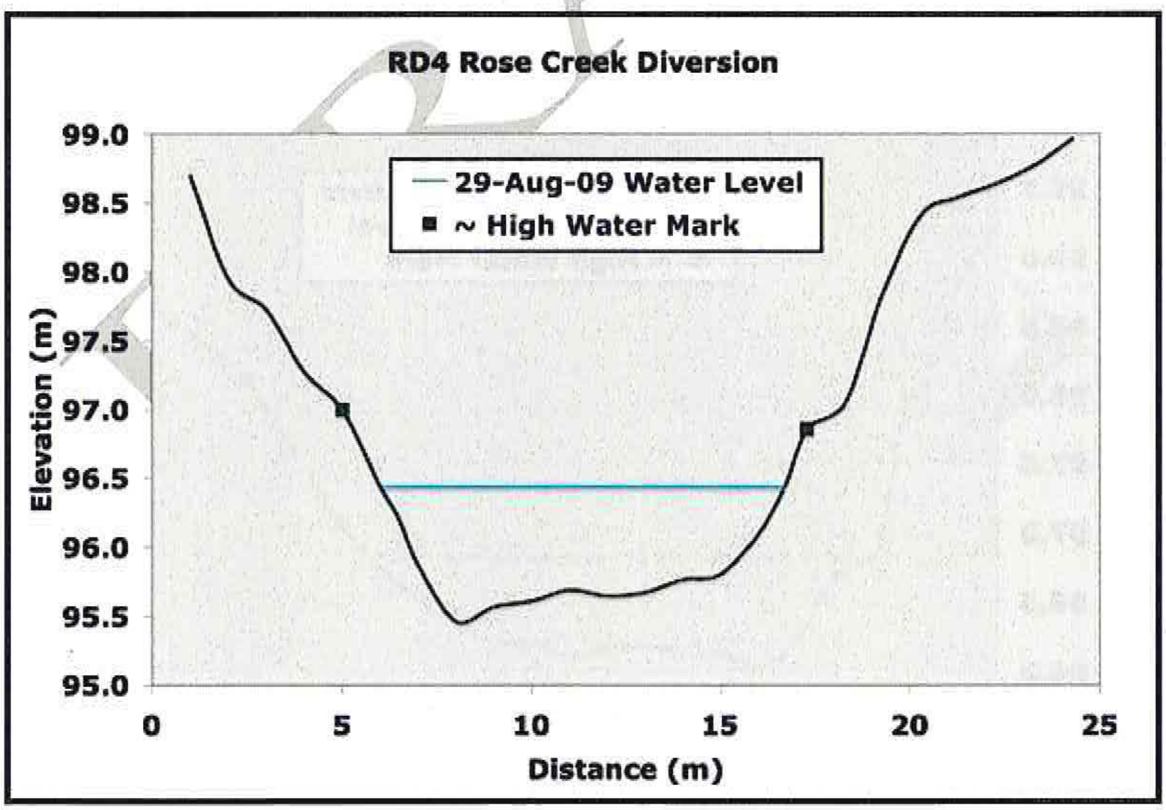
APPENDIX I

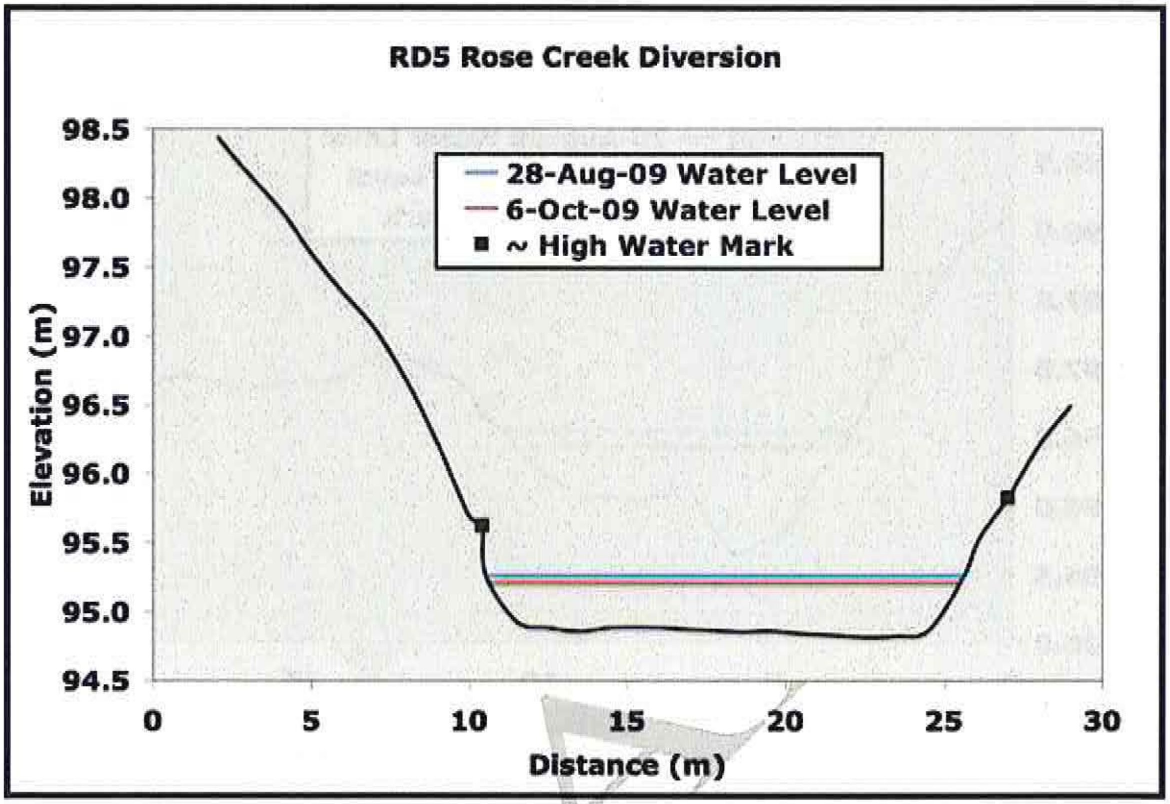
SITE CHANNEL CROSS SECTIONS

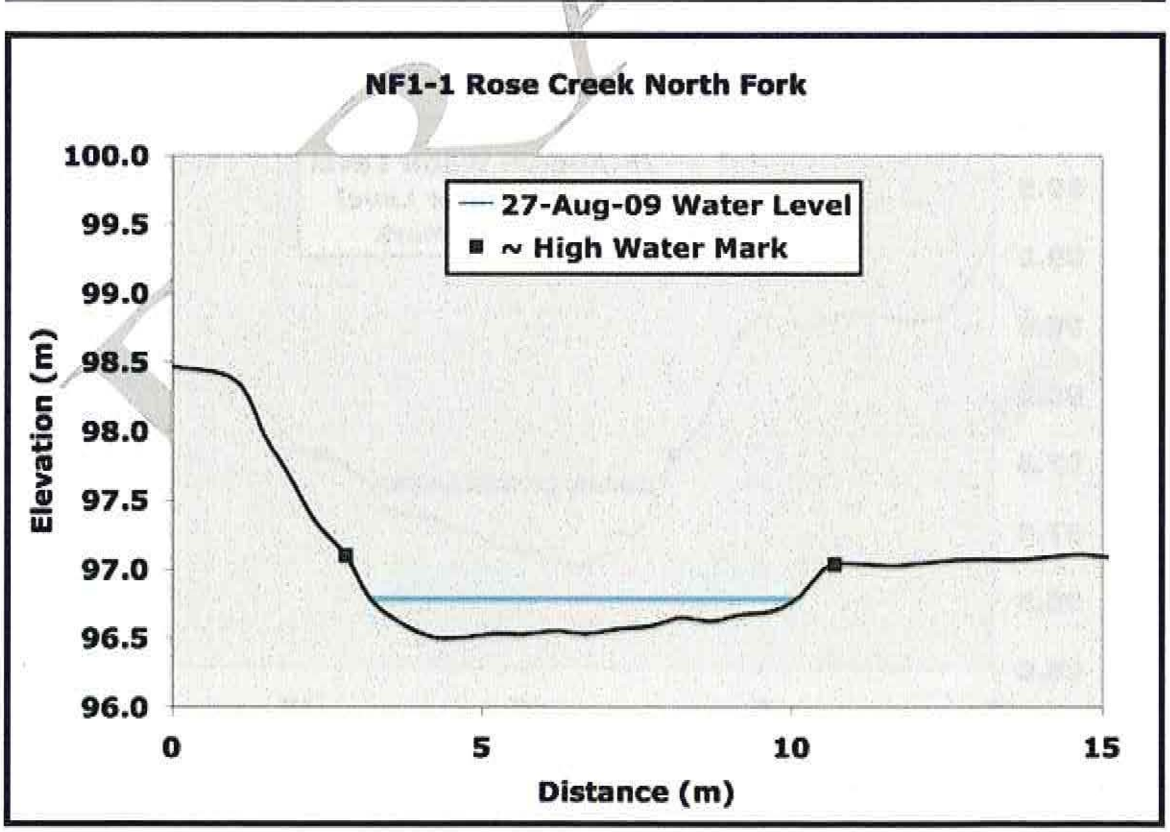

RD1 Rose Creek Diversion
30-Aug-09 Water Level
~ High Water Mark
Elevation (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
0
5
10
15
20
Distance (m)

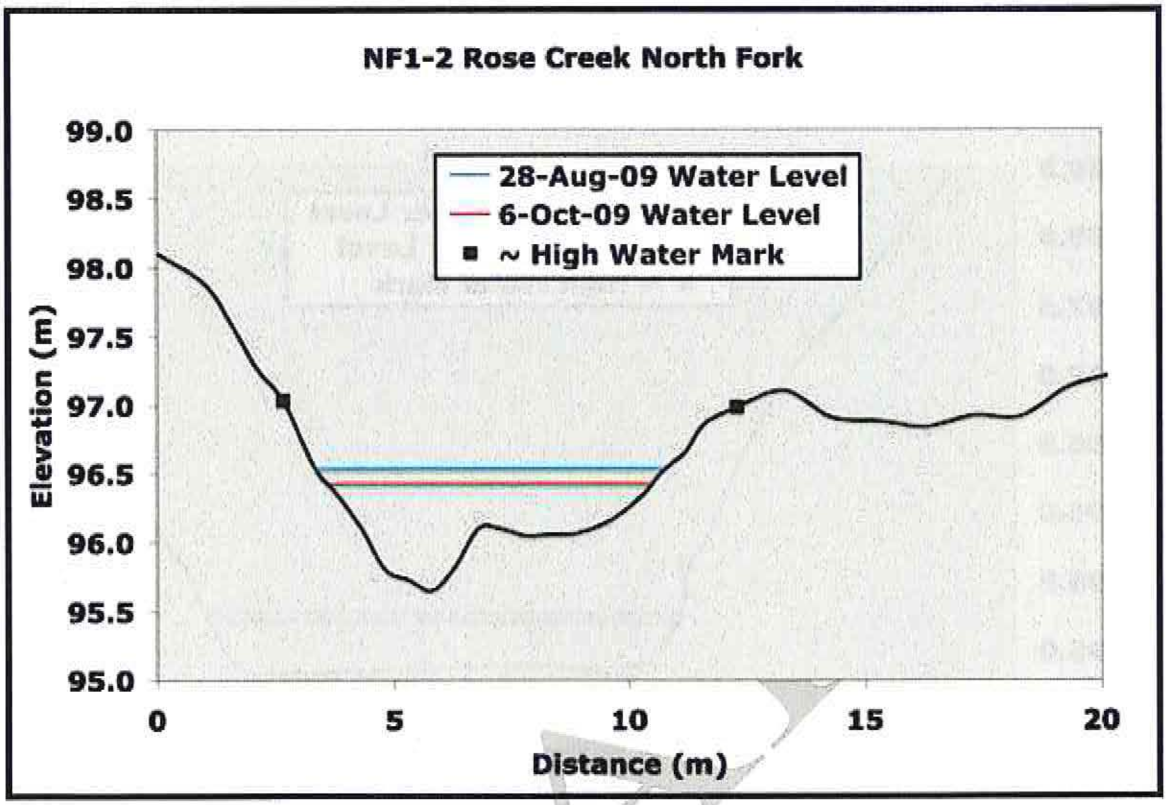

RD2 Rose Creek Diversion
30-Aug-09 Water Level
7-Oct-09 Water Level
~ High Water Mark
Elevation (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
0
5
10
15
20
25
Distance (m)

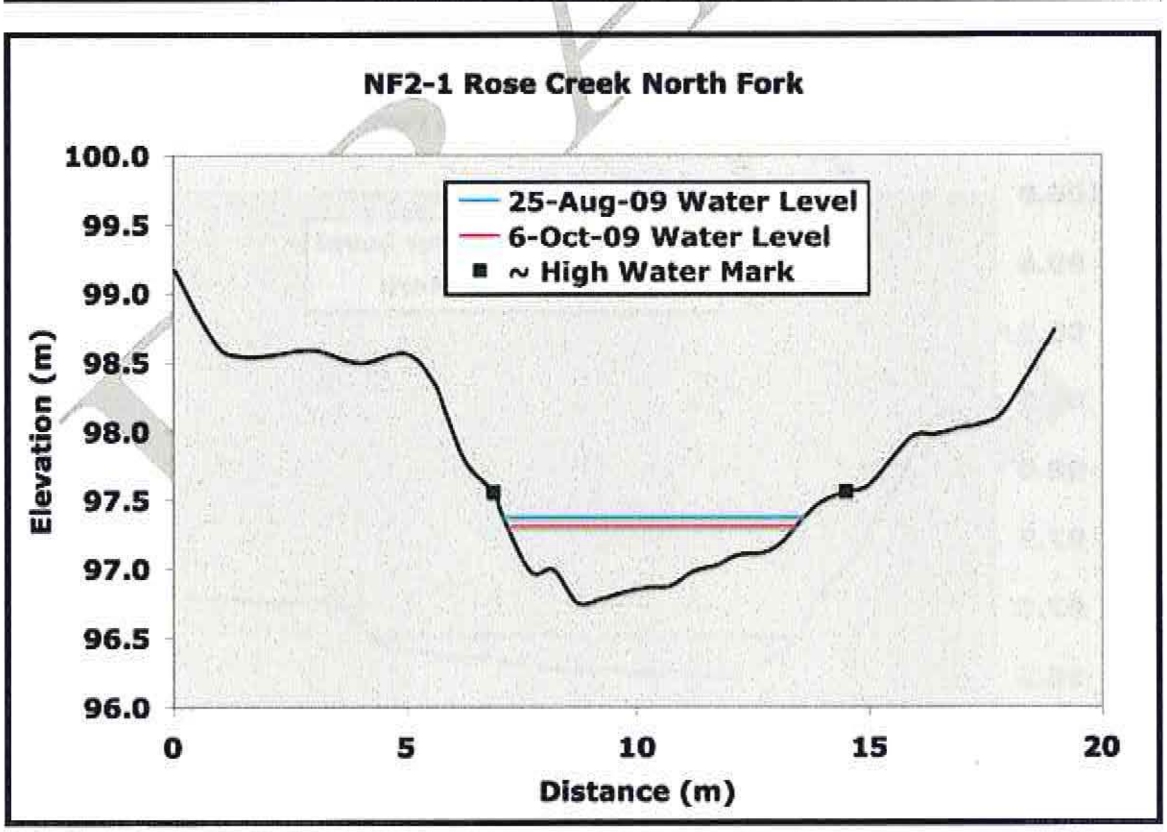

RD3 Rose Creek Diversion
29-Aug-09 Water Level
6-Oct-09 Water Level
~ High Water Mark
Elevation (m)
100.5
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
0
5
10
15
20
Distance (m)

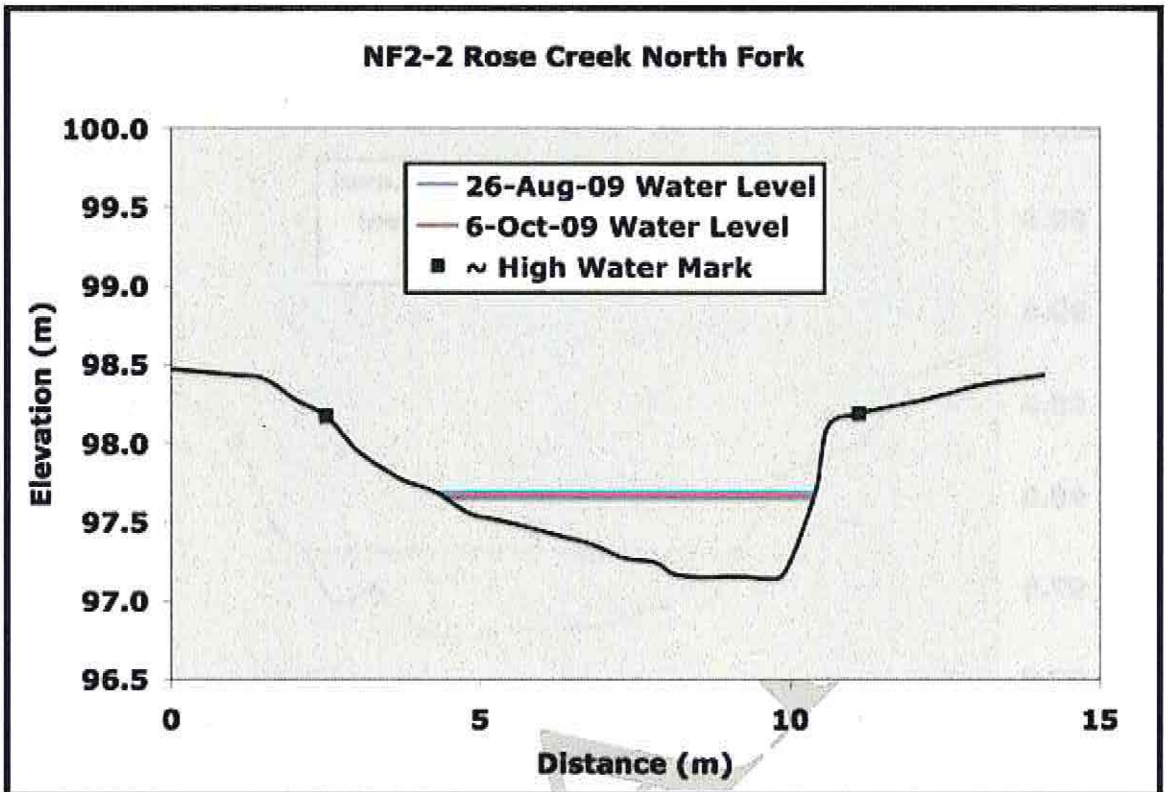

RD4 Rose Creek Diversion
29-Aug-09 Water Level
~ High Water Mark
Elevation (m)
99.0
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
0
5
10
15
20
25
Distance (m)

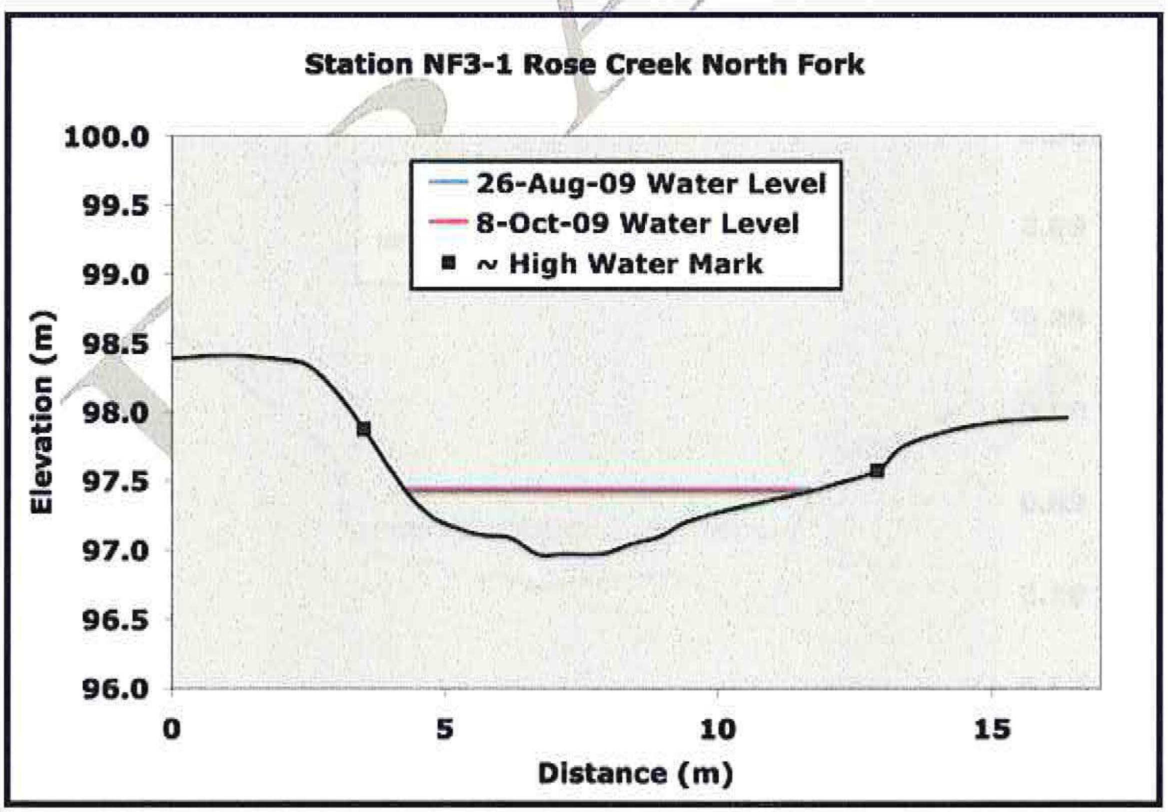

RD5 Rose Creek Diversion
28-Aug-09 Water Level
6-Oct-09 Water Level
~ High Water Mark
Elevation (m)
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
94.5
0
5
10
15
20
25
30
Distance (m)

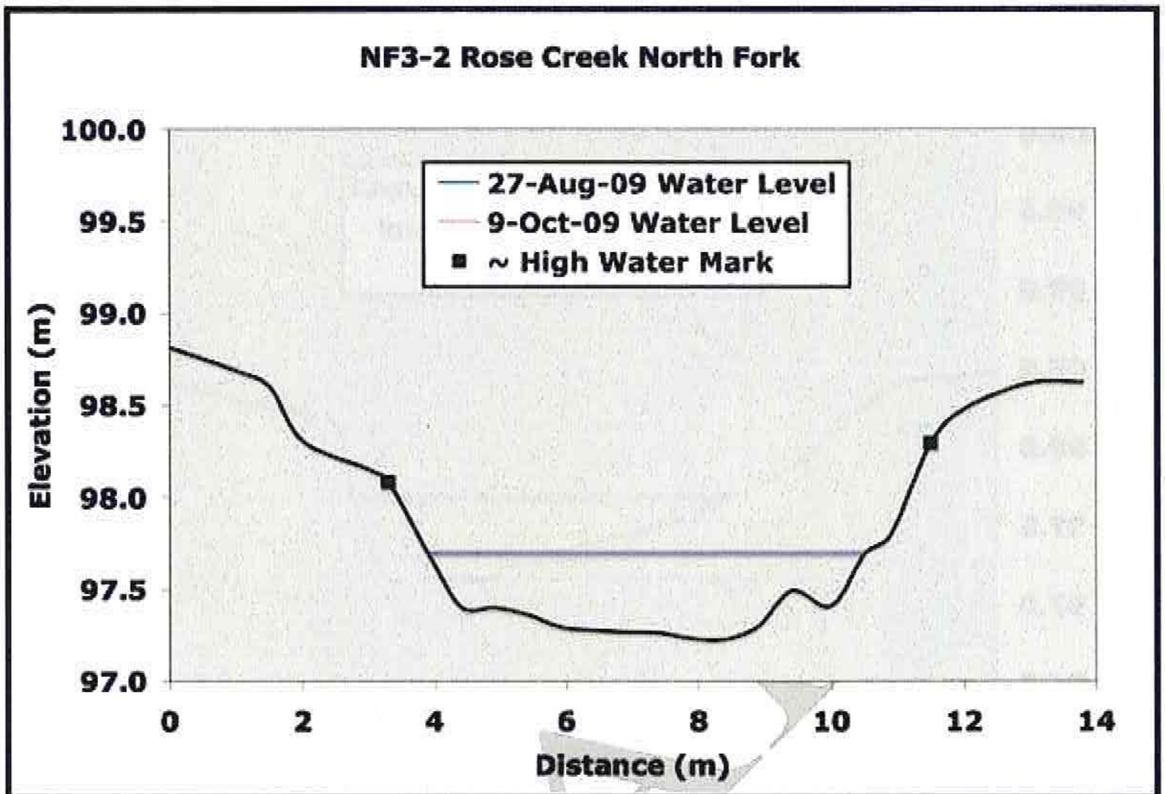

NF1-1 Rose Creek North Fork
27-Aug-09 Water Level
~ High Water Mark
Elevation (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
0
5
10
15
Distance (m)


NF1-2 Rose Creek North Fork
28-Aug-09 Water Level
6-Oct-09 Water Level
~ High Water Mark
Elevation (m)
99.0
98.5
98.0
97.5
97.0
96.5
96.0
95.5
95.0
0
5
10
15
20
Distance (m)

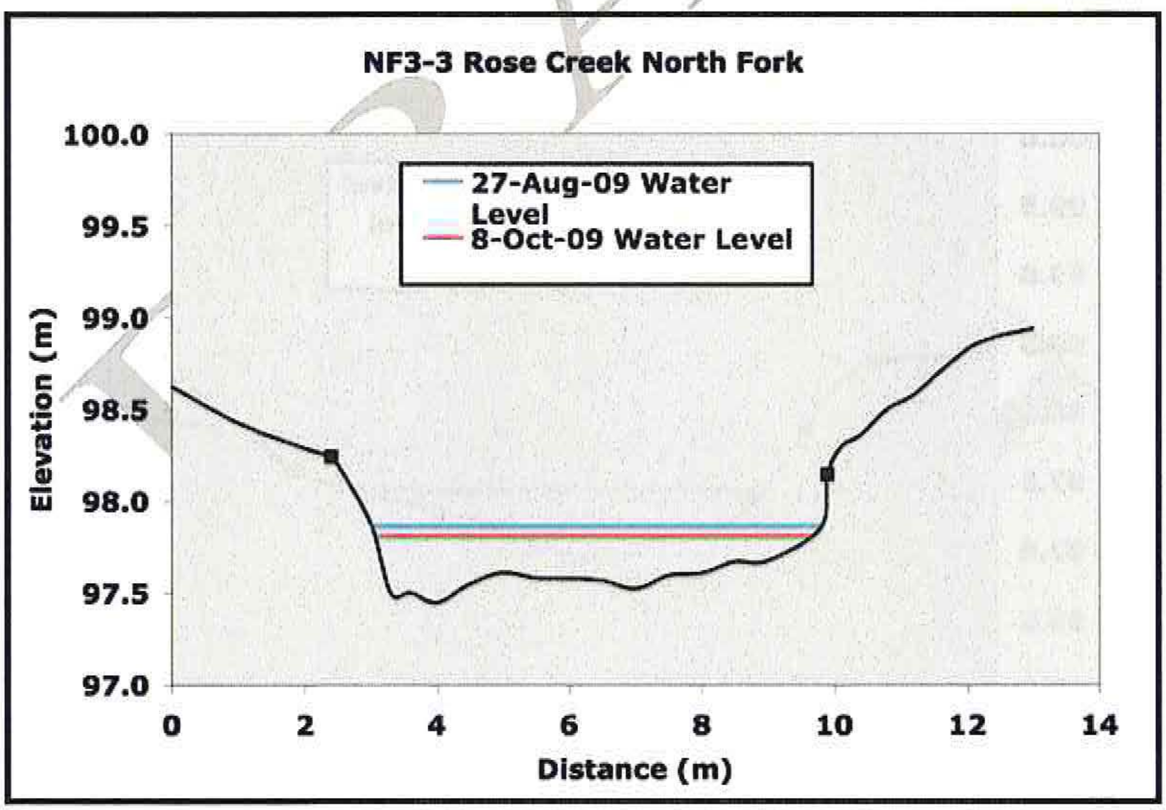

NF2-1 Rose Creek North Fork
25-Aug-09 Water Level
6-Oct-09 Water Level
~ High Water Mark
Elevation (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
0
5
10
15
20
Distance (m)


NF2-2 Rose Creek North Fork
26-Aug-09 Water Level
6-Oct-09 Water Level
~ High Water Mark
Elevation (m)
Distance (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
0
5
10
15


Station NF3-1 Rose Creek North Fork
26-Aug-09 Water Level
8-Oct-09 Water Level
~ High Water Mark
Elevation (m)
Distance (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.5
96.0
0
5
10
15



NF3-2 Rose Creek North Fork
27-Aug-09 Water Level
9-Oct-09 Water Level
~ High Water Mark
Elevation (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
0
2
4
6
8
10
12
14
Distance (m)



NF3-3 Rose Creek North Fork
27-Aug-09 Water Level
8-Oct-09 Water Level
Elevation (m)
100.0
99.5
99.0
98.5
98.0
97.5
97.0
0
2
4
6
8
10
12
14
Distance (m)

APPENDIX II

PERIPHYTON RESULTS

Prepared by Fraser Environmental Services

Prepared for Can-nic-a-nick Environmental

Periphyton Taxa and Abundance for Faro Mine Complex, Yukon

Inv. # 807

RD = Rose Creek Diversion

NF = Rose Creek North Fork Reach

units = cells/cm²

FES Sample Number			090505	090506	090507	090508	090509	090510	090511	090512	090513	090514	090515	090516
Label Number			RD1	RD2	RD3	RD 4	RD5	NF1-1	NF1-2	NF2-1	NF2-2	NF3-1	NF3-2	NF3-3
Sampling Date			Aug30/09	Aug30/09	Aug29/09	Aug29/09	Aug28/09	Aug27/09	Aug29/09	Aug25/09	Aug25/09	Aug26/09	Aug27/09	Aug27/09
Area Sampled (cm²)			400.5	400.5	400.5	400.5	400.5	400.5	320.4	240.3	320.4	400.5	400.5	400.5
# discs			5	5	5	5	5	5	4	3	4	5	5	5
Phylum	Order	Genera and Species												
Bacillariophyceae	Centrales	*Cyclotella sp.*				<60.0	<90.8	<39.7						
		Melosira spp.	588.0	268.8	1,596.4	360.0	1,271.2	555.8	1,818.0	2,262.4	1,680.0	166.2		<7.1
	Pennales	*Achnanthes flexella*	7,604.0	1,737.5	40,315.0	23,293.4	21,658.4	158.8	<101.0	141.4	<56.0	<13.9	<8.8	7.1
		Achnanthes lanceolata	1,140.6	347.5		465.6	1,407.0	615.2	202.0	1,095.8	434.4	27.7	52.8	14.2
		Achnanthes leavis	2,661.4	2,085.0	12,827.5	8,959.0	21,658.4	9,469.6	4,700.4	7,670.6	868.4		68.4	<7.1
		Achnanthes linearis	11,704.0	16,048.8	10,995.0	2,328.0	24,365.7	8,285.9	2,350.2	5,479.0	434.4	3,310.4	136.8	<7.1
		Achnanthes minutissima	392,084.0	393,195.6	469,120.0	401,363.2	768,873.2	262,781.4	1,024,998.0	354,202.8	230,708.4	96,001.6	31,034.0	494.1
		Achnanthes spp.	4,389.0	9,361.8	21,990.0	14,334.4	8,121.9	4,734.8	6,029.4	12,650.1	3,343.6	5,379.4	1,315.0	54.9
		Amphipleura pellucida	490.0	537.6	8,571.6	3,724.8	2,814.0	238.2	202.0	141.4	224.0	27.7	17.6	
		Amphora spp.	<49.0	<44.8	61.4	240.0	726.4	39.7	101.0	<141.4	<56.0		<8.8	
		Anomoeoneis spp.	1,901.0	1,390.0	95,290.0	89,590.0	37,902.2		<101.0					<7.1
		Caloneis spp.	2,281.2	448.0	9,524.0	480.0	3,517.5	317.6	202.0	282.8	224.0	138.5	<8.8	<7.1
		Ceratoneis arcus	7,315.0	695.0	2,857.2	931.2	3,517.5	2,153.2	10,184.2	6,574.8	16,718.0	1,505.0	6,575.0	3,380.8
		Cocconies placentula	490.0	44.8	368.4	360.0	726.4	1,538.0	6,267.2	7,670.6	2,172.0	537.5	342.0	71.0
		Cymatopleura elliptica				<60.0	90.8	<39.7		<141.4				
		Cymatopluera solea	<49.0		<61.4	60.0	<90.8	<39.7	<101.0	<141.4	<56.0			
		Cymbella cestaii	90.8	179.2	245.6	720.0	1,407.0							

Cymbella cistula	98.0	89.6	736.8	840.0	2,905.6	<39.7	<101.0	<141.4	<56.0		<8.8	
Cymbella lanceolata	<49.0	<44.8	<61.4	<60.0	<90.8	<39.7		<141.4			<8.8	
Cymbella mexicana		<44.8	<61.4	<60.0	<90.8							
Cymbella minuta	81,928.0	28,085.4	98,955.0	78,839.2	124,535.8	63,919.8	217,058.4	151,801.2	106,995.2	19,034.8	33,664.0	3,169.5
Cymbella sinuata	1,140.6	268.8	2,857.2	360.0	2,110.5	922.8	3,133.6	5,497.0	868.8	83.1	<8.8	109.8
Cymbella spp.	4,182.2	2,085.0	18,325.0	19,709.8	13,536.5	<39.7	<101.0	<141.4	168.0	110.8	17.6	
Denticula sp.	1,140.6	1,042.5	1,904.8	4,190.4	703.5							
Diatoma elongatum	58,520.0	16,048.8	29,320.0	35,836.0	75,804.4	158.8	3,917.0		868.8	27.7		<7.1
Diatoma hiemale					<90.8				<56.0	<13.9	<8.8	
Diatoma mesodon	196.0	<44.8	122.8	120.0	181.6	238.2	606.0	<141.4	<56.0	55.4	<8.8	<7.1
Diatoma sp.	49.0	<44.8	<61.4				<101.0					
Diatomella sp.					<90.8							
Didymosphenia geminata	294.0	179.2	245.6	600.0	544.8	158.8	1,010.0	565.6	358.4	193.9	2,464.0	<7.1
Diploneis spp.	196.0	89.6	368.4	480.0	1,089.6	<39.7	<101.0	<141.4	<56.0	<13.9		<7.1
Epithemia turgida	49.0	<44.8	<61.4	<60.0	90.8	79.4	101.0	<141.4	<56.0	27.8	<8.8	
Epithemia sp.						<39.7	<101.0					
Eunotia spp.	588.0	448.0	491.2	<60.0	908.0	158.8	808.0	<141.4	<56.0	55.4	<8.8	<7.1
Fragilaria capucina	147.0	<44.8	<61.4	1,680.0	2,179.2	79.4	303.0	1,131.2	784.0	387.8	140.8	35.5
Fragilaria construens	3,041.6	1,737.5	11,905.0	15,830.4	15,477.0	11,837.0	18,801.6	25,300.2	21,733.4	2,896.6	342.0	42.6
Fragilaria crotonensis			2,381.0	600.0	1,407.0							
Fragilaria leptostauron	392.0	695.0	2,381.0	480.0	908.0	158.8	202.0	282.8	336.0	83.1	17.6	
Fragilaria pinnata	1,520.8	3,822.5	11,905.0	12,571.2	9,145.5	2,153.2	3,133.6	5,479.0	2,172.0	1,655.2		
Fragilaria vaucheria	19,019.0	1,042.5	5,497.5	10,750.8	27,073.0	44,980.6	120,588.0	126,501.0	110,338.8	2,896.6	4,734.0	1,482.3
Fragilaria spp.	57,057.0	22,735.8	14,660.0	30,460.6	40,609.5	40,245.8	355,734.6	371,069.6	117,026.0	16,552.0	9,205.0	1,043.1
Frustulia sp.	49.0	<44.8	122.8	<60.0	181.6	79.4	1,818.0	1,696.8	224.0	97.3	<8.8	
Gomphonema acuminata	<49.0	<44.8	61.4									<7.1
Gomphonema angustatum/parvulum	1,140.6	347.5	4,285.8	465.6	3,517.5	2,460.8	16,451.4	4,383.2	3,909.6	537.5	205.2	219.6
Gomphonema brebissonii	588.0	358.4	368.4	240.0	90.8	238.2	606.0	282.8	224.0	138.5	35.2	<7.1
Gomphonema olivaceum	1,901.0	<44.8	476.2	<60.0	1,407.0	922.8	3,133.6	1,095.8	1,303.2	322.5	205.2	274.5
Gomphonema truncatum		<44.8										
Gomphonema spp.	1,520.8	8,024.4	3,333.4	1,862.4	3,517.5	1,538.0	6,267.2	3,287.4	868.8	752.5	273.6	329.4
Gyrosigma sp.			<61.4	<60.0	<90.8							
Meridion circulare	686.0	<44.8	736.8	600.0	2,110.5	1,230.4	2,350.2	2,262.4	1,737.6	304.7	52.8	21.3

		Navicula aurora		<44.8	<61.4	<60.0			<101.0	<141.4	<56.0	<13.9		
		Navicula cryptonella	3,041.6	347.5	1,904.8	3,259.2	21,658.4	3,998.8	4,700.4	4,382.8	11,702.6	1,182.5	342.0	42.6
		Navicula cuspidata			<61.4	<60.0				<141.4	<56.0			
		Navicula radiosa	490.0	268.8	1,719.2	1,440.0	7,990.4	1,349.8	5,656.0	2,828.0	5,600.0	415.5	334.4	7.1
		Navicula spp.	5,703.0	1,390.0	18,325.0	12,542.6	75,804.4	5,918.5	19,585.0	21,083.5	10,030.8	1,827.5	136.8	42.6
		Neidium spp.							<101.0	<141.4				
		Nitzschia acicularis						307.6		<141.4			<8.8	
		Nitzschia dissipata	1,463.0		952.4	2,328.0	5,414.6	7,102.2	5,483.8	4,383.2	6,687.2	1,655.2	478.8	164.7
		Nitzschia palea	760.4	695.0	10,995.0	8,959.0	16,243.8	8,285.9	9,400.8	8,766.4	10,030.8	2,482.8	136.8	109.8
		Nitzschia spp.	70,224.0	14,711.4	67,802.5	39,419.6	89,340.9	35,511.0	13,317.8	67,467.2	66,872.0	21,517.6	3,156.0	988.2
		Pinnularia spp.	588.0	179.2	368.4	240.0	2,110.5	238.2	606.0	848.4	224.0	55.4	<8.8	<7.1
		Rhoicosphenia curvata	<49.0					79.4	202.0	141.4	56.0	<13.9		
		Rhopalodia gibba	<49.0	<44.8	245.6	60.0	90.8					<13.9		
		Stauroneis sp.	<49.0	<44.8	<61.4	<60.0	<90.8	<39.7	<101.0	<141.4	<56.0	<13.9		<7.1
		Surirella spp.	49.0	89.6	184.2	240.0	363.2	39.7	101.0	<141.4	56.0	<13.9		
		Synedra ulna	14,630.0	7,645.0	23,822.5	16,126.2	35,194.9	7,960.0	21,102.9	37,950.3	30,092.4	4,138.0	4,997.0	494.1
		Synedra spp.	49,742.0	6,687.0	45,812.5	35,836.0	119,121.2	47,348.0	42,205.8	59,033.8	76,902.8	7,448.4	2,630.0	1,427.4
		Tabellaria fenestrata	98.0	358.4	61.4	360.0	726.4	<39.7	<101.0	<141.4	<56.0	<13.9		
		Tabellaria flocculosa	392.0	268.8	614.0	720.0	363.2	79.4	<101.0	<141.4	112.0	<13.9		<7.1
		UID girdle view												54.9
Chlorophyta	Chaetophorales	*Stigeoclonium sp.*					<90.8					249.3	1,504.8	227.2
		UID Chaetophorales							<101.0		<56.0		2,599.2	113.6
	Chlorococcales	*Ankistrodesmus spp.*	<49.0		1,428.6	4,190.4	1,407.0	1,538.0	783.4		1,303.2	430.0	615.6	164.7
		Selanastrum spp.				240.0		158.8	<101.0		112.0	55.4		<7.1
		Scenedesmus spp	<49.0	89.6	<61.4	300.0	1,089.6	<39.7						
		Tetraedron minimum						<39.7						
	Oedogoniales	*Oedogonium spp.*	441.0	224.0	245.6	480.0	363.2		<101.0			<13.9		
	Ulothricales	*Geminella sp.?*										<13.9		
		Microspora sp.			<61.4	1,440.0	908.0	1,349.8	35,253.0	70,131.2	16,128.0	<13.9	44.0	
		Ulothrix zonata					<90.8		<101.0		2,016.0	110.8	2,358.4	63.9
		Ulothrix spp.						<39.7			<56.0	166.2	668.8	<7.1
		Ulothrix sp. ?					<90.8							
	Zygnematales	*Closterium spp*	196.0	268.8	614.0	840.0	1,089.6	635.2	4,444.0	1,979.6	3,136.0	720.2	193.6	<7.1
		Cosmarium spp.	49.0	44.8	184.2	720.0	544.8	<39.7	<101.0	<141.4	<56.0	<13.9	<8.8	

		Euastrum sp.									<56.0			
		Hyalotheca sp.				<60.0						<13.9		
		Mougeotia spp.	98.0	358.4	4,762.0	8,846.4	4,221.0	39.7			<56.0	55.4	<8.8	<7.1
		Spirogyra sp									<56.0			
		Staurastrum spp.	98.0	44.8	122.8	120.0	<90.8	79.4	606.0	1,414.0	560.0	13.9	8.8	<7.1
		Teilingia granulata				<60.0	<90.8							
Chlorophyta		UID Chlorophyta colonial						238.2		<141.4	<56.0	<13.9	1,573.2	1,866.6
		UID Chlorophyta flagellate					703.5	615.2		1,095.8	434.4	83.1	52.8	7.1
		UID Chlorophyta unicellular	380.2	347.5		465.6	1,407.0	2,153.2	<101.0		868.8	430.0	615.6	219.6
Chrysophyta	Chromulinales	*Chrysococcus sp.*			122.8	465.6								<7.1
	Mischococcales	*Ophiocytium sp.*							<101.0					
	Ochromonadales	*Pseudokephyrion sp.*		<44.8		600.0	181.6							
		Hyalobryon sp.					90.8							
Chrysophyta		UID Chrysophyte colonial			491.2							860.0		84,027.5
		UID Chrysophyte cyst	7,315.0	1,390.0	2,381.0	4,190.4	3,517.5	4,306.4	5,483.8	7,670.6	3,475.2	322.5		<7.1
		UID Chrysophyte unicellular				120.0	703.5		202.0					
Cryptophyta	Cryptomonadales	UID Cryptomonadales				60.0	363.2	<39.7						
Cyanophyta	Chamaesiphonales	*Chamaesiphon spp.*	14,630.0	26,748.0	9,162.5	7,449.6		15,388.1	45,220.5	4,216.7	35,107.8	48,000.8	81,530.0	352,640.0
		Clastidium setigerum										413.8	13,676.0	31,682.5
	Chroococcales	*Aphanocapsa sp.*			<61.4	<60.0		<39.7						
		Aphanothece sp.		4,170.0		2,880.0		<39.7						
		Chroococcus sp. ?				<60.0	4,221.0							
		Gloeothece sp.				<60.0								
		Gomphosphaeria sp.				2,880.0	<90.8							
		Merismopedia sp.	<49.0	<44.8	<61.4	360.0	726.4				<56.0			
		Microcystis sp.		<44.8										
		UID Chroococcales		5,349.6	1,904.8	5,375.4							<8.8	
	Nostocales	*Anabaena / Nostoc sp.*									<56.0	<13.9		
		Calothrix / Rivularia sp.		<44.8	<61.4	1,080.0	2,179.2							<7.1
		Nostoc sp.			<61.4			<39.7				<13.9		

		Tolypothrix sp.		<44.8										
		UID Nostocales	<49.0		<61.4									<7.1
	Oscillatoriales	*Homoeothrix varians*		5,560.0		<60.0	11,256.0	21,839.6	49,354.2		38,661.6	147,312.8	911,032.0	1,997,375.0
		Lyngbya spp.										4,192.5		
		Oscillatoria spp.												2,196.0
		Phormidium sp.	13,307.0					5,844.4	2,828.0			29,379.8	9,028.8	7,576.2
		Pseudanabaena spp.		7,645.0	16,667.0	670,133.2	341,119.8	22,762.4		848.4	7,819.2	4,945.0	9,468.0	384.3
		UID Oscillatoriales	7,223.8	1,612.8	13,809.8	3,000.0	31,657.5	3,691.2	<101.0	1,696.8	10,860.0	12,414.0	9,205.0	2,031.3
Euglenophyta	Euglenales	UID Euglenales					<90.8							
Rhodophyta	Nemalionales	*Audouinella sp.*				<60.0	51,438.7	<39.7	28,202.4	4,524.8	13,552.0	858.7	23,144.0	1,098.0
		Batrachospermum sp.		<44.8	614.0	<60.0	544.8		808.0					
		Lemanea sp.	286,290.6	112,242.5	7,143.0	3,724.8	726.4	2,858.4	409,999.2	21,775.6	5,040.0	50,632.5	<8.8	<7.1
UID colonial				<44.8		480.0	<90.8		<101.0		<56.0			
UID filamentous						<60.0								
UID flagellate						465.6								
UID unicellular			380.2	1,337.4	3,665.0	12,542.6	10,829.2	4,734.8	12,058.8	16,866.8	6,687.2	827.6	1,315.0	633.9

UID = unidentified due to lack of size and / or missing morphological characters.

? = possibly for genus

APPENDIX III

BENTHIC RESULTS

		090764	090765	090766	090767	090768	090769	090770	090771	090772	090773	090774	090775
		Site 1	Site 2	Site 3	Site 4	Site 5	NF1-S1	NF1-S2	NF2-S1	NF2-S2	NF3-S1	NF3-S2	NF3-S3
	Subsample/100	19/100	46/100	31/100	25/100	11/100	6/100	2/100	11/100	6/100	37/100	8/100	15/100
	Stage												
Order : Ephemeroptera	juv												
Family : Ameletidae	nymph												
Ameletus sp.	nymph	1	2		1	1					3	2	9
Family : Baetidae	juv					11							
Acentrella sp.	nymph		1			2			3	2		5	16
Baetis sp.	nymph	13	1		1			2	2			1	10
Baetic bicaudatus	nymph										3		4
Family : Ephemerellidae	juv	1									24	8	12
Drunella doddsii	nymph			1						1	7	8	14
Drunella spinifera	nymph					1				1			
Ephemerella sp.	nymph				1	12		4		1			1
Family Heptageniidae	juv			1	4							6	20
Cinygmula sp.	nymph		1								8	7	3
Epeorus sp.	nymph								3				3
Family : Leptophlebiidae	juv												
Paraleptophlebia sp.	nymph			1									
Order : Plecoptera	larvae												
Family : Capniidae	juv	1		1		2	2		1	1	62	42	76
Family : Chloroperlidae	larvae												
Suwallia sp.	larvae										11	14	28
Sweltsa sp.	larvae	1	1	3	1	1			1				
Family : Nemouridae	juv												
Nemoura sp.	larvae						1				1	2	
Zapada oregonensis group	larvae	5	3	10	1	13	1	7	10	3	26	58	10
Zapada cinctipes	larvae			4	1	7			6	3			3
Family : Perlodidae	juv	5	3	3		2			1		2		
Family : Taeniopterygidae	larvae	1				3			2		3	3	14

Order : Trichoptera	larvae												
Family : Brachycentridae	juv												
Micrasema sp.	larvae							1					
Family : Glossosomatidae	larvae												
Glossosoma sp.	larvae									2		2	4
Family : Hydropsychidae	juv												1
Parapsyche sp.	larvae										1		1
Family : Rhyacophilidae	larvae												
Rhyacophila sp.	larvae		3						2		1	1	1
Family : Limniphilidae	juv												
Ecclissomyia sp.	larvae										2		2
Family : Lepidostomatidae	larvae												
Lepidostoma sp.	larvae								1				
Order : Coleoptera													
Family : Dytiscidae													
Oreodytes sp.	adult			1	2								
Oreodytes sp.	larvae				1								
Order : Diptera													
Family : Chironomidae	juv												
Subfamily : Orthocladiinae	larvae												
Cardiocladius sp.	larvae										3		
Cricotopus/Orthocladius sp.	larvae	98	87	61	47	67	147	81	57	225	51	89	33
Eukiefferiella sp.	larvae								37	55		20	
Tvetenia sp.	larvae								42	35		34	3
Subfamily : Chironiminae	larvae												
Stictiochironomus sp.	larvae												
Polypedilum sp.	larvae												
Pseudosmittia sp.	larvae						1						
Stempinella sp.	larvae	2		1			1						
Micropsectra sp.	larvae		31	22	73	26	178	210	79	29	4	51	9
Subfamily : Tanypodinae	larvae	6	32	39	67	15		1				2	

Subfamily : Diamesinae	larvae												
Diamesa sp.	larvae												32
Potthastia longimana	larvae		5	7	21	5							
Pagastia sp.	larvae	164	125	87	12	84	5	14	78	10	57	16	9
Pseudodiamesa sp.	larvae						1						
Family : Empididae	larvae												
Chelifera/Metachela sp.	larvae	3	4	9	3	2		1			2		
Family : Simuliidae	pupa	1											
Family : Simuliidae	juv												
Prosimulium sp.	larvae												5
Family : Dolichopodidae							1						
Family : Ceratopogonidae	larvae												
Bezzia/Palpomyia sp.	larvae			8	15	27	1	2	6	1			1
Family : Tipulidae	larvae												
Dicranota sp.	larvae			1			1	1	1	2	3		2
Limnophila sp.	larvae					1							
Tipula sp.	larvae					2							
Family : Psychodidae	larvae												
Pericoma sp.			1	1		2					1	4	
Order : Colembola sp.				1			2						
Class : Arachnoida	juv												
Family : Aturidae	adult												
Aturus sp.	adult									1			
Family : Feltriidae	adult												
Feltria sp.	adult								2	2		1	
Family : Sperchontidae	adult												
Sperchon sp.	adult	20	16	39	45	31	1	4	5	5	7	8	2
Family : Lebertiidae	adult												
Lebertia sp.	adult	7	7	18	23	9	1	3	4	3	4	1	1
Class : Crustacea													

Order : Ostracoda		3	4	3	2	8						
Order : Copepoda			3									
Class : Oligochaeta												
Family : Lumbriculidae					3							
Family : Naididae	3							4		4		
Subfamily : Naidinae						28						
Phylum : Nemata			2			1				3		1
Hydra sp.					1							

APPENDIX IV

CABIN ASSESSMENT REPORTS

Site Assessment Report

Site Metadata

Site	RO1
Sample Date	Aug 30 2009
Latitude	N 62° 21' 17"
Longitude	W 133° 27' 52"
Altitude	3069
Feature Name	Rose Creek
Stream Order	4

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	1.0
Bray Curtis Reference Median	381.05

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Unstressed
Vector 1 Vs Vector 3	Potentially Stressed
Vector 2 Vs Vector 3	Potentially Stressed
Overall	Potentially Stressed

Site Assessment Report

Site Metadata

Site	RO2
Sample Date	Aug 30 2009
Latitude	N 62° 21' 3"
Longitude	W 133° 27' 37"
Altitude	3079
Feature Name	Rose Creek
Stream Order	4

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	1.0
Bray Curtis Reference Median	361.05

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Potentially Stressed
Vector 1 Vs Vector 3	Unstressed
Vector 2 Vs Vector 3	Potentially Stressed
Overall	Potentially Stressed

Site Assessment Report

Site Metadata

Site	RO3
Sample Date	Aug 29 2009
Latitude	N 62° 20' 45"
Longitude	W 133° 26' 27"
Altitude	3383
Feature Name	Ross Creek
Stream Order	4

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	1.2
Bray Curtis Reference Median	361.05

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Potentially Stressed
Vector 1 Vs Vector 3	Unstressed
Vector 2 Vs Vector 3	Potentially Stressed
Overall	Potentially Stressed

Site Assessment Report

Site Metadata

Site	NF 1-1
Sample Date	Aug 27 2009
Latitude	N 62° 20' 11"
Longitude	W 130° 23' 29"
Altitude	3458
Feature Name	Rose Creek
Stream Order	3

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	0.94
Bray Curtis Reference Median	361.08

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Severely Stressed
Vector 1 Vs Vector 3	Severely Stressed
Vector 2 Vs Vector 3	Severely Stressed
Overall	Severely Stressed

Site Assessment Report

Site Metadata

Site	NF 1-2
Sample Date	Aug 28 2009
Latitude	N 62° 20' 11"
Longitude	W 133° 22' 41"
Altitude	3510
Feature Name	Rose Creek
Stream Order	3

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	0.99
Bray Curtis Reference Median	361.05

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Severely Stressed
Vector 1 Vs Vector 3	Severely Stressed
Vector 2 Vs Vector 3	Severely Stressed
Overall	Severely Stressed

Site Assessment Report

Site Metadata

Site	NF2-1
Sample Date	Aug 25 2009
Latitude	N 62° 20' 14"
Longitude	W 133° 22' 36"
Altitude	3533
Feature Name	Rose Creek
Stream Order	3

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	0.99
Bray Curtis Reference Median	381.05

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Unstressed
Vector 1 Vs Vector 3	Stressed
Vector 2 Vs Vector 3	Stressed
Overall	Stressed

Site Assessment Report

Site Metadata

Site	NF2-2
Sample Date	Aug 26 2009
Latitude	N 62° 20' 22"
Longitude	W 133° 22' 4"
Altitude	3569
Feature Name	Rose Creek
Stream Order	3

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	1.0
Bray Curtis Reference Median	381.05

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Severely Stressed
Vector 1 Vs Vector 3	Severely Stressed
Vector 2 Vs Vector 3	Severely Stressed
Overall	Severely Stressed

Site Assessment Report

Site Metadata

Site	NF3-1
Sample Date	Aug 26 2009
Latitude	N 62° 20' 37"
Longitude	W 132° 21' 23"
Altitude	3605
Feature Name	Rose Creek
Stream Order	3

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	1.0
Bray Curtis Reference Median	361.05

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Unstressed
Vector 1 Vs Vector 3	Unstressed
Vector 2 Vs Vector 3	Unstressed
Overall	Unstressed

Site Assessment Report

Site Metadata

Site	NF3-2
Sample Date	Aug 27 2008
Latitude	N 62° 20' 45.5'
Longitude	W 133° 20' 46"
Altitude	2642
Feature Name	Rose Creek
Stream Order	3

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	1.0
Bray Curtis Reference Median	361.08

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Stressed
Vector 1 Vs Vector 3	Unstressed
Vector 2 Vs Vector 3	Stressed
Overall	Stressed

Site Assessment Report

Site Metadata

Site	NF3-3
Sample Date	Aug 27 2009
Latitude	N 62° 21' 3"
Longitude	W 133° 20' 1"
Altitude	3675
Feature Name	Rose Creek
Stream Order	2

Site Photograph

Up Stream

Bray-Curtis Analysis

Description	Value
Bray-Curtis Distance	1.0
Bray Curtis Reference Median	381.08

Site Assessment Vector Data

Assessment For The Test Site

Vector 1 Vs Vector 2	Unstressed
Vector 1 Vs Vector 3	Unstressed
Vector 2 Vs Vector 3	Potentially Stressed
Overall	Potentially Stressed

APPENDIX V

FISH CAPTURE SUMMARIES
(AUGUST AND OCTOBER)

Appendix V Summary of sampling effort and total catch using various fish capture methods at each Rose Creek study site during August 2009.

SAMPLE SITE	CAPTURE METHOD	SAMPLE EFFORT	CATCH			OBSERVATIONS
			Arctic Grayling	Burbot	Slimy Sculpin	
RD1	Angle	30 min	2	0	0	
RD1	Electro	647 sec	2	0	0	2 AG sub-adult and 1 juv, 2 SS
RD1	MNT	18.8 hrs	1	0	0	
RD2	Angle	30 min	2	0	0	
RD2	Electro	660 sec	0	0	0	4 AG sub-adult and several SS adult/juv
RD2	MNT	20.6 hrs	0	0	1	
RD3	Angle	30 min	0	0	0	
RD3	Electro	946 sec	1	1	33	45 SS adult/juv and 2 fry
RD3	MNT	19.2 hrs	0	0	0	
RD4	Angle	30 min	0	0	0	
RD4	Electro	895 sec	0	0	52	46 SS adult/juv and 6 fry, 1 AG fry, 1 BB juv
RD4	MNT	20.4 hrs	0	1	0	
RD5	Angle	45 min	0	0	0	
RD5	Electro	1,205 sec	0	0	50	90 SS adult/juv
RD5	MNT	18.7 hrs	1	0	1	
NF1-1	Electro	901 sec	8	0	11	
NF1-1	MNT	22.4 hrs	0	0	0	
NF1-2	Angle	30 min	2	0	0	

SAMPLE SITE	CAPTURE METHOD	SAMPLE EFFORT	CATCH			OBSERVATIONS
			Arctic Grayling	Burbot	Slimy Sculpin	
NF1-2	Electro	903 sec	2	0	34	15 SS adult/juv and 30 fry
NF1-2	MNT	18.7 hrs	0	0	4	
NF2-1	Angle	20 min	0	0	0	
NF2-1	Electro	772 sec	2	0	2	1 SS adult/juv
NF2-1	MNT	19.0 hrs	1	0	0	
NF2-2	Angle	45 min	4	0	0	
NF2-2	Electro	831 sec	0	0	18	5 SS adult/juv, 1 BB juv, 1 RWF adult and 1 AG juv
NF2-2	MNT	17.8 hrs	0	0	3	
NF3-1	Angle	30 min	0	0	0	
NF3-1	Electro	963 sec	1	0	25	10 SS adult/juv and 17 fry
NF3-1	MNT	18.1 hrs	0	0	1	
NF3-2	Angle	30 min	0	0	0	
NF3-2	Electro	895 sec	0	0	16	5 SS adult/juv and 1 fry
NF3-2	MNT	21.1 hrs	0	0	4	
NF3-3	Angle	30 min	0	0	0	
NF3-3	Electro	978 sec	0	0	16	7 SS adult/juv and 22 fry, 1 AG sub-adult
NF3-3	MNT	22.3 hrs	0	0	3	

Legend: MNT = Minnow trap (10 traps)
Electro = Electrofisher
Angle = Angling

Appendix V Summary of sampling effort and total catch using various fish capture methods at each Rose Creek study site during October 2009.

SAMPLE SITE	CAPTURE METHOD	SAMPLE EFFORT	CATCH			OBSERVATIONS
			Arctic Grayling	Burbot	Slimy Sculpin	
RD2	Angle	20 min	0	0	0	
RD2	Electro	623 sec	0	0	4	2 SS adult/juv and fry common
RD2	MNT	19.0 hrs	0	0	0	
RD3	Angle	20 min	0	0	0	
RD3	Electro	928 sec	0	0	34	24 SS adult/juv and fry common
RD3	MNT	18.0 hrs	0	0	0	
RD5	Angle	15 min	0	0	0	1 AG juv strike
RD5	Electro	915 sec	0	0	40	11 SS adult/juv and abundant fry
RD5	MNT	18.5 hrs	0	0	0	
NF1-1	Electro	896 sec	19	0	14	10 AG fry, 14 SS adult/juv and abundant fry
NF1-1	MNT	26.5 hrs	1	0	1	
NF1-2	Angle	20 min	0	0	0	
NF1-2	Electro	963 sec	0	0	22	24 SS adult/juv, 1 AG juv and occasional fry
NF1-2	MNT	19.0 hrs	0	0	2	
NF2-1	Angle	15 min	0	0	0	1 AG sub-adult strike
NF2-1	Electro	924 sec	5	0	4	1 SS adult/juv and 34 fry, 1 AG
NF2-1	MNT	18.0 hrs	0	0	0	
NF2-2	Angle	25 min	1	0	0	
NF2-2	Electro	737 sec	4	0	23	8 SS adult/juv and abundant fry

SAMPLE SITE	CAPTURE METHOD	SAMPLE EFFORT	CATCH			OBSERVATIONS
			Arctic Grayling	Burbot	Slimy Sculpin	
NF2-2	MNT	24.5 hrs	0	0	1	
NF3-1	Angle	20 min	0	0	0	
NF3-1	Electro	917 sec	1	0	14	19 SS adult/juv and fry common
NF3-2	Angle	20 min	0	0	0	
NF3-2	Electro	928 sec	0	0	21	11 SS adult/juv and fry common
NF3-3	Angle	15 min	0	0	0	
NF3-3	Electro	946 sec	2	0	23	

Legend: MNT = Minnow trap (10 traps)
Electro = Electrofisher
Angle = Angling