# FRPA Region II Effectiveness Monitoring

Jeffrey C. Davis and Gay A. Davis
P.O. Box 923, Talkeetna, AK 99676
(907) 733.5432 www.arrialaska.org

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## Acknowledgements

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## Summary

Reference stream physical, chemical and biological characteristics were measured at four stream locations in order to provide pre-harvest data for the evaluation of the effectiveness of the Forest Resources and Practices Act (FRPA) and accompanying regulations at protecting water quality and fish habitat. Effectivenss will be determined through comparisons between reference and post-harvest data. The stream locations are within FRPA region II and are all classified as type II-C. Sites were located on both state and Matanuska-Susitna Borough (MSB) lands and were selected based upon discussions with state and MSB foresters and the review of planning documents. One site was selected within the Willer-Kash state harvest area due to scheduled timber harvest. The remaining sites were selected to provide data for low-sloped, brown-water streams common throughout the lower Susitna River drainage.

The physical characteristics measured included channel morphology, substratum size distribution, riparian and instream coarse wood, solar radiation, water temperature and discharge. Chemical characteristics included spring, summer, and fall measures of pH, specific conductivity, dissolved oxygen, nitrate + nitrite-N, ammonia-N, total phosphorus, total dissolved phosphorus, alkalinity and dissolved organic carbon. Biotic characteristics included measures of benthic organic matter, periphyton chlorophyll-*a*, macroinvertebrates and juvenile salmonids.

There was a large variation in stream characteristics among these four type II-C streams. Stream slopes ranged from less than 1 to 6 percent, channel ratios of width to depth from 8 to near 40, and channel substrate from gravel and cobble to fine sand and silt. Stream water temperatures were near 10°C for most of the season at the coldest sites and near 15°C at the warmest. Stream riparian vegetation ranged from a dense zone of alder followed by closed birch spruce forest to a *Calamagrostis* meadow. Differences in riparian vegetation resulted in differences in riparian and instream woody debris. The macroinvertebrate and fish community composition varied among sites. The abundance and species of salmonids varied among sites and among seasons.

Results from this study support the need to obtain reference data from streams prior to potential impacts in order to evaluate the influence of different land management actions.

# Introduction

Timber harvesting in the Matanuska-Susitna Region (Mat-Su) has the potential to expand with the development of new markets for spruce and hardwood chips. As the potential for timber harvest increases in the Mat-Su, opportunities in other areas of Region II, most notably on the Kenai Peninsula, have decreased. While demand for timber in Region I (Southeast AK) remains high, the state’s allowable cut limits the amount of timber that can be harvested, and no increase in timber harvest may occur there. Demand for timber in Region III remains relatively low. Therefore, timber harvest within the Mat-Su has the greatest probability for increased activity in the near future.

In 2004, 2005 and 2006, a science and technical committee, followed by an implementation group, developed new riparian standards for Region II. The riparian standards (AS 41.17.116, AS 41.17.118, and AS 41.17.119) apply to state, federal, and private commercial timber lands in the region. Region-wide, timber harvest operations have not been documented to cause adverse effects to fish habitat and water quality. Due to the limited scale of harvest activity in Region II in the past, little monitoring has been conducted to determine the effectiveness of the FRPA’s best management practices in protecting and maintaining water quality and fish habitat. Most of the work that has been done in Region II has focused on the Kenai Peninsula and its spruce bark beetle infestation. The scarcity of research on the effectiveness of FRPA in Region II (and specifically in Mat-Su) is a problem because conditions in Region II are markedly different from the other regions. A major difference between Region II and the other regions in Alaska are the relatively low values of timber compared to adjacent high-value fish habitat values and recreation opportunities. The risk of impacts to fisheries are greater in Region II than elsewhere because of the greater diversity of fish species, wider distribution of fish, more intense use of the fish populations and higher productivity of the fish streams.

A monitoring plan has been developed to evaluate FRPA effectiveness within Region II and the MSB (Davis et al. 2006; Davis and Davis 2008). The monitoring plan uses reference data collected from stream systems prior to harvest to evaluate potential changes in these conditions following harvest activities. Replication for statistical comparisons is obtained by obtaining reference data from multiple streams of similar classification. Stream condition is described through measures of physical, chemical, and biotic characteristics. These characteristics were selected based upon the management intent of the FRPA for riparian areas. The management intent for riparian areas through the FRPA is protection from the adverse effects of timber harvest on fish habitat and water quality. Preservation of fish habitat is accomplished through the maintenance of “short- and long-term sources of large woody debris, streambank stability, channel morphology, water temperatures, stream flows, water quality, adequate nutrient cycling, food sources, clean spawning gravels, and sunlight” (AS 41.17.115).

The FRPA effectiveness monitoring plan has been implemented, obtaining pre-harvest data on four streams within the Willer-Kash State harvest area. These small streams drain the forested slopes of the Talkeetna Mountains, have well developed forested riparian areas, gravel and cobble substrate, moderate slopes, and abundant woody debris. The cold-water streams support spawning and rearing coho and Chinook salmon (Davis and Davis 2008). These streams are representative of systems common within regional forests. However, timber harvest activities are also proposed to be conducted along streams draining the lowland areas within the Susitna and Little Susitna River drainages. These streams often flow through unforested areas of open low scrub or *Calimagrostis* meadows. Stream slopes are low; the substrate is often composed of sand, silt, or organic material; and water temperatures much higher. These streams provide important coho and Chinook salmon rearing habitat. The response of these stream systems to forest harvest activity likely will differ in comparison to the upland streams.

The objective of this study is to increase the amount of baseline data within stream systems prior to timber harvest. Previous pre-harvest data collection efforts in 2006 and 2007 have been focused on four streams within the Willer-Kash Harvest area. These small moderate-sloped streams drain Willow Mountain and are tributaries to Little Willow Creek. Measures will be continued at one of the locations within the Willer-Kash Harvest area, while additional sites outside of the Willer-Kash Harvest Area, will be selected that represent additional II-C stream classification types. Additional sites will include low-sloped, brown-water streams found within the Susitna River lowlands.

## Methods

Detailed descriptions of project sampling design and methods are provided within the QAPP attached as an appendix to this report.

### Sampling Locations

Sites were selected on streams within proposed state or MSB timber harvest areas. Proposed harvest areas were determined by reviewing the State 5-year timber sale plan, draft MSB land management plans, and discussions with state and MSB foresters. Sampling locations include Fish Creek above Flathorn Lake, Chijuk Creek, Whiskers Creek, and the North Fork of Iron Creek (Table 1). Chijuk Creek and Whiskers Creek are located within Forest Management Units 5 and 1, respectively, as per the MSB Forest Management-General Information distributed March 21, 2008. The North Fork of Iron Creek was within portions of the State Tin and Copper sale areas that have been combined in the calendar year 2009 and 2013 Five-Year Schedule of Timber Sales.

### Chemical Characteristics

Stream water samples were collected in July and September, 2008 and May or June, 2009. Water samples were preserved with $H_2SO_4$ or kept at 6°C until shipped to a commercial laboratory for processing. Water samples were analyzed for alkalinity, dissolved organic carbon (DOC), total and total dissolved phosphorus, nitrate + nitrite nitrogen, and ammonia nitrogen.

Dissolved oxygen, as percent saturation and concentration; pH, specific conductivity, turbidity and color were measured in the field.

**Table 1. Stream sampling locations and site names.**

| Site Name | Stream | Headwater Elev. (ft) | Elev. at Site (ft) | Segment Slope | Latitude | Longitude |
|---|---|---|---|---|---|---|
| Whiskers | Whiskers Creek | 1000 | 400 | 1.1% | 62.37681 | 150.17172 |
| Chijuk at Oilwell | Chijuk Creek | 750 | 400 | 0.8% | 62.07945 | 150.58334 |
| WK2 | N. Fk. Iron Creek | 2350 | 650 | 6.2% | 61.83500 | 149.83278 |
| Fish Creek (Flathorn) | Fish Creek | 200 | 50 | 0.2% | 61.52770 | 150.26069 |

## Physical Characteristics

Stream water discharge was measure concurrently with water sample collection using a Swoffer 3000 meter. We collected water temperature (Chijuk Creek) or temperature and pressure (Whiskers, Fish, and North Fork of Iron Creeks) using Onset Water temp ProV2 or water level loggers. Values were recorded hourly and daily average values were calculated from hourly recordings. Pressure due to changes in water level were obtained by subtracting average daily atmospheric pressure at the Talkeetna Airport.

Stream channel slope was measured using a hand-held level or laser level and leveling rod. Water surface and bed height was measured at three locations within each sampling reach and used to calculate water surface and bed slope. Channel shape was measured at three cross-sections located at 20-m intervals. Substrate size distribution was measured by Wolman pebble counts of 100 stones within a 100-m sampling reach.

All large wood and debris dams within the 100-m stream sampling site was counted and ranked based upon size and position. Ranking was used to calculate a large woody debris index (Davis et al. 2001) which is a measure of the influence of large woody debris on channel processes. We counted all wood within 30 m of the right bank for a 100-m length of stream. Coarse riparian wood was categorized based upon diameter, length, and tree species (Alder, Birch, or Spruce).

We measured photosynthetically active radiation (PAR) using a Licor sensor and meter. PAR was measured at 10 locations at the stream water surface throughout the sampling reach and at 10 locations unobstructed by trees or topography. Percent light transmission was calculated as the portion of total available PAR reaching the stream surface.

## Biotic Characteristics

Periphytic algae were sampled from all sites in July 2008. Five replicate samples were obtained by scraping algae from submerged rocks and collecting dislodged material on a filter. The filter and algae were placed within a plastic test tube, covered with aluminum foil, and frozen. Frozen samples were shipped to AM Test analytical laboratory where they were processed for chlorophyll-*a* and phaeophytin.

Benthic organic matter was collected using a Surber sampler or Ekman dredge (Whiskers Creek). Five replicate samples were collected within each sampling reach and sorted into coarse (>1 mm) and fine (0.363 to 1 mm) fractions. AFDM of both fractions were determined through mass loss of dry material following ignition at 550 °C.

Macroinvertebrates were collected at all sites in May or early June of 2009. Samples were collected following the Alaska Stream Condition Index (ASCI) (Major and Barbor 2001) methodology. Samples were preserved with 70% ethanol until processing. A minimum of 300 organisms were identified from composite samples. Macroinvertebrate metrics were calculated and overall ASCI scores determined.

Juvenile salmon and resident fish were sampled in September 2008 (except Fish Creek) and spring 2009 (May or early June). Fish were sampled using 10 (Chijuk and Fish Creeks) or 20 (Whiskers Creek and North Fork Iron Creek) baited minnow traps fished for 20 to 24 hours. All fish were identified to species and all salmon measured to fork length.

## Results

### Chemical Characteristics

Stream water macronutrient concentrations are shown if Figures 1 through 4. Ammonia nitrogen concentrations were generally below 0.05 mg/L at all sites and dates with exceptions in Fish Creek and Whiskers Creek in July 2008 where concentrations were an order of magnitude higher. Nitrate +nitrite concentrations differed among sites with concentrations considerably higher at Whiskers and Iron Creek, moderate at Chijuk Creek and below detection limits in Fish Creek. There were no consistent seasonal differences in total phosphorus or total dissolved phosphorus at any of the sites. Dissolved phosphorus was approximately 30% of total phosphorus at all sites in the spring. The ratio of total dissolved to total phosphorus was low in Fish Creek and the North Fork of Iron Creek in July, but all of the phosphorus was dissolved in July in Whiskers and Chijuk Creek. Total and total dissolved phosphorus were generally lowest in Whiskers Creek on each sampling date. Molar ratios of total inorganic nitrogen to total or total dissolved phosphorus suggest nitrogen limitation at Chijuk Creek (ratios < 16) and phosphorus limitation at all other sites.

Alkalinity, a measure of pH buffering, ranged from 2 to 32 mg/L $CaCO_3$. Within each site, values were lowest during spring sampling. Alkalinity was lowest in Chijuk Creek during each season followed by Whiskers Creek. Alkalinity was highest in Fish Creek. Stream water pH followed alkalinity with low values in Chijuk Creek and Whiskers Creek particularly during spring runoff when pH dropped to 6.2 in Chijuk Creek (Figures 5 and 6).

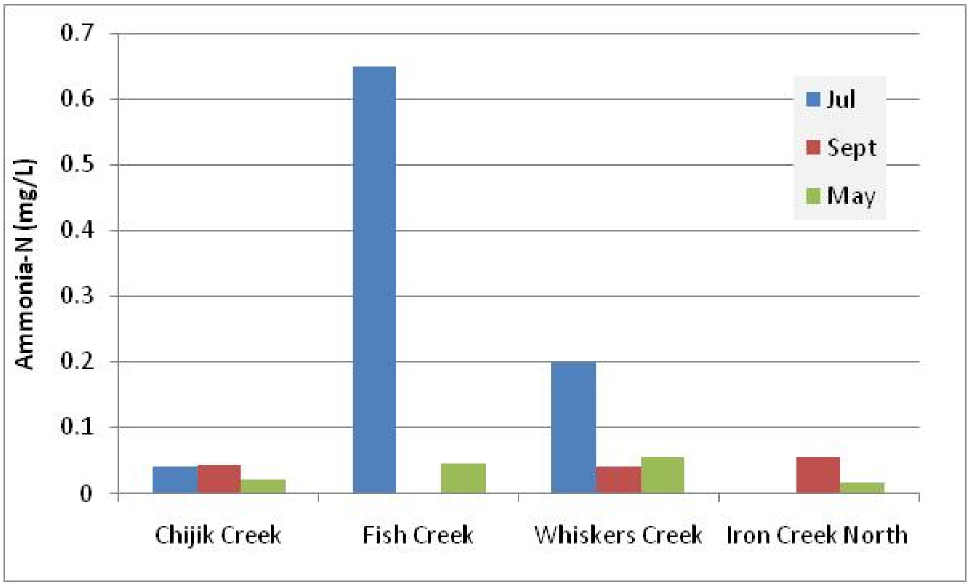


**Figure 1. Stream water ammonia-N concentrations for the four sampling sites July and September 2008 and May 2009.**

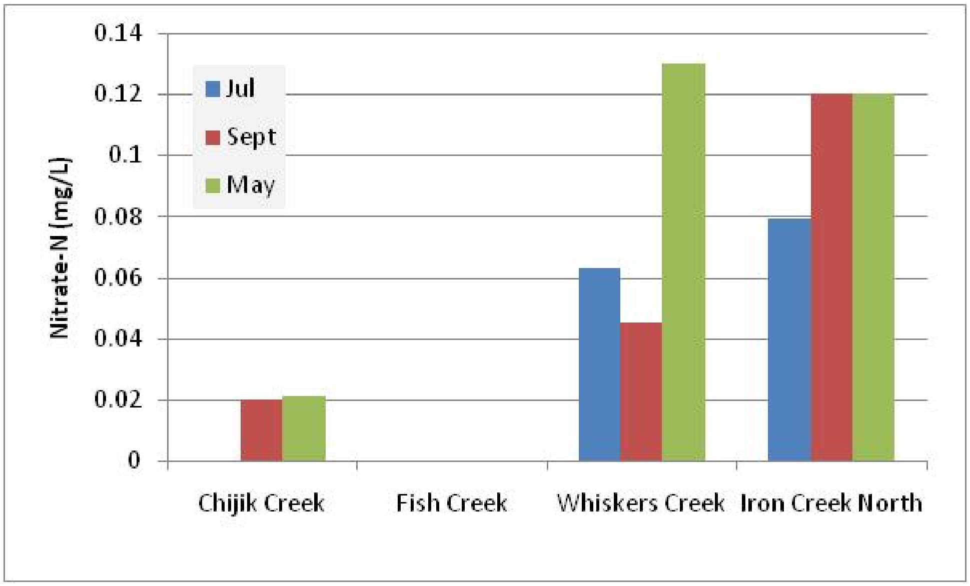


**Figure 2. Nitrate + nitrite nitrogen concentrations. Concentrations in Chijuk Creek in July and Fish Creek in July and May were below detection limits (0.01 mg/L).**

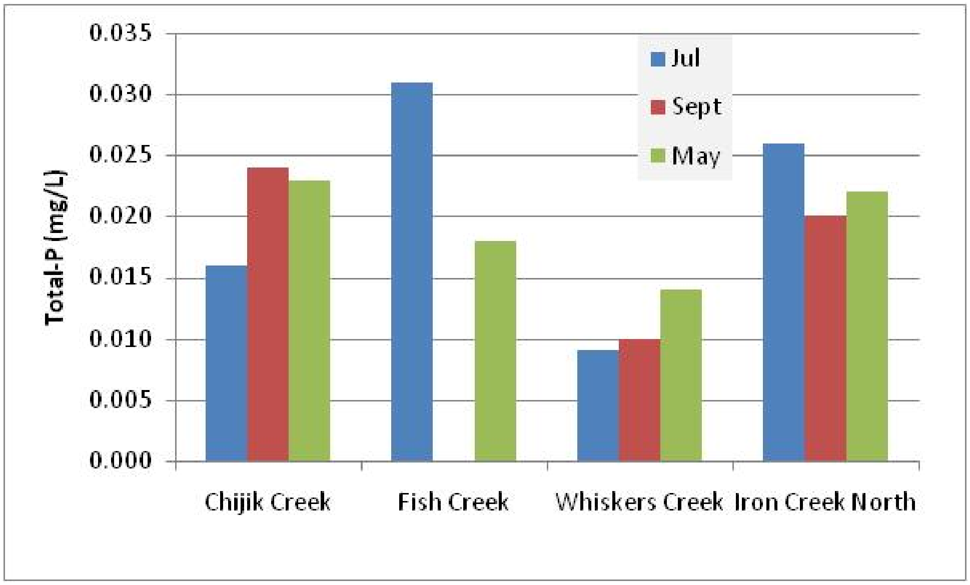


**Figure 3. Total phosphorus concentrations for all sites and dates.**

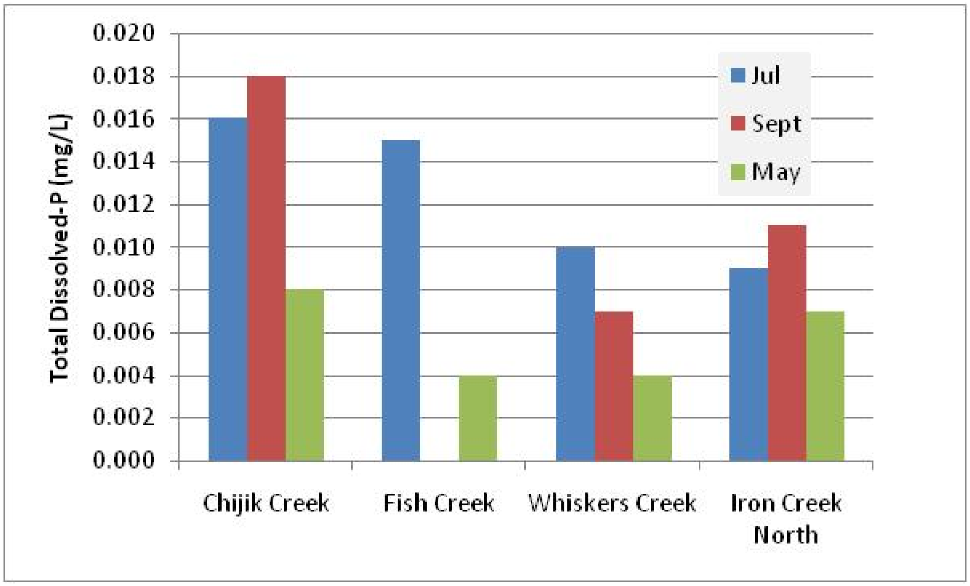


**Figure 4. Concentrations of total dissolved phosphorus for all dates.**

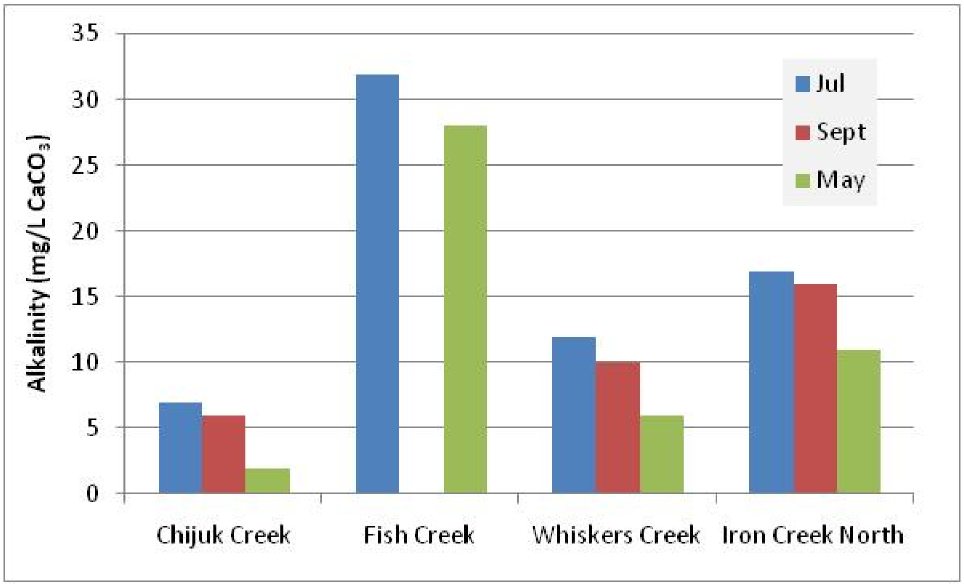


Figure 5. Seasonal measures of alkalinity at all sampling sites.

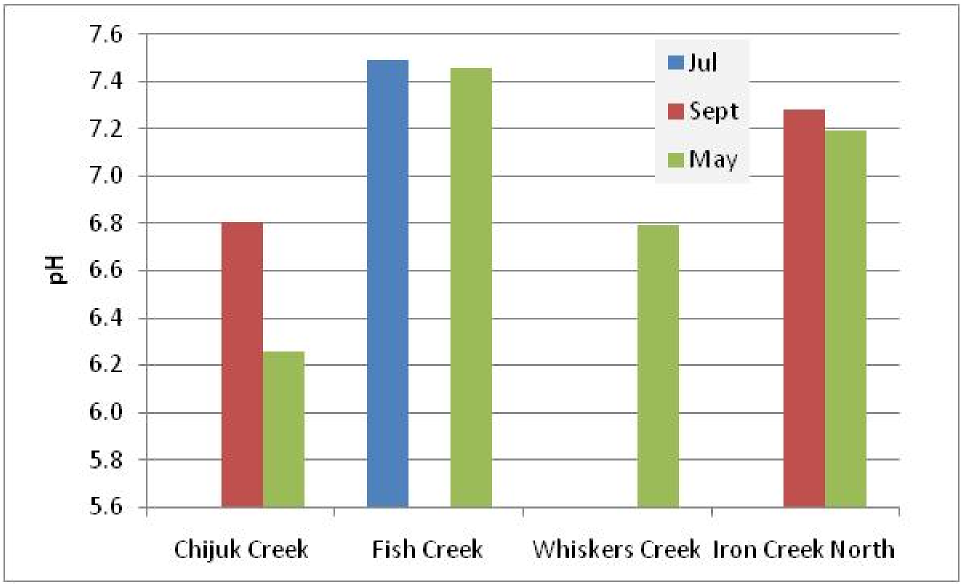


Figure 6. Seasonal stream water pH among the sampling sites.

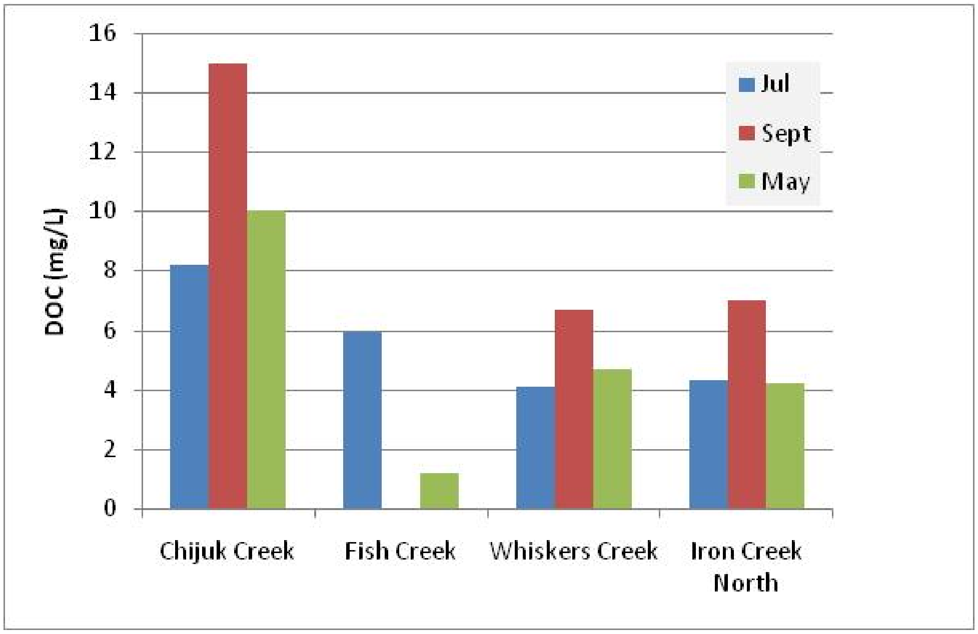


Figure 7. Seasonal dissolved organic carbon for the four sampling locations.

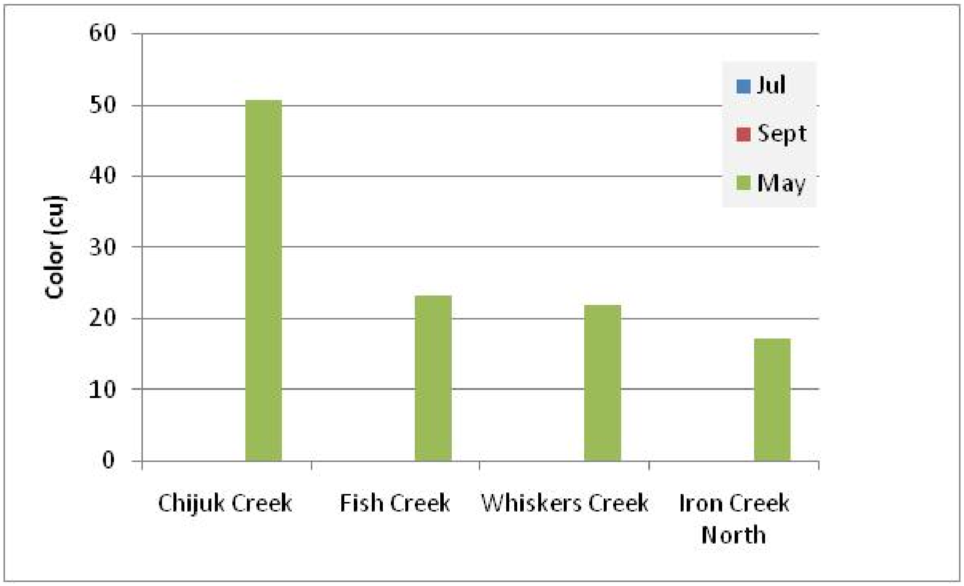


Figure 8. Spring measures of water color for the four sampling locations.

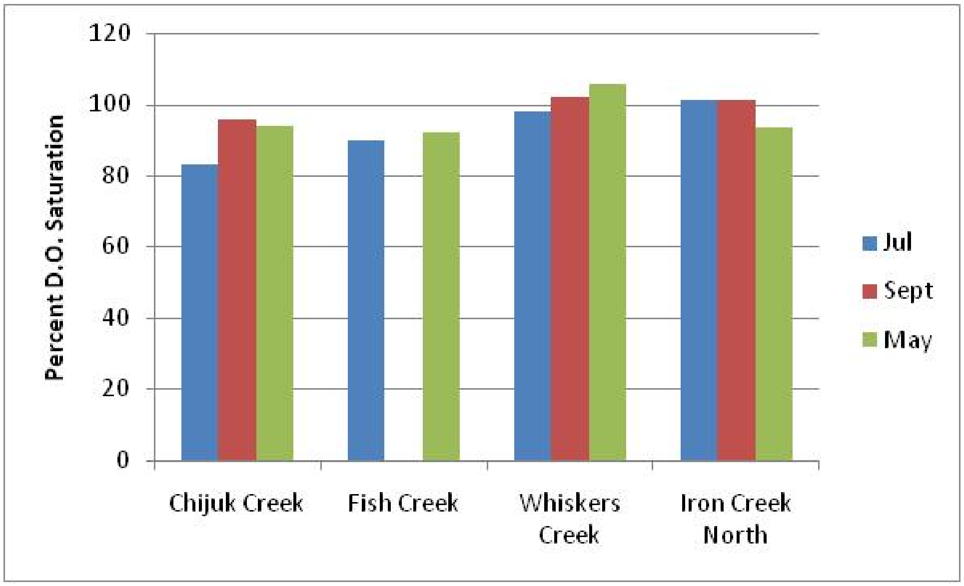


**Figure 9. Seasonal measures of dissolved oxygen as percent saturation for the four sampling locations.**

Chijuk Creek had the greatest amount of dissolved carbon at 15 mg/L in fall samples. Concentrations of DOC were highest in all streams during fall sampling. Concentrations were similar among the other sites, but lowest in Fish Creek in the spring. Spring measures of stream color largely followed measures of DOC (Figures 7 and 8).

Concentrations of dissolved oxygen were near saturation in Whiskers and Iron Creek, but below saturation at Fish Creek and Chijuk Creek (Figure 9). Dissolved oxygen concentrations were lowest in Chijuk Creek during mid-summer sampling at near 80% saturation. Concentrations also were below saturation in Fish Creek, at approximately 90% during mid summer and the following spring.

## Physical Characteristics

Stream channel characteristics are shown in Table 1. The stream channels at all sites were confined within high banks of near 2 meters. Stream channels at most sites were narrow and deep with ratios of channel width to depth below 10. Chijuk Creek was the exception with very high ratios of channel width to depth. Streambanks were undercut from 0.2 to 0.3 m. Stream bed and water surface slopes were very low, below 1% at all sites except for the North Fork of Iron Creek.

Iron Creek contains the largest substrate particle size composed of large gravel and cobble. Chijuk Creek also has a gravel cobble substrate but with a slightly smaller size distribution than Iron Creek (Table 2, Figures 10 and 11). The substrate within Chijuk Creek is embedded with over 50% of the particles embedded more that 30%. Substrate within the sampling reaches of Whiskers Creek and Fish Creek is composed entirely of fines less than 2 mm. Fine substrate appears to be the dominant particle size within Fish Creek, based upon qualitative surveys above and below the sampling reach. However, Whiskers Creek contains reaches of gravel cobble substrate above and below the sampling reach.

**Table 2. Stream channel characteristics for the four sampling locations. UC is bank undercut.**

| | N. Fk. Iron Creek | Whiskers | Chijuk Creek | Fish Creek |
|---|---|---|---|---|
| **Channel Width (m)** | 2.73 | 5.83 | 5.73 | 4.90 |
| **Area ($m^2$)** | 0.97 | 4.40 | 0.86 | 3.07 |
| **Mean Depth (m)** | 0.35 | 0.78 | 0.16 | 0.63 |
| **Width to Depth ratio** | 8.62 | 7.92 | 42.55 | 7.82 |
| **Max Bank Height (m)** | 2.30 | 2.31 | 1.40 | 1.70 |
| **Min Bank Height (m)** | 0.25 | 0.98 | 0.16 | 1.20 |
| **Average UC (m)** | 0.34 | 0.31 | 0.26 | 0.21 |
| **WS Slope** | 0.0140 | 0.0008 | 0.0060 | <0.005 |
| **Bed Slope** | 0.0240 | 0.0090 | 0.0062 | <0.005 |

**Table 3. Size distribution of sediments within sampling reaches.**

| | Size (mm) | N. Fk. Iron Creek | Whiskers | Chijuk Creek | Fish Creek |
|---|---|---|---|---|---|
| **Sand** | <2 | 4% | 100% | 6% | 100% |
| **Gravel** | 2 to 64 | 52% | | 90% | |
| **Fine Gravel** | 2 to 8 | 0% | | 5% | |
| **Medium Gravel** | 8 to 16 | 2% | | 10% | |
| **Coarse Gravel** | 16 to 64 | 49% | | 63% | |
| **Cobble** | 64 to 256 | 42% | | 4% | |
| **Boulder** | > 256 | 2% | | 0% | |
| **D50 (mm)** | | 60 | N/A | 22.6 | N/A |
| **Percent Embedded > 30%** | | 20% | | 51% | |

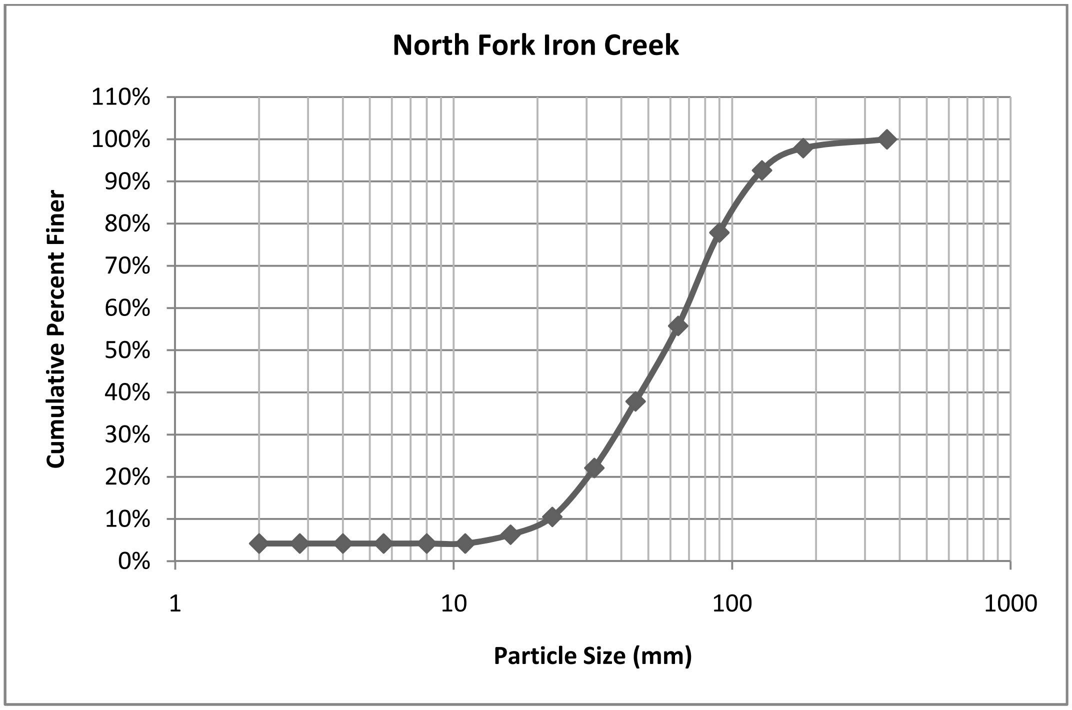


**Figure 10. Sediment particle size distribution for North Fork Iron Creek.**

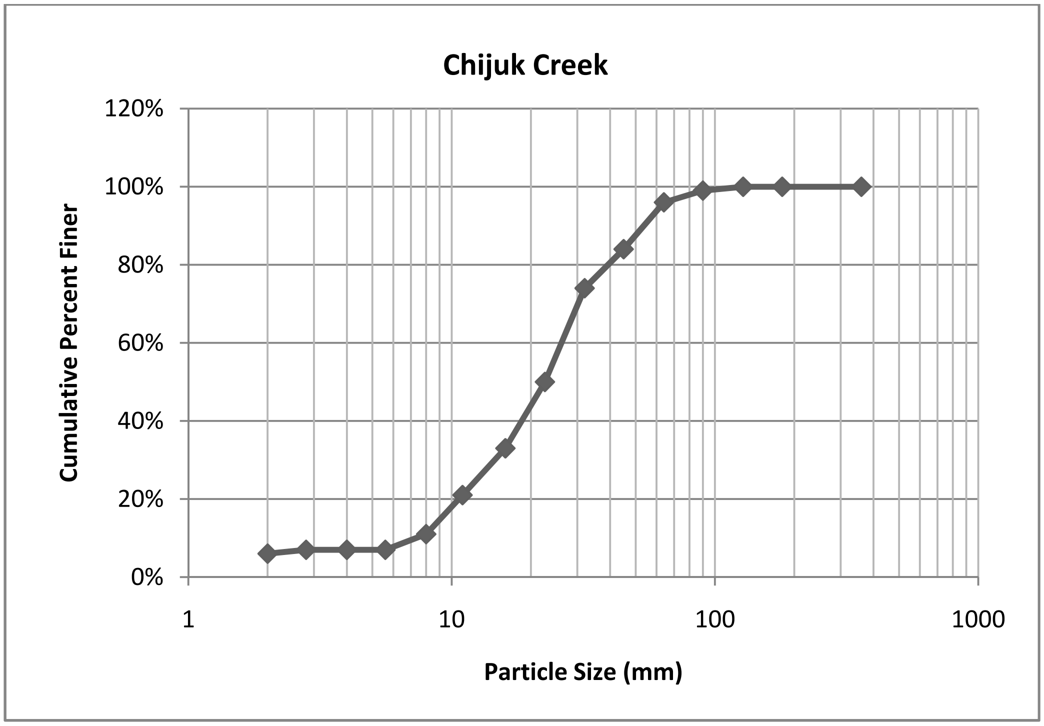


**Figure 11. Sediment particle size distribution for Chijuk Creek.**

Stream flows were measured on four dates at three of the sites but only twice at Fish Creek due to the remote location and helicopter access. Pressure loggers were deployed at all sites. Stream pressure differences were determined by subtracting average daily pressure recorded at the Talkeetna Airport. We were only able to develop a pressure discharge relationship at the North Fork of Iron Creek. Relationships at other sites were not possible due to limited discharge measures (Fish Creek), and movement of the pressure logger by wildlife or high flows. Stream flows at all sites were highest during spring runoff (Figure 12). The greatest variability in stream flow occurred in Chijuk and Whiskers Creeks. Stream flow in Chijuk Creek ranged from over 80 cfs in the spring to 1.6 cfs during mid-summer. Similarly, stream flow in Whiskers Creek increased 6 fold from 10 cfs in the summer to 60 cfs the following spring.

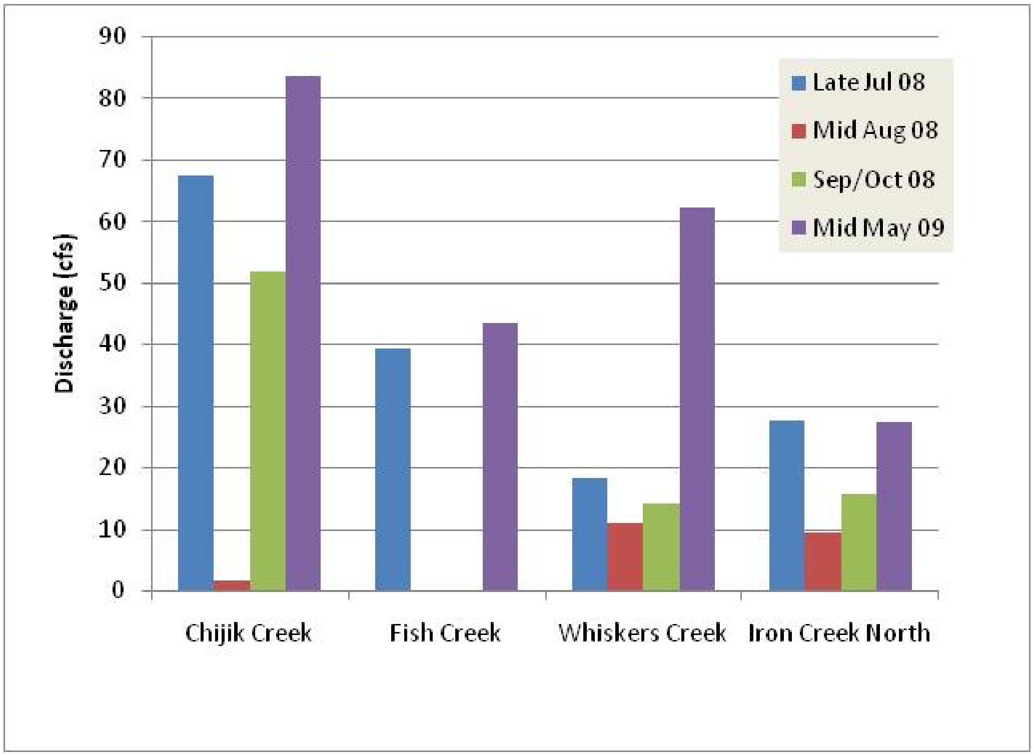


**Figure 12. Seasonal measures of discharge for the four sampling locations.**

Chijuk Creek and the North Fork of Iron Creek flow through a mixed forest of birch and spruce, often with a zone of alder from 1 to 3 meters wide along the stream margin. The riparian vegetation surrounding Fish Creek and Whiskers Creek was composed primarily of *Calamagrostis*. This grass extended from 3 to 10 meters at Whiskers Creek and up to 50 meters at Fish Creek, with the birch forest extending lateral from this point. This type of riparian plant community extended upstream on Fish Creek to Lynx Lake. Portions of Whiskers Creek, upstream, were similar to Chijuk Creek and Iron Creek with a zone of alder followed by the birch and spruce forest. Over 90% of available solar radiation reached the stream surface of Chijuk and Fish Creek during early spring compared to 70% at Whiskers Creek and Iron Creek. In mid-summer, the portion of solar radiation reaching the stream surface was reduced to near 60% at all sites except Fish Creek, where solar radiation did not decrease following leaf out (Table 4).

**Table 4. Percent of total available solar radiation (PAR) reaching the stream surface.**

| | Chijuk Creek | Fish Creek | Whiskers Creek | N. Fk Iron Creek |
|---|---|---|---|---|
| **August** | 57% | 87% | 60% | 55% |
| **Sept/Oct** | | | | 71% |
| **May** | 96% | 93% | 77% | 72% |

Chijuk Creek contained the largest amounts of large woody debris within the stream channel and Fish Creek the least (Table 5). Chijuk, Whiskers, and Iron Creeks all had a similar number of woody debris pieces. Debris dams were slightly more common in Chijuk Creek and Iron Creek. The woody debris index also was highest in Chijuk Creek. The abundance of coarse wood within the riparian area was similar among Chijuk, Whiskers, and Iron Creeks with 16 to 19 pieces counted within 3000 $m^2$ (Table 6). Fish Creek contained the lowest amount of coarse wood at 10 pieces within the 3000 $m^2$ riparian area. Coarse wood within the riparian area was mainly birch and spruce next to Iron Creek and Chijuk Creek, birch and alder next to Whiskers Creek, and entirely alder next to Fish Creek.

Stream water temperatures were warmest in Chijuk Creek and coolest within the North Fork of Iron Creek (Table 7 and Figure 13). Maximum stream temperatures in the North Fork of Iron Creek did not exceed 13°C. Maximum daily water temperatures in Fish Creek and Whiskers Creek rarely exceed 15°C, while maximum daily water temperatures in Chijuk Creek exceeded 15°C on 30% of the days temperature was recorded. There was very little difference between daily maximum and minimum temperatures in Fish Creek.

**Table 5. Count of coarse wood within the 100-m sampling reach by piece and debris dam and ranked to provide a woody debris index score.**

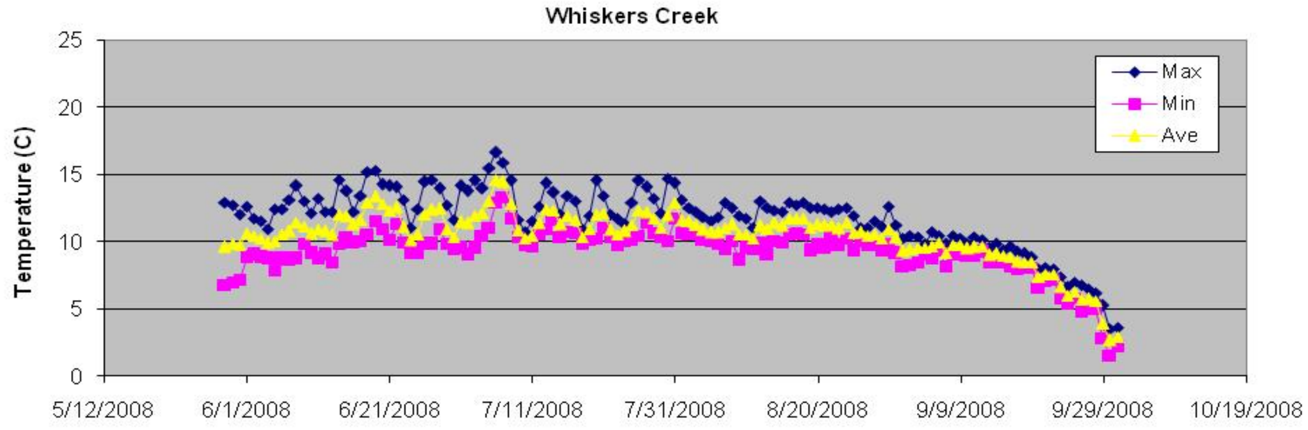
| | Chijuk Creek | Fish Creek | Whiskers Creek | N. Fk. Iron Creek |
|---|---|---|---|---|
| **Pieces** | 11 | 3 | 10 | 9 |
| **Dams** | 4 | 1 | 1 | 3 |
| **LWDI Score** | 556 | 72 | 312 | 375 |

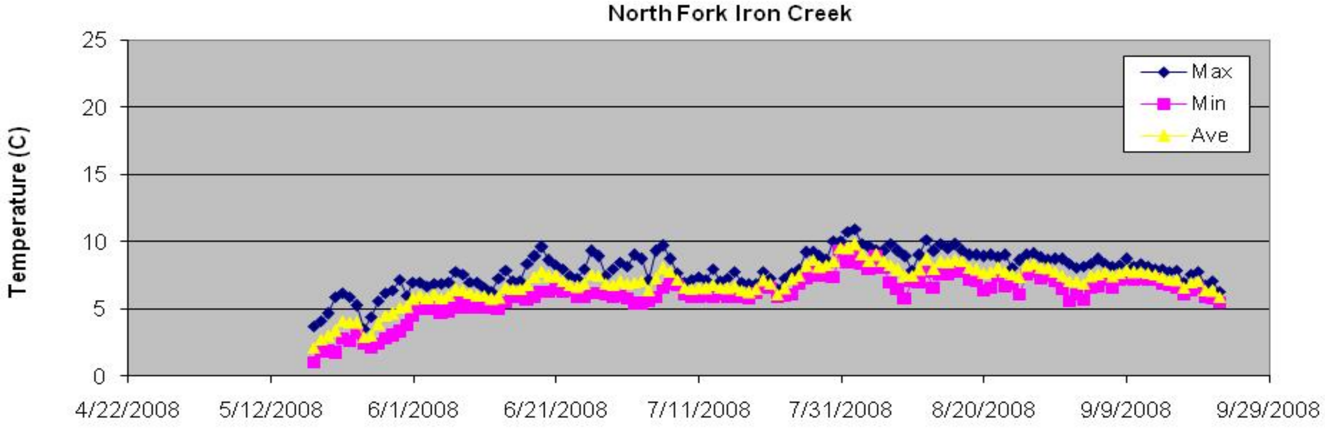
**Table 6. Counts of riparian coarse woody debris within a 3000 $m^2$ area by diameter, length and species.**

| **Diameter** | **10-19cm** | **20-29 cm** | **>30 cm** | **Total** |
|---|---|---|---|---|
| North Fork Iron Creek | 14 | 1 | 1 | 16 |
| Fish Creek | 9 | 1 | 0 | 10 |
| Chijuk Creek | 12 | 3 | 2 | 17 |
| Whiskers Creek | 14 | 3 | 2 | 19 |
| **Length** | **1-4 m** | **5-9 m** | **>10m** | **Total** |
| North Fork Iron Creek | 7 | 7 | 2 | 16 |
| Fish Creek | 6 | 4 | 0 | 10 |
| Chijuk Creek | 5 | 5 | 7 | 17 |
| Whiskers Creek | 8 | 10 | 1 | 19 |
| **Species** | **Spruce** | **Birch** | **Alder** | **Total** |
| North Fork Iron Creek | 5 | 4 | 7 | 16 |
| Fish Creek | 0 | 0 | 10 | 10 |
| Chijuk Creek | 4 | 9 | 4 | 17 |
| Whiskers Creek | 0 | 5 | 14 | 19 |

**Table 7. Seasonal temperature statistics for the four sampling locations. (* indicates incomplete data)**

| | **Season Maximum** | **Maximum Daily Range** | **Total Days** | **Days Max Temp >13** | **Percent of Total Days > 13** | **Days Max Temp >15** | **Percent of Total Days >15** | **Days Max Temp >20** | **June Cumulative Degree Days** | **July Cumulative Degree Days** | **August Cumulative Degree Days** | **September Cumulative Degree Days** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **North Fork Iron Creek** | 10.94 | 4.20 | 128 | 0 | 0 | 0 | 0 | 0 | 198 | 224 | 251 | 151 |
| **Whiskers Creek** | 16.62 | 6.11 | 126 | 34 | 27 | 5 | 4 | 0 | 339 | 365 | 338 | 234 |
| **Fish Creek above Flathorn Lake** | 14.13 | 1.78 | 102 | 15 | 15 | 0 | 0 | 0 | | 120* | 394 | 306 |
| **Chijuk Creek at Oilwell Road** | 20.82 | 6.31 | 94 | 62 | 66 | 31 | 33 | 2 | | 429 | 412 | 269 |


Whiskers Creek
Temperature (C)
25
20
15
10
5
0
5/12/2008
6/1/2008
6/21/2008
7/11/2008
7/31/2008
8/20/2008
9/9/2008
9/29/2008
10/19/2008
Max
Min
Ave


North Fork Iron Creek
Temperature (C)
25
20
15
10
5
0
4/22/2008
5/12/2008
6/1/2008
6/21/2008
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9/29/2008
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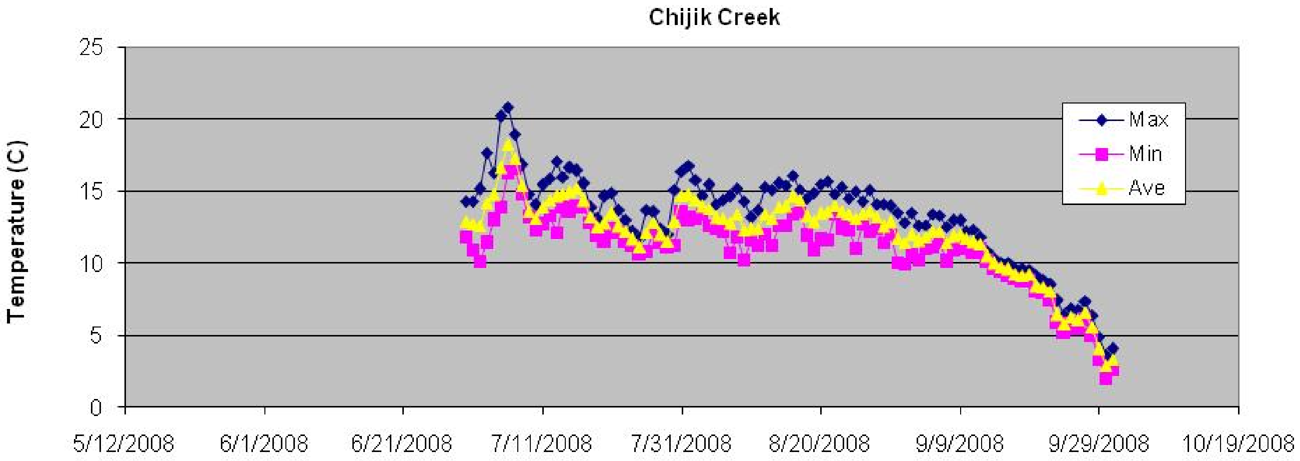


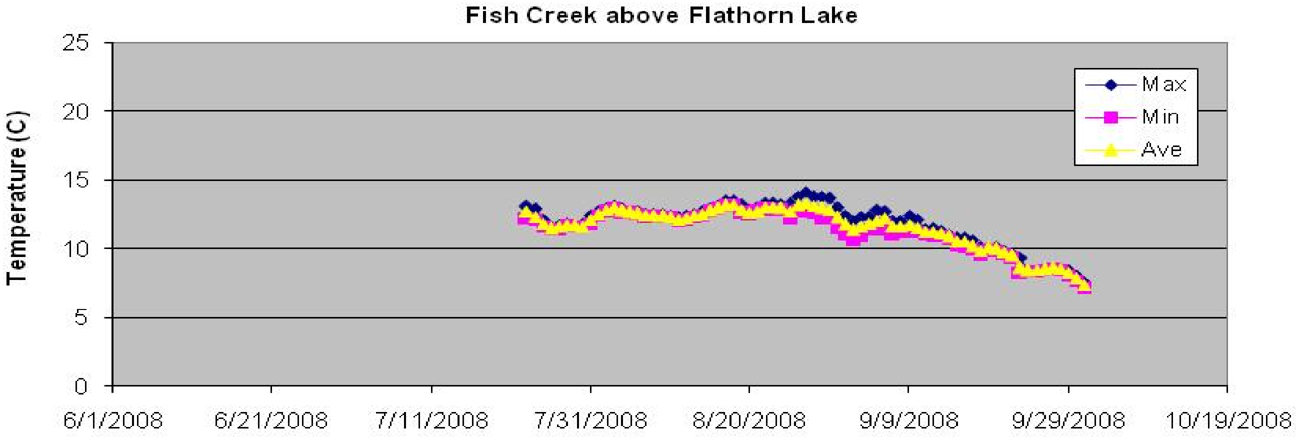


**Figure 13. Graphical presentation of daily stream water temperature statistics for the four sampling locations.**

## Biological Characteristics

Measures of algal abundance as chlorophyll-*a* and allochthonus food sources as benthic organic matter are provided in Figures 14 and 15. Algal samples from Fish Creek were collected from the fine sediment surface; however, we did not collect enough material to provide a measure of chlorophyll-*a* in this stream. The largest amounts of chlorophyll-*a* were found in the North Fork of Iron Creek with similar but lower values in Chijuk and Whiskers Creeks. Whiskers Creek contained over 200 g/m$^2$ of coarse particulate organic matter compared to values of 8 to 40 g/m$^2$ in the remaining streams. Whiskers Creek also had the largest amount of fine particulate organic matter at 160 g/m$^2$. The next highest value of fine particulate organic matter was found in Fish Creek at 60 g/m$^2$. Fish Creek was the only site where fine material was more abundant than coarse organic matter.

Differences in the macroinvertebrate community reflected differences in substrate and sources of organic matter. Diptera dominated the invertebrate community in Fish Creek and Whiskers Creek, making up approximately 80% of the sample (Table 8). Chijuk Creek was intermediate at near 65%, while 40% of the community was of this order in Iron Creek. Conversely, Iron Creek and Chijuk Creek had the greatest percent of EPT (sum of Ephemeroptera, Plecoptera, and Trichoptera) and the greatest percent of grazing organisms. Water quality based upon ASCI scores was ranked “good” at Whiskers Creek, Chijuk Creek, and Iron Creek, but only “fair” in Fish Creek.

The greatest diversity and abundance of salmonids during fall sampling was found in Iron Creek, which contained coho and Chinook salmon, rainbow trout, and Dolly Varden char. Whiskers Creek contained coho and Chinook salmon, and at Chijuk Creek, coho salmon and rainbow trout. Highest fall catch rates were in the North Fork of Iron Creek at almost 10 fish per trap followed by Whiskers Creek at approximately 6 fish per trap. Catch rates in Chijuk Creek were extremely low at less than 2 fish per trap (Figure 16). Fall fish sampling was not conducted in Fish Creek.

Spring catch rates were similar to fall samples in Whiskers Creek for the number of coho, Chinook and total salmonids captured. However, catch rates of coho and Chinook salmon were much lower in the North Fork of Iron Creek in the spring compared to the previous fall. We did not capture any coho salmon in Chijuk Creek or Fish Creek in the spring. Rainbow trout were captured in spring Chijuk Creek samples. Pike and suckers were observed and sticklebacks captured in Fish Creek during spring sampling.

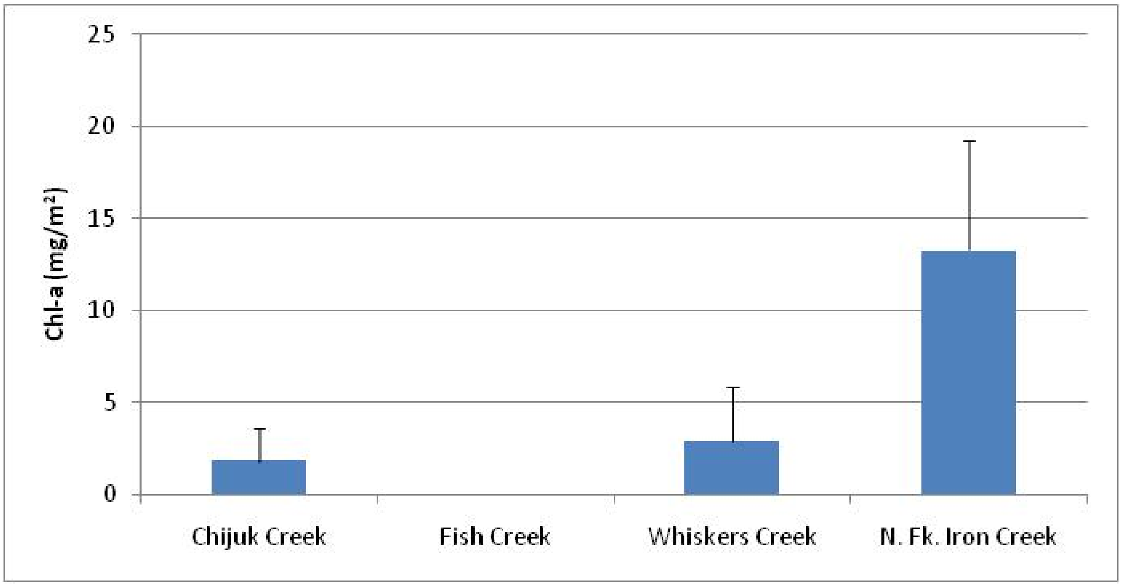


**Figure 14. Chlorophyll-a from algal samples collected in late August or early September 2008. Values are the average of 5 samples from each location.**

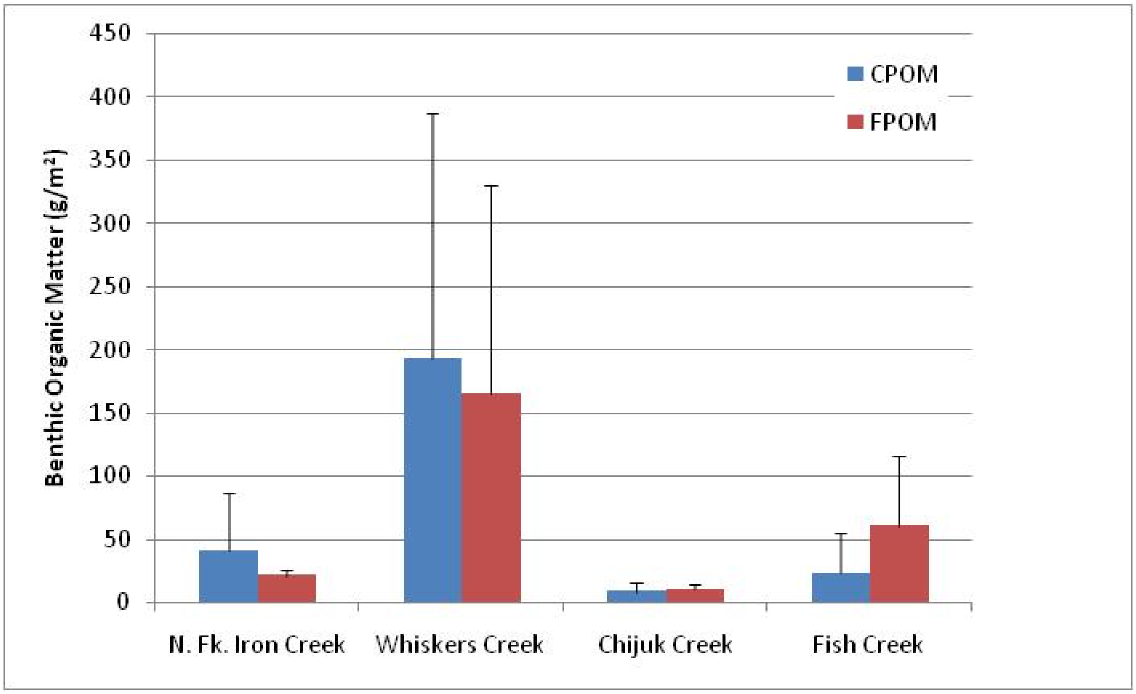
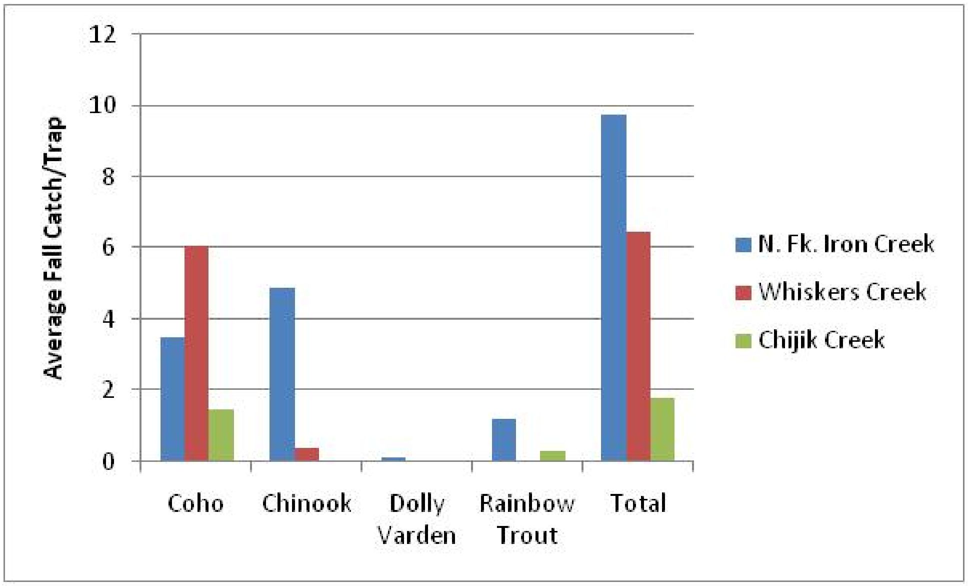


**Figure 15. Benthic organic matter as coarse particles (CPOM) > 1.0 mm and fine particles (FPOM) form 0.3 to 1.0 mm.**

**Table 8. Macroinvertebrate metrics and ASCI scores for samples collected in May of 2009.**

| | **Fish Creek** | **Whiskers Creek** | **N. Fk. Iron Creek** | **Chijuk Creek** |
|---|---|---|---|---|
| **Total Organisms** | 352 | 220 | 459 | 331 |
| **Ephemeroptera** | 7 | 17 | 219 | 20 |
| **Plecoptera** | 0 | 8 | 22 | 6 |
| **Trichoptera** | 2 | 6 | 27 | 52 |
| **Diptera** | 310 | 175 | 174 | 215 |
| **Richness** | 13 | 15 | 20 | 23 |
| **Ephemeroptera Taxa** | 2 | 3 | 6 | 3 |
| **Trichoptera Taxa** | 1 | 3 | 4 | 6 |
| **% Plectopera** | 0.00 | 3.64 | 4.79 | 1.81 |
| **% Ephemptera (no Baetidae)** | 1.70 | 4.09 | 9.15 | 3.93 |
| **% Diptera** | 88.07 | 79.55 | 37.91 | 64.95 |
| **Baetidae/Ephemeroptera** | 0.14 | 0.47 | 0.79 | 0.35 |
| **% Non-insects** | 9.38 | 5.91 | 3.70 | 10.27 |
| **HBI** | 5.66 | 5.44 | 4.46 | 5.06 |
| **%Scrapers** | 0.57 | 0.45 | 8.28 | 10.27 |
| **% Collectors** | 76.70 | 77.27 | 72.33 | 63.14 |
| **% EPT no Baetids or Zapada** | 2.27 | 9.09 | 15.47 | 15.41 |
| **Low /Gradient Coarse Substrate** | **Fish Creek** | **Whiskers** | **N. Fk. Iron Creek** | **Chijuk Creek** |
| **Ephemeroptera taxa 100 * X / 5.5** | 36.4 | 54.6 | 109.1 | 54.6 |
| **% Ephemeroptera (no Baetidae) 100 * X / 20** | 8.5 | 20.5 | 45.8 | 19.6 |
| **% Plecoptera 100 * X / 14** | 0.00 | 26.0 | 34.2 | 13.0 |
| **Baetidae / Ephemeroptera 100 * (100 - X) / 100** | 85.7 | 52.9 | 20.6 | 65.0 |
| **% non-insects 100 * (30 - X) / 30** | 68.8 | 80.3 | 87.7 | 65.8 |
| **O/E (family 75%) 2 100 * X** | 60 | 90 | 70 | 80 |
| **% scrapers 100 * X / 15** | 3.8 | 3.0 | 55.2 | 68.5 |
| **HBI 100 * (6.5 - X) / 2** | 41.8 | 53.2 | 100.0 | 72.1 |
| **Average** | 38.1 | 47.6 | 65.3 | 54.8 |
| **Ranking** | Fair | Fair | Good | Good |
| | | | | |
| **Low Gradient Fine Substrate** | **Fish Creek** | **Whiskers** | **N. Fk. Iron Creek** | **Chijuk Creek** |
| **Trichoptera taxa 100 * X / 7** | 28.6 | 85.7 | | |
| **% EPT (no Baetidae or Zapada) 100 * X / 15)** | 15.2 | 60.6 | | |
| **% Diptera 100 * (100— X) / 70** | 17.0 | 29.2 | | |
| **O/E (family 75%) 1 100 * X** | 77.8 | 66.7 | | |
| **% collectors 100 * (100 - X) / 70** | 33.3 | 32.5 | | |
| **HBI 100 * (6.5 - HBI) / 2** | 41.8 | 53.2 | | |
| **Average** | 35.6 | 54.6 | | |
| **Ranking** | Fair | Good | | |



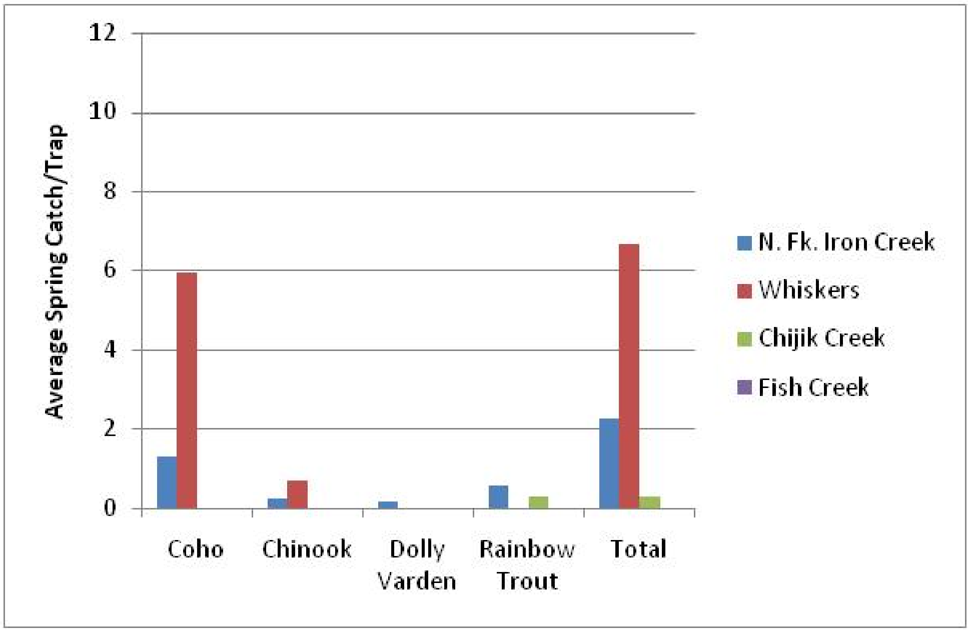


**Figure 16. Average catch/trap in September 2008 (Fall) and late May or early June 2009 (Spring).**

## Discussion

This is the third year of data collection for FRPA effectiveness monitoring since the development of the monitoring plan. There have been consistent problems with some data collection efforts and some methods have been refined. High fall flows, or weather, and wildlife have been the major impediment to data collection efforts. High flows in the fall have limited our ability to collect some of the physical and biotic measures. We were unable to access Fish Creek by helicopter as scheduled due to rain and high winds. When the weather cleared flows were too high to collect samples. Substratum size distribution, channel morphology and instream woody debris should be collected in late June or July to avoid high flows following rain storms common in August and early September. Measures of instream benthic organic matter and periphyton also should be conducted during mid summer in order to obtain measures that are not influenced by large inputs from deciduous trees during the fall (benthic organic matter), or algal senescence. Measures of riparian coarse wood are easiest during the early spring or late fall when observations are not hindered by understory growth. We have used a number of different methods to sample the fish community. We currently believe that fall fish trapping using 20 traps provides the most consistent measure. Traps should be separated by at least 10-m to avoid reducing catch rates by dividing fish into separate traps.

These four sites varied in overall valley slope from over 6% at the North Fork of Iron Creek to less than 0.2% at Fish Creek. All of the sites are within stable single channels, held in place by riparian vegetation, with little or no point bar formation. Physically, the North Fork of Iron Creek and Chijuk Creek were similar with steeper slopes, cobble and gravel substrate, and riparian vegetation of alder, birch, and spruce. Coarse woody was common within the stream and riparian area. Roughly 60% of available sunlight reached the stream surface at each location; however, Chijuk Creek was acidic with low alkalinity, high DOC concentrations, higher color values, low amounts of nitrate + nitrite nitrogen, more embedded substrate, and highly variable discharge. These differences likely can be explained by the relatively greater amount of saturated soils wetland plant communities relative to forests within the watershed which produce high amounts of organic acids. Changes in hydrology commonly reported following timber harvest, and changes in solar input to the stream channel would likely have a greater influence on water temperature in Chijuk Creek relative to the North Fork of Iron Creek where ground water buffers stream temperatures. Sediment input into Chijuk Creek may have a greater influence on the benthic organisms given the embedded stream substrate. Juvenile salmon were abundant in the North Fork of Iron Creek but catch rates were low in Chijuk Creek. Therefore, changes in the biotic community following harvest must be compared to baseline measures within each stream.

Whiskers Creek and Fish Creek both had relatively low slopes, beds composed of fine substrate, flowed through a riparian area composed of grasses open to solar radiation inputs. Water temperatures in Fish Creek; however, were considerably cooler than expected base upon solar energy inputs. The proximity of the mixed birch and spruce forest both lateral and upstream from the Whiskers Creek sampling reach is the likely cause of differences in riparian and instream coarse woody debris. The proximity of the forest also may explain the large differences in benthic organic matter. Fish Creek had high alkalinity, high pH, with DOC and color values similar to those in Whiskers Creek, which would not be expected for this stream flowing through predominantly wetland vegetation types. The macroinvertebrate community within Fish Creek is consistent with that found in low sloped impacted streams, which also is unexpected for this apparently unimpacted and remote location. Juvenile salmon were not captured within Fish Creek, which may be due to the presence of larger predatory fish.

Results from this study demonstrate the variability among streams classified as type II-C under the FRPA. Even streams with similar physical characteristics may vary chemically and biologically. Therefore, comparisons to evaluate the effectiveness of the FRPA must compare changes within a specific stream over time, and not use the average among a given stream type for comparisons.

## References

Davis, J.C., and G.A. Davis. 2008. FRPA Effectiveness Monitoring within the Willer-Kash State Forest Harvest Area: July 2006 through May 2008 Summary. Aquatic Restoration and Research Institute, Final Report for the Alaska Department of Environmental Conservation. Talkeetna, Alaska.

Davis, J.C., G.A. Davis, and L. Eldred. 2006. FRPA Effectiveness Monitoring within the Willer-Kash State Forest Harvest Area Aquatic Restoration and Research Institute. Final Report for the Alaska Department of Environmental Conservation. Talkeetna, Alaska.

Davis, J. C., G. W. Minshall, C. T. Robinson, and P. Landrus. 2001. Monitoring wilderness stream ecosystems. USDA Forest Service, Rocky Mountain Research Station, General Technical Report, RMRS-GTR-70.

Major, E.B., and M.T. Barbour. 2001. Standard operating procedures for the Alaska Stream Condition Index: A modification of the U.S. EPA rapid bioassessment protocols, 5th edition. Prepared for the Alaska Department of Environmental Conservation, Anchorage, Alaska.

## Appendix A. Quality Assurance Project and Sampling Plan

# Quality Assurance Project and Sampling Plan

# MAT-SU FRPA Effectiveness Monitoring

(Revision Number 3.0)

## Updated July 2008

ARRI
Aquatic Restoration & Research Institute

P.O. Box 923, Talkeetna, AK.
(907) 733-5432 arri@mtaonline.net

July 2008

## A1. Mat-Su FRPA Effectiveness Monitoring

**Aquatic Restoration and Research Institute**

**Project Manager:** Jeffrey C Davis **Date:** 7/31/08

**Quality Assurance Officer:** Gay a davis **Date:** 7/31/08

**Alaska Department of Environmental Conservation**

**Project Manager:** Laura K. Eldred **Date:** 8/12/08

**Quality Assurance Officer:** James Gendron **Date:** 8/14/08

Effective Date:______________________________

## A2. Table of Contents

## A3. Distribution List

Ms. Laura Eldred
Alaska Department of Environmental Conservation
1700 E. Bogard Rd., Bldg B, Suite 103
Wasilla, AK 99654
Ph: 907-376-1855
Laura.eldred@alaska.gov

Mr. Jim Gendron
ADEC Quality Assurance Officer
410 Willoughby Ave., Suite 103
P.O. Box 111800
Juneau, AK 99811
Ph: 907-465-5305
Jim.gendron@alaska.gov

## A4. Project/Task Organization

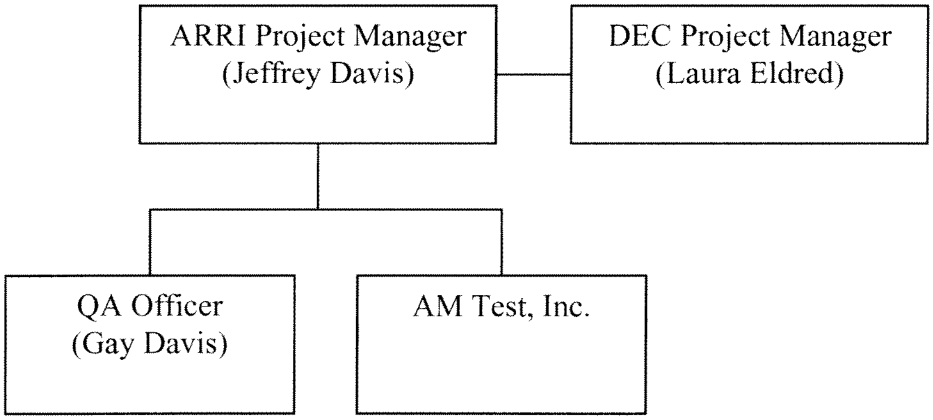
The ARRI project manager listed below will be responsible for all project components including data collection, entry, analyses, and reports.

Laura Eldred (DEC) DEC Project Manager. Ms. Eldred will oversee the project for DEC, provide technical support, QAPP review and approval, review of any proposed sampling plan modifications, and the review of all reports.

Jeffrey C. Davis (ARRI) Project Manager. Mr. Davis will make sure that all field data are collected as specified in the QAPP. He will test and maintain all equipment prior to use and perform the review of data entry and analyses. He will be responsible for preparing all reports.

Gay A. Davis (ARRI) will act as Quality Assurance Officer. Ms. Davis will be responsible for making sure that all data are collected, replicate samples taken and analyzed, and all data entered and analyzed correctly.

AM Test, Inc.—AM Test, Inc. Laboratories, 14603 NE 87th Street, Redmond, WA 98052. AM Test will be responsible for analyzing all collected water samples for the macronutrients nitrogen and phosphorus and providing quality control and quality assurance reports relative to parameters tested.



## A5. Problem Definition/Background

### Growing timber industry

Timber harvesting in the Mat-Su is rapidly expanding with the development of new markets for spruce and hardwood chips. As timber harvest increases in the Mat-Su, the opportunities for timber harvest have decreased in other areas of Region II, most notably on the Kenai Peninsula, where spruce bark beetle infestations have devastated the timber supply. While demand for timber in Region I (Southeast AK) remains high, the state's allowable cut limits the amount of timber that can be harvested, and no increase in timber harvest may occur there. Demand for timber in Region III remains relatively low. Timber harvest in the Mat-Su is increasing at a greater rate than anywhere else in Alaska and almost no FRPA BMP effectiveness monitoring research has been conducted in the area.

### Population

As timber harvest has increased in the Mat-Su, so has its population. The Mat-Su Valley is home to about 80,500 people, and its abundant wildlife and world-class fisheries provide economic and recreational opportunities to a very large constituency living in the area.

### Research deficiency

Due to the limited scale of harvest activity in Region II in the past, little monitoring has been done to determine the effectiveness of the FRPA's best management practices in protecting and maintaining water quality and fish habitat. Most of the work that has been done in Region II has focused on the Kenai Peninsula and its spruce bark beetle infestation. The scarcity of research on the effectiveness of FRPA in Region II (and specifically in Mat-Su) is a problem because conditions in Region II are markedly different from the other regions. A major difference between Region II and the other regions in Alaska are the relatively low values of timber compared to adjacent high-value fish habitat values and recreation opportunities. The risk of impacts to fisheries are greater in Region II than elsewhere because of the greater diversity of fish species, wider distribution of fish, more intense use of the fish populations, and higher productivity of the fish streams.

In 2004, 2005, and 2006, a science and technical committee, followed by an implementation group, developed new riparian standards for Region II. The riparian standards (AS 41.17.116, AS 41.17.118, and AS 41.17.119) apply to state, federal, and private commercial timber lands in the region. Region-wide, timber harvest operations have not been documented to cause adverse effects to fish habitat and water quality. However, neither the old riparian standards nor the new standards have been documented by research to be effective.

A monitoring plan has been developed to evaluate FRPA effectiveness within Region II and the Mat-Su Borough (Davis and Davis 2007; Davis and Davis 2008). The monitoring plan uses reference data collected from stream systems prior to harvest to evaluate potential changes in these conditions following harvest activities. Replication for statistical comparisons is obtained by obtaining reference data from multiple streams of similar classification. Stream condition is described through measures of stream physical, chemical, and biotic characteristics. These characteristics were selected based upon the management intent of the FRPA for riparian areas. The management intent for riparian areas through the FRPA is protection from the adverse effects of timber harvest on fish habitat and water quality. Preservation of fish habitat is accomplished through the maintenance of "short- and long-term sources of large woody debris, streambank stability, channel morphology, water temperatures, stream flows, water quality, adequate nutrient cycling, food sources, clean spawning gravels, and sunlight" (AS 41.17.115).

The FRPA effectiveness monitoring plan has been implemented, obtaining pre-harvest data on four streams within the Willer-Kash state harvest area. These small streams drain the forested slopes of the Talkeetna Mountains, have well developed forested riparian areas, gravel and cobble substrate, moderate slopes, and abundant woody debris. The cold-water streams support spawning and rearing coho and Chinook salmon (Davis and Davis 2008). These streams are representative of systems common within regional forests. However, timber harvest activities are also proposed to be conducted along streams draining the lowland areas within the Susitna and Little Susitna River drainages. These streams often flow through unforested areas of open low scrub or *Calimagrostis* meadows. Stream slopes are low; the substrate is often composed of sand, silt, or organic material; and water temperatures are much higher. These streams provide important coho and Chinook salmon rearing habitat. The response of these stream systems to forest harvest activity likely will differ in comparison to the upland streams.

The objectives of this study are to (1) obtain reference stream condition information on these lowland streams, and (2) obtain post-harvest data following harvest within the Willer-Kash harvest area through the implementation of the FRPA monitoring plan.

## A6. Project/Task Description

**OBJECTIVE 1:** Evaluate the effectiveness of the FRPA by quantifying the physical, chemical, and biological stream characteristics of small lowland streams prior to timber harvest activities.

**TASK 1:** Final site selection, QAPP and Sampling Plan Approval

**Start and end date:** July 1, 2008 – July 31, 2008

**Description:** The ARRI project manager will modify the existing approved QAPP and Sampling Plan for DEC review and approval. Previously approved QAPP and Sampling Plan will be modified for the specific project tasks. We anticipate that only minor modification of the existing plans will be necessary. Through this process we will work with the Division of Forestry and the Mat-Su Borough to finalize site selection. The QAPP and sampling plan will describe in detail the frequency, duration, and location of all proposed sampling, including those listed under separate objectives. They will identify the equipment that will be used and how the equipment will be calibrated and maintained. It will describe the analytical methods that will be used and who will be handling and analyzing the water samples. The methods that will be used to determine data accuracy, precision, and completeness will be outlined. Data handling, management and reporting will be described. It will detail the responsibilities of all staff members and contractors and who will be responsible for each phase of the project. The project manager will coordinate with the DEC project manager to address any inadequacies in the documents. ARRI will focus on completing this task as soon as possible.

**Product:** DEC approved QAPP and Sampling Plan.

**TASK 2:** Obtain measures of stream physical characteristics at different stream locations.

**Start and end date:** July 15, 2008 – June 30, 2009

**Description:** Most of the data will be collected in July through September of 2008; however, some measures (temperature and discharge) will continue in the spring of 2009.

Substratum Size Distribution

The stream bed material provides the primary habitat for aquatic organisms. The size and stability of the channel material is a function of the sediment source and the stream transport capacity. The removal of upland vegetation through timber harvest operations can alter evapotranspiration processes leading to changes in the timing and amplitude of stream hydrographs and channel transport capacity. Mechanical disruption of soil layers and the exposure of mineral soil through yarding and road construction have the potential to increase sediment delivery rates to adjacent streams. Increases in fine sediment (< 2 mm) above transport capacity can have negative effects on aquatic biota through the restriction of water and dissolved oxygen movement through the stream bed material.

Stream substrate and the distribution of fines will be determined through Wolman pebble counts, estimates of percent embeddedness and measures of turbidity (see water chemistry section). Wolman pebble counts will measure the intermediate axis of 100 randomly selected stones within a 100-m long sampling section. Embeddedness is recorded concomitant with pebble counts, and is a semi-qualitative estimate of the portion of the selected stones that are embedded within fine material.

Dependent variables will include D20, D50, and D70 (cumulative percent of bed material with diameters less than or equal to 20 mm, 50 mm, and 70 mm, respectively) and size distribution relative to critical grain size. For embeddedness, the relative percent of the particles embedded over 30% will be used as the dependent variable.

Large Woody Debris

Woody debris provides a number of different functions within stream systems. Woody debris can reduce stream energy and contain sediments. Wood alters flow paths and creates diverse habitats. Large wood is a site of nutrient and organic matter storage and provides a substrate for aquatic invertebrates. The amount of large woody debris within a stream is a function of inputs and transport. Changes in the density of streamside woody vegetation and hydrologic changes can influence the amount and type of debris within a stream.

Large woody debris and debris dams within a 100-m sampling reach will be counted, and measured and identified by plant species within each stream system. An index of woody debris influence on the stream system will be calculated. Dependent variables will include total amount of woody debris per length of stream and the large woody debris index.

### Water Temperature

Stream water temperatures affect most biochemical processes and further define the physical habitat of biotic organisms. Stream water temperatures are the result of a number of factors. Some of these include the surface area exposed to solar energy, which can be affected by the density of riparian vegetation as well as channel width, confinement and aspect. Total stream volume and the portion of surface or subsurface recharge can influence stream water temperatures. Many of these factors are influenced by the community of riparian and upland vegetation.

Stream water temperatures will be measured using HOBO combined temperature and water level loggers. Loggers will be placed within a well-mixed portion of each stream sampling site within proposed harvest units. Loggers will be set to record water temperature every 15 minutes. Dependent variables will be the daily maximum change in temperature, longitudinal temperature differences, and daily maximums as a function of air temperature recorded at regional weather stations.

### Turbidity

Turbidity is a measure of the reflective properties of water and is influenced by the amount of inorganic and organic sediment within the water column. High turbidity levels can affect the feeding and survival of fish and invertebrates. High turbidity is often associated with increased fines within the sediment which can alter the flow path and transport of nutrients and oxygen within and below the stream bed. This has a direct and negative effect on aquatic organisms and incubating fish eggs that are living within the substrate.

Water samples will be collected concurrent with sampling for chemical measures. Water samples will be analyzed for turbidity. Samples will be collected during the rising limb of the hydrograph, when possible.

### Discharge

Stream flow or discharge provides the living space for stream organisms, affects substrate and channel form, water temperatures and sedimentation. Discharge can change with the removal of upland vegetation due to modified rates of snowmelt, interception of precipitation, evapotranspiration and soil infiltration.

Discharge will be measured on each water chemistry sampling date. Discharge will be calculated from the relationship between water level and measured discharge (rating curve). Dependent variables will be timing and volume of peak and base flows relative to total yield, and discharge response to precipitation events.

Solar Radiation

For small streams, the riparian vegetation and surrounding forest absorbs solar radiation, reducing the amount reaching the stream surface. The amount of solar radiation reaching a stream surface affects water temperature and primary productivity. Stream water temperatures can affect the distribution, development rates, and health of fish and invertebrates. Increasing the amount of solar radiation and instream production relative to external organic food sources can cause a change in the invertebrate community.

Solar radiation at the stream surface will be obtained by taking 20 measures distributed systematically throughout the 100-m sampling reach. Measurements will be taken during the spring, summer, and fall. Concurrent measures will be taken of direct solar radiation adjacent to the stream site not shaded by riparian vegetation. Dependent variables will be the portion of total daily solar radiation at stream sites relative to open locations.

**Product:** The project will provide quantitative measures of the physical characteristics of four small lowland streams. Physical data will be presented in the draft and final reports.

**TASK 3:** Obtain measurements of stream chemical characteristics

**Start and end date:** July 15, 2008 – June 30, 2009

**Description:** Most measures will be obtained in July through September of 2008. Spring sampling will be conducted in late May or early June of 2009.

Dissolved oxygen

Oxygen affects the chemical state and physical properties of elements and is required for the respiration of aquatic organisms. The saturation point of oxygen in water varies with water temperature. Oxygen enters the water through diffusion and as a product of photosynthesis. Oxygen is consumed through chemical reactions and biotic respiration. Oxygen concentration should be near saturation in most turbulent streams; however, excessive organic matter, high temperatures, and low turbulence can result in concentrations well below saturation.

Dissolved oxygen concentrations will be measured in the field using oxygen probes and meters concomitant with water chemistry sampling during spring runoff, summer baseflow, and in the fall during plant senescence. Dissolved oxygen readings will be corrected for differences in water temperature and pressure.

Specific Conductance, pH, Hydrocarbons and Foam

Specific conductance is a measure of total ion concentrations and is used as a surrogate for total dissolved solids. Specific conductance is a gross indication of the availability of elements necessary for the growth and survival of biotic organisms.

Ion concentrations within streams reflect the underlying geology as modified by terrestrial processes. Ion concentrations can change as the flow paths from the catchment change. Ion concentrations often decrease when streamflow is composed of surface runoff in greater proportion than groundwater. Similarly, pH is a measure of hydrogen ion concentrations and can be affected by geology, flow pathways, and biological processes. High and low concentrations of hydrogen ions can affect the survival of aquatic organisms.

Depth integrated water samples will be collected in 500 ml sample bottles. The sample bottles will be filled and emptied 3 times before a sample is retained. Water characteristics will be measured using appropriate meters. Support equipment will include extra batteries and sample bottles. Clean sample bottles will be used. All meters will be tested and calibrated prior to use.

Water sampling will be conducted to document water chemistry during snowmelt, base flow conditions, and fall precipitation. May and September sampling will be linked with the rising hydrograph, when possible. Qualitative observations will be made looking for the presence of foam deposits and any oil sheen. Dependent variables will be mean concentrations and the difference in concentration between base flow and surface runoff.

### Macronutrients and Dissolved Organic Carbon

The macronutrients, nitrogen and phosphorus, along with solar radiation, often control the rates of autochthonus production. Nitrogen, while the dominant atmospheric gas, requires microbial fixation prior to use by biological organisms. Nitrogen is made available through the decomposition and release of nitrogen from organic material. Stream nitrogen concentrations often decrease during summer as biological uptake in terrestrial systems increases. Forest timber removal can increase nitrogen availability through increased decomposition while reducing terrestrial uptake resulting in increasing stream concentrations and total annual flux. Phosphorus is primarily from geological sources, but can increase as more mobile oxidized forms are flushed from storage within saturated riparian and wetland soils. Increases in nutrients can cause short-term increases in production followed by reduced productivity as soil storage is diminished and terrestrial uptake increases with forest regeneration. Lowland wetland streams contain high concentrations of dissolved organics. The concentration of these organics, when labile, may provide an important energy source for small wetland streams.

Nitrogen (nitrate + nitrite, ammonium) and phosphorus (total and dissolved), and dissolved organic carbon will be measured at the same frequency as pH and conductivity described above. Water samples will be collected in sample containers provided by AM Test, Inc. or other certified laboratory. Sample bottles will contain preservative where required ($H_2SO_4$ for nitrogen and total phosphorus, 4°C for dissolved phosphorus). Samples will be collected using the "clean hands" method. Samples will be sealed within a cooler with frozen gel-paks and shipped by Federal Express to the laboratory for analyses. Maximum holding time for preserved samples is 28 days; however, sample turn-around is 14 to 21 days. Chain of custody forms will be used by ARRI staff and the receiving laboratory to track sample handling.

**Product:** Project will provide a measure of stream water chemistry at three different seasons. Data will be presented in the draft and final reports or as requested by the DEC project manager.

**TASK 4:** Obtain measures of stream biotic characteristics

**Start and end date:** July 15, 2008 – June 30, 2009

**Description:** Most data collection will occur in the summer and fall of 2008. Spring fish sampling will be conducted in May or early June of 2009.

Periphyton Algae

Instream or autochthonus production in the form of algae or aquatic plants is one of the two major energetic pathways supporting stream organisms. The amount of algae within a stream can increase when productivity is greater than losses to grazing insects and sloughing. As mentioned previously, productivity can increase following forest harvest with increasing temperatures, solar radiation, and nutrients. Chlorophyll-a, a pigment used in photosynthesis, while not a true measure of algal biomass, can be used to indicate increases in stream periphyton.

Algae will be collected from accumulations on natural rocks or artificial substrates. Where natural rocks are not available, non-glazed ceramic tiles will be placed within the stream 4 weeks prior to sampling. Sampling will be conducted during mid-summer when algal biomass should be near maximum seasonal high. Algae will be sampled by scraping a known area of rock or tile and collecting the dislodged material onto a Whatman GF/C filter with 0.45 μm pore site. The algal sample will be analyzed for chlorophyll-a and phaeophyton. Mean chlorophyll-a concentrations will be the dependent variable.

Benthic Organic Matter

Organic matter derived from terrestrial sources, or allochthonous organic matter, is the other major energy source for stream systems. Organic matter on the stream bed is the result of leaves and other terrestrial material deposited in the stream by wind or water. The amount of debris at a given location can be influenced by factors that retain organic material. These include large woody debris and debris dams, stable substrate, and diverse flow habitats (i.e. side channels and pools). The loss of terrestrial vegetation within a watershed can increase discharge during storm events and flush organic material from the stream channel. Dissolved organic matter is leached from terrestrial vegetation or is a product of decomposition and transported to streams. Dissolved organic matter; therefore, is also affected by processes which influence decomposition rates and hydrology.

Benthic organic matter will be collected on one occasion in mid-summer. Benthic organic matter will be collected in nested nets of different pore size held onto a Surber sampler frame. The sampler will be held on the stream bottom and the substrate from a known area upstream of the sampler will be disturbed, dislodging organic matter from the bottom, which will be carried into the nets by the current. The material from each net will be transferred into whirl-pak bags and preserved with alcohol. The ash free dry mass (AFDM) of both the large and small size fractions will be determined through weight loss upon combustion at 500° C.

Dependent variables will be the mean total, coarse, and fine benthic organic matter, and the total dissolved organic matter.

### Macroinvertebrates

The larval stage of aquatic insects and other invertebrates are a diverse group of organisms. The abundance, diversity, feeding habits, and relative density of the many different aquatic organisms have been used to assess changes in water quality and habitat. Macroinvertebrates have been used because of their relative immobility, and differential responses to stream conditions.

Macroinvertebrates will be collected, processed, and analyzed using the standard operating procedures for the Alaska Stream Condition Index (ASCI). Composite invertebrate samples will be placed within pre-labeled whir-pak bags. Paper labels will be placed into the bags with the sample and the sample preserved with ethanol. Labels will include date, time, location, and investigators. Stream invertebrate collections will be returned to the ARRI laboratory, sorted, and identified to genus (except for Chironomidae, Simuliidae, and Oligochaeta). Stream habitat will be evaluated using the habitat assessment methods of ASCI, or EMAP habitat assessment methodology. Sample collection will be conducted in the fall. Dependent variables will include multiple different invertebrate metrics as well as the ASCI score.

### Juvenile Fish

Similar to aquatic insects, egg incubation and juvenile salmon survival depends upon a consistent source of water. Changes in water temperature, dissolved oxygen concentration, volume, turbidity, pH, and food abundance can all affect the distribution and development of resident and anadromous juvenile fish.

Juvenile fish will be collected in baited minnow traps in the spring and fall. We will use a minimum of 10 traps for each site. Traps will be fished for approximately 24 hours. Fish will be identified to species and fork-length measured. The catch for each trap will be determined independently to obtain catch/trap/hour. Fish will be inspected for any deformities, eroded fins, lesions, or tumors (DELT anomalies). Dependent variables will be the total number of juvenile fish by species and the relative amount of different species collected per sample effort.

### Riparian Vegetation and Coarse Woody Debris

The plant community adjacent to streams often differs from the surrounding forest.

Retaining a buffer of natural vegetation around streams is one of the primary means used to maintain natural water chemistry and physical characteristics of streams draining timber harvest areas. The riparian plant community can intercept groundwater flow and nutrients, provide shade, reduce stream energy and retain sediment and nutrients during floodplain inundation. Coarse wood on the forest floor also provides diverse habitat for terrestrial animals. The riparian plant community and trees can be modified following timber harvest by changes in solar input and wind speed, which can affect soil moisture, humidity, and cause blowdowns.

The riparian plant community within the unharvested buffer zone along a representative reach will be classified and all coarse woody debris on the forest floor within the buffer will be counted, measured and identified by species. The dependent variable will be the amount of coarse wood per area within the buffer zone.

**Product:** The results of biotic sampling will be presented in the draft and final reports

**TASK 5:** Data Formatting for STORET, Draft and Final Reports

**Start and end date:** January 1, 2009 – June 30, 2009

**Description:** Sampling locations, dates, methods, and resulting measurement values will be formatted for uploading into the STORET database. Data will either be transferred to DEC or uploaded by ARRI staff.

Draft and final written reports will be prepared. The final report will provide background information and describe why the project is necessary, the project objectives, and the approach that was taken to meet the objectives. Field methods will be described and the project QAPP and sampling plan will be attached. All of the data results will be presented and described relative to the project objectives. We will make recommendations on further data collection, if necessary. Data will be discussed relative to water quality standards and potential impact to aquatic biota. Project success will be determined based upon the completeness of data collection and whether project objectives were accomplished.

Most of the data analyses and draft report work will be conducted prior to the end of the third quarter. We will incorporate the spring 2009 data as results are returned from the laboratory. The final report will be submitted prior to the end of July 2009.

**Product:** The draft report will be submitted to the DEC project manager by the end of the 3rd Quarter. Comments on the draft document will be incorporated and a final document submitted prior to the end of July 2009, or as requested by the DEC project manager.

## A7. Quality Objectives and Criteria for Measurement of Data

The parameters in the following table will be measured at the indicated performance level. All parameters are critical to meeting project objectives. Criteria for Measurements of Data are the performance criteria: accuracy, precision, comparability, representativeness and completeness of the tests. These criteria must be met to ensure that the data are verifiable and that project quality objectives are met.

**Table 1. Accuracy, precision, and completeness objectives for measurement parameters.**

| Parameter | Method | Resolution/ Limit | Expected Range | Accuracy% | Precision | Completeness |
|---|---|---|---|---|---|---|
| pH | Meter | 0.01 | 6.5 to 8.5 | 95 to 105 @ 7.0 | 5% | 95% |
| Turbidity (NTU) | Meter | 0.1 | 1 to 6 | 75 to 125 | 20% | 95% |
| Conductivity (μS/cm) | Meter | 0.1 | 100 to 200 | 95 to 105 @ 100μS/cm | 5% | 95% |
| DO (mg/L) | Meter | 0.01 | 8 to 16 | 95 to 105 @ 10mg/L | 5% | 95% |
| Nitrate-N (mg/L) | EPA 353.2 | 0.010 | 0.05 to 0.5 | 75 to 125 | 20% | 95% |
| Ammonia-N (mg/L) | EPA 350.1 | 0.005 | 0.01 to 0.05 | 75 to 125 | 20% | 95% |
| Total-P (mg/L) | EPA 365.3 | 0.005 | 0.001 to 0.005 | 75 to 125 | 20% | 95% |
| Dissolved-P (mg/L) | EPA 365.3 | 0.001 | 0.001 to 0.005 | 75 to 125 | 20% | 95% |
| Chlorophyll-a (mg/m$^2$) | SM 1002G | 0.03 | 1 to 50 | 75 to 125 | 20% | 95% |
| Benthic Organic Matter (mg/m$^2$) | SM 2540G | 0.1 | 1 to 50 | 75 to 125 | 20% | 95% |
| Large Woody Debris | Counts/100 -m | 1 | 0 to 20 | N/A | N/A | 95% |
| Coarse Woody Debris | Counts | 1 | 1 to 200 per 100m | N/A | 25% | 95% |
| Substratum (mm) | Wolman Counts | N/A | 0.2 to 500 | N/A | 10% | 95% |
| Substratum Embeddedness | Visual Estimate | 10% | 0 to 100% | N/A | N/A | 95% |
| Substratum percent fines | Benthic Grab | 0.01 mm | 0 to 100 g | N/A | N/A | 95% |
| Macroinvertebrates | ASCI | N/A | N/A | N/A | 20% | 95% |
| Juvenile Fish | Minnow Traps | 1.0 | 0 to 20/hr | N/A | 25% | 95% |
| Solar Radiation (μmol/m$^2$/s) | Meter | 0.01 | 20 to 2000 | 75 to 125 | N/A | 95% |
| Temperature (°C) | Hobo | 0.1 | 0 to 15 | 97 to 103 @ 15°C | 5% | 95% |
| Discharge (m$^3$/s) | Measure | 1 | 15 to 40 | N/A | 10% | 95% |

## Quality Assurance Definitions

Accuracy

*Accuracy is a measure of confidence that describes how close a measurement is to its "true" value. Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures.*

$$Accuracy = \frac{MeasuredValue}{TrueValue} \times 100$$

Precision

*Precision is the degree of agreement among repeated measurements of the same characteristic, or parameter, and gives information about the consistency of methods. Precision is expressed in terms of the relative percent difference between two measurements (A and B).*

$$\Pr ecision = \frac{(A - B)}{((A + B)/2)} \times 100$$

Representativeness

*Representativeness is the extent to which measurements actually represent the true condition. Measurements that represent the environmental conditions are related to sample frequency and location relative to spatial and temporal variability of the condition one wishes to describe.*

Comparability

*Comparability is the degree to which data can be compared directly to similar studies. Standardized sampling and analytical methods and units of reporting with comparable sensitivity will be used to ensure comparability.*

Completeness

*Completeness is the comparison between the amounts of usable data collected versus the amounts of data called for.*

## Quality Assurance for Measurement Parameters

Accuracy

The percent accuracy for the acceptance of data is shown for each parameter in Table 1. Accuracy will be determined for those measurements where actual values are known. For pH, conductivity, turbidity, and dissolved oxygen, measurements of commercially purchased standards within the range of expected values will be used. For dissolved oxygen, 100% saturated air will be used as a standard. Measurements of accuracy will be determined for each sampling event. Contract laboratories will provide the results of accuracy measures along with chemical analytical reports. Accuracy for Stowaway temperature loggers has been calculated to be 0.40°C by the manufacturer, which at 15°C is 97% to 103%. Accuracy will not be determined where true values are unknown: substratum, macroinvertebrates, and discharge. However, for discharge, the velocity meter will be spin tested as per manufacturer's recommendation prior to each use. Accuracy of discharge rating curves will be determined by comparing measured value (as actual) with calculated value.

### Precision

Table 1 shows the precision value for the acceptance of data. Precision will be determined for all chemical measures by processing a duplicate for every 8 samples. A discharge measure will be repeated at one site on one occasion to determine measurement precision. Precision of stowaway meters will be determined by placing all meters in one location for 24 hours. Precision for substratum size distribution will be determined by repeating the pebble count at one location and comparing the number of stones within each size class.

### Representativeness

The monitoring design site locations, sampling frequency, and timing will ensure that the measurement parameters adequately describe and represent actual stream conditions for the sampling period. Chemical measures should represent baseflow conditions. Repeated measures over multiple years are necessary to describe the variability among years.

### Comparability and Completeness

The use of standard collection and analytical methods will allow for data comparisons with previous or future studies and data from other locations. We expect to collect all of the samples, ensure proper handling, and ensure that they arrive at the laboratory and that analyses are conducted. Our objective is to achieve 100% completeness for all measures. Sample collection will be repeated if problems arise such as equipment malfunction or lost samples. For spring runoff samples, due to laboratory turnaround time, repeating sample collection may need to occur the following year.

## Data Management

Field data will be entered into rite-in-the-rain books. The quality assurance officer will copy the field books and review the data to ensure that it is complete and check for any errors. Field and laboratory data sheets will be given to the project manager. The project manager will enter data into Excel spreadsheets. The quality assurance officer will compare approximately 10% of the field and laboratory data sheets with the Excel files. If any errors are found they will be corrected and the project manager will check all of the field and laboratory data sheets with the Excel files. The quality assurance officer will then verify correct entry by comparing another 10% of the sheets. This process will be repeated until all errors are eliminated. The project manager will then summarize and compare the data and submit it to a statistician for review or analyses. The quality control officer will review any statistical or other comparisons made. The project manager will write the final report, which will be proofed by the quality assurance officer and the DEC project manager. The DEC project manager will distribute the report for peer review. The quality assurance officer will check the results in the report and associated statistical error (i.e. standard deviation and confidence interval) against those calculated with computer programs. Any errors found will be corrected by the project manager. Any errors will be corrected.

Water quality data collected by the project will be provided to DEC in accordance with guidance and templates at, http://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm.

## A8. Special Training Requirements/Certification Listed

Jeffrey C. Davis (Project Manager) has a B.S. degree in Biology from University of Alaska Anchorage and a M.S. degree in Aquatic Ecology from Idaho State University. He has 17 years of experience in stream research. Mr. Davis has experience in all of the assessment techniques outlined in this document. He has experience in laboratory chemical analyses, macroinvertebrate collection pursuant to the USGS NAWQA program, the EPA Rapid bioassessment program, modification of these methodologies for Idaho and Alaska. Mr. Davis also has experience in aquatic invertebrate and vertebrate species identification.

Gay Davis (Quality Assurance Officer) has a B.S. degree In Wildlife Biology from the University of Maine. She has 16 years of experience in stream restoration and evaluation. Ms. Davis has over 10 years of experience in stream ecological field assessment methods and water quality sampling.

Chemical analyses will be conducted through AM Test, Inc. in Redmond, Washington.

With the combined experience of these investigators, no additional training will be required to complete this project.

## A9. Documentation and Records

Field data including replicates measures for quality assurance will be recorded in Rite-in-the-Rain field books. Upon returning to the laboratory, the field book will be photocopied (daily or weekly). The field data book will be kept and stored by the project manager and the quality assurance officer will store the photocopies. ARRI will maintain records indefinitely. The final data report will include as appendices Excel data sheets, and results of QC checks. Any sampling problems will be recorded on the data sheets and included in the field sampling report. Laboratory reporting and requested laboratory turn around times of 6 to 10 days are discussed in section B4.

**Reporting Requirements**

- Quarterly Reports: Quarterly progress, financial, and MBE/WBE reports will be submitted for the periods ending **September 30, 2008**, **December 31, 2008 and March 31, 2009.** Reports are due 15 days after the final date of the quarter and are considered late if received more than 15 days after these dates. A final progress, financial, MBE/WBE reports, and all required deliverables are due **July 31, 2009, and are considered late if received after that date**. All reports will be submitted in written and electronic formats requested by DEC.

- Monitoring Data Entry. In addition to a written project report, any water quality monitoring data collected by the project will be provided to the DEC in accordance with the guidance and templates provided at: http://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm. The guidance and templates show the layout required for STORET compatible files and detail the valid values for various fields used in STORET (e.g. characteristics, analytic procedures, HUCs, etc). The data will be provided to DEC electronically via email, CD, diskette, or via an FTP website (to be determined). All data collected by Dec 31, 2008 will be furnished to DEC by March 31, 2009, and all data collected by the project will be furnished to DEC by July 31, 2009.

- Project Photographs. At least 3 electronic photograph(s) of the project will be submitted in a format suitable for publishing. Additional project photos are appreciated. These photos will represent all of the following: the problem the project addresses, the project in progress, and the environmental benefit of the project. At least one of these photos must be submitted with the first quarterly report; the remainder will be submitted with the final report or sooner if available. Each photo will be at least 800 x 600 pixels in size and in JPEG format or other format acceptable to the department. Included will be background information on what the photo represents and when and where it was taken. If possible, the information will be in the photo's file name, such as "Fish_Ck_samplesite1_iron_floc_101608". Alternatively, it may be provided with a caption that states the date, location, and describes the subject: for example "MCV-023X.JPG. Taken 10-16-08, Ditch along south side of Alaska Highway that empties into Fish Creek: Note channelization."

- Final Report Evaluating Project Accomplishments and Benefits:
  A final report will be produced that evaluates and describes the project accomplishments and their environmental benefit. These environmental benefits will be determined by the reference information that is collected from representative streams. Data will be collected from sampling reaches on three or four small wetland streams. However, the data will be representative of similar stream types ubiquitous within the Susitna River drainage. These data can be used to evaluate changes to stream conditions due to forest harvest activities. The data also can be used to assess potential impacts related to recreational use or residential development.

- Deliverables: (at least 1 electronic and 3 hard copies of each)
  In addition to submitting the information identified in the reporting requirements, the following products will be delivered to the Department. All written products will be submitted to the department in both hard copy and electronic format.

| | |
|---|---|
| Draft QAPP and Sampling Plan | July 15, 2008 |
| Final QAPP and Sampling Plan | July 31, 2008 |
| Draft Final Report | April 15, 2009 |
| Final Project Report | July 31, 2009 |

## B1. Sampling Process Design

### Study Design

Treatment

The treatment will be timber harvest conducted under the guidelines of the FRPA and regulations for state land within Region II. Actual timber harvest operations will be determined by the timber operator. Therefore, actual treatment can vary considerably. Sources of variation include the number, location, density, and type of spur roads, landings, and material sites; whether the area will be harvested in summer or winter, how the wood will be processed (on- or off-site), and the harvest's proximity to buffers and stream terraces. Therefore, the type of harvest will be closely monitored and recorded. Information on harvest activities will likely be obtained from the State Forester.

Hypothesis and Statistical Approach

A paired (pre- and post-harvest) sampling approach will be applied. This approach would allow for statistical comparisons using paired T-test or non-parametric alternatives for the first post-treatment measure with repeated measures using ANOVA thereafter. The approach will provide a means for evaluation of BMP effectiveness that could be expanded over time and space to include harvests occurring along other stream types and over a larger geographical area. In addition, over time, the approach will allow for comparisons of sites for multiple stream types with different levels of area harvested and road construction methods. Under this approach, stream types within a harvest area will be identified through the Forest Land Use Plan (FLUP) development or upon the submission of Detailed Plans of Operation (if the harvest is on private land). Sampling reaches will be identified on each stream type or a subset of available stream types. Sample reaches will be selected with reference to the area of proposed upstream harvest and miles and type of proposed road construction (winter or all season, number of crossings, etc.). Pre-harvest data will be collected from each sampling reach. Following timber harvest, sampling would be repeated. Changes between pre- and post-harvest parameters will be analyzed; however, similar trends would need to be observed among all stream types for differences to be statistically significant. This approach is more cost efficient and more sensitive to change than the comparison of means or variability among reference and treatment groups, and does not require a large set of reference streams within a timber harvest area. In addition, by tracking the amount and type of harvest within each stream drainage, like comparisons can be ensured.

## Study Area and Sampling Locations

Sampling sites will be located on one upland stream within the Willer-Kash Harvest Area and four lowland streams distributed throughout the Mat-Su Borough, and located on both state and Mat-Su Borough lands. Descriptions of the study sites are as follows.

WK2. This site is an upland stream located within the Willer-Kash harvest area. The stream is the northern tributary to Iron Creek. The study site is located upstream from the road crossing and is within an area scheduled to be harvested as part of the Copper Timber Sale.

Whiskers Creek. This site is a pre-harvest lowland site. The site is located on Mat-Su Borough land and is within the proposed Whiskers Creek Forest Management Unit. Whiskers Creek (62.38002 N x 150.16841 W) is located north of the community of Talkeetna between the Susitna and Chulitna Rivers, and flows into the Susitna River.

Wiggle Creek. This site is a lowland stream reference site. Timber harvest is not proposed to occur along this stream. The site is located (62.26953N x 150.26258W) north of the community of Talkeetna and is a tributary to the Talkeetna River.

Fish Creek. This site is a pre-harvest lowland site. The site is located on state land and is within the Fish Creek #1 Timber Sale area. Fish Creek flows into Flathorn Lake near Cook Inlet. The site is located (61.53169N x 150.26258W) within section 25 of T17N, R5W of the Seward Meridian.

Chijik Creek. This stream is a pre-harvest lowland site located on Mat-Su Borough land. The stream is a tributary to Kroto Creek. The proposed site (62.08036N x 150.58125W) will be located upstream from the previous harvest location near Oilwell Road.

## Sample Measurements, Frequency, and Dependent Variables

The monitoring plan requires the description of the physical, chemical, and biological parameters to be measured, measurement frequency and duration, and methods of parameter measurement (qualitative or quantitative). Stream parameters were selected based upon applicable State Water Quality Standards (18 AAC 70) and the statutory regulatory intent for riparian areas. The management intent for riparian areas is the maintenance of large woody debris (LWD), bank stability and channel morphology, water temperature, water quality including nutrient cycling, food sources (for fish), clean (free of fine sediment and organics) spawning gravel, and sunlight (AS 41.17.115). Applicable water quality parameters include dissolved oxygen, pH, specific conductance (surrogate for total dissolved solids (TDS)), fine sediment, petroleum hydrocarbons, and debris. Sampling frequency for water chemistry is hierarchical so that level 1 sampling frequency is obtained at all stream sites with more detailed level 2 sampling at a portion of the total sites. Proposed sample parameters, frequency, and measurement methods are listed in Table 3.

## Physical Characteristics

### Substratum Size Distribution

The stream bed material provides the primary habitat for aquatic organisms. The size and stability of the channel material is a function of the sediment source and the stream transport capacity. The removal of upland vegetation through timber harvest operations can alter evapotranspiration processes leading to changes in the timing and amplitude of stream hydrographs and channel transport capacity. Mechanical disruption of soil layers and the exposure of mineral soil through yarding and road construction have the potential to increase sediment delivery rates to adjacent streams. Increases in fine sediment (< 2 mm) above transport capacity can have negative effects on aquatic biota through the restriction of water and dissolved oxygen movement through the stream bed material.

Stream substrate and the distribution of fines will be determined through Wolman pebble counts, estimates of percent embeddedness and measures of turbidity (see water chemistry section). Wolman pebble counts will measure the intermediate axis of 100 randomly selected stones within a 100-m long sampling section. Embeddedness is recorded concomitant with pebble counts, and is a semi-qualitative estimate of the portion of the selected stones that are embedded within fine material. As substratum is largely a function of peak flows, initial sampling frequency should be annual. Potential forestry effects should diminish with regeneration, so sampling frequency can decrease to every other year following the first 5 years.

Dependent variables will include D20, D50, and D70 (cumulative percent of bed material with diameters less than or equal to 20 mm, 50 mm, and 70 mm, respectively) and size distribution relative to critical grain size. For embeddedness, the relative percent of the particles embedded over 30% will be used as the dependent variable.

### Large Woody Debris

Woody debris provides a number of different functions within stream systems. Woody debris can reduce stream energy and contain sediments (Estep and Beschta 1985, Buffington and Montgomery 1999). Wood alters flow paths and creates diverse habitats. Large wood is a site of nutrient and organic matter storage and provides a substrate for aquatic invertebrates. The amount of large woody debris within a stream is a function of inputs and transport. Changes in the density of streamside woody vegetation and hydrologic changes can influence the amount and type of debris within a stream.

Large woody debris will be counted and measured (length and width) and identified by plant species within each stream system. An index of woody debris influence on the stream system will be calculated. Dependent variables will include total amount of woody debris per length of stream and the large woody debris index (Davis et al. 2001).

### Water Temperature

Stream water temperatures affects most biochemical processes and further defines the physical habitat of biotic organisms. Stream water temperatures are the result of a number of factors. Some of these include the surface area exposed to solar energy, which can be affected by the density of riparian vegetation as well as channel width, confinement and aspect (Johnson 2004, Poole and Berman 2001). Total stream volume and the portion of surface or subsurface recharge can influence stream water temperatures. Many of these factors are influenced by the community of riparian and upland vegetation.

Stream water temperatures will be measured using Onset Watertemp Pro V2 temperature loggers and Onset combined temperature and water level loggers. Loggers will be placed within a well-mixed portion of each stream sampling site within proposed harvest units and on the stream margin to record air temperature. Loggers will be set to record water temperature every 15 minutes. Dependent variables will be the daily maximum change in temperature, longitudinal temperature differences, and daily maximums as a function of air temperature recorded at the Talkeetna and Palmer Airports and local air temperatures.

### Turbidity

Turbidity is a measure of the reflective properties of water and is influenced by the amount of inorganic and organic sediment within the water column. High turbidity levels can affect the feeding and survival of fish and invertebrates. High turbidity is often associated with increased fines within the sediment which can alter the flow path and transport of nutrients and oxygen within and below the stream bed. This has a direct and negative effect on aquatic organisms and incubating fish eggs that are living within the substrate.

Stream water turbidity will be measured during the rising limb of the hydrograph during storm events using meters and automated samplers. Maximum turbidity and the change in turbidity following storms and spring runoff will be used as dependent variables.

### Discharge

Stream flow or discharge provides the living space for stream organisms, affects substrate and channel form, water temperatures and sedimentation. Discharge can change with the removal of upland vegetation due to modified rates of snowmelt, interception of precipitation, evapotranspiration and soil infiltration.

Discharge will be monitored continuously using pressure gauges and data recorders or directly measured concurrent with water sampling. A rating curve will be developed through the relationship between physical measures of discharge on multiple occasions. Dependent variables will be timing and volume of peak and base flows relative to total yield, and discharge response to precipitation events.

### Solar Radiation

For small streams, the density of riparian vegetation and surrounding forest absorbs solar radiation reducing the amount reaching the stream surface. The amount of solar radiation reaching a stream surface affects water temperature and primary productivity. Stream water temperatures can affect the distribution, development rates, and health of fish and invertebrates. Increasing the amount of solar radiation and instream production relative to external organic food sources can cause a change in the invertebrate community.

Solar radiation at the stream surface will be obtained by taking 20 measures distributed systematically throughout the 100-m sampling reach. Concurrent measures will be taken of direct solar radiation adjacent to the stream site not shaded by riparian vegetation. Dependent variables will be the portion of total daily solar radiation at stream sites relative to open locations.

## Chemical Characteristics

### Dissolved Oxygen

Oxygen affects the chemical state and physical properties of elements and is required for the respiration of aquatic organisms. The saturation point of oxygen in water varies with water temperature. Oxygen enters the water through diffusion and as a product of photosynthesis. Oxygen is consumed through chemical reactions and biotic respiration. Oxygen concentration should be near saturation in most turbulent streams; however, excessive organic matter, high temperatures, and low turbulence can result in concentrations well below saturation.

Dissolved oxygen concentrations will be measured in the field using oxygen probes and meters concomitant with water chemistry sampling during spring runoff, summer baseflow, and in the fall during plant senescence. Dissolved oxygen reading will be corrected for differences in water temperature and pressure.

### Specific Conductance, pH, Hydrocarbons and Foam

Specific conductance is a measure of total ion concentrations and is used as a surrogate for total dissolved solids. Specific conductance is a gross indication of the availability of elements necessary for the growth and survival of biotic organisms. Ion concentrations within streams reflect the underlying geology as modified by terrestrial processes. Ion concentrations can change as the flow paths from the catchment change. Ion concentrations often decrease when streamflow is composed of surface runoff in greater proportion than groundwater. Similarly, pH is a measure of hydrogen ion concentrations and can be affected by geology, flow pathways, and biological processes. High and low concentrations of hydrogen ions can affect the survival of aquatic organisms.

Water sampling will be conducted to document water chemistry during snowmelt, base flow conditions, and fall precipitation. Water samples will be collected in late July, late September, and May. May and September sampling will be linked with the rising hydrograph, when possible.

Qualitative observations will be made looking for the presence of foam deposits and any oily sheen, which may be indicative of hydrocarbon pollution. The presence of an oily sheen prior to road construction and timber harvest will be an indication of natural causes.

Macronutrients

The macronutrients, nitrogen and phosphorus, along with solar radiation, often control the rates of autochthonus production. Nitrogen, while the dominant atmospheric gas, requires microbial fixation prior to use by biological organisms. Nitrogen is made available through the decomposition and release of nitrogen from organic material. Stream nitrogen concentrations often decrease during summer as biological uptake in terrestrial systems increases. Forest timber removal can increase nitrogen availability through increased decomposition while reducing terrestrial uptake resulting in increasing stream concentrations and total annual flux. Phosphorus is primarily from geological sources, but can increase as more mobile oxidized forms are flushed from storage within saturated riparian and wetland soils. Stream increases in nutrients can cause short-term increases in production followed by reduced productivity as soil storage is diminished and terrestrial uptake increases with forest regeneration.

Nitrogen (nitrate + nitrite, ammonium, and organic) and phosphorus (total and dissolved) will be measured at the same frequency as pH and conductivity described above.

**Biological Characteristics**

Periphyton Algae

Instream or autochthonus production in the form of algae or aquatic plants is one of the two major energetic pathways supporting stream organisms. The amount of algae within a stream can increase when productivity is greater than losses to grazing insects and sloughing. As mentioned previously, productivity can increase following forest harvest with increasing temperatures, solar radiation, and nutrients. Chlorophyll-a, a pigment used in photosynthesis, while not a true measure of algal biomass, can be used to indicate increases in stream periphyton.

Algae will be collected from accumulations on natural rocks or artificial substrates. If natural rocks are not present, non-glazed ceramic tiles will be placed within the stream at 5 locations, 4 weeks prior to sampling. Sampling will be conducted during mid summer when algal biomass should be near maximum seasonal high. Algae will be collected on filters, frozen, and transported to an analytical laboratory for chlorophyll-a analyses. Samples will be collected once a year for three to five years following harvest and then on five year intervals. Sampling will be conducted in late July during the peak growing season. Mean chlorophyll-a concentrations will be the dependent variable.

Benthic and Dissolved Organic Matter

Organic matter derived from terrestrial sources, or allochthonous organic matter, is the other major energy source for stream systems. Organic matter on the stream bed is the result of leaves and other terrestrial material deposited in the stream by wind or water. The amount of debris at a given location can be influenced by factors that retain organic material. These include large woody debris and debris dams, stable substrate, and diverse flow habitats (i.e. side channels and pools). The loss of terrestrial vegetation within a watershed can increase discharge during storm events and flush organic material from the stream channel. Dissolved organic matter is leached from terrestrial vegetation or is a product of decomposition and transported in water to streams. Dissolved organic matter;

therefore, is also affected by processes which influence decomposition rates and hydrology.

Benthic organic matter will be collected on one occasion in mid-summer by dislodging the bed material at 5 randomly selected points within the sampling reach and collecting the resuspended material in mesh nets. The material will be divided into coarse and fine fractions. The amount of organic material will be based upon the mass lost upon ignition or the ash free dry mass. Dissolved organic matter will be collected concomitantly with water samples collected for chemical analyses.

Dependent variables will be the mean total, coarse, and fine benthic organic matter, the maximum dissolved organic matter and the variability in dissolved organic matter with changes in stream flow.

### Macroinvertebrates

The larval stage of aquatic insects and other invertebrates are a diverse group of organisms. The abundance, diversity, feeding habits, and relative density of the many different aquatic organisms have been used to assess changes in water quality and habitat (Allen et al. 2003, Plafkin et al. 1989). Macroinvertebrates have been used because of their relative immobility, and differential responses to stream conditions.

Macroinvertebrates will be sampled using the technical level Alaska Stream Condition Index (ASCI) methodology. Sample collection will be conducted either in the spring, autumn, or both occasions. Dependent variables will include multiple different invertebrate metrics as well as the ASCI score.

### Juvenile Fish

Similar to aquatic insects, egg incubation and juvenile salmon survival depends upon a consistent source of water. Changes in water temperature, dissolved oxygen concentration, volume, turbidity, pH, and food abundance can all affect the distribution and development of resident and anadromous juvenile fish (Murphy and Milner 1997).

Juvenile fish will be collected in baited minnow traps in the spring and fall. Fish will be identified to species and fork-length measured. Fish will be inspected for any deformities, eroded fins, lesions, or tumors. Dependent variables will be the total number of juvenile fish by species and the relative amount of different species collected per sample effort.

### Riparian Vegetation and Coarse Woody Debris

The plant community surrounding streams often differs from the surrounding forest. Retaining a buffer of natural vegetation around streams is one of the primary means used to maintain natural water chemistry and physical characteristics of streams draining timber harvest areas. The riparian plant community can intercept groundwater flow and nutrients, provide shade, reduce stream energy and retain sediment and nutrients during floodplain inundation. Coarse wood on the forest floor also provides diverse habitat for terrestrial animals.

**Table 2. Stream sample parameters and sampling frequency.**

| Sample Parameter | Frequency (prior to and 1-5years post harvest) | Frequency (6 to 10+ years post harvest) | Methods |
|---|---|---|---|
| **Physical** | | | |
| Substratum | Annual | Biannual | Wolman Pebble Counts, Percent Embeddedness |
| Temperature | Continuous (May - Oct) | Continuous for One Year, Every 5 years. | Data Loggers |
| Flow (Level 1) | Concurrent with Water Chemistry Sampling | Concurrent with Water Chemistry Sampling, Every 5 years. | Direct Measure |
| Flow | Continuous (May – Oct) | Continuous (May – Oct) | Pressure Data Logger and rating curve |
| Morphometery (cross-section, confinement, sinuosity) | Annual | Every 5 years | Surveys |
| Large Woody Debris | Annual | Every 5 years | Counts/LWDI |
| Solar Radiation | Three times a year, spring, summer, and fall | Three times a year, spring, summer, and fall, Every 5 years | Pyranometer or PAR meters |
| **Level 1 Water Chemistry** | | | |
| Turbidity | Three times a year, spring breakup, summer baseflow, and fall storm events) | Three times a year, spring, summer, and fall, Every 5 years | Water Sample Analyses—Meter Measurement |
| Dissolved Oxygen | Three times a year, spring breakup, summer baseflow, and fall storm events) | Three times a year, spring, summer, and fall, Every 5 years | Water Sample Analyses—Meter Measurement |
| pH | Three times a year, spring | Three times a year, spring, | Water Sample Analyses— |

| **Sample Parameter** | **Frequency (prior to and 1-5years post harvest)** | **Frequency (6 to 10+ years post harvest)** | **Methods** |
|---|---|---|---|
| | breakup, summer baseflow, and fall storm events) | summer, and fall, Every 5 years | Meter Measurement |
| Specific Conductance | Three times a year, spring breakup, summer baseflow, and fall storm events) | Three times a year, spring, summer, and fall, Every 5 years | Water Sample Analyses—Meter Measurement |
| Hydrocarbons/Foam | Concurrent with water sampling | Concurrent with water sampling | Qualitative Observations |
| Nutrients ($NO_3$-N, $NH_4$-N, Total-P, Dissolved P) | Three times a year, spring breakup, summer baseflow, and fall storm events) | Three times a year, spring, summer, and fall, Every 5 years | Water Sample Laboratory Analyses |
| **Level 2 Water Chemistry** | | | |
| Turbidity | Weekly (Spring) Biweekly or Continuous (May – Oct) | Weekly (Spring) Biweekly Every 5 years (May – Oct) | Water Sample Analyses—Meter Measurement |
| Dissolved Oxygen | Weekly (Spring), Biweekly (May – Oct) | Weekly (Spring) Biweekly Every 5 years (May – Oct) | Water Sample Analyses—Meter Measurement |
| pH | Weekly (Spring), Biweekly or Continuous (May – Oct) | Biweekly Every 5 years (May – Oct) | Water Sample Analyses—Meter Measurement |
| Specific Conductance | Biweekly (May – Oct) | Biweekly Every 5 years (May – Oct) | Water Sample Analyses—Meter Measurement |
| Hydrocarbons/Foam | Biweekly (May – Oct) | Biweekly Every 5 years (May – Oct) | Qualitative Observations |
| Nutrients ($NO_3$-N, $NH_4$-N, Total-P, Dissolved P) | Weekly (Spring), Biweekly (May – Oct) | Biweekly Every 5 years (May – Oct) | Water Sample Laboratory Analyses |
| **Biological Organisms/Food Sources** | | | |
| Fish (juvenile) | Biannual (Spring and Fall) | Biannual (Spring and Fall) | Baited Minnow Traps |
| Macroinvertebrates | Annual | Every 5 years | ASCI |
| Periphyton Biomass | Annual | Every 5 years | Accumulation on tiles |

| **Sample Parameter** | **Frequency (prior to and 1-5years post harvest)** | **Frequency (6 to 10+ years post harvest)** | **Methods** |
|---|---|---|---|
| Benthic Organic Matter | Annual | Every 5 years | Substrate Samples (AFDM) |
| Dissolved Organic Matter | Spring Runoff, Base Flow, and Fall Storm Events (May – Oct) | Every 5 years | Water sample analyses |
| Riparian Vegetation Community Composition | Annual | Every 5 years | Qualitative classification |
| Riparian Coarse Wood | Annual | Every 5 years | Counts of Coarse Wood Within Riparian. |

The riparian plant community and trees can be modified following timber harvest by changes in solar input and wind speed, which can affect soil moisture, humidity, and cause blowdowns.

The riparian plant community within the unharvested buffer zone along the sampling reach will be classified lateral to channel-morphometry transects to 100 m. Coarse wood surveys will be conducted along one bank. All coarse woody debris (>10 cm diameter and 1-m long) on the forest floor within the riparian area along the 100-m sampling reach and extending 30-m lateral to the channel will be counted and identified by species. Coarse wood will be placed into three distinct diameter categories (greatest diameter is from 10 to 20 cm, 21 to 30 cm, and > 30 cm) and three distinct length categories (1 to 5 m, 6 to 10 m, and > 11 m).

**External Data**

Discharge and weather data will be obtained from U.S. government agency web sites. Weather data downloaded or purchased through the National Oceanic and Atmospheric Administration (NOAA) web site (http://www.ncdc.noaa.gov/oa/ncdc.html).

**Sample Timing**

To minimize diel variability, water sample collection will be standardized to the time between 10:00 AM to 4:00 PM.

## B2. Sampling Methods Requirements

Field Data Collection

Field data collection will be conducted by ARRI staff. Latitude and longitude of sampling locations will be recorded using a GPS recorder. Photographs will be used to further identify locations and conditions during field sampling. Measures of dissolved oxygen, pH, specific conductance and temperature will be conducted in the field. Samples for turbidity and alkalinity will be collected in clean sample bottles and returned to the ARRI laboratory for analyses. Samples will be collected from a well-mixed area at each sampling site. Water-column integrated samples will be collected by drawing water into a 60 ml syringe while drawing the syringe up from near the stream bottom to near the water surface. The water within the syringes will be discharged into pre-labeled sample bottles.

pH, Specific Conductance, Turbidity, and Dissolved Oxygen

Depth integrated water samples will be collected in 500 ml sample bottles. The sample bottles will be filled and emptied 3 times before a sample is retained. Water characteristics will be measured using appropriate meters. Meters, pH, Hanna HI 9023, conductivity, SPER Scientific model 840039, and turbidity, LaMotte TC-3000e. Support equipment will include extra batteries and sample bottles. Clean sample bottles will be used. All meters will be tested and calibrated prior to use.

Materials Required: Data book, pencils, sharpie, 500-ml sample bottles (16 minimum), labels, 60-ml syringe, cooler, gel-paks, pH meter with standards, dissolved oxygen meter, thermometer, extra batteries, and camera.

### Weather Conditions

Weather conditions for the 24 hours previous to sampling will be obtained through direct observations and from on-line National Weather Service Website for Talkeetna.

### Site Locations and Photographs

Latitude and longitude of sampling locations will be recorded using a GPS recorder. Photographs will be used to further identify locations and changing seasonal riparian and stream conditions during field sampling.

Materials Required: Garmin GPS III and Nikon Coolpix L5 digital camera.

### Nitrogen and Phosphorus

Water samples will be collected in sample containers provided by AM Test, Inc. Sample bottles will contain preservative where required ($H_2SO_4$ for nitrogen and total phosphorus, 4°C for dissolved phosphorus). Samples will be collected using the "clean hands" method. This method required two samplers, one to handle sample labels, containers and other equipment. The second sampler, while wearing sterile gloves, collects the sample and within sterile syringes or other sampling device and discharges the sample into the sample container. Sterile procedures are maintained. Samples will be sealed within a cooler with frozen gel-packs and shipped by Federal Express or UPS to the laboratory for analyses. Chain of custody forms will be used by ARRI staff and the receiving laboratory to track sample handling.

Materials Required: sample bottles, labels, markers, chain-of-custody forms, cooler, frozen gel-packs, 60-cc syringe, syringe filters, thermometer, and sterile gloves.

### Temperature

Stream water temperature data loggers (Water Temp Pro V2 by Onset Corporation) will be placed within each stream within the area of proposed harvest units. Loggers will be secured to the bank using plastic coated wire rope. Loggers will be downloaded concurrent with water samples.

Materials Required: 4-m sections of wire rope (3), clamps (6), temperature data loggers with backup (4), software, base station, coupler, and shuttle.

### Solar Radiation

Solar radiation at the stream surface will be obtained by taking 20 measures distributed systematically throughout the 100-m sampling reach. Concurrent measures will be taken of direct solar radiation adjacent to the stream site not shaded by riparian vegetation. Dependent variables will be the portion of total daily solar radiation at stream sites relative to open locations.

Materials Required. Light meter and sensor.

Discharge

Discharge will be measured using the methods of Rantz et al. (1982). A meter tape will be suspended across the stream. Water velocity will be measured at multiple intervals across the stream using a Price AA or Swofffer 3000 velocity meter. The meter will be spin tested prior to use. A top-setting wading rod will be used to ensure velocity is measured at 0.6 depth. Water level loggers will be secured at each discharge sampling points and a rating curve developed to calculate discharge when direct measurements are not possible. Discharge will be measured or estimated from the rating curve on each sampling date.

Materials Required: Rite-in-the-Rain data book, pencils, Onset water level loggers, nylon rope, 2"pvc vented with caps, 100-meter tape, top-setting wading rod, and velocity meter.

Substratum/Embeddedness

Substratum size distribution will be determined through Wolman (Wolman 1954) pebble counts of 100 stones as modified by Bevenger and King (1995). Beginning at the downstream end of the sampling reach, the intermediate axis of rocks is measured at roughly one-meter intervals as the investigator moves upstream, continually moving at an angle from bank to bank. The rock axis will be determined using an aluminum measuring template. The portion of each rock submerged below the substrate will be estimated from differences in algae or other markings on the rock and recorded as percent embedded (Davis et al. 2001).

Materials Required: Rite-in-the-Rain data book, pencils, aluminum template, meter stick.

Morphometry

Stream cross-sections will be measured using a laser level and leveling rod. A meter tape will be secured across the stream channel. Elevations will be measured at 0.5 to 1.0 m intervals beginning and ending above bankfull flows. The location of bankfull flows, ordinary high water and undercut depth will be noted or measured.

Materials Required: Rite-in-the-Rain data book, pencils, 100-meter tape, laser level and tripod, leveling rod, meter stick.

Algae/Benthic Organic Matter

Algae will be sampled by scraping a known area of stone or tile and collecting the dislodged material on to a Whatman GF/C filter with 0.45 μm pore size (Davis et al. 2001). The algal sample will be analyzed for chlorophyll-*a*, and AFDM. Benthic organic matter will be collected in nested nets of different pore size held onto a Surber sampler frame. The sampler will be held on the stream bottom and the substrate from a known area upstream of the sampler will be disturbed, dislodging organic matter from the bottom, which will be carried into the nets by the current. The material from each net will be transferred into 500-ml nalgene bottles and preserved with alcohol. The AFDM of both the large and small size fractions will be determined through weight loss upon combustion at 500 C.

Materials Required. Brush, template, filters, foil, surber sampler with nested nets, squirt bottle, whirl-pak bags, 500 ml poly bottles, alcohol, sharpies, pencils, labels.

Large Woody Debris and Coarse Woody Debris

Large woody debris (LWD) will be measures using the methods described in Davis et al. (2001). All large wood within the bankfull channel will be counted and scored based upon size and position in the stream relative to channel size. All debris dams are counted and scored relative to size and position in the stream. Scored values are converted into a large woody debris index (LWDI).

Coarse wood within the riparian area will be quantified by species within the sampling reach. Coarse wood is counted along one bank for 100-m length of stream extending out 30-m lateral to the channel. Downed coarse wood on the forest floor is identified by species and placed into one of three diameter and length categories (greatest diameter is from 10 to 20 cm, 21 to 30 cm, and > 30 cm) and three distinct length categories (1 to 5 m, 6 to 10 m, and > 11 m).

Materials Required. Data book, meter stick or calipers, meter tape, distance finder.

Macroinvertebrates/Habitat Assessment

Macroinvertebrates will be collected, processed, and analyzed using the Standard operating procedures for the Alaska Stream Condition Index (ASCI) (Major and Barbour 2001). Composite invertebrate samples will be placed within pre-labeled 500-ml nalgene bottles. Paper labels will be placed into the bags with the sample and the sample preserved with 95% ethanol. Labels will include date, time, location, and investigators. Stream invertebrate collections will be returned to the ARRI laboratory, sorted, and identified to genus (except for Chironomidae, Simuliidae, and Oligochaeta). .

Materials Required: ASCI Habitat Assessment Data Sheets, nalgene bottles, 5-gallon bucket, ethanol, D-Nets, gauntlets, labels, pencils, sieve, and sharpies.

Juvenile Fish

Fish will be collected in 10 baited minnow traps soaked for 12 to 24-hours. Captured fish will be identified, measured to fork length, and observed for deformities, eroded fins, lesions or tumors (DELT anomalies) using the USGS NAWQA methodology (Moulton II et al. 2002).

Materials Required: Minnow traps, salmon roe, buckets (2), small net, plastic bags, collection permit, measuring device.

## B3. Sample Handling and Custody Requirements

Water samples will be labeled in the field. Sample labels will record the date, time, location, preservation, and initials of collector. Chain of custody forms will be initiated in the field and completed each time samples are transferred to a laboratory, or other carrier. Field samples that are to be transferred to the contract laboratory will be placed within a cooler and the cooler sealed closed using plastic packing tape. Samples will be transported to the laboratory where they will be placed in a secure location until analyses are completed.

## B4. Analytical Methods Requirements

Sample analytical methods are shown in Table 4. Field samples will be collected by ARRI staff and either delivered to the commercial laboratory for subsequent analyses by the identified standard method. Meter measures will be conducted in the field except for turbidity and conductivity, which will be measured in the ARRI laboratory.

**Table 3. List of Analytical methods and detection limits for study parameters.**

| Measurement | Collection/ Analyses | Method | Limits | Turnaround Time (days) |
|---|---|---|---|---|
| Total Phosphorus | ARRI/AM Test Inc. | EPA 365.3 | 0.005 mg/L | 14 |
| Total Dissolved Phosphorus | ARRI/AM Test Inc. | EPA 365.3 | 0.005 mg/L | 14 |
| Ammonia-N | ARRI/AM Test Inc. | EPA 350.1 | 0.005 mg/L | 30 |
| Nitrate + Nitrite-N | ARRI/AM Test Inc. | EPA 353.2 | 0.01 mg/L | 30 |
| pH | ARRI/ARRI | Meter (Hanna HI 9023) | 0.01 pH units | 15 minutes |
| Algal Chlorophyll-a | ARRI/AM Test Inc. | SM 1002G | 0.1 $mg/m^2$ | 30 |
| Benthic Organic Matter | ARRI/AM Test Inc. | SM 2540-G | 0.1 $mg/m^2$ | 30 |
| Specific Conductance | ARRI/ARRI | Meter (SPER 840039)<br>Hydrolab MS5 | mhos (0 to 200)<br>1.0 mhos (>200) | 1 |
| Turbidity | ARRI/ARRI | LaMotte TC-3000e | 0.1 NTU (0 to 10)<br>1.0 NTU (10 to 100) | 1 |
| Dissolved Oxygen | ARRI/ARRI | Meter (YSI Model 55)<br>Hydrolab MS5 | 0.01 mg/L (0 to 20) | 15 minutes |
| Temperature | ARRI | HOBO Stowaway | 0.1 Degree C | Monthly Download |
| Discharge | ARRI | Price AA pygmy | 0.1 cfs | Direct Measure |

**Corrective Action**

ARRI will be responsible for ensuring that all samples are collected and delivered to the laboratory. The QA officer will make sure all samples are labeled and stored correctly and that all equipment has been calibrated and accuracy tests completed as needed. The project manager will be informed of any errors and will be responsible for corrective action including repeating sample collection or analyses (for metered measures). If any samples are lost or are determined to be contaminated by the laboratory or if there are any laboratory problems, the project manager will be responsible for collecting new samples and delivering them to the laboratory.

## B5. Quality Control Requirements

The following table (Table 5) lists the percent of field and laboratory replicates to be used for quality control (See section A7 for discussion on calculation of precision and accuracy). The precision of field and laboratory measures will be calculated using the equation in section A7. Accuracy will be measured using the equation in A7 for known standards. If accuracy and precision are not met for analyses ARRI is conducting, the meters will be recalibrated and measures will be repeated or meters or probes will be replaced. Data measurements that do not meet the limits described in A7 may or may not be used in the final report depending on degree to which limits are not met. However, the report will clearly state if there are any questions regarding used data.

**Table 4. Field and laboratory replicates for quality control.**

| Parameter | Field Replicates | Laboratory Replicates | Comments |
|---|---|---|---|
| pH, Cond, Turb, DO. | 10 Percent | 10 Percent | Replicate measurements one of every 8 samples. |
| Nitrogen, Phosphorus | 10 Percent | 10 Percent | Laboratory replicates may include samples from other locations. |
| Substrate | 25% | None | Pebble counts will be repeated at one site. |
| Temperature | 1% | None | Water temperature will be measured on each sampling event with meters and compared with stowaway readings. Loggers will be placed in the same location for 24 hours and reading compared. |
| Solar Radiation | 25% | None | Solar radiation measurements will be repeated at one location. |
| Discharge | None | None | Discharge measurements will be reported as measured. |
| Morphometry | None | None | Channel characteristic statistics will be reported based upon measures taken at 5 transects. |
| Algae | None | 10 percent | Algal chlorophyll-a will be reported at the average of 3 replicate samples. Standards and laboratory replicates will be used by the laboratory to calculated accuracy and precision. |
| Benthic Organics | None | None | Benthic organic matter will be reported from the statistics of 3 replicate samples. |
| Large Woody Debris | 25% | None | Large woody debris counts will be repeated at one location. |
| Coarse Woody Debris | 25% | None | Riparian coarse wood counts will be replicated at one location. |
| Macroinvertebrates | None | None | Macroinvertebrate sampling will not be repeated. |
| Juvenile Fish | None | None | Fish sampling will not be repeated. |

## B6. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Instruments and meters will be tested for proper operation as outlined in respective operating manuals. Inspections and calibration will occur prior to use at each site. Equipment that does not calibrate or is not operating correctly will not be used. For most parameters (temperature, conductivity, and pH), duplicate instruments and meters are available. In the case of complete equipment failure, new equipment will be purchased. The project manager will be responsible for calibrating and testing and storing equipment and completing log sheets. All calibrating, testing and storage will follow the manufacturer's recommendations. The quality assurance officer will inspect the log sheets. Spare batteries and repair equipment will be taken during field sampling events.

## B7. Instrument Calibration and Frequency

The pH meter (Hanna HI 9023), conductivity meter (SPER 840039), dissolved oxygen (YSI Model 550), and turbidity meter (LaMotte TC-3000e), and any other analytical equipment will be calibrated in accordance to instructions in the manufacturer's operations manual by the project manager prior to each use and a log will be maintained documenting calibration. Standards are required for pH, turbidity and conductivity.

## B8. Inspection/Acceptance Requirements for Supplies and Consumables

Sample containers will be obtained from AM Test, Inc. Any needed standards for equipment calibration will be purchased directly from the equipment manufacturer if possible or from a well established chemical company. The QA officer will be responsible for ensuring that standards are not outdated and for the purchase of replacements. The date and source of all purchased materials will be recorded within a separate file for each piece of equipment and kept on file by ARRI along with equipment calibration records.

## B9. Data Acquisition Requirements for Non-Direct Measurements

Weather data downloaded or purchased through the National Oceanic and Atmospheric Administration (NOAA) web site (http://www.ncdc.noaa.gov/oa/ncdc.html) also will be used and assumed accurate. Maps and information on proposed road and harvest locations will be obtained from the Alaska Department of Natural Resources, Division of Forestry and the Matanuska Susitna Borough. Some supplemental data such as maps, water quality data, may be obtained from other currently unknown sources for comparisons.

## B10. Data Management

Field data will be entered onto rite-in-the-rain books. The quality assurance officer will copy the field books and review the data to ensure that it is complete and check for any errors. Field and laboratory data sheets will be given to the project manager. The project manager will enter data into Excel spreadsheets. The quality assurance officer will compare approximately 10% of the field and laboratory data sheets with the Excel files. If any errors are found they will be corrected and the project manager will check all of the field and laboratory data sheets with the Excel files. The quality assurance officer will then verify correct entry by comparing another 10% of the sheets. This process will be repeated until all errors are eliminated. The project manager will then summarize and compare the data. The quality assurance officer will review any statistical or other comparisons made. Any errors will be corrected. The project manager will write the final report, which will be proofed by the quality assurance officer and submitted to the DEC project manager.

Parameters from stream characteristics will be compared with repeated measures following timber harvest. Statistical tests (paired t-test or repeated measures ANOVA) will be used for comparisons. Parameters from the unharvested site will be used to identify any variables that are changing in the absence of timber harvest.

Along with the final report tables and graphs of water quality data, the information will also be provided to DEC in a modernized STORET compatible format. Data will be formatted into STORET compatible files as described at the following DEC web site http://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm.

## C1. Assessments and Response Actions

Project assessment will primarily be conducted through the preparation of field sampling event reports for DEC by the project manager. Section A6 contains more information on the type and date of each required report. At that time the project manager will review all of the tasks accomplished against the project Sample Plan to ensure that all tasks are being completed. The project manager will review all data sheets and entered data to make sure that data collection is complete. If necessary, data collection processes or data entry will be modified as necessary. Any modifications of the data collection methods will be reviewed against the processes described within the QAPP to determine whether the document needs to be updated.

The Project Manager will check on contractor's laboratory practices to ensure that samples are handled correctly and consistently. The final report will contain an appendix that will detail all of the QA procedures showing precision and accuracy. Representativeness, completeness, and comparability will be discussed in the body of the report. Any QA problems will be outlined and discussed relative to the validity of the conclusions in the report. Any corrective actions will be discussed as well as any actions that were not correctable, if any.

The QA officer will report to ARRI Project Manager any consistent problems in data collection, analyses, or entry identified either internally or through a 3rd party audit. ARRI management will be responsible for developing and implementing a course of action to correct these problems. Where consistent problems may have affected project validity, these will be identified and reported to the DEC project manager directly and included in project reports as directed.

## C2. Reports to Management

Reports will be prepared by the ARRI Project Manager and distributed to the DEC Project Manager. Reports will update the status of the project relative to the schedule and tasks of the work plan. Reports include Quarterly Progress Reports, Draft Final Report, and Final Report. Any field QA problems will be identified and reported in the Quarterly Reports or more often if necessary. The project manager will prepare the draft and final reports. The final report also will be submitted in electronic format along with the data tables and photo log. Any potential problems with data due to QA will be identified and reported in all submitted reports.

## D1. Data Review, Validation, and Verification

The project manager and the quality assurance officer will conduct data review and validation. Data errors can occur during collection, laboratory analyses, data entry, and reporting. The QA officer will review all field data sheets to ensure that field measures and sample collection followed the QAPP and sampling plan procedures. The QA officer will ensure that all field replicate samples and measures were collected. The QA officer will review and store copies of all chain of custody forms to ensure proper sample handling and delivery.

The QA officer will be responsible for reviewing data received from contract laboratories. The review will include an evaluation of the laboratory quality control measures including laboratory controls, duplicates, and spikes. The review will check to make sure the proper analytical methods were used. Site names and dates will be compared to field notes.

For samples analyzed by ARRI, the QA officer will check to make sure that all meters are calibrated and operating correctly and that the calibration and measures of standards is being recorded.

The QA officer will conduct reviews of data entry, analyses, and reporting to ensure that there are no errors in data entry and reporting.

Data that are obtained using equipment that has been stored and calibrated correctly and that meets the accuracy and precision limits will be used. Data that does not meet the accuracy and precision limits may be used; however, we will clearly identify these data and indicate the limitations.

## D2. Validation and Verification Methods

### Data Collection

The project manager will be responsible for field physical and biotic measures and water sampling and handling. Field data collection will be conducted as described in the approved sampling plan and QAPP. Any variation in methods or problems in data collection will be reported to the ADEC project manager. The project manager will ensure that the samples for laboratory analyses are identified by the correct site location name, date, and sampling personnel. The project manager will ensure proper sample storage and handling and will fill out and sign all chain of custody forms. Copies of chain of custody forms will be turned over to the QA officer. A log of sampling locations, personnel, labeling, and handling will be kept within the field data book.

### Analytical Methods

The QA officer will be responsible for quality control from all contract laboratories. This will include review of sample labeling, analytical method used, turn around time, and laboratory quality control measures. The QA officer will work with the contract laboratory to correct or clarify any errors. Analytical results that are below the method detection limit will be reported as such with no numeric value.

The Project Manager will conduct all precision calculations for field replicates. The QA officer will review the resulting values relative to data criteria. Data accuracy, precision, and completeness results will be presented within the Final Project Report.

### Data Entry and Statistical Analyses

The Project Manager and the Quality Assurance Officer will conduct data validation and verification. The Project Manager will enter all data from laboratory and field data sheets into Excel worksheets. The Project Manager will double-check all entries to ensure that they are correct. The Quality Assurance Officer will compare 10% of the laboratory and field data sheets with the Excel worksheets. The Project Manager will enter all formulas for calculation of parameters and basic statistics. All of these formulas will be checked by the Quality Assurance Officer. If any errors are found, the Project Manager will correct the errors and then check all entries. The Quality Assurance Officer will then repeat a check of 10% of the data entry and all of the formulas and statistics. This process will be repeated until any errors are eliminated.

### Data Reporting

The project manager will organize and write the final report. The quality assurance officer will check the results in the report and associated statistical error (i.e. standard deviation and confidence interval) against those calculated with computer programs. Any errors found will be corrected by the project manager. The project manager will review and respond or incorporate all comments received from the ADEC project manager and other reviewers. The QA officer will check the final report to ensure that all review comments were addressed.

## D3. Reconciliation with User Requirements

The project results and associated variability, accuracy, precision, and completeness will be compared with project objectives. If results do not meet criteria established at the beginning of the project, this will be explicitly stated in the final report. Based upon data accuracy some data may be discarded. If so the problems associated with data collection and analysis, or completeness, reasons data were discarded, and potential ways to correct sampling problems will be reported. In some cases accuracy project criteria may be modified. In this case the justification for modification, problems associated with collecting and analyzing data, as well as potential solutions will be reported in the project Final Report.

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# Appendix B.  Site Photographs

Photograph 1.  Chijuk Creek upstream of Oilwell Road crossing.

Photograph 2.  Chijuk Creek showing open birch and spruce canopy with *Calamagrostis* and alder riparian vegetation.

Photograph 3.  ATV bride across Chijuk Creek at Oilwell Road.

Photograph 4. Measuring bank undercut of Chijuk Creek.

Photograph 5. Large Woody Debris surveys of Chijuk Creek.

Photograph 6. Chijuk Creek showing channel shape, riparian vegetation and surrounding forest.

Photograph 7. *Calamagrostis* riparian vegetation surrounding Fish Creek at the sampling location.

Photograph 8. Aerial view of Fish Creek showing channel shape, riparian vegetation, and surrounding birch and spruce forest.

Photograph 9. Aerial view of Fish Creek at the sampling location.

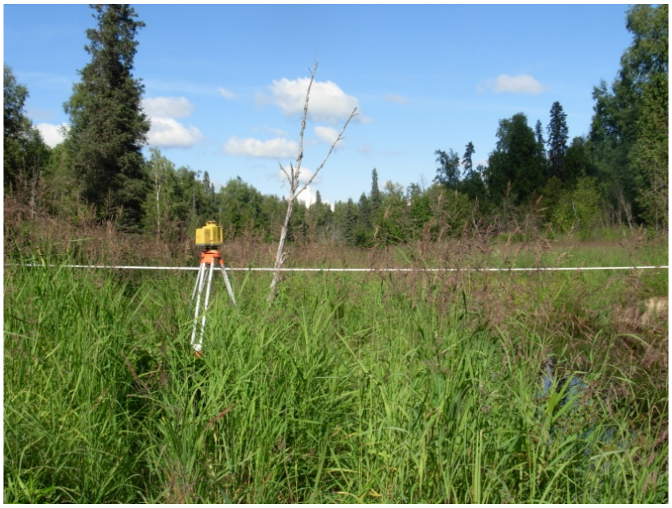
Photograph 10. Fish Creek approaching forest at an outside bend.

Photograph 11. Measuring Whiskers Creek channel morphometry.

Photograph 12. Whiskers Creek showing alder and fern riparian vegetation and birch within the channel.

Photograph 13. Measuring Whiskers Creek discharge.

Photograph 14. Measuring Whiskers Creek slope and channel cross-sections.



Photograph 15. North Fork of Iron Creek, May 2009.

Photograph 16. Riparian vegetation and North Fork Iron Creek stream channel.

Photograph 17. North Fork Iron Creek during spring runoff.