

2012 Aquatic Biomonitoring Report

Donlin Gold Project

2004 through 2012 Data Compilation

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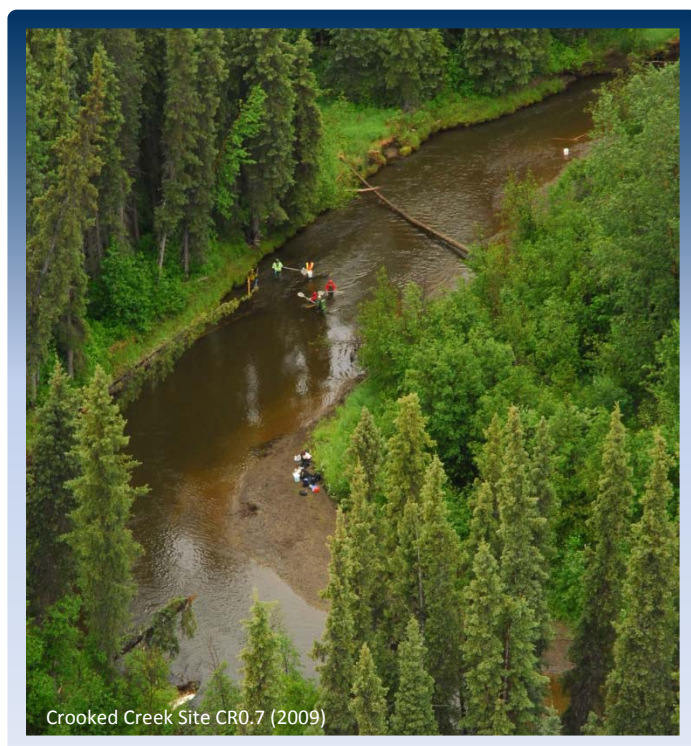
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Abstract

In 2004, OtterTail Environmental Inc. established an annual aquatic resources biomonitoring program in the Crooked Creek drainage of the Kuskokwim River, in the area of the proposed Donlin Gold Project. Components of the program include macroinvertebrate sampling, electrofishing, fish trapping, aerial salmon surveys, and fish tissue metals analysis. The main objective of this program was twofold; first to establish baseline aquatic resources data within the areas potentially influenced by the proposed mining development and second, to establish permanent monitoring sites to provide quantitative data to enable detection of changes to the aquatic community that could be caused by this development. Within the scope of this biomonitoring program, aerial salmon counts were conducted to determine the distribution of adult salmon within the Crooked Creek system. However, in order to accurately estimate the size of adult salmon populations migrating into Crooked Creek, a resistance board fish weir was added to the program in 2008.

Results from 2004-2012 data have consistently indicated that the Crooked Creek drainage supports relatively small and viable, populations of chum, Chinook, and coho salmon. Very limited numbers of pink and sockeye salmon have also been documented in the fish weir. In addition, several other resident fish species typical of the Kuskokwim River drainage have been found throughout the program area, typically in relatively limited numbers.

Our surveys suggest that macroinvertebrate communities are composed of taxa typical of this region, but their relative abundance is rather low. The low abundance of macroinvertebrates, salmon, and other fish species may be due to the naturally high siltation and cobble embeddedness in this system, which appears to be above average as compared to other similarly sized systems of the Kuskokwim River. Embeddedness reduces the extent of interstitial spaces in the substrate that, in turn, reduces the physical habitat and increases the likelihood of full substrate freezing and mortality.

Multiple years of baseline data coupled with the low sample variability observed in fish tissue metal concentrations within sites, not only have provided insight into the annual variability in background metal concentrations but also have allowed for the assessment of differences in metal concentrations across sites. For example, a significantly higher concentration of arsenic and mercury was observed in the uppermost sampling site along the mainstem of Crooked Creek, which could be associated to natural mineralization or the current and historic placer mining in that area. Being able to statistically test and detect these relatively small changes in metal concentrations indicates that the monitoring program would be capable to detect potential increases in metal concentrations caused by the implementation of the Project.

In 2007, the program expanded to include aquatic biomonitoring on drainages crossed by proposed road corridors. The methods used in these drainages were similar, but did not include fish tissue metals analysis because the proposed roads are outside the area of potential influence by the mining operations. These surveys show aquatic communities similar to many of the drainages of Crooked Creek. In 2009 and 2011, additional culvert and bridge crossing sites were added to the program with the expansion of the Project. In 2011 and 2012, sampling was conducted in the Kuskokwim River adjacent to a proposed port site facility.

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1.0 INTRODUCTION

Donlin Gold LLC. (Donlin) is assessing the feasibility of developing a lode gold resource within the Crooked Creek drainage of the Kuskokwim River in southwestern Alaska, near the village of Crooked Creek (**Figure 1.1-1**). An extensive geological exploration program is currently ongoing at the Donlin Gold Project (Project). For detailed information on the Project, refer to the Project Description and Environmental Evaluation Document¹. In 2004, OtterTail Environmental, Inc. (OtterTail) established an aquatic resources biomonitoring program within the Crooked Creek drainage. An additional aquatic survey program area was added in 2007 to provide baseline aquatic data for drainages of the proposed Road Alternative: Jungjuk Road (**Figure 1.1-1**). To facilitate distinction, these two program areas are described in separate sections of this report and are named core aquatic biomonitoring program (Core Program) and road alternatives aquatic survey program (Road Alternatives Program). Refer to *Section 4.0* for the Road Alternatives Program.

1.1 CORE PROGRAM

In 2004, OtterTail established an aquatic resources biomonitoring program within the Crooked Creek drainage. Refer to *Section 2.0* for Core Program methods, and to *Section 3.0* for Core Program results. The Core Program consists of macroinvertebrate sampling, electrofishing, fish trapping, aerial adult salmon counts, fish weir adult salmon counts and a fish tissue metals analysis. A map of the project area can be found in **Figure 1.1-1**.

1.2 GOALS (CORE PROGRAM)

The primary goal of the Core Program was twofold; first, to establish permanent biomonitoring sites within areas that could be potentially influenced by the Project, and second, to gather baseline aquatic resources data, that could be used in the future to detect and quantify changes to the health and structure of the aquatic community as a result of the mine development. It is anticipated that any effects on the aquatic biota would likely result from changes in water quality, water quantity, or aquatic habitat modification (e.g., habitat removal, stream siltation or stream channel down-cutting). Information made available by this biomonitoring is important to assist with Project design and planning of impact mitigation.

1.3 STUDY AREA (CORE PROGRAM)

The biomonitoring program area encompasses the entire Crooked Creek drainage. Crooked Creek is a tributary to the Kuskokwim River, entering the Kuskokwim on the north side near the village of Crooked Creek (**Figure 1.1-1**). The Crooked Creek drainage includes major upper tributaries such as Flat Creek and Donlin Creek, as well as a number of tributaries entering the mainstem further downstream, including Getmuna Creek and Bell Creek (**Figure 1.1-1**). The mainstem of Crooked Creek begins at the confluence of Flat Creek and Donlin Creek, flowing approximately 17.4 linear miles (33 river miles), or 28 linear km (53.1 river km), to the Kuskokwim River [approximately at river mile 259 (416.7 km)] (Whitmore 2008). The Project is located near the upper mainstem section of Crooked Creek (**Figure 1.1-1**).

¹ These documents will be available to State and Federal agencies once permit applications are submitted.

2.0 METHODS (CORE PROGRAM)

Primary components of the biomonitoring program included (1) site and reach selection (2) the selection of target aquatic parameters to sample, and (3) the selection of adequate methods to use for each parameter. The development of these components was based on OtterTail staff's previous experience establishing numerous mining biomonitoring programs, advice from the Alaska Department of Fish and Game (ADF&G) and biologists from other agencies, and aquatic biomonitoring efforts from other regional mining operations.

2.1 SITE AND REACH SELECTION METHODS (CORE PROGRAM)

Sampling sites were selected to evaluate existing conditions both upstream (reference reaches) and downstream (potential impacts reaches) of historical and proposed mining activity, and to detect and measure potential future Project impacts on aquatic resources. Locations were also selected to correspond, when practical, to sites previously established for water quality and flow monitoring. Each biomonitoring site was selected to establish the current condition of the aquatic community for a stream segment. However, in some cases a site was selected as a representative area of an entire stream. Where possible, sites were located at the furthest downstream reach so that disturbances occurring within any portion of the watershed could be monitored in that single location. All sites were located upstream of man-made and natural obstructions (e.g., winter access roads) to avoid tracking potential impacts from other non-Project related activities (**Figure 1.1-1; Table 2.1-1 and 2.1-2**). During the process of site selection, aerial photographs, topographical maps, historical data, and the proposed areas of disturbance were considered.

The upper Crooked Creek drainage (**Figure 1.1-1**) has the greatest potential for Project-related impacts due to its location within the mineralized zone, and its proximity to the Project. The mineralized zone extends from Ophir Creek on the north, to American Creek on the south. Several of the tributary streams in the upper Crooked Creek drainage have been or are currently being disturbed by independent placer mining; especially Quartz Creek, and Snow, Queen and Lewis gulches. In contrast, Ophir and Dome creeks are relatively undisturbed streams.

In 2004, six sites were established and sampled: two sites in Upper Crooked Creek and one site in each of Donlin, Flat, American, and Anaconda creeks. As the Project expanded, anticipated potential impacts to other areas in the drainage lead to the addition of six more sites to the program in 2006 including one site in Crevice Creek and one site in Crooked Creek downstream of Crevice Creek to capture impacts of potential groundwater and surface water reductions. A site was added near the mouth of Crooked Creek to fully encompass the drainage. A second site higher in Anaconda Creek was added to further characterize this system. The sixth additional site was located within Snow Gulch due to a proposed fresh water reservoir within this watershed.

Further, one site in Getmuna Creek was added to the program in 2007 to assess the potential impact of a proposed material site location (**Figure 1.1-1**). In 2008, the potential impact area was expanded to include Grouse and Dome creeks leading to the addition of a new site in the lower portions of those two creeks to monitor any potential effects. In 2009, sites were added in small drainages within the Project footprint, including Quartz, Lewis, and Omega Gulches. A site was also added in Eagle Creek due to new Project facilities within the drainage. In 2010, an additional site was added to the middle portion of American Creek, and sites were added to unnamed (BC), and unnamed (AC) creeks to further define fish populations within the Project area. In 2011 two additional sites were surveyed in the upper portion of the American Creek drainage, and a new site was established and surveyed in Bell Creek. A complete list of sites within the Project area and their UTM coordinates is provided in **Appendix A**. The purpose of each site selected for biomonitoring is included in **Table 2.1-1**.

2.1.1 DONLIN AND FLAT CREEK MAINSTEM SITE SELECTION (CONTROL SITES)

Upper Donlin Creek (DO1) and Flat Creek (FL1) were selected as control sites because they are located upstream of any present or proposed mining activities (**Figure 1.1-1**). These sites will allow the assessment of differences between Project and non-Project related impacts and account for the natural variability of the system.

2.1.2 DONLIN CREEK TRIBUTARIES: DOME, QUARTZ AND SNOW DRAINAGES SITE SELECTION

Dome Creek (DM1) and Quartz Gulch (QZ1) are located within the mineralized zone, upstream of current and proposed mine facilities. Snow Gulch (SN1 and SN2) is currently affected by placer mine activities. These sites were established to document the current condition of aquatic resources within the drainages (**Figure 1.1-1**).

2.1.3 CROOKED CREEK MAINSTEM SITE SELECTION

The uppermost mainstem site along Crooked Creek (CR2) is located several hundred meters upstream of American Creek and approximately one hundred meters downstream of the currently active Lyman Mine diversion canal (**Figure 1.1-1**). Site CR2 was selected as a partial-reference site downstream of all known existing placer mining activities and upstream of most of the Project's footprint. This site can be used to establish a baseline dataset and evaluate the impacts of the placer mining operations that continue to occur above this point in the watershed. In addition, the location of CR2 above the tailings impoundment was intended as a control for possible future evaluation of any impacts in Crooked Creek downstream of Anaconda Creek associated to the tailings impoundment.

Crooked Creek site (CR1) is located several hundred meters downstream of the confluence of Crooked Creek and Anaconda Creek (**Figure 1.1-1**). Sampling at CR1 will allow detection of potential effects on the Crooked Creek mainstem from mine-related activities in Anaconda Creek, Omega Gulch, and American Creek drainages.

A lower Crooked Creek site (CR0.7) was added later in the program to capture any possible effects from Crevice Creek, and will also serve to determine the extent of recovery of Crooked Creek if any effects are found upstream in site CR1 (**Figure 1.1-1**).

The lowest site on Crooked Creek (CR0.3) is located near its mouth (**Figure 1.1-1**). This site was selected to provide a baseline dataset that encompasses the full Crooked Creek watershed and to assess the recovery of Crooked Creek if impacts are detected in upstream sites.

2.1.4 CROOKED CREEK TRIBUTARIES: LEWIS, AMERICAN, GROUSE, OMEGA, ANACONDA, CREVICE, EAGLE, UNNAMED (BC), UNNAMED (AC), GETMUNA, AND BELL DRAINAGES SITE SELECTION

Lewis Gulch (LE1) is a small drainage within the proposed location of the ultimate pit (**Figure 1.1-1**). Site LE1 was monitored in 2009 to document the aquatic resources that would be impacted as a result of drainage removal. The site was sampled both upstream and downstream of the road crossing to fully capture the aquatic resources within the drainage.

American Creek (AM1) would be directly impacted by the proposed ultimate pit and waste rock facility (**Figure 1.1-1**). The study site AM1 is located just upstream of the winter access road. This site was established to document the aquatic resources that would be impacted as a result of Project facilities filling much of this drainage. For the same purpose, a new upstream site in this drainage (AM2) was added in 2011. Sites AM3 and AM4 were established in 2011 to assess current condition and potential future impacts associated to a proposed shoofly access road crossing (**Figure 1.1-1**).

Grouse Creek (GR1) was added in 2008 to assess potential baseflow reductions within the drainage. Grouse Creek is near the potential cone of depression associated with proposed groundwater pumping around the ultimate pit.

Omega Gulch (OM1) is within the Project footprint. The Project would divert water from upper American Creek into Omega Gulch. Study site OM1 is located just upstream of the winter road crossing (**Figure 1.1-1**).

Anaconda Creek (AN1 and AN2) is the location of the proposed tailings storage facility (**Figure 1.1-1**). Site AN1 is downstream of the proposed tailings impoundment and will enable detection of any potential effects from the tailings storage facility to the stream. Site AN1 is located just upstream of the winter access road, a few hundred meters from the mouth of Anaconda Creek. Site AN2 is within the portion of the drainage proposed to be filled by tailings and was established to document aquatic resources in Anaconda Creek that would be removed as a result of the Project.

Crevice Creek (CV1) is a site selected to assess potential groundwater and surface water impacts from the adjacent Anaconda Creek drainage (**Figure 1.1-1**). During mine closure, a tunnel is proposed to divert water from the upper Anaconda Creek watershed into Crevice Creek.

The site in Eagle Creek (EG1) was added in 2009 to address the changes in the Project footprint. The camp facilities for the Project were relocated into this drainage, and potential effluent may enter Eagle Creek (**Figure 1.1-1**).

Sites were added to two unnamed creeks (BC1 and AC1) located south of the Project area. These sites were added to address potential water withdraw impacts associated with the construction and operation of a winter access road (**Figure 1.1-1**).

A site in Getmuna Creek (GM1) was added in 2007 due to a proposed gravel borrow location near the upper reaches of the stream (**Figure 1.1-1**). This site was selected to document the aquatic biota present within the drainage and to record any changes that could occur as a result of the materials site upstream. Three additional Getmuna sites (GM2, GM3, and GM4) were added in 2012. Data from Getmuna Creek also allows for better understanding of the distribution of anadromous salmon throughout the Crooked Creek drainage given that a large portion of the Crooked Creek salmon run use Getmuna Creek for spawning and rearing.

A site in Bell Creek near its confluence with Crooked Creek (BL1), was added and surveyed in 2011 to document aquatic resources that could be affected by an adjacent proposed winter access road (**Figure 1.1-1**).

2.1.5 CROOKED CREEK WEIR SITE SELECTION

Although aerial salmon counts were effective to assess the distribution and uppermost extent of salmon within the Crooked Creek system, these point-in-time surveys do not obtain the total adult salmon escapement in Crooked Creek. To address the need for total salmon escapement within the Crooked Creek drainage, OtterTail installed a resistance board fish weir in 2008 equipped with an underwater video system. This type of weir has been shown to be a highly effective method to determine total salmon escapement even under the fluctuating water levels, high turbidity, and debris loads that are common in small Alaskan streams such as Crooked Creek. Placed 1.5 river miles (2.4 km) upstream of the Kuskokwim River confluence and downstream of all tributaries to Crooked Creek, the location of the weir was intended to encompass the entire Crooked Creek drainage (**Figure 1.1-1**).

At the weir site, the river channel is approximately 120 feet (36.6 m) wide with an average depth of about 2.5 feet (0.76 m) during normal summer flows. Water depth is fairly consistent across the channel, with a slightly deeper section near the left bank (**Figure 2.1-1**). The weir is located along the only reach in the targeted segment of Crooked Creek that remains straight for an extended distance. This straight run produces the desired laminar flow across the channel that is critical for proper weir operation. Areas further downstream were considered unsuitable for operational success due to deeper water, non-laminar flow across the channel, asymmetrical bank profiles, and the potential for transient fish species temporarily migrating up from the Kuskokwim River. In addition, it was

thought that tampering would be more likely if the weir was located further downstream and in closer proximity to the Crooked Creek Village.

2.2 PARAMETER SELECTION METHODS (CORE PROGRAM)

Equally important to the selection of sites and reaches for this biomonitoring program was the selection of parameters and methodologies to effectively identify short-term and long-term changes to the aquatic community. To address the goal of baseline data collection and impact assessment, the following parameters were identified: macroinvertebrates, fish populations (adult salmon aerial surveys, fish weir counts, fish traps, electrofishing, and angling), and a fish tissue metals analysis. The methodologies used are described in detail below.

Macroinvertebrate populations are effective indicators of water quality and habitat impairment due to elevated concentrations of metals, sediment, and other contaminants. The varied life histories and contaminant tolerances of indicator species can be used to identify both short- and long-term environmental changes, and to establish a relative index of water quality. Specific inventories conducted for the Project will characterize macroinvertebrate communities and provide baseline data to assess potential mining impacts.

Fish populations were selected to be assessed due to their economic and cultural importance to subsistence communities in the study area, and their important role within Alaskan aquatic ecosystems. However, adult returns to spawning streams are variable and subject to a host of natural and anthropogenic factors within both freshwater and marine environments. Characterizing fish communities in reference streams and Project affected streams may help Project planners to broadly describe existing conditions, but should not be used to measure project impacts based on natural variability.

The primary purpose of the fish tissue metals analysis is to establish statistically reliable baseline data at key sites in the Crooked Creek drainage and to assess potential changes over time in metal concentrations at these sites. Most studies of fish tissue metals done in the Kuskokwim River region focus on determining concentrations of metals present in hazardous concentrations for human consumption. In contrast, the goal of this study is to assess the natural variation in metal concentrations within the system and detect changes caused by the Project.

2.3 MACROINVERTEBRATE METHODS (CORE PROGRAM)

2.3.1 CROOKED CREEK DRAINAGE MACROINVERTEBRATES

Benthic macroinvertebrates were collected at 23 Core Program sample locations: DO1, FL1, DM1, QZ1, SN2, QU1, CR2, CR1, CR0.7, CR0.3, AM1, AM2, GR1, OM1, AN1, AN2, CV1, EG1, GM1, GM2, GM3, GM4 and BL1 (**Figure 1.1-1**). These sites have been sampled from one to nine years and sampling has typically occurred between July 14 and August 2. As described above, some of the sites were added in recent years due to changes to the Project. Multiple years of quantitative macroinvertebrate community monitoring were conducted in order to assess the natural variation, both among sites and years, within the Crooked Creek drainage. Controlling for the natural variation in the system, it would be possible to assess changes in the aquatic macroinvertebrate community due to Project-related impacts.

Macroinvertebrate sampling methods were standardized to minimize sampling variability. Five replicate samples were collected to reduce sampling variability within a single site and to increase statistical power. At all Crooked Creek sites, samples were collected each year from the same riffle(s) using a Surber sampler (1 ft², 600 µm mesh). The Surber sampler was placed on the stream bottom with its opening perpendicular to stream flow. Substrates within the 1 ft² (0.09 m²) Surber base were scrubbed with a nylon brush to remove invertebrates and organic

matter. Organic matter retained by the net was drained onto a 600 µm sieve, placed in plastic bags, and preserved in 70 percent ethanol.

In the laboratory, samples were lightly rinsed with water in a 600 µm (standard #30) sieve. Macroinvertebrates were removed by hand under magnification, identified to the lowest possible taxonomic level (typically genus), and counted. Large samples (>300 individuals) were sub-sampled using a white tray subdivided into four quadrants. Samples were evenly distributed across the tray, and each quarter was picked until a minimum of 300 individuals was reached (typically ¼ or ½ of the original sample). Large samples were also viewed in their entirety before sub-sampling; large and/or rare taxa found in this search were removed and added to the sample total. A reference collection was created for future sample verification.

2.3.2 MACROINVERTEBRATE METRICS

A brief description of the macroinvertebrate metrics calculated is provided below.

Abundance - Number of organisms per square foot of stream bottom. Under certain types of stresses, this value may increase (by tolerant organisms) or decrease (excluding non-tolerant taxa), depending on stream conditions.

Total Taxa - The total number of taxa in all replicates combined for each site. Also called richness, this metric generally increases with improved biotic condition.

Total EPT Taxa - The total number of taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera from all replicates combined at a site. This value summarizes taxa richness within the orders considered to be most sensitive to pollution.

Percent EPT Taxa - The percent contribution of the orders Ephemeroptera, Plecoptera, and Trichoptera to total macroinvertebrate abundance in all replicates combined at each site. This value summarizes the percent contribution within the orders considered to be most sensitive to pollution.

Percent Dominant Taxa - The percent contribution of the most abundant taxa at each sample site (all replicates combined). Less disturbed environments tend to support communities with evenly distributed taxa rather than a large number of individuals within one group.

Percent Chironomidae - The percent contribution of the family Chironomidae at each sample site (all replicates combined). Disproportionate dominance of this generally tolerant group usually indicates poor biotic condition. However, in many Alaska streams, this is not always the case as Chironomidae tend to be abundant at high latitudes, regardless of biotic condition.

EPT/Chironomidae - The ratio of the more sensitive EPT taxa to the more tolerant chironomids. A larger ratio indicated healthier streams, whereas a smaller number (i.e. more Chironomidae) may indicate environmental stress. However, it should be noted that Chironomidae tend to dominate communities at high latitudes.

HBI - The modified Hilsenhoff Biotic Index (HBI) summarizes the overall tolerance of the benthic community to pollution on the following scale: 0.00-3.50 (excellent), 3.51-4.50 (very good), 4.51-5.50 (good), 5.51-6.50 (fair), 6.51-7.50 (fairly poor), 7.51-8.50 (poor), and 8.51-10.00 (very poor). Tolerance scores were assigned to taxa after Hilsenhoff (1987 and 1988). Tolerance values were multiplied by the number of individuals in each taxa and summed for the entire sample, then divided by the total number of individuals.

Shannon H - A diversity index that takes into account the relative abundance and evenness of each taxa. In general, H values range from 1 to 3.5, with higher values indicating high taxa diversity and better water quality; values approaching 0 suggest a less diverse community and poor water quality.

Evenness - The measure of how evenly individuals are distributed among species. Values ranging from 0.5 to 1 represent an evenly mixed community and are indicative of unpolluted streams (natural water quality condition). Values from 0.3 to 0.5 suggest some degradation (fair condition), and from 0 to 0.3 represent a skewed community composition (poor condition).

2.3.3 MACROINVERTEBRATE METALS ANALYSIS

In 2011, metals analyses were conducted on aquatic macroinvertebrates (mayflies and stoneflies) at sites DO1, CR2, CR1, and CR0.7 in support of an ecological risk assessment being developed for the proposed pit lake. Macroinvertebrates were collected with Surber samplers and kick nets (500 µm mesh size). Samples were hand sorted and picked using plastic tweezers. Samples were processed with the same field and laboratory methods described for the Core Program metals analysis (*Section 2.5*) with the exception that only enough specimens were collected to analyze one replicate at the laboratory.

2.4 FISH POPULATION ASSESSMENT METHODS (CORE PROGRAM)

From 2004-2012, methods to assess fish population included aerial salmon surveys and resident fish surveys (i.e., electrofishing, trapping, and angling surveys). In 2008, a resistance board fish weir was installed near the mouth of Crooked Creek to more accurately estimate the size and timing of adult salmon populations migrating into the Crooked Creek drainage. The fish weir was operated during the 2008-2012 summer seasons.

2.4.1 ADULT SALMON AERIAL SURVEY

Helicopter salmon counts were conducted within the Crooked Creek drainage from 2004 to 2012. Target species included Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*Oncorhynchus keta*), and coho salmon (*Oncorhynchus kisutch*). Counts were timed to sample peak numbers of adult salmon in the system and to determine how far upstream into the drainages they migrate. Therefore, the timing of aerial survey dates was intended to coincide with the end of the migration peak. These dates for Crooked Creek were determined to be late July for Chinook and chum salmon, and mid-to-late September for coho salmon. Specifically, the flight dates for Chinook and chum salmon were July 25/2004, July 23/2005, July 19-20/2006, July 24-28/2007, July 23-25/2008, July 19-22/2009, July 24-25/2010, July 21-22/2011, and July 20-24/2012. For the coho salmon run, the flight dates were September 23-24/2004, September 26-27/2005, September 19-20/2006, September 11-13/2007, September 18-20/2008, September 13-15/2009, September 17-18/2010, September 15-18/2011, and September 19-24/2012.

2.4.1.1 AERIAL SURVEY- REACH SELECTION

Helicopter facilitated aerial surveys along the Crooked Creek drainage began at the mouth of Crooked Creek (confluence with the Kuskokwim River) and continued upstream to an unnamed but recognizable tributary located approximately 12.1 river miles (19.5 km) upstream of the confluence of Donlin Creek and Dome Creek (**Figure 1.1-1**). Streams were separated into reaches to document populations per segment and to document the upstream extent of migrations. Three reaches were delineated within Donlin Creek (DO-R1, DO-R2, and DO-R3) and five reaches within Crooked Creek (CR-R1, CR-R2, CR-R3, CR-R4, and CR-R5).

Tributaries that had potential to be affected by the Project were also aerially surveyed. These included Flat Creek (FL-R1), Dome Creek (DM-R1), Snow Gulch (SN-R1), American Creek (AM-R1), Grouse Creek (GR-R1), Anaconda

Creek (AN-R1), Crevice Creek (CV-R1), Eagle Creek (EG-R1), five reaches in Getmuna Creek (GM-R1, GM-R2, GM-R3, GM-R4, and GM-R5), and three reaches in Bell Creek (BL-R1, BL-R2, and BL-R3; **Figure 1.1-1**).

Two main factors were considered in setting the length of aerial reaches: 1) the reach cannot be too long as to lose detail concerning salmon distribution; and 2) reach boundaries needed to be set at easily identifiable landmarks to facilitate identification of the reach boundaries from the air. The upper-most reach within a particular basin was typically ended at a tributary confluence upstream of all documented salmon. In some instances, these upper boundaries have been slightly modified across years, as additional fish observations were collected. Current boundaries are displayed in **Figure 1.1-1**.

2.4.1.2 AERIAL SURVEY- VARIABILITY REDUCTION

The nine years of aerial salmon counts have been effective in determining the distribution of adult salmon within the Crooked Creek system. However, in order for these point-in-time surveys to provide a more informative index of the populations per stream reach, reduction of survey variability was necessary.

Annual salmon populations are inherently variable due to several natural factors affecting the return run success in a given year. The baseline data collection seeks to document this variation in the salmon run from year to year. In addition to the natural variation in the salmon run, other sources of variation in aerial surveys include decreased visibility due to tannins (organic leachate), tree canopy, daylight, and water turbidity. Some of these factors can be controlled and/or reduced as part of the aerial sampling methods but others cannot. The amount of tannins in the water cannot be reduced or avoided as tannin concentrations are related to seasonal changes in the hydrology of the catchment (e.g., flushing). Similarly, tree canopy or the amount of vegetative cover is proportionally related to sample effectiveness. On the other hand, daylight influences sampling accuracy considerably so every attempt was made to shift flight schedules to sunny or bright days, as well as during mid-day periods. Turbidity appears to be higher within the Crooked Creek system than in comparable systems of the Kuskokwim River drainage. Turbidity is primarily due to the natural geology, as silt is washed into the stream channel and suspended in the water column with any substantial rainfall. Field observations document that several watersheds in the Kuskokwim River drainage have lower levels of turbidity than Crooked Creek, with the same level of rainfall (e.g., Holukuk River, Holitna River, and even Getmuna Creek within the Crooked Creek drainage). To reduce variability, every attempt was made to fly during the best water clarity conditions, but still within the set run-timing window. This involved promptly shifting flight schedules to days where the stream water was clearest, typically after a few days without precipitation.

2.4.2.3 AERIAL ACCURACY

In order to understand the variability of aerial survey fish counts and compare the accuracy of aerial surveys across years, the ratio of the aerial counts to the weir passage counts was employed. Aerial accuracy is determined as the fraction of aerial fish counts divided by the total weir counts, expressed as a percentage. Comparisons were made between the three most numerous species of salmon found in the Crooked Creek drainage as well as the totals of these species.

2.4.2 ADULT SALMON CROOKED CREEK WEIR

2.4.2.1 FISH WEIR - DESIGN METHODS

The resistance board weir consists of floating resistance board panels, boat passage panels, a fish passage panel and chute, fixed picket near-bank weirs, bulkheads, and a video system (**Figure 2.4-1**). The weir was constructed using specifications outlined by Tobin (1994) with minor changes to some of the components. The substrate rail and floating resistance board panels covered the middle 110 foot (33.5 m) portion of the channel. Fixed pickets extended five feet (1.5 m) from the weir to each bank (**Figure 2.4-1**). Each panel was four feet (1.22 m) wide with

pickets 1-1/4 inch (3.17 cm) diameter and spaced to leave a gap of 1-5/8 inches (4.13 cm) between each picket. This spacing was designed to allow smaller resident fish to pass upstream through the pickets and to restrict the crossing of targeted salmon species. Each panel was attached to a steel rail (substrate rail) anchored to the river bottom and attached to one another by connection pickets. Specialized boat passage panels were designed and installed in the deeper portion of the channel to temporarily submerge and to allow boats to pass over the weir. The weir was configured to allow fish passage near, but not at, the deepest part of the channel through a specialized panel. The video system, consisting of a sealed camera box and fish passage chute, was attached directly to the fish passage panel (Gates and Palmer 2007). Bulkheads were installed near each bank to keep the panels taut across the channel thus preventing shifting/buckling, and protecting the banks from erosion (**Figure 2.4-1**).

A primary difference between the Crooked Creek weir and many other resistance board weir designs in Alaska is the absence of a live trap for fish collection. Fish collection was not an objective of this study. The absence of the live trap allowed fish to pass freely through the passage chute at any time of day, reduced obstruction of stream flow, and minimized stress on migrating fish. The absence of a live trap also permits uninterrupted video monitoring of fish passage events, allowing for assessment of diel (24 hour) movement patterns (Johnson et al. 2007).

2.4.2.2 FISH WEIR VIDEO- DESIGN AND OPERATIONS

Setup and design of the video system was similar to that used by Gates and Palmer (2008) and Anderson et al. (2004). The weir was unmanned and outfitted with a video system to monitor upstream fish passage. This design requires no sampling or handling of fish and is a passive, non-invasive counting method. Digital video images can be reviewed numerous times without degradation, are easily archived, and can reduce possible study impacts to the species being observed (Edwards 2005).

Attached to the upstream end of the fish passage panel, the sealed video box recorded fish passage via motion detection. The video system consisted of a video camera and a pair of 12-volt underwater pond lights. The box was filled with distilled water and separated from the river water with a glass plate, allowing the camera to easily capture images of fish passing through. An external surveillance camera was installed in a tree on the bank and was used to remotely view live footage of the weir and monitor for vandalism or debris jams.

Video footage was recorded on a digital video recorder (DVR) located in the village of Crooked Creek, Alaska. On-site power was available at this location. The DVR was equipped with motion detection to minimize the amount of blank video footage recorded and reduce review time (Gates and Palmer 2008). The camera is designed to monitor for movement 24 hours per day, seven days a week and record the motion-detected video permanently on its hard drive.

The two video signals from the cameras were transmitted from the weir site to the DVR in Crooked Creek via two-5.8 GHz microwave frequency video repeaters. Microwave transmission of the video signal minimized the power requirements needed at the remote site and allowed staff to remotely monitor the weir operation. Staff were able to monitor the efficiency of the weir system, ensure all parts were in working order, conduct daily checks, view real-time video from both cameras, and download video footage. Video footage could be viewed onsite as well as from remote locations through a static Internet Protocol (IP) address and Intellex Network Client® software.

The electrical system at the weir was powered by eight solar panels charging a bank of eight deep-cycle batteries. Water level and flow during the operational weir periods were obtained from the Crooked Creek USGS gauge station located approximately 1.37 river miles (2.2 river km) upstream of the weir (**Figure 1.1-1**).

2.4.2.3 FISH WEIR VIDEO- DATA ANALYSIS

Data recorded throughout the operational period were stored on the DVR and 1TB external hard drive. The data were brought back to the office where each recorded video segment was reviewed and analyzed by experienced fish biologists. Data parameters collected for each recorded fish passage included: date and time of passage, species, sex, direction of passage, estimated total length (TL), presence and location of tags, and any other relevant notes. Sex was determined by observing external morphological features. Using measurement marks on the backdrop board of the video passage chute, length measurements were estimated using TL to the nearest inch. Although not an exact measurement, the estimated length allowed for relative comparison between each species.

2.4.2.4 ESCAPEMENT ANALYSIS

Escapement is defined as the number of spawning adult salmon that passed through the weir within a season. Daily escapement numbers at the Crooked Creek weir were calculated by counting upstream passage, minus any downstream passage during a 24 hour period. This method was continued over the entire operational period.

2.4.2.4 ESCAPEMENT MODELING METHODS

In order to compare data on escapement of salmon from 2008 to 2012, missing daily counts as well as periods of incomplete counts were modeled using methods presented in ADF&G's Tatlawiksuk River Salmon Studies, 2010 (Clark et al. 2011). Estimates for each species of salmon were modeled in order to compare counts between species as well as overall escapement of all salmon species over time. According to the Tatlawiksuk Study, 2010, three approaches may be taken to model the different types of losses that occur in a data set: proportional, linear, and single day methods. The various methods require data from water bodies that exhibit similar characteristics and hydraulic regimes. For relevant data gaps, data from Crooked Creek in either 2009 or 2010 were used due to the facts that 1) data were for the same water body; 2) the data sets were complete for those years; and 3) the hydraulic profiles for those years were deemed similar enough to the years in question for comparison.

The following guidelines are used when deciding which model to use in estimating passage data:

- 1) Where either start or ending data are missing for a season, the "proportional method" is used based on complete data sets for a similar flow year of the same or similar water body.
- 2) The "linear method" is used to model data gaps between existing data in the same year in order to interpolate daily estimates from average observed passages two days before and two days after the inoperable period.
- 3) Where passage data for a single day are missing, the "single day method" is utilized. The single day method passage estimates are based on the average observed passage two days before and two days after the inoperable day.
- 4) On occasion when the weir is inoperative for only part of the period or the weir is over-topped; estimates of missed passage are generated using the appropriate method minus any observed passage from the compromised day.
- 5) In the event where the compromised day passage count is higher than the modeled data, the compromised numbers are used.

For data missing at the start of 2008 and ends of 2008 and 2012, passage counts from both 2009 and 2010 complete data sets were used together with the proportion method and Equation 1.

$$n_{d_i} = \left(\frac{(n_{2d_i} \times n_{1t_1})}{n_{2t_1}} \right) - n_{o_i} \quad (1)$$

where

n_{d_i} = passage estimate for a given day (i) of the inoperable period;
 n_{2d_i} = passage for the i^{th} day in the model data set 2 ;
 n_{1t_1} = known cumulative passage for the operational time period (t_i) from the estimated data set 1;
 n_{2t_1} = known cumulative passage for the operational time period (t_i) from the estimated data set 2;
 and
 n_{o_i} = observed passage (if any) from the given day (i) being estimated.

The substantial mid-season data gaps in 2011 as well as the two-day gaps and larger compromised period in 2012 were modeled using the “linear method” based on days before after the gap using Equation 2.

$$m_{d_i} = \alpha + \beta \cdot i - n_{o_i} \quad (2)$$

$$\alpha = \frac{n_{d_1-1} + n_{d_1-2}}{2}$$

$$\beta = \frac{(n_{d_{I+1}} + n_{d_{I+2}}) - (n_{d_1-1} + n_{d_1-2})}{2(I + 1)}$$

for ($d_1, d_2, \dots, d_i, \dots, d_I$)

where

m_{d_i} = passage estimate for the i^{th} day of the period ($d_1, d_2, \dots, d_i, \dots, d_I$) when the weir was inoperative;
 n_{d_1-1} = observed passage of 1 day before the weir was inoperative or washed out;
 n_{d_1-2} = observed passage of the 2nd day before the weir was inoperative or washed out;
 $n_{d_{I+1}}$ = observed passage the first day after the weir was reinstalled;
 $n_{d_{I+2}}$ = observed passage the second day after the weir was reinstalled; and
 I = number of inoperable days.
 n_{o_i} = observed passage (if any) from the given day (i) being estimated

The single day method passage estimates are calculated as the average observed passage two days before and two days after the inoperable day according to Equation 3.

$$m_d = \frac{n_{d_1-1} + n_{d_1-2} + n_{d_{I+1}} + n_{d_{I+2}}}{4} \quad (3)$$

where

m_d = passage estimate for the day (i) day when the weir was inoperative;
 n_{d_1-1}, n_{d_1-2} = observed passage of 1,2 days before the weir was inoperative;
 $n_{d_{I+1}}, n_{d_{I+2}}$ = observed passage of 1,2 days after the weir was inoperative;

The single day method was applied to all species counts on the single day when the weir was inoperable in 2008.

2.4.3 RESIDENT FISH AND JUVENILE SALMON SURVEYS

Resident fish and juvenile salmon populations were evaluated at 27 Crooked Creek Core Program sites (i.e., DO1, FL1, DM1, QZ1, SN1, SN2, QU1, CR2, CR1, CR0.7, CR0.3, LEI, AM1, AM2, AM3, AM4, GR1, OM1, AN1, AN2, CV1, EG1, BC1, AC1, GM1, BL1, and Weir; **Figure 1.1-1**) between July 21-28/2004, July 23-28/2005, July 18-30/2006; July 21-31/2007; July 24-28/2008, July 16-23/2009, July 20-24/2010, July 14-21/2011, and July 20-30/2012. Fish populations were monitored with backpack electrofishers, minnow traps, angling surveys, and fish weir.

2.4.3.1 ELECTROFISHING

Consistent with the Core Program goal, electrofishing is intended to provide baseline fishery data for the assessment of any future mine-related impacts. Permanent electrofishing reaches were established so the number of fish collected could be compared between years. Each reach is intended to encompass representative habitat types and to capture the majority of the species occurring in each stream segment. Electrofishing was conducted with Smith-Root, Inc. LR-24 Backpack Electrofisher® units. Sample reach boundaries were typically delineated by natural obstructions to fish movement (e.g., shallow riffle areas or pools). No block nets were used. Fish captured were identified to species, measured by grouping into pre-determined length bins, and released. Length bins were developed by OtterTail for this project based on general observations of fish life histories observed in the study area, and to allow for expedited processing of captured fish to reduce mortality. Additionally, bins provide a rough estimate of age. Bins selected were <45 mm, 45-55 mm, 55-80 mm, 80-120 mm, 120-300 mm, and >300 mm. Fish under 55 mm were generally considered young-of-the-year (YOY), whereas fish less than 120 mm were generally considered to be 1+ years in age. The bins were also developed to allow for quick sorting of slimy sculpin (*Cottus cognatus*) < 55 mm for the fish tissue metals analysis without having to physically handle each fish.

In 2004 surveys, OtterTail staff used a multiple-pass electrofishing method for fish collection. Consecutive electrofishing passes were conducted and fish were removed from the reach after each pass. Two passes were conducted if the number of fish removed in pass one accounted for more than 70 percent of the total number of fish collected in pass one and two. The reach was electrofished a third time if this criterion was not met. Due to concern for spawning salmon, Alaska Department of Fish and Game (ADF&G) requested that only a single-pass be conducted in 2005 and 2006, which precludes a true statistical fish population estimate for these years. However, OtterTail considers the single-pass method to represent minimum population of that stream reach. The multiple pass survey method was allowed after 2006.

Fish population estimates in the results section are based on the single-pass minimum given that first pass efficiency was consistently greater than 70 percent of the total catch and that single-pass data enables relative comparison with the Road Alternative Program data, which was performed using the single-pass method. In addition, including the two restricted years of data in the population analysis increases the sample size and statistical power for future assessments of potential impacts.

2.4.3.2 TRAPPING METHODS

Fish were also captured using minnow traps set well outside of the electrofishing reaches to eliminate influence from the electrofishing survey. Three traps were set at each site and baited with preserved salmon eggs in the best habitats for trap use, which was typically pool habitat. Minnow traps were set for approximately 24 hours. Fish captured were identified, measured (same methods described for electrofishing in *Section 2.4.3.1*), and released.

2.4.3.2 FISH WEIR METHODS

Resident species were incidentally observed passing through the weir. Because these observations resulted in documentation of new species within the Crooked Creek drainage, the data was incorporated into the monitoring program. The methods used for observation of resident species are the same as those described in *Section 2.4.2* for adult salmon.

2.5 FISH TISSUE METAL CONCENTRATIONS METHODS (CORE PROGRAM)

In 2004, three key sites (CR1, CR2, and DO1) were selected for fish tissue metals analysis (**Figure 1.1-1**). Site DO1 was selected as a control site because of its location upstream of the Project and the currently active independent placer mining operation. Site CR2 is just downstream of all historic and active placer mining in the watershed and was selected to differentiate between these activities and any potential effects from the Project. Site CR1, located

downstream of the proposed waste rock and tailings facilities, will be used to assess changes due to the Project. A fourth site (CR0.7) was added in 2006, downstream of the Crevice Creek confluence, to capture the predicted possible impacts due to a proposed water diversion from the Anaconda Creek drainage. Due to the fact that this site is further downstream than CR1, data gathered may be useful for the evaluation of recovery from any impacts that may be detected at CR1.

2.5.1 TARGET AGE CLASS AND SIZE CLASS SELECTION

To minimize variability in the dataset it was necessary to select a target age and size class, as well as a target fish species. Juvenile fish <55mm in total length (TL) were selected for three primary reasons:

- 1) Low Variability: fish in this size class rapidly accumulate potentially toxic metals. Ott and Morris (2007) documented accumulation of metals in juvenile Dolly Varden (*Salvelinus malma*) within five to six weeks after dispersing from their un-mineralized overwintering grounds to mineralized tributaries. Testing these juvenile fish increases the likelihood that metals present at the site will be detected in the fish tissue. In addition, testing juvenile fish from the same cohort is likely to reduce sample variability as those fish would be consistently exposed to one year of bioaccumulation.
- 2) Limited Mobility: Juvenile fish <55 mm TL, slimy sculpin in particular, have relatively limited mobility (Cunjak et al. 2005) and can reasonably be assumed to have resided in the stream reach being surveyed since birth. This would not be the case for adult fish of other species, especially with regards to migratory species such as Arctic grayling (*Thymallus arcticus*) and salmon.
- 3) Assurance of Age: Sampling fish <55 mm TL also improves the likelihood that the fish sampled are all of a similar age (< 1 year old). It is important to limit samples to one age class because bioaccumulation of metals in fish tissue increases with age (Bowman et al. 2010), and testing fish of different ages can skew results and increase variability in the dataset.

Early sampling indicated that slimy sculpin <55 mm TL were likely to be YOY. However, 2005 samples suggested that YOY and age-1+ fish were present in the <55 mm size class. Additional sampling was conducted in 2006 to determine whether there was difference between the year classes at this size (OtterTail 2007). Results from this study indicated that there were no statistical differences in metals concentrations between YOY and age-1 sculpin <55 mm TL, therefore this target length (<55 mm) was considered a good criterion to minimize sample variation.

2.5.2 TARGET SPECIES SELECTION – SLIMY SCULPIN

Initially, the preferred target species for metals analysis was coho salmon due to its value as a human food source. However, juvenile and YOY salmon are known to move considerable distances from their natal stream and into side tributaries (Davis and Davis 2010; Kahler and Quinn 1998), and abundance of <55 mm coho salmon during the 2004 and 2005 field seasons was limited for this analysis. This uncertainty of residence time within a reach, and low assurance of capturing sufficient numbers of fish annually to conduct the analysis ruled out using juvenile salmon as a target species. Juvenile slimy sculpin are more abundant and were also collected at all sampling sites in all years of this analysis. For the purposes of this study, slimy sculpin are considered a better target species than salmon due to their limited mobility and high abundance in the study sites. Several mark-recapture studies of freshwater sculpin have found that the majority of recaptured fish move less than 50 meters (McLeave 1964; Brown and Downhower 1982; Hill and Grossman 1987; Morgan and Ringler 1992). Slimy sculpin are relatively abundant at all metal sampling sites, and are expected to continue to be abundant in these sites for future study. Sculpin are resident fish at these sites and spawning migration access is not a limiting factor as with salmon.

species. Consistent abundance is essential to the success of this monitoring program as large sample numbers are necessary for statistical analyses.

2.5.3 DETERMINING NUMBER OF SAMPLES

In the development of this monitoring program, multiple replicate samples were established at each site in order to conduct statistical tests. Establishing a robust baseline dataset is important for the future comparison of pre- and post-Project effects along Crooked Creek study sites. Five to six fish were used for each composite sample in order to have enough tissue for laboratory analysis of metals. Initially, a target of 15 composite samples of each species was collected from each site. Multiple years of sampling indicated that at least 90 individuals were needed at each site to obtain the target 15 composite samples. Therefore, only slimy sculpin were collected in later years of the study because salmon were not present in high enough abundance.

2.5.4 FISH TISSUE FIELD SAMPLING

Fish were collected primarily by electrofishing. Minnow traps were used at sites where samples were difficult to obtain with this method. Specimens from minnow traps were kept separate to evaluate potential contamination from the metal trap frame. Clean hand techniques were used during sampling. Fish were collected and transferred directly from the sampling nets to Ziploc® freezer bags and double bagged. Fish were measured through the sample bag to prevent contamination. From 2004 to 2007, YOY and age-1+ coho and Chinook salmon were sampled along with sculpin. Salmon were no longer sampled after 2007 for the reasons described above. Fish samples were frozen as soon as possible and sent to Columbia Analytical Laboratory in Kelso, Washington for analysis.

2.5.5 FISH TISSUE LABORATORY ANALYSIS

Each composite sample consisted of homogenized whole-body fish specimens. Results are reported in wet weight (mg/kg); a dry weight correction calculation is provided in **Appendix I**.

In the laboratory, samples were frozen and stored at -20°C. When possible, the same number of fish (usually 5 to 8) were used to create each composite, however due to the varying sizes of specimens, this was not always possible. Based upon the weights needed for each procedure and the number of fish available, the maximum number of composites (i.e. replicates) was created from each sampling site.

Whole-body fish tissue samples were freeze-dried, grinded, and homogenized prior to digestion for metals analysis. The digestion procedure for all elements, except mercury, consisted of an acid digestion and oxidation of organic materials under elevated temperature and pressure in a closed system.

For mercury analysis, a large aliquot of sample was digested, allowing representative sub-sampling of tissues. The digestion procedure incorporates similar ratios of digesting/oxidizing reagents as found in standard EPA procedures. Additional concentrated nitric acid was added to facilitate the digestion of the high organic content.

The digested material was analyzed using a combination of laboratory methods. Selenium were analyzed using GFAAS because of uncorrectable isobaric interferences when using ICP-MS. Mercury was analyzed in tissue using standard cold vapor techniques. All other elements were analyzed using ICP-MS or ICP-OES, depending on the required sensitivity. **Table 2.5-1** contains a summary of the parameters, analytical methods, and detection limits.

2.5.6 FISH TISSUE STATISTICAL ANALYSIS

Analyses included the calculation of basic statistical summaries, box-and-whisker plots, analysis of variance (ANOVA), and estimates of percent detectable change. Statistical analyses were conducted with JMP software. Box-and-whisker plots and ANOVA were used to assess differences over the nine year sample period on each site.

The percent detectable change was estimated by using the grand mean of each component at each site plus or minus three times the standard deviation for that mean. In other words, the conservative assumption is that any change in the data greater than the mean plus three times the standard deviation falls outside the natural variance of the data set.

2.5.7 SUPPLEMENTARY METALS ANALYSIS (BURBOT AND NORTHERN PIKE)

Additional metals analyses were conducted on non-target species that are important to local subsistence communities. In 2009, four burbot (*Lota lota*) were collected at site CR0.3 to test mercury (Hg) concentrations in resident fish species close to the village of Crooked Creek. Burbot, a resident fish often used as a food source by humans in the area, were collected via electrofishing and the same field and laboratory techniques listed above were applied. In 2010, two northern pike (*Esox lucious*) were collected from Crooked Creek and analyzed. Northern pike were specifically targeted as they are an important food fish for local communities, grow to large sizes and would be likely to bioaccumulate metals in their tissue. Northern pike were collected with hook and line sampling and the same field and laboratory techniques listed above were applied.

2.6 AQUATIC LIFE TOXICITY TEST METHODS (CORE PROGRAM)

In 2008, an aquatic life toxicity test, or whole effluent toxicity (WET) test, was performed on Crooked Creek surface water collected at Site CR0.7, downstream of all existing placer mining activities and potential impacts from the Project. This toxicity test was intended to determine if the current/historical placer mining or any natural metal releases coming from the mineralized zone were causing any detectable level of toxicity to aquatic life downstream of the Project. The detection of toxic pollutants would also be important for future NPDES permitting requirements.

Toxicity testing measures the effects of pollutants in the water column on aquatic life. The test also estimates the “safe” or “no effect” concentrations of substances in the sampled water that would allow normal propagation of aquatic life. The chronic toxicity test was selected for the Crooked Creek biomonitoring program because it is more sensitive than acute testing. Therefore, if the water passes the chronic test, it can be assumed that it would have also passed the acute tests. Chronic toxicity tests are conducted over seven days as opposed to 48-hour and 96-hour acute tests.

All field and laboratory procedures followed USEPA and State of Alaska guidelines. Two gallons of stream water were collected on September 22, 24, and 26, 2008 at site CR0.7 (**Figure 1.1-1**). Samples were chilled (0-6° C) and express-delivered to the SeaCrest Group in Colorado for laboratory testing. Analyses were performed to determine concentrations of alkalinity, hardness, conductivity, dissolved oxygen, ammonia, chlorine, and pH (**Appendix B**).

Over a seven day period, the chronic test measures significant differences in lethality and reproduction (using the cladoceran - *Ceriodaphnia dubia*) and growth (using the fathead minnow - *Pimephales promelas*) between control and test organisms. Test organisms were exposed to sample concentrations of 0, 12.5, 25, 50, 75, and 100 percent. Test concentrations were created by diluting the sampled stream water with moderately hard laboratory reconstituted water (sodium bicarbonate, calcium sulfate, magnesium sulfate, potassium chloride added to deionized water).

Individual *C. dubia* were placed in 30 ml plastic containers containing approximately 15 ml of exposure medium. Ten replicates of each concentration were used. The animals were fed daily with a mixture of yeast, cereal leaves, and trout chow (YCT). This was supplemented with an equal volume of green algae (*Selenastrum capricornutum*). The exposure medium was changed daily in each container and the number of young released overnight were

counted and recorded. Young were removed from the containers daily and discarded. Measurements of temperature, dissolved oxygen, and pH before and after water changes were recorded daily.

Less than one-day-old fathead minnows, cultured in the laboratory, were exposed in 500 ml plastic cups with 250 ml of media that was replaced daily. Four replicates were used for each concentration. Ten fish were placed in each cup, monitored daily for survival, and fed live brine shrimp at least twice per day. After seven days, the fish were removed from the cups, euthanized, and then placed in aluminum pans and dried in an oven overnight at 100°C. The pans were then weighed on a five-place analytical balance to determine the average dry weight of the fish from each replicate.

Data from the tests were analyzed using TOXSTAT statistical package. Following USEPA guidelines, test acceptability was determined using control survival and performance criteria, concentration-response relationships and percent minimum significant differences.

3.0 RESULTS AND DISCUSSION (CORE PROGRAM)

3.1 MACROINVERTEBRATE RESULTS (CORE PROGRAM)

A list of macroinvertebrate taxa found within the Crooked Creek drainage is presented in **Table 3.1-1**. Macroinvertebrate bioassessment metrics for sites are presented in **Appendix C** and the nine year averages of these metrics are provided in **Table 3.1-2**. Additional statistics on the 2004 through 2012 data set are included in **Appendix D**; **Figures 3.1-1, 3.1-2, 3.1-3, and 3.1-4**.

3.1.1 CROOKED CREEK DRAINAGE MACROINVERTEBRATE COMMUNITY - OVERVIEW

Aquatic macroinvertebrate communities found in streams within the Crooked Creek drainage are consistent with other studies of Alaskan streams (Milner and Piorkowski 2004). In general, although macroinvertebrate communities in Crooked Creek and its tributaries are composed of taxa indicating relatively good water quality (**Table 3.1-1**), the Shannon diversity (H), evenness (e), and HBI indices (**Figure 3.1-4**) suggested that natural stressors are present in the system. A plausible explanation for this discrepancy is based on the drastic seasonal changes in habitat conditions often observed in streams in this area. Macroinvertebrate abundance and taxa richness in Alaskan streams are often strongly affected by freezing during winter, and flooding and associated movement of the stream bottom during summer (Miller and Stout 1989). Within the Crooked Creek drainage, several of the smaller tributaries can freeze to the stream bottom during winter (NES 1999). In addition, the underlying geology of the area causes siltation in the Crooked Creek drainage, which in turn leads to a highly armored (or embedded) stream bottom. Siltation and the resulting decreased amount of interstitial space can reduce both the abundance and taxa richness of the macroinvertebrate community, and exacerbate the effects of winter freezing by limiting the amount of habitat available for colonization.

3.1.1.1 MACROINVERTEBRATE METRICS

The observed dominant taxon at most sites from 2004 to 2012 was Chironomidae, which is a family generally thought to be tolerant to pollution (**Table 3.1-2**; **Appendix D**). The high prevalence of chironomids in the Crooked Creek drainage as well as in other Alaskan streams is due to their short life cycles and their tendency to be more tolerant of the drastic natural disturbances common in this geographical area.

In 2009 and 2010, Chironomidae were identified to genus which, in relation to previous surveys, increased the total taxa count in Crooked Creek sites by 5 to 10 taxa depending on the stream. However, Chironomidae were grouped as one taxon for consistency with previous data and to conduct multi-year comparisons (**Appendix C**). Individual chironomid genera continued to be the dominant taxa at most sites (**Table 3.1-2**). Overall, Eukieferiella and Orthocladius, two common and widespread chironomid genera, were the most common taxon in the Crooked Creek drainage. However, Pagastia, a genus with a low HBI tolerance value (i.e. an indicator of good water quality), was also abundant suggesting that although the high abundance of chironomids would suggest poor water quality, individual genera within this family can actually indicate good water quality conditions. This is especially important in Alaskan streams where chironomids often make up 50 percent or more of the macroinvertebrate abundance in a given stream.

In general, macroinvertebrate abundance in streams tends to be variable and highly dependent on the flow conditions. Across all sites sampled in the Crooked Creek drainage from 2004 to 2012, invertebrate abundance varied from year to year with lower abundances observed in 2007, 2008, 2011, and 2012 (**Figure 3.1-2**). The highest macroinvertebrate abundance across all sites was observed in 2010 (**Figure 3.1-2**; **Appendix C**).

As expected, the smaller tributary streams had lower average macroinvertebrate abundance than the Crooked Creek reference and mainstem sites (FL1, DO1, CR2, CR1, CR0.7, and CR0.3) from 2004 through 2012 (**Figures 3.1-1 and 3.1-2**). GM1, a tributary stream to Crooked Creek, was not grouped with the tributaries for this analysis because it shows consistently high macroinvertebrate abundance across all years, and is more similar to the reference and mainstem sites than to the other tributaries.

Contrary to the high annual variability in total macroinvertebrate abundance and other metrics, the variability in EPT taxa richness across years was relatively low (**Figure 3.1-3**). Higher EPT taxa was observed at Crooked Creek reference (FL1, DO1), mainstem sites (CR2, CR1, CR0.7, CR0.3), and at GM1. Given the low annual variability, EPT richness may be the most useful metric to compare pre- and post-Project effects on the macroinvertebrate community.

The Hilsenhoff Biotic Index (HBI) suggested that water quality in sites along the Crooked Creek drainage typically ranged from “very good” to “good” (**Figure 3.1-4**). However, HBI values indicating “excellent” water quality were observed at the Donlin Creek tributary DM1 and the Crooked Creek tributaries AM2, OM1 and EG1. It should be noted here that although the HBI tolerance values were developed for streams in Wisconsin, this metric is still widely used in other Alaskan studies and can be used in our study to compare sites and track changes across years.

3.1.1.2 REFERENCE SITES: MACROINVERTEBRATES IN UPPER DONLIN CREEK AND FLAT CREEK DRAINAGES

The reference sites DO1 and FL1 are upstream tributaries to Crooked Creek that appear to have similar macroinvertebrate community composition and abundance to the Crooked Creek mainstem (i.e., Sites CR2, CR1, CR0.7, and CR0.3; **Table 3.1-2; Figure 3.1-1; Appendix C**). An analysis of variance for macroinvertebrate abundance for these sites with data from 2006 to 2009 indicated that there are significant differences across years (ANOVA, $p < 0.01$; $df = 3$) but no significant differences occur across sites (ANOVA, $p > 0.05$, $df = 5$). A similar test including more current data (2006-2011), also indicated annual differences occurred (ANOVA, $p < 0.05$, $df = 5$) and no differences in abundance across sites (Sites CR2, CR1, CR0.7 and DO1; ANOVA, $p = 0.9$, $df = 3$).

Macroinvertebrate abundance tended to be slightly higher in FL1 than in DO1 and the Crooked Creek mainstem sites, likely due to the unique large and angular substrate in FL1. This substrate is less likely to be disturbed by increases in stream flow thus favoring the colonization of aquatic mosses and the creation of a more suitable habitat for aquatic macroinvertebrates. Similarities in total taxa richness and number of EPT taxa were also observed at Sites DO1 and FL1 (**Figure 3.1-3**).

No significant differences in EPT taxa were found between reference and mainstem sites (ANOVA, $p > 0.05$, $df = 4$) or across years (ANOVA based on 2006-2009 data; $p > 0.05$, $df = 3$). The similarity of these reference sites to the Crooked Creek mainstem sites, along with their relatively low annual variability in macroinvertebrate community composition and abundance, suggests that these two locations are good control sites to assess future Project-related impacts to the Crooked Creek mainstem.

3.1.1.3 MACROINVERTEBRATES IN DONLIN CREEK TRIBUTARIES: DOME CREEK, QUARTZ, AND SNOW DRAINAGES

Macroinvertebrate abundance was lower at the Upper Donlin Creek tributary Snow Gulch (SN2) and at Dome Creek (DM1) than at the reference (DO1, FL1) and mainstem sites (CR2, CR1, CR0.7, and CR0.3; **Table 3.1-2; Figure 3.1-1**). However, significant differences between these sites were not found when comparing data from 2007 and 2008, when all of these locations were sampled (ANOVA, $p > 0.05$, $df = 3$). Abundance at Quartz Gulch (QZ1) was similar to the reference and mainstem sites.

The observed total number of taxa and total EPT taxa appeared lower at DM1, QZ1 and SN2 than in mainstem and reference sites (**Table 3.1-2; Figure 3.1-3**). However, the difference between Site SN2 and the reference sites is

only marginally significant (ANOVA, $p=0.059$, $df=2$). This comparison was based on the three years for which data was collected at all these sites (i.e., 2007-2009).

The overall higher number of EPT taxa and species diversity at Site DM1 than those observed at QZ1 and SN2, is consistent with the excellent water quality conditions indicated by the HBI index at this site (**Table 3.1-2; Figures 3.1-3 and 3.1-4**). HBI metrics were also indicative of excellent water quality conditions at Site QZ1 and good quality conditions at reference and mainstem sites (**Figure 3.1-4**).

3.1.1.4 MACROINVERTEBRATES IN CROOKED CREEK MAINSTEM

The Crooked Creek mainstem sites (CR2, CR1, CR0.7, and CR0.3) are similar to each other in terms of macroinvertebrate abundance, species composition, and total taxa and EPT richness (**Table 3.1-2; Figures 3.1-1 and 3.1-3**). Significant differences in abundance (ANOVA, $p>0.05$, $df=3$) and EPT taxa (ANOVA, $p>0.05$, $df=3$) between these sites were not found. In general, mainstem sites have substantially higher macroinvertebrate abundance than the tributaries to Crooked Creek, which is likely a result of stream and catchment size. The larger size of Crooked Creek mainstem reduces the likelihood of substrate freezing during winter, allowing colonization by a larger number of taxa and favors higher macroinvertebrate abundance. Although macroinvertebrate composition and abundance was similar across Crooked Creek mainstem sites, a substantial amount of variability from year to year has been observed (**Figure 3.1-2**). These annual differences in abundance at these sites was significant (ANOVA, $p<0.05$, $df=4$) but no significant differences in EPT taxa were found across years (ANOVA, $p>0.05$, $df=4$).

3.1.1.5 MACROINVERTEBRATES IN CROOKED CREEK TRIBUTARIES: AMERICAN CREEK, GROUSE CREEK, OMEGA GULCH, ANACONDA CREEK, CREVICE CREEK, EAGLE CREEK, GETMUNA CREEK, AND BELL CREEK DRAINAGES

Macroinvertebrate abundance, taxa richness, and EPT richness was typically lower in Crooked Creek tributaries than in reference or mainstem sites (**Table 3.1-2; Figures 3.1-1 and 3.1-3**). The differences in abundance between tributary Sites AN1, CV1, GM4 and reference sites were significant (ANOVA, $p<0.05$, $df=3$). Significant annual differences in abundance at these sites were not observed (ANOVA, $p>0.05$, $df=3$). Macroinvertebrate abundance at Sites AM1 and GM4 were slightly higher than other tributary sites. No significant differences in abundance were found between Sites AM1 and GM4 and reference Site DO1 (ANOVA, $F=0.65$, $p>0.05$), but the difference between Sites AM1 and GM4 and reference Site FL1 were significant (ANOVA, $F=6.48$, $p<0.05$).

Total and EPT taxa were also lower in GR1, OM1, AN1, AN2, CV1, EG1, GM2, GM3, GM4 and BL1 than in AM1. The total number of taxa at this site and at reference and mainstem sites was similar (**Table 3.1-2; Figure 3.1-3**). Significant differences between the total number of taxa at Site AM1 and reference Site FL1 were not found (ANOVA, $F=3.3$, $P>0.05$). However, the total number of taxa at Site AM1 and reference Site DO1 were significantly different (ANOVA, $F=4.93$, $p<0.05$). The overall abundance and composition of the macroinvertebrate communities at BL1 and at GM2 and GM3, which were sampled for the first time in 2012, were similar to what has been observed in other Crooked Creek tributaries. However, Chironomidae were found in substantially larger numbers at sites BL1, GM2 and GM3 (**Table 3.1-2**).

The average HBI for tributary sites ranged from 2.38 at OM1 to 5.27 at GM2, suggesting that water quality conditions are good to excellent (**Table 3.1-2; Figure 3.1-4**). These sites are located in relatively small channels and their overall lower macroinvertebrate abundance and total and EPT taxa may be related to freezing during winter. Site OM1 in particular has an unexpectedly low HBI value, likely due to the dominance of shredders (Plecoptera, Nemouridae) in the macroinvertebrate community at this site. The substrate of OM1 was dominated by woody debris and leaf litter, thus the dominance of Nemoura is not surprising at this site.

The downstream tributary Getmuna Creek site GM1 was significantly different from all other tributaries sites surveyed along the Crook Creek drainage. GM1 tended to have substantially higher macroinvertebrate abundance, number of taxa, and number of EPT taxa than all other tributaries sites. Macroinvertebrate composition at GM1 was similar to reference sites (**Table 3.1-2**), but abundance was typically higher than at DO1 and all mainstem sites (**Figures 3.1-1**). GM1 likely supports higher macroinvertebrate abundance because of its abundant riffle-pool habitats, low cobble embeddedness, and larger catchment size. Further, unlike most other tributary sites in this study, GM1 is also likely to provide unfrozen refugia for aquatic organisms during winter.

3.1.2 DETERMINATION OF NATURAL VARIABILITY IN MACROINVERTEBRATE METRICS

In general, macroinvertebrate abundance at all Crooked Creek study sites appears to change substantially across years. A distinct pattern of increasing or decreasing abundance across years has not been observed (**Figure 3.1-2**). In general since 2004, higher abundances were observed in 2005, 2006, 2009, and 2010. Natural variability is an important factor in biological monitoring programs. One of the primary goals of the macroinvertebrate biomonitoring program is to document the natural variation at each site over the course of several years. A substantial amount of spatial and temporal variability in the composition and abundance of macroinvertebrates is typically anticipated because stream environments are known to be patchy and highly dependent on a variety of natural (physical, chemical, biological) factors, including stream flow and temperature.

Because of the potential natural variability in macroinvertebrate communities within a small spatial scale (e.g., within a site) five replicate samples were collected at each Crooked Creek site to reduce variance and increase statistical power. In general, the observed within site variance was negligible for all years of the study (**Figure 3.1-1**). The greatest variation was observed between sites (**Figure 3.1-1**) and across years (**Figure 3.1-2**). Reference and mainstem sites (larger catchment size) were substantially different than tributaries (smaller catchment size).

To determine whether five replicate samples were adequate to reduce variability within each site, OtterTail increased the number of replicates in 2007. That year, 20 replicate samples were collected at a single site with a riffle large enough to accommodate this number of replicates (CR0.7). We found that there were no significant differences between metrics calculated with 5-replicate samples and with 20-replicates (OtterTail 2008). Therefore, it appears that there is no justification for increasing the sampling effort to more than the current 5 replicates per site.

3.1.3 METALS CONCENTRATIONS IN MAYFLIES AND STONEFLIES WITHIN THE CROOKED CREEK DRAINAGE

Mayflies (order Ephemeroptera) and stoneflies (order Plecoptera) were collected from sites DO1, CR2, CR1, and CR0.7 on July 18 and 19, 2011 (**Figure 1.1-1**). Results can be found in **Table 3.1-3**. In general, metals concentrations were highest at CR2. Overall, metal concentrations in stoneflies were slightly lower than those of mayflies. For most metals analyzed, aquatic macroinvertebrates showed low levels at site DO1 (reference site), rising to peak levels at site CR2, then decreasing downstream to sites CR1 and CR0.7. This pattern closely matches the pattern seen for arsenic and mercury in the Core Program fish tissue metals analysis (refer to *Section 3.3*). Particular metals that did not follow this upstream to downstream trend included cadmium, manganese, and selenium, where no consistent trend was observed (**Table 3.1-3**).

3.2 FISH POPULATION ASSESSMENT RESULTS (CORE PROGRAM)

The fish assemblage in the Crooked Creek system is typical of tributaries to the Kuskokwim River. The fish species known to occur within the drainages sampled are shown in **Table 3.2-1**. **Figure 1.1-1** presents the estimated average annual adult salmon distribution and relative density observed by aerial surveys as well as the resident fish species occurrence within the Crooked Creek drainage. It should be noted that the uppermost extent of the

salmon distribution is a best guess estimate based strictly on OtterTail field observations, and that these distributions and densities are based on aerial survey observations alone (which have their own inherent variability). Sampling date ranges and corresponding stream discharge from the USGS gauging station on Crooked Creek can be found in **Appendix E**.

Fish population assessments from 2010-2012 indicate that Crooked Creek drainage continues to support relatively small, but viable, populations of Chinook, chum, and coho salmon. Since the construction of the fish weir in 2008, limited numbers of sockeye salmon (*Oncorhynchus nerka*) and pink salmon (*Oncorhynchus gorbuscha*) have also been documented. With the exception of the larger Donlin Creek, Bell Creek, and Getmuna Creek drainages, neither Chinook nor chum salmon have been documented in tributaries to Crooked Creek. However, limited numbers of coho salmon have been reported in several tributaries. Several other resident fish species typical of the Kuskokwim River drainage have also been found throughout the study area (**Table 3.2-1**).

3.2.1 ADULT SALMON POPULATIONS

3.2.1.1 ADULT CHINOOK SALMON

Summer Aerial Survey

The nine-year aerial running average Chinook salmon count for the Crooked Creek drainage (excluding Getmuna Creek) is 13.8 fish per year (range: 0-55; **Table 3.2-2; Figure 1.1-1**). The only tributary in which Chinook salmon were observed in 2010 was Getmuna Creek. In 2011 and 2012, a total of 16 and 20 Chinook salmon were observed in Getmuna Creek and the mainstem of Crooked Creek, respectively. Although these numbers are low in relation to other regional salmon populations, they have been consistently observed each year and indicate that these are small viable populations. With the addition of Getmuna Creek to the Crooked Creek program, average annual counts increased to approximately 36 (range: 5-62) fish, indicating that Getmuna Creek is an important spawning tributary for Chinook salmon in the Crooked Creek watershed (**Table 3.2-2; Figure 1.1-1; Appendix F**).

We have noted in previous surveys that the majority of Chinook salmon spawning occurs in lower Crooked Creek in reaches CR-R1, CR-R2, & GM-R1. In 2010 through 2012, most Chinook salmon observed in Getmuna Creek were reported in the lowermost site GM-R1 (**Table 3.2-2; Figure 1.1-1**). Chinook salmon have been very sparsely found as far up as the upper Crooked Creek mainstem (CR-R5) but neither adults nor juveniles of this species have been found in Donlin Creek or in other upper side tributaries. Annual surveys conducted to date also indicate that nearly half of the Chinook salmon observed in the Crooked Creek drainage use Getmuna Creek for spawning.

Chinook Salmon Weir Counts

The total Chinook salmon escapement through the Crooked Creek weir has continually decreased from 100 fish in 2009 to 29 fish in 2012 (**Table 3.2-3; Figure 3.2-1**). Of this number in 2012, 22 were observed passing through the weir and an estimated 7 passed through the weir on days when the weir was not operable between July 14 and July 22 (**Table 3.2-3**). The majority (64 percent) of Chinook salmon observed since 2008 were males and averaged 871 mm TL; the average size of females was 997 mm TL (**Appendix G**).

In 2010, peak run-timing for Chinook salmon occurred between July 10 and July 30, eight days longer than in 2009 with over 50 percent of the run passing through the weir before July 13, 2010. The last Chinook salmon passed through the weir on August 12, 2010 (**Table 3.2-3; Figure 3.2-1**). The onset of the Chinook salmon peak run in 2011 (including estimated counts) occurred on July 12 with over 50 percent of fish observed passing through the weir by July 14, and the last fish was observed on August 13. The peak run in 2012 appeared between July 15 and July 21, which was a shorter time interval than previous years. Over 50 percent of the observed and estimated Chinook had passed through the weir by July 18, which is four days later than the latest date from previous years. Other

weir studies on tributaries to the Kuskokwim River, such as the George River (2006) and Tatlawiksuk River (2007), displayed similar peak Chinook salmon passage from approximately June 26 to July 20 (Whitmore 2008). Further, similar to previous years, the observed diel variation in the run of Chinook salmon during 2011 and 2012 indicated that most fish passed through the weir during night time hours (**Figure 3.2-3**).

Chinook salmon accounted for approximately 2 percent of the total salmon run recorded between 2008 and 2012 (**Table 3.2-3**). This is consistent with aerial surveys conducted to date indicating that Chinook salmon account for 3 percent of the annual salmon totals in Crooked Creek (**Table 3.2-2 and 3.2-3**). Aerial surveys for Chinook salmon in 2010 accounted for 15 percent of the total Chinook salmon run recorded at the weir during the same period (**Table 3.2-6**). Slightly reduced water quality conditions experienced during the aerial surveys (surveys rated 'fair') likely contributed to this lower aerial survey accuracy. In 2011 and 2012, the aerial count accounted for 90 and 95 percent of estimated and actual weir passages, respectively, which corresponds to good water quality conditions and aerial counts conducted on all tributaries above the weir in those years (**Table 3.2-6**).

3.2.1.2 ADULT CHUM SALMON

Chum Salmon Summer Aerial Survey

The nine-year aerial average count for the Crooked Creek drainage (excluding Getmuna Creek) is approximately 278 chum salmon per year (**Table 3.2-2**). With the addition of Getmuna Creek, average annual counts for the drainage increased to approximately 569 chum salmon, indicating Getmuna Creek is an important spawning tributary for chum salmon in the Crooked Creek watershed (**Table 3.2-2; Figure 1.1-1**).

In 2012, as in previous years, the distribution of chum salmon along the Crooked Creek drainage was similar to the distribution of Chinook salmon with their relative abundance decreasing with distance upstream from the mouth. Adult chum salmon have been very sparsely found as far upstream as Donlin Creek just above Dome Creek. Typically, chum salmon have not been observed in the upper tributaries of Crooked Creek or Donlin Creek but in 2011, seven fish were observed in Bell Creek. Relatively high densities of chum salmon have been consistently observed in Getmuna Creek, primarily in aerial reach GM-R1 (**Table 3.2-2; Figure 1.1-1**). Aerial surveys conducted in 2008 documented the lowest chum salmon numbers to date; only 82 chum salmon were observed in the entire Crooked Creek drainage this year. A total of 271 chum salmon were observed in the Crooked Creek drainage in 2010, 825 in 2011, and 311 in 2012.

Chum Salmon Weir Counts

Total chum salmon escapement in 2010 and 2011 through the Crooked Creek weir was 1,257 and 3,755 fish, respectively (**Table 3.2-3**). Of the 3,755 fish that passed through in 2011, 1,916 were estimated counts. This high number of modeled estimates was incorporated due to the inoperative camera during the peak run period for chum salmon between July 14 and July 26. In 2012, total chum salmon escapement through the weir was 832 fish, including 169 estimated passages for four two-day periods between June 30 and July 22 (**Table 3.2-3**). As noted for Chinook salmon, most observed chum salmon passed the weir during night-time hours (**Figure 3.2-3**). Male chum salmon accounted for 51 percent of the runs recorded since 2008. The mean length was 684 mm for females and 756 mm for males (**Appendix G**).

Three peaks in counts were observed during the 2010 chum salmon run; July 5, July 15-16, and July 25-31. The median passage day was July 26 and the last chum salmon was observed on August 30 (**Table 3.2-3; Figure 3.2-2**). In 2011, the median passage day was July 20. The last chum salmon in 2011 was recorded on September 6. In 2012, the median passage day was July 20 with the last chum salmon recorded on August 30. Overall, weir data indicates that the chum salmon run in Crooked Creek is consistent with other weir studies along the Kuskokwim

that suggest the peak run-timing on Kuskokwim River tributaries range anywhere from July 4 to July 25 (Costello et al. 2007; Hildebrand et al. 2007).

Between 2010 and 2012, chum salmon accounted for an average of 61 percent of the total weir escapement. This is consistent with results showing that this species accounts for 60 percent of the total salmon observed during aerial surveys conducted over the last nine years (**Tables 3.2-3 and 3.2-2**). Weir escapement numbers for chum salmon show that the aerial survey accuracy in 2010 was approximately 50 percent (**Tables 3.2-2 and 3.2-5**). The low percentage is likely due to a low run year and poor conditions for aerial surveys in lower Crooked Creek reaches. Aerial survey accuracies in 2011 and 2012 were 38 and 70 percent, respectively, which incorporated observed and modeled data for the fish weir counts. The low accuracy of the 2011 counts may have been due to the estimated water clarity (rated 'fair') during aerial surveys.

3.2.1.3 ADULT COHO SALMON

Coho Salmon Fall Aerial Survey

The nine-year average aerial coho salmon count for the Crooked Creek drainage (excluding Getmuna Creek) is approximately 209 fish (**Table 3.2-2**). During the 2012 peak run period, flow conditions were significantly higher than normal, making visibility almost zero and were likely to substantially affect counts. Coho salmon have been consistently observed each year indicating the population is viable. The nine-year average count for coho salmon in the Crooked Creek drainage including Getmuna Creek is approximately 524 fish, and suggests this tributary supports a coho salmon population similar to that in the Crooked Creek mainstem. As expected, coho salmon migrate further upstream than Chinook and chum salmon, with significant numbers occurring in upper Donlin Creek as well as in many of the tributaries. Generally, the majority of coho salmon has been observed at Donlin Creek reaches DO-R1, DO-R2, and DO-R3, and in Getmuna Creek reaches GM-R1, GM-R2 and GM-R3. A total of 350 coho salmon were also observed along Bell Creek during the first survey conducted in this stream during 2011 (**Table 3.2-2; Figure 1.1-1**).

Previous surveys showed that beaver dam success in a given year seems to influence whether or not coho salmon have access to spawning areas in upper Donlin Creek (OtterTail 2009c). In 2010 and 2011, many dams along Donlin Creek were breached and allowed fish access to upper reaches of the drainage. Fish were observed nearly to the end of reach DOR3 in 2010 and 2011. Fall surveys have documented very limited numbers of adult coho salmon in the lower most segments of Flat Creek and Dome Creek (**Table 3.2-2; Figure 1.1-1**). Adult coho salmon have been observed in Snow Gulch in 2004, 2005, and 2008, but these salmon were all observed just upstream of the stream mouth. Snow Gulch has been rerouted by placer mine activities and has recently been connected to a settling pond, though the stream channel was most recently routed around the pond by a bypass channel. In the past, the pond may have acted as a migration barrier for salmon passage into Snow Gulch.

Small coho salmon populations have also been observed in other Crooked Creek tributaries. The only official recording of adult salmon in American Creek was in 2008, when three adult coho salmon were observed during the aerial survey. In 2007, there was anecdotal information of one coho salmon observed at the road crossing. Adult salmon were expected, as YOY coho salmon have been found in four of seven years of resident fish surveys (**Table 3.2-4**). Although juvenile coho salmon are known to aggressively migrate, the small size of the YOY coho salmon found suggest either adult coho salmon spawning in American Creek or nearby spawning in the mainstem Crooked Creek. Because of documentation of more than one adult coho salmon, this stream is a candidate to be included to the ADF&G catalog of anadromous waters. In addition, the single aerial survey conducted in 2008 over Grouse Creek indicated that a limited population of coho salmon occurs in this stream.

Coho salmon have not been found in Anaconda Creek, Crevice Creek or Eagle Creek. A single coho salmon has been observed in the lowermost reach of Anaconda Creek since 2004. Anaconda Creek and Eagle Creek have little suitable salmon spawning substrate.

Coho Salmon Weir Counts

The total escapement of coho salmon through the Crooked Creek weir was 1,212 fish in 2010 and 591 fish in 2011. An observed 714 fish were counted in 2012 and an estimated 154 passed between September 5 and September 28 while the weir was overtopped for a total of 868 fish (**Table 3.2-3**). In 2011, the weir was overtopped from August 3 to August 26, resulting in incomplete coho counts of 591 fish and modeled data did not estimate any additional passages. Consistent with peak run-timing from approximately July 23 to September 9 in other weirs along the Kuskokwim River tributaries (Crane et al. 2007), and similar to Crooked Creek weir records from the two previous years, peak coho salmon passage occurred between August 29 and September 7 in 2010, and between September 3 and September 16 in 2011. In 2012, peak coho salmon passage occurred between August 20 and Sept 8, with the median passage date on August 26, which is earlier than previous years but not outstanding (**Table 3.2-3**). During the last three years, the median passage dates were September 4, September 6, and August 26, respectively (**Table 3.2-3; Figure 3.2-2 and 3.2-4**). Similar to the other salmon species observed, coho salmon escapement occurred during night time hours (**Figure 3.2-2**). No correlation was observed between peak run-timing of coho salmon and river stage height in Crooked Creek in any year (**Figure 3.2-4**).

Overall, female fish averaging 680 mm TL accounted for 53 percent of the coho salmon escapement from 2008 to 2012; males averaged 714 mm TL (**Appendix G**). Larger male salmon dominated the early part of the run and larger females moved later through the weir. The difference in the timing of the run between male and female salmon has also been observed throughout the Kuskokwim River drainage (Molyneaux et al. 2006; Hildebrand et al. 2007).

Based on the number of coho salmon observed passing through the weir, the aerial survey accuracy in 2010 was 62 percent (**Table 3.2-6**). This is likely an underestimate given that the Bell Creek tributary was not surveyed in 2010 or previous years, and the 2011 aerial survey revealed that approximately one third of the coho salmon observed in the drainage occurred in this tributary stream. Similar to the survey conducted in 2009, the high degree of accuracy was likely a result of good aerial survey conditions, mostly water clarity. The aerial survey accuracy for 2011 and 2012 was 180 and 7 percent, respectively (**Table 3.2-6**). The large discrepancy in 2012 may have been due to the extremely low visibility as a result of 'poor' water clarity and the low accuracy in 2011 was likely due to the fact that coho salmon spawn in the lower reaches of Crooked Creek, including a stretch below the weir (CR-R1), which is included in aerial surveys, resulting in fish aerial numbers that are likely missed in weir counts.

3.2.1.4 ADULT SOCKEYE AND PINK SALMON POPULATIONS

Sockeye Salmon Aerial Survey

A total of four sockeye salmon were observed during aerial surveys in the lowermost reach of Getmuna Creek (GMR1) in 2009, only one was observed in 2010, and four were again observed in 2011 (**Figure 1.1-1; Table 3.2-2**). No sockeye salmon were observed during aerial flights in 2012 (**Table 3.2-2**). Since 2004, nine sockeye salmon have been observed during aerial surveys. These unexpected and isolated events, coupled with observations of adult sockeye salmon moving through the weir, and juveniles found at biomonitoring sites GM1 and CR0.7, indicated that only a few sockeye salmon use the Crooked Creek drainage.

Sockeye Salmon Weir Counts

A total of five sockeye passed through the weir between July 27 and August 13, 2010; six were observed in 2011 between July 16 and September 9 with an additional 10 that were estimated to have passed between July 19 and August 3; and one was observed on July 17, 2012 (**Table 3.2-3**). The aerial surveys and the weir observations conducted to date indicate that a very small sockeye salmon population use Crooked Creek and possibly Getmuna Creek for spawning. Juvenile sockeye salmon have been observed at biomonitoring sites CR0.7 and GM1, further indicating that sockeye salmon use the Crooked Creek drainage.

Compared to other salmon, little is known about the distribution and abundance of Kuskokwim River sockeye (Costello et al. 2007). Although juvenile anadromous sockeye salmon typically require lake rearing areas (Burgner 1991), some sockeye salmon populations spawn in river systems without connected lakes. The ecological contribution of these atypical “river type” sockeye salmon on the Kuskokwim drainage may be larger than previously believed (Costello et al. 2007). Gilk et al. (2011) found that tributaries with no associated lake system accounted for 81 percent and 78 percent of the total tributary sockeye salmon tag recovery distribution in the mainstem Kuskokwim River and its main tributaries in 2006 and 2007, respectively, including fish from the Holitna River, Aniak River, Oskawalik River, and George River.

Pink Salmon Aerial Survey

Because of their small size and neutral coloration, pink salmon can be mistaken for resident species during aerial surveys and therefore are not a target species. A single pink salmon was observed just upstream of the fish weir during an aerial survey in 2011. Identification was verified on the ground after the survey.

Pink Salmon Weir Counts

The 2009 peak run-timing for pink salmon occurred between July 20 and July 31. With only five pink salmon observed in 2010, four in 2011, and 17 in 2012, a clear peak passage at any time throughout these seasons was not observed (**Table 3.2-3; Figure 3.2-1**). In 2010, all pink salmon were observed before June 30th and in 2011 the first two fish were observed on July 14 and the last one on August 18, showing a long distribution for the run. In 2012, the run occurred between July 18 and August 11, with a median passage date of July 26 (**Table 3.2-3**). The eight pink salmon observed at the weir in 2008 was the first documentation of this species in the Crooked Creek drainage (OtterTail 2009b) and suggested their population is small. However, the pink salmon totals through the Crooked Creek fish passage chute could be an underestimate as some of the smaller individuals of the pink salmon run could potentially swim between the weir pickets. It should also be noted that no weir data was recorded from July 19 to August 3, 2011, which could have affected total fish counts for this year and no additional fish counts were estimated in the model.

This species typically follows a fixed two-year life cycle that results in genetically distinct odd- and even-year runs. Alaska pink salmon runs typically follow an even-numbered year increase (ADF&G 2004) but this may vary by river drainage and over time. The data does not allow for a clear comparison and therefore any conclusions to be drawn. Multiple years of weir data will be needed for an accurate assessment of odd- or even-year peaks within Crooked Creek.

Unlike the other four salmon species that use the Crooked Creek drainage, the pink salmon run did not follow the distinct diel run-timing pattern with most fish swimming upstream during night time hours. Often, they would pass through the weir in the middle of the day, and would rarely pass through in conjunction with other pink salmon.

Little is known about pink salmon abundance in the Kuskokwim River drainage, but they generally make less extensive spawning migrations into freshwater than other Pacific salmon species (Heard 1991). The relatively few pink salmon that return to spawn in upper Kuskokwim River tributaries are among the farthest-known migrating pink salmon in the world. Continued monitoring is needed to better understand the population dynamics of this unique stock and their importance to the ecosystem (Hildebrand et al. 2007).

Future years of weir and aerial survey data should allow for more detailed comparisons and trend observations of salmon species using the Crooked Creek drainage. This also ought to allow for better accuracy between annual aerial and weir counts (**Table 3.2-6**).

3.2.2 RESIDENT FISH AND JUVENILE SALMON POPULATIONS

Resident species in the Crooked Creek drainage are typical of other tributaries in the Kuskokwim River drainage. We observed stable populations of slimy sculpin, Dolly Varden, burbot, and Arctic grayling. Small populations of nine-spine stickleback (*Pungitius pungitius*), longnose sucker (*Catostomus catostomus*), Alaskan brook lamprey (*Lampetra alaskensis*), Alaska blackfish (*Dallia pectoralis*), and round whitefish (*Prosopium cylindraceum*) were also present. Slimy sculpin was typically the most abundant species and were consistently found at all sample sites except Dome Creek, Quartz Creek, Snow Gulch, Lewis Gulch, Omega Gulch, upper Anaconda Creek, and two unnamed creeks (AC and BC; **Tables 3.2-4** and **3.2-5**).

As described in the methods section, the electrofishing multiple pass removal method was only approved by the ADF&G in 2004, 2007, 2008, and 2009. Although multiple-pass population estimates could not be calculated for 2005 and 2006, relative one-pass population estimates for these years provide a minimum population size estimate for each reach. To conduct year to year comparisons, all fish population estimates are based on one-pass data (**Table 3.2-4**).

As in previous years, juvenile coho salmon were present in many of the sites surveyed throughout the Crooked Creek drainage in 2010, 2011, and 2012. However, a substantial decline was observed in the juvenile coho salmon population from the 2009 peak that followed a high count of adults in the weir during the previous year. Fish population summaries are provided in **Table 3.2-4**.

3.2.2.1 REFERENCE SITES: UPPER DONLIN CREEK AND FLAT CREEK

Upper Donlin Creek (DO1)

Upper Donlin Creek supports populations of slimy sculpin, Dolly Varden, burbot, Arctic grayling, and juvenile and adult coho salmon. Juvenile Chinook salmon have not been found at this site. Coho salmon YOY have been found every year, except 2011, suggesting that this reach, or one nearby, is likely used by coho salmon for spawning and rearing. Overall, slimy sculpin and coho salmon juveniles appear to be the most abundant species at this site; Dolly Varden, Arctic grayling, and burbot were fairly common. The round whitefish, a species that had not been observed in previous surveys, was found at this site in 2010 and 2011 (**Table 3.2-5**).

From 2004 through 2012, the electrofishing reach at DO1 had an average population of 143 fish per 300 ft per year. Population size at DO1 ranged from 45 fish per 300 ft in 2007 to 313 fish per 300 ft in 2009. In 2011, 78 fish per 300 ft were collected at this site and 51 fish per 300 ft were collected in 2012 (**Table 3.2-5**). Coho salmon were not observed in this site in 2011. The annual variability in the size of the overall fish assemblage is largely driven by the variability in abundance of juvenile coho salmon. This variability is most likely attributed to changes in both

adult spawner return (natural recruitment) and access to spawning grounds (successful passage past beaver dams).

The angling surveys indicated an abundance of Arctic grayling in large pool habitat (OtterTail 2007). These surveys confirm this upper section of Donlin Creek is used by Arctic grayling for summer feeding. More recent surveys at Site DO1 also have found juvenile Arctic grayling, suggesting that at least some spawning may occur in this stream section.

Flat Creek (FL1)

Flat Creek was not sampled in 2010, 2011, and 2012 but in previous years, coho salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, and burbot have been found in this site. The total number of fish observed in this reach has ranged from 65 fish per 300 ft in 2004 to 242 fish per 300 ft in 2009. The annual average number of fish captured at this site is 137 fish per 300 ft (**Table 3.2-5**).

Slimy sculpin has consistently been the most dominant species at Site FL1. Coho salmon appear to use Flat Creek for rearing of young in very limited numbers and possibly by adults for spawning. The only adult coho salmon observed at this site was reported in the 2008 aerial survey (**Table 3.2-2**), suggesting that coho salmon spawning could occur in this drainage. However, it is also possible that this single adult in could have been a stray, as it was observed near the mouth of Flat Creek. This creek is not currently on the ADF&G anadromous catalog (ADF&G 2004), and the single adult coho salmon observed in 2008 does not provide enough evidence to change that status. Further, no Chinook or chum salmon of any life stage have been observed in this creek (**Table 3.2-4**).

Species composition at Flat Creek and Donlin Creek is very similar, but substantially more juvenile and adult coho salmon have been observed at Donlin Creek. YOY fish (TL < 55mm) have been observed consistently at both creeks, indicating that rearing occurs in these drainages.

3.2.2.2 DONLIN CREEK TRIBUTARIES: DOME CREEK, QUARTZ GULCH, AND SNOW GULCH DRAINAGE RESULTS

Dome Creek (DM1)

Site DM1 was not sampled in 2010, 2011 or 2012. The 2008 and 2009 resident fish surveys found Dolly Varden as well as juvenile and adult coho salmon in Dome Creek, with a two year average of 55 fish per 300 ft (**Table 3.2-4**). Juvenile coho salmon were found in relatively abundant numbers in 2009 and adult coho salmon have been observed in both years of the aerial surveys (**Tables 3.2-5** and **3.2-2**).

Quartz Gulch (QZ1)

No fish were observed in Quartz Gulch during 2009 surveys (**Table 3.2-4; Appendix H**). There is very little suitable habitat and it is not likely that overwintering could occur in the drainage. This site was not sampled in 2010, 2011 or 2012.

Snow Gulch (SN1 & SN2)

Fish habitat in Snow Gulch is limited by the drainage's small size. As described above, previous aerial spawning surveys documented coho salmon in the lower reach. Placer mining activities have filled in the migration corridor and likely preclude coho salmon and other resident species from moving past this obstruction to upper mainstem portions of this stream. Survey site SN2 is located well above ongoing independent placer mining activities.

Qualitative fish sampling at sites SN1 and SN2 was conducted in 2006 to determine which species were present (**Figure 1.1-1**). In 2007, the objective shifted to a comprehensive biomonitoring survey within Snow Gulch; SN2 was selected as the site to permanently add to the program.

Sites SN1 and SN2 were not sampled in 2010 but previous surveys showed that the only fish species occurring in these reaches was Dolly Varden. This species was observed in 2011 and 2012 at SN2 with an annual average approximately 3 fish per 300 ft (**Table 3.2-4**). All Dolly Varden collected were over 80 mm TL.

3.2.2.3 CROOKED CREEK MAINSTEM

Crooked Creek Mainstem at CR2

Crooked Creek was sampled just downstream of all historic and current placer mining at site CR2 (**Figure 1.1-1**). At this site, juvenile coho and Chinook salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, burbot, and Alaska blackfish have been found (**Table 3.2-4; Figure 1.1-1**). The total number of fish captured at this reach ranged from 81 fish per 300 ft in 2008 to 314 fish per 300 ft in 2010. The annual average number of fish captured at this site was 199 fish per 300 ft. Slimy sculpin was consistently the most abundant species at CR2 (**Table 3.2-4**). Juvenile Arctic grayling and Dolly Varden were found at this site, suggesting they may overwinter this far upstream in the drainage. Burbot, round whitefish, and Alaska blackfish were also found in low abundance (**Table 3.2-4**).

From 2004 to 2012, juvenile coho and Chinook salmon have been found at Site CR2 in low numbers (**Table 3.2-5**). This is consistent with aerial surveys that have documented adults of both species in the reach. Coho salmon fry abundance was higher than Chinook salmon in this stream segment. Juvenile coho salmon abundance has remained substantially lower after 2005; neither one of these species were observed at this site in 2011 and only a few juvenile coho salmon were found in 2012. Although aerial surveys and field observations documented limited numbers of chum salmon spawning in this reach, no juveniles were found during the electrofishing surveys, likely because fry migrate downstream soon after hatching.

Crooked Creek Mainstem at CR1

Crooked Creek site CR1 was originally established to assess all potential impacts to Crooked Creek from the Project. However, given that potential impacts to Crevice Creek could influence Crooked Creek further downstream of CR1, this location will be used to assess potential impacts associated to the tailings impoundment (located within Anaconda Creek) and the mine pit and waste rock facilities (located within American Creek; **Figure 1.1-1**).

Species occurring in site CR1 include Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, burbot, nine-spine stickleback, and juvenile and adult coho and Chinook salmon. Juvenile chum salmon were not found during electrofishing surveys likely due to their downstream migration soon after emerging from the gravel. However, the aerial surveys document that chum salmon spawn in this area in limited numbers (**Table 3.2-2**). The dominant species in this site are slimy sculpin followed by coho salmon. YOY round whitefish and Arctic grayling were found in limited numbers suggesting they likely overwinter in high elevation reaches of the drainage. Site CR1 is also the only site in the Crooked Creek drainage where nine-spine stickleback have been observed. Dolly Varden and burbot were found in limited numbers (**Table 3.2-4; Figure 1.1-1**).

Overall, fish population estimates have ranged from 145 fish per 300 ft in 2012 to 1,248 fish per 300 ft in 2009. The eight-year average was 467 fish per 300 ft (**Table 3.2-4; Figure 1.1-1**). A total of 637 fish per 300 ft were captured in 2011 and 145 fish per 300 ft were captured in 2012 a substantial decline from the 2009 total, which was largely

driven by the 832 juvenile coho salmon observed that year (compared to the average of 110 coho per year) (**Table 3.2-5**).

Crooked Creek Mainstem at CR0.7

Mainstem Site CR0.7 was added to the biomonitoring program in 2006 to assess potential impacts from Crevice Creek (**Figure 1.1-1**). Because of their proximity, the fish assemblages at Sites CR0.7 and CR1 were fairly similar. The population total over the seven years of sampling ranged from 166 fish per 300 ft in 2012 to 787 fish per 300 ft in 2010, and the annual average number of fish captured was 442 fish per 300 ft (**Tables 3.2-4**). The only additional species at CR0.7 were Alaska blackfish, longnose sucker, and juvenile sockeye salmon, which were found in limited numbers. Juvenile sockeye salmon have only been observed in this site during the surveys conducted in 2009 and 2010; these are the only records of juvenile sockeye salmon in the Crooked Creek mainstem.

Crooked Creek Mainstem at CR0.3

Site CR0.3 was added to the biomonitoring program in 2006 near the mouth of Crooked Creek to fully encompass the watershed and to provide a site to monitor recovery in the event that effects are documented in the upper watershed (**Figure 1.1-1**). As expected, most of the species found in the drainage also occur at Site CR0.3. The Alaska brook lamprey has not been found at any other site within the Crooked Creek drainage. Both longnose sucker and Alaska brook lamprey were found during most surveys, suggesting viable populations exist in this lowermost reach of Crooked Creek (**Table 3.2-4**).

Total fish captures at Site CR0.3 have ranged from 236 fish per 300 ft in 2007 to 452 fish per 300 ft in 2010. On average, 323 fish per 300 ft have been captured at this site on an annual basis (**Table 3.2-4; Figure 1.1-1**). Site CR0.3 was not sampled in 2011 or 2012.

3.2.2.4 CROOKED CREEK TRIBUTARIES: QUEEN GULCH, LEWIS GULCH; AMERICAN CREEK, GROUSE CREEK, OMEGA GULCH, ANACONDA CREEK, CREVICE CREEK, EAGLE CREEK, UNNAMED CREEK (BC), UNNAMED CREEK (AC), GETMUNA CREEK, AND BELL CREEK

Queen Gulch (QU1)

In 2010, an electrofishing survey documented no fish in site QU1 and subsequent surveys have not been carried out since aquatic habitat is very limited near the sampling site and independent placer mining operations have heavily affected the lower portions of this stream (**Table 3.2-4; Figure 1.1-1**).

Lewis Gulch (LE1)

No fish were found at Site LE1 in 2009 during the only survey that has been conducted at this site (**Table 3.2-4**). Much like the 2006 Snow Gulch surveys, the sampling at LE1 consisted of qualitative fish sampling at various sites to determine which species were present. Lewis Gulch has been re-routed by independent placer mine activities and the lowermost reach is a manmade canal that diverts water into Crooked Creek just upstream of biomonitoring site CR2 (**Figure 1.1-1**).

American Creek (AM1 and AM2) – Proposed Waste Rock and Mine Pit Location

In 2010, only the site AM2 was surveyed and this effort resulted in the capture of a total of 57 fish/300 ft, all of which were Dolly Varden (**Table 3.2-4**). Previous surveys in Site AM1 have reported good numbers of resident Dolly Varden and slimy sculpin (**Table 3.2-4; Figure 1.1-1**). A limited number of Arctic grayling and burbot have also been

found during resident fish surveys in deep pool habitat. Coho salmon juveniles (both YOY and age 1+) were found four out of six years, suggesting that limited spawning may occur in this drainage. Supporting this conclusion, aerial surveys documented limited adult coho salmon use in this drainage (**Table 3.2-2**). The small size of American Creek limits its potential as a significant coho salmon stream.

The annual population estimate for all fish species in American Creek at AM1 ranged from 11 fish per 300 ft in 2011 to 114 fish per 300 ft in 2005, with a mean of 56 fish per 300 ft. Only 11 fish were observed at this site in 2011 (**Table 3.2-5**). The wide range population estimates can be explained, in part, by better water clarity in 2005, 2006, and 2009 that allowed a better capture rate for slimy sculpin, which was the species driving the annual differences. The NES (1999) winter-use survey found that surface flow was discontinuous within American Creek during winter, so overwinter fish distribution may be limited to localized unfrozen areas. Due to the 2008 aerial survey documenting the presence of three adult coho salmon, this stream has been added to the ADF&G anadromous stream catalog. In 2012 no fish were collected at sites AM3, and AM4, which were established in 2011 to document fish presence in the upper portions of the watershed.

Grouse Creek (GR1)

Grouse Creek was only surveyed in 2008. The 2008 resident survey found only two species, Dolly Varden and slimy sculpin, with a total of 38 fish per 300 ft (**Table 3.2-4**). This species assemblage was expected for this reach based on its substrate, flow, and location within the drainage. It is possible that coho salmon use this drainage for spawning, but no juvenile coho salmon were found in 2008. However, adult coho salmon were observed in the lower drainage during the aerial survey indicating they likely use Grouse Creek in some capacity (**Figure 1.1-1**).

Omega Gulch (OM1)

Site OM1 was electrofished in 2009 to document the fish species assemblage. No fish were captured in limited aquatic habitat (**Table 3.2-4**).

Anaconda Creek (AN1 and AN2) – Proposed Tailings Impoundment Location

Surveys of Anaconda Creek have documented the presence of low numbers of burbot, slimy sculpin, and Dolly Varden at AN1. In addition, Arctic grayling, burbot, and coho salmon were observed just downstream of this site in 2011 (**Table 3.2-5; Figure 1.1-1**). AN1 is located approximately 0.25 miles (0.4 km) upstream of the mouth, immediately upstream of the winter road. Aerial surveys documented the presence of one adult coho salmon in 2004, just upstream of its mouth and downstream of the winter road crossing (which is also site AN1). Due to the thickness of the riparian canopy and the deep narrow channel, it is possible that other coho salmon were overlooked during the fall helicopter surveys. However, the presence of an adult salmon population in Anaconda Creek appears unlikely. Spawning habitat is very limited, as silt is the dominant substrate type. The lower portion of Anaconda Creek has been added to ADF&G's anadromous stream catalog.

Lower Anaconda Creek's (AN1) annual fish population ranged from two fish per 300 ft in 2004 to 36 fish per 300 ft in 2011, with a mean of 15 fish per 300 ft (**Table 3.2-5**). The 2008 trapping survey documented 26 slimy sculpin, but in other years, trapping abundance averaged 1 fish/trap (**Appendix H**). The difference in electrofishing survey abundance between years appeared to be a direct result of turbid water conditions in 2004 and 2008, reducing the survey effectiveness considerably compared to surveys done in the other five years. This stream is highly turbid during rainfall, and its silty substrate and correspondingly low macroinvertebrate production are likely important factors limiting fish abundance (**Appendix E**).

In 2006, an additional site was added in upper Anaconda Creek (AN2) to document the fish population in this stream segment that is proposed to be filled (**Figure 1.1-1**). Dolly Varden have been found consistently in this site, with an average abundance over four years of 3 fish per 300 ft (**Table 3.2-4**). Some sand and gravel substrate occurs in the upper Anaconda Creek reach, but the majority of this reach is heavily incised and has silt substrate similar to the lower section. The limited number of YOY fish observed during resident surveys along reaches AN1 and AN2 could indicate potential freezing during winter and/or unsuitable habitat for this life stage. Consistently, macroinvertebrate indicator species found at this site such as Perlodidae are also found in little or no abundance some years suggesting freezing or other natural disturbances occur some years (refer to *Section 3.1.1.5*).

Crevice Creek (CV1)

Site CV1 was not surveyed in 2010, 2011 or 2012 but Dolly Varden and slimy sculpin have been documented at this site in previous surveys (**Table 3.2-4; Figure 1.1-1**). A large discrepancy in slimy sculpin abundance occurred over the four year period, with 134 fish per 300 ft in 2006 and an average of 11 fish per 300 ft in subsequent years (**Table 3.2-4**). Unlike the comparably sized Anaconda Creek, the predominant gravel substrate in many sections of the Crevice Creek reach provides more favorable fish habitat conditions.

Eagle Creek (EG1)

Eagle Creek (EG1) was added to the Project in 2009. A small population of Dolly Varden, slimy sculpin, and burbot were observed in this site (**Figure 1.1-1**). Similar to Anaconda Creek (AN1), the stream channel at EG1 is very incised and dominated by silt substrate. This site was not surveyed in 2010, 2011 or 2012.

Unnamed (BC1)

In 2010, Site BC1 was surveyed to document the fish species assemblage. One Dolly Varden was captured during the electrofishing survey and 3 more were captured with minnow traps. No other species were documented (**Table 3.2-4; Appendix H**).

Unnamed (AC1)

Site AC1 was only surveyed in 2010 to document the fish species assemblage. No fish were captured in the electrofishing survey or minnow traps (**Table 3.2-4; Appendix H**).

Getmuna Creek (GM1, GM2, GM3, and GM4)

Getmuna Creek (GM1) was added to the program in 2007 to document aquatic baseline conditions. This drainage had been identified as the probable location for a gravel mine to supply material to the proposed Jungjuk road. The sample reach has similar aquatic biota diversity to the lower Crooked Creek mainstem sites illustrating that it is an important tributary (**Table 3.2-4; Figure 1.1-1**). Getmuna Creek sites (GM2, GM3, and GM4) were added in 2012 to incorporate potential impacts in proximity to the proposed gravel mine.

Getmuna Creek (GM1) was not surveyed in 2010, 2011 or 2012. The number of fish captured at this site in previous surveys ranged from 199 to 802 fish per 300 ft, and averaged of 518 fish per 300 ft (**Table 3.2-4**). Six of the seven species identified in Getmuna Creek were salmonids (**Table 3.2-1; Figure 1.1-1**). The 2009 study documented the highest abundance of slimy sculpin throughout the Crooked Creek drainage with a total of 536 fish per 300ft (**Table 3.2-4**). To date, aerial surveys along Getmuna Creek have consistently found relatively high numbers of Chinook, chum and coho salmon, and low numbers of sockeye salmon (**Table 3.2-2; Figure 1.1-1**).

In 2012, Getmuna Creek sites GM2, GM3, GM4 were added to document fish populations in close proximity to the proposed gravel mine that may be affected from future impacts to the system (Figure 1.1-1). The two resident species found at all three sites were Dolly Varden and slimy sculpin ranging from 9 fish per 300 ft to 36 fish per 300 ft and 31 fish per 300 ft to 59 fish per 300 ft, respectively (**Tables 3.2-4** and **3.2-6**). A single Arctic grayling was captured at GM2. Juvenile coho salmon were captured at all three sites ranging in abundance from nine fish per 300 ft to 31 fish per 300 ft (**Tables 3.2-4** and **3.2-5**).

Bell Creek (BL1)

Bell Creek (BL1) was added to the Project in 2011. Fish species observed in this site during 2011 and 2012 surveys include Chinook and coho salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, and nine-spine stickleback. The predominant species was slimy sculpin accounting for 86 percent of the 225 per 300 ft (**Table 3.2-4**).

3.2.2.5 CROOKED CREEK WEIR- RESIDENT FISH

The Crooked Creek weir was added to the Program in 2008 to document the entire adult salmon escapement through the Crooked Creek drainage. The weir system is designed to allow smaller resident species to pass between the weir pickets. However, some resident fish choose to pass through the video box and those species are also counted and measured via video data.

Resident species observed at the weir include Dolly Varden, Arctic grayling, round whitefish, longnose sucker, slimy sculpin, lamprey (unidentified), burbot, rainbow trout (*Oncorhynchus mykiss*), humpback whitefish (*Coregonus pidschian*), and northern pike. Of these, the latter three species had not been previously documented within the Crooked Creek drainage. Total counts of each species observed at the weir can be found in **Table 3.2-7**. Because smaller resident species can pass through the pickets of the weir, the non-salmon counts are provided only for general information and cannot be used as population estimates.

3.3 FISH TISSUE METAL CONCENTRATION RESULTS (CORE PROGRAM)

Extensive fish tissue sampling has been conducted as part of the aquatic biomonitoring program since 2004. A consistent pattern of increasing or decreasing metal concentrations across years or sites has not been observed. Metals concentrations were generally lower in 2009 than in previous years but an increase to levels observed in previous years was noted in 2010, 2011, and 2012 (**Figures 3.3-1 through 3.3-11**). Metal concentrations observed thus far display considerable variability from year to year but well below levels that are toxic to humans and other organisms (ADEC 2009; **Appendix P**). All fish tissue metal concentrations presented are based on wet weight. A wet weight to dry weight conversion for the sampled fish, slimy sculpin, is available in **Appendix I**.

In 2012, we continue to observe low variance in slimy sculpin tissue samples at each site, suggesting that 15 replicate composite samples collected at each location are adequate to accomplish the objectives of this biomonitoring program (**Table 3.3-1; Appendix J**). In addition, data from 2012 continues to suggest that juvenile slimy sculpin (< 55 mm TL) is the optimal species to use for long-term monitoring of metals in fish tissue due to the sample size needed for the analyses and the observed low variability in metal concentrations among the replicates collected at each site (**Table 3.3-1; Figures 3.3-1 through 3.3-11; Appendix K**). Potential changes in metals concentrations in Crooked Creek resulting from the Project can be detected by slimy sculpin tissue analyses.

Given that increased precipitation can lead to increased surface runoff and transportation of minerals and metals into stream channels, it was hypothesized that the annual variation in metal concentrations could be caused, in part, by annual variations in precipitation and stream flow. High precipitation and stream flows were observed in

2010. Drier years, such as 2009, appear to be associated with lower metal concentrations in fish tissues. To test this hypothesis we ran a series of simple regressions between the average concentration of each metal constituent (i.e., all sites combined) and the total annual discharge from 2004 to 2010 (annual discharge data for 2011 is not yet available). Since continuous flow data at Crooked Creek is only available from 2007 to date, we used flow data from the USGS gage station on the Kuskokwim River at Crooked Creek (Station 15304000). We found that the only metal for which there is a significant relationship between annual discharge and concentration is copper ($r^2 = 0.56$, $t=2.94$, $df=6$, $p=0.03$); a marginally significant relationship between discharge and manganese concentration was also noted ($r^2 = 0.44$, $t=2.4$, $df=6$, $p=0.06$). These results suggest that there are other unknown factors that influence the annual variability in metal concentrations.

3.3.1 VARIABILITY IN METAL CONCENTRATION ACROSS YEARS AND SITES

We analyzed the annual variability in tissue metal concentrations at each site to assess natural changes in background levels. As stated previously, the underlying reasons for natural changes in metals concentrations are largely unknown.

Across all sites, mercury, selenium, and zinc tended to have the smallest coefficients of variation (CV) (**Table 3.3-1**). Therefore, future increases in the concentration of these metals above background levels may be more easily detected than other metals.

A two-way ANOVA test to assess changes in metal concentrations across sites and years indicated that significant annual differences were evident for all metals except iron, lead, and manganese. Significant differences across sites were only evident for arsenic, cadmium, manganese, and mercury (**Table 3.3-2**).

As observed in previous years, samples collected at Site CR2 during 2010 and 2011 appeared to have higher concentrations of arsenic than samples from any other site (**Figure 3.3-2**). It should be noted that a drainage ditch from an active placer mining operation flows into Crooked Creek just upstream of this site. In 2010, trapping mortalities for coho salmon were observed in the effluent of this ditch. A Tukey-Kramer HSD test indicated that the concentration of arsenic at CR2 is significantly higher than the concentrations at other sites ($q=2.79$, $\alpha=0.05$). Consistently across all years, low arsenic concentrations have been observed at Site DO1 (the reference site; **Figure 3.3-2**). Arsenic appeared to decrease consistently from 2006 to 2009 at all sites but a slight increase was noted in 2010 (**Figure 3.3-2**).

Aluminum, cadmium, copper, and manganese, show similar trends with higher concentrations observed in 2005-2006 at all sites, and a declining trend each year until 2009. For these metals, concentrations observed in 2010 are very similar or higher than those observed in 2009 (**Figures 3.3-1, 3.3-3, 3.3-5, and 3.3-8**). As noted above, it was hypothesized that the higher metal concentrations observed some years could be related to high precipitation and subsequent sediment transport from the naturally occurring mineralized zone in the area, however, results of analysis conducted did not support this hypothesis.

Similar to arsenic, the average concentration of mercury across all years was significantly higher at site CR2 than at the other three sites (**Figure 3.3-9**; Tukey-Kramer, $q=2.79$, $p=0.05$). As noted above, the higher concentration of mercury at Site CR2 could also be related to the placer mining operation located upstream of this site. Although mercury appeared to be higher in 2008 than in any other year (**Figure 3.3-9**), this concentration is only significantly different than the average concentration observed in 2009 (Tukey-Kramer, $q=3.17$, $p=0.05$), which as for other metals, is the year associated with the lowest concentrations. At this point, it is unknown what factor or factors could be associated to the higher mercury concentration observed in 2008.

3.3.2 DETERMINATION OF THE PERCENT UNNATURAL CHANGE NEEDED TO DETECT IMPAIRMENT

Multiple years of baseline data have provided insight into the annual variability in background metal concentrations, which will allow the detection of potential increases in metal concentrations caused by the implementation of the Project. In **Table 3.3-1**, the “Detectable change” statistic represents a conservative estimate of the percent change that would need to occur before the assumption could be made that such change exceeds the expected range of natural variability. Because metal sample collection at Site CR0.7 has been two years shorter than at other sites, the detectable change statistic for most metals at this site is much higher. Consequently, smaller changes in metal concentrations may be detectable in the future at Sites DO1, CR2, and CR1.

The estimated average percent change needed to be considered out of the range of natural variation for arsenic, mercury, selenium, and zinc, are 77, 53, 53, and 45 percent, respectively (**Table 3.3-1**). Other metals have higher annual variation and therefore potential concentration increases would need to be larger to exceed the range of natural variation. At some sites, the concentration of aluminum, chromium, iron, and lead would have to increase 100 percent or more to exceed the documented background concentrations. Based on mercury concentrations in fish tissue recorded from 2004 to 2011, a conservative estimate of future detectable change for this metal would be a difference of 55, 46, 52, and 57 percent at Sites DO1, CR2, CR1, and CR0.7, respectively (**Table 3.3-1**).

In the early stage of this biomonitoring program, it was assumed that the baseline data collection phase of this program would only be able to achieve the first of the two primary goals: to document natural annual variation in metals concentrations, and predict future changes that are outside the range of this natural variance. However, good sampling practices and relatively low variation in the data within each site suggests that significant differences can be detected even among sites. In general, the reference site DO1 has lower concentrations of most metals than the downstream sites (CR2, CR1, CR0.7), and significant differences in metal concentrations have been documented across sites. This indicates that data collected thus far is reliable for the future detection and assessment of potential Project impacts.

3.3.3 JUVENILE SALMON MERCURY CONCENTRATIONS WITHIN THE CROOKED CREEK DRAINAGE

During the first four years of this program, juvenile and YOY salmon were collected when present at the four pre-determined metals sites. Although juvenile slimy sculpin (<55mm) were ultimately determined to be the best target species and size class for metals analyses, review of the juvenile salmon results from 2004-2007 show interesting trends in mercury concentration, especially within the context of other studies within the Kuskokwim River region (Gray et al. 1996, Mueller and Matz 2002, Jewett and Duffy 2007).

Since YOY salmon are less likely to migrate long distances as adults do, it can reasonably be assumed that metals found in their tissue were absorbed near the sampling location. In general, mercury concentrations were very low in YOY coho and Chinook salmon, ranging from 0.012 to 0.028 mg/kg wet weight (**Table 3.3-3**). Year 1+ juvenile coho and Chinook salmon were also sampled at some sites, and their mercury concentrations tended to be at least double that of the YOY, ranging from 0.042 to 0.056 mg/kg wet weight. But given that salmon age 1+ are more likely to migrate, we cannot assume that heavy metal absorption occurred at the sampling site. Mercury concentrations in juvenile salmon tissues in the Crooked Creek drainage were comparable to concentrations found in nearby waters, such as the Innoko National Wildlife Refuge and elsewhere in the Kuskokwim region (Gray et al. 1996, Mueller and Matz 2002). The higher mercury concentration observed in juvenile coho and Chinook salmon suggests that bioaccumulation occurs in the Crooked Creek drainage. It should also be noted that these concentrations fall well below the State of Alaska consumption guidelines, currently set at 1 mg/kg (Jewett and Duffy 2007).

3.3.4 BURBOT MERCURY CONCENTRATIONS WITHIN THE CROOKED CREEK DRAINAGE

Burbot samples for mercury analysis were not collected in 2010, 2011, or 2012. In 2009, burbot were sampled at the study site closest to the village of Crooked Creek (Site CR0.3) in an attempt to quantify mercury concentrations in large resident fish populations. Burbot are consumed by humans in the area, and monitoring mercury concentrations in their tissues is imperative to human health. Only four individuals were captured in 2009 (**Table 3.3-4**). In comparison to other fish-tissue mercury studies conducted in the Kuskokwim and Yukon regions, mercury concentrations in Crooked Creek burbot are relatively low. This is likely due to bioaccumulation, as the burbot caught at CR0.3 were smaller than those used for testing in other studies (Alaska DEC 2009, Duffy et al. 1999, Hinck et al. 2006, and Pulliainen et al. 1992). Bioaccumulation of mercury is common in fish tissues with older and larger fish being more likely to have higher concentrations of this metal accumulated in their tissues. Although accumulation of mercury appears to be present in burbot in Crooked Creek, concentrations fall well below the State of Alaska consumption guidelines currently set at 1 mg/kg (Jewett and Duffy 2007).

3.3.5 NORTHERN PIKE MERCURY CONCENTRATIONS WITHIN THE CROOKED CREEK DRAINAGE

Two northern pike were collected in 2010 to analyze mercury concentrations in their tissue. The fish collected at the fish weir was 795 mm TL. This fish was captured upstream of the weir panels and it may have migrated in from another location. The second fish was 295 mm TL and was collected approximately 1.25 miles (2 km) downstream of Crevice Creek, in a backwater that was disconnected to the main channel at the time of collection. Mercury concentrations in these specimens were 0.085 and 0.421 mg/kg (wet weight), respectively (**Table 3.3-5**).

3.4 AQUATIC LIFE TOXICITY TEST RESULTS (CORE PROGRAM)

Toxicity tests conducted in 2008 at Site CR0.7 indicated that current water quality conditions at that site have no toxic effects on aquatic life. Chronic tests using *Ceriodaphnia dubia* show that survival was 100 percent in the 100 percent concentration and ranged from 80 to 100 percent in the remaining concentrations. Control survival was 90 percent. No statistically significant mortality was measured in any concentration. The 25 percent inhibition concentration (IC25) for survival was >100 percent (**Appendix B**). Average number of neonates (offspring) was 25.7 in the 100 percent concentration and ranged from 19.9-25.2 in the remaining concentrations. Average number of neonates in the control was 19.7. No statistically significant differences in number of neonates were found between the control and any concentration. The IC25 for reproduction was >100 percent (**Appendix B**).

Chronic tests on fathead minnow showed that survival was 95 percent in the 100 percent concentration and ranged from 90 percent-100 percent in the remaining concentrations. Control survival was 98 percent. No statistically significant differences for survival were measured in any concentration when compared to the control. The IC25 for survival was >100 percent (**Appendix B**). Average weight in the 100 percent concentration was 0.433 mg per individual, and average weight ranged from 0.400 mg to 0.455 mg in the remaining concentrations. Average weight for control minnows was 0.406 mg. No statistically significant differences were measured for growth in any concentration when compared to the control. The IC25 for growth was >100 percent (**Appendix B**).

4.0 ROAD ALTERNATIVES PROGRAM

In order to sustain the proposed mining activities, the Project identified a proposed transportation corridor to facilitate the transport of fuels, chemicals, reagents and other mining supplies from outside locations to the Project. The proposed transportation corridor will include two main components; the proposed Jungjuk Port Site (Port), and the proposed Jungjuk Road (Road) (**Figure 1.1-1**). The Road would provide vehicle access for the transportation of commodities between the Port and the Project. The Port would be developed to receive shipments from barges operating on the Kuskokwim River and provide storage for commodities and diesel fuel

bound for the Project. The Port would contain a large on-river docking facility for offloading commodities as well as a 2.8 million USgal (10.6 ML) diesel fuel storage facility. Transporting fuel and supplies to the Project is expected to increase barge traffic on the Kuskokwim River from less than 10 to approximately 122 barge trips annually.

In 2007, an additional aquatic survey program area was added to provide baseline aquatic data in the drainages potentially affected by this proposed transportation corridor. Two additional studies were added in conjunction with the road alternative study. The first, added in 2009, was a culvert crossing study performed to fulfill the Alaska Department of Fish & Game (ADF&G) requirements for the Title 16 permit regarding culvert construction at streams crossings. The second, added in 2011, was a study performed on the Kuskokwim River near the Port. Methods and results of these studies are presented below (**Figure 1.1-1**).

4.1 GOALS (ROAD ALTERNATIVE)

The goals of the Road Alternative Program are similar to the goals of the Core Program. One of the main differences is that there are no planned hard rock mining operations for this area. With drainages not exposed to the effects of tailings or waste rock, the potential for increased metal concentrations downstream of the area of disturbance is much lower and fish tissue metals analysis was not warranted.

With the proposed construction and operation of the Road, Port, and the development of road building materials source sites, the most significant potential impacts within this Program area are increased erosion and sedimentation at the stream crossings and spills from transportation vehicles. This area had no existing background aquatic information, so an initial reconnaissance of primary drainages was an important step to understand which aquatic resources were present, and in what locations.

4.2 STUDY AREA (ROAD ALTERNATIVE)

The 27 mile (43.5 km) Road would cross streams within the Crooked Creek and Jungjuk Creek drainages as well as a small unnamed tributary to the Kuskokwim River (**Figure 1.1-1**). The Port will be located on the Kuskokwim River, approximately 8.1 river miles (13.1 km) downstream of the village of Crooked Creek (**Figure 1.1-1**).

There is considerable overlap between the Core and Road Alternative Programs in terms of the study area. Specifically, Crooked Creek and one of its larger tributaries, Getmuna Creek are represented in both sections. Refer to *Section 1.3* for more information about the Crooked Creek Drainage study area.

The Jungjuk Creek drains an area of 17.4 mi² (45 km²) originating on the northern flanks of the Horn Mountains. Jungjuk Creek has an average wetted width of 17 ft (5.18 m) and runs relatively clear as compared to Crooked Creek, likely due to a different underlying geology. Jungjuk Creek has a higher gradient, and lower sinuosity than Crooked Creek, and primarily made up of riffle habitat, with few pools. Beaver activity is heavy upstream of sampling Site JJ1, likely limiting upstream migration of anadromous fish in most years.

The Kuskokwim River is the second largest river in Alaska, draining approximately 50,193 mi² (129,999 km²) or 11 percent of the total area of Alaska (Brown 1983). Near the Port, the Kuskokwim River is a wide river with an average wetted width of 1,500 ft (457.3 m). The habitat around the Port is relatively uniform, mostly consisting of deep run habitat typical of rivers this size. Several mid-channel islands are present upstream of the Port; abandoned channels and off-channel habitats located on these islands provide some habitat for fish.

5.0 METHODS (ROAD ALTERNATIVE)

Because the methods in this study are similar to the Core Program, only clarifications of any differences from the Core Program methods are described in this section. Refer to *Section 2.0* for a complete listing of the Core Program methods. For the purposes of this report, the term “bridge” will refer to either a traditional bridge or an oversized, stream simulation-type culvert.

5.1 SITE AND REACH SELECTION METHODS (ROAD ALTERNATIVE)

5.1.1 ROAD CORRIDOR BIOMONITORING SITE SELECTION

Sampling sites were generally selected to document aquatic conditions near or downstream of Road crossings. To reduce duplicate sampling, data collected at sites or reaches sampled under the Core Program were used. Coordinates for all sampling sites within the Road Alternative Program can be found in **Appendix A**.

A sampling site was selected at Jungjuk Creek (Site JJ1) to capture effects from all significant drainages that could be crossed by the road alternative. This site was established downstream from all the Road crossings within the Jungjuk Creek drainage to document any changes that may occur from future activities in that drainage (**Figure 1.1-1**).

Core Program Site CR2 was used as a surrogate site for the road crossing over Crooked Creek (BR3). Refer to the Core Program sections for more information about the CR2 sampling site (**Figure 1.1-1**). Bridges BR47 and BR48 will span the North and South Forks of Getmuna Creek near a proposed gravel mine. Aerial survey data from Core Program reaches GM-R2, GM-R3, GM-R4, GM-R5, and FN-R1 was used to describe fish assemblages at these crossings (**Figure 1.1-1**). Additionally, Core Program Sites GM2, GM3, and GM4 provide information about the North and South forks immediately downstream of both of these crossings as well as Getmuna Creek.

5.1.2 CULVERT CROSSING FISH PRESENCE/ABSENCE SITE SELECTION

The proposed plans for the road alternative included using culverts for some of the smaller streams and wetted crossings. To conform to all ADF&G Title 16 permit requirements regarding culvert size and design, additional survey sites were added for some of the smaller drainages. Additional sites where salmon were not observed during road corridor surveys were not proposed to be spanned by a bridge or oversized culvert; crossings found to contain salmon are proposed to be either bridged or constructed with an oversized culvert per ADF&G (2001) and Alaska Department of Transportation (ADOT) recommendations.

All drainages proposed to have a bridge or oversized culvert installed had an established road corridor survey site downstream of the crossing. Drainages known to contain juvenile and/or adult salmon were omitted from this survey (**Figure 1.1-1**). Streams found to contain salmon were to be spanned by a bridge or designed with an oversized culvert following the ADF&G and ADOT recommendations regarding the design, permitting, and construction of culverts for fish passage (ADF&G 2001).

Prior to fish surveys conducted in 2009, the Project proposed to span unnamed (FN) creek with a culvert. Surveys documented salmon in the stream thus prompting the Project to change the span to a bridge (BR49). Survey data at unnamed (FN) creek was collected with methods described in *Section 5.4.2.2*.

5.1.3 JUNGJUK PORT SITE SELECTION

Sites were selected on the Kuskokwim River just downstream (KU9, KU10, KU11, KU12), upstream (KU13, KU14, KU15), and at the Port Site (KU8), to collect a representative sample within the vicinity of the Port. Each site contained slightly different habitat types, therefore different sampling methods were used within the Kuskokwim

River. Sites were selected with the intention of maximizing the number of fish species documented during the study. In 2012, several alternative sites were sampled both upstream (KU25, KU24) and downstream (KU20) of the Port Site (KU8) on the Kuskokwim River (Figure 1.1-1).

5.2 PARAMETER SELECTION METHODS (ROAD ALTERNATIVE)

For this study, OtterTail developed a list of parameters that would be useful to establishing baseline conditions and for future impact assessments. Parameters included aquatic macroinvertebrates, adult salmon aerial surveys, fish traps, fish seines, fyke nets, and electrofishing. The methodologies used are described in each of their respective sections below.

5.3 MACROINVERTEBRATE METHODS (ROAD ALTERNATIVE)

5.3.1 ROAD CORRIDOR AND JUNGJUK PORT SITE MACROINVERTEBRATE SURVEY

Benthic macroinvertebrates were collected at a single Road Alternative site location (Jungjuk Creek Site JJ1) and at twelve locations on the Kuskokwim River associated to the Jungjuk Port Site (Sites KU8, KU9, KU10, KU11, KU12, KU13, KU14, KU15, KU20, KU23, KU24, and KU25). Macroinvertebrates were quantitatively sampled at Site JJ1 in 2007 and 2008 by taking three replicate Surber samples as described in the Core Program (refer to *Section 2.3*). Macroinvertebrates at Jungjuk Port sites were sampled in 2011 and 2012 with a combination of Surber and Ponar® Samplers. Surber samples were collected at Sites KU8, KU10, KU11, KU12, KU14, KU20, KU23 and KU25 following the standard protocols described previously. A Ponar® Sampler was used to sample deepwater habitats with a high fine sediment load (Sites KU8, KU9, KU13, KU15 and KU24). The Ponar® samples a 9 x 9 inch (22.9 cm x 22.9 cm) area of stream bottom, approximately 3-5 inches (7.6-12.7 cm) deep. Three replicate samples were taken at each site. The sediments collected in the Ponar® Sampler were washed with river water on a 600 µm sieve in the field to remove excess fine sediments. Samples were preserved in alcohol and shipped to the laboratory for analyses.

5.4 FISH POPULATION ASSESSMENT METHODS (ROAD ALTERNATIVE)

5.4.1 ADULT SALMON AERIAL SURVEY

An aerial salmon survey was conducted along Jungjuk Creek as part of the Road Alternative drainages sampling from 2007 to 2011. The same methods described for the Core Program were used. Jungjuk Creek was flown to document presence or absence of adult salmon. The reach flown is shown on **Figure 1.1-1**. Surveys were conducted in the fall (September 13, 2007, September 19, 2008, September 18, 2010, and September 18, 2011), September 13-17, 2009, 2010, and 2011) to document coho salmon presence/absence. Aerial surveys were not conducted during the fall of 2012. Summer aerial surveys were conducted to document the presence/absence of Chinook and chum salmon (July 26, 2007; July 25, 2010; July 22, 2011; and July 24, 2012).

5.4.2 RESIDENT FISH AND JUVENILE SALMON SURVEY

5.4.2.1 ROAD CORRIDOR BIOMONITORING SURVEY

Resident fish populations were evaluated at a single location in Jungjuk Creek (i.e., Site JJ1; **Figure 1.1-1**). These surveys were conducted on September 12, 2007 and August 2, 2008. Surveys were conducted with a backpack electrofisher as described in the Core Program section for one-pass minimum population assessments. Fish trapping with minnow traps was also conducted at JJ1 with methods identical to those listed for the Core Program in *section 2.4.3.2*.

5.4.2.2 CULVERT CROSSING FISH PRESENCE/ABSENCE SURVEY

The objective of the culvert crossing survey was to document fish species in drainages that were to have culverts installed as a result of the Road. Single pass electrofishing was the sampling method for fish. No block nets were used. As a general guideline, electrofishing reach lengths were set to, but not limited to 40 times the wetted width of the stream, therefore reach lengths varied depending upon the stream size and changes in habitat types within the reach. Electrofishing surveys were conducted as described in *Section 2.4.3.1*.

The drainages were analyzed to assess the need of culverts. If a site did not contain a wetted drainage (such as a swale or wetland), that site was photo documented at the spot of the Road crossing. Typically, if a wetted drainage was found, a one pass electrofishing survey was performed from just downstream of the road crossing point to the road crossing. No macroinvertebrate collection was performed as part of this study.

Crossing points CU43 and BR49 were sampled on July 31, 2009. Sampling for crossing point BR61 was conducted on July 17, 2011. Crossing points BR63, CU59, CU60, and CU62 were sampled on July 18, 2011.

5.4.2.3 KUSKOKWIM RIVER PORT SITE FISH SURVEY

The Kuskokwim River port site study contained different sampling conditions than the road corridor and culvert survey sites, and therefore the methods used for fish collection differed as well. Multiple sampling methods were used in attempt to capture the fish assemblage in the Kuskokwim River. Methods included fish seines, fyke nets, and electrofishing, depending on what the conditions warranted at each sampling site.

Fyke nets were used to sample fish assemblages in the deeper water areas along the Kuskokwim. Setup and design of each fyke net varied depending upon the conditions at the site. Often, the fyke was set up with a center net (leader) and two wings facing downstream at approximately 30 degree angles to divert fish into the traps. In other situations, fyke nets were set with a single leader to divert fish into to the trap. Fyke net traps were baited with commercial salmon eggs and/or canned tuna fish. Fyke nets were set for approximately 24 hours.

Fish seines were also used for sampling the fish assembly along the shallower margins of the Kuskokwim River. Seines were typically 4 ft (1.2 m) deep by 30 ft (9.1 m) long with 1/8" (3.18 mm) mesh size. Depending on site conditions, 20 ft (6.1 m) and 40 ft (12.2 m) long seines were also used. The number of seine hauls at each site ranged from three to seven to capture different habitat types within the site. The single pass electrofishing method was performed at Sites KU8 and KU9, as these sites were shallow enough to allow for effective electrofishing.

Site KU9 is located mid-channel on the Kuskokwim River near the downstream tip of an island (**Figure 1.1-1**). Habitat consists mostly of deep eddying margins with heavy silt deposition and very little physical habitat structure. The margins of the stream were sampled using three passes with a fish seine [30 ft (9.1 m) seine length]. Electrofishing was also conducted along stream margins and in some off channel habitat found upstream of the sampling site.

Sampling Site KU10 is located just downstream of Site KU9, on the north side of the Kuskokwim River (**Figure 1.1-1**). The site can be characterized as a monotonous slow riffle with gravel, sand, and silt dominating the substrate. This site was sampled with both a seine [30 ft (9.1 m) seine length], and a fyke net.

Sites KU11 and KU12 are located on the eastern side of an island, near the upstream end (**Figure 1.1-1**). Habitats at both sites are made up of a slow riffle with gravel and silt dominating the substrate. Site KU25, sampled in 2012, is located just upstream of site KU11 on the northern side of the island (**Figure 1.1-1**). The habitat at this site is similar to Site KU11, with a dominant substrate of gravel and silt within the littoral zone. Three seine tows and electrofishing were conducted at this site. Sites KU23 and KU24, sampled in 2012, are located just downstream of

Site KU25 on the northern side of the island (**Figure 1.1-1**). Generally, the habitat for both sites could be classified as backwater, with substrate dominated by gravel and sand, covered in fine silt. Electrofishing and a single fyke net set were conducted at both sites, with three additional seine tows [30 ft (9.1 m) seine length] conducted at KU24.

Port Site (KU8)

Site KU8 is located adjacent to the Port (**Figure 1.1-1**). Habitat consists of slow, nearly slack, water with silt dominating the substrate and very little habitat complexity. A total of three fyke nets were set in 2011 as well as three seine tows and electrofishing conducted along the margins and small backwater areas. In 2012, the site was sampled via electrofishing and a single fyke net was set.

Downstream Sites (KU13, KU14, KU15, KU20)

Site KU14 was located on the northwest side of the river, downstream of the Port (**Figure 1.1-1**). Substrate at Site KU14 consists of a mix of gravel and larger cobbles, mixed with finer sediments. Generally, the habitat could be classified as a run. Clear water entering the Kuskokwim River from Jungjuk Creek resulted in lower turbidity at this site. The lack of deep mud made seining considerably more effective, so a total of seven tows were conducted. No electrofishing was conducted at any downstream sites in 2011. The site was sampled in 2012, with collection methods consisting of six seine tows [30 ft (9.1 m) seine length] and a single fyke net.

Site KU20 was the only alternative site in 2012 sampled downstream of the Port, located on the northwest side of the river (**Figure 1.1-1**). The habitat features for this site are similar to Sites KU13 and KU15, consisting of substrate dominated by sand and gravel covered with a layer of silt. Electrofishing and a single fyke net were conducted.

6.0 RESULTS AND DISCUSSION (ROAD ALTERNATIVE)

6.1 MACROINVERTEBRATE RESULTS (ROAD ALTERNATIVE)

A list of macroinvertebrate taxa found within the Road Alternative drainages and Jungjuk Port Site is shown in **Table 6.1-1** and **Table 6.1-2**. A summary of macroinvertebrate metrics for sites sampled from 2007 to 2011 are included in **Appendix L** and **M**. Average macroinvertebrate metrics for 2007-2011 are shown in **Table 6.1-3**.

6.1.1 JUNGJUK CREEK – ROAD ALTERNATIVE (SITE JJ1)

Jungjuk Creek Site (Site JJ1) was sampled in 2007 and 2008. Macroinvertebrate abundance was consistent both years (**Figures 6.1-1** and **6.1-2**) but a higher number of total and EPT taxa were collected in 2007 (**Appendix M**). Consistently, the Shannon Diversity Index (H) and Evenness (e) suggest that water quality conditions were slightly better in 2007. These differences could also result from natural variability in stressors occurring in the system. Freezing, flooding, and high natural siltation rates are likely the most significant factors affecting stream community structure in drainages near the Kuskokwim River. Siltation limits macroinvertebrate colonization by filling the interstitial spaces in the gravel-cobble stream bottom, reducing the amount of area in the stream bottom that could be colonized. Furthermore, these interstitial spaces are used by macroinvertebrates as refugia from freezing during winter, so fewer interstitial spaces would also decrease the ability of macroinvertebrates to overwinter. Overall, the HBI index suggested that water quality conditions are very good at Site JJ1 (**Figure 6.1-3**).

In relation to core program sampling sites, the observed macroinvertebrate abundance and community composition at Site JJ1 was similar to the sites sampled within the Crooked Creek drainage (**Tables 6.1-3** and **3.1-2**). On average, abundance at this site was 211 invertebrates / ft²; 22 taxa were found of which 12 were EPT taxa. As in core Crooked Creek drainage sites, Chironomidae was the predominant taxa at Site JJ1.

6.1.2 JUNGJUK PORT SITE SURVEY (SITES KU8, KU9, KU10, KU11, KU12, KU13, KU14, KU15, KU20, KU23, KU24, KU25)

The Jungjuk Port sites (KU8, KU9, KU10, KU11, KU12, KU13, KU14, and KU15) located in the Kuskokwim River were surveyed for the first time in 2011. In 2012, several alternative sites were selected (KU20, KU23, KU24, KU25) along with sites KU8, KU9, and KU14 in an attempt to increase the number of different aquatic habitat types sampled for the study. These sites present different habitat types than the shallow riffles typically sampled for macroinvertebrates at other biomonitoring sites. Generally, Jungjuk Port sampling sites consist of deep, slow moving water with fine sediments and gravels on the river bottom. Therefore, it is not surprising that the macroinvertebrate community identified at these sites was substantially different present at other sites sampled in this study.

Overall, macroinvertebrate abundance at Jungjuk Port sites was low, similar to the abundance levels observed in some of the Crooked Creek tributaries (e.g., Anaconda Creek- Sites AN1 and AN2; **Tables 6.1-3** and **3.1-2**). Similarly, both total and EPT taxa found at these sites was substantially lower than at other sites surveyed in this study (**Table 6.1-3**; **Figure 6.1-4**). The macroinvertebrate community was composed primarily of Chironomidae and Oligochaeta taxa (**Table 6.1-3**). Based on macroinvertebrate samples collected using surbers, the dominance of Chironomidae taxa ranged from 70 percent at Site KU8 to 99 percent at Site KU12 (**Table 6.1-3**; **Appendices L** and **M**). The Shannon diversity and evenness indices reflect the dominance of a single taxa and low diversity at these sites. The HBI index suggested fair water quality conditions at most of the Jungjuk Port sites sampled; this index indicated good water quality conditions at Sites KU8 and KU15 (**Figure 6.1-3**; **Appendices L** and **M**). However, given the proximity between these sites, the observed differences in HBI may reflect slight differences in the habitats sampled and not necessarily differences in water quality.

6.2 FISH POPULATION ASSESSMENT RESULTS (ROAD ALTERNATIVE)

Fish surveys associated to the Road Alternative are limited to electrofishing Jungjuk Creek in 2007 and 2008, and aerial surveys in the same creek from 2007 to 2012. The fish assemblage found during these surveys is typical of tributaries of the Kuskokwim River. A list of fish species found during Road Alternative surveys is included in **Table 6.2-1**.

6.2.1 ADULT SALMON AERIAL SURVEY

Coho salmon is the only species that has been observed during aerial surveys along Jungjuk Creek. Annual coho salmon counts have ranged from two fish in 2008 to eight fish in 2011 (**Table 6.2-2**). **Figure 1.1-1** includes the estimated adult salmon density and distribution observed by aerial surveys as well as the resident fish species occurrence within the road alternative drainages. It should be noted that the uppermost extent of the salmon distribution is a best guess estimate based strictly on observations from OtterTail, and that these distributions and densities are based on aerial survey observations alone. A large beaver dam complex appears to be limiting the upstream extent of coho salmon in this drainage.

Chinook, chum and coho salmon have been documented in the North and South Forks of Getmuna Creek (**Table 3.2-2**). Refer to *Section 3.2.1* of the Core Program for more information about salmon runs on Getmuna Creek.

6.2.2 RESIDENT FISH AND JUVENILE SALMON SURVEY

Resident populations in Jungjuk Creek were surveyed in October, 2007 and in August, 2008. Surveys found adult and juvenile coho salmon, Dolly Varden, Arctic grayling, round whitefish, and slimy sculpin. The electrofishing surveys showed a two year average population of 98 fish per 300 ft (**Table 6.2-3; Appendix N**).

Fish species collected at GM1 include Chinook and coho salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, and nine-spine stickleback (**Table 3.2-4**). Refer to *Section 3.2.2.4* of the Core Program for more information on electrofishing results from site GM1.

6.2.2.1 BRIDGE AND CULVERT STREAM CROSSING FISH PRESENCE/ABSENCE SURVEYS

Presence/absence surveys were conducted in summer 2009, and 2011 to assess fish species assemblages at streams to be crossed by the Road. Information gathered from other sampling sites or reaches was used to further refine the documented species at each location.

Culvert Crossings (CU43, CU59, CU60, and CU62)

Culvert crossing location CU43 is in the headwaters of North Fork Getmuna Creek. Culverts CU59, CU60, and CU62 are all tributaries to Jungjuk Creek. No fish were found at any of the culvert crossings (**Figure 1.1-1; Appendix O**).

Bridge Crossings (BR3, BR47, BR48, BR49, BR61, and BR63)

The Road crosses Crooked Creek (BR3) downstream of Core Program site CR2 (**Figure 1.1-1**). Fish species present at this location include Chinook, chum and coho salmon adults, which were documented during aerial surveys of reach CRR4 (**Table 3.2-2**). Chinook and coho salmon juveniles, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, burbot, and Alaska blackfish were collected at site CR2 (**Tables 3.2-2 and 3.2-4**).

The North Fork of Getmuna Creek is crossed by the Road at BR47 (**Figure 1.1-1**). Aerial surveys have documented Chinook, chum and coho salmon adults in this reach (GM-R2) (**Table 3.2-2**). Electrofishing surveys at site GM2, conducted in 2012 as part of the Core program show that Dolly Varden, Arctic grayling, and slimy sculpin are present downstream of the bridge in this reach (**Table 3.2-5 and Section 3.2.2.1**). To the south, the Road crosses

the South Fork of Getmuna Creek at BR48 (**Figure 1.1-1**). During aerial surveys conducted in reach GM-R3, and GM-R4, adult Chinook, chum and coho salmon have been documented (**Table 3.2-2**). Additionally, species collected during the 2012 survey at GM4 show that Dolly Varden and slimy sculpin reside in the reach below BR48 (**Table 3.2-5** and *Section 3.2.2.1*).

Crossing point BR49 spans the small unnamed (FN) creek, a tributary to the South Fork of Getmuna Creek. This crossing point is located just to the south of BR48. Electrofishing surveys conducted in 2009 sampled juvenile coho salmon, Dolly Varden, Arctic grayling, and slimy sculpin (**Appendix O**). The results of this survey prompted the Project to upgrade the crossing structure from a culvert to a bridge.

West of the Port, the Road follows Jungjuk Creek, crossing the mainstem in two locations (BR61, and BR63). Electrofishing surveys conducted in 2011 documented a population of Dolly Varden at each location (**Appendix O**). Surveys conducted downstream of these bridge crossings in 2007 and 2008 at Site JJ1 documented Arctic grayling, round whitefish and slimy sculpin. Additionally, aerial surveys conducted in reach JJR1 during fall in 2007, 2008, 2010, and 2011 documented limited numbers of adult coho salmon. Aerial surveys conducted during 2012 found no Chinook, chum or sockeye salmon in the system (**Table 6.2-2**).

6.2.2.2 PORT SITE FISH SURVEY RESULTS

In 2011, eight sites were sampled, four upstream, three downstream and one adjacent to the Port. The sampling effort resulted in the collection of over 1,100 fish measured and identified. Though a variety of sampling methods were deployed, including seines, fyke nets and electrofishing, a majority of fish were collected with seines (88 percent). In general the most abundant species captured along Kuskokwim River sites by all methods was the longnose sucker (25 percent total relative abundance) and Arctic grayling (22 percent total relative abundance) (**Table 6.2-4**). In 2012, seven sites were sampled that included three sites from 2011 (KU8, KU9, KU14) along with three alternative sites upstream (KU23, KU24, KU25) and one alternative site downstream (KU20) of the Port. A total of 1,221 fish were identified and measured with the majority being collected by electrofishing (74 percent). The longnose sucker was the most abundant species collected across all sampling methods (seine, fyke, electrofishing) with a 52, 44, and 63 percent total relative abundance, respectively (**Table 6.2-4**). Juvenile sockeye salmon were the second most abundant species collected across all sites (267 fish) constituting 22 percent of the total fish collected in 2012 (**Table 6.2-4**).

Upstream Sites (KU9, KU10, KU11, KU12, KU23, KU24, KU25)

Site KU9 is located mid-channel on the Kuskokwim River near the downstream tip of an island (**Figure 1.1-1**). Results of electrofishing revealed a high abundance of round whitefish (46 percent), as well as the presence of sockeye salmon, Arctic grayling, longnose sucker, Alaskan brook lamprey, burbot, and slimy sculpin. Only 81 total fish were collected at this site, the fewest of any port sampling site in 2011 (**Table 6.2-4**). In 2012, four species of fish were collected electrofishing. A total of 116 fish were collected with a high abundance of longnose sucker (61 percent) and juvenile sockeye salmon (35 percent), in addition to three undifferentiated juvenile whitefish and a single slimy sculpin (**Table 6.2-4**).

Site KU10 is located just downstream of Site KU9, on the north side of the Kuskokwim River (**Figure 1.1-1**). Species assemblage in 2011 for Site KU10 included Chinook, chum, pink, and sockeye salmon juveniles, Arctic grayling, round whitefish, longnose sucker, and slimy sculpin. The fyke net deployed at this location became fouled with debris during the set, and caught only a single sockeye salmon fry (**Table 6.2-4**).

Sites KU11 and KU12 are located on the eastern side of an island, near the upstream end (**Figure 1.1-1**). In 2011, longnose sucker was the most abundant species at both sites with 28 and 25 percent relative abundance

respectively. Other fish documented at these locations include sockeye salmon fry, Arctic grayling, round whitefish, broad whitefish (*Coregonus nasus*), humpback whitefish, least cisco, and slimy sculpin (**Table 6.2-4**).

Site KU25, sampled in 2012, is located just upstream of site KU11 on the northern side of the island (**Figure 1.1-1**). The most abundant species collected at this site were longnose sucker (79 percent total relative abundance electrofishing and 47 percent total relative abundance in seine nets) and juvenile sockeye salmon (17 percent total relative abundance electrofishing and 33 percent total relative abundance in seine nets (**Table 6.2-4**). Other species collected at this site included Arctic grayling, slimy sculpin, and undifferentiated juvenile whitefish.

Sites KU23 and KU24, sampled in 2012, are located just downstream of Site KU25 on the northern side of the island (**Figure 1.1-1**). Fish species included juvenile Chinook, coho, and sockeye salmon, Arctic grayling, round whitefish, undifferentiated juvenile whitefish, and slimy sculpin. Longnose sucker was the most abundant species collected at both sites (**Table 6.2-4**).

Port Site (KU8)

Site KU8 is located adjacent to the Port (**Figure 1.1-1**). The most abundant fish documented at this site was Arctic grayling juveniles (77 percent in seines and 15 percent in fyke nets). Other species collected include Chinook, coho, sockeye, and pink salmon juveniles, Dolly Varden, round whitefish, humpback whitefish, least cisco, sheefish, longnose sucker, slimy sculpin, burbot, and lamprey (undifferentiated). In 2012, Longnose sucker and juvenile sockeye salmon were the most abundant, consisting of 38 and 30 percent of the total fish collected, respectively (**Table 6.2-4**).

Downstream Sites (KU13, KU14, KU15, KU20)

Site KU14 is located on the northwest side of the river, downstream of the Port (**Figure 1.1-1**). Longnose sucker and juvenile Arctic grayling were the dominant fish species in samples with 36 and 42 percent relative abundance, respectively (**Table 6.2-4**). In 2012, longnose sucker was the most abundant fish species at this site, accounting for 33 percent of total fish collected (**Table 6.2-4**). Only 39 fish were collected at this site, the fewest of any port sampling site in 2012.

Sites KU13 and KU15 are located on the northwest side of the river, downstream of the Port (**Figure 1.1-1**). Both sites displayed habitat features similar to Site KU8, but with a bit higher water velocity. Fish species found included coho and sockeye salmon juveniles, Arctic grayling, round whitefish, humpback whitefish, sheefish, least cisco, longnose sucker, slimy sculpin, northern pike, and burbot. Round whitefish was the most abundant fish sampled (**Table 6.2-4**).

Site KU20 was the only alternative site in 2012 sampled downstream of the Port and is located on the northwest side of the river (**Figure 1.1-1**). A total of 52 fish were identified and measured at this site collected via electrofishing and a single fyke net set. The most abundant fish species at this site were slimy sculpin and juvenile coho salmon, accounting for 33 and 27 percent of total fish caught (**Table 6.2-4**). Other species collected included juvenile sockeye salmon, Dolly Varden, Arctic grayling, round whitefish, and whitefish (undifferentiated).

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8.0 TABLES

Table 2.1-1

Stream Characteristics and Purpose for Sites Selected for the Donlin Gold Mine Project Aquatic Biomonitoring Program

Stream Characteristics and Purpose for Sites Selected for the Donlin Gold mine Project Aquatic Biomonitoring Program						
Stream	Drainage Area		Current Status	Sampling Site	Location ¹	Purpose
	mi ²	km ²				
Reference Sites						
Donlin Creek	48.8	126.4	No historical or proposed mining	DO1	Approx. 0.16 mi. (0.26 km) downstream of confluence with Ophir Creek and 0.62 mi. (1.0 km) upstream of confluence with Dome Creek.	Reference site above mineralized zone in major tributary creating Crooked Creek
Flat Creek	19.5	50.5	No proposed mining	FL1	Approx. 750 ft. (229 m) upstream of Crooked Creek confluence	Reference site above mineralized zone in major tributary creating Crooked Creek
Potentially Affected Sites						
Crooked Creek	335.0	867.6	Historical mining; possible small portion of proposed mining affects (above most activities) Historical/current placer mining upstream	CR2	upstream of American Creek confluence and approx. 330 ft. (100 m) downstream of currently active placer mine diversion canal	Mainstem site downstream of all historical mining activities; therefore, site used to assess if any detected changes are from placer mining operations or proposed Donlin project
				CR1	Approx. 0.5 mi. (0.8 km) downstream of Anaconda Creek confluence	Mainstem site downstream of most currently known possible proposed mine affects
				CR0.7	Approx. 0.35 mi. (0.56) downstream of Crevice Creek confluence	Mainstem site downstream of all historical mining activities and downstream of all currently known possible proposed mine affects
				CR0.3	Approx. 0.84 mi. (1.35 km) upstream of confluence with Kuskokwim River	Mainstem site at the mouth of Crooked Creek; assess amount of recovery if possible potential affects are observed at upstream sites
				Weir	1.5 mi. (2.4 km) upstream of the Kuskokwim River Confluence and 0.67 mi. (1.08 km) upstream of CR0.3	Count adult salmon migrating into Crooked Creek drainage
Snow Gulch	3.3	8.5	No historical/current placer mining upstream of this location in watershed	SN2	Approx. 1.5 mi. (2.4 km) upstream of Crooked Creek confluence and upstream of current placer mining operation	Potentially affected by possible mine disturbance that may enter into upper watershed, location of proposed reservoir
Queen Gulch	0.9	2.3	Historical Mining	QU1	Approx. 0.3 mi. (0.48 km) upstream of historic confluence with Crooked Creek, and upstream of placer mining influence	Potentially affected by proposed pit, upstream of placer mine disturbances
Lewis Gulch	0.8	2.1	Historical and proposed mining	LE1	Sites both upstream and downstream of current road approx. 0.3 mi. (0.48 km) upstream of historic confluence with Crooked Creek	Document aquatic resources potentially affected by proposed pit and wasterock filling
American Creek	6.5	16.8	Proposed mining Pit and Waste Rock Facility	AM1	Above historic winter access road and approx. 0.5 mi. (0.8 km) upstream of confluence with Crooked Creek	Document aquatic resources potentially affected by proposed pit and wasterock filling
				AM2	Approx. 2.3 mi. (3.7 km) upstream of confluence with Crooked Creek	Document aquatic resources potentially affected by proposed pit and wasterock filling
			Proposed mining Waste Rock Facility and Natural Gas Pipeline Shoofly Access Road.	AM3	Upper extent of American Creek watershed	Potentially affected by Natural Gas Pipeline shoofly access road crossings (kAM2_sh)
				AM4	Upper extent of American Creek watershed	Potentially affected by Natural Gas Pipeline shoofly access road crossings (kAM3_sh)
Omega Gulch	1.0	2.6	Proposed mining	OM1	Approx. 0.4 mi. (0.64 km) upstream of Crooked Creek confluence	Document aquatic resources potentially affected by proposed activities within the drainage
Anaconda Creek	7.6	19.7	Proposed tailings impoundment	AN1	Approx. 0.25 mi. (0.40 km) upstream of confluence with Crooked Creek and immediately upstream of the historic winter road	Document aquatic resources in Anaconda Creek potentially affected by proposed tailings impoundment upstream
				AN2	Approx. 2.6 mi. (4.2 km) upstream of Crooked Creek confluence	Document aquatic resources in upper Anaconda Creek potentially affected by proposed tailings impoundment
Crevice Creek	6.8	17.6	No historical mining; proposed possible impacts	CV1	Approx. 930 ft. (283 m) upstream of Crooked Creek confluence	Potentially affected by proposed surface water diversion from Anaconda Creek
Potentially Indirectly Affected						
Dome Creek	6.8	17.6	No historical or proposed mining	DM1	Approx. 0.53 mi. (0.85 km) upstream of Crooked Creek confluence	Potentially affected by possible mine disturbance that may enter into upper watershed
Quartz Gulch	1.2	3.1	No historical or proposed mining	QZ1	Approx. 0.47 mi. (0.76 km) upstream of Crooked Creek confluence	Potentially affected by possible mine disturbance that may enter into upper watershed
Grouse Creek	12.1	31.3	No historical or proposed mining	GR1	Approx. 0.5 mi. (0.8 km) upstream of Crooked Creek confluence	Potential groundwater affects within watershed from pit dewatering activities
Eagle Creek	8.5	22.0	no historical or proposed mining	EG1	Approx. 0.83 mi. (1.34 km) upstream of Crooked Creek confluence	Road and material sites in upper watershed
Unnamed (BC)	0.4	1.0	No historical mining; proposed possible impacts	BC1	Approx. 0.22 mi. (0.35 km) upstream of confluence with Crooked Creek	Potentially affected by winter access road
Unnamed (AC)	0.3	0.8	No historical mining; proposed possible impacts	AC1	Approx. 0.25 mi. (0.40 km) upstream of confluence with Crooked Creek	Potentially affected by winter access road
Getmuna Creek	98.6	255.4	No historical disturbance	GM1	Approx. 2.5 mi. (4.0 km) upstream of Crooked Creek confluence	Document aquatic resources potentially affected by proposed Gravel Mine and road crossings
				GM2	Approx. 0.47 mi. (0.76 km) downstream of proposed Gravel Mine	Document aquatic resources potentially affected by proposed Gravel Mine and road crossings
				GM3	Approx. 1.5 mi. (2.4 km) downstream of proposed Gravel Mine	Document aquatic resources potentially affected by proposed Gravel Mine and road crossings
				GM4	Approx. 0.55 mi. (0.88 km) downstream of proposed Gravel Mine	Document aquatic resources potentially affected by proposed Gravel Mine and road crossings
Unnamed (FN)	5.6	14.5	No historical disturbance	FN1	Approx. 0.34 mi. (0.55 km) upstream of confluence with South Fork Getmuna Creek	Document aquatic resources potentially affected by proposed road corridor
Bell Creek	71.3	184.5	No historical disturbance	BL1	Just upstream of historic winter access road	Document aquatic resources potentially affected by proposed winter access road

Notes:

A map displaying site locations can be found in **Figure 1.1-1**. A list of coordinates (latitude and longitude) can be found in **Appendix A**.

1) Lengths listed in location descriptions are estimated stream lengths.

Table 2.1-2
Crooked Creek Stream Characteristics

Stream Name	Percent of Crooked Creek Watershed ¹	Drainage Area		Aerial Reach	Site within Reach	Slope	Sinuosity	Rosgen Type ²	Dominant Substrate in Riffles ³	AVG Wetted Width ⁴	
		(mi ²)	(km ²)							(ft)	(m)
Donlin Creek	9.09	30.5	79.0	DOR1	na	0.30%	1.47	na	na	na	na
				DOR2	DO1	0.40%	1.82	B5c	gravel	19.9	6.1
				DOR3	na	0.70%	1.48	na	na	na	na
Dome Creek	2.03	6.8	17.6	DMR1	DM1	2.60%	1.06	G4	gravel/cobble	8.6	2.6
Quartz Gulch	0.35	1.2	3.1	na	QZ1	3.20%	1.03	G3g	gravel/cobble	8	2.4
Snow Gulch	1.01	3.4	8.8	SNR1	SN2	1.90%	1.04	G6	sand	4.4	1.3
Queen Gulch	0.21	0.7	1.8	na	QU1	2.60%	1.01	G3g	sand/gravel	6.6	2
Flat Creek	5.8	19.5	50.5	FLR1	FL1	0.60%	1.12	B3c	cobble	12.1	3.7
Lewis Gulch	0.23	0.8	2.1	na	LE1	4.40%	1.01	G3g	gravel/cobble	2.5	0.8
American Creek	2.04	6.9	17.9	AMR1	AM1	2.20%	1.4	B5	gravel/cobble	10.5	3.2
				AMR1	AM2	2.20%	1.4	B5	gravel/cobble	13.1	4
Grouse Creek	3.56	12	31.1	GRR1	GR1	0.90%	1.07	B5c	gravel	13.2	4
Omega Gulch	0.3	1	2.6	na	OM1	4.50%	1.06	G6da	silt/sand	3.3	1
Anaconda Creek	2.34	7.9	20.5	ANR1	AN1	1.40%	1.4	G6c	silt/sand	7.3	2.2
				ANR1	AN2	1.40%	1.4	G6c	silt/sand	7.4	2.3
Crevice Creek	2.01	6.8	17.6	CVR1	CV1	0.70%	1.14	B5c	gravel	5.3	1.6
Eagle Creek	2.53	8.7	22.5	EGR1	EG1	1.00%	1.05	G6c	silt/sand	5	1.5
Unnamed (BC)	0.1	0.4	1.0	na	BC1	2.80%	1.03	G6da	sand	5	1.5
Unnamed (AC)	0.08	0.3	0.8	na	AC1	2.30%	1.04	G6da	sand	3	0.9
Bell Creek	21.23	71.3	184.7	BLR1	BL1	0.40%	1.68	C4	gravel/cobble	29.5	9.0
				BLR2	na	1.20%	1.21	na	na	na	na
				BLR3	na	1.00%	1.26	na	na	na	na
Getmuna Creek	29.39	98.6	255.4	GMR1	GM1	0.40%	1.65	C4	gravel/cobble	51.6	15.7
					GM3	na	na	C4	gravel/cobble	na	na
				GMR2	GM2	0.50%	1.39	na	gravel/cobble	na	na
				GMR3	GM4	1.00%	1.2	na	gravel/cobble	na	na
				GMR4	na	2.3 %	1.03	na	na	na	na
				GMR5	na	2.10%	1.01	na	na	na	na
Unnamed (FN)	1.67	5.6	14.5	FNR1	na	1.10%	1.02	na	na	na	na
Crooked Creek	100	335.5	868.9	CRR1	CR0.3	0.20%	1.62	C4	gravel/cobble	⁵ 23.4	⁵ 7.1
				CRR2	na	0.20%	1.97	na	na	na	na
				CRR3	CR1	0.10%	2.06	C4	gravel/cobble	54.2	16.5
				CRR3	CR0.7	0.10%	2.06	C4	gravel/cobble	49.3	15
				CRR4	na	0.10%	2.7	na	na	na	na
				CRR5	CR2	0.30%	1.65	C4	gravel/cobble	36	11

Notes:

Refer to Figure 1.1-1 for aerial reach and sampling site locations.

1) Percent of Crooked Creek Watershed and Drainage area are estimates.

2) Data on entrenchment, or flood prone width has not been collected. Therefore, definitive classifications cannot be made and should be used only as a relative estimate of stream type (Rosgen et al. 1996).

3) This classification was not quantified and was determined by field notes, photographs, and general knowledge of the streams.

4) Average wetted width measured at biomonitoring site.

5) Wetted width at CR0.3 represents only the side channel in which the survey is conducted; Total wetted width for the entire mainstem at this location is ~60 ft. (18 m).

Table 2.5-1

Fish Tissue Analytes, Analytical Methods, and Method Detection Limits (2004-2012)

Component	Symbol	EPA Analytical Method	Ranges for Method Detection Limits ¹ (mg/kg)									Average Range	Maximum Range
			2004	2005	2006	2007	2008	2009	2010	2011	2012		
Aluminum	Al	6010B-ICP/MS	1.1-1.3	0.9-1.1	0.9-1.1	1.3-1.6	0.1-0.1	0.05-0.07	0.05-0.1	0.05-0.07	0.04-0.05	0.5-0.61	0.04-1.6
Antimony	Sb	6020-ICP/MS	0.001-0.001	0.002-0.002	0.005-0.006	0.004-0.005	-	-	-	-	-	0-0	0.001-0.006
Arsenic	As	6020-ICP/MS	0.01-0.01	0.01-0.01	0.01-0.01	0.01-0.013	0.013-0.016	0.009-0.013	0.007-0.013	0.003-0.005	0.004-0.005	0.01-0.01	0.003-0.02
Cadmium	Cd	6020-ICP/MS	0.001-0.001	0.001-0.001	0.005-0.006	0.002-0.003	0.0008-0.001	0.0008-0.0011	0.001-0.002	0.0003-0.0005	0.0004-0.0005	0-0	0.0003-0.006
Chromium	Cr	6010B-ICP/MS	0.07-0.08	0.07-0.08	0.09-0.11	0.1-0.13	0.011-0.014	0.013-0.018	0.01-0.03	0.01-0.02	0.0038-0.0048	0.04-0.05	0.0038-0.13
Copper	Cu	6020-ICP/MS	0.02-0.02	0.005-0.006	0.005-0.006	0.006-0.008	0.008-0.01	0.005-0.007	0.005-0.01	0.003-0.005	0.004-0.005	0.01-0.01	0.003-0.02
Iron	Fe	6010B-ICP	0.1-0.1	0.12-0.14	0.2-0.2	0.9-1.1	0.1-0.1	0.1-0.1	0.07-0.13	0.06-0.09	0.04-0.05	0.19-0.22	0.04-1.1
Lead	Pb	6020-ICP/MS	0.002-0.002	0.002-0.003	0.001-0.002	0.001-0.0013	0.0006-0.0008	0.0003-0.0004	0.001-0.002	0.0001-0.0001	0.0001-0.0001	0-0	0.0001-0.003
Manganese	Mn	6010B-ICP/MS	0.001-0.001	0.09-0.11	0.02-0.02	0.004-0.005	0.003-0.004	0.002-0.01	0.003-0.006	0.005-0.007	0.004-0.005	0.01-0.02	0.001-0.11
Mercury	Hg	1631E-AFS	0.3-0.3	-	0.05-0.09	0.05-0.2	0.1-0.1	0.1-0.2	0.3-1.1	0.1-0.3	0.3-0.6	0.16-0.36	0.05-0.6
Selenium	Se	7740-GFAA	0.09-0.1	0.07-0.08	0.1-0.1	0.1-0.13	0.05-0.06	0.05-0.07	0.06-0.1	0.05-0.07	0.04-0.05	0.07-0.08	0.04-0.13
Zinc	Zn	6020-ICP/MS	0.01-0.02	0.12-0.14	0.02-0.05	0.01-0.02	0.01-0.01	0.009-0.013	0.01-0.03	0.009-0.011	0.011-0.014	0.02-0.03	0.009-0.14

Notes:

1) The Method Detection Limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix

2) No MDL available for mercury in 2005.

Table 3.1.1

Macroinvertebrate Taxa Collected within the Crooked Creek Drainage (2004-2012)

Order	Family	Genus	Total count ¹	Order	Family	Genus	Total count ¹
Ephemeroptera	Ameletidae	<i>Ameletus</i>	191	Diptera	Chironomidae ²	<i>Pseudokieferiella</i>	14
	Baetidae	<i>Acentrella</i>	6119			<i>Rheocricotopus</i>	200
		<i>Baetis</i>	4104			<i>Rheotanytarsus</i>	474
		Ephemerellidae	<i>Drunella</i>			345	<i>Thienameniella</i>
	<i>Ephemerella</i>		1746			<i>Trichotanypus</i>	2
	Heptageniidae	<i>Serratella</i>	14			<i>Trissopelopia</i>	9
		<i>Cinygmula</i>	4261			<i>Tvetenia</i>	135
		<i>Epeorus</i>	511			<i>Stempellina</i>	6
		<i>Rhithrogena</i>	21			Dixidae	<i>Dixa</i>
	Plecoptera	Capniidae	<i>Capnia</i>				1182
Chloroperlidae		<i>Paraperla</i>	29	Empididae	<i>Chelifera</i>	763	
		<i>Plumiperla</i>	105		<i>Oreogeton</i>	2	
		<i>Suwallia</i>	2281		Limoniidae	<i>Limnophila</i>	17
Nemouridae		<i>Nemoura</i>	312	<i>Rhabdomastix</i>		13	
		<i>Podmosta</i>	175	Psychodidae	<i>Pericoma</i>	205	
		<i>Zapada</i>	3871		Simuliidae	<i>Gymnopais</i>	397
Perlodidae		<i>Arcynopteryx</i>	54	<i>Metacnephia</i>		970	
		<i>Isoperla</i>	661	<i>Prosimulium</i>	6108		
Trichoptera		Apataniidae	<i>Apatania</i>	1349	<i>Simulium</i>	5572	
	Brachycentridae	<i>Brachycentrus</i>	269	<i>Stegopterna</i>	9		
	Glossosomatidae	<i>Glossosoma</i>	13	Tipulidae	<i>Dicranota</i>	168	
	Hydroptilidae	<i>Hydroptila</i>	26		<i>Tipula</i>	22	
		<i>Stactobiella</i>	2	Dolichopodidae		16	
	Limnephilidae	<i>Dicosmoecus</i>	46		Acariformes	Hydrachnidae	1696
		<i>Ecclisiomyia</i>	313		251		
		<i>Hydatophylax</i>	54	Amphipoda		3	
	<i>Psychoglypha</i>	43	Cladocera		3		
	Rhyacophilidae	<i>Rhyacophila</i>	34	Coleoptera	Dytiscidae	<i>Colymbytes</i>	3
Diptera	Ceratopogonidae				20		
	Chironomidae ²		5	<i>Laccophilus</i>	1		
		21884	<i>Oreodytes</i>	9			
<i>Corynoneura</i>		9	Collembola		106		
<i>Diamesa</i>		425	Copepoda		5		
<i>Diplocladius</i>		5	Gastropoda	Physidae	<i>Physa</i>	2	
<i>Eukieferiella</i>		8255		Valvatidae	<i>Valvata</i>	1	
<i>Limnophyes</i>		3	Oligochaeta		3067		
<i>Micropsectra</i>		1052	Ostracoda		14		
<i>Orthocladius</i>		6562	Turbellaria		74		
<i>Pagastia</i>		5898	Grand Total		93202		
<i>Paraphaenocladius</i>		24					
<i>Parorthocladius</i>		437					
<i>Pseudodiamesa</i>		15	Grand Total		93202		

1) Total abundance is shown for all sites and years of study.

2) Chironomidae were identified to genus in 2009 and 2010 only.

Table 3.1-2
Macroinvertebrate Bioassessment Summary Statistics within the Crooked Creek Drainage (2004-2012)

Site n years n reps	DO1	FL1	DM1	QZ1	SN2	QU1	CR2	CR1	CR0.7	CR0.3	AM1	AM2	GR1	OM1	AN1	AN2	CV1	EG1	GM1	GM2	GM3	GM4	BL1	
	9	6	2	1	5	1	9	9	7	5	6	1	1	1	4	4	4	1	3	1	1	1	2	
	45	28	10	5	25	3	45	45	35	25	30	3	5	5	20	20	20	5	13	5	5	5	10	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
General Metrics ¹																								
Abundance(# / ft ²)	244.3	181.3	498.8	290.9	155.8	116.0	259.2	--	89.1	38.0	435.3	--	212.4	190.1	229.9	169.6	262.7	196.1	377.9	272.2	175.5	110.1	587.0	--
# Taxa	20.2	4.1	20.0	1.7	16.5	2.1	15.0	--	14.2	4.4	13.0	--	19.8	4.2	19.4	3.6	20.1	3.7	19.8	2.9	17.7	2.7	21.0	--
# EPT Taxa	11.8	2.0	11.5	1.2	8.5	2.1	6.0	--	7.6	1.5	4.0	--	11.3	1.9	10.7	2.9	11.1	1.6	11.2	2.5	9.2	1.6	7.0	--
% EPT Taxa	30.7	12.4	20.6	7.0	57.6	15.2	51.7	--	27.6	8.9	59.0	--	34.8	12.9	35.6	8.3	28.6	8.2	27.2	7.4	35.8	14.7	14.8	--
% Dominant Taxon	54.7	19.1	56.4	18.0	30.7	13.9	45.4	--	52.9	2.6	25.1	--	39.1	10.4	41.7	12.3	58.0	14.7	52.7	9.5	43.1	16.3	69.0	--
% Chironomidae	54.7	19.1	54.1	21.6	14.5	1.7	42.3	--	47.9	11.5	14.2	--	32.3	13.9	38.8	15.3	58.0	14.7	52.7	9.5	35.5	20.8	8.1	--
EPT/Chironomidae Ratio	0.7	0.6	0.5	0.4	3.9	0.6	1.2	--	0.6	0.1	4.1	--	1.7	1.7	1.1	0.6	0.6	0.3	0.5	0.2	1.4	0.9	1.8	--
Diversity Indices																								
Shannon (H)	1.68	0.5	1.50	0.4	2.02	0.2	1.21	--	1.55	0.1	1.75	--	1.95	0.2	1.82	0.3	1.56	0.4	1.75	0.2	1.69	0.3	1.30	--
Evenness (e)	0.57	0.2	0.50	0.1	0.72	0.0	0.45	--	0.60	0.1	0.68	--	0.66	0.1	0.62	0.1	0.52	0.1	0.59	0.1	0.59	0.1	0.43	--
Biotic Indices																								
HBI	4.83	0.4	5.03	0.4	3.28	0.5	3.41	--	4.60	0.3	3.93	--	4.59	0.4	4.73	0.3	4.95	0.3	4.88	0.4	4.28	0.6	3.34	--
% Composition Per Order																								
Ephemeroptera	20.5	10.1	10.1	6.5	28.3	3.7	0.8	--	12.8	3.4	24.0	--	22.6	9.5	25.6	8.6	17.5	8.8	14.8	5.9	27.7	14.0	8.2	--
Plecoptera	8.5	3.5	9.2	5.0	29.1	18.9	50.8	--	14.0	5.8	35.0	--	10.5	7.4	7.5	6.0	7.5	3.4	8.9	6.6	7.4	3.0	6.0	--
Trichoptera	1.7	1.9	1.3	1.0	0.3	0.0	--	--	0.8	0.6	--	--	1.6	1.9	2.5	3.1	3.3	3.0	3.6	3.0	0.7	1.0	0.5	--
Diptera	62.7	16.1	74.6	8.4	32.1	11.0	43.2	--	55.7	12.4	39.5	--	57.6	13.1	59.9	7.4	67.5	7.9	63.8	11.4	48.0	25.4	80.9	--
Oligochaeta	3.1	6.1	1.2	0.9	9.1	5.6	3.5	--	16.6	21.0	1.2	--	3.5	3.6	1.6	1.1	1.8	1.7	6.7	7.0	15.7	15.6	3.1	--
Acariformes	3.5	4.2	3.6	2.9	0.0	0.1	--	--	0.0	0.1	0.1	--	3.2	3.5	2.0	3.4	2.2	2.2	2.3	1.8	0.4	0.3	0.2	--
Amphipoda	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.2	--	
Cladocera	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Coleoptera	0.0	0.0	--	--	--	--	--	--	--	--	--	--	0.4	1.1	0.4	1.1	0.1	0.1	--	--	0.0	0.1	--	
Collembola	0.0	0.0	0.0	0.0	0.1	0.1	0.2	--	0.1	0.1	--	--	0.5	1.3	0.4	0.7	0.1	0.2	--	--	0.0	0.1	--	
Copepoda	--	--	--	--	--	--	--	--	--	--	--	--	0.1	0.4	0.0	0.0	--	--	--	--	--	0.1	--	
Gastropoda	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
Ostracoda	0.0	0.0	--	--	--	--	--	--	--	--	--	--	0.1	0.3	--	--	0.0	0.0	0.0	0.0	--	--	--	
Turbellaria	--	--	--	--	1.1	1.2	1.3	--	0.0	0.1	0.2	--	--	--	--	--	0.0	0.1	0.7	--	--	0.7	--	

Notes:
For sample site locations, refer to Figure 1.1-1. Chironomidae genera grouped as one taxon for multi-year comparisons.
1) Refer to the text for definitions of metrics.
n years = Number of years site has been sampled
n reps = Total number of replicates sampled
Mean = Average of all samples for all years
SD = Standard deviation of the mean. SD not calculated for sites with only one year of data.

Table 3.1-3

Metal Concentrations in Mayflies and Stoneflies for Sites within the Crooked Creek Drainage (2011)

Order	Component	Detection Limit AVG (Range)	Metal Concentrations per Site (mg/kg Wet Weight)				Average
			DO1	CR2	CR1	CR0.7	
Mayflies	Solids, Total		1.32	18.6	18.6	2.4	10.23
	Aluminum	0.0305 (0.004 - 0.056)	82.2	566	550	95.4	323.4
	Antimony	0.000205 (0.00003 - 0.00037)	0.00067	0.0144	0.0081	0.0016	0.006193
	Arsenic	0.00205 (0.0003 - 0.0037)	0.0541	1.54	0.97	0.126	0.672525
	Cadmium	0.000205 (0.00003 - 0.00037)	0.016	0.238	0.244	0.0228	0.1302
	Chromium	0.00825 (0.001 - 0.015)	0.12	0.777	0.679	0.145	0.43025
	Copper	0.00205 (0.0003 - 0.0037)	0.198	2.91	2.59	0.484	1.5455
	Iron	0.04075 (0.005 - 0.074)	93.6	727	546	105	367.9
	Lead	0.00005 (0.00001 - 0.00009)	0.02311	0.17558	0.15158	0.03817	0.09711
	Manganese	0.00305 (0.0004 - 0.0056)	11.4	91.7	109	11.5	55.9
	Mercury	0.00006 (0.00001 - 0.00011)	0.00084	0.0157	0.00715	0.00105	0.006185
	Selenium	0.0305 (0.004 - 0.056)	0.041	0.979	0.721	0.085	0.4565
	Zinc	0.006 (0.001 - 0.011)	1.39	22.3	14.8	2.36	10.2125
Average Mayflies			14.6	110.2	95.7	16.7	59.3
Stoneflies	Solids, Total		1.62	13.7	13.5	0.77	7.3975
	Aluminum	0.0235 (0.005 - 0.041)	206	528	288	21.6	260.9
	Antimony	0.000155 (0.00003 - 0.00027)	0.0035	0.016	0.0097	0.00064	0.00746
	Arsenic	0.00155 (0.0003 - 0.0027)	0.242	1.22	0.583	0.036	0.52025
	Cadmium	0.000155 (0.00003 - 0.00027)	0.0055	0.0378	0.0237	0.0026	0.0174
	Chromium	0.00625 (0.001 - 0.011)	0.325	0.755	0.453	0.035	0.392
	Copper	0.00155 (0.0003 - 0.0027)	0.308	2.58	2.63	0.18	1.4245
	Iron	0.0315 (0.006 - 0.055)	366	593	425	25	352.25
	Lead	0.00004 (0.00001 - 0.00007)	0.08481	0.18678	0.10175	0.0294	0.100685
	Manganese	0.00235 (0.0005 - 0.0041)	48.7	38.7	17	2.07	26.6175
	Mercury	0.0000475 (0.00001 - 0.00008)	0.00147	0.0162	0.00867	0.00043	0.006693
	Selenium	0.0235 (0.005 - 0.041)	0.017	0.393	0.285	0.02	0.17875
	Zinc	0.00475 (0.001 - 0.008)	1.38	17.2	17	0.758	9.0845
Average Stoneflies			48.1	92.0	58.8	3.9	50.7
Average Total			31.3	101.1	77.2	10.3	55.0

Notes:

Samples collected on July 18, 2011. Refer to Figure 1.1-1 for sampling site locations.

Samples were collected with a variety of methods including kick nets and surber samplers.

Method detection limits are shown as an average for all sites followed by a range for all sites.

Wet weight to dry weight conversion for Mayflies is 0.239.

Wet weight to dry weight conversion for Stoneflies is 0.198.

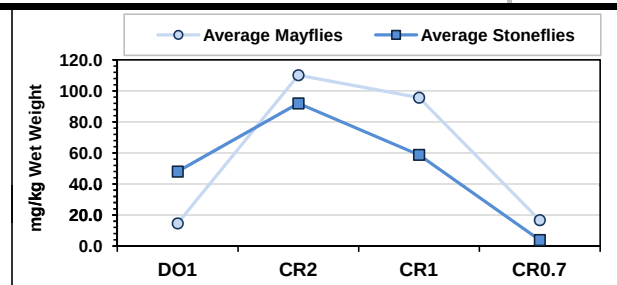


Table 3.2-1

Fish Species Identified within the Crooked Creek Drainage (2004-2012)

Fish Species			Drainage																		
			Donlin Creek	Flat Creek	Dome Creek	Quartz Gulch	Snow Gulch	Queen Gulch	Crooked Creek	Lewis Gulch	American Creek	Grouse Creek	Omega Gulch	Anaconda Creek	Crevice Creek	Eagle Creek	B Creek	A Creek	Getmuna Creek	Bell Creek	Grand Total
Family	Species	Common Name																			
Salmonidae	<i>Oncorhynchus tshawytscha</i>	Chinook salmon							X										X	X	X
	<i>Oncorhynchus keta</i>	Chum salmon	X						X										X	X	X
	<i>Oncorhynchus kisutch</i>	Coho salmon	X	X	X		X		X		X	X		X ²					X	X	X
	<i>Oncorhynchus gorbuscha</i>	Pink Salmon							X ¹												X
	<i>Oncorhynchus nerka</i>	Sockeye salmon							X										X		X
	<i>Oncorhynchus mykiss</i>	Rainbow trout							X ¹												X
	<i>Salvelinus malma</i>	Dolly Varden		X	X	X		X		X	X		X	X	X	X			X	X	X
	<i>Thymallus arcticus</i>	Arctic grayling		X	X				X		X			X					X	X	X
	<i>Prosopium cylindraceum</i>	Round whitefish		X	X				X										X	X	X
	<i>Coregonus pidschian</i>	Humpback whitefish							X ¹												X
Catostomidae	<i>Catostomus catostomus</i>	Longnose sucker						X												X	
Cottidae	<i>Cottus cognatus</i>	Slimy sculpin	X	X				X		X	X		X	X	X			X	X	X	
Esocidae	<i>Esox lucius</i>	Northern pike						X												X	
Umbridae	<i>Dallia pectoralis</i>	Alaska blackfish						X												X	
Petromyzontidae	<i>Lampetra alaskensis</i>	Alaskan brook lamprey						X												X	
Gadidae	<i>Lota lota</i>	Burbot	X	X				X		X	X		X		X					X	
Gasterosteidae	<i>Pungitius pungitius</i>	Nine-spine stickleback						X											X	X	
Total Species Count			7	6	2	0	2	0	17	0	5	4	0	5	2	3	1	0	8	8	17

Notes:

Includes data from trapping, all electrofishing passes, aerial surveys, and weir counts.

1) Observed at weir site only

2) Only one adult coho salmon has been observed to date. Therefore, site does not meet the ADF&G criteria for anadromous waters.

3) Mouth to endpoint of survey approximately 4.8 km (3 mi) upstream from confluence with Ophir Creek

4) Mouth to terminus at confluence of Flat and Donlin Creeks

REACH # of Years Surveyed (Summer, Fall)		Crooked Creek Drainage																											Crooked Creek Drainage Total	Species RA(%) ²	Est. Water Clarity ³
		Reference Streams				Donlin Tribs		Crooked Creek Mainstem					Crooked Creek Tributaries																		
		DOR3	DOR2	DOR1	FLR1	DMR1	SNR1	CRR5	CRR4	CRR3	CRR2	CRR1	AMR1	GRR1	ANR1	CVR1	EGR1	GMR5	GMR4	GMR3	GMR2	GMR1	FNR1	BLR3	BLR2	BLR1					
		8, 9	9, 9	9, 9	7, 8	2, 5	4, 9	9, 9	9, 8	9, 8	9, 8	9, 8	6, 8	2, 2	6, 8	6, 8	4, 3	2, 2	3, 4	6, 6	6, 6	6, 7	1, 2	2, 2	2, 2	2, 2					
Chinook	2004	0	0	0	0	ns	ns	0	2	4	20	29	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	55		F F/G F G E F F/G P/G		
	2005	ns	0	0	0	ns	ns	6	2	0	6	1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	15					
	2006	0	0	0	0	ns	ns	0	1	1	5	5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	12					
	2007	0	0	0	0	ns	0	0	1	1	2	0	0	ns	0	0	ns	ns	ns	1	4	44	ns	ns	ns	ns	53				
	2008	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	ns	ns	ns	3	0	15	ns	ns	ns	ns	21				
	2009	0	0	0	0	ns	0	0	3	3	6	10	0	ns	0	0	0	ns	0	11	0	29	ns	ns	ns	ns	62				
	2010	0	0	0	ns	ns	ns	0	0	0	0	0	0	ns	0	0	0	ns	ns	2	0	3	ns	ns	ns	ns	5				
	2011	0	0	0	ns	ns	ns	0	0	0	1	5	0	ns	0	0	0	0	0	0	0	10	ns	0	0	0	16				
	2012	0	0	0	0	0	0	0	0	2	1	5	0	0	0	0	0	0	0	0	0	12	0	0	0	0	20				
Mean ¹	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.0	1.2	4.8	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.7	18.8	0.0	0.0	0.0	0.0	36.2	3.2%				
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	5					
Max	0	0	0	0	0	0	6	3	4	20	29	0	0	0	0	0	0	0	11	4	44	0	0	0	0	62					
Chum	2004	0	1	0	0	ns	ns	0	1	3	134	52	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	191		F F/G F/G F G E F F/G P/G		
	2005	ns	4	7	0	ns	ns	7	15	24	178	291	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	526				
	2006	0	0	0	0	ns	ns	0	0	1	146	280	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	427				
	2007	0	0	2	0	ns	0	8	17	21	89	264	0	ns	0	0	ns	ns	ns	8	113	701	ns	ns	ns	ns	1223				
	2008	0	0	0	0	0	0	0	0	1	30	16	0	0	0	0	ns	ns	ns	4	3	28	ns	ns	ns	ns	82				
	2009	0	1	0	0	ns	0	2	10	4	72	77	0	ns	0	0	0	ns	3	50	8	145	ns	ns	ns	ns	372				
	2010	0	0	0	ns	ns	ns	0	2	3	37	66	0	ns	0	0	0	ns	ns	21	0	142	ns	ns	ns	ns	271				
	2011	0	0	0	ns	0	ns	0	0	4	177																				

Aerial flight dates for Chinook, chum, and sockeye salmon: July 25, 2004; July 23, 2005; July 19–20, 2006; July 24–28, 2007; July 23–25, 2008; July 19–22, 2009; July 24–25, 2010; July 21–22, 2011; and July 20–24, 2012. Aerial flight dates for coho salmon: September 23–24, 2004; September 26–27, 2005; September 19–20, 2006; September 11–13, 2007; September 18–20, 2008; September 13–15, 2009; September 17–18, 2010; September 15–18, 2011; and September 19–24, 2012.

Daily Salmon Escapement at the Crooked Creek Weir (2008-2012)

Notes:

Boxed area = the second and third quartile passage dates.

Shaded area denotes a period when the weir was inoperable or partially operable and fish passage was estimated using the Proportion Method from ADF&G report, Tatlawiksuk River Salmon Studies, 2010 (Fishery Data Series no. 07-56).

Shaded area denotes a period when the weir was inoperable or partially operable and fish passage was estimated using the Single Day Method from ADF&G report. Tatlawiksuk River Salmon Studies, 2010 (Fishery Data Series no. 07-56)

Shaded area denotes a period when the weir was inoperable or partially operable and fish passage was estimated using the Linear Method from ADF&G report, Tatlawiksuk River Salmon Studies, 2010 (Fishery Data Series no. 07-56).

% =Cumulative Proportion of the total run

Table 3.2-4
Summary of Electrofishing Results by Site within the Crooked Creek Drainage (2004-2012)

				Average # Fish Captured ¹ (#/300 ft)																								
Streams	Site	n (years)	# Species	Chinook salmon (Juvenile)		Coho salmon (Juvenile)		Sockeye salmon (Juvenile)		Dolly Varden		Arctic grayling		Round whitefish		Longnose sucker		Slimy sculpin		Alaska blackfish		Alaskan brook lamprey		Burbot		Nine-spine stickleback		Total
				Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
Donlin Creek	DO1	9	6	--		36.3	(1-182)	--		3.6	(0-6.9)	2.3	(0-6.9)	0.2	(0-1)	--		99.1	(18.7-167.1)	--		--		1.5	(0-3)	--		143.0
Flat Creek	FL1	6	6	--		1.6	(0-3.1)	--		2.1	(0-10.9)	1.0	(0-3.1)	0.3	(0-1.5)	--		129.0	(55.8-225.4)	--		--		2.8	(0-6.2)	--		136.7
Dome Creek	DM1	2	2	--		28.0	(0-56.1)	--		26.8	(22-31.7)	--		--		--		--		--		--		--		--		54.9
Quartz Creek	QZ1	1	0	--		--		--		--		--		--		--		--		--		--		--		--		0.0
Snow Gulch	SN1	1	1	--		--		--		10.8	(10.8-10.8)	--		--		--		--		--		--		--		--		10.8
	SN2	6	1	--		--		--		3.2	(1.2-9.4)	--		--		--		--		--		--		--		--		3.2
Queen Gulch	QU1	1	0	--		--		--		--		--		--		--		--		--		--		--		--		0.0
Crooked Creek	CR2	9	8	2.0	(0-7.6)	18.3	(3-70.1)	--		4.6	(1.5-11.8)	6.1	(0-27.6)	1.3	(0-7.9)	--		165.1	(6.2-274.3)	0.2	(0-2)	--		1.1	(0-3.9)	--		198.7
	CR1	9	8	2.1	(0-10.9)	110.0	(1.6-831.6)	--		0.3	(0-1.6)	5.2	(0-29.5)	1.7	(0-9.1)	--		345.1	(13.7-430.6)	--		--		1.2	(0-4.7)	1.4	(0-3.1)	467.0
	CR0.7	7	10	2.1	(0-8.5)	35.9	(6.4-195.7)	3.6	(0-23.4)	4.9	(0-8.5)	12.5	(0-36.2)	2.1	(0-6.4)	0.3	(0-2.1)	375.4	(42.6-704.3)	0.3	(0-2.1)	--		4.6	(2.1-12.8)	--		441.6
	CR0.3	5	10	5.5	(0-22.7)	11.8	(1.5-45.5)	--		3.0	(0-12.1)	40.3	(10.6-71.2)	5.8	(0-12.1)	7.0	(1.5-15.2)	242.1	(121.2-319.7)	0.3	(0-1.5)	2.7	(1.5-6.1)	4.2	(1.5-7.6)	--		322.7
Lewis Gulch	LE1	1	0	--		--		--		--		--		--		--		--		--		--		--		--		0.0
American Creek	AM1	7	5	--		6.0	(0-18.3)	--		8.2	(2.7-15.5)	0.4	(0-1.8)	--		--		41.0	(3.7-99.7)	--		--		0.3	(0-0.9)	--		55.9
	AM2	1	1	--		--		--		57.0	(57-57)	--		--		--		--		--		--		--		--		57.0
	AM3	1	0	--		--		--		--		--		--		--		--		--		--		--		--		0.0
	AM4	2	0	--		--		--		--		--		--		--		--		--		--		--		--		0.0
Grouse Creek	GR1	1	2	--		--		--		1.4	(1.4-1.4)	--		--		--		36.2	(36.2-36.2)	--		--		--		--		37.7
Omega Gulch	OM1	1	0	--		--		--		--		--		--		--		--		--		--		--		--		0.0
Anaconda Creek	AN1	7	5	--		0.1	(0-1)	--		0.8	(0-3)	0.9	(0-6)	--		--		12.4	(0.9-18)	--		--		1.1	(0-2.7)	--		15.3
	AN2	4	1	--		--		--		3.4	(2-3.9)	--		--		--		--		--		--		--		--		3.4
Crevice Creek	CV1	4	2	--		--		--		0.6	(0-2.2)	--		--		--		42.0	(2.2-134.3)	--		--		--		--		42.5
Eagle Creek	EG1	1	3	--		--		--		0.9	(0.9-0.9)	--		--		--		11.8	(11.8-11.8)	--		--		0.9	(0.9-0.9)	--		13.6
BC Creek	BC1	1	0	--		--		--		(1-1)		--		--		--		--		--		--		--		--		0.0
AC Creek	AC1	1	1	--		--		--		1.0	--	--		--		--		--		--		--		--		--		1.0
Getmuna Creek	GM1	3	7	12.0	(6-21.6)	90.8	(15.6-231.6)	0.8	(0-2.4)	2.4	(0-7.2)	1.2	(0-2.4)	0.4	(0-1.2)	--		410.8	(175.2-536.4)	--		--		--		--		518.4
	GM2	1	4	--		16.0	(1-15)	--		36.0	(36-36)	1.0	(1-1)	--		--		59.0	(59-59)	--		--		--		--		112.0
	GM3	1	3	--		31.0	(2-29)	--		9.0	(9-9)	--		--		--		48.0	(13-35)	--		--		--		--		88.0
	GM4	1	3	--		9.0	(1-8)	--		17.0	(17-17)	--		--		--		31.0	(31-31)	--		--		--		--		57.0
Bell Creek	BL1	2	7	1.0	(1-1)	6.0	(1-8)	--		3.0	(3-3)	3.0	(1-5)	3.0	(3-3)	--		99.0	(44-154)	--		--		--		2.0	(2-2)	117.0
Totals		12		24.7		400.8		4.4		200.1		73.9		14.7		7.3		2147.0		0.8		2.7		17.8		3.4		2,897.6

Notes:

Refer to Figure 1.1-1 for site locations.

Any adult salmon observed in electrofishing reaches were not shocked and were allowed to pass or avoided. Adult salmon are not included in the above counts.

1) #/300 ft = number of fish per 300 feet. Only one pass was allowed in 2005 & 2006; therefore, one pass minimum population was used in each year in this table to enable comparison between years.

2) A total of 17 species have been found in Crooked Creek: northern pike, chum salmon, pink salmon, humpback whitefish and rainbow trout were documented with other methods including aerial surveys and weir video.

Range = minimum to maximum number of fish captured across all years that the site was sampled

Table 3.2-5

The Accuracy of Aerial Surveys for Crooked Creek (2008-2012)

a. The Accuracy of Aerial Surveys Compared to Observed Fish Weir Counts

Species	2004			2005			2006			2007			2008			2009			2010			2011			2012		
	Weir ¹	Aerial ⁴	% Accuracy	Weir ¹	Aerial ⁴	% Accuracy	Weir ¹	Aerial ⁴	% Accuracy	Weir ¹	Aerial ⁴	% Accuracy	Weir ²	Aerial ⁴	% Accuracy	Weir	Aerial ⁵	% Accuracy	Weir	Aerial ⁴	% Accuracy	Weir ³	Aerial	% Accuracy	Weir ⁶	Aerial	% Accuracy
Chinook salmon	na	55	na	na	15	na	na	12	na	na	53	na	0	21	0.0%	61	60	98.4%	33	5	15.2%	18	16	88.9%	17	20	117.6%
Chum salmon	na	191	na	na	526	na	na	427	na	na	1223	na	0	82	0.0%	544	372	68.4%	552	271	49.1%	1673	825	49.3%	341	312	91.5%
Coho salmon	na	311	na	na	3	na	na	83	na	na	132	na	2430	427	17.6%	791	434	54.9%	666	415	62.3%	385	1064	276.4%	165	56	33.9%
TOTALS	0	557	0	0	544	0	0	522	0	0	1408	0	2430	530	21.8%	1396	866	62.0%	1251	691	55.2%	2076	1905	91.8%	523	388	74.2%

b. The Accuracy of Aerial Surveys Compared to Observed and Modeled Fish Weir Counts⁷

Chinook salmon	na	55	na	na	15	na	na	12	na	na	53	na	62	21	33.9%	61	60	98.4%	33	5	15.2%	18	16	88.9%	21	20	95.2%
Chum salmon	na	191	na	na	526	na	na	427	na	na	1223	na	821	82	10.0%	544	372	68.4%	552	271	49.1%	2161	825	38.2%	446	312	70.0%
Coho salmon	na	311	na	na	3	na	na	83	na	na	132	na	4204	427	10.2%	1295	434	33.5%	1212	415	34.2%	591	1064	180.0%	868	56	6.5%
TOTALS	0	557	0	0	544	0	0	522	0	0	1408	0	5087	530	10.4%	1900	866	45.6%	1797	691	38.5%	2770	1905	68.8%	1335	388	29.1%

c. Differences Between Accuracies Based on Modeled and Actual Fish Weir Counts

Chinook salmon	na	na	na	na	-33.9%	0.0%	0.0%	0.0%	22.4%
Chum salmon	na	na	na	na	-10.0%	0.0%	0.0%	11.1%	21.5%
Coho salmon	na	na	na	na	7.4%	21.4%	28.1%	96.3%	27.5%
TOTALS					11.4%	16.5%	16.8%	23.0%	45.1%

Notes:

The operational periods of the Crooked Creek weir were from 7/28/2008 to 9/29/2008, 6/3/2009 to 9/28/2009, 6/17/2010 to 9/27/2010, 6/27/2011 to 9/27/2011 and 6/27/2012 to 9/28/2012.

Aerial surveys in Crooked Creek began on 7/25/2004, 7/23/2005, 7/19/2006, 7/26/2007, 7/23/2008, 7/19/2009, 7/24/2010, 7/21/2011, and 7/20/2012 for the chinook and chum salmon runs and on 9/23/2004, 9/26/2005, 9/20/2006, 9/11/2007, 9/19/2008, 9/13/2009, 9/17/2010, 9/15/2011, and 9/19/2012 for the coho salmon run.

To allow for comparison, weir counts shown in this table reflect only those salmon that passed the weir on a date equal to or prior to the date of the aerial survey for a given year. Shaded areas denote (a) incomplete weir counts that were (b) estimated using modeled data based on ADFG methods.

Weir = weir count; Aerial = aerial survey count; % Accuracy = (aerial count)/(weir count) x 100

1) Crooked Creek weir counts not available for 2004-2007.

2) Crooked Creek weir not operational until after the chinook and chum salmon aerial flights had been conducted. Weir was partially operational during the coho salmon run on 9/8/2008 and from 9/10/2008 to 9/20/2008, 9/22/2008 to 9/28/2008.

3) The Crooked Creek weir was not operational from 7/18/2011 to 8/6/2011. Weir was overtopped by high flows from 8/3/2011 to 8/26/2011.

4) Prior to 2011, aerial counts for Crooked Creek did not include Bell Creek.

5) Two chinook salmon were documented downstream of weir during the aerial survey, and therefore were removed from the aerial count for comparison purposes.

6) Crooked Creek weir not operational from 6/30 - 7/1, 7/7 - 7/8, 7/14 - 7/15 and 7/21 - 7/22, 2012. Weir was overtopped by high flows from 9/5 - 9/12 and 9/16 - 9/28, 2012.

7) Weir counts in 2008, 2011, and 2012 incorporate modeled fish passage data during fully and partially inoperable weir dates.

Table 3.2-6 (Page 1 of 2)

Summary of Electrofishing Results by Site and Year within the Crooked Creek Drainage (2004-2012)

		Fish Captured ¹ (#/300 ft)												
		Chinook salmon (juvenile)	Coho salmon (juvenile)	Sockeye salmon (juvenile)	Dolly Varden	Arctic grayling	Round whitefish	Longnose sucker	Slimy sculpin	Alaska blackfish	Alaskan brook lamprey	Burbot	Nine-spine stickleback	Grand Total
DO1	2004	--	85.6	--	--	1.0	--	--	69.8	--	--	3.0	--	159.3
	2005	--	15.7	--	--	--	--	--	144.5	--	--	2.9	--	163.2
	2006	--	13.8	--	5.9	--	--	--	100.3	--	--	2.0	--	121.9
	2007	--	2.0	--	3.9	2.0	--	--	34.4	--	--	2.9	--	45.2
	2008	--	16.7	--	3.9	4.9	--	--	167.1	--	--	1.0	--	193.7
	2009	--	182.0	--	6.9	3.0	--	--	121.0	--	--	--	--	312.8
	2010	--	5.9	--	3.9	6.9	1.0	--	144.6	--	--	--	--	162.3
	2011	--	--	--	5.9	3.0	1.0	--	66.9	--	--	1.0	--	77.7
	2012	--	4.9	--	2.0	--	--	--	43.3	--	--	1.0	--	51.1
	Mean	--	36.3	--	3.6	2.3	0.2	--	99.1	--	--	1.5	--	143.0
SD	--	60.6	--	2.5	2.4	0.5	--	56.4	--	--	1.1	--	83.0	
FL1	2004	--	3.1	--	--	--	--	--	55.8	--	--	6.2	--	65.1
	2005	--	1.5	--	--	1.5	1.5	--	114.7	--	--	4.6	--	124.0
	2006	--	--	--	--	--	--	--	136.4	--	--	--	--	136.4
	2007	--	1.5	--	--	--	--	--	106.9	--	--	1.5	--	110.0
	2008	--	1.5	--	1.5	3.1	--	--	134.5	--	--	1.5	--	142.3
	2009	--	1.6	--	10.9	1.6	--	--	225.4	--	--	3.1	--	242.5
	Mean	--	1.6	--	2.1	1.0	0.3	--	129.0	--	--	2.8	--	136.7
	SD	--	1.0	--	4.4	1.3	0.6	--	55.5	--	--	2.3	--	58.7
DM1	2008	--	--	--	22.0	--	--	--	--	--	--	--	--	22.0
	2009	--	56.1	--	31.7	--	--	--	--	--	--	--	--	87.8
	Mean	--	28.0	--	26.8	--	--	--	--	--	--	--	--	54.9
SD	--	39.7	--	6.9	--	--	--	--	--	--	--	--	46.6	
QZ1	2009	--	--	--	--	--	--	--	--	--	--	--	--	--
SN1	2006	--	--	--	10.8	--	--	--	--	--	--	--	--	10.8
SN2	2006	--	--	--	9.4	--	--	--	--	--	--	--	--	9.4
	2007	--	--	--	2.7	--	--	--	--	--	--	--	--	2.7
	2008	--	--	--	1.2	--	--	--	--	--	--	--	--	1.2
	2009	--	--	--	2.4	--	--	--	--	--	--	--	--	2.4
	2011	--	--	--	1.2	--	--	--	--	--	--	--	--	1.2
	2012	--	--	--	2.4	--	--	--	--	--	--	--	--	2.4
	Mean	--	--	--	3.2	--	--	--	--	--	--	--	--	3.2
	SD	--	--	--	3.1	--	--	--	--	--	--	--	--	3.1
QU1	2010	--	--	--	--	--	--	--	--	--	--	--	--	
CR2	2004	3.0	70.1	--	1.5	3.0	1.5	--	187.5	--	--	1.5	--	268.2
	2005	--	62.5	--	7.6	--	--	--	117.3	--	--	--	--	187.5
	2006	7.6	3.0	--	7.6	--	--	--	99.1	--	--	--	--	117.3
	2007	--	3.0	--	3.0	--	--	--	173.7	--	--	--	--	179.8
	2008	1.5	9.1	--	1.5	10.7	--	--	56.4	--	--	1.5	--	80.8
	2009	5.9	5.9	--	11.8	5.9	2.0	--	232.9	--	--	--	--	264.5
	2010	--	5.9	--	5.9	27.6	--	--	274.3	--	--	--	--	313.8
	2011	--	--	--	2.0	7.9	7.9	--	254.6	2.0	--	3.9	--	278.3
	2012	--	4.7	--	--	--	--	--	90.2	--	--	3.1	--	97.9
	Mean	2.0	18.3	--	4.6	6.1	1.3	--	165.1	0.2	--	1.1	--	198.7
	SD	3.2	28.4	--	3.7	8.8	2.9	--	93.3	0.7	--	1.6	--	86.5
	CR1	2004	--	43.5	--	--	--	--	--	228.5	--	--	--	1.6
2005		--	12.4	--	--	--	--	--	248.7	--	--	--	3.1	264.2
2006		4.7	6.2	--	--	29.5	--	--	399.5	--	--	3.1	3.1	446.1
2007		--	4.7	--	--	1.6	--	--	267.4	--	--	3.1	3.1	279.8
2008		3.1	10.9	--	1.6	3.1	1.6	--	416.6	--	--	4.7	1.6	443.0
2009		--	831.6	--	--	--	--	--	416.6	--	--	--	--	1248.2
2010		10.9	9.3	--	--	12.4	3.1	--	430.6	--	--	--	--	466.3
2011		--	1.6	--	1.6	--	1.6	--	632.6	--	--	--	--	637.3
2012		--	70.1	--	--	--	9.1	--	65.5	--	--	--	--	144.7
Mean		2.1	110.0	--	0.3	5.2	1.7	--	345.1	--	--	1.2	1.4	467.0
SD		4.1	258.3	--	0.8	11.0	3.0	--	147.1	--	--	2.1	1.3	327.4
CR0.7		2006	4.3	6.4	--	4.3	2.1	--	2.1	391.5	--	--	8.5	--
	2007	--	8.5	--	4.3	--	2.1	--	208.5	--	--	12.8	--	236.2
	2008	2.1	12.8	--	4.3	4.3	--	--	221.3	--	--	4.3	--	248.9
	2009	8.5	195.7	2.1	--	12.8	2.1	--	325.5	--	--	4.3	--	551.1
	2010	--	14.9	23.4	8.5	27.7	6.4	--	704.3	2.1	--	--	--	787.2
	2011	--	--	--	8.5	36.2	2.1	--	634.0	--	--	2.1	--	683.0
	2012	--	12.8	--	4.3	4.3	2.1	--	142.6	--	--	--	--	166.0
	Mean	2.1	35.9	3.6	4.9	12.5	2.1	0.3	375.4	0.3	--	4.6	--	441.6
SD	3.6	75.5	9.4	2.9	14.1	2.1	1.1	191.5	1.0	--	4.3	--	240.0	
CR0.3	2006	3.0	3.0	--	1.5	10.6	--	10.6	284.8	--	1.5	1.5	--	316.7
	2007	22.7	7.6	--	--	63.6	6.1	4.5	121.2	--	4.5	6.1	--	236.4
	2008	1.5	1.5	--	--	37.9	9.1	15.2	257.6	--	1.5	7.6	--	331.8
	2009	--	1.5	--	1.5	18.2	12.1	3.0	227.3	1.5	6.1	6.1	--	277.3
	2010	--	45.5	--	12.1	71.2	1.5	1.5	319.7	--	--	--	--	451.5
	Mean	5.5	11.8	--	3.0	40.3	5.8	7.0	242.1	0.3	2.7	4.2	--	322.7
	SD	10.7	19.0	--	5.1	26.8	5.1	5.7	75.7	0.8	2.3	2.6	--	81.0

Table 3.2-6 (Page 2 of 2)

Summary of Electrofishing Results by Site and Year within the Crooked Creek Drainage (2004-2012)

Site	Year	Fish Captured ¹ (#/300 ft)												Grand Total
		Chinook salmon (juvenile)	Coho salmon (juvenile)	Sockeye salmon (juvenile)	Dolly Varden	Arctic grayling	Round whitefish	Longnose sucker	Slimy sculpin	Alaska blackfish	Alaskan brook lamprey	Burbot	Nine-spine stickleback	
LE1	2009	--	--	--	--	--	--	--	--	--	--	--	--	--
AM1	2004	--	--	--	2.7	--	--	--	11.0	--	--	0.9	--	14.6
	2005	--	3.7	--	11.0	--	--	--	99.7	--	--	--	--	114.3
	2006	--	18.3	--	6.4	--	--	--	75.9	--	--	--	--	100.6
	2007	--	--	--	7.3	0.9	--	--	3.7	--	--	--	--	11.9
	2008	--	2.7	--	15.5	1.8	--	--	6.4	--	--	--	--	26.5
	2009	--	17.4	--	11.9	--	--	--	82.3	--	--	0.9	--	112.5
	2011	--	--	--	2.7	--	--	--	8.2	--	--	--	--	11.0
	Mean	--	6.0	--	8.2	0.4	--	--	41.0	--	--	0.3	--	55.9
	SD	--	8.5	--	4.8	0.8	--	--	42.7	--	--	0.5	--	50.2
AM2	2010	--	--	--	57.0	--	--	--	--	--	--	--	--	57.0
AM3 ²	2011	--	--	--	--	--	--	--	--	--	--	--	--	--
AM4 ²	2011	--	--	--	--	--	--	--	--	--	--	--	--	--
GR1	2008	--	--	--	1.4	--	--	--	36.2	--	--	--	--	37.7
OM1	2009	--	--	--	--	--	--	--	--	--	--	--	--	--
AN1	2004	--	--	--	0.9	--	--	--	0.9	--	--	--	--	1.8
	2005	--	--	--	1.8	--	--	--	8.2	--	--	0.9	--	11.0
	2006	--	--	--	--	--	--	--	16.5	--	--	2.7	--	19.2
	2007	--	--	--	--	--	--	--	13.0	--	--	1.0	--	14.0
	2008	--	--	--	3.0	--	--	--	3.0	--	--	--	--	6.0
	2009	--	--	--	--	--	--	--	18.0	--	--	1.0	--	19.0
	2011	--	1.0	--	--	6.0	--	--	27.0	--	--	2.0	--	36.0
	Mean	--	0.1	--	0.8	0.9	--	--	12.4	--	--	1.1	--	15.3
	SD	--	0.4	--	1.2	2.3	--	--	6.6	--	--	0.8	--	11.1
AN2	2006	--	--	--	3.9	--	--	--	--	--	--	--	--	3.9
	2007	--	--	--	2.0	--	--	--	--	--	--	--	--	2.0
	2008	--	--	--	3.9	--	--	--	--	--	--	--	--	3.9
	2009	--	--	--	3.9	--	--	--	--	--	--	--	--	3.9
	Mean	--	--	--	3.4	--	--	--	--	--	--	--	--	3.4
	SD	--	--	--	1.0	--	--	--	--	--	--	--	--	1.0
CV1	2006	--	--	--	--	--	--	--	134.3	--	--	--	--	134.3
	2007	--	--	--	--	--	--	--	4.5	--	--	--	--	4.5
	2008	--	--	--	--	--	--	--	2.2	--	--	--	--	2.2
	2009	--	--	--	2.2	--	--	--	26.9	--	--	--	--	29.1
	Mean	--	--	--	0.6	--	--	--	42.0	--	--	--	--	42.5
	SD	--	--	--	1.1	--	--	--	62.6	--	--	--	--	62.4
EG1	2009	--	--	--	0.9	--	--	--	11.8	--	--	0.9	--	13.6
AC1	2010	--	--	--	--	--	--	--	--	--	--	--	--	0.0
BC1	2010	--	--	--	1.0	--	--	--	--	--	--	--	--	1.0
GM1	2007	8.4	15.6	--	--	--	--	--	175.2	--	--	--	--	199.2
	2008	6.0	25.2	--	--	1.2	1.2	--	520.8	--	--	--	--	554.4
	2009	21.6	231.6	2.4	7.2	2.4	--	--	536.4	--	--	--	--	801.6
	Mean	12.0	90.8	0.8	2.4	1.2	0.4	--	410.8	--	--	--	--	518.4
	SD	8.4	122.0	1.2	4.2	1.2	0.7	--	204.2	--	--	--	--	302.8
GM2 ³	2012	--	16.0	--	36.0	1.0	--	--	59.0	--	--	--	--	112.0
GM3 ³	2012	--	31.0	--	9.0	--	--	--	48.0	--	--	--	--	88.0
GM4 ³	2012	--	9.0	--	17.0	--	--	--	31.0	--	--	--	--	57.0
BL1 ²	2011	1.0	4.0	--	3.0	5.0	3.0	--	154.0	--	--	--	2.0	172.0
	2012	--	8.0	--	--	1.0	--	--	44.0	--	--	--	--	53.0
	Mean	1.0	6.0	--	3.0	3.0	3.0	--	99.0	--	--	--	2.0	117.0
	SD	1.0	3.6	--	3.0	2.8	3.0	--	77.8	--	--	--	2.0	84.1

Notes:

Refer to Figure 1.1-1 for site locations

DO=Donlin Creek; FL=Flat Creek; DM=Dome Creek; QZ=Quartz Creek; SN=Snow Gulch; CR=Crooked Creek; LE=Lewis Gulch; AM=American Creek; GR=Grouse Creek; OM=Omega Gulch; AN=Anaconda Creek; CV=Crevice Creek; EG=Eagle Creek; AC=A Creek; BC=B Creek; GM=Getmuna Creek; BL=Bell Creek

Any adult salmon observed in electrofishing reaches were not shocked and were allowed to pass or avoided; Adult salmon are not included in the above counts

1) #/300 ft = number of fish per 300 feet. Only one pass was allowed in 2005 and 2006. Therefore, to enable comparison between years, one pass minimum population was used in each year in this table

2) Added site in 2011

3) Newly added site in 2012

SD = standard deviation over n (years)

-- = species not found at biomonitoring site that year

Table 3.2-7

Average Weekly Counts of Non-Salmon Species at the Crooked Creek Weir (2008-2012)

Date	Rainbow Trout	Dolly Varden	Arctic Grayling	Round Whitefish	Humpback Whitefish	Longnose Sucker	Slimy Sculpin	Northern Pike	Alaskan Brook Lamprey	Burbot	Grand Total
5/30 - 6/5						1.2					1.2
6/6 - 6/12			0.4	1.4		1.0					2.8
6/13 - 6/19		0.2	0.6	0.8		24.4					26.0
6/20 - 6/26		0.2	1.0	0.2		7.2	0.4				9.0
6/27 - 7/3		0.6	1.0	0.8	0.2	14.4	0.4				17.4
7/4 - 7/10		1.6	0.2	0.6	0.2	50.0	1.0		0.4		54.0
7/11 - 7/17		0.8	0.6	0.8		55.6	0.8				58.6
7/18 - 7/24	0.2	2.2	0.4	0.4		17.0	1.6				21.8
7/25 - 7/31	0.2	2.6		0.4		6.6	1.0				10.8
8/1 - 8/7		3.8	0.2	0.8		10.6	0.4				15.8
8/8 - 8/14	0.2	5.8		0.2		13.2	0.6				20.0
8/15 - 8/21	0.2	5.8	0.2	0.2		6.8					13.2
8/22 - 8/28		2.2	0.4	0.8		5.8	0.2				9.4
8/29 - 9/4	0.2	1.2	0.4	2.6	0.2	3.8	0.2		0.2		8.8
9/5 - 9/11	0.2	1.6	0.2	3.2		6.4					11.6
9/12 - 9/18	0.2	1.4	0.2	2.4		0.8	0.4				5.4
9/19 - 9/25		1.6	0.8	5.2	0.2	1.2		0.2	0.2	0.4	9.8
9/26 - 10/2			0.6	0.4		1.0					2.0
Annual Avg Count	1.4	31.6	7.2	21.2	0.8	227.0	7.0	0.2	0.8	0.4	297.6
Min Length¹ (mm)	432	102	152	127	330	51	51	483	152	432	51
Max Length¹ (mm)	610	686	483	559	483	584	152	483	203	559	686
Avg Length¹ (mm)	457	408	295	319	364	359	69	483	178	546	345
Length Range (mm)	(432-610)	(102-686)	(152-483)	(127-559)	(330-483)	(51-584)	(51-152)	(483-483)	(152-203)	(533-559)	(51-686)

Notes:

See Table 3.2-3 for weir operational periods.

Weekly counts include all observations regardless of direction of travel. Totals should not be considered an escapement. Individuals of all species may be small enough to move between the weir pickets.

1) Length measurements were estimated as described in the methods.

Table 3.3-1

Average Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004-2012)

Average Metal Concentrations in Smelter Soils (mg/kg Wet Weight) (2004 - 2012)													
Site ID	Year	n	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Se	Zn
DO1	2004	6	131	0.18	0.019	0.30	0.73	185	0.047	23.58	0.023	1.00	21.8
	2005	6	115	0.18	0.019	0.47	0.88	131	0.026	23.15	0.032	0.84	19.3
	2006	9	94	0.25	0.023	0.12	0.84	108	0.024	14.90	0.038	0.72	26.9
	2007	15	68	0.17	0.018	0.12	0.69	89	0.023	14.90	0.034	0.93	21.1
	2008	15	83	0.17	0.018	0.20	0.62	104	0.026	14.55	0.038	0.68	20.5
	2009	15	46	0.12	0.010	0.06	0.49	58	0.012	23.03	0.027	0.62	15.4
	2010	15	86	0.14	0.014	0.21	0.67	81	0.038	11.79	0.029	0.88	20.9
	2011	15	70	0.13	0.014	0.16	0.52	85	0.027	12.19	0.025	0.72	17.5
	2012	15	34	0.12	0.015	0.97	0.84	63	0.041	11.76	0.025	1.22	19.9
	Grand Mean		81	0.16	0.017	0.29	0.70	100	0.029	16.65	0.030	0.85	20.4
	SD		31	0.04	0.004	0.28	0.14	39	0.011	5.11	0.006	0.19	3.2
	CV		0.38	0.25	0.22	0.97	0.20	0.39	0.37	0.31	0.19	0.22	0.16
Detectable change		115%	74%	67%	290%	60%	116%	112%	92%	56%	66%	47%	
CR2	2004	6	64	0.48	0.015	0.24	0.65	82	0.021	10.98	0.032	1.08	20.5
	2005	6	92	0.61	0.019	0.35	0.87	120	0.025	19.98	0.045	0.87	18.2
	2006	3	116	0.56	0.025	0.10	0.90	127	0.029	12.10	0.045	0.90	27.5
	2007	15	80	0.45	0.016	0.21	0.74	102	0.028	10.69	0.042	1.27	21.7
	2008	15	44	0.45	0.014	0.17	0.63	77	0.014	7.16	0.048	0.95	22.0
	2009	15	36	0.31	0.013	0.04	0.61	59	0.012	8.80	0.032	1.12	18.0
	2010	15	103	0.46	0.013	0.58	0.62	128	0.041	11.03	0.040	0.87	17.0
	2011	15	143	0.66	0.016	0.52	0.65	258	0.048	13.21	0.042	0.65	17.9
	2012	15	40	0.34	0.015	0.76	0.98	84	0.016	9.77	0.042	1.10	21.3
	Grand Mean		80	0.48	0.016	0.33	0.74	115	0.026	11.52	0.041	0.98	20.5
	SD		37	0.12	0.004	0.24	0.14	59	0.012	3.63	0.005	0.18	3.2
	CV		0.47	0.24	0.23	0.74	0.19	0.51	0.47	0.32	0.13	0.19	0.16
Detectable change		140%	72%	69%	221%	58%	153%	142%	95%	40%	57%	48%	
CR1	2004	15	54	0.29	0.016	0.15	0.62	66	0.019	11.96	0.029	1.05	18.3
	2005	15	82	0.31	0.025	0.36	1.16	100	0.025	15.65	0.033	1.10	19.5
	2006	25	104	0.45	0.026	0.13	0.83	113	0.027	14.95	0.035	0.84	21.4
	2007	15	86	0.31	0.021	0.15	0.65	87	0.026	11.42	0.027	0.86	19.4
	2008	15	50	0.29	0.018	0.16	0.58	69	0.017	9.78	0.041	0.85	21.6
	2009	15	79	0.23	0.012	0.09	0.52	76	0.018	10.66	0.026	0.71	15.5
	2010	15	61	0.23	0.012	0.18	0.53	57	0.022	12.55	0.029	0.62	19.2
	2011	15	97	0.23	0.017	0.17	0.54	89	0.034	10.51	0.026	0.65	18.6
	2012	15	56	0.23	0.016	1.13	1.14	73	0.146	11.98	0.029	0.86	21.2
	Grand Mean		74	0.29	0.018	0.28	0.73	81	0.037	12.16	0.031	0.84	19.4
	SD		20	0.07	0.005	0.33	0.26	18	0.041	1.98	0.005	0.16	1.9
	CV		0.27	0.25	0.28	1.16	0.35	0.22	1.10	0.16	0.16	0.19	0.10
Detectable change		80%	75%	84%	349%	106%	66%	331%	49%	49%	58%	29%	
CR0.7	2006	29	109	0.43	0.032	0.17	0.98	123	0.028	16.74	0.031	1.01	23.2
	2007	15	94	0.30	0.021	0.19	0.70	98	0.027	12.02	0.034	1.03	19.5
	2008	15	42	0.27	0.016	0.14	0.53	52	0.016	10.25	0.038	0.90	19.9
	2009	15	46	0.22	0.013	0.05	0.58	47	0.012	9.07	0.022	0.97	15.5
	2010	15	61	0.21	0.015	0.33	0.56	57	0.028	13.00	0.034	0.67	18.0
	2011	15	70	0.22	0.017	0.11	0.53	75	0.024	9.88	0.031	0.64	17.0
	2012	15	47	0.23	0.021	0.39	0.93	74	0.026	14.22	0.032	1.19	21.1
	Grand Mean		67	0.27	0.019	0.20	0.69	75	0.023	12.17	0.032	0.92	19.2
	SD		26	0.08	0.006	0.12	0.20	27	0.006	2.72	0.005	0.20	2.6
	CV		0.38	0.30	0.33	0.62	0.28	0.36	0.28	0.22	0.16	0.22	0.13
Detectable change		115%	90%	98%	187%	85%	109%	84%	67%	47%	65%	40%	
GM3.0	2012	14	29	0.22	0.012	0.44	1.30	57	0.061	7.77	0.051	1.32	20.6

Notes:

Al=Aluminum, As=Arsenic, Cd=Cadmium, Cr=Chromium, Cu=Copper, Fe=Iron, Pb=Lead, Mn=Manganese, Hg=Mercury, Se=Selenium, Zn=Zinc

Antimony was not detected at the MDL, therefore is not presented here

n = the number of composite samples analyzed per year

Grand Mean = Average of all years sampled; SD=Standard Deviation of the means per year; CV=Coefficient of Variation (SD/Mean); Detectable change=3*SD/Grand Mean

A wet weight to dry weight conversion chart is available in Appendix I. Method detection limits (MDL) for each analyte can be found in Table 2.5-1.

Table 3.3-2

Comparison of Slimy Sculpin <55mm Metals
Concentration within the Crooked Creek Drainage
Between Sites and Years Sampled (2006-2012)

Metal	Symbol	Statistical Differences
Aluminum	Al	Y
Arsenic	As	Y/S
Cadmium	Cd	Y/S
Chromium	Cr	Y
Copper	Cu	Y
Iron	Fe	--
Lead	Pb	--
Manganese	Mn	S
Mercury	Hg	Y/S
Selenium	Se	Y
Zinc	Zn	Y

Notes:

Statistical comparison based on the results of a two-way ANOVA test.

Y: significant statistical differences between years sampled

S: significant statistical differences between sites

Y/S: significant statistical differences between both years and sites

p< 0.05

Table 3.3-3

Mean Mercury (Hg) Concentrations in Young-of-Year (YOY) and Age 1+ Coho and Chinook Salmon within the Crooked Creek Drainage (2004-2007)

Site	Year	Mean Hg (n, SD) (mg/Kg)				Reference
		Coho YOY	Coho 1+	Chinook YOY	Chinook 1+	
DO1	2004	0.013 (4, 0.001)				present study
	2005	0.021 (3, 0.002)	0.042 (6, 0.004)			present study
	2006	0.006 (1, n/a)	0.047 (4, 0.009)			present study
	2007	0.012 (2, 0.003)				present study
CR2	2004	0.017 (5, 0.001)				present study
	2005	0.026 (4, 0.002)	0.056 (2, 0.013)			present study
	2006		0.045 (2, 0.001)	0.016 (1, n/a)		present study
CR1	2004	0.019 (10, 0.003)				present study
	2005	0.018 (1, n/a)		0.028 (6, 0.005)		present study
	2006	0.017 (2, 0.001)		0.021 (2, 0.003)		present study
	2007	0.025 (1, n/a)				present study
CR0.7	2006	0.016 (2, 0.004)		0.018 (2, 0.001)		present study
Innoko NWR	1996		0.04 (5, 0.006)		0.04 (19, 0.004)	Mueller & Matz (2002)
Kuskokwim R. region	unknown		0.07 (10, 0.032)			Gray et al. (1996)

Notes:

SD = Standard deviation of mean for each year. SD not available (n/a) for years with a single sample.

Table 3.3-4

Mean Mercury (Hg) Concentrations in Burbot at Crooked Creek Site CR0.3 (2009)

Site	Year	Habitat	Mean Hg (n, SD) mg/Kg	Total Length (mm)	Reference
CR0.3	2009	river	0.013 (4 , 0.04)	121-300	present study
Alaska statewide	2009	river, lake	0.319 (21 , 0.28)	N/A	Alaska DEC 2009
Yukon River, AK	2002	river	0.130 (13 , 0.26)	565-700	Hinck et al. 2006
Bethel, AK	1997	river	0.100 (3 , 0.01)	N/A	Duffy et al. 1999
Sweden & Norway	1987-1990	river	0.308 (25 , 0.18)	>400	Pulliainen et al. 1992

Notes:

SD = Standard deviation of mean for each year.

Table 3.3-5
Mercury Concentrations in Northern Pike Collected in the Crooked Creek Drainage (2010)

Site ID	Total Length (mm)	Weight ¹ (g)	Species	Mercury (mg/Kg wet weight)	Solids Total (g)	Notes
AFMA7.0	295	46.65	Northern pike	0.085	17.8	Collected at 61.966872°, -158.266335° (1.25 miles straight line downstream of Crevice Creek, in backwater that was disconnected to the main channel at the time of collection)
WE1.0	795	698.24	Northern pike	0.421	21	Collected at 61.877497°, -158.139881° (fish weir, may have migrated in, but was captured upstream of the panels)

Notes:

1) Weight of sample after homogenization.

Table 6.1-1

Macroinvertebrate Taxa Collected within the Road
Alternative Drainages (2007-2008)

Order	Family	Genus	Total count ¹
Ephemeroptera	Ameletidae	<i>Ameletus</i>	1
	Baetidae	<i>Acentrella</i>	9
		<i>Baetis</i>	53
	Ephemerellidae	<i>Drunella</i>	177
	Heptageniidae	<i>Cinygmula</i>	95
		<i>Epeorus</i>	67
Plecoptera	Chloroperlidae	<i>Paraperla</i>	27
		<i>Plumiperla</i>	3
		<i>Suwallia</i>	9
	Nemouridae	<i>Zapada</i>	127
	Perlodidae	<i>Isoperla</i>	24
	Taeniopterygidae	<i>Taenionema</i>	127
Trichoptera	Apataniidae	<i>Apatania</i>	8
	Limnephilidae	<i>Dicosmoecus</i>	1
		<i>Ecclisiomyia</i>	1
		<i>Psychoglypha</i>	2
	Rhyacophilidae	<i>Rhyacophila</i>	19
Diptera	Ceratopogonidae		6
	Chironomidae		623
	Empididae	<i>Chelifera</i>	27
		<i>Oreogeton</i>	15
	Psychodidae	<i>Pericoma</i>	6
	Simuliidae	<i>Prosimulium</i>	45
		<i>Simulium</i>	2
	Tipulidae	<i>Dicranota</i>	10
Acariformes	Hydrachnidae		42
Amphipoda			1
Gastropoda	Physidae	<i>Physa</i>	1
Oligochaeta			147
Ostracoda			2
Grand Total			1677

1) Total abundance for all sites and all years of study

Table 6.1-2

Macroinvertebrate Taxa Collected in the Kuskokwim River near Jungjuk Port Site (2011-2012)

Order	Family	Genus	Total count
Ephemeroptera	Ameletidae	<i>Ameletus</i>	2
	Baetidae	<i>Acentrella</i>	9
		<i>Baetis</i>	60
	Ephemerellidae	<i>Ephemerella</i>	1
	Heptageniidae	<i>Cinygmula</i>	44
Plecoptera	Chloroperlidae	<i>Suwallia</i>	26
	Nemouridae	<i>Zapada</i>	6
	Perlodidae	<i>Isoperla</i>	1
Trichoptera	Hydropsychidae	<i>Arctopsyche</i>	1
	Hydroptilidae	<i>Hydroptila</i>	1
	Limnephilidae	<i>Ecclisiomyia</i>	2
		<i>Hydatophylax</i>	1
Diptera	Ceratopogonidae		5
	Chironomidae		2135
	Empididae	<i>Chelifera</i>	16
		<i>Oreogeton</i>	1
	Simuliidae	<i>Gymnopais</i>	1
		<i>Prosimulium</i>	5
		<i>Simulium</i>	2
	Tipulidae	<i>Dicranota</i>	1
Acariformes	Hydrachnidae		48
Oligochaeta			223
Grand Total			2591

1) Total abundance for all sites and all years of study

Table 6.1-3

Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road Alternative Drainages and Jungjuk Port Site (2007-2012)

Location ¹	Site ID	Jungjuk Creek		Kuskokwim River - Jungjuk Port Site Sampling Sites											
		JJ1	KU8	KU8	KU9	KU10	KU11	KU12	KU13	KU14	KU15	KU20	KU23	KU24	KU25
	year	2007-08	2011	2012	2011	2011	2011	2011	2011	2012	2011	2012	2012	2012	2012
	n reps	8	3	4	3	3	3	3	3	5	3	5	5	5	5
	Sample Method	Surber	Surber	Ponar®	Ponar®	Surber	Surber	Surber	Ponar®	Surber	Ponar®	Surber	Surber	Ponar®	Surber
		Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
General Metrics²															
Abundance (# / ft ²)		210.8 6.5	245.7 --	53.2 --	32.3 --	32.7 --	5.3 --	76.0 --	51.7 --	22.4 --	15.3 --	134.4 --	7.4 --	19.8 --	5.6 --
# Taxa		21.5 7.8	10.0 --	2.0 --	2.0 --	4.0 --	4.0 --	2.0 --	3.0 --	6.0 --	5.0 --	11.0 --	6.0 --	2.0 --	7.0 --
# EPT Taxa		11.5 3.5	5.0 --	NA --	NA --	1.0 --	1.0 --	NA --	NA --	3.0 --	2.0 --	6.0 --	3.0 --	NA --	2.0 --
% EPT Taxa		44.3 2.5	14.5 --	NA --	NA --	2.0 --	6.3 --	NA --	NA --	10.7 --	13.0 --	3.1 --	8.11 --	NA --	7.1 --
% Dominant Taxon		38.1 6.1	70.4 --	93.2 --	76.3 --	92.9 --	81.3 --	99.1 --	56.1 --	82.1 --	60.9 --	91.7 --	86.5 --	87.9 --	78.6 --
% Chironomidae		38.1 6.1	70.4 --	93.2 --	76.3 --	92.9 --	81.3 --	99.1 --	56.1 --	82.1 --	60.9 --	91.7 --	86.5 --	87.9 --	78.6 --
EPT/Chironomidae Ratio		1.2 0.3	0.2 --	NA --	NA --	0.0 --	0.1 --	NA --	NA --	0.1 --	0.2 --	0.0 --	0.1 --	NA --	0.1 --
Diversity Indices															
Shannon (H)		2.1 0.23	1.1 --	0.2 --	0.5 --	0.3 --	0.7 --	0.1 --	0.7 --	0.7 --	1.1 --	0.4 --	0.61 --	0.4 --	0.9 --
Evenness (e)		0.69 0.01	0.49 --	0.36 --	0.79 --	0.24 --	0.50 --	0.07 --	0.65 --	0.40 --	0.65 --	0.18 --	0.34 --	0.53 --	0.46 --
Biotic Indices															
HBI		3.9 0.29	5.5 --	5.9 --	5.8 --	5.9 --	5.8 --	6.0 --	5.6 --	5.5 --	5.0 --	5.9 --	5.68 --	5.9 --	5.7 --
% Composition Per Order															
Ephemeroptera		25.77 11.06	12.35 --	-- --	-- --	-- --	6.25 --	-- --	-- --	4.46 --	-- --	2.38 --	5.41 --	-- --	3.57 --
Plecoptera		16.99 11.77	2.17 --	-- --	-- --	2.04 --	-- --	-- --	-- --	5.36 --	13.04 --	0.45 --	-- --	-- --	-- --
Trichoptera		1.56 1.77	-- --	-- --	-- --	-- --	-- --	-- --	-- --	0.89 --	-- --	0.30 --	2.70 --	-- --	3.57 --
Diptera		44.30 3.25	71.23 --	93.23 --	76.29 --	92.86 --	87.50 --	99.12 --	56.13 --	83.04 --	60.87 --	94.35 --	91.89 --	87.88 --	89.29 --
Oligochaeta		8.60 1.00	8.55 --	6.77 --	23.71 --	2.04 --	-- --	0.88 --	43.23 --	6.25 --	23.91 --	2.53 --	-- --	12.12 --	3.57 --
Acariformes		2.59 0.50	5.70 --	-- --	-- --	3.06 --	6.25 --	-- --	0.65 --	-- --	2.17 --	-- --	-- --	-- --	-- --
Amphipoda		0.05 0.07	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
Gastropoda		0.05 0.07	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
Ostracoda		0.10 0.14	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
Turbellaria		-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --

Notes:

1) For sample site locations, refer to Figure 1.1-1. *Chironomidae* genera grouped as a single taxon for multi-year comparisons.

2) Refer to the text for definitions of metrics.

year = Year site was sampled

n reps = Total number of replicates sampled

Mean = Average of all samples for all years

SD = Standard deviation of the mean

NA = Not Applicable (no EPT taxa collected)

Table 6.2-1
Fish Species Identified within the Road Alternative Drainages (2007-2012)

			Jungjuk Creek	Kuskokwim River												
Family	Species	Common Name	JJ1	KU25	KU24	Upstream of Port			KU9	KU10	Port KU8	Downstream of Port				Total
						KU23	KU11	KU12				KU20	KU14	KU13	KU15	
Salmonidae	<i>Oncorhynchus tshawytscha</i>	Chinook salmon			X					X	X					X
	<i>Oncorhynchus keta</i>	Chum salmon								X			X			X
	<i>Oncorhynchus kisutch</i>	Coho salmon	X		X						X	X	X	X		X
	<i>Oncorhynchus gorbuscha</i>	Pink salmon								X	X					X
	<i>Oncorhynchus nerka</i>	Sockeye salmon		X	X	X	X	X	X	X	X	X	X	X	X	X
	<i>Salvelinus malma</i>	Dolly Varden	X								X	X	X			X
	<i>Thymallus arcticus</i>	Arctic grayling	X	X	X	X	X	X	X	X	X		X	X	X	X
	<i>Prosopium cylindraceum</i>	Round whitefish	X		X	X	X	X	X	X	X	X	X	X	X	X
	<i>Coregonus nasus</i>	Broad whitefish					X									X
	<i>Coregonus pidschian</i>	Humpback whitefish					X	X			X		X	X	X	X
	<i>Coregonus clupeaformis</i>	Lake whitefish										X				X
	<i>Coregonus spp</i>	Whitefishes undifferentiated		X	X	X				X	X					X
	<i>Coregonus sardinella</i>	Least cisco					X	X			X				X	X
	<i>Stenodus leucichthys</i>	Sheefish									X			X		X
Catostomidae	<i>Catostomus catostomus</i>	Longnose sucker		X	X	X	X	X	X	X	X	X	X	X	X	X
Cottidae	<i>Cottus cognatus</i>	Slimy sculpin	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Esocidae	<i>Esox lucius</i>	Northern pike											X	X	X	X
Petromyzontidae	<i>Lampetra alaskensis</i>	Alaskan brook lamprey							X							X
	<i>Lampetra spp</i>	Lamprey undifferentiated									X					X
Gadidae	<i>Lota lota</i>	Burbot			X				X		X		X	X	X	X
Total Species Count			5	5	9	6	8	7	8	9	14	7	10	10	8	20

Notes:

Refer to Figure 1.1-1 for biomonitoring site and aerial reach locations.

Includes data from trapping, fyke nets, seines, electrofishing, and aerial surveys.

Table 6.2-2

Adult Salmon Aerial Counts for the Road Alternative Drainages (2007-2012)

Species	Year	JJR1	Est. Water Clarity²
Chinook salmon	2007	ns	F
	2008	ns	G
	2009	ns	E
	2010	ns	P/F
	2011	0	G
	2012	0	G
	Mean¹	0.0	
	<i>Max</i>	0	
	<i>Min</i>	0	
Chum salmon	2007	ns	F/G
	2008	ns	G
	2009	ns	E
	2010	ns	G
	2011	0	G
	2012	0	G
	Mean¹	0.0	
	<i>Max</i>	0	
	<i>Min</i>	0	
Coho salmon	2007	3	F
	2008	2	G
	2009	ns	E
	2010	6	P/F
	2011	8	E
	2012	ns	P
	Mean¹	4.8	
	<i>Max</i>	8	
	<i>Min</i>	2	
Sockeye salmon	2007	ns	F
	2008	ns	G
	2009	ns	E
	2010	ns	P/F
	2011	0	G
	2012	0	G
	Mean¹	0.0	
Mean Total Salmon		1.9	

Notes:

Refer to Figure 1.1-1 for aerial reach locations.

ns = not surveyed

1) Mean = (total # fish seen)/(# years surveyed)

2) Estimated water clarity based on field observations during sampling: E = excellent; G = good; F = fair; P = poor

Table 6.2-3
Summary of Electrofishing Results within the Road Alternative Drainages (2007-2008)

Drainage Basin	River System	Site	Fish (#/300 ft) ¹										Grand Total
			Coho salmon (juvenile)	Chinook salmon (juvenile)	Chum salmon (juvenile)	Dolly Varden	Arctic grayling	Round whitefish	Slimy sculpin	Alaska blackfish	Alaskan brook lamprey	Burbot	
Kuskokwim	Jungjuk Creek	JJ1	2007	21	--	--	34	6	--	19	--	--	79
			2008	34	--	--	37	10	1	34	--	--	116
			Mean	27.2	--	--	35.3	8.1	0.7	26.5	--	--	97.8
			SD	9.4	--	--	2.1	3.1	1.0	10.4	--	--	26.0

Notes:

Refer to Figure 3.2-1 for site locations

Any adult salmon observed in electrofishing reaches were not shocked and were allowed to pass or avoided; Adult salmon are not included in the above counts

1) #/300 ft = number of fish per 300 feet of stream length

-- = species not found

Table 6.2-4
Summary of Fish Sampling in the Kuskokwim River Near the Proposed Jungjuk Port Site (2011-2012)

% Relative Fish Abundance at Kuskokwim River Sampling Sites																													
Survey Method	Species	Year	Upstream of Port												Port		Downstream of Port										Total Fish	Total % RA ²	Total % RA ²
			KU25		KU24		KU23		KU11		KU12		KU9		KU10		KU8		KU20		KU14		KU13		KU15				
			2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012			
Seine	Chinook salmon	--	-	--	0.7	--	--	-	--	-	--	-	--	0.8	--	2.0	--	--	--	-	-	-	--	-	--	4	0.3	0.4	
	Chum salmon	--	-	--	-	--	--	-	--	-	--	-	--	1.6	--	-	--	--	--	0.8	-	-	--	-	--	3	0.3	-	
	Coho salmon	--	-	--	0.7	--	--	-	--	-	--	-	--	-	--	1.0	--	--	--	0.8	-	0.9	--	-	--	4	0.3	0.4	
	Pink salmon	--	-	--	-	--	--	-	--	-	--	-	--	2.4	--	-	--	--	--	-	-	-	--	-	--	3	0.3	-	
	Sockeye salmon	--	32.7	--	15.6	--	--	2.0	--	2.5	--	-	--	7.2	--	-	--	--	--	0.8	25.7	2.8	--	-	--	68	2.2	20.9	
	Dolly Varden	--	-	--	-	--	--	-	--	-	--	-	--	-	--	-	--	--	--	1.6	-	-	--	-	--	2	0.2	-	
	Arctic grayling	--	4.1	--	0.7	--	--	20.1	--	10.6	--	4.5	--	3.2	--	76.5	--	--	--	41.9	5.7	23.4	--	7.1	--	230	23.1	2.2	
	Round whitefish	--	-	--	4.3	--	--	19.1	--	30.4	--	45.5	--	17.6	--	5.1	--	--	--	4.7	17.1	31.8	--	35.3	--	227	22.1	5.3	
	Broad whitefish	--	-	--	-	--	--	0.5	--	-	--	-	--	-	--	-	--	--	--	-	-	-	--	-	--	1	0.1	-	
	Humpback whitefish	--	-	--	-	--	--	13.2	--	17.4	--	-	--	-	--	1.0	--	--	--	1.6	-	3.7	--	10.6	--	71	7.3	-	
	Whitefishes undifferentiated	--	12.2	--	16.3	--	--	-	--	-	--	19.7	--	0.8	--	-	--	--	--	-	-	-	--	-	--	43	1.4	12.9	
	Least cisco	--	-	--	-	--	--	15.7	--	7.5	--	-	--	-	--	1.0	--	--	--	-	-	-	--	-	--	45	4.6	-	
	Longnose sucker	--	46.9	--	56.7	--	--	27.5	--	24.8	--	22.7	--	50.4	--	6.1	--	--	--	35.7	37.1	12.1	--	17.6	--	370	26.1	51.6	
	Slimy sculpin	--	4.1	--	5.0	--	--	2.0	--	6.8	--	4.5	--	16.0	--	7.1	--	--	--	10.9	14.3	24.3	--	25.9	--	121	11.0	6.2	
Northern pike	--	-	--	-	--	--	-	--	-	--	-	--	-	--	-	--	--	--	1.6	-	0.9	--	3.5	--	6	0.6	-		
Alaskan brook lamprey	--	-	--	-	--	--	-	--	-	--	3.0	--	-	--	-	--	--	--	-	-	-	--	-	--	2	0.2	-		
	Total # Fish Captured	--	49	--	141	--	--	204	--	161	--	66	--	125	--	98	--	--	--	129	35	107	--	85	--	1200			
	# Seine Tows ¹	--	3	--	4	--	--	3	--	3	--	3	--	3	--	3	--	--	--	7	6	3	--	3	--	41			
	# Fish/Tow	--	16.3	--	35.3	--	--	68.0	--	53.7	--	22.0	--	41.7	--	32.7	--	--	--	18.4	5.8	35.7	--	28.3	--	29.3			
	# Species (All Samples)	--	5	--	8	--	--	8	--	7	--	6	--	9	--	8	--	--	--	10	5	8	--	6	--	16			
Fyke	Coho salmon	--	--	--	-	--	--	-	--	--	--	--	-	--	-	7.7	--	11.1	--	-	-	-	--	-	--	3	-	3.2	
	Sockeye salmon	--	--	--	-	--	--	-	--	--	--	--	100.0	--	-	-	--	-	--	-	-	7.7	--	-	--	2	6.5	-	
	Dolly Varden	--	--	--	-	--	--	-	--	--	--	--	-	--	-	-	--	11.1	--	25.0	-	--	-	--	3	-	3.2		
	Arctic grayling	--	--	--	-	--	2.9	-	--	--	--	--	-	--	15.4	7.7	--	-	--	50.0	-	--	-	--	6	6.5	4.3		
	Round whitefish	--	--	--	-	--	--	-	--	--	--	--	-	--	-	-	--	5.6	--	-	15.4	--	-	--	3	6.5	1.1		
	Least cisco	--	--	--	-	--	--	-	--	--	--	--	-	--	-	-	--	-	--	-	-	--	25.0	--	1	3.2	-		
	Sheefish	--	--	--	-	--	--	-	--	--	--	--	-	--	7.7	-	--	-	--	-	7.7	--	-	--	2	6.5	-		
	Longnose sucker	--	--	--	70.8	--	41.2	-	--	--	--	--	-	--	46.2	69.2	--	5.6	--	-	46.2	--	50.0	--	55	45.2	44.1		
	Slimy sculpin	--	--	--	12.5	--	55.9	-	--	--	--	--	-	--	15.4	7.7	--	66.7	--	25.0	-	--	-	--	38	6.5	38.7		
	Burbot	--	--	--	16.7	--	--	-	--	--	--	--	-	--	15.4	-	--	-	--	-	23.1	--	25.0	--	10	19.4	4.3		
Northern pike	--	--	--	-	--	--	-	--	--	--	--	-	--	-	7.7	--	-	--	-	-	-	--	-	--	1	-	1.1		
	Total # Fish Captured	--		--	24	--	34	0	--	--	--	--	1	--	13	13	--	18	--	4	13	--	4	--	124				
	# Fyke Net Sets ¹	--		--	1	--	1	1	--	--	--	--	1	--	3	1	--	1	--	1	1	--	1	--	12				
	# Fish/24hr Set	--		--	24.0	--	34.0	0.0	--	--	--	--	1.0	--	4.3	13.0	--	18.0	--	4.0	13.0	--	4.0	--	10.3				
	# Species (All Samples)	--		--	3	--	3	0	--	--	--	--	1	--	5	5	--	5	--	3	5	--	3	--	11				
Electrofishing	Coho salmon	--	-	--	-	--	--	--	--	--	--	-	--	--	2.4	2.5	--	35.3	--	--	--	--	--	--	--	18	2.1	1.8	
	Pink salmon	--	-	--	-	--	--	--	--	--	--	-	--	--	1.2	-	--	-	--	--	--	--	--	--	--	1	1.0	-	
	Sockeye salmon	--	16.9	--	30.4	--	26.7	--	--	--	20.0	35.3	--	--	1.2	32.7	--	20.6	--	--	--	--	--	--	--	224	4.1	24.4	
	Dolly Varden	--	-	--	-	--	--	--	--	--	--	-	--	--	7.3	4.9	--	23.5	--	--	--	--	--	--	--	22	6.2	1.8	
	Arctic grayling	--	0.5	--	-	--	--	--	--	--	--	-	--	--	22.0	7.4	--	-	--	--	--	--	--	--	--	32	18.6	1.6	
	Round whitefish	--	-	--	8.7	--	1.5	--	--	--	--	--	-	--	6.1	-	--	-	--	--	--	--	--	--	--	11	5.2	0.7	
	Lake whitefish	--	-	--	-	--	--	--	--	--	--	--	-	--	-	-	--	5.9	--	--	--	--	--	--	--	2	-	0.2	
	Whitefishes undifferentiated	--	1.4	--	2.2	--	7.6	--	--	--	--	-	2.6	--	--	-	-	--	-	--	--	--	--	--	--	20	-	2.2	
	Longnose sucker	--	79.2	--	56.5	--	63.4	--	--	--	--	6.7	61.2	--	--	9.8	35.8	--	-	--	--	--	--	--	--	575	9.3	62.7	
	Slimy sculpin	--	1.9	--	2.2	--	0.8	--	--	--	--	66.7	0.9	--	--	48.8	15.4	--	14.7	--	--	--	--	--	--	91	51.6	4.5	
	Burbot	--	-	--	-	--	--	--	--	--	--	6.7	-	--	--	-	-	--	-	--	--	--	--	--	--	1	1.0	-	
	Northern pike	--	-	--	-	--	--	--	--	--	--	-	-	--	--	-	1.2	--	-	--	--	--	--	--	--	2	-	0.2	
	Lamprey undifferentiated	--	-	--	-	--	--	--	--	--	--	-	-	--	--	1.2	-	--	-	--	--	--	--	--	--	1	1.0	-	
	Total # Fish Captured	--	414	--	46	--	131	--	--	--	--	15	116	--	--	82	162	--	34	--	--	--	--	--	--	1000			
	# Electrofishing Passes ¹	--	1	--	1	--	1	--	--	--	--	1	1	--	--	1	1	--	1	--	--	--	--	--	--	8			
	# Fish/100ft	--	414.0	--	46.0	--	131.0	--	--	--	--	15.0	116.0	--	--	82.0	162.0	--	34.0	--	--	--	--	--	--	125.0			
	# Species (All Samples)	--	5	--	5	--	5	--	--	--	--	4	4	--	--	9	7	--	5	--	--	--	--	--	--	13			

Notes:
Refer to **Figure 1.1-1** for site locations.
Sampling methods were determined based on existing habitat conditions
1) Samples are defined as: Seine Tow = One seine tow (~30ft Length, 4ft depth, 1/8" mesh); Fyke Net Set= One 24 hour fyke net set (4' x 3' opening, 3/8" mesh,15' wings, 30' leader); Electrofishing Pass = One electrofisher with two netters for a distance of ~100ft along river bank
2) Total % RA = Total percent relative abundance for each fish species across all sites per sampling method
-- Sampling method not performed at this site

9.0 FIGURES

Figure 1.1-1

Resident Species Occurrence and Estimated Adult Salmon Density and Distribution within the Project Study Area

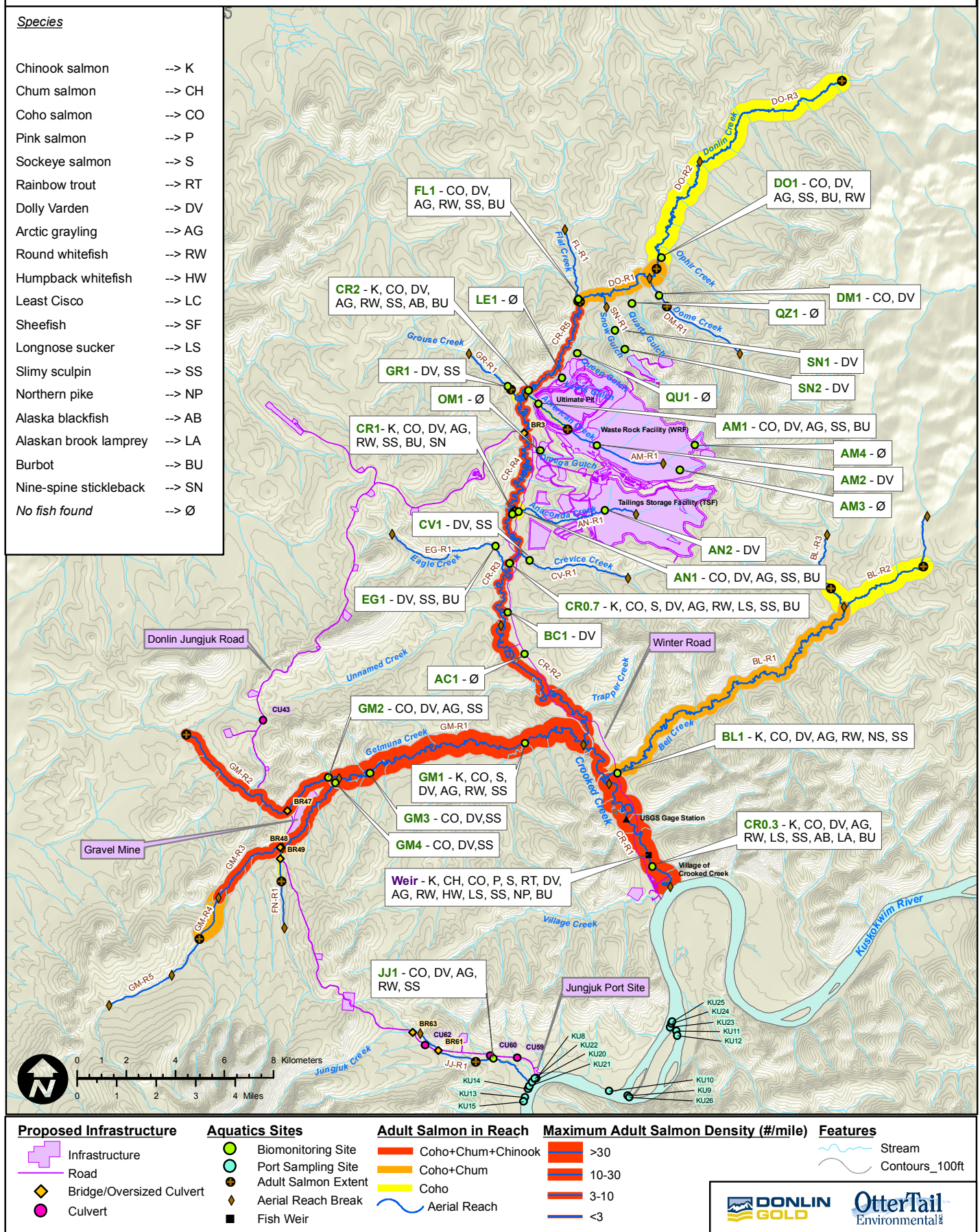


Figure 2.1-1
Aerial Photograph of the Crooked Creek Weir (2008)



Figure 2.4-1

Cross Section Photograph of the Crooked Creek Weir (2008)



Figure 3.1-1

Macroinvertebrate Abundance for Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)

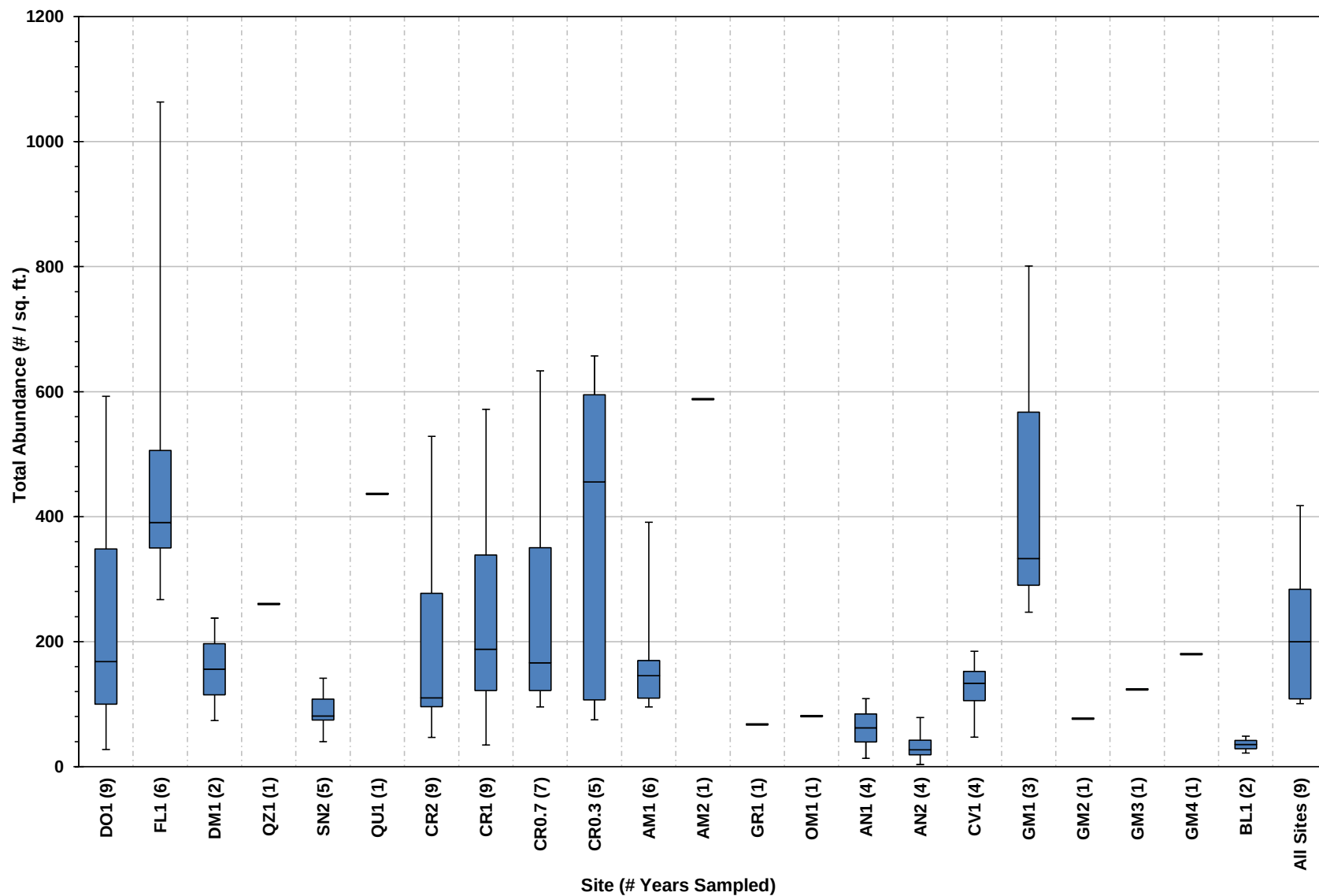
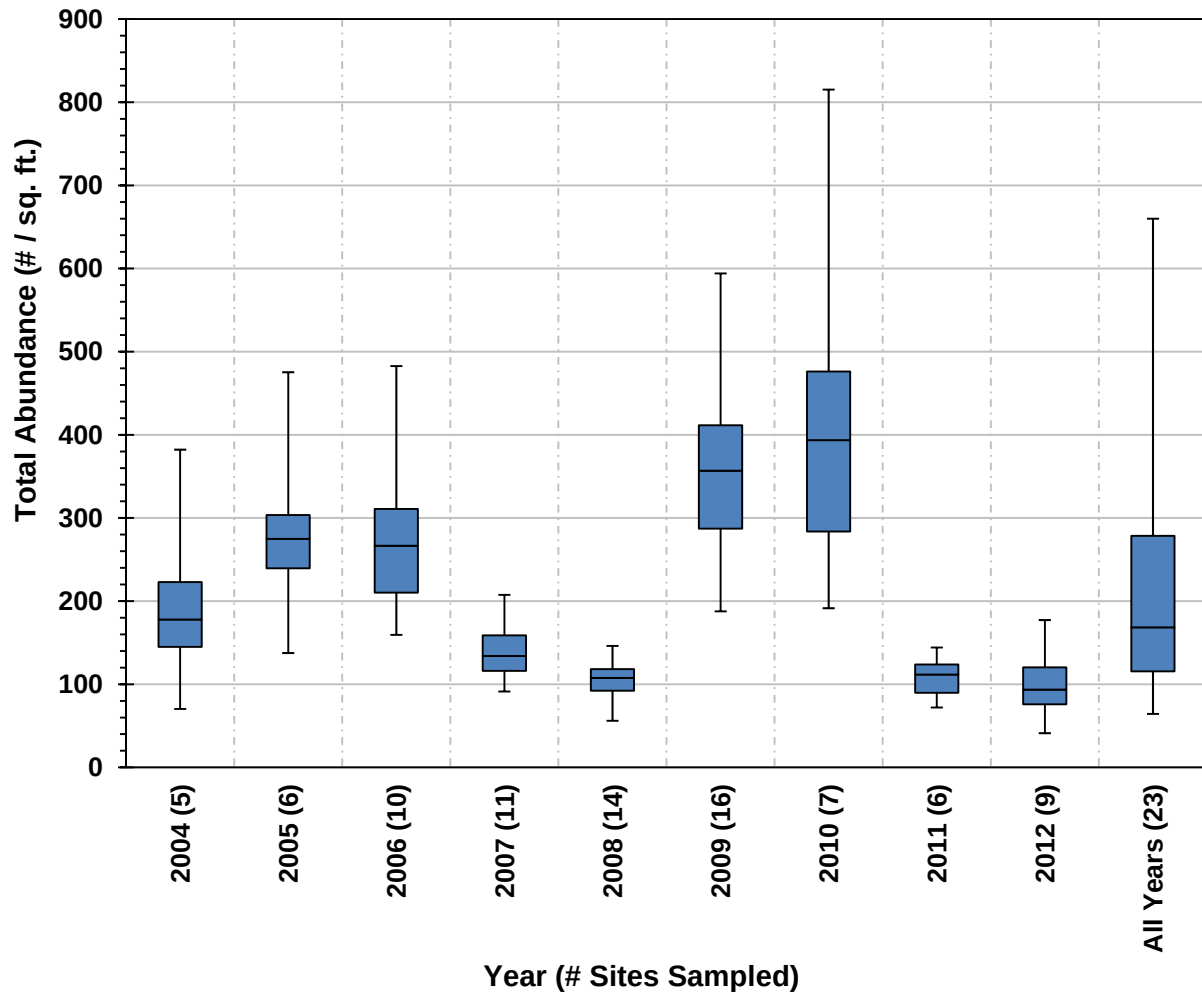


Figure 3.1-2

Macroinvertebrate Abundance for Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)



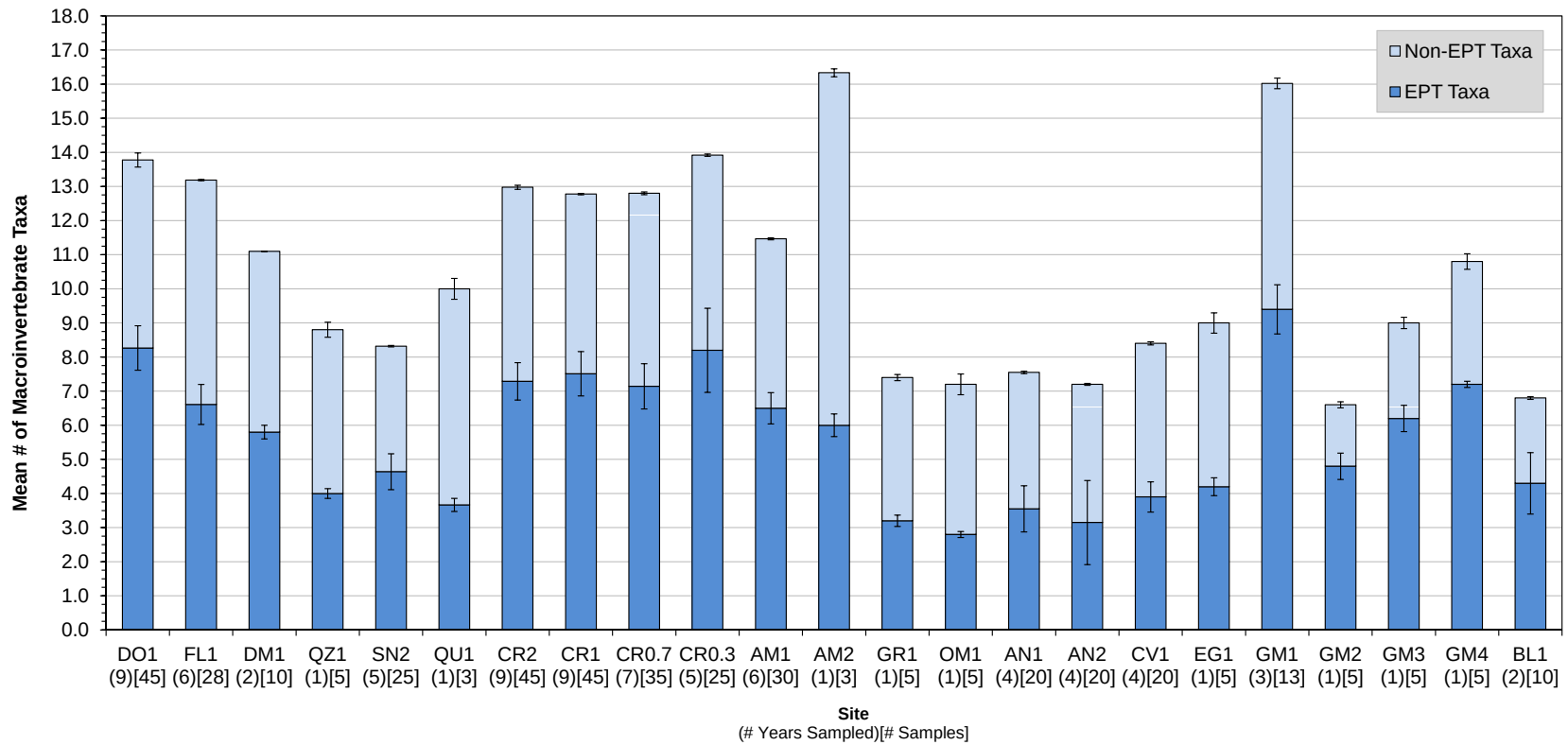
Notes:

For sample site locations, refer to Figure 1.1-1.

Samples were collected each year using the surber sampling method

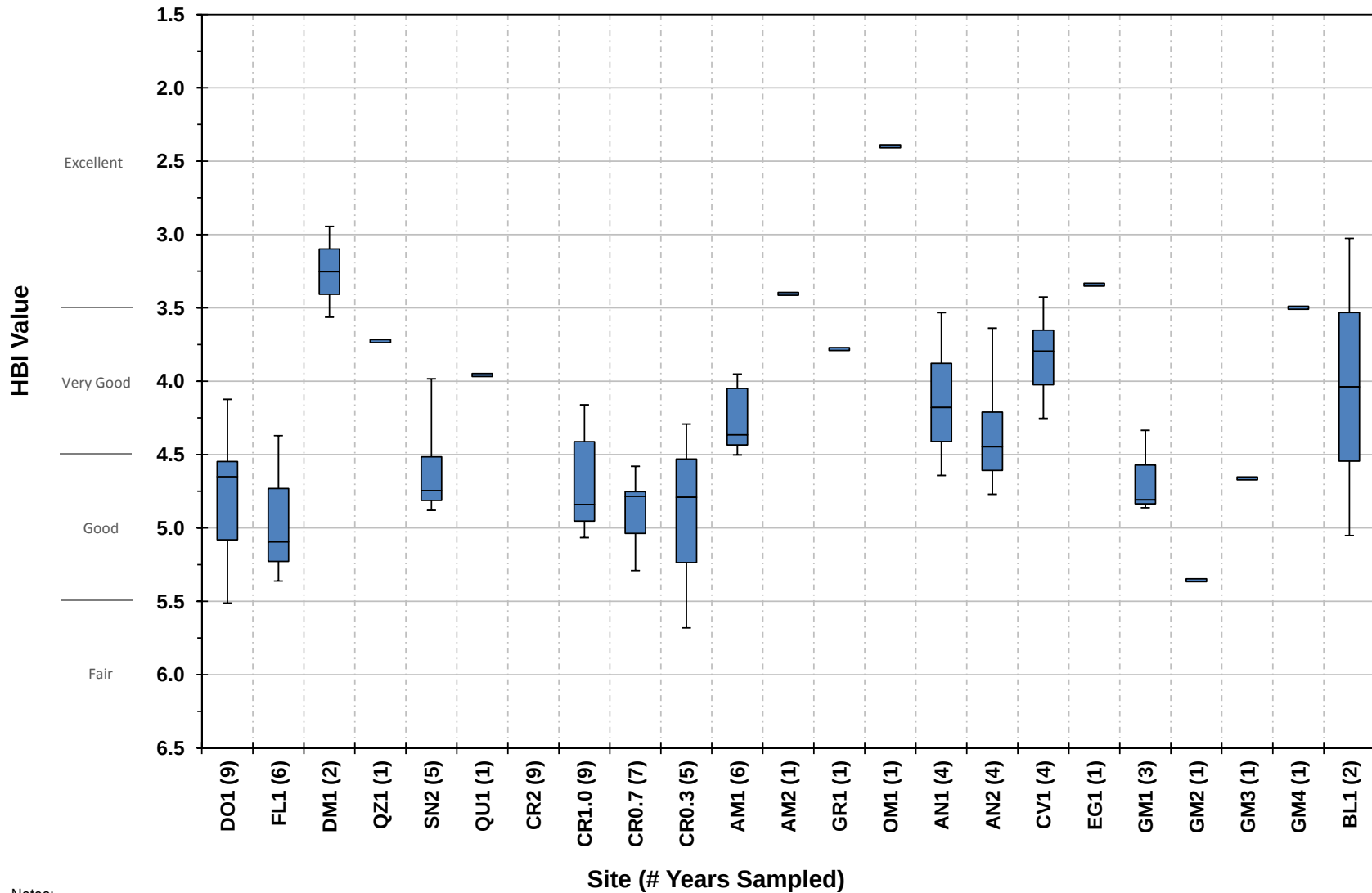
Figure 3.1-3

Mean Number of EPT and Non-EPT Macroinvertebrate Taxa (Combined for Total Mean Number of Taxa) Found at Sites within the Crooked Creek Drainage (2004-2012)



Notes:
For sample site locations, refer to Figure 1.1-1.
Error bars represent one standard error.

Figure 3.1-4
Hilsenhoff Biotic Index (HBI)¹ for Aquatic Macroinvertebrates within the Crooked Creek Drainage (2004-2012)

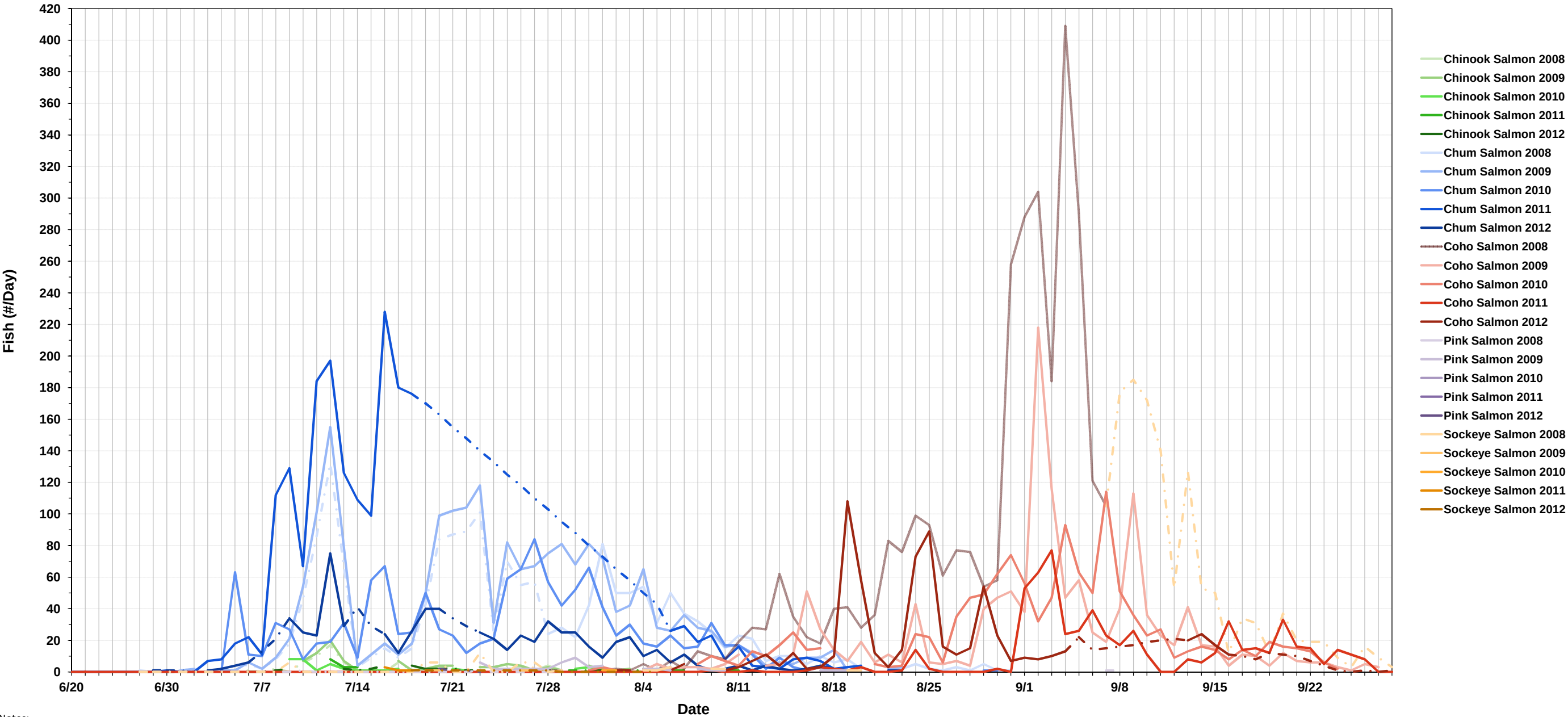


Notes:

For sample site locations, refer to Figure 1.1-1.

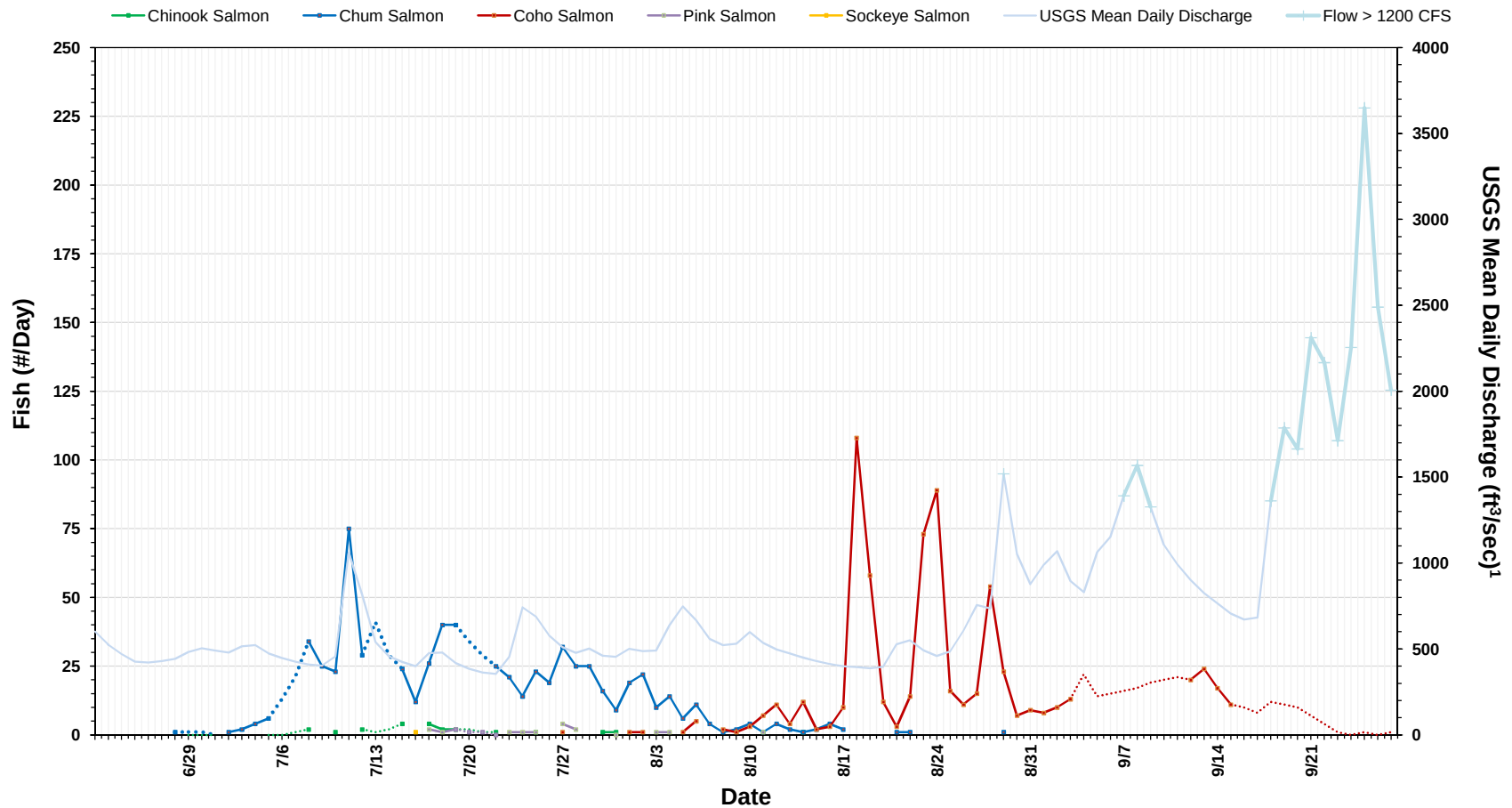
1) The Hilsenhoff Biotic Index (HBI) was developed using tolerance values for macroinvertebrates in Wisconsin streams (Hilsenhoff 1987, 1988). HBI takes into account the tolerance value and number of individuals of each taxon in the sample and rates streams on a scale of 0 (excellent water quality) to 10 (polluted). Values are as follows: 0.00-3.50 (excellent), 3.51-4.50 (very good), 4.51-5.50 (good), 5.51-6.50 (fair), 6.51-7.50 (fairly poor), 7.51-8.50 (poor), and 8.51-10.00 (very poor).

Figure 3.2-1
 Salmon Escapement at the Crooked Creek Weir (2008-2012)



Notes:
 1) Weir operational from 7/28/2008 to 9/29/2008, from 6/3/2009 to 9/29/2009, from 6/17/2010 to 9/27/2010, from 6/17/2011 to 9/27/2011, and from 6/27/2012 to 9/28/2012. See **Table 3.2-3** for complete operational periods.
 2) Dashed lines denote an estimate of fish passage calculated with methods found in ADF&G report, Tatlawiksuk River Salmon Studies, 2010. (Fishery Data Series no. 07-56)

Figure 3.2-2
Daily Salmon Escapement at the Crooked Creek Weir (2012)

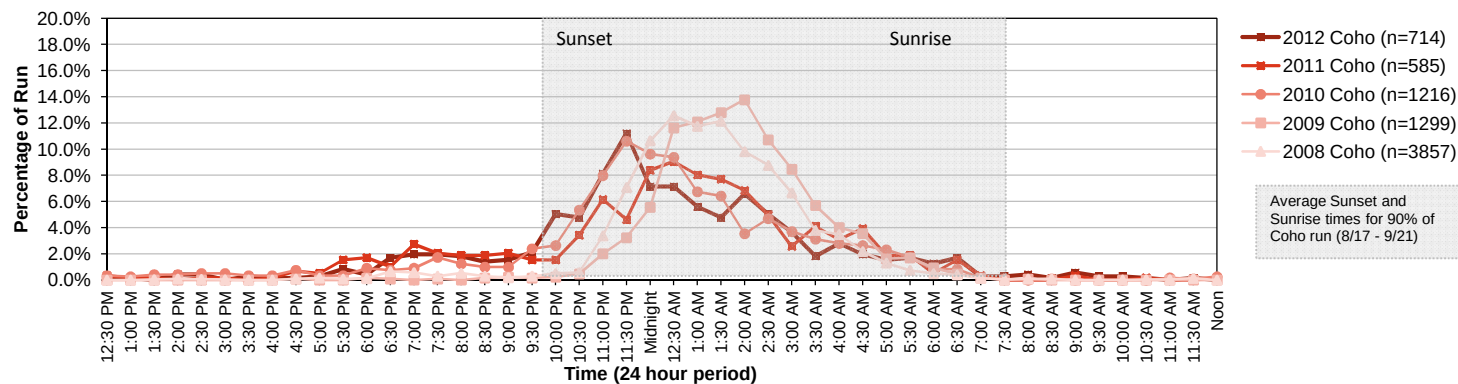


Notes:

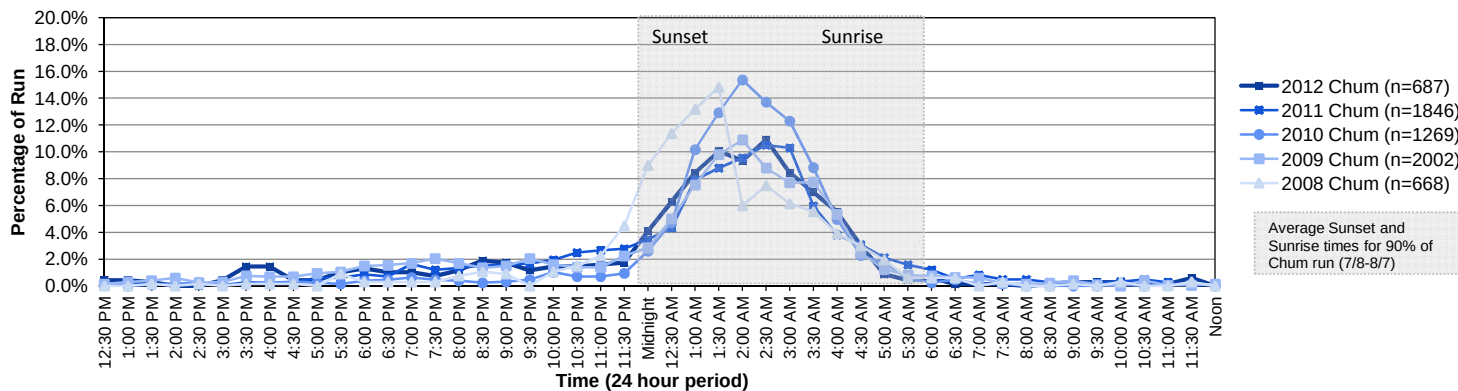
- 1) Discharge measurements taken from USGS gauge station on Crooked Creek (USGS 15304010). Weir video not recorded between 6/30 - 7/1, 7/7 - 7/8, 7/14 - 7/15 and 7/21 - 7/22. Weir was overtopped between 9/5 - 9/12 and 9/16 - 9/28.
- 2) Dashed lines denote an estimate of fish passage calculated with methods found in ADF&G report, Tatlawiksuk River Salmon Studies, 2010 (Fishery Data Series no. 07-56).

Figure 3.2-3
Diel Run Timing for Observed Salmon at the Crooked Creek Weir (2008-2012)

COHO



CHUM



CHINOOK

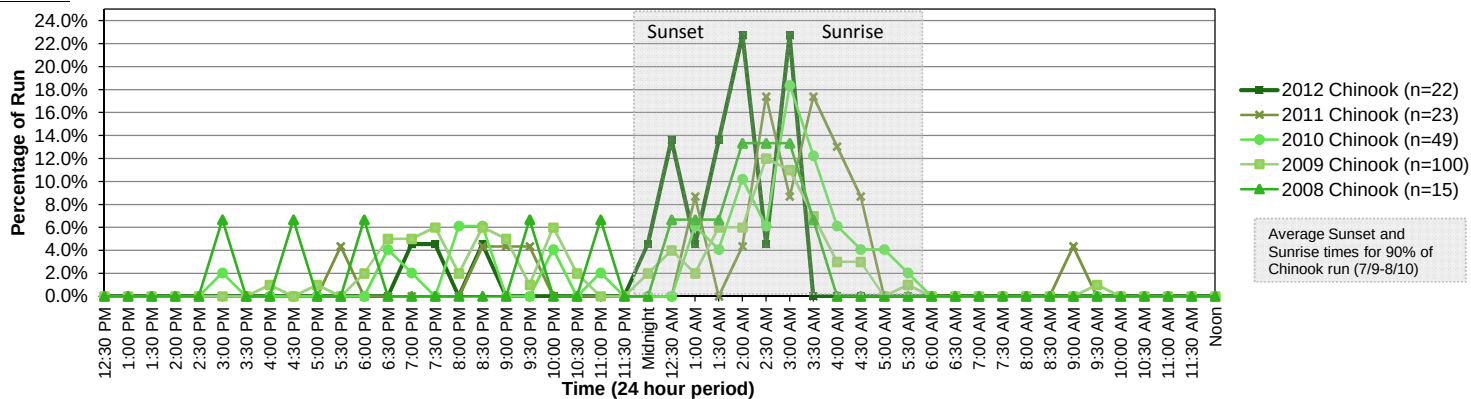
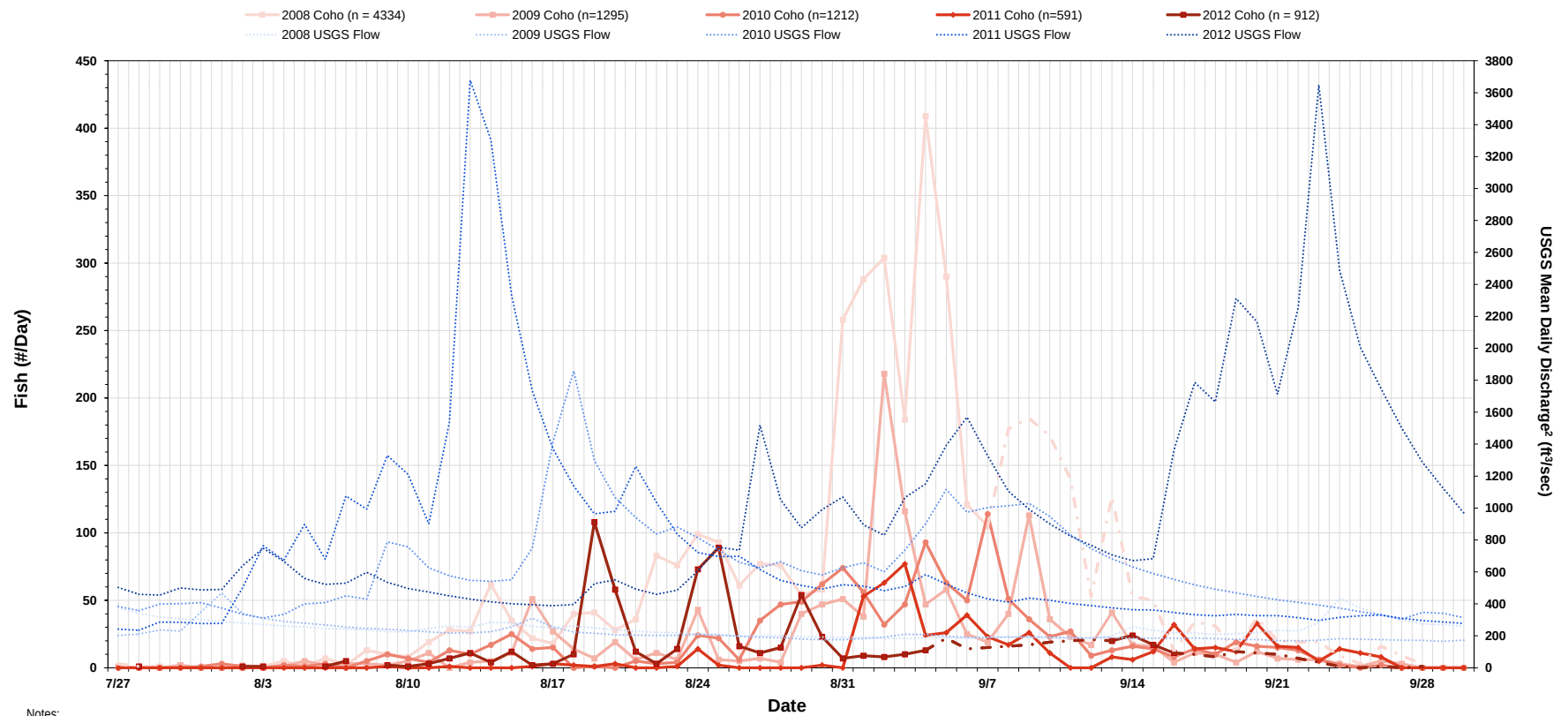


Figure 3.2-4
Daily Coho Salmon Escapement at the Crooked Creek Weir (2008-2012)¹



Notes:

- 1) Weir operational from 7/28/2008 to 9/29/2008, 6/3/2009 to 9/29/2009, 6/17/2010 to 9/27/2010, 6/17/2011 to 9/27/2011, and 6/27/2012 to 9/28/2012. See Table 3.2-3 for complete operational periods.
- 2) Discharge measurements were taken from the USGS gauge station on Crooked Creek (USGS 15304010).
- 3) Dashed lines denote an estimate of fish passage calculated with methods found in ADF&G report, Tatlawiksuk River Salmon Studies, 2010 (Fishery Data Series no. 07-56).

Aluminum Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

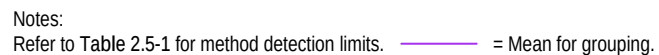
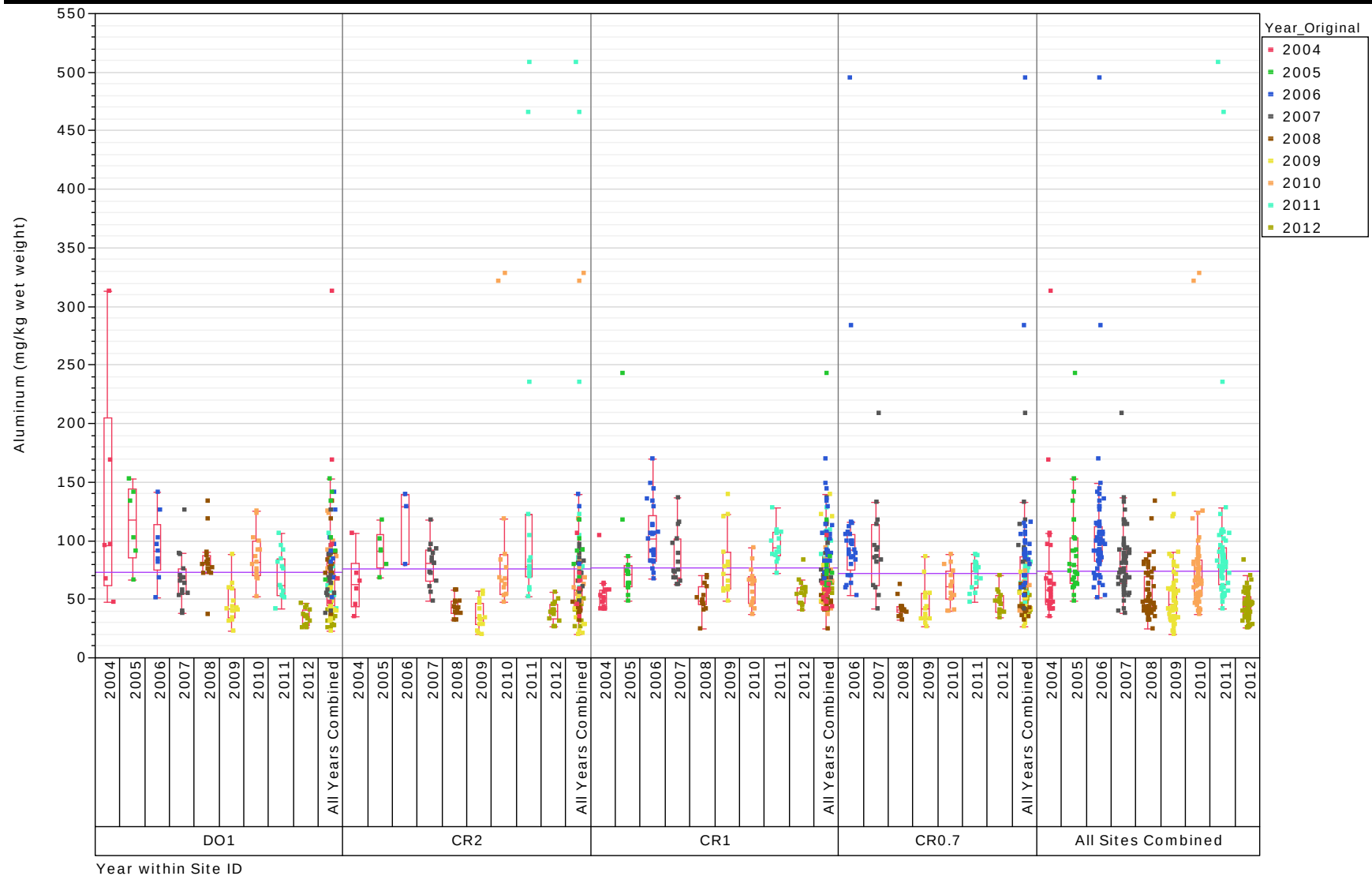


Figure 3.3-1 (Page 2 of 2)

Aluminum Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)

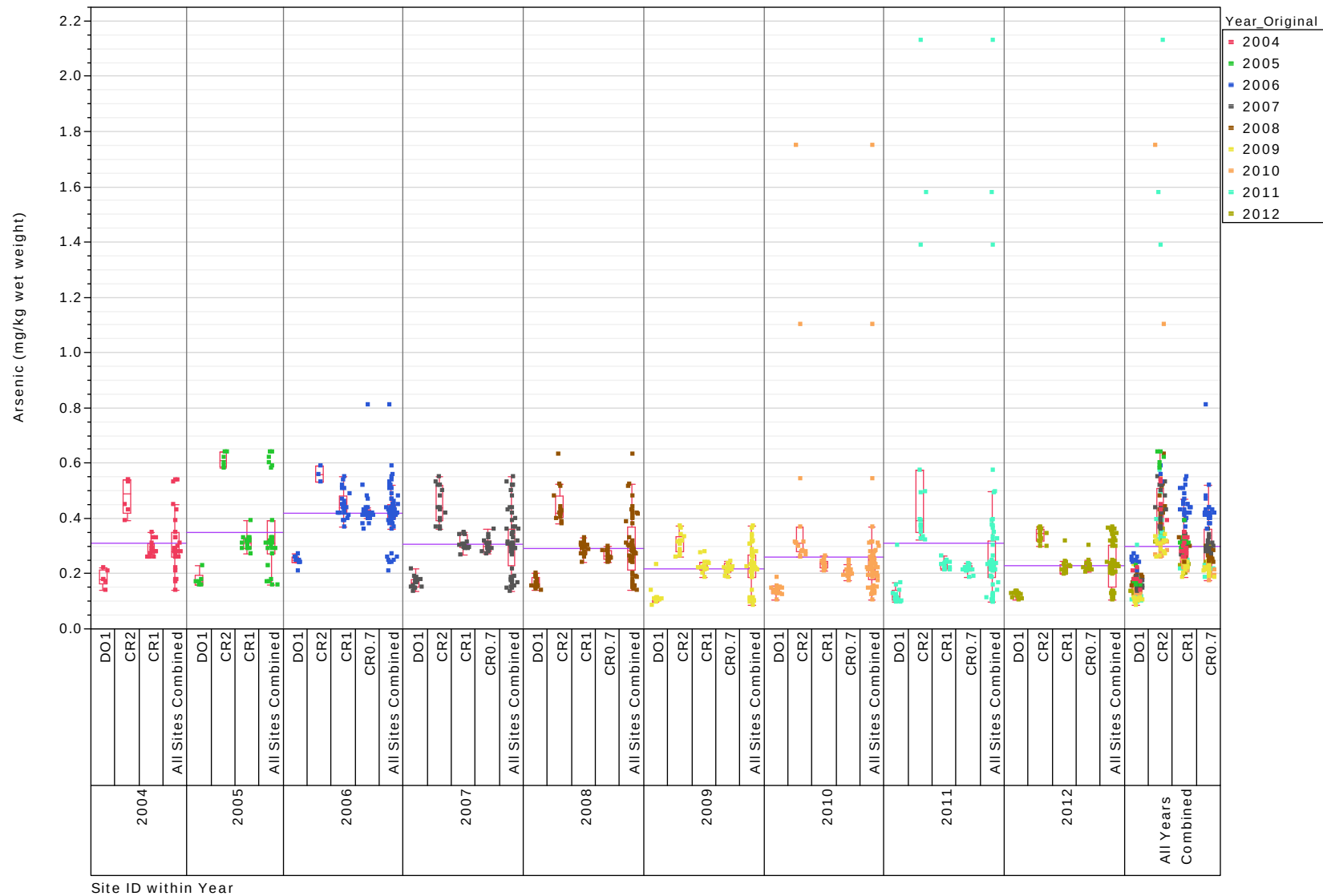


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-2 (Page 1 of 2)

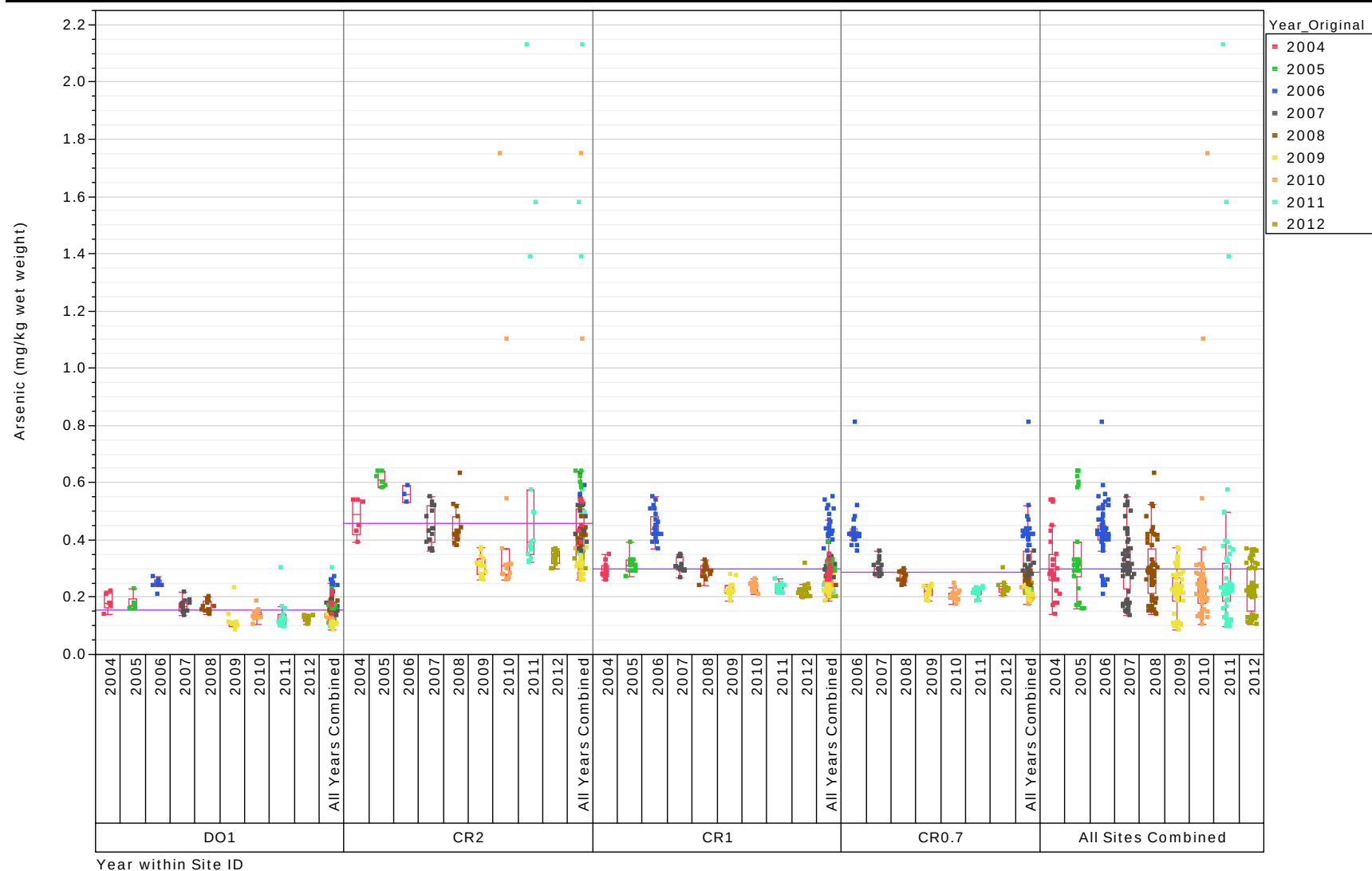
Arsenic Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-2 (Page 2 of 2)

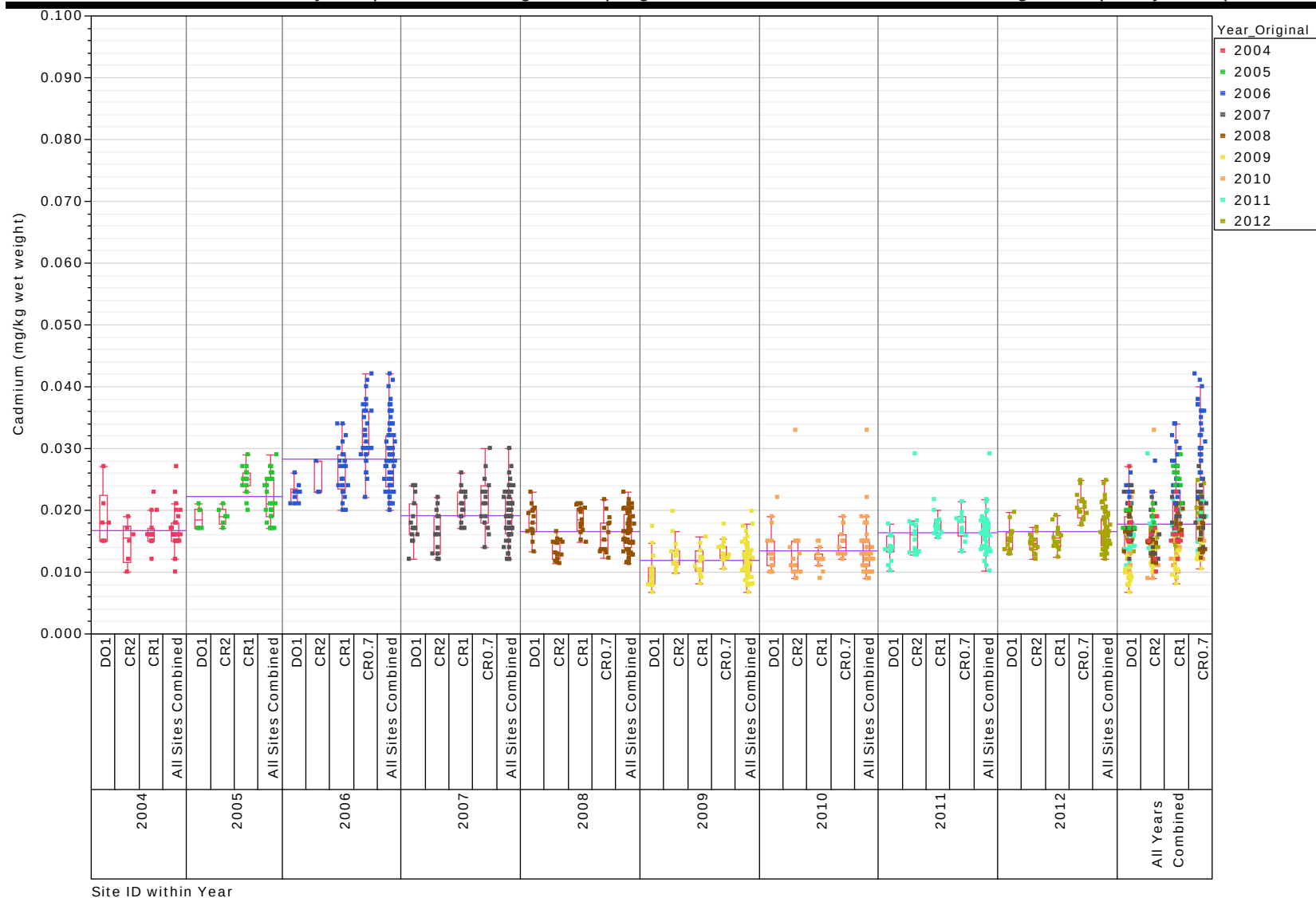
Arsenic Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-3 (Page 1 of 2)

Cadmium Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

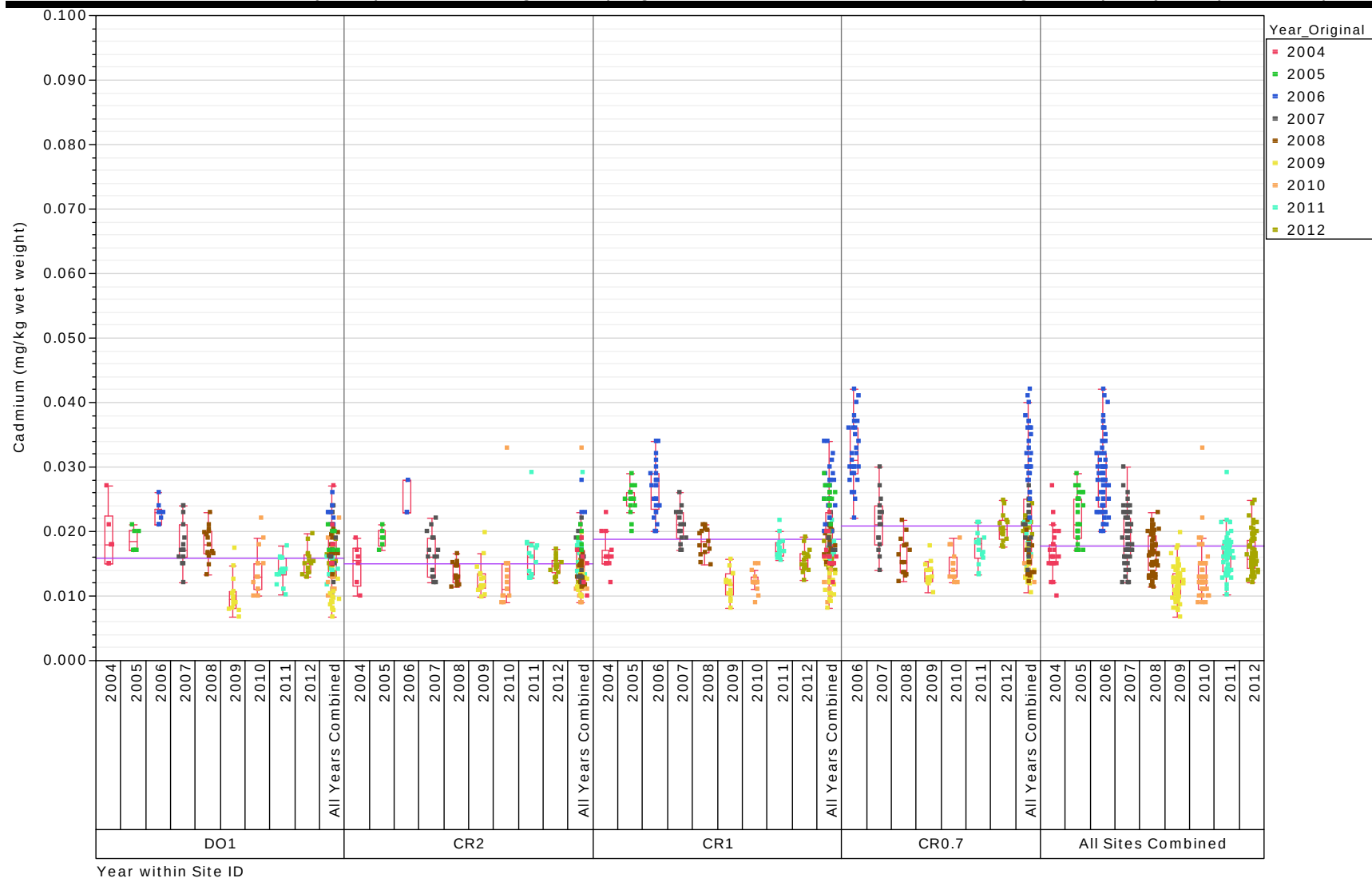


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-3 (Page 2 of 2)

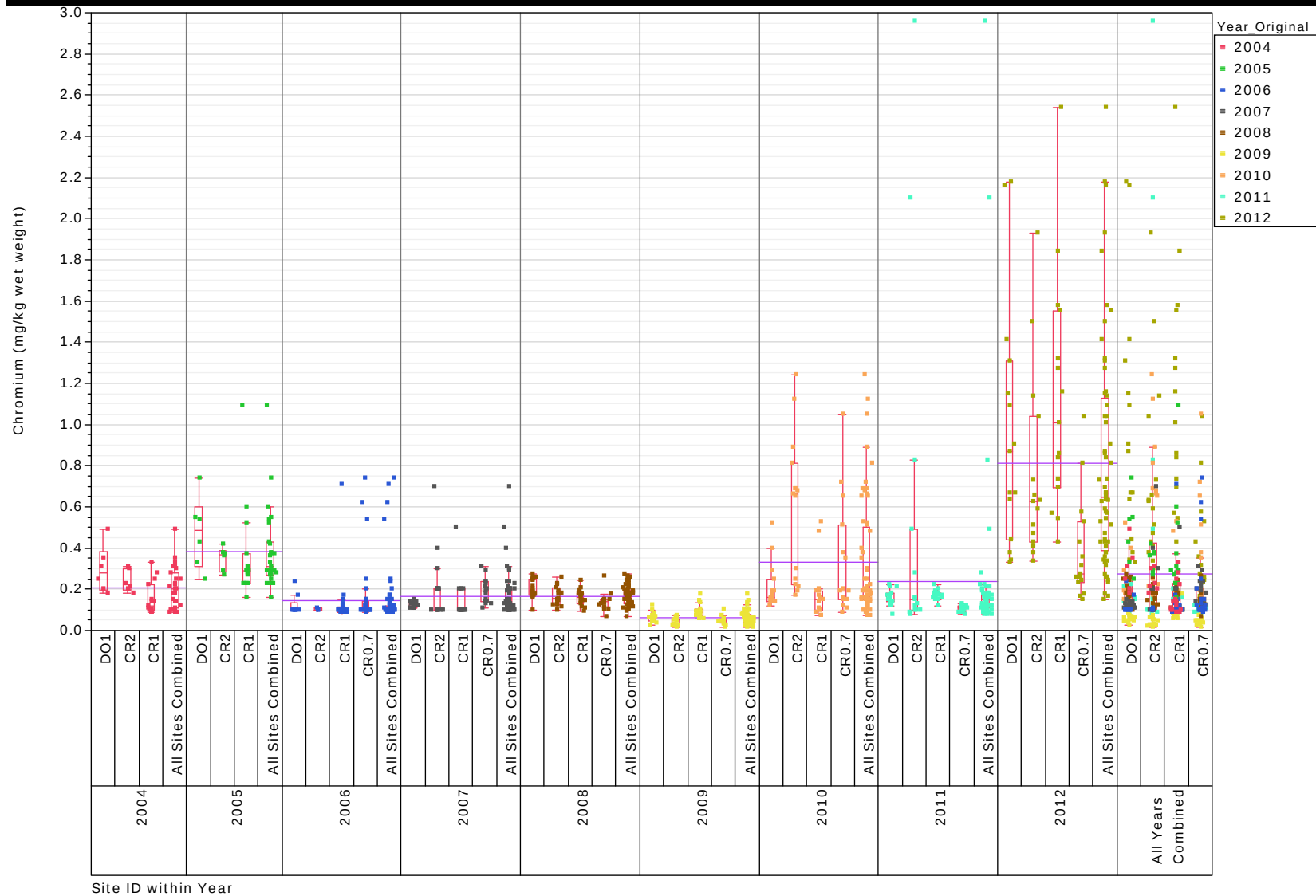
Cadmium Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-4 (Page 1 of 2)

Chromium Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

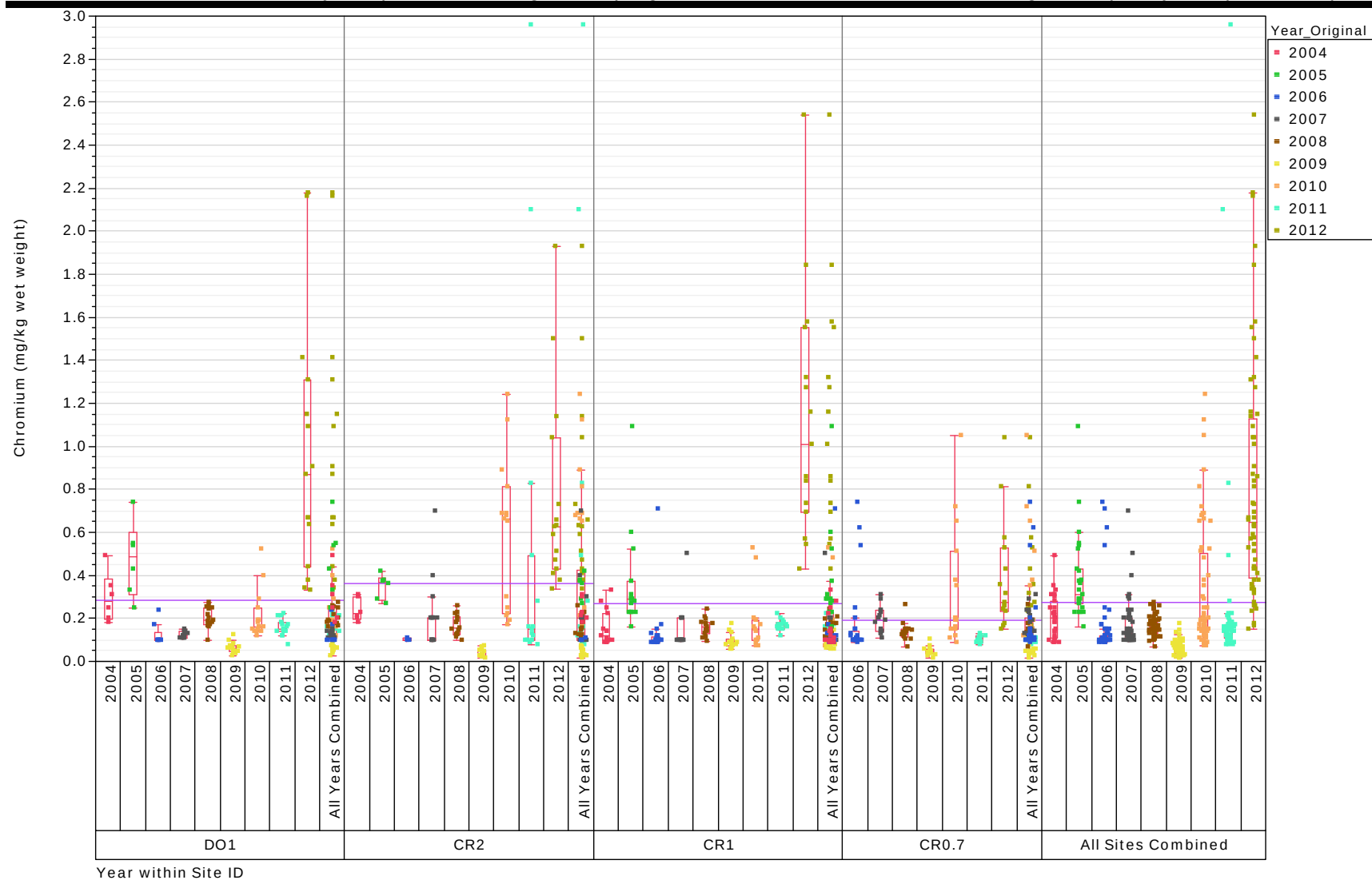


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-4 (Page 2 of 2)

Chromium Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)

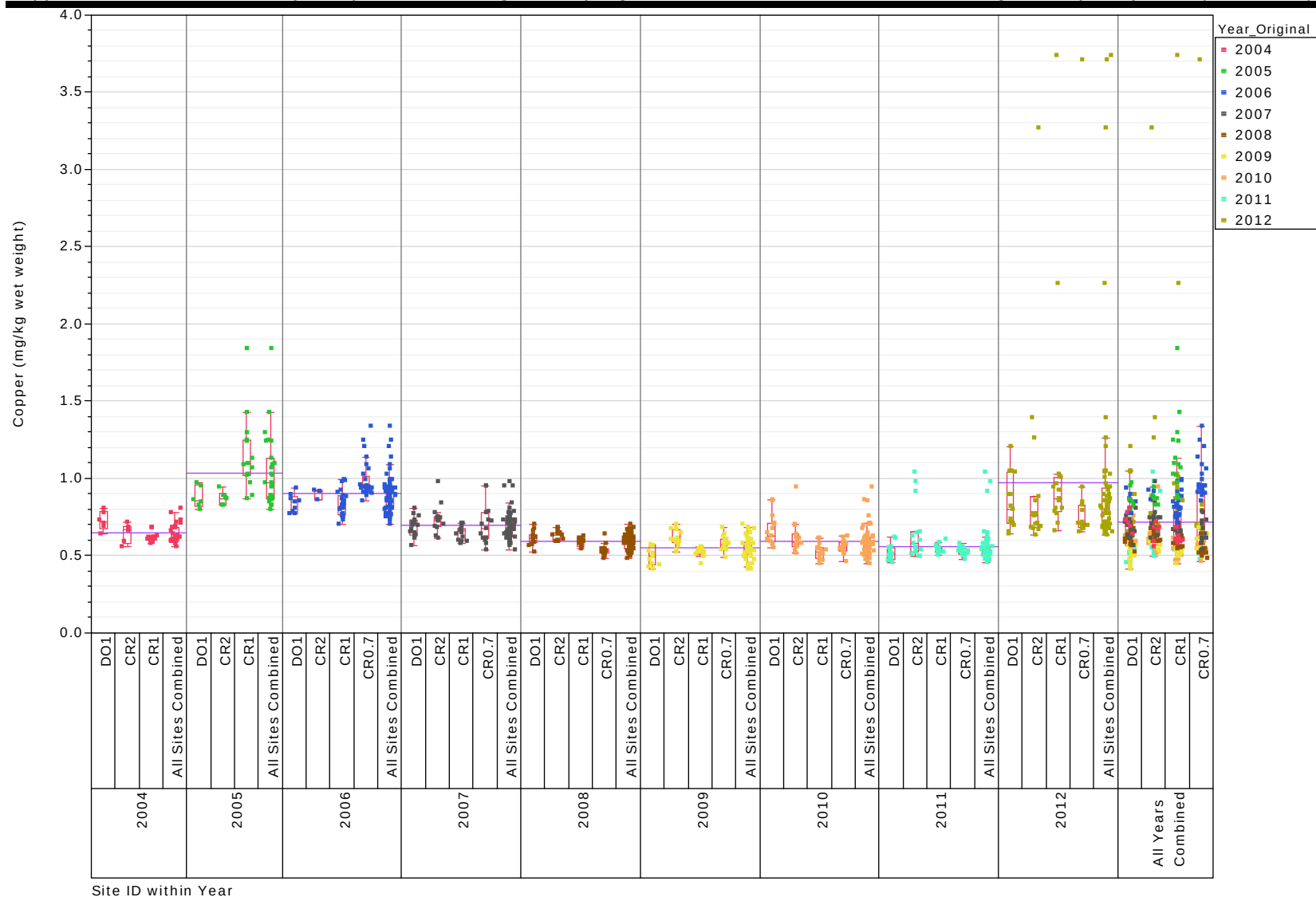


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-5 (Page 1 of 2)

Copper Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

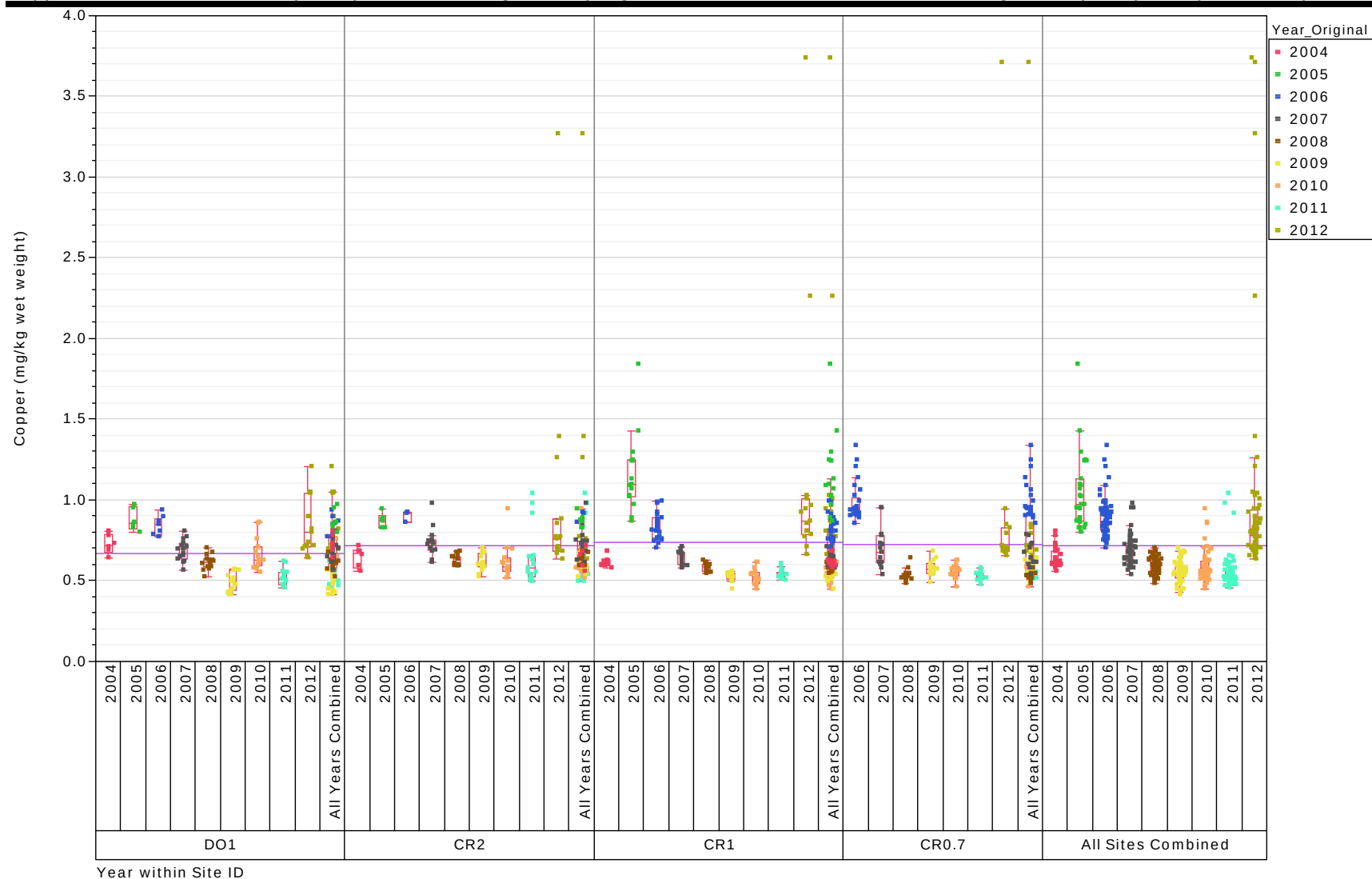


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-5 (Page 2 of 2)

Copper Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)

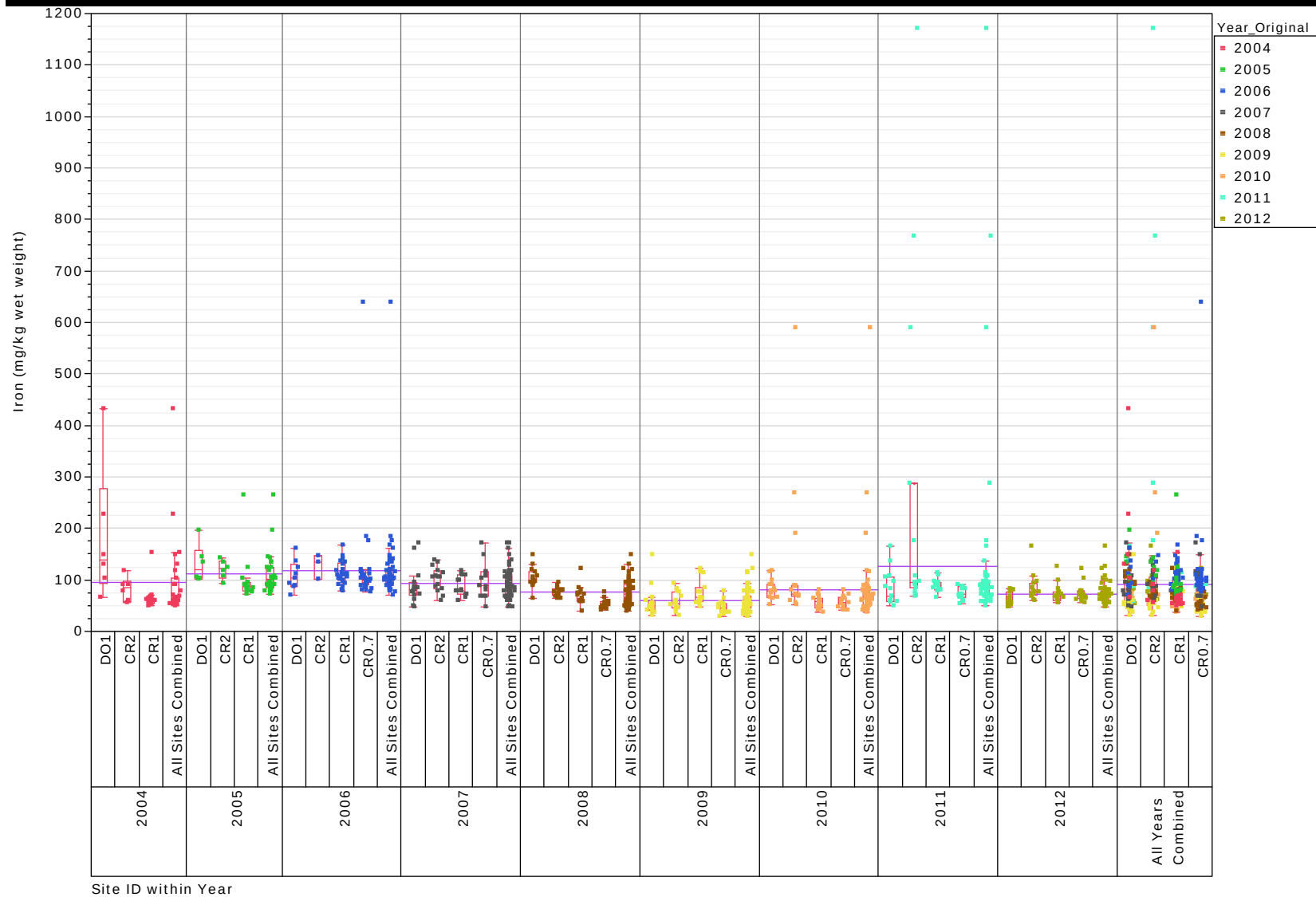


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-6 (Page 1 of 2)

Iron Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

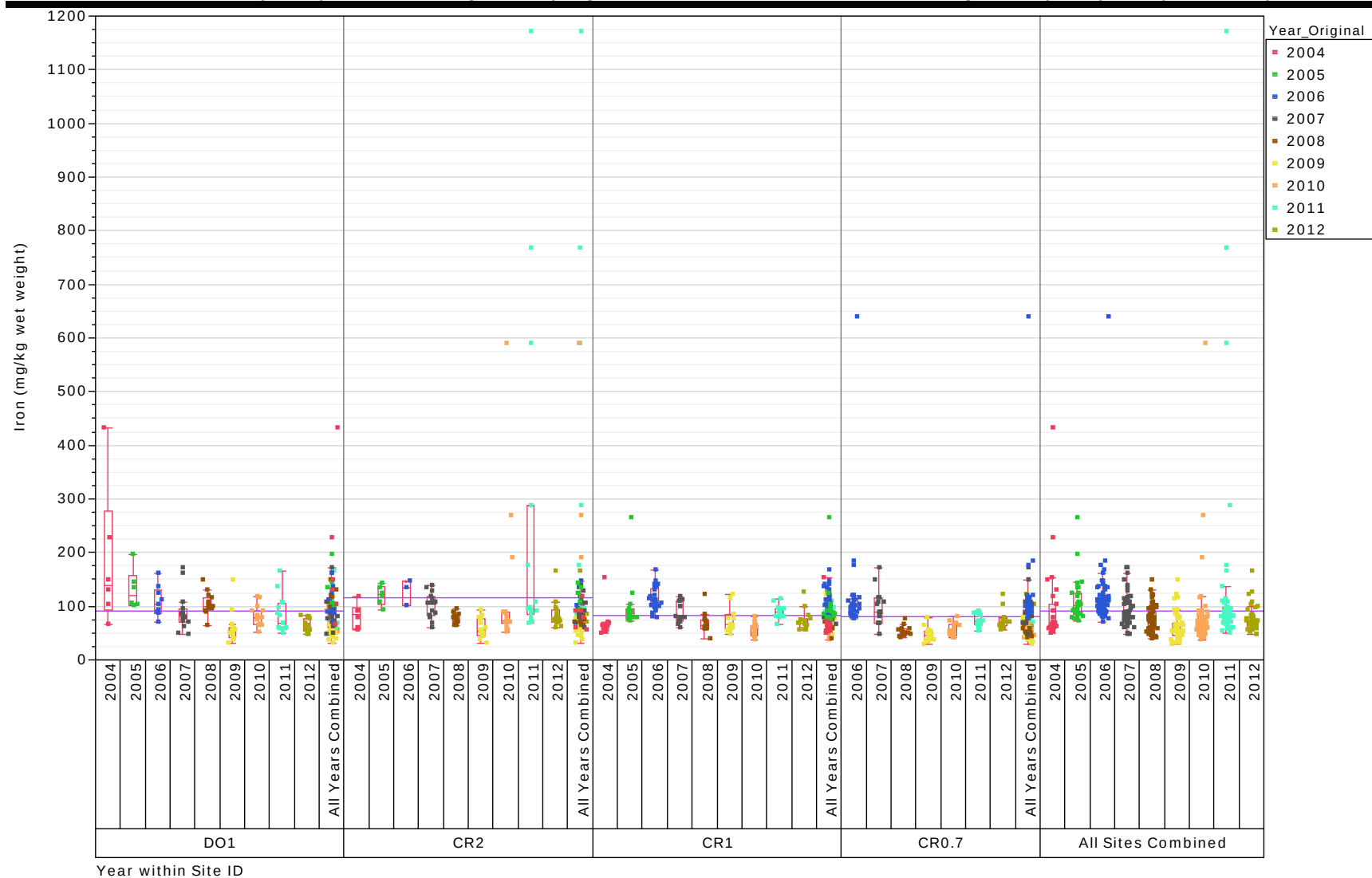


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-6 (Page 2 of 2)

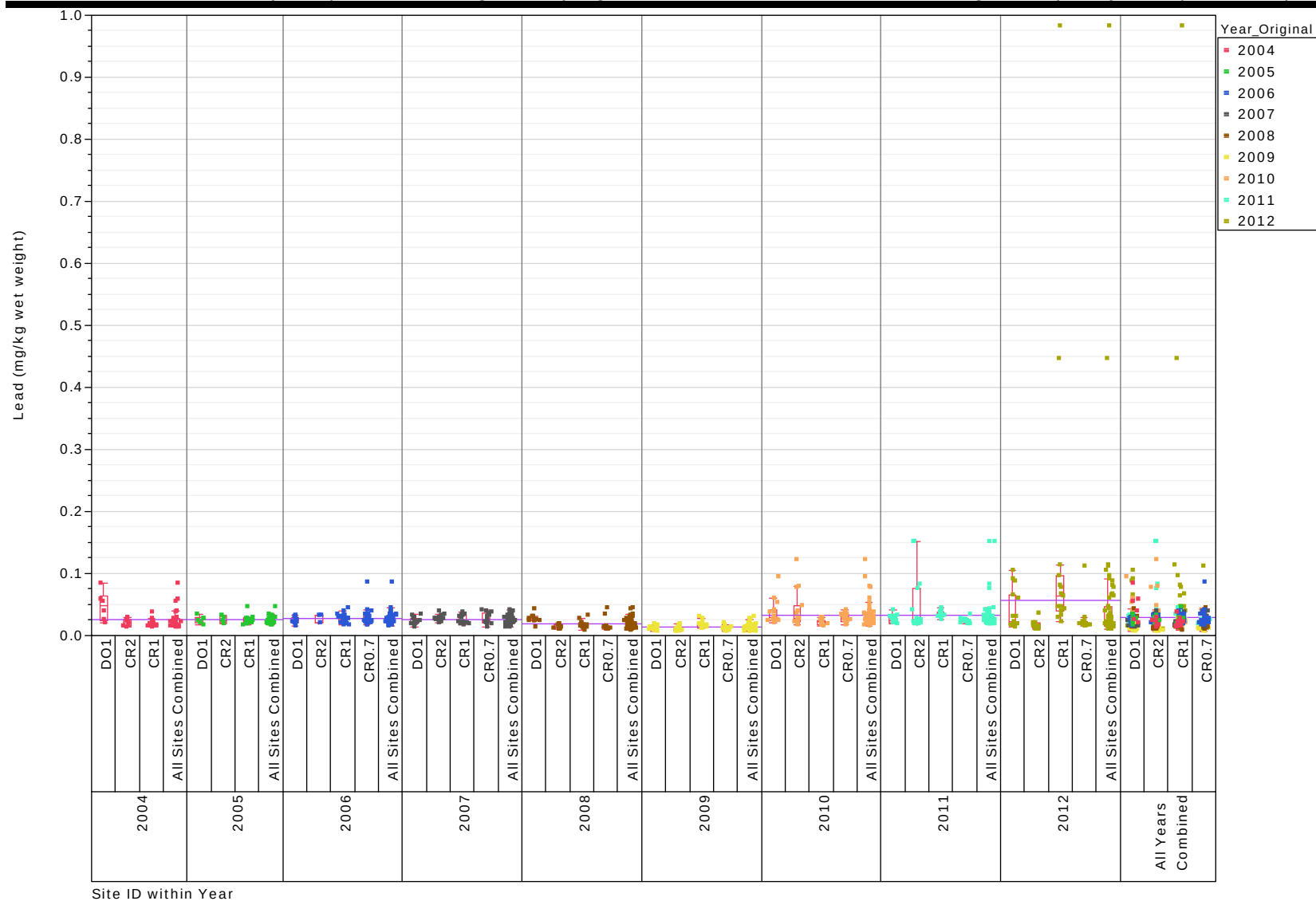
Iron Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-7 (Page 1 of 2)

Lead Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

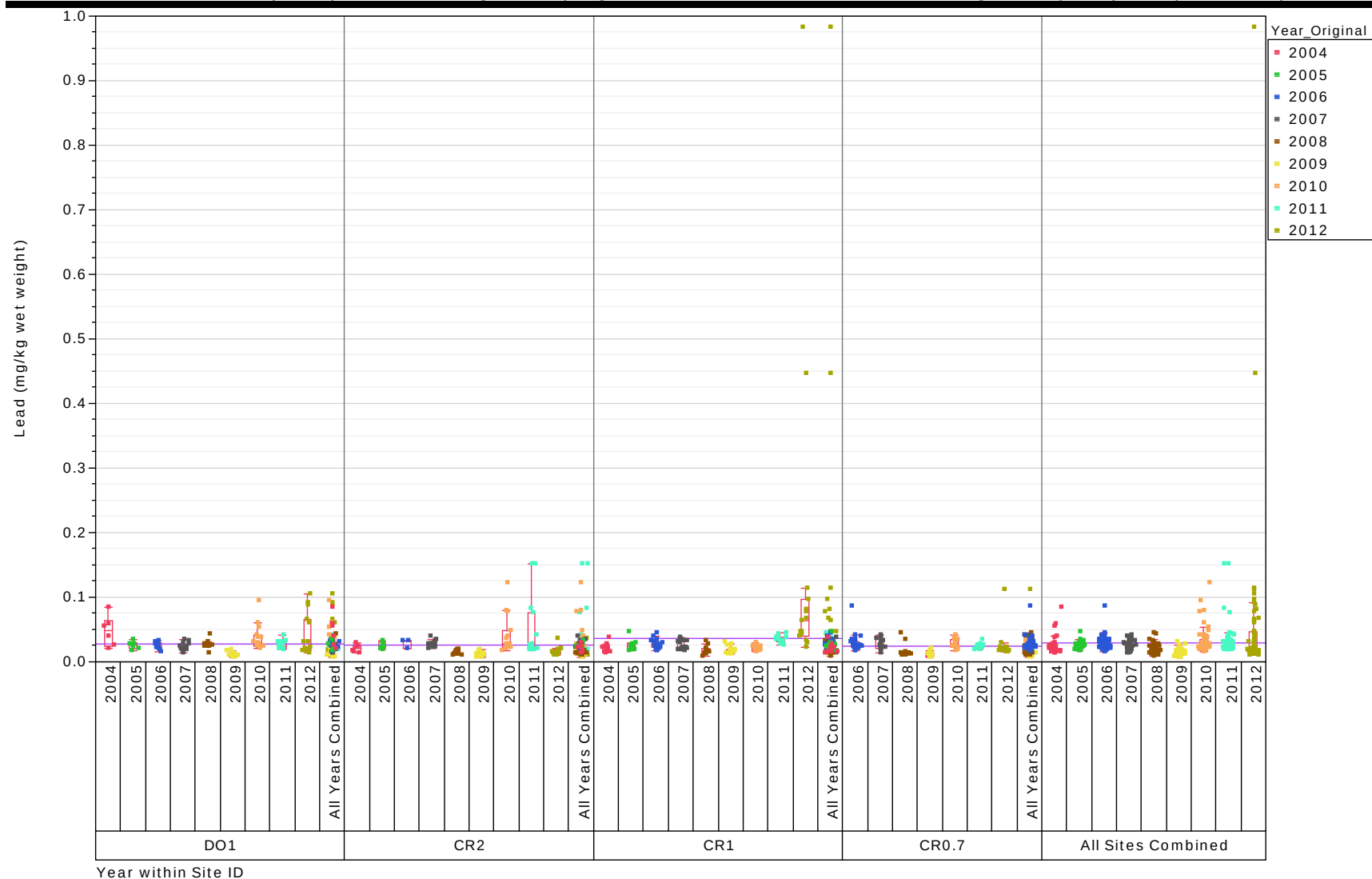


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-7 (Page 2 of 2)

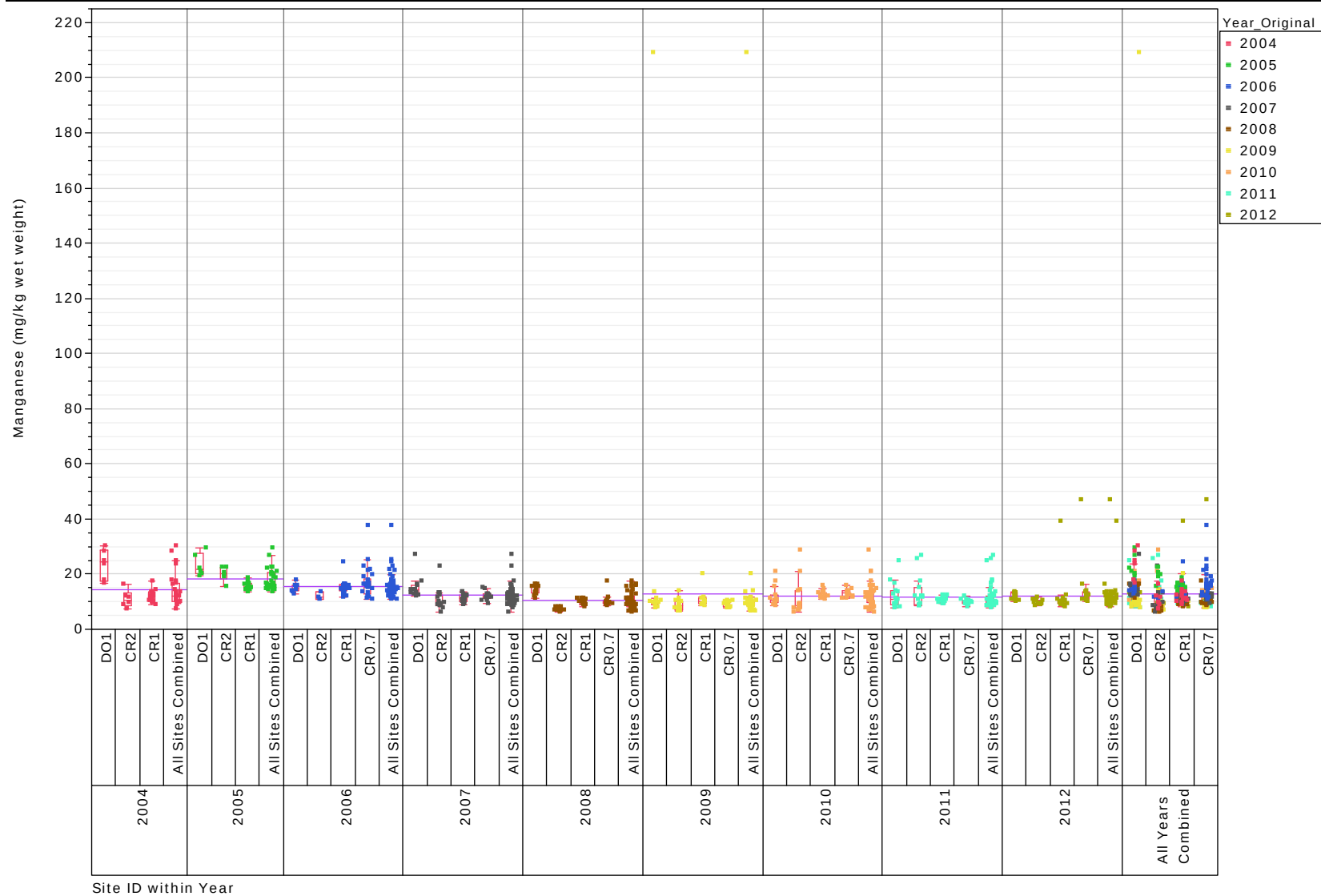
Lead Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-8 (Page 1 of 2)

Manganese Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

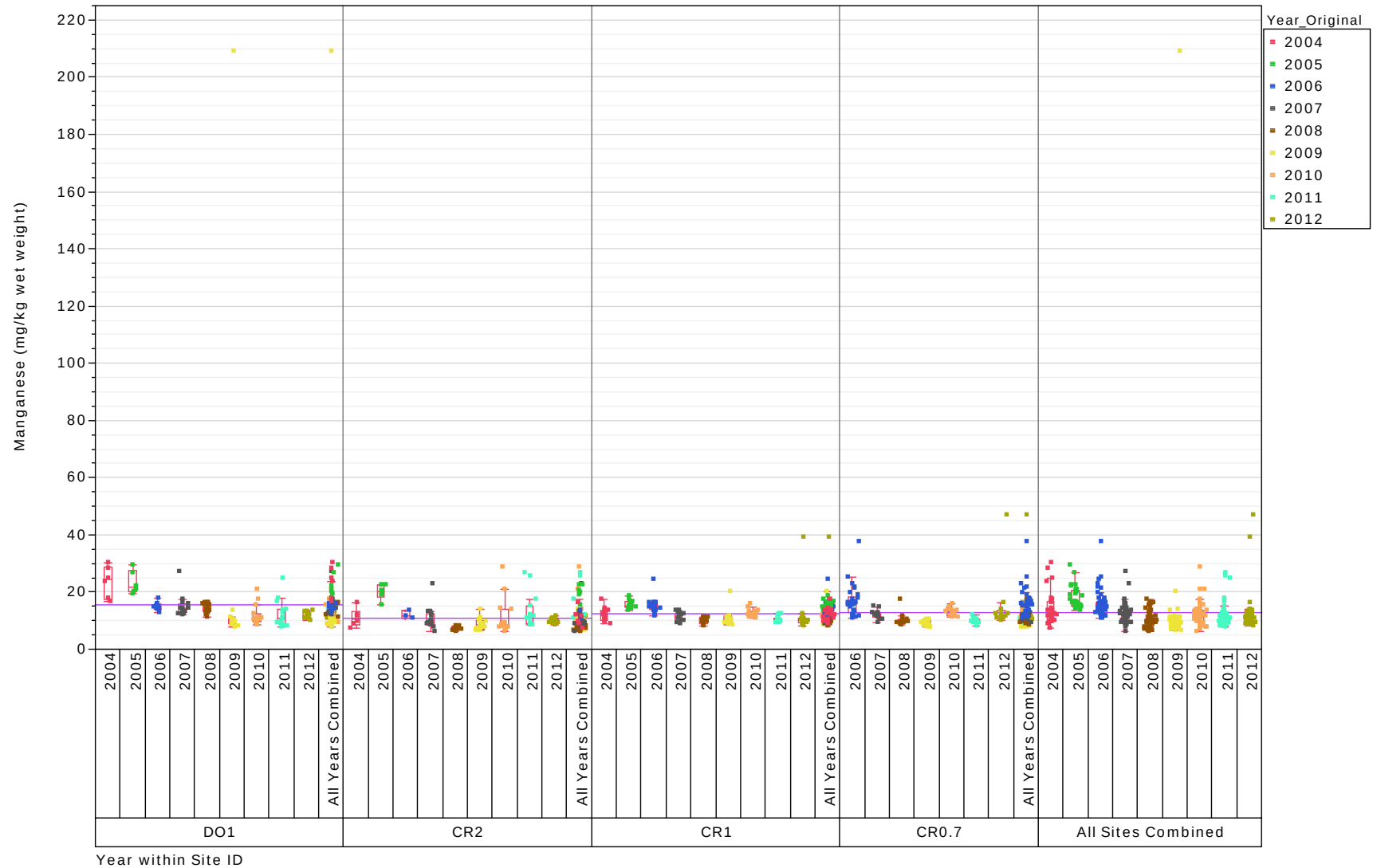


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-8 (Page 2 of 2)

Manganese Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Mercury Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

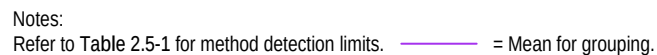
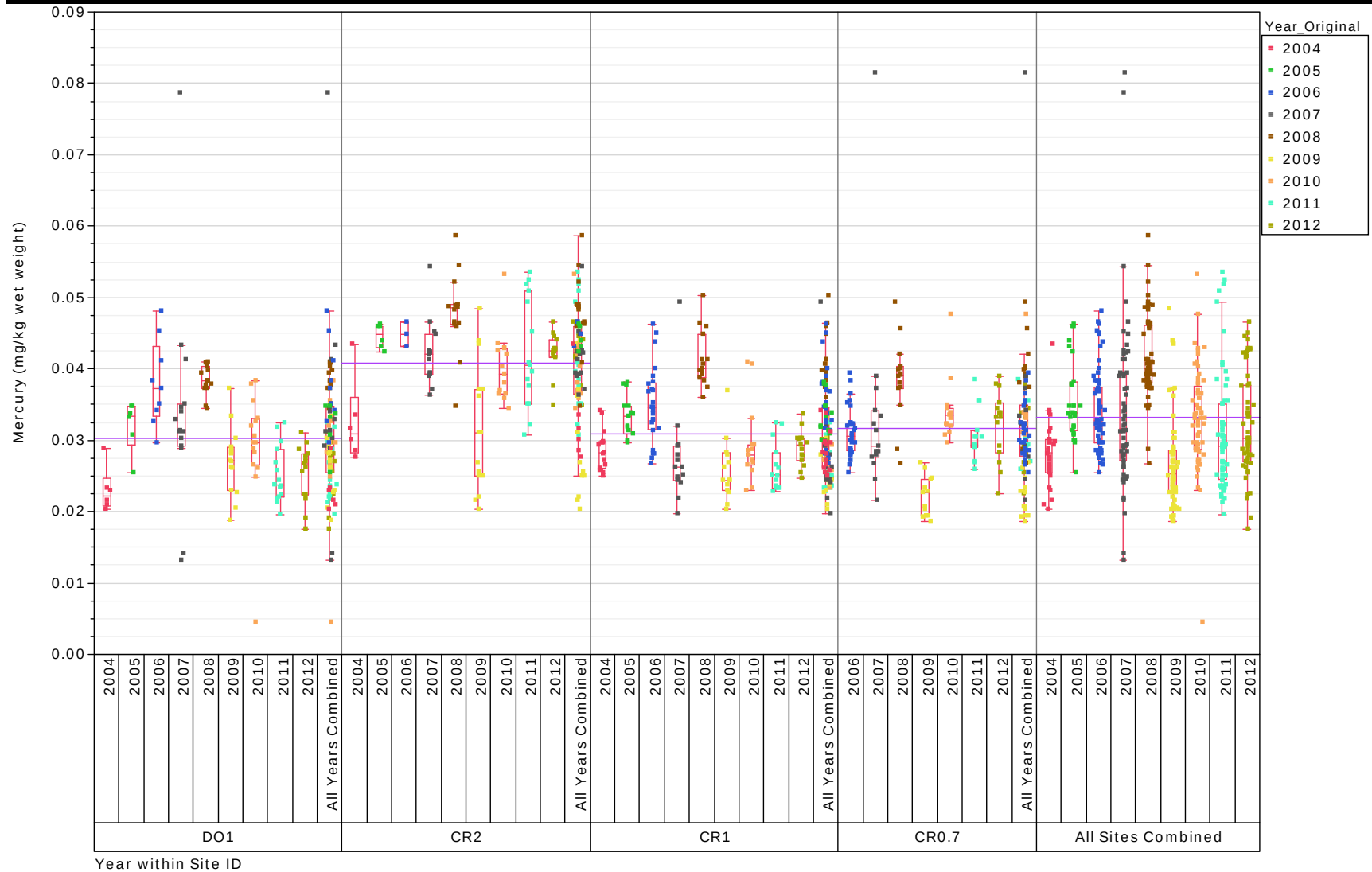


Figure 3.3-9 (Page 2 of 2)

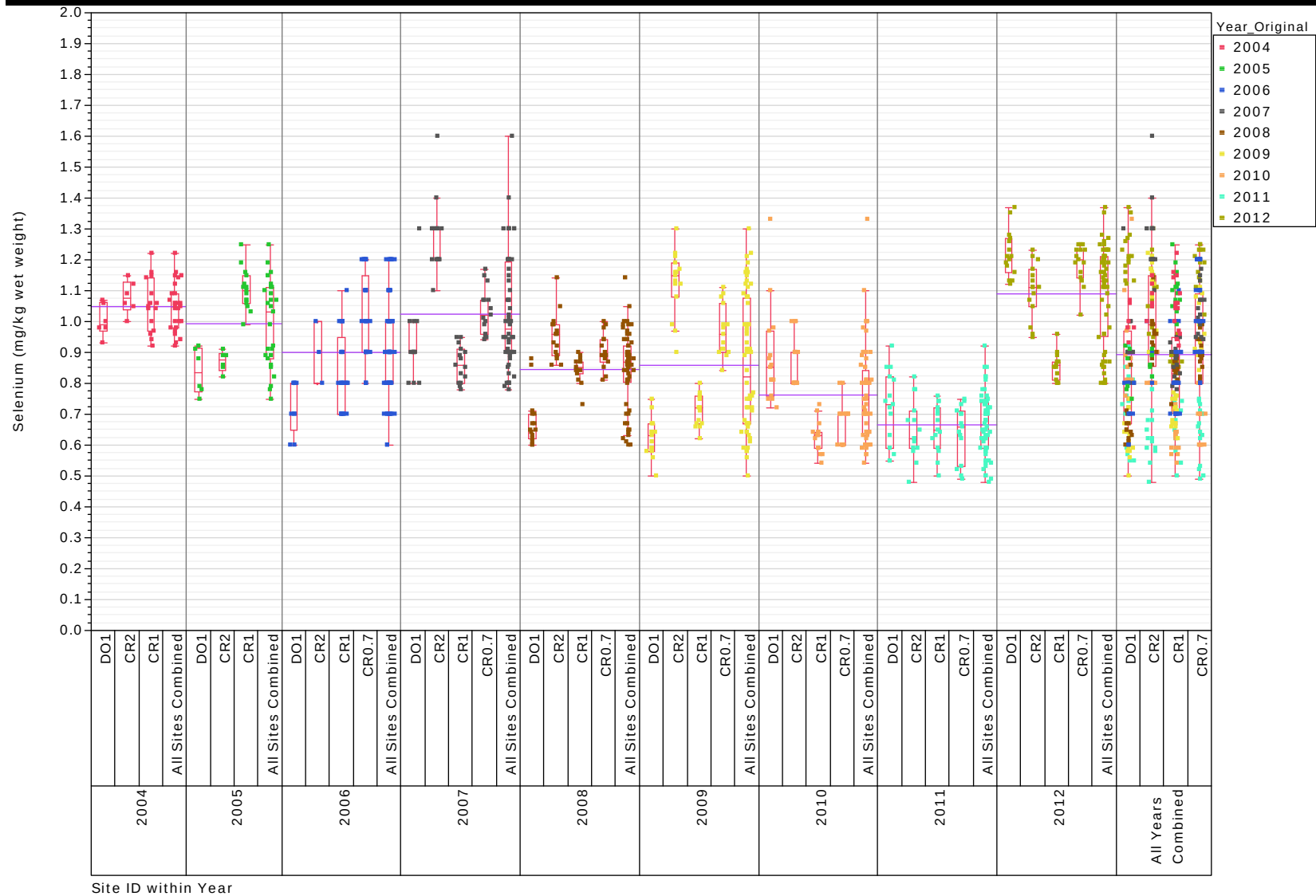
Mercury Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-10 (Page 1 of 2)

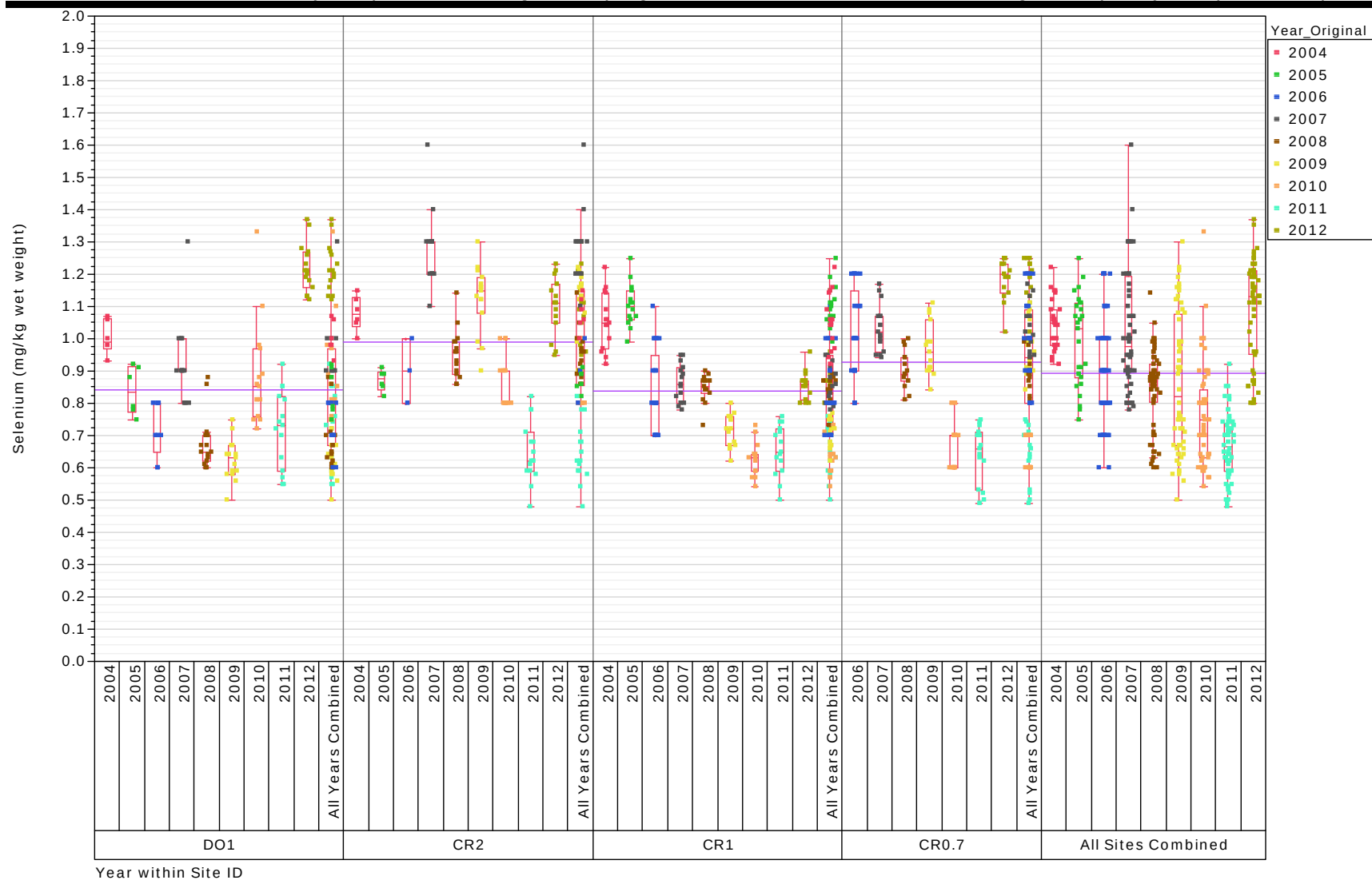
Selenium Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-10 (Page 2 of 2)

Selenium Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)

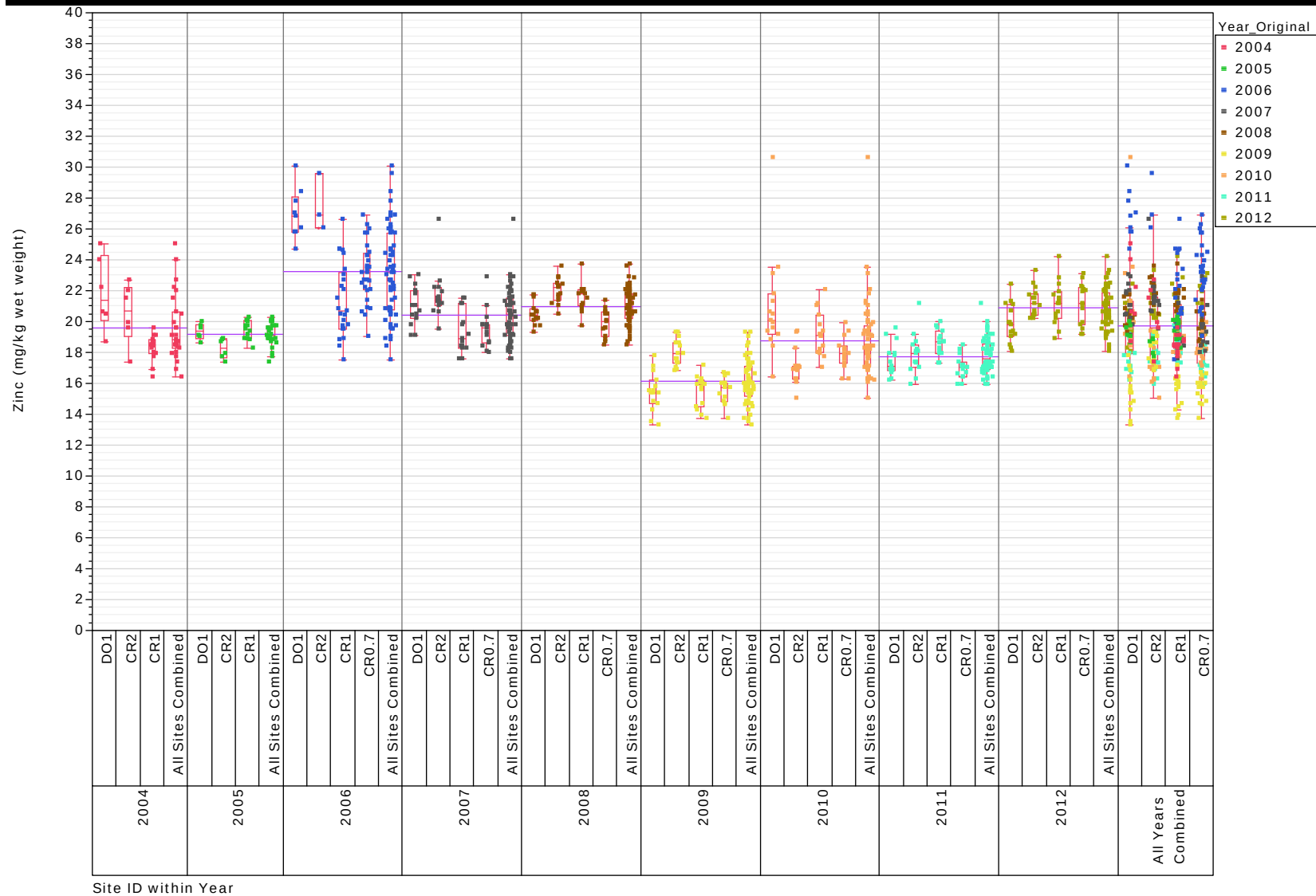


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-11 (Page 1 of 2)

Zinc Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Year (2004-2012)

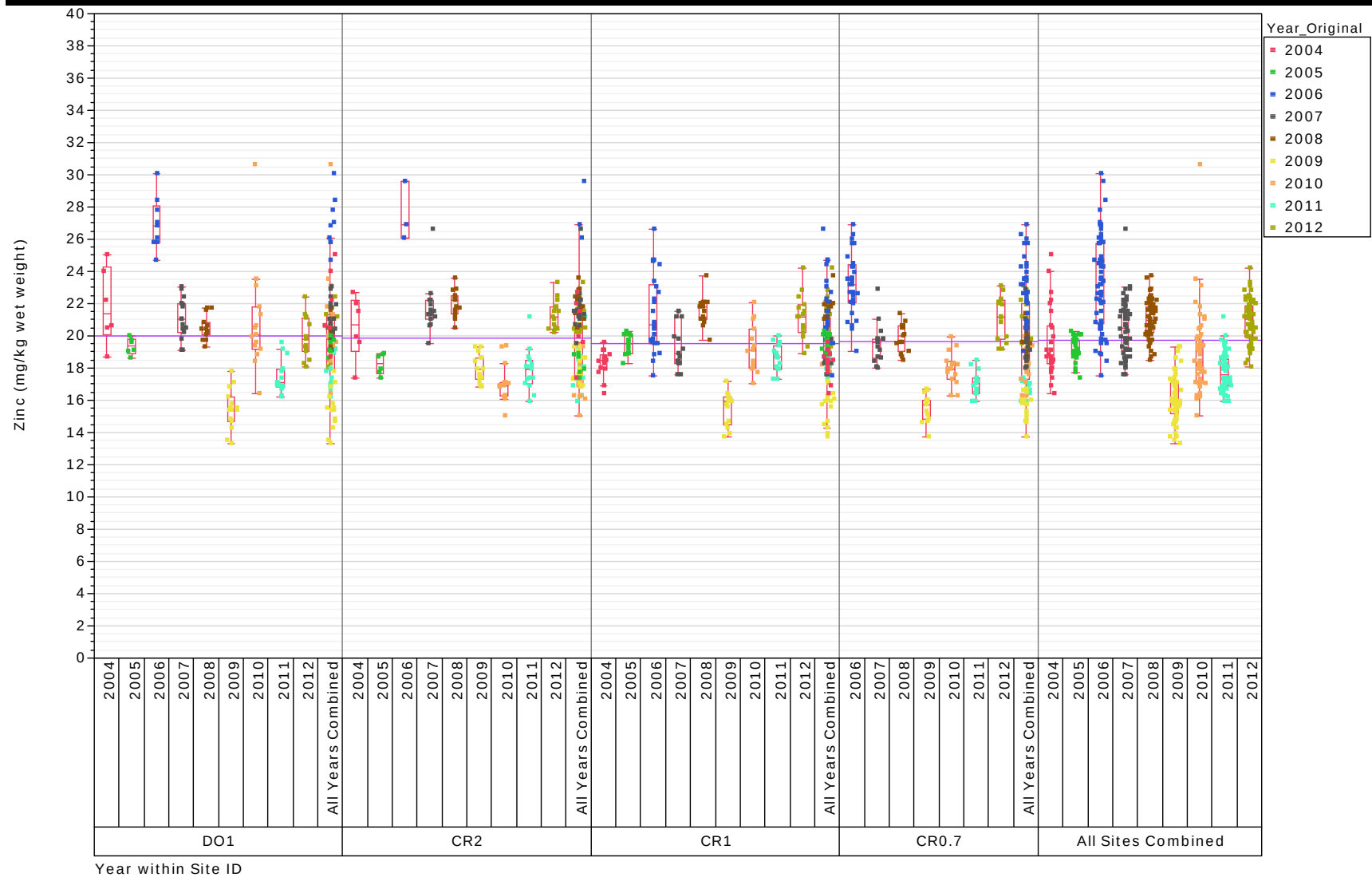


Notes:

Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 3.3-11 (Page 2 of 2)

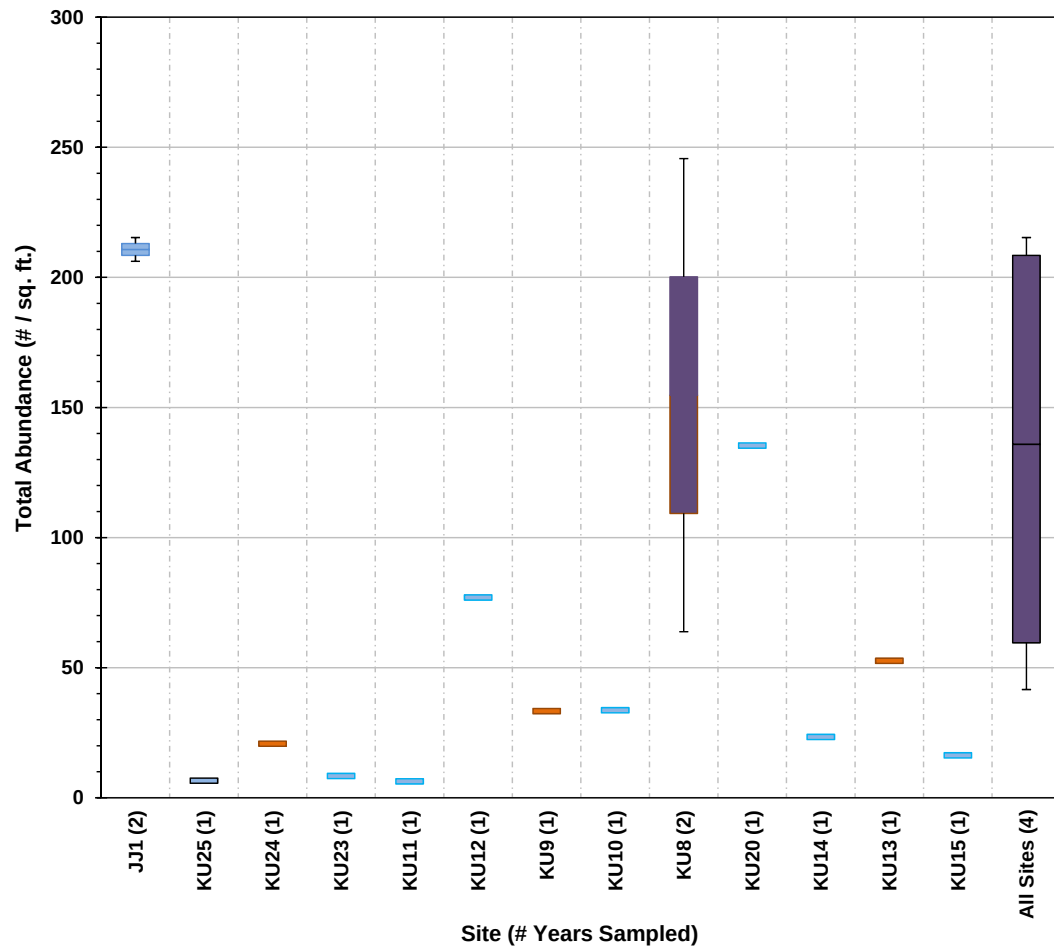
Zinc Concentrations in Slimy Sculpin <55mm Long at Sampling Sites within the Crooked Creek Drainage, Grouped by Site (2004-2012)



Notes:
Refer to Table 2.5-1 for method detection limits. — = Mean for grouping.

Figure 6.1-1

Macroinvertebrate Abundance for Sites near the Jungjuk Port Site and Along the Drainages Crossed by the Road Alternative, Grouped by Site (2007-2012)



Notes:

For sample site locations, refer to Figure 1.1-1.

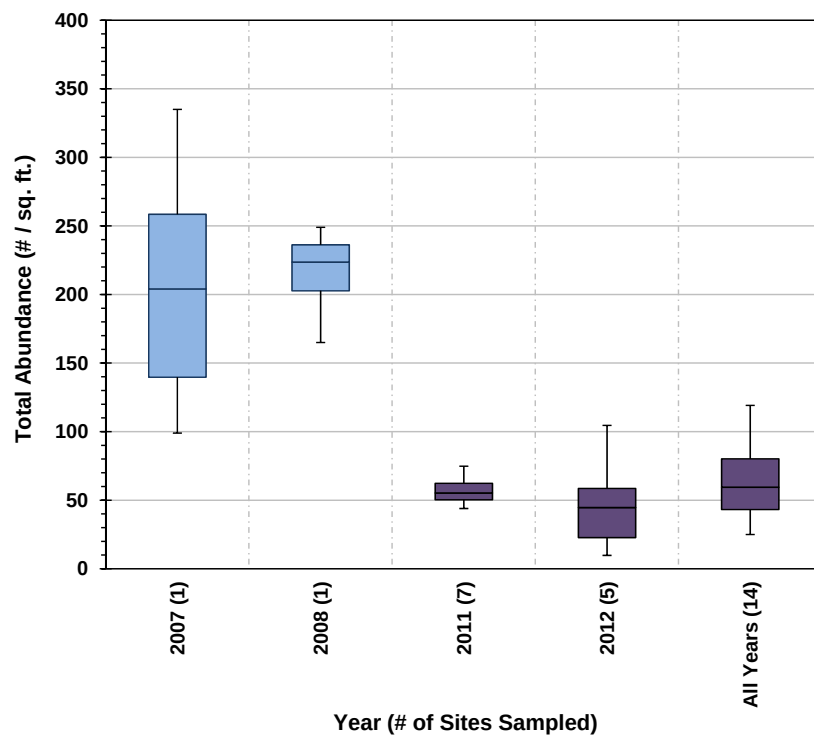
Both Ponar and Surber sampling methods used. Data were combined to form a composite data set.

Only Ponar sampling method used

Only Surber sampling method used

Figure 6.1-2

Macroinvertebrate Abundance for Sites near the Jungjuk Port Site and Along the Drainage Crossed by the Road Alternative, Grouped by Year (2007-2012)



Notes:

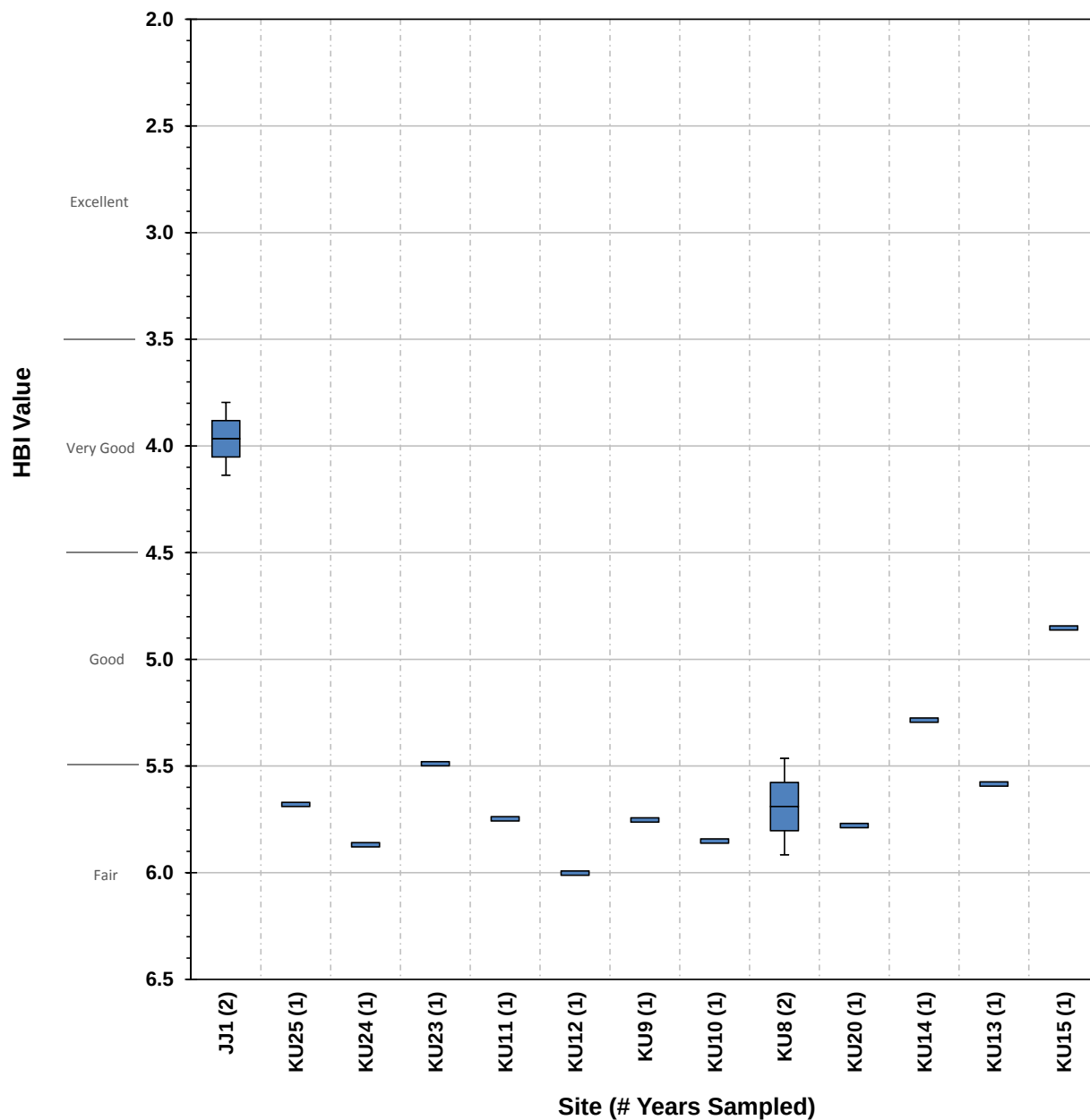
For sample site locations, refer to Figure 1.1-1.

Both Ponar and Surber sampling methods used. Data were combined to form a composite data set.

Only Surber sampling method used

Figure 6.1-3

Hilsenhoff Biotic Index (HBI)¹ for Aquatic Macroinvertebrates within the Road Alternative and Jungjuk Port Site (2007-2012)



Notes:

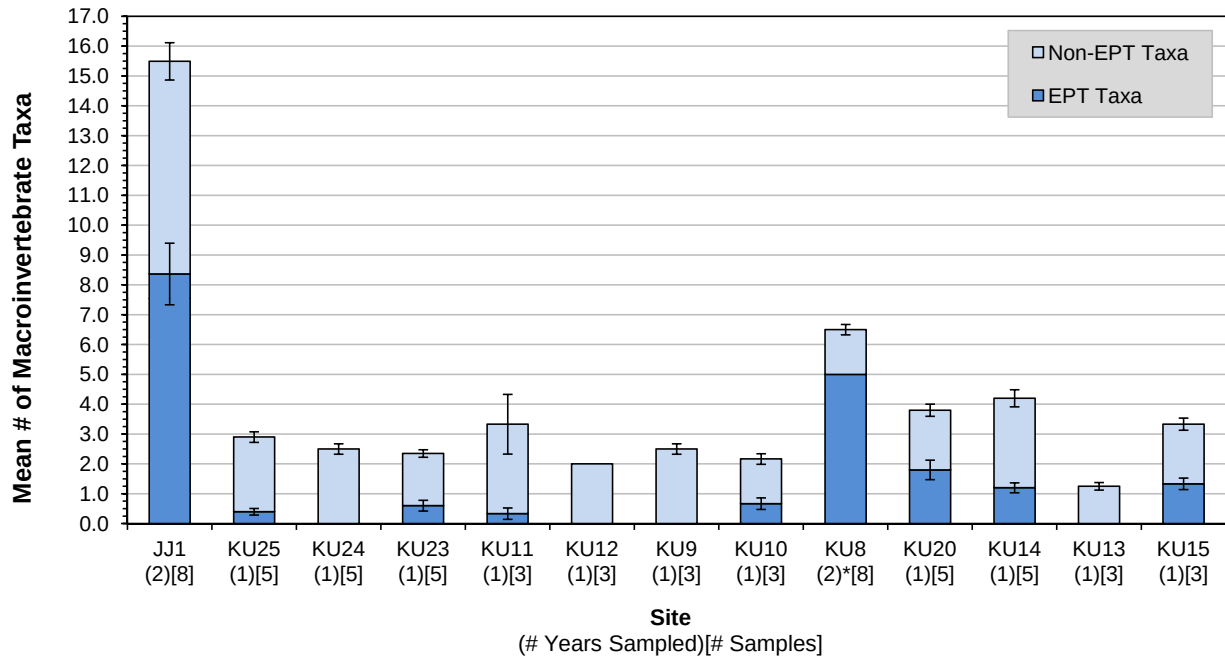
For sample site locations, refer to Figure 1.1-1.

1) The Hilsenhoff Biotic Index (HBI) was developed using tolerance values for macroinvertebrates in Wisconsin streams (Hilsenhoff 1987, 1988). HBI takes into account the tolerance value and number of individuals of each taxon in the sample and rates streams on a scale of 0 (excellent water quality) to 10 (polluted). Values are as follows: 0.00-3.50 (excellent), 3.51-4.50 (very good), 4.51-5.50 (good), 5.51-6.50 (fair), 6.51-7.50 (fairly poor), 7.51-8.50 (poor), and 8.51-10.00 (very poor).

2) Site KU8 was sampled by surber in 2011 and ponar in 2012.

Figure 6.1-4

Mean Number of EPT and Non-EPT Macroinvertebrate Taxa (Combined for Total Mean Number of Taxa) Found at Sites within the Road Alternative and the Jungjuk Port Site (2004-2012)



Notes:

For sample site locations, refer to Figure 1.1-1.

*Data set includes data collected using both Surber and Ponar sampling methods.

Error bars represent one standard error.

10.0 APPENDIX

Appendix A

Coordinates for Sampling Sites

Stream Name	Site	Latitude ¹	Longitude ¹	Status	Assessment Purpose
<u>Core Program Sites</u>					
Donlin Creek	DO1	62.09588	-158.16086	Existing Site	Reference Site
Flat Creek	FL1	62.07869	-158.22037	Existing Site	Reference Site
Dome Creek	DM1	62.08156	-158.15794	Existing Site	Reference Site
Quartz Gulch	QZ1	62.07806	-158.17928	Existing Site	Mine Facilities
Snow Gulch	SN1	62.06799	-158.19064	2006 Only	Mine Facilities
	SN2	62.06194	-158.18391	Existing Site	Mine Facilities
Queen Gulch	QU1	62.05879	-158.21972	Existing Site	Mine Facilities
Crooked Creek	CR2	62.04409	-158.25466	Existing Site	Mine Facilities
	CR1	61.99911	-158.26268	Existing Site	Mine Facilities
	CR0.3	61.87118	-158.12645	Existing Site	Mine Facilities
	CR0.7	61.98088	-158.26043	Existing Site	Mine Facilities
Lewis Gulch	LE1	62.04902	-158.22965	Existing Site	Mine Facilities
American Creek	AM1	62.03892	-158.24591	Existing Site	Mine Facilities
	AM2	62.02552	-158.19938	Existing Site	Mine Facilities
	AM3	62.01863	-158.13311	New Site for 2011	Pipeline Shoo-fly Road
	AM4	62.02816	-158.12154	New Site for 2011	Pipeline Shoo-fly Road
Grouse Creek	GR1	62.04477	-158.27194	Existing Site	Mine Facilities
Omega Gulch	OM1	62.02188	-158.24318	Existing Site	Mine Facilities
Anaconda Creek	AN1	61.99957	-158.25700	Existing Site	Mine Facilities
	AN2	62.00147	-158.19104	Existing Site	Mine Facilities
Crevice Creek	CV1	61.98334	-158.25012	Existing Site	Mine Facilities
Eagle Creek	EG1	61.98708	-158.27827	Existing Site	Jungjuk Road
Unnamed (BC)	BC1	61.96397	-158.25635	Existing Site	Winter Road
Unnamed (AC)	AC1	61.94896	-158.24227	Existing Site	Winter Road
Getmuna Creek	GM1	61.91521	-158.24043	Existing Site	Gravel Pit
	GM2	61.898705	-158.391377	New Site for 2012	Gravel Pit
	GM3	61.901276	-158.359436	New Site for 2012	Gravel Pit
	GM4	61.896945	-158.385648	New Site for 2012	Gravel Pit
Bell Creek	BL1	61.90735	-158.16523	New Site for 2011	Winter Road
Crooked Creek Weir	WE1	61.87749	-158.13988	Existing Site	Mine Facilities
<u>Road Alternative Program Sites</u>					
Jungjuk Creek	JJ1	61.79950	-158.24500	Existing Site	Jungjuk Road
<u>Bridge and Culvert Crossings</u>					
Getmuna Creek	BR 47	61.88687	-158.41989	New Site for 2012	Gravel Pit
	BR 48	61.87004	-158.42754	New Site for 2012	Gravel Pit
Unnamed	CU43	61.91800	-158.44490	2009 Sampling	Jungjuk Road
Unnamed (FN)	BR49	61.86810	-158.42450	2009 Sampling	Jungjuk Road
Jungjuk Creek	CU59	61.80121	-158.23113	New Site for 2011	Jungjuk Road
	CU60	61.80137	-158.25182	New Site for 2011	Jungjuk Road
	BR61	61.80220	-158.29241	New Site for 2011	Jungjuk Road
	CU62	61.80370	-158.30291	New Site for 2011	Jungjuk Road
	BR63	61.80815	-158.31324	New Site for 2011	Jungjuk Road
	BR3	62.02853	-158.25679	2009 Sampling	Jungjuk Road
<u>Jungjuk Port Site</u>					
Kuskokwim River	KU8	61.79439	-158.21512	New Site for 2011	Jungjuk Port Facility
	KU9	61.79013	-158.14374	New Site for 2011	Jungjuk Port Facility
	KU10	61.79132	-158.15800	New Site for 2011	Jungjuk Port Facility
	KU11	61.81474	-158.10905	New Site for 2011	Jungjuk Port Facility
	KU12	61.81309	-158.10804	New Site for 2011	Jungjuk Port Facility
	KU13	61.78708	-158.22296	New Site for 2011	Jungjuk Port Facility
	KU14	61.79012	-158.22011	New Site for 2011	Jungjuk Port Facility
	KU15	61.78554	-158.22408	New Site for 2011	Jungjuk Port Facility
	KU20	61.79288	-158.21815	New Site for 2012	Jungjuk Port Facility
	KU23	61.81601	-158.11394	New Site for 2012	Jungjuk Port Facility
	KU24	61.81731	-158.11326	New Site for 2012	Jungjuk Port Facility
	KU25	61.81805	-158.11248	New Site for 2012	Jungjuk Port Facility

Notes:

Refer to Figure 1.1-1 for a map of site locations.

1) Latitude and longitude are displayed in decimal degrees.

Appendix B

Sample Dates, Times, and Results of the Whole Effluent Toxicity (WET) Tests for Water Quality Parameters and Toxicity Tests for *Ceriodaphnia dubia*, and Fathead Minnows from Crooked Creek Site CR0.7 (2008)

Sample Collection		Sample Receipt		Lapsed Time (hh:mm)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Temp (°C)	pH	Alkalinity (mg/L)	Hardness (mg/L)	Ammonia (mg/L)	Chlorine (mg/L)
Date	Time	Date	Time									
7/29/2008	1835	7/31/2008	0800	37:25	241	12	1.2	8.5	97	238	0	<0.01
8/4/2008	NTR ¹	8/5/2008	1010	<34:10	365	12.5	3.9	8.2	122	155	0	<0.01
8/7/2008	1835	8/8/2008	1215	18:40	238	10.6	5.4	7.9	112	119	0	<0.01
9/22/2008	1017	9/23/2008	1420	30:03	251	9.5	2.1	8	113	123	0	<0.01
9/24/2008	0917	9/25/2008	0900	23:43	192	10.1	4.2	8.2	101	116	0	<0.01
9/26/2008	0850	9/27/2008	0930	24:40	198	10.4	4.8	8.3	109	118	0	<0.01
Mean					247.5	10.9	3.6	8.2	109.0	144.8		
SD					62.4	1.2	1.6	0.2	9.0	47.9		

Summary of Toxicity Test Results for *Ceriodaphnia dubia*

TC ²	% Adult Survival	Births		
		Mean	Min	Max
Control (0%)	90	19.7	0	30
12.5%	100	19.9	3	30
25.0%	80	23.9	0	36
50.0%	90	21.4	0	40
75.0%	100	25.2	15	33
100.0%	100	25.7	17	28

Notes:

1) NTR-No Time Recorded

2) TC-Toxic Concentration

Growth Results for Fathead Minnows (*Pimephales promelas*)

TC ²	% Survival	Dry Weight (mg)		
		Mean	Min	Max
Control (0%)	98	0.406	0.330	0.455
12.5%	95	0.400	0.357	0.438
25.0%	100	0.401	0.371	0.435
50.0%	100	0.455	0.388	0.483
75.0%	90	0.405	0.353	0.429
100.0%	95	0.433	0.352	0.495

Appendix C

Macroinvertebrate Bioassessment Metrics for Sites within the Crooked Creek Drainage (2004-2012)

Stream	Site	Year	General Metrics							Diversity Indices		Biotic Indices
			Total Abundance (# / ft²)	Total Taxa #	EPT Taxa #	EPT %	Dominant Taxa %	Chironomidae %	EPT Chironomidae Ratio	Shannon (H)	Evenness (e)	HBI
Donlin Creek	DO1	2004	151.20	19	11	19.18	72.49	72.49	0.26	1.28	0.44	5.22
		2005	319.20	20	13	53.20	37.41	37.41	1.42	2.10	0.70	4.14
		2006	348.40	20	10	12.51	77.04	77.04	0.16	1.10	0.37	5.53
		2007	27.60	19	10	36.23	18.84	18.84	1.92	2.49	0.84	4.49
		2008	168.20	23	14	35.43	49.35	49.35	0.72	1.98	0.63	4.64
		2009	392.40	22	13	27.93	69.06	69.06	0.40	1.27	0.41	4.93
		2010	592.60	28	15	20.25	69.36	69.36	0.29	1.35	0.41	5.22
		2011	100.00	13	9	32.00	49.20	49.20	0.65	1.70	0.66	4.74
		2012	99.40	18	11	39.64	49.50	49.50	0.80	1.84	0.64	4.58
		2012	99.40	18	11	39.64	49.50	49.50	0.80	1.84	0.64	4.58
Flat Creek	FL1	2004	380.80	21	13	9.03	76.58	76.58	0.12	1.09	0.36	5.62
		2005	540.80	22	13	28.22	59.10	59.10	0.48	1.51	0.49	5.04
		2006	400.40	20	11	22.18	54.80	54.80	0.40	1.63	0.55	5.17
		2007	339.67	20	11	22.77	35.82	35.82	0.64	2.05	0.68	4.63
		2008	267.60	17	10	25.49	36.32	22.42	1.14	1.77	0.62	4.39
		2009	1,063.60	20	11	15.78	75.87	75.87	0.21	0.96	0.32	5.31
		2009	73.80	18	10	46.88	20.87	13.28	3.53	2.16	0.75	3.60
Dome Creek	DM1	2009	237.80	15	7	68.38	40.54	15.73	4.35	1.87	0.69	2.96
		2009	259.20	15	6	51.70	45.37	42.28	1.22	1.21	0.45	3.41
Quartz Creek	QZ1	2009	108.00	15	7	26.11	54.81	54.81	0.48	1.54	0.57	4.71
Snow Gulch	SN2	2008	40.20	14	8	13.43	52.74	27.86	0.48	1.44	0.55	4.98
		2009	141.60	21	10	34.46	55.51	55.51	0.62	1.64	0.54	4.57
		2011	74.40	9	6	35.75	52.69	52.69	0.68	1.37	0.62	4.05
		2012	81.20	12	7	28.08	48.77	48.77	0.58	1.74	0.70	4.70
Queen Gulch	QU1	2010	435.33	13	4	59.04	25.11	14.24	4.15	1.75	0.68	3.93
Crooked Creek	CR2	2004	156.20	17	11	43.79	36.75	36.75	1.19	1.81	0.64	4.74
		2005	277.40	23	14	49.68	32.23	32.23	1.54	2.15	0.69	4.27
		2006	528.60	24	13	13.20	37.19	37.19	0.36	1.69	0.53	5.17
		2007	108.80	20	12	26.29	58.27	4.78	5.50	1.68	0.56	4.78
		2008	63.00	15	9	49.84	22.54	15.56	3.20	2.22	0.82	3.71
		2009	524.20	22	13	34.07	44.75	44.75	0.76	1.89	0.61	4.83
		2010	47.00	26	11	19.15	31.49	31.49	0.61	2.33	0.71	4.93
		2011	96.00	14	8	38.13	41.04	41.04	0.93	1.98	0.75	4.43
		2012	110.20	17	11	38.66	47.19	47.19	0.82	1.78	0.63	4.44
		2004	127.40	22	12	47.10	38.93	38.93	1.21	2.09	0.68	4.49
		2005	377.20	24	16	43.74	31.07	31.07	1.41	1.99	0.63	4.66
		2006	338.60	19	10	38.22	34.26	22.74	1.68	1.83	0.62	4.93
	CR1	2007	210.60	23	13	20.61	37.70	32.86	0.63	1.72	0.55	5.14
		2008	99.20	17	10	42.54	28.43	18.35	2.32	2.08	0.73	4.14
		2009	571.93	22	11	31.85	55.60	55.60	0.57	1.59	0.51	4.97
		2010	34.80	18	6	28.16	32.76	32.76	0.86	2.24	0.78	4.98
		2011	187.80	13	8	33.44	55.06	55.06	0.61	1.48	0.58	4.91
		2012	121.60	17	10	34.54	61.51	61.51	0.56	1.40	0.49	4.36
		2006	351.20	20	13	41.40	40.26	40.26	1.03	2.01	0.67	4.80
		2007	100.20	21	10	29.54	36.13	36.13	0.82	2.05	0.67	5.00
		2008	166.00	19	13	20.84	64.82	64.82	0.32	1.47	0.50	5.06
		2009	349.53	23	12	36.16	56.78	56.78	0.64	1.60	0.51	4.77
		2010	633.40	26	10	18.10	74.89	74.89	0.24	1.15	0.35	5.45
		2011	143.00	15	9	29.09	62.94	62.94	0.46	1.43	0.53	4.81
		2012	95.80	17	11	25.05	70.15	70.15	0.36	1.21	0.43	4.75
	CR0.7	2006	455.60	21	12	33.14	48.73	48.73	0.68	1.92	0.63	4.77
		2007	75.00	19	11	36.80	43.20	43.20	0.85	2.03	0.69	4.42
		2008	106.80	15	7	24.53	45.88	45.88	0.53	1.75	0.65	4.59
		2009	594.80	22	13	19.54	63.28	63.28	0.31	1.57	0.51	5.34
		2010	657.40	22	13	22.21	62.52	62.52	0.36	1.49	0.48	5.29
	CR0.3	2006	455.60	21	12	33.14	48.73	48.73	0.68	1.92	0.63	4.77
		2007	75.00	19	11	36.80	43.20	43.20	0.85	2.03	0.69	4.42
		2008	106.80	15	7	24.53	45.88	45.88	0.53	1.75	0.65	4.59
		2009	594.80	22	13	19.54	63.28	63.28	0.31	1.57	0.51	5.34
		2010	657.40	22	13	22.21	62.52	62.52	0.36	1.49	0.48	5.29
American Creek	AM1	2004	176.00	18	11	33.41	42.61	21.82	1.53	1.67	0.58	3.40
		2005	140.40	19	9	44.02	42.02	42.02	1.05	1.89	0.64	4.34
		2006	150.40	15	7	43.75	33.38	33.38	1.31	1.90	0.70	4.41
		2007	95.80	19	9	30.69	39.67	22.96	1.34	1.79	0.61	4.34
		2008	99.20	14	8	52.42	27.02	18.75	2.80	1.78	0.67	3.93
		2009	391.20	21	11	10.43	74.03	74.03	0.14	1.09	0.36	5.26
		2010	587.00	21	7	14.76	68.99	8.12	1.82	1.30	0.43	3.34
	AM2	2008	66.60	12	6	18.92	51.65	6.01	3.15	1.59	0.64	3.71
		2009	79.80	11	4	64.66	41.35	10.03	6.45	1.60	0.67	2.38
Grouse Creek	GR1	2008	48.20	12	7	76.76	36.51	11.62	6.61	1.89	0.76	3.39
Omega Gulch	OM1	2009	79.80	11	4	64.66	41.35	10.03	6.45	1.60	0.67	2.38
Anaconda Creek	AN1	2005	48.20	12	7	76.76	36.51	11.62	6.61	1.89	0.76	3.39
		2006	75.80	14	6	32.72	22.43	11.61	2.82	2.05	0.78	4.35
		2008	13.60	9	3	44.12	25.00	19.12	2.31	1.81	0.82	4.49
		2009	109.00	15	9	52.84	29.17	29.17	1.81	1.85	0.68	3.81
		2006	30.20	15	7	50.99	22.52	20.53	2.48	2.03	0.75	4.36
	AN2	2007	23.80	13	5	26.89	26.89	26.89	1.00	2.07	0.81	4.40
		2008	3.60	6	2	11.11	38.89	38.89	0.29	1.57	0.87	4.83
		2009	78.60	17	9	54.96	37.66	37.66	1.46	1.93	0.68	3.83
		2006	141.80	16	7	18.48	35.26	35.26	0.52	1.78	0.64	4.51
		2007	125.20	17	7	7.51	63.10	9.58	0.78	1.27	0.45	3.63
Crevice Creek	CV1	2008	47.20	15	9	38.14	46.61	1.27	30.00	1.71	0.63	3.45
		2009	184.80	14	8	20.78	55.19	21.65	0.96	1.34	0.51	3.78
Eagle Creek	EG1	2009	59.00	14	6	68.81	29.83	18.31	3.76	1.92	0.73	3.35
Getmuna Creek	GM1	2007	333.00	22	13	59.76	32.33	30.33	1.97	1.87	0.60	4.32
		2008	247.20	20	13	31.31	59.47	59.47	0.53	1.57	0.52	4.79
		2009	801.20	26	15	31.63	60.98	60.98	0.52	1.53	0.47	4.92
		2012	75.80	12	9	15.83	79.68	79.68	0.20	0.95	0.38	5.27
	GM2	2012	122.60	12	8	33.44	49.27	49.27	0.68	1.60	0.64	4.73
		2012	179.00	13	8	74.19	29.39	8.38	8.85	2.08	0.81	3.51
Bell Creek	BL1	2011	48.80	11	7	21.72	70.08	70.08	0.31	1.22	0.51	5.15
		2012	21.80	10	7	61.47	29.36	28.44	2.16	1.75	0.76	2.94

Notes:

For sample site locations, refer to Figure 1.1-1. Chironomidae genera grouped as one taxon for multi-year comparisons. Refer to the text for definitions of metrics.

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage
(2004-2012)

DO1.0						
<i>(n years=9) (n reps=45)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	244.3	168.2	27.6	592.6	181.3	0.7
# Taxa	20.2	20.0	13.0	28.0	4.1	0.2
# EPT Taxa	11.8	11.0	9.0	15.0	2.0	0.2
% EPT Taxa	30.7	32.0	12.5	53.2	12.4	0.4
% Dominant Taxon	54.7	49.5	18.8	77.0	19.1	0.3
% Chironomidae	54.7	49.5	18.8	77.0	19.1	0.3
EPT/Chironomidae Ratio	0.7	0.7	0.2	1.9	0.6	0.8
Diversity Indices						
Shannon (H)	1.68	1.70	1.10	2.49	0.46	0.28
Evenness (e)	0.57	0.63	0.37	0.84	0.17	0.29
Biotic Indices						
HBI	4.83	4.74	4.14	5.53	0.43	0.09
% Composition Per Order						
Ephemeroptera	20.51	21.74	9.99	39.72	10.09	0.49
Plecoptera	8.50	8.54	1.78	13.91	3.49	0.41
Trichoptera	1.70	1.27	0.20	6.52	1.90	1.12
Diptera	62.68	61.24	42.03	83.87	16.05	0.26
Oligochaeta	3.11	0.41	--	18.84	6.08	1.96
Acariformes	3.47	2.19	0.12	13.80	4.24	1.22
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	0.01	--	--	0.13	0.04	3.00
Collembola	0.01	--	--	0.05	0.02	2.04
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	0.01	--	--	0.10	0.03	3.00
Turbellaria	--	--	--	--	--	--
FL1.0						
<i>(n years =6) (n reps =28)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	498.8	390.6	267.6	1063.6	290.9	0.6
# Taxa	20.0	20.0	17.0	22.0	1.7	0.1
# EPT Taxa	11.5	11.0	10.0	13.0	1.2	0.1
% EPT Taxa	20.6	22.5	9.0	28.2	7.0	0.3
% Dominant Taxon	56.4	56.9	35.8	76.6	18.0	0.3
% Chironomidae	54.1	56.9	22.4	76.6	21.6	0.4
EPT/Chironomidae Ratio	0.5	0.4	0.1	1.1	0.4	0.7
Diversity Indices						
Shannon (H)	1.50	1.57	0.96	2.05	0.41	0.27
Evenness (e)	0.50	0.52	0.32	0.68	0.14	0.29
Biotic Indices						
HBI	5.03	5.10	4.39	5.62	0.45	0.09
% Composition Per Order						
Ephemeroptera	10.09	10.07	1.64	20.48	6.45	0.64
Plecoptera	9.23	9.41	2.99	15.16	5.01	0.54
Trichoptera	1.26	0.95	0.22	2.45	1.00	0.79
Diptera	74.56	72.19	62.91	85.66	8.41	0.11
Oligochaeta	1.24	0.84	0.36	2.69	0.92	0.75
Acariformes	3.63	3.89	0.37	8.25	2.86	0.79
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.00	--	--	0.02	0.01	2.45
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

DM1.0						
<i>(n years =2) (n reps =10)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	155.8	155.8	73.8	237.8	116.0	0.7
# Taxa	16.5	16.5	15.0	18.0	2.1	0.1
# EPT Taxa	8.5	8.5	7.0	10.0	2.1	0.2
% EPT Taxa	57.6	57.6	46.9	68.4	15.2	0.3
% Dominant Taxon	30.7	30.7	20.9	40.5	13.9	0.5
% Chironomidae	14.5	14.5	13.3	15.7	1.7	0.1
EPT/Chironomidae Ratio	3.9	3.9	3.5	4.3	0.6	0.1
Diversity Indices						
Shannon (H)	2.02	2.02	1.87	2.16	0.20	0.10
Evenness (e)	0.72	0.72	0.69	0.75	0.04	0.05
Biotic Indices						
HBI	3.28	3.28	2.96	3.60	0.45	0.14
% Composition Per Order						
Ephemeroptera	28.27	28.27	25.65	30.89	3.71	0.13
Plecoptera	29.10	29.10	15.72	42.47	18.92	0.65
Trichoptera	0.26	0.26	0.25	0.27	0.01	0.05
Diptera	32.07	32.07	24.31	39.84	10.98	0.34
Oligochaeta	9.07	9.07	5.13	13.01	5.57	0.61
Acariformes	0.04	0.04	--	0.08	0.06	1.41
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.08	0.08	--	0.17	0.12	1.41
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	1.10	1.10	0.27	1.93	1.18	1.07
QZ1.0						
<i>(n years =1) (n reps =5)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	259.2	259.2	259.2	259.2	--	--
# Taxa	15.0	15.0	15.0	15.0	--	--
# EPT Taxa	6.0	6.0	6.0	6.0	--	--
% EPT Taxa	51.7	51.7	51.7	51.7	--	--
% Dominant Taxon	45.4	45.4	45.4	45.4	--	--
% Chironomidae	42.3	42.3	42.3	42.3	--	--
EPT/Chironomidae Ratio	1.2	1.2	1.2	1.2	--	--
Diversity Indices						
Shannon (H)	1.21	1.21	1.21	1.21	--	--
Evenness (e)	0.45	0.45	0.45	0.45	--	--
Biotic Indices						
HBI	3.41	3.41	3.41	3.41	--	--
% Composition Per Order						
Ephemeroptera	0.85	0.85	0.85	0.85	--	--
Plecoptera	50.85	50.85	50.85	50.85	--	--
Trichoptera	--	--	--	--	--	--
Diptera	43.21	43.21	43.21	43.21	--	--
Oligochaeta	3.55	3.55	3.55	3.55	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.23	0.23	0.23	0.23	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	1.31	1.31	1.31	1.31	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

SN2.0						
<i>(n years =5) (n reps =25)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	89.1	81.2	40.2	141.6	38.0	0.4
# Taxa	14.2	14.0	9.0	21.0	4.4	0.3
# EPT Taxa	7.6	7.0	6.0	10.0	1.5	0.2
% EPT Taxa	27.6	28.1	13.4	35.8	8.9	0.3
% Dominant Taxon	52.9	52.7	48.8	55.5	2.6	0.0
% Chironomidae	47.9	52.7	27.9	55.5	11.5	0.2
EPT/Chironomidae Ratio	0.6	0.6	0.5	0.7	0.1	0.2
Diversity Indices						
Shannon (H)	1.55	1.54	1.37	1.74	0.15	0.10
Evenness (e)	0.60	0.57	0.54	0.70	0.07	0.11
Biotic Indices						
HBI	4.60	4.70	4.05	4.98	0.34	0.07
% Composition Per Order						
Ephemeroptera	12.80	13.55	7.46	16.81	3.42	0.27
Plecoptera	13.97	13.79	5.47	20.70	5.79	0.41
Trichoptera	0.80	0.74	--	1.67	0.62	0.79
Diptera	55.66	60.45	33.83	63.44	12.41	0.22
Oligochaeta	16.62	9.11	0.81	52.74	20.96	1.26
Acariformes	0.03	--	--	0.14	0.06	2.24
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.09	--	--	0.28	0.13	1.42
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	0.03	--	--	0.14	0.06	2.24
QU1.0						
<i>(n years =1) (n reps =3)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	435.3	435.3	435.3	435.3	--	--
# Taxa	13.0	13.0	13.0	13.0	--	--
# EPT Taxa	4.0	4.0	4.0	4.0	--	--
% EPT Taxa	59.0	59.0	59.0	59.0	--	--
% Dominant Taxon	25.1	25.1	25.1	25.1	--	--
% Chironomidae	14.2	14.2	14.2	14.2	--	--
EPT/Chironomidae Ratio	4.1	4.1	4.1	4.1	--	--
Diversity Indices						
Shannon (H)	1.75	1.75	1.75	1.75	--	--
Evenness (e)	0.68	0.68	0.68	0.68	--	--
Biotic Indices						
HBI	3.93	3.93	3.93	3.93	--	--
% Composition Per Order						
Ephemeroptera	24.04	24.04	24.04	24.04	--	--
Plecoptera	34.99	34.99	34.99	34.99	--	--
Trichoptera	--	--	--	--	--	--
Diptera	39.51	39.51	39.51	39.51	--	--
Oligochaeta	1.23	1.23	1.23	1.23	--	--
Acariformes	0.08	0.08	0.08	0.08	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	0.15	0.15	0.15	0.15	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage
(2004-2012)

CR2.0						
<i>(n years =9) (n reps =45)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	212.4	110.2	47.0	528.6	190.1	0.9
# Taxa	19.8	20.0	14.0	26.0	4.2	0.2
# EPT Taxa	11.3	11.0	8.0	14.0	1.9	0.2
% EPT Taxa	34.8	38.1	13.2	49.8	12.9	0.4
% Dominant Taxon	39.1	37.2	22.5	58.3	10.4	0.3
% Chironomidae	32.3	36.7	4.8	47.2	13.9	0.4
EPT/Chironomidae Ratio	1.7	0.9	0.4	5.5	1.7	1.0
Diversity Indices						
Shannon (H)	1.95	1.89	1.68	2.33	0.24	0.12
Evenness (e)	0.66	0.64	0.53	0.82	0.09	0.14
Biotic Indices						
HBI	4.59	4.74	3.71	5.17	0.43	0.09
% Composition Per Order						
Ephemeroptera	22.61	24.17	11.09	36.55	9.52	0.42
Plecoptera	10.51	9.23	1.02	26.35	7.44	0.71
Trichoptera	1.63	0.63	--	5.19	1.89	1.16
Diptera	57.58	54.67	38.50	81.04	13.12	0.23
Oligochaeta	3.51	2.55	0.38	11.62	3.57	1.02
Acariformes	3.21	2.55	0.18	11.25	3.55	1.11
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	0.39	--	--	3.40	1.13	2.93
Collembola	0.46	--	--	3.83	1.27	2.79
Copepoda	--	--	--	--	--	--
Gastropoda	0.01	--	--	0.08	0.03	3.00
Mollusca	--	--	--	--	--	--
Ostracoda	0.10	--	--	0.85	0.28	2.74
Turbellaria	--	--	--	--	--	--
CR1.0						
<i>(n years =9) (n reps =45)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	229.9	187.8	34.8	571.9	169.6	0.7
# Taxa	19.4	19.0	13.0	24.0	3.6	0.2
# EPT Taxa	10.7	10.0	6.0	16.0	2.9	0.3
% EPT Taxa	35.6	34.5	20.6	47.1	8.3	0.2
% Dominant Taxon	41.7	37.7	28.4	61.5	12.3	0.3
% Chironomidae	38.8	32.9	18.3	61.5	15.3	0.4
EPT/Chironomidae Ratio	1.1	0.9	0.6	2.3	0.6	0.6
Diversity Indices						
Shannon (H)	1.82	1.83	1.40	2.24	0.30	0.16
Evenness (e)	0.62	0.62	0.49	0.78	0.10	0.16
Biotic Indices						
HBI	4.73	4.91	4.14	5.14	0.34	0.07
% Composition Per Order						
Ephemeroptera	25.58	25.00	13.82	38.49	8.62	0.34
Plecoptera	7.54	5.49	1.72	18.42	6.03	0.80
Trichoptera	2.46	0.86	0.18	8.63	3.14	1.28
Diptera	59.90	60.13	50.08	75.12	7.37	0.12
Oligochaeta	1.61	1.92	--	2.87	1.06	0.66
Acariformes	2.03	1.11	0.07	10.86	3.39	1.67
Amphipoda	--	--	--	--	--	--
Cladocera	0.01	--	--	0.09	0.03	3.00
Coleoptera	0.39	--	--	3.45	1.15	2.91
Collembola	0.35	--	--	1.72	0.70	1.99
Copepoda	0.13	--	--	1.15	0.38	3.00
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

CR0.7						
<i>(n years =7) (n reps =35)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	262.7	166.0	95.8	633.4	196.1	0.7
# Taxa	20.1	20.0	15.0	26.0	3.7	0.2
# EPT Taxa	11.1	11.0	9.0	13.0	1.6	0.1
% EPT Taxa	28.6	29.1	18.1	41.4	8.2	0.3
% Dominant Taxon	58.0	62.9	36.1	74.9	14.7	0.3
% Chironomidae	58.0	62.9	36.1	74.9	14.7	0.3
EPT/Chironomidae Ratio	0.6	0.5	0.2	1.0	0.3	0.5
Diversity Indices						
Shannon (H)	1.56	1.47	1.15	2.05	0.36	0.23
Evenness (e)	0.52	0.51	0.35	0.67	0.12	0.23
Biotic Indices						
HBI	4.95	4.81	4.75	5.45	0.25	0.05
% Composition Per Order						
Ephemeroptera	17.47	14.10	7.79	32.63	8.80	0.50
Plecoptera	7.48	7.23	1.78	12.32	3.44	0.46
Trichoptera	3.25	1.54	0.84	8.54	3.00	0.92
Diptera	67.53	68.67	55.07	78.43	7.86	0.12
Oligochaeta	1.83	1.48	0.28	5.42	1.74	0.95
Acariformes	2.23	1.93	--	6.71	2.17	0.98
Amphipoda	--	--	--	--	--	--
Cladocera	0.01	--	--	0.04	0.01	2.65
Coleoptera	0.05	--	--	0.27	0.10	1.93
Collembola	0.12	--	--	0.38	0.17	1.50
Copepoda	0.01	--	--	0.07	0.03	2.65
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	0.02	--	--	0.13	0.05	2.65
Turbellaria	--	--	--	--	--	--
CR0.3						
<i>(n years =5) (n reps =25)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	377.9	455.6	75.0	657.4	272.2	0.7
# Taxa	19.8	21.0	15.0	22.0	2.9	0.1
# EPT Taxa	11.2	12.0	7.0	13.0	2.5	0.2
% EPT Taxa	27.2	24.5	19.5	36.8	7.4	0.3
% Dominant Taxon	52.7	48.7	43.2	63.3	9.5	0.2
% Chironomidae	52.7	48.7	43.2	63.3	9.5	0.2
EPT/Chironomidae Ratio	0.5	0.5	0.3	0.9	0.2	0.4
Diversity Indices						
Shannon (H)	1.75	1.75	1.49	2.03	0.23	0.13
Evenness (e)	0.59	0.63	0.48	0.69	0.09	0.15
Biotic Indices						
HBI	4.88	4.77	4.42	5.34	0.42	0.09
% Composition Per Order						
Ephemeroptera	14.76	13.48	8.61	24.54	5.87	0.40
Plecoptera	8.87	6.98	2.32	15.92	6.58	0.74
Trichoptera	3.61	3.36	--	7.73	3.04	0.84
Diptera	63.77	57.30	52.53	76.16	11.41	0.18
Oligochaeta	6.65	5.87	0.52	18.16	6.97	1.05
Acariformes	2.32	2.52	--	4.80	1.82	0.78
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	0.02	--	--	0.09	0.04	2.24
Turbellaria	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

AM1.0						
<i>(n years =6) (n reps =30)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	175.5	145.4	95.8	391.2	110.1	0.6
# Taxa	17.7	18.5	14.0	21.0	2.7	0.2
# EPT Taxa	9.2	9.0	7.0	11.0	1.6	0.2
% EPT Taxa	35.8	38.6	10.4	52.4	14.7	0.4
% Dominant Taxon	43.1	40.8	27.0	74.0	16.3	0.4
% Chironomidae	35.5	28.2	18.8	74.0	20.8	0.6
EPT/Chironomidae Ratio	1.4	1.3	0.1	2.8	0.9	0.6
Diversity Indices						
Shannon (H)	1.69	1.79	1.09	1.90	0.30	0.18
Evenness (e)	0.59	0.63	0.36	0.70	0.12	0.21
Biotic Indices						
HBI	4.28	4.34	3.40	5.26	0.61	0.14
% Composition Per Order						
Ephemeroptera	27.65	28.64	5.57	47.38	14.03	0.51
Plecoptera	7.43	6.87	4.44	12.50	3.03	0.41
Trichoptera	0.70	0.38	--	2.71	1.00	1.43
Diptera	48.01	42.54	20.16	88.45	25.35	0.53
Oligochaeta	15.71	13.02	0.68	39.67	15.63	1.00
Acariformes	0.38	0.23	0.11	0.84	0.31	0.82
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	0.03	--	--	0.21	0.09	2.45
Collembola	0.03	--	--	0.14	0.06	1.79
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	0.04	--	--	0.20	0.08	1.92
AM2.0						
<i>(n years =1) (n reps =3)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	587.0	587.0	587.0	587.0	--	--
# Taxa	21.0	21.0	21.0	21.0	--	--
# EPT Taxa	7.0	7.0	7.0	7.0	--	--
% EPT Taxa	14.8	14.8	14.8	14.8	--	--
% Dominant Taxon	69.0	69.0	69.0	69.0	--	--
% Chironomidae	8.1	8.1	8.1	8.1	--	--
EPT/Chironomidae Ratio	1.8	1.8	1.8	1.8	--	--
Diversity Indices						
Shannon (H)	1.30	1.30	1.30	1.30	--	--
Evenness (e)	0.43	0.43	0.43	0.43	--	--
Biotic Indices						
HBI	3.34	3.34	3.34	3.34	--	--
% Composition Per Order						
Ephemeroptera	8.23	8.23	8.23	8.23	--	--
Plecoptera	6.02	6.02	6.02	6.02	--	--
Trichoptera	0.51	0.51	0.51	0.51	--	--
Diptera	80.92	80.92	80.92	80.92	--	--
Oligochaeta	3.12	3.12	3.12	3.12	--	--
Acariformes	0.17	0.17	0.17	0.17	--	--
Amphipoda	0.17	0.17	0.17	0.17	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.11	0.11	0.11	0.11	--	--
Copepoda	0.06	0.06	0.06	0.06	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	0.68	0.68	0.68	0.68	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

GR1.0						
<i>(n years =1) (n reps =5)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	66.6	66.6	66.6	66.6	--	--
# Taxa	12.0	12.0	12.0	12.0	--	--
# EPT Taxa	6.0	6.0	6.0	6.0	--	--
% EPT Taxa	18.9	18.9	18.9	18.9	--	--
% Dominant Taxon	51.7	51.7	51.7	51.7	--	--
% Chironomidae	6.0	6.0	6.0	6.0	--	--
EPT/Chironomidae Ratio	3.2	3.2	3.2	3.2	--	--
Diversity Indices						
Shannon (H)	1.59	1.59	1.59	1.59	--	--
Evenness (e)	0.64	0.64	0.64	0.64	--	--
Biotic Indices						
HBI	3.71	3.71	3.71	3.71	--	--
% Composition Per Order						
Ephemeroptera	16.22	16.22	16.22	16.22	--	--
Plecoptera	2.40	2.40	2.40	2.40	--	--
Trichoptera	0.30	0.30	0.30	0.30	--	--
Diptera	64.86	64.86	64.86	64.86	--	--
Oligochaeta	16.22	16.22	16.22	16.22	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
OM1.0						
<i>(n years =1) (n reps =5)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	79.8	79.8	79.8	79.8	--	--
# Taxa	11.0	11.0	11.0	11.0	--	--
# EPT Taxa	4.0	4.0	4.0	4.0	--	--
% EPT Taxa	64.7	64.7	64.7	64.7	--	--
% Dominant Taxon	41.4	41.4	41.4	41.4	--	--
% Chironomidae	10.0	10.0	10.0	10.0	--	--
EPT/Chironomidae Ratio	6.5	6.5	6.5	6.5	--	--
Diversity Indices						
Shannon (H)	1.60	1.60	1.60	1.60	--	--
Evenness (e)	0.67	0.67	0.67	0.67	--	--
Biotic Indices						
HBI	2.38	2.38	2.38	2.38	--	--
% Composition Per Order						
Ephemeroptera	0.25	0.25	0.25	0.25	--	--
Plecoptera	64.41	64.41	64.41	64.41	--	--
Trichoptera	--	--	--	--	--	--
Diptera	16.54	16.54	16.54	16.54	--	--
Oligochaeta	17.29	17.29	17.29	17.29	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	1.25	1.25	1.25	1.25	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	0.25	0.25	0.25	0.25	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

AN1.0						
<i>(n years =4) (n reps =20)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	61.7	62.0	13.6	109.0	40.5	0.7
# Taxa	12.5	13.0	9.0	15.0	2.6	0.2
# EPT Taxa	6.3	6.5	3.0	9.0	2.5	0.4
% EPT Taxa	51.6	48.5	32.7	76.8	18.7	0.4
% Dominant Taxon	28.3	27.1	22.4	36.5	6.2	0.2
% Chironomidae	17.9	15.4	11.6	29.2	8.3	0.5
EPT/Chironomidae Ratio	3.4	2.6	1.8	6.6	2.2	0.6
Diversity Indices						
Shannon (H)	1.90	1.87	1.81	2.05	0.11	0.06
Evenness (e)	0.76	0.77	0.68	0.82	0.06	0.08
Biotic Indices						
HBI	4.01	4.08	3.39	4.49	0.51	0.13
% Composition Per Order						
Ephemeroptera	30.07	31.38	16.36	41.18	10.49	0.35
Plecoptera	11.21	11.86	2.94	18.17	7.05	0.63
Trichoptera	10.33	0.54	--	40.25	19.95	1.93
Diptera	31.69	34.61	14.52	43.01	12.83	0.40
Oligochaeta	15.25	14.88	6.22	25.00	9.84	0.65
Acariformes	0.95	0.66	--	2.49	1.20	1.26
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.50	0.26	--	1.47	0.69	1.39
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
AN2.0						
<i>(n years =4) (n reps =20)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	34.1	27.0	3.6	78.6	31.8	0.9
# Taxa	12.8	14.0	6.0	17.0	4.8	0.4
# EPT Taxa	5.8	6.0	2.0	9.0	3.0	0.5
% EPT Taxa	36.0	38.9	11.1	55.0	20.7	0.6
% Dominant Taxon	31.5	32.3	22.5	38.9	8.1	0.3
% Chironomidae	31.0	32.3	20.5	38.9	8.8	0.3
EPT/Chironomidae Ratio	1.3	1.2	0.3	2.5	0.9	0.7
Diversity Indices						
Shannon (H)	1.90	1.98	1.57	2.07	0.23	0.12
Evenness (e)	0.78	0.78	0.68	0.87	0.08	0.10
Biotic Indices						
HBI	4.36	4.38	3.83	4.83	0.41	0.09
% Composition Per Order						
Ephemeroptera	17.99	16.02	2.52	37.40	16.76	0.93
Plecoptera	14.80	14.90	5.56	23.84	7.48	0.51
Trichoptera	3.20	1.35	--	10.08	4.67	1.46
Diptera	46.58	44.60	30.46	66.67	15.33	0.33
Oligochaeta	15.26	17.88	3.05	22.22	8.99	0.59
Acariformes	1.62	1.26	--	3.97	1.97	1.21
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	0.55	0.33	--	1.53	0.72	1.32

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

CV1.0						
<i>(n years =4) (n reps =20)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	124.8	133.5	47.2	184.8	57.5	0.5
# Taxa	15.5	15.5	14.0	17.0	1.3	0.1
# EPT Taxa	7.8	7.5	7.0	9.0	1.0	0.1
% EPT Taxa	21.2	19.6	7.5	38.1	12.7	0.6
% Dominant Taxon	50.0	50.9	35.3	63.1	11.9	0.2
% Chironomidae	16.9	15.6	1.3	35.3	14.8	0.9
EPT/Chironomidae Ratio	8.1	0.9	0.5	30.0	14.6	1.8
Diversity Indices						
Shannon (H)	1.52	1.52	1.27	1.78	0.26	0.17
Evenness (e)	0.56	0.57	0.45	0.64	0.09	0.17
Biotic Indices						
HBI	3.84	3.70	3.45	4.51	0.47	0.12
% Composition Per Order						
Ephemeroptera	18.09	16.98	4.47	33.90	12.10	0.67
Plecoptera	3.03	3.03	1.83	4.24	0.98	0.32
Trichoptera	0.11	--	--	0.42	0.21	2.00
Diptera	66.79	70.10	50.00	76.95	12.25	0.18
Oligochaeta	11.45	13.48	2.06	16.77	6.58	0.58
Acariformes	0.44	0.45	--	0.85	0.45	1.02
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.06	0.05	--	0.14	0.07	1.17
Copepoda	--	--	--	--	--	--
Gastropoda	0.04	--	--	0.16	0.08	2.00
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
EG1.0						
<i>(n years =1) (n reps =5)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	59.0	59.0	59.0	59.0	--	--
# Taxa	14.0	14.0	14.0	14.0	--	--
# EPT Taxa	6.0	6.0	6.0	6.0	--	--
% EPT Taxa	68.8	68.8	68.8	68.8	--	--
% Dominant Taxon	29.8	29.8	29.8	29.8	--	--
% Chironomidae	18.3	18.3	18.3	18.3	--	--
EPT/Chironomidae Ratio	3.8	3.8	3.8	3.8	--	--
Diversity Indices						
Shannon (H)	1.92	1.92	1.92	1.92	--	--
Evenness (e)	0.73	0.73	0.73	0.73	--	--
Biotic Indices						
HBI	3.35	3.35	3.35	3.35	--	--
% Composition Per Order						
Ephemeroptera	15.59	15.59	15.59	15.59	--	--
Plecoptera	30.85	30.85	30.85	30.85	--	--
Trichoptera	22.37	22.37	22.37	22.37	--	--
Diptera	23.73	23.73	23.73	23.73	--	--
Oligochaeta	4.75	4.75	4.75	4.75	--	--
Acariformes	0.68	0.68	0.68	0.68	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	0.34	0.34	0.34	0.34	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	1.69	1.69	1.69	1.69	--	--

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Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)

GM1.0						
<i>(n years =3) (n reps =13)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	460.5	333.0	247.2	801.2	298.2	0.6
# Taxa	22.7	22.0	20.0	26.0	3.1	0.1
# EPT Taxa	13.7	13.0	13.0	15.0	1.2	0.1
% EPT Taxa	40.9	31.6	31.3	59.8	16.3	0.4
% Dominant Taxon	50.9	59.5	32.3	61.0	16.1	0.3
% Chironomidae	50.3	59.5	30.3	61.0	17.3	0.3
EPT/Chironomidae Ratio	1.0	0.5	0.5	2.0	0.8	0.8
Diversity Indices						
Shannon (H)	1.66	1.57	1.53	1.87	0.18	0.11
Evenness (e)	0.53	0.52	0.47	0.60	0.07	0.13
Biotic Indices						
HBI	4.68	4.79	4.32	4.92	0.31	0.07
% Composition Per Order						
Ephemeroptera	22.90	21.93	19.62	27.16	3.86	0.17
Plecoptera	6.38	6.81	3.20	9.14	3.00	0.47
Trichoptera	11.62	1.27	0.24	33.33	18.81	1.62
Diptera	55.39	64.89	34.23	67.05	18.35	0.33
Oligochaeta	1.63	0.90	0.52	3.48	1.61	0.98
Acariformes	1.98	0.72	0.32	4.90	2.54	1.28
Amphipoda	--	--	--	--	--	--
Cladocera	0.03	--	--	0.10	0.06	1.73
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	0.03	--	--	0.10	0.06	1.73
Turbellaria	0.02	--	--	0.07	0.04	1.73
GM2.0						
<i>(n years =1) (n reps =5)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	75.8	75.8	75.8	75.8	--	--
# Taxa	12.0	12.0	12.0	12.0	--	--
# EPT Taxa	9.0	9.0	9.0	9.0	--	--
% EPT Taxa	15.8	15.8	15.8	15.8	--	--
% Dominant Taxon	79.7	79.7	79.7	79.7	--	--
% Chironomidae	79.7	79.7	79.7	79.7	--	--
EPT/Chironomidae Ratio	0.2	0.2	0.2	0.2	--	--
Diversity Indices						
Shannon (H)	0.95	0.95	0.95	0.95	--	--
Evenness (e)	0.38	0.38	0.38	0.38	--	--
Biotic Indices						
HBI	5.27	5.27	5.27	5.27	--	--
% Composition Per Order						
Ephemeroptera	6.33	6.33	6.33	6.33	--	--
Plecoptera	5.01	5.01	5.01	5.01	--	--
Trichoptera	4.49	4.49	4.49	4.49	--	--
Diptera	80.21	80.21	80.21	80.21	--	--
Oligochaeta	3.96	3.96	3.96	3.96	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--

Appendix D (Page 11 of 12)

Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage
(2004-2012)

GM3.0						
<i>(n years =1) (n reps =5)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	122.6	122.6	122.6	122.6	--	--
# Taxa	12.0	12.0	12.0	12.0	--	--
# EPT Taxa	8.0	8.0	8.0	8.0	--	--
% EPT Taxa	33.4	33.4	33.4	33.4	--	--
% Dominant Taxon	49.3	49.3	49.3	49.3	--	--
% Chironomidae	49.3	49.3	49.3	49.3	--	--
EPT/Chironomidae Ratio	0.7	0.7	0.7	0.7	--	--
Diversity Indices						
Shannon (H)	1.60	1.60	1.60	1.60	--	--
Evenness (e)	0.64	0.64	0.64	0.64	--	--
Biotic Indices						
HBI	4.73	4.73	4.73	4.73	--	--
% Composition Per Order						
Ephemeroptera	29.20	29.20	29.20	29.20	--	--
Plecoptera	4.08	4.08	4.08	4.08	--	--
Trichoptera	0.16	0.16	0.16	0.16	--	--
Diptera	50.08	50.08	50.08	50.08	--	--
Oligochaeta	16.31	16.31	16.31	16.31	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	0.16	0.16	0.16	0.16	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--
GM4.0						
<i>(n years =1) (n reps =5)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	179.0	179.0	179.0	179.0	--	--
# Taxa	13.0	13.0	13.0	13.0	--	--
# EPT Taxa	8.0	8.0	8.0	8.0	--	--
% EPT Taxa	74.2	74.2	74.2	74.2	--	--
% Dominant Taxon	29.4	29.4	29.4	29.4	--	--
% Chironomidae	8.4	8.4	8.4	8.4	--	--
EPT/Chironomidae Ratio	8.9	8.9	8.9	8.9	--	--
Diversity Indices						
Shannon (H)	2.08	2.08	2.08	2.08	--	--
Evenness (e)	0.81	0.81	0.81	0.81	--	--
Biotic Indices						
HBI	3.51	3.51	3.51	3.51	--	--
% Composition Per Order						
Ephemeroptera	63.69	63.69	63.69	63.69	--	--
Plecoptera	10.50	10.50	10.50	10.50	--	--
Trichoptera	--	--	--	--	--	--
Diptera	14.19	14.19	14.19	14.19	--	--
Oligochaeta	11.62	11.62	11.62	11.62	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--

Appendix D (Page 12 of 12)**Macroinvertebrate Bioassessment Summary Statistics for Sites within the Crooked Creek Drainage (2004-2012)**

BL1.0						
<i>(n years =2) (n reps =10)</i>	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	35.3	35.3	21.8	48.8	19.1	0.5
# Taxa	10.5	10.5	10.0	11.0	0.7	0.1
# EPT Taxa	7.0	7.0	7.0	7.0	--	--
% EPT Taxa	41.6	41.6	21.7	61.5	28.1	0.7
% Dominant Taxon	49.7	49.7	29.4	70.1	28.8	0.6
% Chironomidae	49.3	49.3	28.4	70.1	29.4	0.6
EPT/Chironomidae Ratio	1.2	1.2	0.3	2.2	1.3	1.1
Diversity Indices						
Shannon (H)	1.49	1.49	1.22	1.75	0.37	0.25
Evenness (e)	0.64	0.64	0.51	0.76	0.18	0.28
Biotic Indices						
HBI	4.04	4.04	2.94	5.15	1.56	0.39
% Composition Per Order						
Ephemeroptera	17.66	17.66	11.48	23.85	8.75	0.50
Plecoptera	21.18	21.18	10.25	32.11	15.46	0.73
Trichoptera	2.75	2.75	--	5.50	3.89	1.41
Diptera	50.79	50.79	30.28	71.31	29.02	0.57
Oligochaeta	4.74	4.74	1.23	8.26	4.97	1.05
Acariformes	2.87	2.87	--	5.74	4.06	1.41
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
Turbellaria	--	--	--	--	--	--

Notes:

For sample site locations, refer to Figure 1.1-1. Chironomidae genera grouped as one taxon for multi-year comparisons.

1) Refer to the text for definitions of metrics.

n years = Number of years site has been sampled

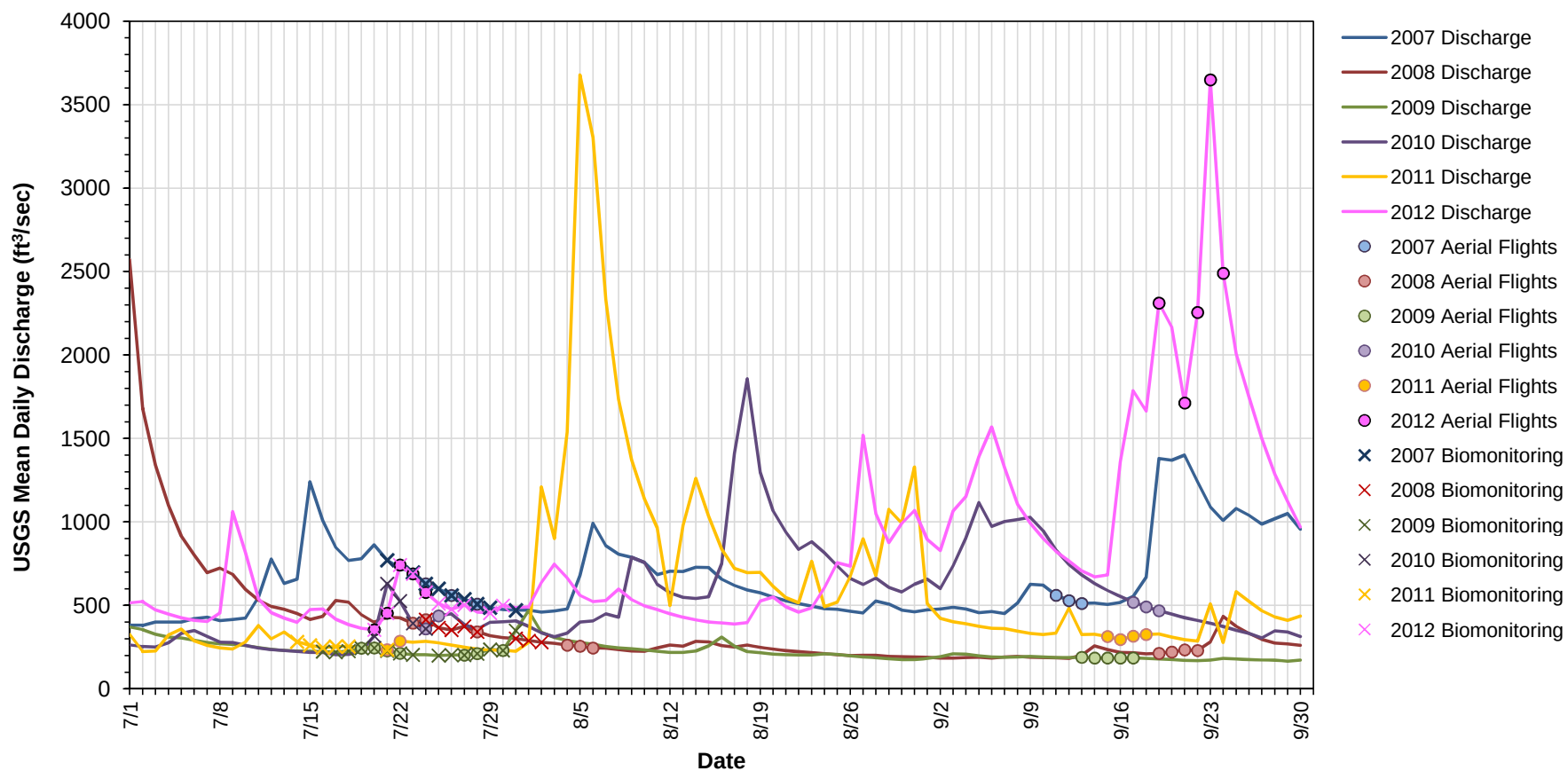
n reps = Total number of replicates sampled

SD = Standard deviation of the mean; CV = Coefficient of variance of the mean

Mean = Average of all samples for all years

Appendix E

Mean Daily Discharge, Aerial, and Biomonitoring Survey Dates for Crooked Creek (July through September, 2007-2012)



Notes:

Discharge data was collected from USGS gauge 15304010 CROOKED C AB AIRPORT RD NR CROOKED CREEK, AK.

Appendix F

Crooked Creek Aerial Salmon Redd Counts (2009-2012)

Stream Name	Reach ID	Survey Year	Summer	Fall	Stream Name	Reach ID	Survey Year	Summer	Fall
Donlin Creek	DOR1	2009	0	21	American Creek	AMR1	2009	0	0
		2010	0	3			2010	0	0
		2011	2	16			2011	0	1
		2012	0	0			2012	0	0
	DOR2	2009	0	23	Anaconda Creek	ANR1	2009	0	0
		2010	0	5			2010	0	0
		2011	2	36			2011	0	0
		2012	0	0			2012	0	0
	DOR3	2009	0	0	Crevice Creek	CVR1	2009	0	0
		2010	0	46			2010	0	0
		2011	0	80			2011	0	0
		2012	0	0			2012	0	0
Flat Creek	FLR1	2009	0	0	Eagle Creek	EGR1	2009	0	0
		2010	ns	0			2010	0	0
		2011	0	0			2011	0	0
		2012	0	ns			2012	0	ns
Dome Creek	DMR1	2009	0	11	Getmuna Creek	GMR1	2009	0	62
		2010	ns	1			2010	67	29
		2011	0	2			2011	103	50
		2012	0	0			2012	12	0
Snow Gulch	SNR1	2009	0	0		GMR2	2009	0	9
		2010	ns	0			2010	0	16
		2011	0	0			2011	6	63
		2012	0	0			2012	2	0
Crooked Creek	CRR1	2009	0	101		GMR3	2009	0	6
		2010	50	16			2010	0	9
		2011	44	23			2011	2	30
		2012	29	ns			2012	0	0
	CRR2	2009	0	97		GMR4	2009	0	2
		2010	20	19			2010	ns	9
		2011	43	10			2011	0	3
		2012	21	ns			2012	0	0
	CRR3	2009	0	29		GMR5	2011	0	0
		2010	6	2			2012	0	0
		2011	2	18	49.0 Creek	FNR1	2011	0	1
		2012	1	ns			2012	0	0
	CRR4	2009	0	6	Bell Creek	BLR1	2011	0	66
		2010	0	1			2012	0	0
		2011	3	23		BLR2	2011	0	33
		2012	0	ns			2012	0	0
	CRR5	2009	0	6		BLR3	2011	0	13
		2010	0	3			2012	0	0
		2011	0	13					
		2012	0	0					

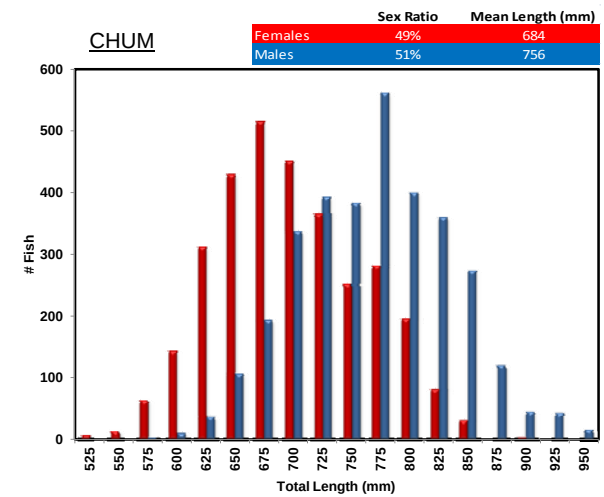
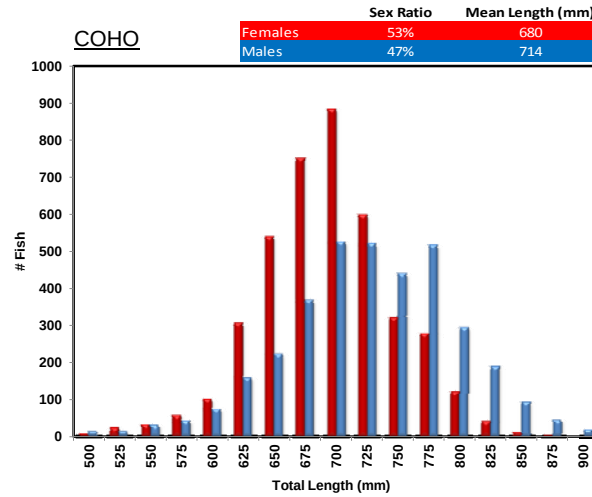
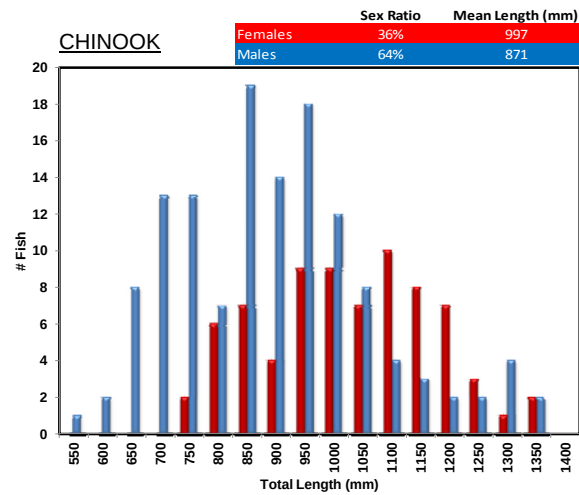
Notes:

ns = not surveyed

Aerial flights and redd counts conducted July 19-25, 2009-2012 and September 13-24, 2009-2012.

Appendix G

Size Distribution and Sex Ratios for Chinook, Chum, and Coho Salmon Observed at the Crooked Creek Weir (2008-2012)



Appendix H (Page 1 of 3)
Summary of Fish Trapping Results within the Crooked Creek Drainage (2004-2012)

# of Fish Caught per 3 Traps										
SITE	Year	Chinook (juvenile)	Coho (juvenile)	Dolly Varden	Arctic Grayling	Longnose Sucker	Slimy Sculpin	Burbot	Nine-spine Stickleback	Total
DO1	2004	0	0	4	0	0	0	0	0	4
	2005	0	6	1	0	0	1	0	0	8
	2006	0	0	0	0	0	3	0	0	3
	2007	0	2	2	0	0	2	1	0	7
	2008	0	0	0	0	0	2	1	0	3
	2009	0	0	0	0	0	1	0	0	1
	2010	0	2	0	0	0	0	1	0	3
	2011	0	0	0	0	0	1	0	0	1
	2012	0	0	0	0	0	3	0	0	3
	Mean	--	1.1	0.8	--	--	1.4	0.3	--	3.7
	Range	--	(0 to 6)	(0 to 4)	--	--	(0 to 3)	(0 to 1)	--	(1 to 8)
FL1	2004	0	0	0	0	0	0	0	0	0
	2005	0	0	3	0	0	1	0	0	4
	2006	0	0	0	0	0	6	1	0	7
	2007	0	0	3	0	0	1	0	0	4
	2008	0	0	0	0	0	0	0	0	0
	2009	0	0	0	0	0	0	0	0	0
	Mean	--	--	1.0	--	--	1.3	0.2	--	2.5
	Range	--	--	(0 to 3)	--	--	(0 to 6)	(0 to 1)	--	(0 to 7)
DM1	2008	0	0	2	0	0	0	0	0	2
	2009	0	0	4	0	0	0	0	0	4
	Mean	--	--	3.0	--	--	--	--	--	3.0
	Range	--	--	(2 to 4)	--	--	--	--	--	(2 to 4)
QZ1	2009	0	0	0	0	0	0	0	0	0
SN1	2006	0	0	0	0	0	0	0	0	0
SN2	2006	0	0	0	0	0	0	0	0	0
	2007	0	0	4	0	0	0	0	0	4
	2008	0	0	0	0	0	0	0	0	0
	2009	0	0	2	0	0	0	0	0	2
	2011	0	0	1	0	0	0	0	0	1
	2012	0	0	0	0	0	0	0	0	0
	Mean	--	--	1.2	--	--	--	--	--	1.2
	Range	--	--	(0 to 4)	--	--	--	--	--	(0 to 4)
CR2	2004	1	1	0	0	0	2	1	0	5
	2005	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	2	0	0	2
	2007	1	0	1	0	0	1	0	0	3
	2008	0	0	2	0	0	2	0	0	4
	2009	0	1	2	0	0	1	1	0	5
	2010	0	2	0	0	0	5	0	0	7
	2011	0	0	0	0	0	1	0	0	1
	2012	0	0	0	0	0	8	0	0	8
	Mean	0.2	0.4	0.6	--	--	2.4	0.2	--	3.9
	Range	(0 to 1)	(0 to 2)	(0 to 2)	--	--	(0 to 8)	(0 to 1)	--	(0 to 8)
CR1	2004	0	0	0	0	0	0	1	0	1
	2005	7	0	0	0	0	1	0	0	8
	2006	0	0	0	0	0	4	0	0	4
	2007	0	0	0	0	0	1	2	0	3
	2008	0	0	1	0	0	5	1	0	7
	2009	0	0	0	0	0	2	0	0	2
	2010	0	3	0	0	0	3	0	0	6
	2011	0	0	0	0	0	0	0	0	0
	2012	0	0	0	0	0	0	0	0	0
	Mean	0.8	0.3	0.1	--	--	1.8	0.4	--	3.4
	Range	(0 to 7)	(0 to 3)	(0 to 1)	--	--	(0 to 5)	(0 to 2)	--	(0 to 8)

Appendix H (Page 2 of 3)
Summary of Fish Trapping Results within the Crooked Creek Drainage (2004-2012)

# of Fish Caught per 3 Traps										
SITE	Year	Chinook (juvenile)	Coho (juvenile)	Dolly Varden	Arctic Grayling	Longnose Sucker	Slimy Sculpin	Burbot	Nine-spine Stickleback	Total
CR0.7	2006	0	0	0	0	0	3	0	0	3
	2007	0	0	1	0	0	6	2	1	10
	2008	0	0	1	0	0	3	0	0	4
	2009	0	1	1	0	0	3	2	0	7
	2010	0	6	0	0	0	3	0	0	9
	2011	0	0	0	0	0	1	0	0	1
	2012	0	0	0	0	0	1	1	0	2
	Mean	--	1.0	0.4	--	--	2.9	0.7	0.1	5.1
	Range	--	(0 to 6)	(0 to 1)	--	--	(1 to 6)	(0 to 2)	(0 to 1)	(1 to 10)
CR0.3	2006	0	6	2	0	0	5	0	0	13
	2007	5	5	0	3	0	3	0	0	16
	2008	1	0	1	0	1	0	0	0	3
	2009	3	1	0	0	1	2	0	0	7
	2010	4	0	0	0	3	1	0	0	8
	Mean	2.6	2.4	0.6	0.6	1.0	2.2	--	--	9.4
	Range	(0 to 5)	(0 to 6)	(0 to 2)	(0 to 3)	(0 to 3)	(0 to 5)	--	--	(3 to 16)
	LE1	2008	4	4	2	3	2	0	0	4
	AM1	2004	0	0	3	0	1	0	0	4
AM2	2005	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	8	0	0	8
	2007	0	0	0	0	0	0	0	0	0
	2008	0	0	0	0	0	0	0	0	0
	2009	0	0	3	0	0	0	0	0	3
	Mean	--	--	1.0	--	--	1.5	--	--	2.5
	Range	--	--	(0 to 3)	--	--	(0 to 8)	--	--	(0 to 8)
	GR1	2008	0	0	0	0	2	0	0	2
	OM1	2009	0	0	0	0	0	0	0	0
AN1	Mean	--	--	--	--	--	--	--	--	--
	Range	--	--	--	--	--	--	--	--	--
	2004	0	0	0	0	0	1	0	0	1
	2005	0	0	0	0	0	3	0	0	3
	2006	0	0	0	0	0	0	0	0	0
	2007	0	0	1	0	0	4	0	0	5
	2008	0	0	0	0	0	26	0	0	26
	2009	0	0	0	0	0	2	0	0	2
	2011	0	0	0	0	0	4	0	0	4
AN2	Mean	--	--	0.1	--	--	5.7	--	--	5.9
	Range	--	--	(0 to 1)	--	--	(0 to 26)	--	--	(0 to 26)
	2006	0	0	2	0	0	0	0	0	2
	2007	0	0	0	0	0	0	0	0	0
	2008	0	0	1	0	0	0	0	0	1
	2009	0	0	0	0	0	0	0	0	0
	Mean	--	--	0.8	--	--	--	--	--	0.8
	Range	--	--	(0 to 2)	--	--	--	--	--	(0 to 2)
	CV1	2006	0	0	0	0	0	0	0	0
CV1	2007	0	0	0	0	0	0	0	0	0
	2008	0	0	0	0	0	0	0	0	0
	2009	0	0	1	0	0	2	0	0	3
	Mean	--	--	0.3	--	--	0.5	--	--	0.8
	Range	--	--	(0 to 1)	--	--	(0 to 2)	--	--	(0 to 3)

Appendix H (Page 3 of 3)

Summary of Fish Trapping Results within the Crooked Creek Drainage (2004-2012)

of Fish Caught per 3 Traps

SITE	Year	Chinook (juvenile)	Coho (juvenile)	Dolly Varden	Arctic Grayling	Longnose Sucker	Slimy Sculpin	Burbot	Nine-spine Stickleback	Total
EG1	2009	0	0	1	0	0	2	0	0	3
BC1	2010	0	0	3	0	0	0	0	0	3
AC1	2010	0	0	0	0	0	0	0	0	0
GM1	2007	19	8	3	0	0	0	0	0	30
	2008	0	0	3	0	0	5	0	0	8
	2009	0	0	3	0	0	0	0	0	3
	Mean	6.3	2.7	3.0	--	--	1.7	--	--	13.7
	Range	(0 to 19)	(0 to 8)	(3 to 3)	--	--	(0 to 5)	--	--	(3 to 30)
GM2	2012	0	2	4	0	0	0	0	0	6
GM3	2012	0	1	34	0	0	1	0	0	36
GM4	2012	0	22	30	0	0	0	0	0	52
BL1	2011	0	1	0	0	0	2	0	0	3
	2012	0	0	0	0	0	1	0	0	1
	Mean	--	1	--	--	--	2	--	--	2.0
	Range	--	(0 to 1)	--	--	--	(1 to 2)	--	--	(1 to 3)
Grand Total		41	70	132	3	5	154	15	1	425

Notes:

Refer to Figure 1.1-1 for biomonitoring site locations.

DO=Donlin Creek; FL=Flat Creek; DM=Dome Creek; QZ=Quartz Creek; SN=Snow Gulch; CR=Crooked Creek; LE=Lewis Gulch; AM=American Creek; GR=Grouse Creek; OM=Omega Gulch; AN=Anaconda Creek; CV=Crevise Creek; EG=Eagle Creek; BC=BC Creek; GM=Getmuna Creek; BL=Bell Creek

Mean = total # of fish caught in 3 traps each year/the number of years sampled n(y).

-- Species not captured at sampling site

Appendix I

Average Percent Solids and Wet Weight to Dry Weight Conversion Factors for Slimy Sculpin Tissue Metals
Samples (2006-2012)

Year	2006	2007	2008	2009	2010	2011	2012
Average Percent Solids	24.87	24.17	19.87	20.19	20.50	19.97	21.78
Standard Deviation (Percent Solids)	1.06	1.14	0.68	1.61	1.32	1.95	0.77
Multiplier to Convert Wet Weight to Dry Weight	4.08	4.13	5.02	5.01	4.92	4.93	4.60

Appendix J (Page 1 of 6)

Scaled Statistics of Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004-2012)

Response Aluminum (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	74.960504	1.656582	45.25	<.0001*
Year[2004]	-1.902102	5.922778	-0.32	0.7481
Year[2005]	15.794195	5.922778	2.67	0.0077*
Year[2006]	31.225247	3.970296	7.86	<.0001*
Year[2007]	6.7949456	4.110322	1.65	0.0985
Year[2008]	-20.04005	4.110322	-4.88	<.0001*
Year[2009]	-23.32172	4.110322	-5.67	<.0001*
Year[2010]	2.6932789	4.110322	0.66	0.5124
Year[2011]	19.888279	4.110322	4.84	<.0001*
Year[2012]	-30.63005	4.110322	-7.45	<.0001*
Year[All Years Combined]	-0.502014	2.771481	-0.18	0.8563
Site ID[DO1]	-0.284947	2.783988	-0.10	0.9185
Site ID[CR2]	3.4800348	2.851631	1.22	0.2225
Site ID[CR1]	0.5298735	2.531758	0.21	0.8343
Site ID[CR0.7]	-3.670431	2.729379	-1.34	0.1789
Site ID[All Sites Combined]	-0.054531	2.431051	-0.02	0.9821

Response Arsenic (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	0.3014998	0.005369	56.16	0.0000*
Year[2004]	0.0081665	0.019194	0.43	0.6706
Year[2005]	0.0489072	0.019194	2.55	0.0109*
Year[2006]	0.1301834	0.012867	10.12	<.0001*
Year[2007]	0.0066224	0.013321	0.50	0.6192
Year[2008]	-0.008044	0.013321	-0.60	0.5460
Year[2009]	-0.082494	0.013321	-6.19	<.0001*
Year[2010]	-0.040094	0.013321	-3.01	0.0027*
Year[2011]	0.0092057	0.013321	0.69	0.4896
Year[2012]	-0.070411	0.013321	-5.29	<.0001*
Year[All Years Combined]	-0.002041	0.008982	-0.23	0.8202
Site ID[DO1]	-0.140776	0.009022	-15.60	<.0001*
Site ID[CR2]	0.1685077	0.009241	18.23	<.0001*
Site ID[CR1]	-0.008212	0.008205	-1.00	0.3171
Site ID[CR0.7]	-0.017106	0.008845	-1.93	0.0533
Site ID[All Sites Combined]	-0.002415	0.007878	-0.31	0.7593

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Scaled Statistics of Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004-2012)

Response Cadmium (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	0.0178301		0.000155	115.28	0.0000*
Year[2004]	-0.001008		0.000553	-1.82	0.0685
Year[2005]	0.0045103		0.000553	8.16	<.0001*
Year[2006]	0.0098819		0.000371	26.66	<.0001*
Year[2007]	0.0013011		0.000384	3.39	0.0007*
Year[2008]	-0.001326		0.000384	-3.45	0.0006*
Year[2009]	-0.005907		0.000384	-15.39	<.0001*
Year[2010]	-0.004416		0.000384	-11.51	<.0001*
Year[2011]	-0.001566		0.000384	-4.08	<.0001*
Year[2012]	-0.001367		0.000384	-3.56	0.0004*
Year[All Years Combined]	-0.000104		0.000259	-0.40	0.6872
Site ID[DO1]	-0.001436		0.00026	-5.53	<.0001*
Site ID[CR2]	-0.002015		0.000266	-7.57	<.0001*
Site ID[CR1]	0.0006518		0.000236	2.76	0.0059*
Site ID[CR0.7]	0.0027053		0.000255	10.62	<.0001*
Site ID[All Sites Combined]	9.4577e-5		0.000227	0.42	0.6770

Response Chromium (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	0.2789465		0.010826	25.77	<.0001*
Year[2004]	-0.081537		0.038708	-2.11	0.0353*
Year[2005]	0.0962405		0.038708	2.49	0.0130*
Year[2006]	-0.117354		0.025947	-4.52	<.0001*
Year[2007]	-0.111013		0.026863	-4.13	<.0001*
Year[2008]	-0.111113		0.026863	-4.14	<.0001*
Year[2009]	-0.217263		0.026863	-8.09	<.0001*
Year[2010]	0.0504867		0.026863	1.88	0.0604
Year[2011]	-0.03918		0.026863	-1.46	0.1449
Year[2012]	0.5329367		0.026863	19.84	<.0001*
Year[All Years Combined]	-0.002202		0.018113	-0.12	0.9032
Site ID[DO1]	0.0042861		0.018194	0.24	0.8138
Site ID[CR2]	0.0778549		0.018637	4.18	<.0001*
Site ID[CR1]	-0.00385		0.016546	-0.23	0.8160
Site ID[CR0.7]	-0.076247		0.017838	-4.27	<.0001*
Site ID[All Sites Combined]	-0.002044		0.015888	-0.13	0.8977

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Scaled Statistics of Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004-2012)

Response Copper (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	0.725583		0.009444	76.83	0.0000*
Year[2004]	-0.079439		0.033765	-2.35	0.0188*
Year[2005]	0.308339		0.033765	9.13	<.0001*
Year[2006]	0.1764367		0.022634	7.80	<.0001*
Year[2007]	-0.032004		0.023433	-1.37	0.1722
Year[2008]	-0.136021		0.023433	-5.80	<.0001*
Year[2009]	-0.174154		0.023433	-7.43	<.0001*
Year[2010]	-0.133354		0.023433	-5.69	<.0001*
Year[2011]	-0.167204		0.023433	-7.14	<.0001*
Year[2012]	0.2494291		0.023433	10.64	<.0001*
Year[All Years Combined]	-0.012028		0.0158	-0.76	0.4466
Site ID[DO1]	-0.035225		0.015871	-2.22	0.0266*
Site ID[CR2]	0.0160354		0.016257	0.99	0.3241
Site ID[CR1]	0.0124145		0.014433	0.86	0.3899
Site ID[CR0.7]	0.0061409		0.01556	0.39	0.6932
Site ID[All Sites Combined]	0.0006345		0.013859	0.05	0.9635

Response Iron (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	93.56881		2.736908	34.19	<.0001*
Year[2004]	2.9606185		9.78527	0.30	0.7623
Year[2005]	18.556915		9.78527	1.90	0.0581
Year[2006]	28.742755		6.559493	4.38	<.0001*
Year[2007]	0.724218		6.790835	0.11	0.9151
Year[2008]	-17.58912		6.790835	-2.59	0.0097*
Year[2009]	-33.45412		6.790835	-4.93	<.0001*
Year[2010]	-12.47245		6.790835	-1.84	0.0665
Year[2011]	33.424218		6.790835	4.92	<.0001*
Year[2012]	-19.89745		6.790835	-2.93	0.0034*
Year[All Years Combined]	-0.995596		4.578881	-0.22	0.8279
Site ID[DO1]	-0.899929		4.599544	-0.20	0.8449
Site ID[CR2]	25.59964		4.7113	5.43	<.0001*
Site ID[CR1]	-10.84329		4.182823	-2.59	0.0096*
Site ID[CR0.7]	-12.79946		4.509321	-2.84	0.0046*
Site ID[All Sites Combined]	-1.056964		4.016442	-0.26	0.7925

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Scaled Statistics of Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004-2012)

Response Lead (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	0.028209	0.001757	16.06	<.0001*
Year[2004]	-0.004416	0.006281	-0.70	0.4822
Year[2005]	-0.005268	0.006281	-0.84	0.4018
Year[2006]	-0.001513	0.004211	-0.36	0.7194
Year[2007]	-0.002396	0.004359	-0.55	0.5827
Year[2008]	-0.009869	0.004359	-2.26	0.0237*
Year[2009]	-0.014911	0.004359	-3.42	0.0006*
Year[2010]	0.0039309	0.004359	0.90	0.3673
Year[2011]	0.0050459	0.004359	1.16	0.2473
Year[2012]	0.0288209	0.004359	6.61	<.0001*
Year[All Years Combined]	0.000575	0.002939	0.20	0.8449
Site ID[DO1]	-0.000576	0.002953	-0.20	0.8454
Site ID[CR2]	-0.002823	0.003024	-0.93	0.3508
Site ID[CR1]	0.0081364	0.002685	3.03	0.0025*
Site ID[CR0.7]	-0.005165	0.002895	-1.78	0.0746
Site ID[All Sites Combined]	0.0004268	0.002578	0.17	0.8685

Response Manganese (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	13.252238	0.348707	38.00	<.0001*
Year[2004]	1.2060986	1.246733	0.97	0.3335
Year[2005]	5.1590615	1.246733	4.14	<.0001*
Year[2006]	2.3906977	0.83574	2.86	0.0043*
Year[2007]	-0.981879	0.865215	-1.13	0.2566
Year[2008]	-2.808212	0.865215	-3.25	0.0012*
Year[2009]	-0.352045	0.865215	-0.41	0.6842
Year[2010]	-1.150379	0.865215	-1.33	0.1839
Year[2011]	-1.793879	0.865215	-2.07	0.0383*
Year[2012]	-1.307045	0.865215	-1.51	0.1311
Year[All Years Combined]	-0.362419	0.583391	-0.62	0.5345
Site ID[DO1]	2.8822791	0.586024	4.92	<.0001*
Site ID[CR2]	-1.907512	0.600263	-3.18	0.0015*
Site ID[CR1]	-0.817661	0.53293	-1.53	0.1252
Site ID[CR0.7]	-0.127704	0.574529	-0.22	0.8241
Site ID[All Sites Combined]	-0.029403	0.511732	-0.06	0.9542

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Scaled Statistics of Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004-2012)

Response Mercury (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	0.0332243		0.000249	133.25	0.0000*
Year[2004]	-0.004696		0.000891	-5.27	<.0001*
Year[2005]	0.0025966		0.000891	2.91	0.0036*
Year[2006]	0.0019313		0.000598	3.23	0.0013*
Year[2007]	0.0011244		0.000619	1.82	0.0693
Year[2008]	0.0084028		0.000619	13.58	<.0001*
Year[2009]	-0.006441		0.000619	-10.41	<.0001*
Year[2010]	2.2767e-5		0.000619	0.04	0.9706
Year[2011]	-0.002141		0.000619	-3.46	0.0006*
Year[2012]	-0.000951		0.000619	-1.54	0.1246
Year[All Years Combined]	0.0001498		0.000417	0.36	0.7197
Site ID[DO1]	-0.003051		0.000419	-7.28	<.0001*
Site ID[CR2]	0.0075804		0.000429	17.66	<.0001*
Site ID[CR1]	-0.002413		0.000381	-6.33	<.0001*
Site ID[CR0.7]	-0.001875		0.000411	-4.56	<.0001*
Site ID[All Sites Combined]	-0.000241		0.000366	-0.66	0.5099

Response Selenium (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	0.913745		0.005815	157.12	0.0000*
Year[2004]	0.1509728		0.020792	7.26	<.0001*
Year[2005]	0.0957876		0.020792	4.61	<.0001*
Year[2006]	-0.003312		0.013938	-0.24	0.8122
Year[2007]	0.1122224		0.014429	7.78	<.0001*
Year[2008]	-0.066278		0.014429	-4.59	<.0001*
Year[2009]	-0.054111		0.014429	-3.75	0.0002*
Year[2010]	-0.151611		0.014429	-10.51	<.0001*
Year[2011]	-0.246944		0.014429	-17.11	<.0001*
Year[2012]	0.1783891		0.014429	12.36	<.0001*
Year[All Years Combined]	-0.015117		0.009729	-1.55	0.1205
Site ID[DO1]	-0.056213		0.009773	-5.75	<.0001*
Site ID[CR2]	0.0927388		0.010011	9.26	<.0001*
Site ID[CR1]	-0.067751		0.008888	-7.62	<.0001*
Site ID[CR0.7]	0.0355823		0.009581	3.71	0.0002*
Site ID[All Sites Combined]	-0.004358		0.008534	-0.51	0.6097

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Scaled Statistics of Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004-2012)

Response Zinc (mg/kg wet weight)

Scaled Estimates

Nominal factors expanded to all levels

Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	19.684569		0.076072	258.76	0.0000*
Year[2004]	-0.08291		0.271982	-0.30	0.7605
Year[2005]	-0.497725		0.271982	-1.83	0.0675
Year[2006]	3.6386069		0.182321	19.96	<.0001*
Year[2007]	0.7432416		0.188752	3.94	<.0001*
Year[2008]	1.3082416		0.188752	6.93	<.0001*
Year[2009]	-3.563425		0.188752	-18.88	<.0001*
Year[2010]	-0.893425		0.188752	-4.73	<.0001*
Year[2011]	-1.918425		0.188752	-10.16	<.0001*
Year[2012]	1.1899082		0.188752	6.30	<.0001*
Year[All Years Combined]	0.0759122		0.12727	0.60	0.5510
Site ID[DO1]	0.3384865		0.127845	2.65	0.0082*
Site ID[CR2]	0.3078378		0.130951	2.35	0.0189*
Site ID[CR1]	-0.312344		0.116262	-2.69	0.0073*
Site ID[CR0.7]	-0.308707		0.125337	-2.46	0.0139*
Site ID[All Sites Combined]	-0.025273		0.111637	-0.23	0.8209

Notes:

Scales Estimates - Parameter estimates are highly dependent on the scale of the factor. If you convert a factor from grams to kilograms, the parameter estimates change by a multiple of a thousand. If the same change is applied to a squared (quadratic) term, the scale changes by a multiple of a million. If you are interested in the effect size, then you should examine the estimates in a more scale-invariant fashion. This means converting from an arbitrary scale to a meaningful one so that the sizes of the estimates relate to the size of the effect on the response. In JMP software, the Scaled Estimates give coefficients corresponding to factors that are scaled to have a mean of zero and a range of two. If the factor is symmetrically distributed in the data then the scaled factor will have a range from -1 to 1. This corresponds to the scaling used in the design of experiments (DOE) tradition. Thus, for a simple regressor, the scaled estimate is half the predicted response change as the regression factor travels its whole range. *Prob>|t| is less than 0.05.

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Metals Concentrations of All Samples of Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2012)

DO1												
	Solids	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Se	Zn
Sample	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Sample 1	21.4	35.7	0.131	0.016	1.090	0.715	63.8	0.019	11.00	0.018	1.35	21.2
Sample 2	22.4	40.4	0.137	0.016	1.410	1.040	80.1	0.060	13.00	0.022	1.21	19.9
Sample 3	22.6	28.1	0.124	0.015	0.665	0.801	48.3	0.021	11.30	0.030	1.28	19.0
Sample 4	22.5	34.8	0.110	0.017	0.440	0.711	56.9	0.018	10.80	0.022	1.26	19.9
Sample 5	23.9	32.9	0.137	0.013	0.636	0.823	56.0	0.031	13.20	0.026	1.23	21.1
Sample 6	22.9	27.3	0.128	0.015	0.906	0.897	55.2	0.031	13.40	0.022	1.27	21.3
Sample 7	21.8	25.8	0.103	0.013	0.870	0.735	55.8	0.017	10.20	0.031	1.18	19.8
Sample 8	22.6	25.2	0.131	0.019	0.379	0.718	47.7	0.016	12.90	0.027	1.20	22.4
Sample 9	23.4	42.8	0.135	0.020	0.341	0.695	64.5	0.018	11.80	0.027	1.37	20.7
Sample 10	23.1	31.6	0.127	0.014	0.331	0.653	53.0	0.023	10.70	0.028	1.19	19.2
Sample 11	22.8	27.9	0.113	0.013	0.667	0.640	50.7	0.014	11.80	0.029	1.13	19.3
Sample 12	21.8	35.5	0.129	0.014	1.150	0.894	68.0	0.105	10.30	0.026	1.12	18.1
Sample 13	21.7	44.7	0.124	0.015	2.180	1.050	77.2	0.065	11.00	0.028	1.16	19.4
Sample 14	21.9	46.2	0.116	0.014	2.160	1.210	82.3	0.092	13.10	0.027	1.21	18.5
Sample 15	21.1	36.7	0.120	0.015	1.310	1.050	80.9	0.089	11.90	0.019	1.13	18.3
Min	21.1	25.2	0.103	0.013	0.331	0.640	47.7	0.014	10.20	0.018	1.12	18.1
Max	23.9	46.2	0.137	0.020	2.180	1.210	82.3	0.105	13.40	0.031	1.37	22.4
Mean	22.4	34.4	0.124	0.015	0.969	0.842	62.7	0.041	11.76	0.025	1.22	19.9
Median	22.5	34.8	0.127	0.015	0.870	0.801	56.9	0.023	11.80	0.027	1.21	19.8
SD	0.8	6.9	0.010	0.002	0.596	0.175	12.3	0.032	1.11	0.004	0.08	1.2
CV	0.03	0.20	0.08	0.13	0.62	0.21	0.20	0.78	0.09	0.15	0.06	0.06

CR2												
	Solids	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Se	Zn
Sample	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Sample 1	21.3	56.2	0.358	0.017	0.336	1.390	97.7	0.021	10.80	0.045	1.17	22.5
Sample 2	21.0	45.7	0.298	0.012	1.930	3.270	108.0	0.021	9.40	0.038	1.11	20.4
Sample 3	21.4	40.5	0.298	0.013	0.626	1.260	71.3	0.015	9.46	0.045	1.11	21.7
Sample 4	21.3	39.3	0.333	0.013	0.727	0.884	69.2	0.014	10.90	0.042	0.96	21.8
Sample 5	21.7	36.9	0.313	0.014	0.590	0.771	73.5	0.013	8.95	0.043	1.07	22.2
Sample 6	21.2	50.0	0.341	0.017	1.500	0.756	93.6	0.018	10.30	0.043	1.05	20.4
Sample 7	22.0	41.0	0.324	0.015	1.040	0.690	77.3	0.012	10.30	0.042	1.11	20.5
Sample 8	21.5	45.1	0.345	0.015	0.658	0.705	71.5	0.012	9.69	0.042	1.13	21.5
Sample 9	22.2	32.8	0.353	0.014	1.140	0.669	71.4	0.011	9.48	0.047	1.09	21.0
Sample 10	21.3	26.9	0.320	0.015	0.407	0.637	59.5	0.011	9.47	0.042	0.95	20.7
Sample 11	21.5	31.2	0.362	0.014	0.377	0.676	84.4	0.015	9.30	0.035	1.15	20.2
Sample 12	20.6	37.8	0.369	0.014	0.512	0.854	165.0	0.036	11.50	0.043	0.98	20.2
Sample 13	21.6	47.7	0.364	0.016	0.629	0.773	78.0	0.014	8.37	0.043	1.20	21.5
Sample 14	21.6	40.3	0.363	0.016	0.470	0.707	76.2	0.014	9.50	0.044	1.23	21.2
Sample 15	22.1	26.9	0.344	0.015	0.428	0.684	62.1	0.012	9.17	0.042	1.21	23.3
Min	20.6	26.9	0.298	0.012	0.336	0.637	59.5	0.011	8.37	0.035	0.95	20.2
Max	22.2	56.2	0.369	0.017	1.930	3.270	165.0	0.036	11.50	0.047	1.23	23.3
Mean	21.5	39.9	0.339	0.015	0.758	0.982	83.9	0.016	9.77	0.042	1.10	21.3
Median	21.5	40.3	0.344	0.015	0.626	0.756	76.2	0.014	9.48	0.043	1.11	21.2
SD	0.4	8.3	0.024	0.001	0.457	0.670	26.0	0.006	0.83	0.003	0.09	0.9
CV	0.02	0.21	0.07	0.10	0.60	0.68	0.31	0.40	0.08	0.07	0.08	0.04

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Metals Concentrations of All Samples of Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2012)

CR1												
	Solids	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Se	Zn
Sample	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Sample 1	21.0	55.7	0.200	0.014	2.540	3.740	98.4	0.983	9.88	0.030	0.80	24.2
Sample 2	21.3	45.1	0.226	0.014	1.840	2.260	74.2	0.446	10.80	0.030	0.83	21.9
Sample 3	20.7	46.0	0.201	0.014	0.429	1.030	56.4	0.114	10.40	0.030	0.87	21.5
Sample 4	21.5	53.4	0.228	0.016	1.010	0.944	71.7	0.096	11.40	0.034	0.86	21.2
Sample 5	22.5	63.9	0.221	0.017	1.550	0.925	83.5	0.077	10.10	0.030	0.87	21.7
Sample 6	20.9	46.8	0.242	0.015	0.737	0.708	60.5	0.033	10.30	0.028	0.80	21.3
Sample 7	21.6	59.2	0.233	0.014	1.270	0.775	66.8	0.047	10.60	0.028	0.96	21.2
Sample 8	22.1	55.4	0.215	0.019	0.567	0.807	63.6	0.047	8.21	0.026	0.87	20.5
Sample 9	22.0	44.2	0.211	0.015	0.693	0.663	55.8	0.023	8.50	0.030	0.85	18.9
Sample 10	21.0	53.8	0.198	0.016	0.860	0.968	67.5	0.063	9.49	0.027	0.89	20.6
Sample 11	20.8	83.6	0.318	0.017	1.160	1.010	126.0	0.081	39.30	0.025	0.85	19.3
Sample 12	21.8	40.4	0.203	0.013	0.836	0.856	54.9	0.067	8.93	0.026	0.80	19.9
Sample 13	21.3	66.4	0.212	0.016	1.580	0.805	68.1	0.040	9.35	0.032	0.81	20.2
Sample 14	22.1	60.2	0.243	0.018	0.543	0.789	68.5	0.030	12.30	0.029	0.87	22.8
Sample 15	22.0	60.2	0.225	0.016	1.320	0.867	75.8	0.044	10.20	0.029	0.90	22.4
Min	20.7	40.4	0.198	0.013	0.429	0.663	54.9	0.023	8.21	0.025	0.80	18.9
Max	22.5	83.6	0.318	0.019	2.540	3.740	126.0	0.983	39.30	0.034	0.96	24.2
Mean	21.5	55.6	0.225	0.016	1.129	1.143	72.8	0.146	11.98	0.029	0.86	21.2
Median	21.5	55.4	0.221	0.016	1.010	0.867	68.1	0.063	10.20	0.029	0.86	21.2
SD	0.6	10.9	0.030	0.002	0.573	0.811	18.6	0.253	7.63	0.002	0.04	1.4
CV	0.03	0.20	0.13	0.12	0.51	0.71	0.26	1.73	0.64	0.08	0.05	0.06

CR0.7												
	Solids	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Se	Zn
Sample	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Sample 1	22.6	39.3	0.215	0.018	0.244	3.710	71.2	0.112	10.70	0.032	1.02	21.1
Sample 2	22.3	50.3	0.304	0.025	0.317	0.945	123.0	0.029	46.80	0.035	1.16	22.0
Sample 3	23.5	47.8	0.248	0.020	0.166	0.849	65.8	0.017	12.50	0.033	1.20	23.1
Sample 4	22.4	40.1	0.216	0.020	0.150	0.680	56.8	0.017	10.70	0.039	1.25	19.9
Sample 5	21.9	56.3	0.223	0.021	0.177	0.711	78.8	0.023	12.00	0.029	1.13	19.2
Sample 6	23.0	41.1	0.230	0.018	0.231	0.792	66.1	0.016	10.50	0.035	1.11	22.3
Sample 7	22.8	38.9	0.215	0.020	0.574	0.825	62.5	0.023	10.50	0.028	1.21	19.8
Sample 8	22.9	34.5	0.207	0.018	0.276	0.715	58.6	0.019	10.10	0.026	1.14	21.2
Sample 9	23.2	48.6	0.228	0.019	0.258	0.695	63.7	0.017	11.20	0.038	1.23	21.9
Sample 10	22.8	53.2	0.241	0.023	0.431	0.680	71.9	0.019	10.70	0.027	1.19	22.8
Sample 11	22.9	45.7	0.234	0.021	1.040	0.700	70.5	0.017	11.50	0.038	1.23	22.1
Sample 12	23.1	38.2	0.226	0.021	0.358	0.658	63.8	0.015	12.50	0.033	1.25	22.2
Sample 13	22.4	49.2	0.232	0.020	0.530	0.685	71.3	0.018	13.80	0.034	1.19	19.2
Sample 14	22.7	57.5	0.237	0.022	0.814	0.678	77.7	0.020	13.40	0.023	1.23	20.8
Sample 15	22.7	69.7	0.229	0.024	0.261	0.687	104.0	0.023	16.40	0.034	1.25	19.5
Min	21.9	34.5	0.207	0.018	0.150	0.658	56.8	0.015	10.10	0.023	1.02	19.2
Max	23.5	69.7	0.304	0.025	1.040	3.710	123.0	0.112	46.80	0.039	1.25	23.1
Mean	22.7	47.4	0.232	0.021	0.388	0.934	73.7	0.026	14.22	0.032	1.19	21.1
Median	22.8	47.8	0.229	0.020	0.276	0.700	70.5	0.019	11.50	0.033	1.20	21.2
SD	0.4	9.3	0.023	0.002	0.255	0.772	17.7	0.024	9.17	0.005	0.06	1.3
CV	0.02	0.20	0.10	0.11	0.66	0.83	0.24	0.94	0.64	0.15	0.05	0.06

Appendix K (Page 3 of 3)

Metals Concentrations of All Samples of Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2012)

GM3.0												
Sample	Solids %	Al mg/kg	As mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Mn mg/kg	Hg mg/kg	Se mg/kg	Zn mg/kg
Sample 1	19.5	12.7	0.169	0.009	0.398	0.633	27.5	0.007	5.56	0.059	1.34	20.8
Sample 2	21.0	37.8	0.224	0.014	0.139	0.580	54.2	0.013	7.41	0.060	1.36	20.6
Sample 3	22.0	16.4	0.194	0.014	0.080	0.618	33.6	0.007	7.38	0.054	1.47	21.1
Sample 4	20.8	13.6	0.188	0.011	0.104	0.475	31.0	0.006	5.80	0.054	1.25	19.7
Sample 5	21.2	18.8	0.206	0.012	0.095	0.530	44.1	0.009	8.74	0.057	1.39	19.3
Sample 6	21.2	18.7	0.202	0.015	0.086	0.500	37.3	0.008	6.65	0.049	1.41	19.8
Sample 7	22.0	21.1	0.247	0.014	1.240	7.640	57.9	0.476	8.02	0.042	1.39	27.8
Sample 8	19.3	32.2	0.299	0.011	0.987	2.170	102.0	0.128	11.60	0.042	1.09	20.7
Sample 9	20.7	40.1	0.252	0.014	1.450	1.730	75.7	0.094	7.46	0.045	1.42	20.9
Sample 10	19.6	26.6	0.216	0.011	0.726	1.180	48.6	0.049	7.67	0.054	1.20	20.0
Sample 11	20.6	30.7	0.194	0.014	0.103	0.538	55.8	0.012	7.00	0.044	1.23	17.7
Sample 12	20.1	63.5	0.234	0.012	0.347	0.576	98.4	0.021	10.10	0.039	1.29	20.3
Sample 13	20.7	37.7	0.232	0.012	0.236	0.491	65.9	0.013	6.99	0.050	1.30	18.1
Sample 14	21.0	35.1	0.251	0.012	0.184	0.520	59.2	0.013	8.40	0.071	1.32	22.2
Min	19.3	12.7	0.169	0.009	0.080	0.475	27.5	0.006	5.56	0.039	1.09	17.7
Max	22.0	63.5	0.299	0.015	1.450	7.640	102.0	0.476	11.60	0.071	1.47	27.8
Mean	20.7	28.9	0.222	0.012	0.441	1.299	56.5	0.061	7.77	0.051	1.32	20.6
Median	20.8	28.7	0.220	0.012	0.210	0.578	55.0	0.013	7.44	0.052	1.33	20.5
SD	0.8	13.7	0.034	0.002	0.468	1.899	23.0	0.125	1.60	0.009	0.10	2.4
CV	0.04	0.48	0.15	0.13	1.06	1.46	0.41	2.05	0.21	0.17	0.08	0.11

Notes:

Al=Aluminum, As=Arsenic, Cd=Cadmium, Cr=Chromium, Cu=Copper, Fe=Iron, Pb=Lead, Mn=Manganese, Hg=Mercury, Se=Selenium, Zn=Zinc. Method detection limits (MDL) for each analyte are listed in Table 2.5-1. SD (standard deviation) = the measure of the spread of a dataset; CV = (coefficient of variation) = measure of variation in a dataset (SD/Mean); Mean = arithmetic average of the dataset; Median = halfway value of an ordered dataset; Min = smallest number of the dataset; Max = largest number of the dataset; For analysis purposes, all samples that were non-detectable were calculated at the MDL level for that sample; Each sample consisted of a composite of several specimens to enable adequate matrix for analysis; Samples were collected from July 20-27, 2012.

Appendix L

Macroinvertebrate Bioassessment Metrics for Sites within the Road Alternative Drainages and Jungjuk Port Site (2007-2012)

Project	Method	Site ID	Year	General Metrics							Diversity Indices		Biotic Indices
				Total Abundance (# / ft²)	Total Taxa #	EPT Taxa #	EPT %	Dominant Taxa %	Chironomidae %	EPT Chironomidae Ratio	Shannon (H)	Evenness (e)	HBI
Jungjuk Port Site	Surber	KU8.0	2011	245.67	10.00	5.00	14.52	70.42	70.42	0.21	1.14	0.49	5.47
		KU10.0	2011	32.67	4.00	1.00	2.04	92.86	92.86	0.02	0.33	0.24	5.86
		KU11.0	2011	5.33	4.00	1.00	6.25	81.25	81.25	0.08	0.69	0.50	5.75
		KU12.0	2011	76.00	2.00	--	--	99.12	99.12	--	0.05	0.07	5.99
		KU13.0	2011	51.67	3.00	--	--	56.13	56.13	--	0.72	0.65	5.57
		KU14.0	2012	22.40	6.00	3.00	10.71	82.14	82.14	0.13	0.71	0.40	5.54
		KU20.0	2012	134.40	11.00	6.00	3.13	91.67	91.67	0.03	0.43	0.18	5.90
		KU23.0	2012	7.40	6.00	3.00	8.11	86.49	86.49	0.09	0.61	0.34	5.68
		KU25.0	2012	5.60	7.00	2.00	7.14	78.57	78.57	0.09	0.90	0.46	5.71
	Ponar®	KU8.0	2012	53.20	2.00	--	--	93.23	93.23	--	0.25	0.36	5.93
		KU9.0	2011	32.33	2.00	--	--	76.29	76.29	--	0.55	0.79	5.76
		KU15.0	2011	15.33	5.00	2.00	13.04	60.87	60.87	0.21	1.05	0.65	5.02
		KU24.0	2012	19.80	2.00	--	--	87.88	87.88	--	0.37	0.53	5.88
Road Alternative	Surber	JJ1.0	2008	215.33	16.00	9.00	42.57	42.41	42.41	1.00	1.94	0.70	4.14
			2007	206.20	27.00	14.00	46.07	33.85	33.85	1.36	2.26	0.69	3.73

Notes:

For sample site locations, refer to Figure 1.1-1. Chironomidae genera grouped as one taxon for multi-year comparisons. Refer to the text for definitions of metrics.

Appendix M (Page 1 of 7)**Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road
Alternative Drainages and Junjuk Port Site (2007-2012)**

JJ1 (sample method: Surber)						
(year 2007-08) (n reps =8)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	210.8	210.8	206.2	215.3	6.5	0.03
# Taxa	21.5	21.5	16.0	27.0	7.8	0.36
# EPT Taxa	11.5	11.5	9.0	14.0	3.5	0.31
% EPT Taxa	44.3	44.3	42.6	46.1	2.5	0.06
% Dominant Taxon	38.1	38.1	33.9	42.4	6.1	0.16
% Chironomidae	38.1	38.1	33.9	42.4	6.1	0.16
EPT/Chironomidae Ratio	1.2	1.2	1.0	1.4	0.3	0.21
Diversity Indices						
Shannon (H)	2.1	2.1	1.9	2.3	0.2	0.11
Evenness (e)	0.7	0.7	0.7	0.7	0.0	0.01
Biotic Indices						
HBI	3.9	3.9	3.7	4.1	0.3	0.07
% Composition Per Order						
Ephemeroptera	25.8	25.8	17.9	33.6	11.1	0.43
Plecoptera	17.0	17.0	8.7	25.3	11.8	0.69
Trichoptera	1.6	1.6	0.3	2.8	1.8	1.13
Diptera	44.3	44.3	42.0	46.6	3.3	0.07
Oligochaeta	8.6	8.6	7.9	9.3	1.0	0.12
Acariformes	2.6	2.6	2.2	2.9	0.5	0.19
Amphipoda	0.0	0.0	--	0.1	0.1	1.41
Gastropoda	0.0	0.0	--	0.1	0.1	1.41
Ostracoda	0.1	0.1	--	0.2	0.1	1.41
KU8 (sample method: Surber)						
(year 2011) (n reps = 3)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	245.7	245.7	245.7	245.7	--	--
# Taxa	10.0	10.0	10.0	10.0	--	--
# EPT Taxa	5.0	5.0	5.0	5.0	--	--
% EPT Taxa	14.5	14.5	14.5	14.5	--	--
% Dominant Taxon	70.4	70.4	70.4	70.4	--	--
% Chironomidae	70.4	70.4	70.4	70.4	--	--
EPT/Chironomidae Ratio	0.2	0.2	0.2	0.2	--	--
Diversity Indices						
Shannon (H)	1.1	1.1	1.1	1.1	--	--
Evenness (e)	0.5	0.5	0.5	0.5	--	--
Biotic Indices						
HBI	5.5	5.5	5.5	5.5	--	--
% Composition Per Order						
Ephemeroptera	12.3	12.3	12.3	12.3	--	--
Plecoptera	2.2	2.2	2.2	2.2	--	--
Trichoptera	--	--	--	--	--	--
Diptera	71.2	71.2	71.2	71.2	--	--
Oligochaeta	8.5	8.5	8.5	8.5	--	--
Acariformes	5.7	5.7	5.7	5.7	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road Alternative Drainages and Junjuk Port Site (2007-2012)

KU8 (sample method: Ponar®)						
(year 2012) (n reps = 4)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	53.2	53.2	53.2	53.2	--	--
# Taxa	2.0	2.0	2.0	2.0	--	--
# EPT Taxa	NA	NA	0.0	0.0	--	--
% EPT Taxa	NA	NA	0.0	0.0	--	--
% Dominant Taxon	93.2	93.2	93.2	93.2	--	--
% Chironomidae	93.2	93.2	93.2	93.2	--	--
EPT/Chironomidae Ratio	NA	NA	0.0	0.0	--	--
Diversity Indices						
Shannon (H)	0.2	0.2	0.2	0.2	--	--
Evenness (e)	0.4	0.4	0.4	0.4	--	--
Biotic Indices						
HBI	5.9	5.9	5.9	5.9	--	--
% Composition Per Order						
Ephemeroptera	--	--	--	--	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	--	--	--	--	--	--
Diptera	93.2	93.2	93.2	93.2	--	--
Oligochaeta	6.8	6.8	6.8	6.8	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Cladocera	--	--	--	--	--	--
Coleoptera	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Copepoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Mollusca	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
KU9 (sample method: Ponar®)						
(year 2011) (n reps = 3)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	32.3	32.3	32.3	32.3	--	--
# Taxa	2.0	2.0	2.0	2.0	--	--
# EPT Taxa	NA	NA	0.0	0.0	--	--
% EPT Taxa	NA	NA	0.0	0.0	--	--
% Dominant Taxon	76.3	76.3	76.3	76.3	--	--
% Chironomidae	76.3	76.3	76.3	76.3	--	--
EPT/Chironomidae Ratio	NA	NA	0.0	0.0	--	--
Diversity Indices						
Shannon (H)	0.5	0.5	0.5	0.5	--	--
Evenness (e)	0.8	0.8	0.8	0.8	--	--
Biotic Indices						
HBI	5.8	5.8	5.8	5.8	--	--
% Composition Per Order						
Ephemeroptera	--	--	--	--	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	--	--	--	--	--	--
Diptera	76.3	76.3	76.3	76.3	--	--
Oligochaeta	23.7	23.7	23.7	23.7	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road Alternative Drainages and Junjuk Port Site (2007-2012)

KU10 (sample method: Surber)						
(year 2011) (n reps = 3)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	32.7	32.7	32.7	32.7	--	--
# Taxa	4.0	4.0	4.0	4.0	--	--
# EPT Taxa	1.0	1.0	1.0	1.0	--	--
% EPT Taxa	2.0	2.0	2.0	2.0	--	--
% Dominant Taxon	92.9	92.9	92.9	92.9	--	--
% Chironomidae	92.9	92.9	92.9	92.9	--	--
EPT/Chironomidae Ratio	0.0	0.0	0.0	0.0	--	--
Diversity Indices						
Shannon (H)	0.3	0.3	0.3	0.3	--	--
Evenness (e)	0.2	0.2	0.2	0.2	--	--
Biotic Indices						
HBI	5.9	5.9	5.9	5.9	--	--
% Composition Per Order						
Ephemeroptera	--	--	--	--	--	--
Plecoptera	2.0	2.0	2.0	2.0	--	--
Trichoptera	--	--	--	--	--	--
Diptera	92.9	92.9	92.9	92.9	--	--
Oligochaeta	2.0	2.0	2.0	2.0	--	--
Acariformes	3.1	3.1	3.1	3.1	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
KU11 (sample method: Surber)						
(year 2011) (n reps = 3)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	5.3	5.3	5.3	5.3	--	--
# Taxa	4.0	4.0	4.0	4.0	--	--
# EPT Taxa	1.0	1.0	1.0	1.0	--	--
% EPT Taxa	6.3	6.3	6.3	6.3	--	--
% Dominant Taxon	81.3	81.3	81.3	81.3	--	--
% Chironomidae	81.3	81.3	81.3	81.3	--	--
EPT/Chironomidae Ratio	0.1	0.1	0.1	0.1	--	--
Diversity Indices						
Shannon (H)	0.7	0.7	0.7	0.7	--	--
Evenness (e)	0.5	0.5	0.5	0.5	--	--
Biotic Indices						
HBI	5.8	5.8	5.8	5.8	--	--
% Composition Per Order						
Ephemeroptera	6.3	6.3	6.3	6.3	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	--	--	--	--	--	--
Diptera	87.5	87.5	87.5	87.5	--	--
Oligochaeta	--	--	--	--	--	--
Acariformes	6.3	6.3	6.3	6.3	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road Alternative Drainages and Junjuk Port Site (2007-2012)

KU12 (sample method: Surber)						
(year 2011) (n reps = 3)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	76.0	76.0	76.0	76.0	--	--
# Taxa	2.0	2.0	2.0	2.0	--	--
# EPT Taxa	NA	NA	0.0	0.0	--	--
% EPT Taxa	NA	NA	0.0	0.0	--	--
% Dominant Taxon	99.1	99.1	99.1	99.1	--	--
% Chironomidae	99.1	99.1	99.1	99.1	--	--
EPT/Chironomidae Ratio	NA	NA	0.0	0.0	--	--
Diversity Indices						
Shannon (H)	0.1	0.1	0.1	0.1	--	--
Evenness (e)	0.1	0.1	0.1	0.1	--	--
Biotic Indices						
HBI	6.0	6.0	6.0	6.0	--	--
% Composition Per Order						
Ephemeroptera	--	--	--	--	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	--	--	--	--	--	--
Diptera	99.1	99.1	99.1	99.1	--	--
Oligochaeta	0.9	0.9	0.9	0.9	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
KU13 (sample method: Ponar®)						
(year 2011) (n reps = 3)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	51.7	51.7	51.7	51.7	--	--
# Taxa	3.0	3.0	3.0	3.0	--	--
# EPT Taxa	NA	NA	0.0	0.0	--	--
% EPT Taxa	NA	NA	0.0	0.0	--	--
% Dominant Taxon	56.1	56.1	56.1	56.1	--	--
% Chironomidae	56.1	56.1	56.1	56.1	--	--
EPT/Chironomidae Ratio	NA	NA	0.0	0.0	--	--
Diversity Indices						
Shannon (H)	0.7	0.7	0.7	0.7	--	--
Evenness (e)	0.7	0.7	0.7	0.7	--	--
Biotic Indices						
HBI	5.6	5.6	5.6	5.6	--	--
% Composition Per Order						
Ephemeroptera	--	--	--	--	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	--	--	--	--	--	--
Diptera	56.1	56.1	56.1	56.1	--	--
Oligochaeta	43.2	43.2	43.2	43.2	--	--
Acariformes	0.6	0.6	0.6	0.6	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road Alternative Drainages and Junjuk Port Site (2007-2012)

KU14 (sample method: Surber)						
(year 2012) (n reps = 5)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	22.4	22.4	22.4	22.4	--	--
# Taxa	6.0	6.0	6.0	6.0	--	--
# EPT Taxa	3.0	3.0	3.0	3.0	--	--
% EPT Taxa	10.7	10.7	10.7	10.7	--	--
% Dominant Taxon	82.1	82.1	82.1	82.1	--	--
% Chironomidae	82.1	82.1	82.1	82.1	--	--
EPT/Chironomidae Ratio	0.1	0.1	0.1	0.1	--	--
Diversity Indices						
Shannon (H)	0.7	0.7	0.7	0.7	--	--
Evenness (e)	0.4	0.4	0.4	0.4	--	--
Biotic Indices						
HBI	5.5	5.5	5.5	5.5	--	--
% Composition Per Order						
Ephemeroptera	4.5	4.5	4.5	4.5	--	--
Plecoptera	5.4	5.4	5.4	5.4	--	--
Trichoptera	0.9	0.9	0.9	0.9	--	--
Diptera	83.0	83.0	83.0	83.0	--	--
Oligochaeta	6.3	6.3	6.3	6.3	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
KU15 (sample method: Ponar®)						
(year 2011) (n reps = 3)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	15.3	15.3	15.3	15.3	--	--
# Taxa	5.0	5.0	5.0	5.0	--	--
# EPT Taxa	2.0	2.0	2.0	2.0	--	--
% EPT Taxa	13.0	13.0	13.0	13.0	--	--
% Dominant Taxon	60.9	60.9	60.9	60.9	--	--
% Chironomidae	60.9	60.9	60.9	60.9	--	--
EPT/Chironomidae Ratio	0.2	0.2	0.2	0.2	--	--
Diversity Indices						
Shannon (H)	1.1	1.1	1.1	1.1	--	--
Evenness (e)	0.7	0.7	0.7	0.7	--	--
Biotic Indices						
HBI	5.0	5.0	5.0	5.0	--	--
% Composition Per Order						
Ephemeroptera	--	--	--	--	--	--
Plecoptera	13.0	13.0	13.0	13.0	--	--
Trichoptera	--	--	--	--	--	--
Diptera	60.9	60.9	60.9	60.9	--	--
Oligochaeta	23.9	23.9	23.9	23.9	--	--
Acariformes	2.2	2.2	2.2	2.2	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road Alternative Drainages and Junjuk Port Site (2007-2012)

KU20 (sample method: Surber)						
(year 2012) (n reps = 5)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	134.4	134.4	134.4	134.4	--	--
# Taxa	11.0	11.0	11.0	11.0	--	--
# EPT Taxa	6.0	6.0	6.0	6.0	--	--
% EPT Taxa	3.1	3.1	3.1	3.1	--	--
% Dominant Taxon	91.7	91.7	91.7	91.7	--	--
% Chironomidae	91.7	91.7	91.7	91.7	--	--
EPT/Chironomidae Ratio	0.0	0.0	0.0	0.0	--	--
Diversity Indices						
Shannon (H)	0.4	0.4	0.4	0.4	--	--
Evenness (e)	0.2	0.2	0.2	0.2	--	--
Biotic Indices						
HBI	5.9	5.9	5.9	5.9	--	--
% Composition Per Order						
Ephemeroptera	2.4	2.4	2.4	2.4	--	--
Plecoptera	0.4	0.4	0.4	0.4	--	--
Trichoptera	0.3	0.3	0.3	0.3	--	--
Diptera	94.3	94.3	94.3	94.3	--	--
Oligochaeta	2.5	2.5	2.5	2.5	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
KU23 (sample method: Surber)						
(year 2012) (n reps = 5)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	7.4	7.4	7.4	7.4	--	--
# Taxa	6.0	6.0	6.0	6.0	--	--
# EPT Taxa	3.0	3.0	3.0	3.0	--	--
% EPT Taxa	8.1	8.1	8.1	8.1	--	--
% Dominant Taxon	86.5	86.5	86.5	86.5	--	--
% Chironomidae	86.5	86.5	86.5	86.5	--	--
EPT/Chironomidae Ratio	0.1	0.1	0.1	0.1	--	--
Diversity Indices						
Shannon (H)	0.6	0.6	0.6	0.6	--	--
Evenness (e)	0.3	0.3	0.3	0.3	--	--
Biotic Indices						
HBI	5.7	5.7	5.7	5.7	--	--
% Composition Per Order						
Ephemeroptera	5.4	5.4	5.4	5.4	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	2.7	2.7	2.7	2.7	--	--
Diptera	91.9	91.9	91.9	91.9	--	--
Oligochaeta	--	--	--	--	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--

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Macroinvertebrate Bioassessment Statistics Summary for Sites within the Road Alternative Drainages and Junjuk Port Site (2007-2012)

KU24 (sample method: Ponar®)						
(year 2012) (n reps = 5)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	19.8	19.8	19.8	19.8	--	--
# Taxa	2.0	2.0	2.0	2.0	--	--
# EPT Taxa	NA	NA	0.0	0.0	--	--
% EPT Taxa	NA	NA	0.0	0.0	--	--
% Dominant Taxon	87.9	87.9	87.9	87.9	--	--
% Chironomidae	87.9	87.9	87.9	87.9	--	--
EPT/Chironomidae Ratio	NA	NA	0.0	0.0	--	--
Diversity Indices						
Shannon (H)	0.4	0.4	0.4	0.4	--	--
Evenness (e)	0.5	0.5	0.5	0.5	--	--
Biotic Indices						
HBI	5.9	5.9	5.9	5.9	--	--
% Composition Per Order						
Ephemeroptera	--	--	--	--	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	--	--	--	--	--	--
Diptera	87.9	87.9	87.9	87.9	--	--
Oligochaeta	12.1	12.1	12.1	12.1	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--
KU25 (sample method: Surber)						
(year 2012) (n reps = 5)	Mean	Median	Min	Max	SD	CV
General Metrics¹						
Abundance (# / ft ²)	5.6	5.6	5.6	5.6	--	--
# Taxa	7.0	7.0	7.0	7.0	--	--
# EPT Taxa	2.0	2.0	2.0	2.0	--	--
% EPT Taxa	7.1	7.1	7.1	7.1	--	--
% Dominant Taxon	78.6	78.6	78.6	78.6	--	--
% Chironomidae	78.6	78.6	78.6	78.6	--	--
EPT/Chironomidae Ratio	0.1	0.1	0.1	0.1	--	--
Diversity Indices						
Shannon (H)	0.9	0.9	0.9	0.9	--	--
Evenness (e)	0.5	0.5	0.5	0.5	--	--
Biotic Indices						
HBI	5.7	5.7	5.7	5.7	--	--
% Composition Per Order						
Ephemeroptera	3.6	3.6	3.6	3.6	--	--
Plecoptera	--	--	--	--	--	--
Trichoptera	3.6	3.6	3.6	3.6	--	--
Diptera	89.3	89.3	89.3	89.3	--	--
Oligochaeta	3.6	3.6	3.6	3.6	--	--
Acariformes	--	--	--	--	--	--
Amphipoda	--	--	--	--	--	--
Gastropoda	--	--	--	--	--	--
Ostracoda	--	--	--	--	--	--

Notes:

For sample site locations, refer to Figure 1.1-1. Chironomidae genera grouped as one taxon for multi-year comparisons.

1) Refer to the text for definitions of metrics.

year = year site has been sampled; n reps = total number of replicates sampled

Mean = Average of all samples for all years; SD = Standard deviation of the mean; CV = Coefficient of variance of the mean

Appendix N

Summary of Trapping Results within the Road Alternative Drainages (2007-2008)

SITE	Year	# of Fish Caught per 3 Traps									Total
		Chinook (juvenile)	Coho (juvenile)	Dolly Varden	Arctic grayling	Longnose sucker	Slimy sculpin	Alaska blackfish	Burbot	Nine-spine stickleback	
JJ1	2007	0	10	5	0	0	0	0	0	0	15
	2008	0	0	5	0	0	0	0	0	0	5
	Mean	0.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0

Notes:

Refer to Figure 1.1-1 for biomonitoring site locations.

JJ=Jungjuk Creek

Mean = total # of fish caught in 3 traps each year / the number of years sampled

Appendix O

Summary of Bridge and Culvert Stream Crossing Surveys within the Road Alternative Drainages for ADF&G Fish Habitat Permit Compliance Through 2012

Structure	Site	Stream Name	Fish Present?	Chinook salmon	Chum salmon	Coho salmon	Dolly Varden	Arctic grayling	Round whitefish	Slimy sculpin	Alaska blackfish	Burbot
Bridges	¹ BR3	Crooked Creek	Y	X	X	X	X	X	X	X	X	X
	² BR47	N.F. Getmuna Creek	Y	X	X	X (n = 16)	X (n = 36)	X (n = 1)		X (n = 59)		
	³ BR48	S.F. Getmuna Creek	Y	X	X	X (n = 9)	X (n = 17)	X		X (n = 31)		
	⁴ BR49	Unnamed (FN)	Y			X (n = 7)	X (n = 4)	X (n = 1)		X (n = 2)		
	⁴ BR61	Jungjuk Creek	Y				X (n = 25)					
	⁴ BR63	Jungjuk Creek	Y				X (n = 16)					
Culverts	CU43	Unnamed	N									
	CU59	Jungjuk Creek	N									
	CU60	Jungjuk Creek	N									
	CU62	Jungjuk Creek	N									

Notes:

Refer to Figure 1.1-1 for bridge and culvert locations. Major stream crossings spanned by bridges or bottomless culverts were not electrofished.

1) Fish data for BR3 is a compilation of CR1, CR2 (see Table 3.2-6) and aerial reach CR-R4 (see Table 3.2-2).

2) Fish data for BR47 is based on aerial survey data from reach GM-R3 (see Table 3.2-2).

3) Fish data for BR48 is based on aerial survey data from reach GM-R2 (see Table 3.2-2) and efish survey data at BR49 (Table 3.2-6).

4) Number of fish sampled shown in parentheses. If no numbers are present, actual counts are unavailable at specific location.

5) X denotes if species present.

Appendix P

Water Quality Standards for Alaska

Dissolved Parameter	Source ⁴	Units	Alaska	Alaska Aquatic Life Standards		Human Health Criteria		Alaska
			Drinking Water Standard (Tap)	Acute	Chronic	HHC (water and aquatic organisms)	HHC (aquatic organisms only)	Stock water and Irrigation water (Agriculture)
pH	1	(pH units)	6.0-8.5	6.5-8.5	6.5-8.5	---	---	5-9
Conductivity		(µS/cm)	---	---	---	---	---	---
Total Alkalinity	1	(mg/L) ¹	---	---	20	---	---	---
Acidity		(mg/L) ¹	---	---	---	---	---	---
Hardness		(mg/L) ¹	---	---	---	---	---	---
TDS	1	(mg/L)	500	1000	1000	---	---	1000
Chloride	2	(mg/L)	250	860	230	---	---	---
Ammonia	2	(mg N/L)	---	2.1-32.6	0.4-2.5	---	---	---
Aluminum	2	(mg/L)	---	0.75	0.087	---	---	5
Arsenic	2	(mg/L)	0.01	0.34	0.15	---	---	0.05-0.1
Cadmium	2	(mg/L)	0.005	³ 0.0014	³ 0.00019	---	---	0.01
Calcium		(mg/L)	---	---	---	---	---	---
Chromium	2	(mg/L)	0.1 (total)	² III,0.409; VI,0.004	² III,0.053; VI,0.005	---	---	0.1 (total)
Copper	2	(mg/L)	---	² 0.009	² 0.006	1.3	---	0.2
Iron	2	(mg/L)	---	---	1	---	---	5
Lead	2	(mg/L)	---	³ 0.041	³ 0.002	---	---	0.05-5.0
Manganese	2	(mg/L)	---	---	---	0.05	0.1	0.2
Mercury	2	(mg/L)	0.002	0.0014	0.00077	0.0018	0.00094	---
Selenium	2	(mg/L)	0.05	---	0.005	0.17	11	0.01-0.02
Zinc	2	(mg/L)	---	² 0.08	² 0.08	9.1	69	2

Notes:

--- indicates there is no standard for this parameter.

The aquatic life standards for ammonia are pH and temperature dependent. Assuming a near neutral pH, the most stringent acute and chronic aquatic life standards for ammonia are 24 mg/l and 2.18 mg/l, respectively.

1) (mg CaCO₃/L)

2) These were hardness-dependant calculations, in which 66.6 was the averaged hardness for Crooked Creek. (Averaged hardness is a rough estimate taken from the USGS website, Bethel Division, Alaska, Hydrological Unit Code 19030501)

3) Hardness-dependant criteria were taken from Appendix A in the "Alaska Water Quality Criteria Manual for Toxic And Other Deleterious Organic and Inorganic Substances" report by the Department of Environmental Conservation revised on December 12, 2008 (<http://www.dec.state.ak.us/water/wqsar/wqs/index.htm>).

4) Source:

1. Alaska Department of Environmental Conservation, Water Quality Standards (18 AAC 70) Amended as of April 8, 2012.

2. Alaska Department of Environmental Conservation, Alaska Water Quality Criteria Manual For Toxic and Other Deleterious Organic and Inorganic Substances. Amended as of December 12, 2008.