Technical Report No. 11-01

Aquatic Biomonitoring at Red Dog Mine, 2010

National Pollution Discharge Elimination System
Permit No. AK-003865-2

by Alvin G. Ott and William A. Morris

North Fork Red Dog Creek, Fyke Nets, Spring 2010
Photograph by Al Ott

March 2011

Alaska Department of Fish and Game
Division of Habitat

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Acknowledgements

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Dr. Phyllis Weber Scannell (Scannell Technical Services) updated our long-term water quality data base with 2010 data. Ms. Nora Foster (NRF Taxonomic Services) was responsible for sorting and identification of aquatic invertebrates collected with drift nets. Mr. Jack Winters and Mr. Robert Napier provided constructive review of our report.

Executive Summary

●Median metals concentrations (Pb, Zn, Al, Cd) in Mainstem Red Dog Creek are consistently lower when compared with pre-mining data. Baseline data for Se and Ni are not available, but Se has remained unchanged since 1999, whereas Ni was somewhat elevated from 2006 to 2010. The pH and total dissolved solids in Mainstem Red Dog Creek are higher than pre-mining. The higher pH and TDS are directly related to the water treatment process used at the Red Dog Mine. When Mainstem Red Dog Creek is compared with reference sites (Buddy and North Fork Red Dog creeks), Cd, Pb, and Zn concentrations are consistently higher. Se concentrations do not show a pattern at these sites. Overall, there is no apparent trend for increasing metals concentrations in Mainstem Red Dog, North Fork Red Dog, and Buddy creeks.

●Algal biomass, as measured by chlorophyll-a concentration, is sampled each year at a number of sites in the Red Dog Creek and Bons/Buddy Creek drainages. Generally, chlorophyll-a concentrations are highest in North Fork Red Dog, Bons, and Buddy creeks and lower in Middle Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks. Chlorophyll-a concentrations track with changes in metals concentrations in Ikalukrok Creek at Station 9, a site that is not affected by wastewater discharge or drainage from the Red Dog Mine. Fish use is higher in those systems exhibiting higher chlorophyll-a concentrations.

●Aquatic invertebrate densities are used to measure stream productivity. In 2010, higher densities were found in the Bons and Buddy Creek and North Fork Red Dog Creek sites. These data continue to follow the same general pattern of higher densities occurring in the Bons and Buddy Creek drainages and in North Fork Red Dog Creek. There appears to be a trend for a decrease in the percent EPT since 2004 at these three sites. However, after looking at EPT densities, we concluded that there is no downward trend in densities of EPTs, but rather an increasing trend in Chironomidae densities. Overall, taxa richness is very similar in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks.

●Juvenile Dolly Varden are collected each year from Mainstem Red Dog, Buddy, and Anxiety Ridge creeks, and are analyzed for whole body metal concentrations. There is less difference among the three sample sites for Se than for Cd, Pb, Zn, and Hg. Whole body metals concentrations in fish from each sample site exhibit a creek specific signature. Median Cd, Pb, and Zn tissue concentrations are highest in Mainstem Red Dog Creek. Se is similar at all three sites. Hg concentrations consistently are higher in Anxiety Ridge Creek. Finally, Cd and Zn are higher in Buddy Creek than they are in Anxiety Ridge Creek.

Concentrations of Cd, Se, and Pb in juvenile Arctic grayling in Bons Pond have remained unchanged over time. Zn median concentrations increased from 2004 to 2007 and Hg concentrations, although low, increased in 2007 and 2010 as compared to 2004.

●Kidney, liver, ovary, testes, and muscle from adult Dolly Varden captured in the Wulik River during spring and fall 2010 were sampled for Cd, Cu, Pb, Se, Zn, and Hg. None of the analytes measured have been found to concentrate in muscle tissue. Various metals do concentrate in specific tissues: Cd in kidney, Cu in liver, Pb in gill, Se in kidney and ovary, Zn in ovary, and Hg in kidney. It is unlikely that tissue metals concentrations or changes could be related to events at the Red Dog Mine since large Dolly Varden attain their growth in the marine environment.

●The number of overwintering Dolly Varden is estimated each fall in the Wulik River. There is some indication, based on surveys from 2005 to 2010, that the number of fish overwintering in the Wulik River has exhibited a decreasing trend. Aerial surveys prior to mine development found that over 90% of overwintering Dolly Varden in the Wulik River are located below the mouth of Ikalukrok Creek. Surveys post mining continue to document this same occurrence. In 2010, 99% of the Dolly Varden counted were in the Wulik River downstream of the mouth of Ikalukrok Creek.

●Annual aerial surveys assess the distribution of chum salmon in Ikalukrok Creek. Aerial counts of adult chum salmon after mine development in 1990 and 1991 were much lower than those reported in baseline studies. The highest estimated number of chum salmon was 4,185 in 2006. Fairly large returns of chum salmon (890 to 3,820) have been seen in 2001, 2002, 2006, 2007, 2008, 2009, and again in 2010 (1,358).

●With almost 20 years of sampling for juvenile Dolly Varden in streams near the Red Dog Mine, we have developed the following conclusions: abundance is higher in the upper reaches of each sampled stream; and peak use occurs from late July to late August; and decreasing fall water temperatures and high water events likely trigger outmigration. In 2010, juvenile Dolly Varden were caught in all sample reaches, with the highest catch (115) in Buddy Creek. Juvenile Dolly Varden continue to use Mainstem Red Dog Creek for rearing.

●The Arctic grayling spring migration into North Fork Red Dog Creek was strong in spring 2010. We caught 261 immature Arctic grayling with 157 of these fish < 200 mm long. Part of the recruitment seen is from fish leaving Bons Pond and returning to North Fork Red Dog Creek. Breakup was early in 2010 and spawning was judged to be substantially completed by May 29. Water flows were extremely low in spring 2010. Fry were abundant in Mainstem Red Dog and Ikalukrok creeks in July and again in mid-August.

●The Bons Pond Arctic grayling population estimate for 2009 (2,180 fish) was very similar to 2008, but much lower than previous estimates (2004 estimate was 6,189 fish). Arctic grayling spawned in Bons Creek and in the outlet channel from Bons Pond.

●Pre-mining slimy sculpin (*Cottus cognatus*) abundance is unknown, but baseline data reports indicated that this species was numerous in the Ikalukrok Creek drainage, but uncommon in the Red Dog Creek drainage. In most years we catch low numbers of large slimy sculpin in the spring in North Fork Red Dog Creek and several in minnow buckets later in the summer in Mainstem Red Dog Creek. In 2010, we only caught one slimy sculpin in Mainstem Red Dog Creek.

Introduction

The Red Dog zinc (Zn) and lead (Pb) deposit is located in northwestern Alaska, about 130 km north of Kotzebue and 75 km inland from the Chukchi Sea coast (Figure 1). Mine operations, facilities, surrounding vegetation, and wildlife are described in Weber Scannell and Ott (1998). A chronology of development and operations at the Red Dog Mine is presented in Appendix 1. Aquatic resources in the Wulik River drainage are described in Weber Scannell et al. 2000.

On January 8, 2010, the US Environmental Protection Agency (EPA) issued National Pollution Discharge Elimination System Permit No. AK-003865-2 (NPDES Permit) to Teck Alaska Incorporated (Teck) to allow discharge of up to 2.418 billion gallons of treated effluent per year. The NPDES Permit required a bioassessment program that included periphyton, aquatic invertebrates, and fish in selected streams near the Red Dog Mine (Table 1). The bioassessment program became fully effective and enforceable on March 31, 2010.

Table 1. Location of NPDES Sample Sites and Factors Measured.

Sample Site	Factors Measured
North Fork Red Dog Creek	Periphyton (chlorophyll-a concentrations) Aquatic Invertebrates (taxonomic richness and abundance) Fish Presence and Use
Mainstem Red Dog Creek	Periphyton (chlorophyll-a concentrations) Aquatic Invertebrates (taxonomic richness and abundance) Fish Presence and Use
Ikalukrok Creek	Periphyton (chlorophyll-a concentrations) Aquatic Invertebrates (taxonomic richness and abundance) Fish Presence and Use

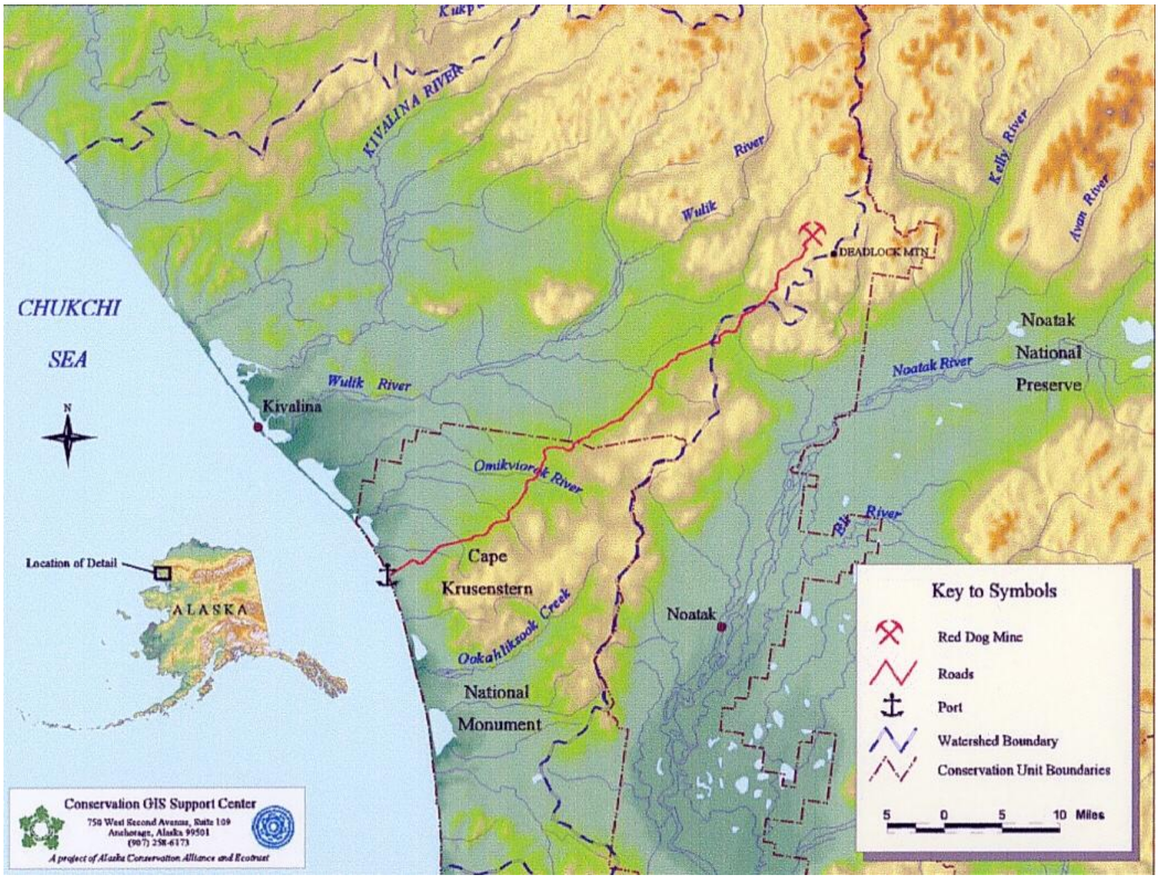

Figure 1. Location of the Red Dog Mine in northwestern Alaska. Map used with permission of Conservation GIS Support Center, Anchorage, Alaska.

On December 2, 2009, the Alaska Department of Environmental Conservation (ADEC) issued Waste Management Permit No. 0132-BA002 for the Red Dog Mine that included a condition that Teck adhere to the requirements of the monitoring plan submitted by Teck in May 2009. The Alaska Department of Fish and Game (ADF&G) submitted Technical Report #10-04 titled "Methods for Aquatic Life Monitoring to Satisfy Requirements of 2010 NPDES Permit, Red Dog Mine Site (Revision #1) in April 2010 to satisfy conditions in the EPA and ADEC permits. Teck's May 2009 monitoring plan includes sample sites, sampling frequency, and parameters for all aquatic sites, including those required by the NPDES Permit (Table 2).

Table 2. Location of Sample Sites and Factors Measured.

			Sampling	
Location	NPDES/ADEC	Location Description	Frequency	Parameters
Wulik River	ADEC	Kivalina Lagoon upstream to about 10 km upstream of the mouth of Ikalukrok Creek (where the canyon starts)	1/year	Fall aerial surveys for overwintering Dolly Varden
Ikalukrok Creek	ADEC	Lower Ikalukrok Creek to mouth of Dudd Creek	1/year	Fall aerial surveys for adult chum salmon
Station 9	NPDES/ADEC	Ikalukrok Creek upstream of confluence with Red Dog Creek	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
			1/year	Fish presence and use
Station 160	ADEC	Lower Ikalukrok Creek	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
			1/year	Fish presence and use
Station 20	ADEC	Middle Fork Red Dog Creek upstream on confluence with North Fork Red Dog Creek	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
Station 10	NPDES/ADEC	Mouth of Red Dog Creek	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
			1/year	Fish presence and use
			1/year	Juvenile Dolly Varden metals in tissue (Zn, Pb, Se, Hg, and Cd)
Station 12	NPDES/ADEC	North Fork Red Dog Creek	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
			1/year	Fish presence and use
			1/year	Record of spawning activity (Arctic grayling)
			Periodic	Capture/mark Arctic grayling
Buddy Creek	ADEC	Below falls, about 1.5 km downstream of Haul Road	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
			1/year	Fish presence and use
			1/year	Juvenile Dolly Varden metals in tissue (Zn, Pb, Se, Hg, and Cd)
Buddy 221	ADEC	Buddy Creek, above road	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
Bons 220	ADEC	Bons Creek, below pond	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
Bons Above Pond	ADEC	Above pond	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
Anxiety Ridge Creek	ADEC	below DMTS road	1/year	Fish presence and use
			1/year	Juvenile Dolly Varden metals in tissue (Zn, Pb, Se, Hg, and Cd)
Evaingiknuk Creek	ADEC	East of DMTS road	1/year	Fish presence and use
Bons Reservoir	ADEC	Above reservoir spillway	1/year	Juvenile Arctic grayling metals in tissue (Zn, Pb, Se, Hg, and Cd)
			1/year	Arctic grayling population estimate

Teck's monitoring plan also is incorporated by reference into the Alaska Department of Natural Resources Reclamation Plan Approval (F20099958) dated December 2, 2009. On March 10, 2010, the U.S. Department of Army issued permit POA-1984-12-M45 to Teck which authorized development of the Aqqaluk Pit. Our report presents data collected during summer 2010 and where applicable, we compare these data with previous years.

Structure of Report

Water quality, periphyton standing crop, and aquatic invertebrate data are presented in the first three sections of our report. Metals concentration data for juvenile Dolly Varden (*Salvelinus malma*) and Arctic grayling (*Thymallus arcticus*) collected from small streams and Bons Pond, and adult Dolly Varden collected from the Wulik River are then presented. Aerial survey estimates of overwintering Dolly Varden in the Wulik River and chum salmon (*Oncorhynchus keta*) spawners in Ikalukrok Creek are covered next. Finally, biological monitoring data for Dolly Varden juveniles, Arctic grayling, and slimy sculpin (*Cottus cognatus*) are presented.

Location of Sample Sites

Biomonitoring is conducted in streams adjacent to and downstream from the Red Dog Mine as required under the EPA NPDES Permit No. AK-003865-2 (Tables 1 and 2 and Figures 2 and 3), and by condition in the ADEC Waste Management Permit and the ADNR Reclamation Plan Approval. Monitoring sites include the Red Dog Creek drainage, Ikalukrok Creek, Bons and Buddy Creek drainage, Anxiety Ridge Creek, and Evaingiknuk Creek.

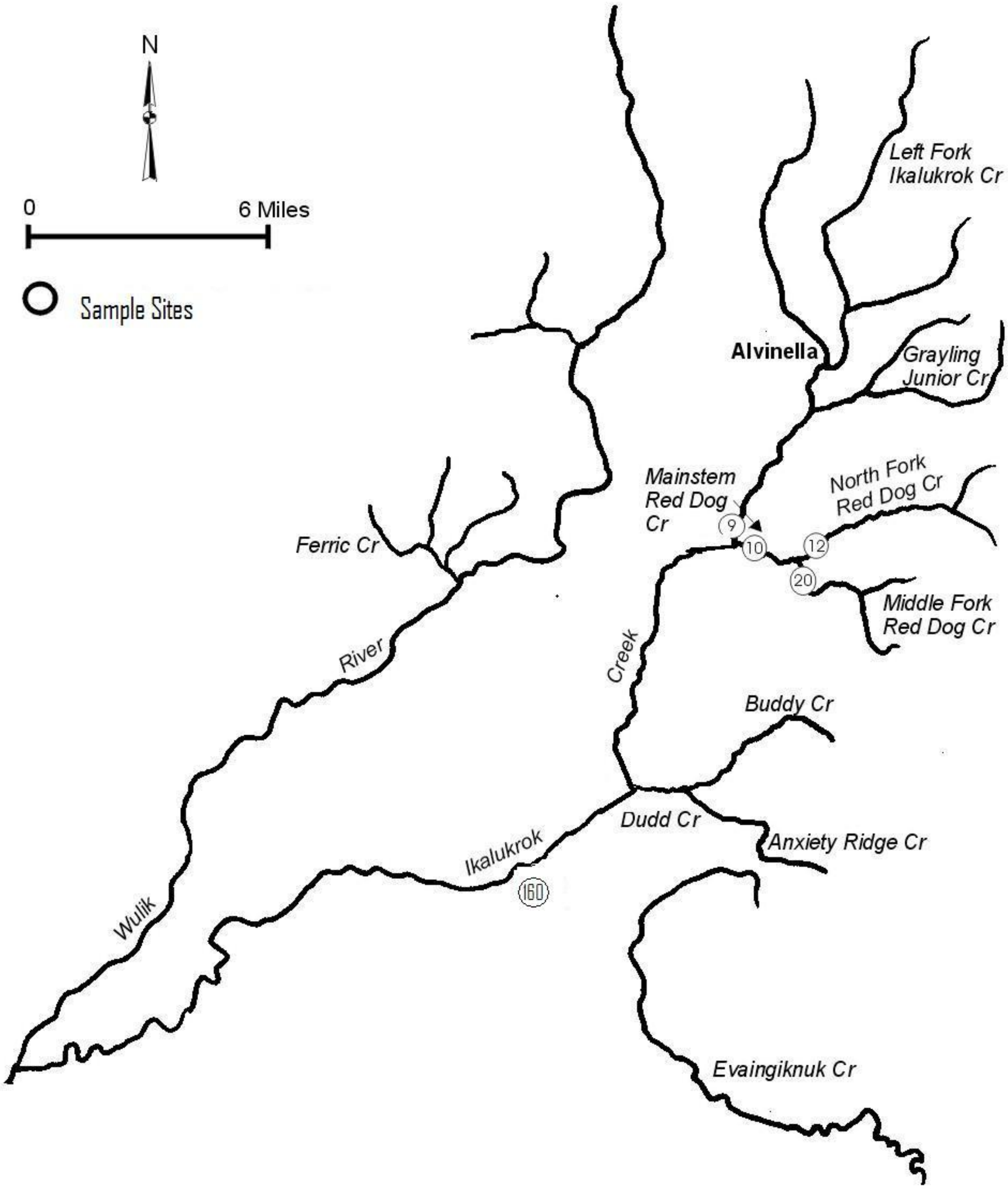

Figure 2. Location of sample sites (Station # on Figure) in the Ikalukrok Creek and Noatak River drainages.

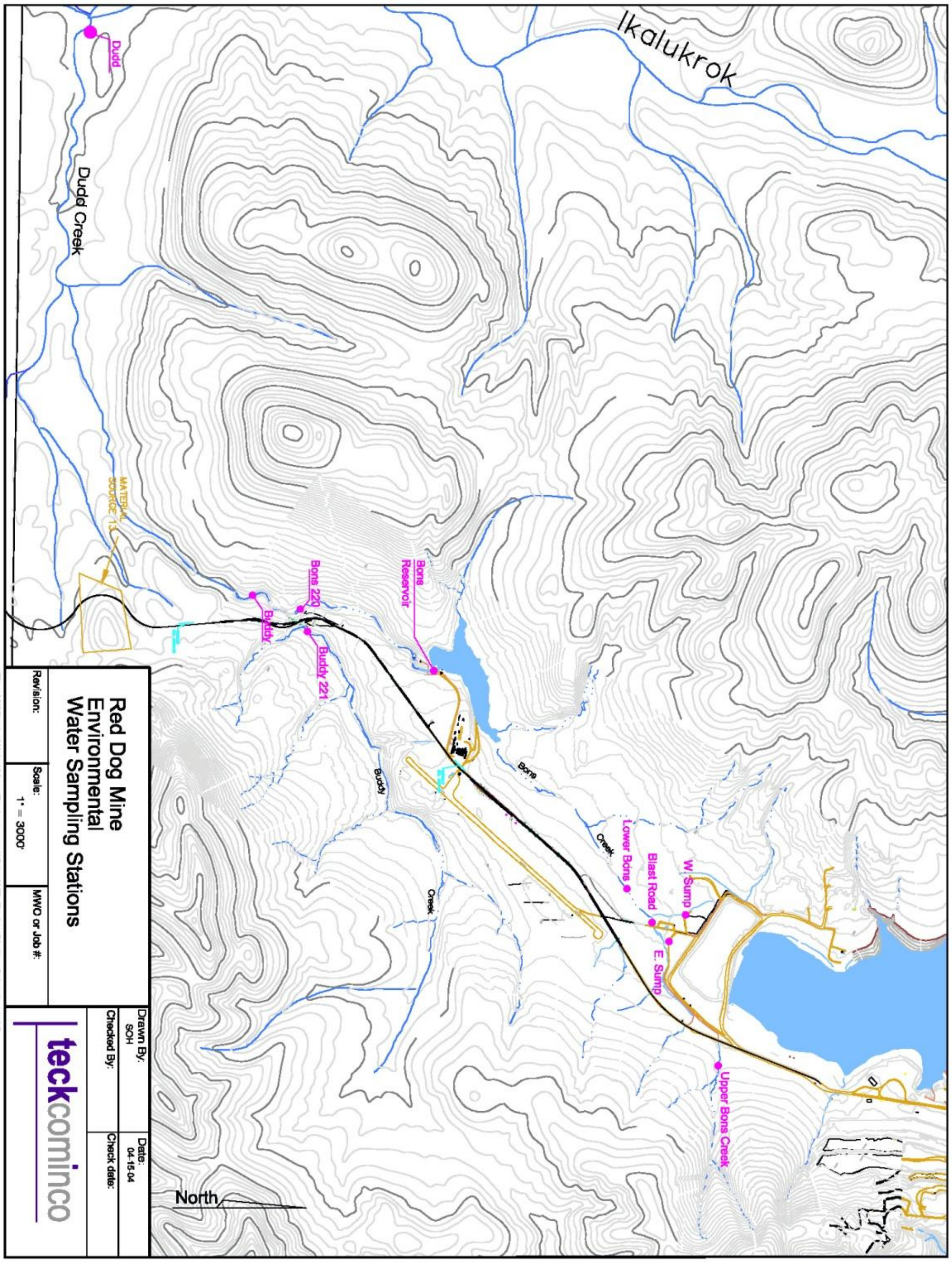

Figure 3. Bons and Buddy creeks and Bons Pond (map provided by Teck).

Description of Streams

All streams in the study area are in the Wulik River drainage, except for Evaingiknuk Creek, which is in the Noatak River drainage. Station numbers correspond either to those used by Dames and Moore (1983) during baseline work or to the current water quality program being conducted by Teck. Water quality and fish data collected during baseline studies (1979 to 1982) represent pre-mining conditions. Comparisons of existing conditions relative to baseline data should take into account that we have many years of data during mining and only a short time frame of baseline data.

Methods

All methods used for the Red Dog Mine aquatic biomonitoring study are described by ADF&G (2010) in Technical Report No. 10-04 titled "Methods for Aquatic Life Monitoring to Satisfy Requirements of 2010 NPDES Permit, Red Dog Mine Site (Revision #1)."

The method detection limit (MDL) in 2000 for copper (Cu), Pb, and selenium (Se) was 50, 20, and 50 *u*g/L, respectively, for a portion of the samples early in the ice-free season. MDL's were changed part way through summer 2000 for Cu, Pb, and Se to 1, 2, and 1 *u*g/L respectively. Because of the high MDLs used in early 2000, water quality data for these samples are not presented. Water quality data presented in our report are for "total recoverable." All water quality data are provided by Teck. The number of water quality samples taken each year varies with the permit condition requirements, but for most analytes samples are collected twice each month with a sample size of 9 to 13 per year.

The abundance of Arctic grayling was estimated using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951),

$$\hat{N}_c = \left\{ \frac{(n_1+1)(n_2+1)}{(m_2+1)} \right\} - 1,$$

where $\hat{N}_c$ = estimated population, n_1=fish marked in first capture event, n_2=fish captured during recapture event, and m_2=fish captured during recapture event that were marked in the capture event. Variance was calculated as: (Seber 1982)

$$\text{var}(\hat{N}_c) = \left\{ \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \right\}.$$

95% CI for the population estimate was calculated as

$$95\% C.I. = N_c \pm (1.960)\sqrt{\hat{\text{var}}(\hat{N}_c)}.$$

Results and Discussion

Water Quality

We will focus on several key sites including Mainstem Red Dog Creek (Station 151 for 2010 data and Station 10 for all previous years). Station 151 is located in Mainstem Red Dog Creek just below the mixing zone with North Fork Red Dog Creek. Station 10 (Figure 4) is located near the mouth of the creek – there are no defined drainages entering Mainstem Red Dog Creek between these two water quality stations. Mainstem Red Dog Creek is directly affected by the mine wastewater effluent and by water from the clean water bypass.

Figure 4. Mainstem Red Dog Creek at Station 10 on July 3, 2010 (left) and on July 3, 2009 (right).

Teck continued to maintain the mine's clean water bypass system which picks up non-mining impacted water from Sulfur, Shelly, Connie, Rachael, and Middle Fork Red Dog creeks. This water is moved through the active pit area to its original channel downstream of the mine via a combination of culverts and lined open ditch. Pb and Zn concentrations at Station 10/151, downstream of the clean water bypass system, indicate that both of these elements are lower now than pre-mining, with the exception of several maximum Pb concentrations. Median Pb and Zn concentrations remain consistently lower than pre-mining (Figures 5 and 6).

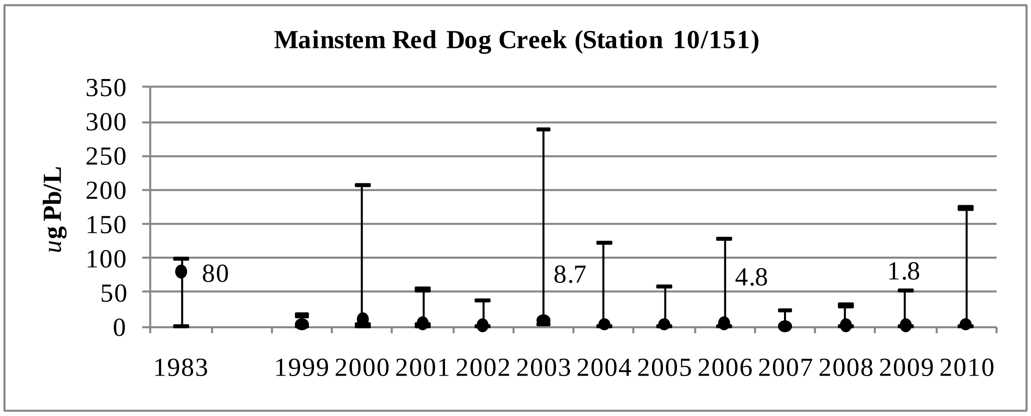

Figure 5. Median, maximum, and minimum Pb concentrations at Station 10/151 (selected median values shown).

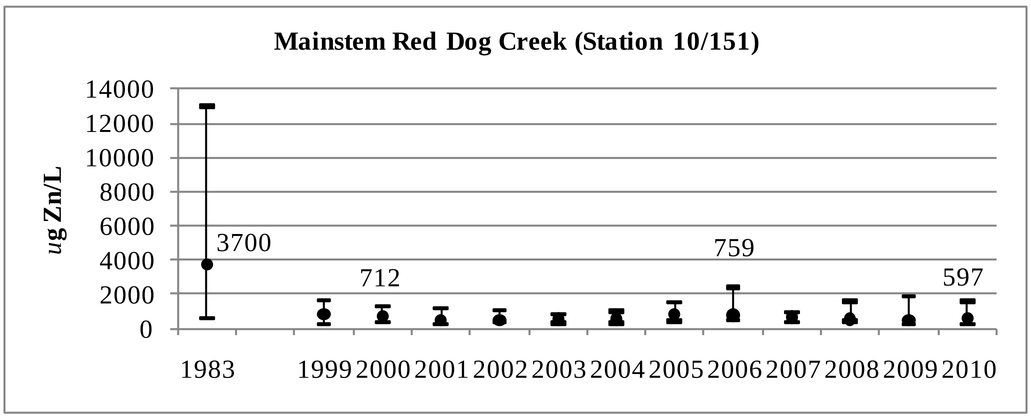

Figure 6. Median, maximum, and minimum Zn concentrations at Station 10/151 (selected median values shown).

We continue to evaluate water quality data being collected in Mainstem Red Dog Creek as part of the ongoing aquatic biomonitoring program. Median Al concentrations at Station 10/151 continue to be lower than pre-mining (Figure 7) and there is a decreasing trend over time for Al concentrations (Figure 7). Cd concentrations also are lower than pre-mining conditions (Figure 8). The median Cd concentration in 1983 was 28 *u*g/L and in summer 2010 it was 3.9 *u*g/L (Figure 8).

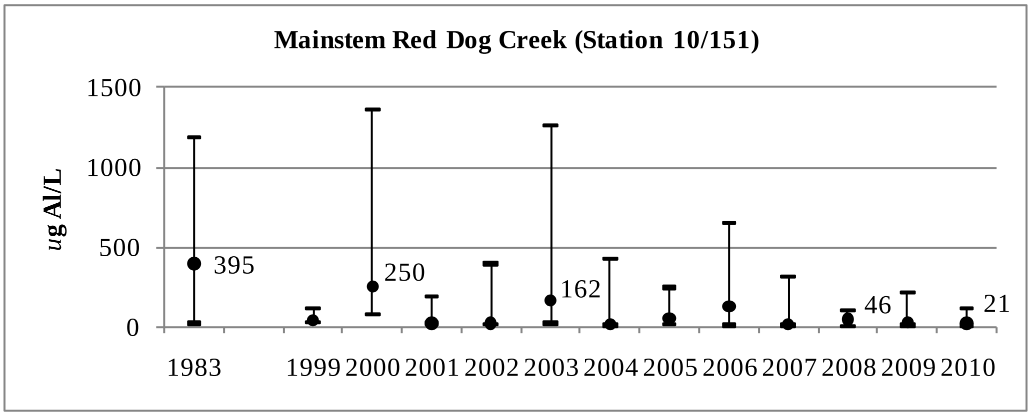

Figure 7. Median, maximum, and minimum Al concentrations at Station 10/151 (selected median values shown).

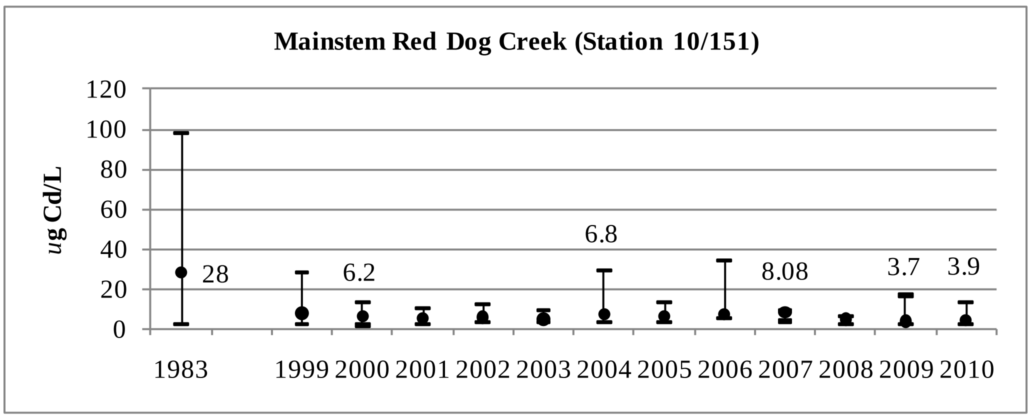

Figure 8. Median, maximum, and minimum Cd concentrations at Station 10/151 (selected median values shown).

Pre-mining data for Se and Ni are not available. Se concentrations in Mainstem Red Dog Creek have remained similar from 1999 to 2010, but have exhibited periods of minor increase and decrease (Figure 9). The highest median Se concentration was 2 *u*g/L in 2008. Ni concentrations at Station 10/151 have been elevated in recent years (Figure 10). Higher median Ni concentrations were observed first in 2006 (19.1 *u*g/L), similar to Se concentrations, Ni has exhibited periods of increase and decrease. The primary source of Ni to the clean water bypass system in previous years has been Rachael Creek (Ott and Morris 2010). Ni concentration data were not collected in summer 2010 for those streams located in the area of the clean water bypass system.

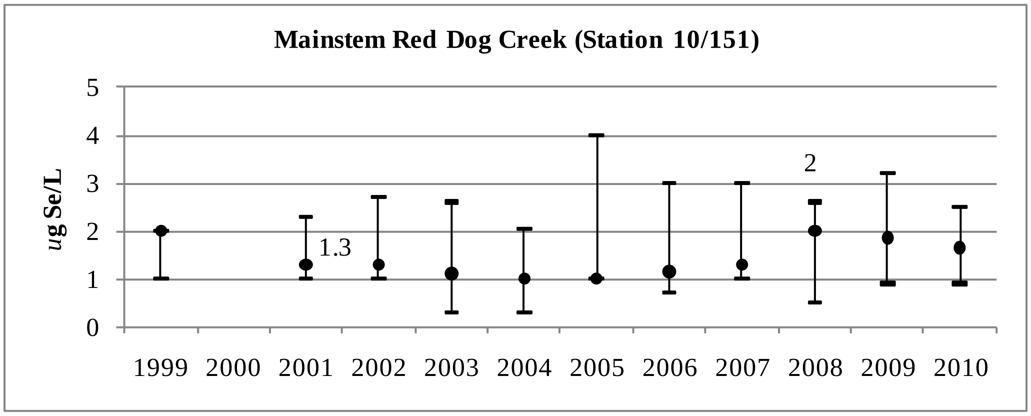

Figure 9. Median, maximum, and minimum Se concentrations at Station 10/151 (selected median values shown).

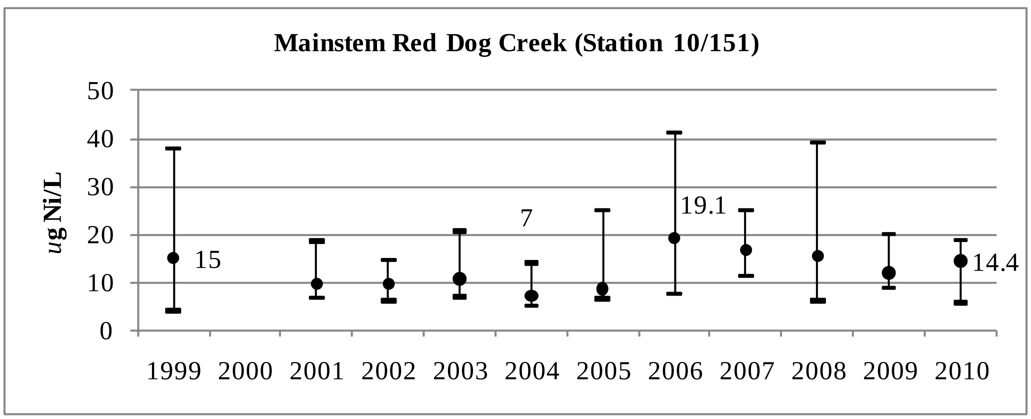

Figure 10. Median, maximum, and minimum Ni concentrations at Station 10/151 (selected median values shown).

The pH at Station 10/151 is higher than pre-mining (Figure 11). The pH is slightly more basic and has not dropped below 6 as seen in 1990. The 1990 data set is during mining, but prior to construction of the clean water bypass system. The clean water bypass system was built prior to spring breakup in 1991. Total dissolved solids (TDS) in Mainstem Red Dog Creek also are higher (Figure 12). Higher TDS is directly related to high concentrations in the treated wastewater discharge at Station 001. $Ca(OH)_2$ is added to precipitate the metals as hydroxides and the sulfates released in this process along with the Ca result in high TDS concentrations in the effluent. TDS concentrations in Mainstem Red Dog Creek in summer 2010 never exceeded 1,500 mg/L at Station 151.

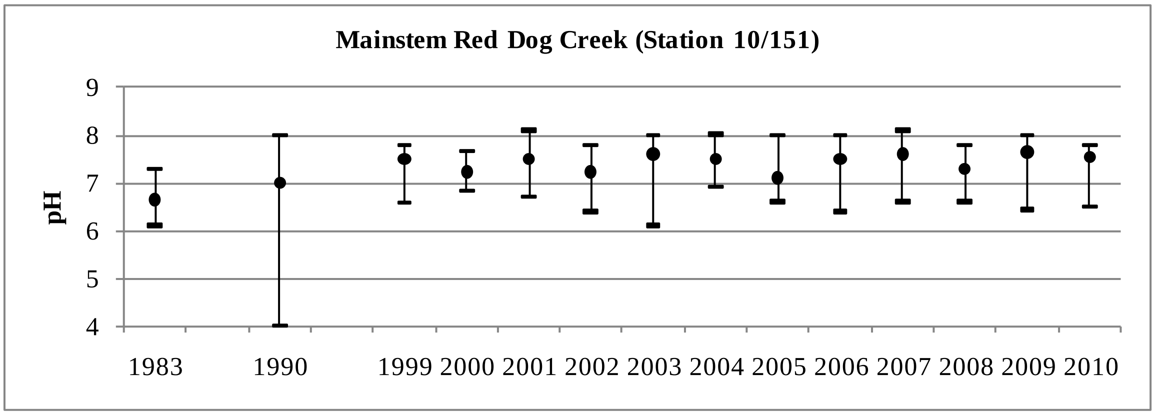

Figure 11. Median, maximum, and minimum pH values at Station 10/151.

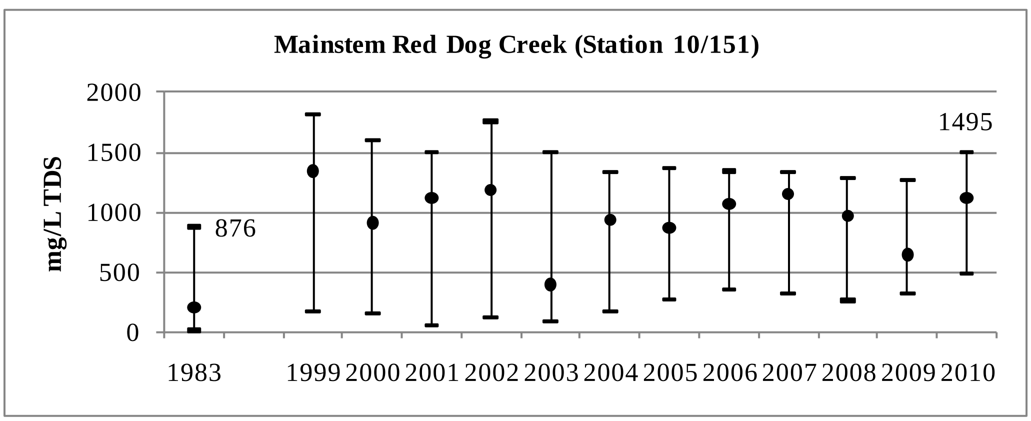

Figure 12. Median, maximum, and minimum TDS concentrations at Station 10/151 (selected maximum values shown).

We next compare Cd, Pb, Se, and Zn concentrations in Mainstem Red Dog Creek (Station 10/151) with those found in North Fork Red Dog Creek (Station 12) and in Buddy Creek (below the confluence of Bons and Buddy creeks). These two sites were selected because they include reference sites with no direct effects from the Red Dog Mine. Mainstem Red Dog Creek is directly downstream of the mine clean water bypass and wastewater effluent point and thus gives us an indication of the effects from the mine. Finally, Buddy Creek also is a reference site, but with the potential to be affected by the road, airport, waste rock dump, Bons Pond, and is down gradient from the backdam on the south end of the tailing pond. Cd, Pb, Se, and Zn were selected for comparison because they also are analyzed for whole body concentrations in juvenile Arctic grayling and Dolly Varden.

Cd, Pb, and Zn median concentrations are highest in Mainstem Red Dog Creek (Figures 13, 14, and 15). In the two reference sites, Cd and Zn are essentially identical over the entire time frame from 1999 to 2010. Pb concentrations have a little more variability, but still are consistently lower in North Fork Red Dog and Buddy creeks.

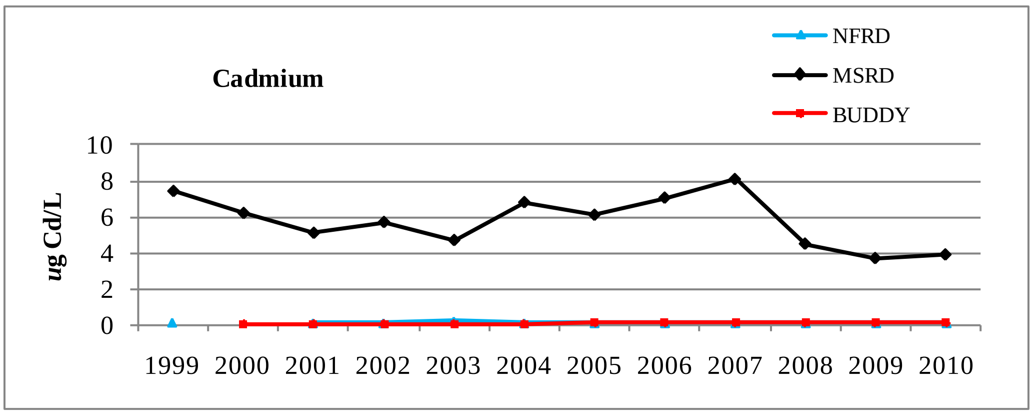

Figure 13. Median Cd concentrations in North Fork Red Dog, Mainstem Red Dog, and Buddy Creeks (1999 to 2010).

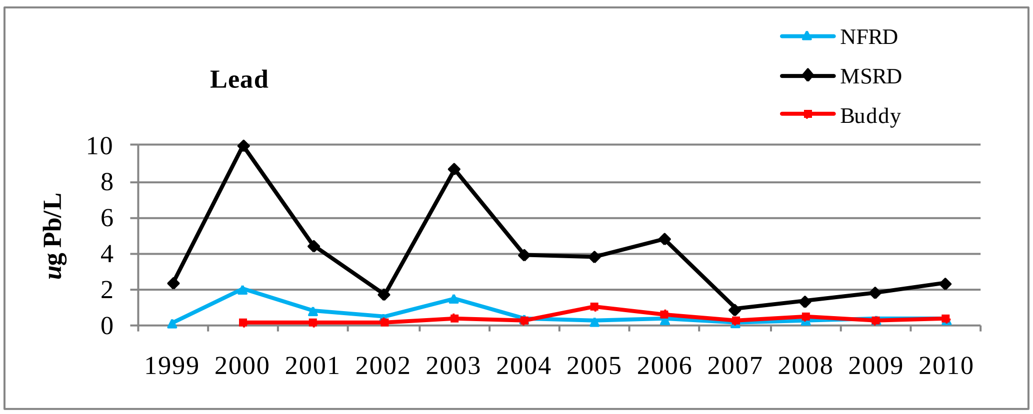

Figure 14. Median Pb concentrations in North Fork Red Dog, Mainstem Red Dog, and Buddy Creeks (1999 to 2010).

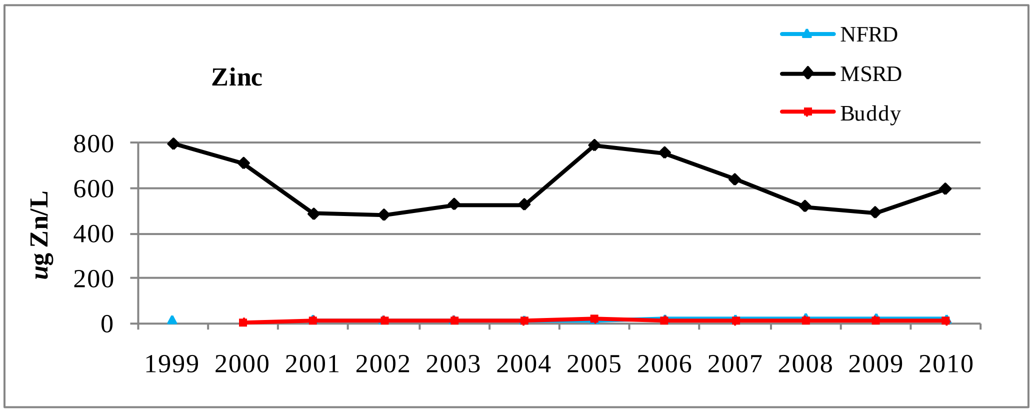

Figure 15. Median Zn concentrations in North Fork Red Dog, Mainstem Red Dog, and Buddy Creeks (1999 to 2010).

Median Se concentrations have not shown any trend with time (Figure 16). Selenium is slightly higher in Buddy Creek while Se is essentially the same in North Fork Red Dog and Mainstem Red Dog creeks.

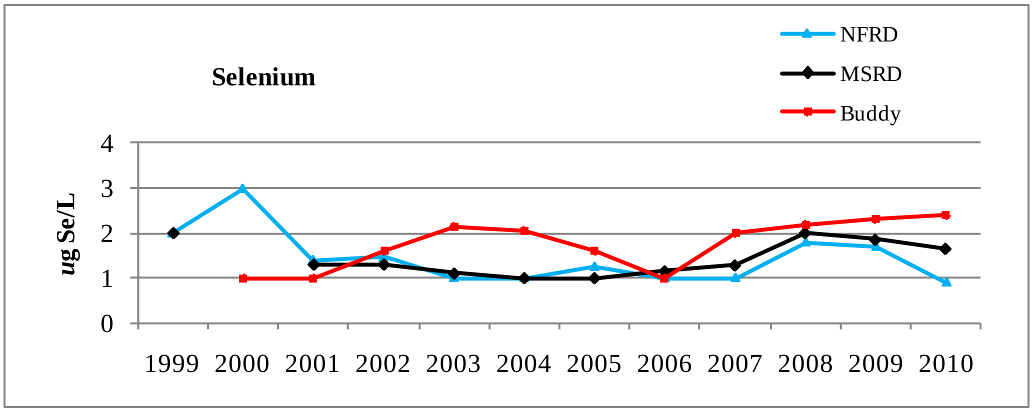

Figure 16. Median Se concentrations in North Fork Red Dog, Mainstem Red Dog, and Buddy Creeks (1999 to 2010).

Periphyton Standing Crop

Algal biomass samples, as estimated by chlorophyll-a concentrations (mg/m^2), are collected each year. Under the new program initiated in 2010, sampling occurred at eight of the nine sites because there was no surface flow at Bons Creek (Station 220). Chlorophyll-a concentrations in 2010 were highest in Buddy Creek (10.5 mg/m^2) above the road and in Buddy Creek (9.7 mg/m^2) below the falls, and lowest in Middle Fork Red Dog Creek (1.4 mg/m^2) (Figure 17). This pattern is consistent with previous years' data in that periphyton standing crops are higher in the Buddy and Bons Creek and North Fork Red Dog Creek drainages. However, in 2010, chlorophyll-a concentrations were also fairly high in Mainstem Red Dog and Ikalukrok creeks (Figure 17) and were the highest ever seen in Middle Fork Red Dog Creek.

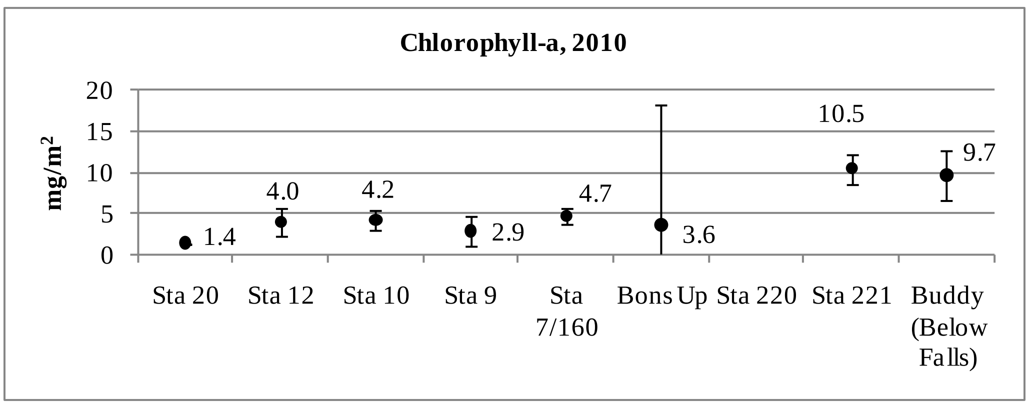

Figure 17. Average concentration of chlorophyll-a (plus and minus one SD).

Average chlorophyll-a concentrations in Mainstem Red Dog Creek from 2004 through 2010 varied from a low of 0.3 to a high of 10.1 mg/m^2 (Figure 18). In 2010, the average chlorophyll-a concentration was 4.2 mg/m^2. In North Fork Red Dog and Buddy creeks, the average chlorophyll-a concentration in 2010 was 4.0 and 9.7 mg/m^2 (Figures 19 and 20). Generally, periphyton standing crop is high in Buddy Creek and concentrations are similar in North Fork Red Dog and Mainstem Red Dog creeks with the exception of 2004 and 2007.

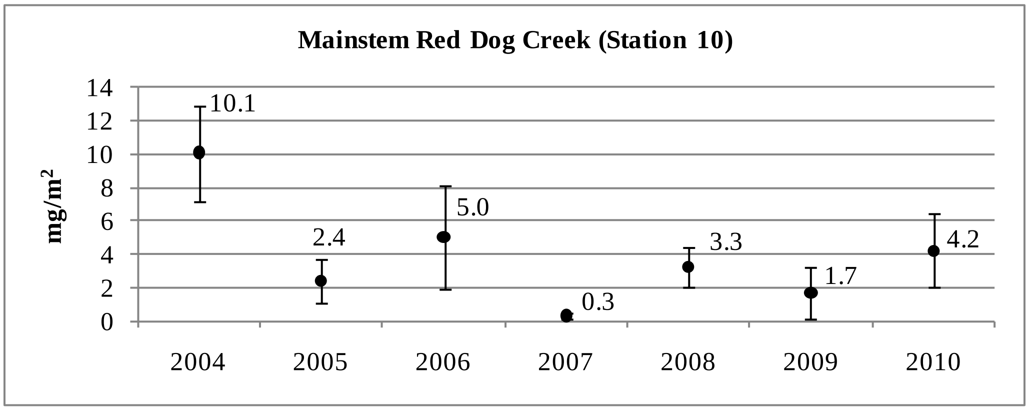

Figure 18. Average concentration of chlorophyll-a (plus and minus one SD).

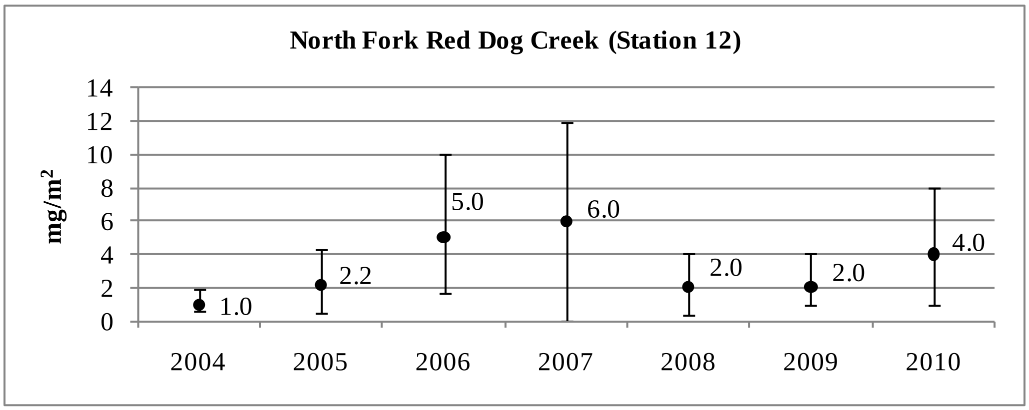

Figure 19. Average concentration of chlorophyll-a (plus and minus one SD)

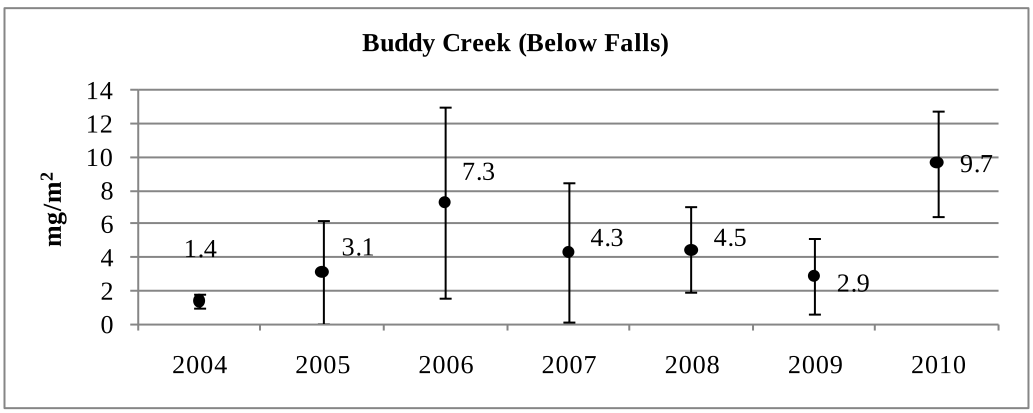

Figure 20. Average concentration of chlorophyll-a (plus and minus one SD).

Periphyton standing crop tracks very closely with elevated Zn and Cd in Ikalukrok Creek at Station 9. Water quality at Station 9 is not affected by water from the Red Dog Mine facility, but is affected by natural mineral seeps located upstream and along Ikalukrok Creek (Ott and Morris, 2007). Chlorophyll-a concentrations are higher when the Zn and Cd concentrations are lower (Figures 21 and 22). One of the major sources of Zn and Cd to Ikalukrok Creek is the Cub Creek seep (Figure 23).

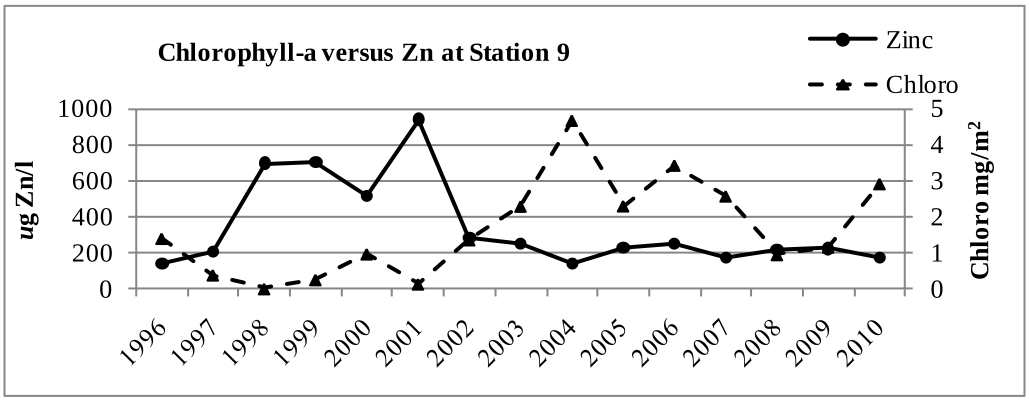

Figure 21. Chlorophyll-a concentrations versus Zn in Ikalukrok Creek.

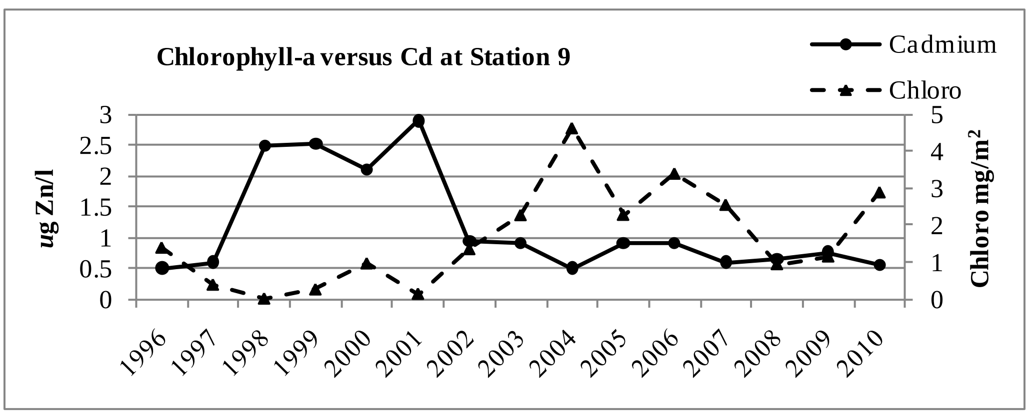

Figure 22. Chlorophyll-a concentrations versus Cd in Ikalukrok Creek.

Figure 23. Ikalukrok Creek (on left of photo) at the Cub Creek seep about 10 km upstream of Station 9 – note iron staining in and along the edge of Cub Creek with noticeable effects to Ikalukrok Creek.

Aquatic Invertebrates

Aquatic invertebrate samples are collected annually using drift nets. In 2010, all nine sites, except for Bons Creek (Station 220), were sampled in early July. Bons Creek (Station 220) was not sampled because there was no surface flow. Low flow conditions which began with a minimal breakup persisted throughout the early part of the summer. Summary data are presented in Appendix 3.

In 2010, the density of aquatic invertebrates was highest ($52.5/m^3$) in Buddy Creek below the falls (Figure 24). The higher densities reflect large numbers of Chironomidae and Simuliidae. The lowest density found was $1.8/m^3$ in Ikalukrok Creek at Station 7/160. These data continue to follow the same general pattern with higher densities occurring in the Bons and Buddy Creek drainages and in North Fork Red Dog Creek. Generally, densities are lowest in Middle Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks.

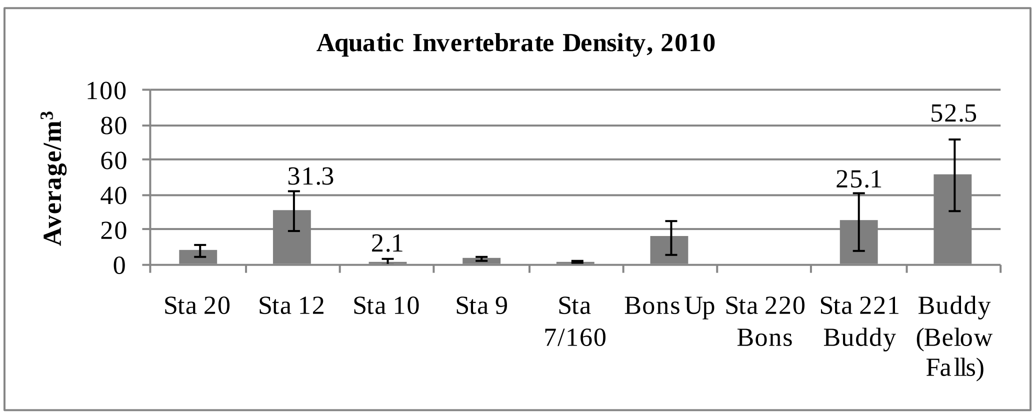

Figure 24. Aquatic invertebrate densities (average plus and minus one SD). Selected average values shown.

The average aquatic invertebrate densities vary among the sample years. Densities in Mainstem Red Dog Creek generally are lower than in North Fork Red Dog and Buddy creeks (Figures 25, 26, and 27). The Buddy Creek site was first sampled in 2004. Aquatic invertebrate densities in Mainstem Red Dog and North Fork Red Dog creeks have been higher in recent years.

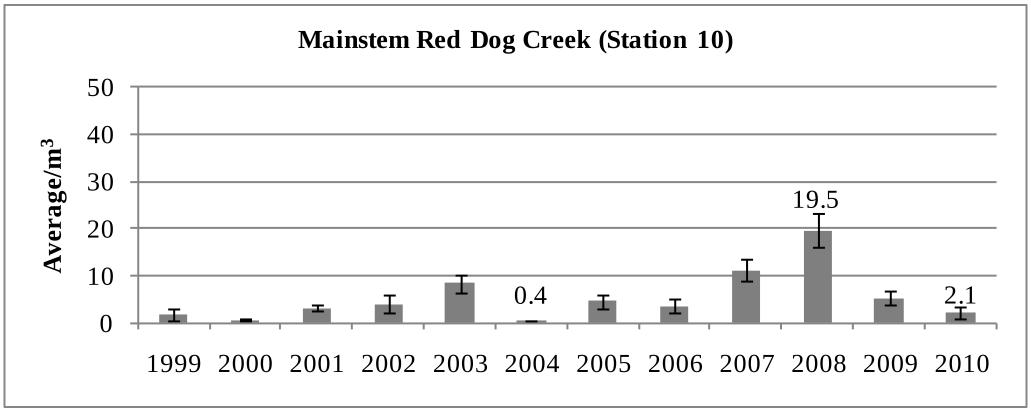

Figure 25. Mainstem Red Dog Creek aquatic invertebrate densities (average plus and minus one SD). Selected average values shown.

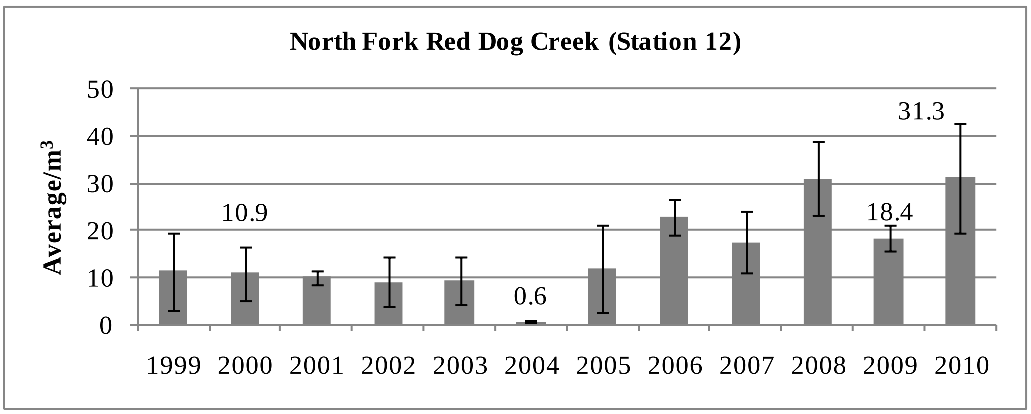

Figure 26. North Fork Red Dog Creek aquatic invertebrate densities (average plus and minus one SD). Selected average values shown.

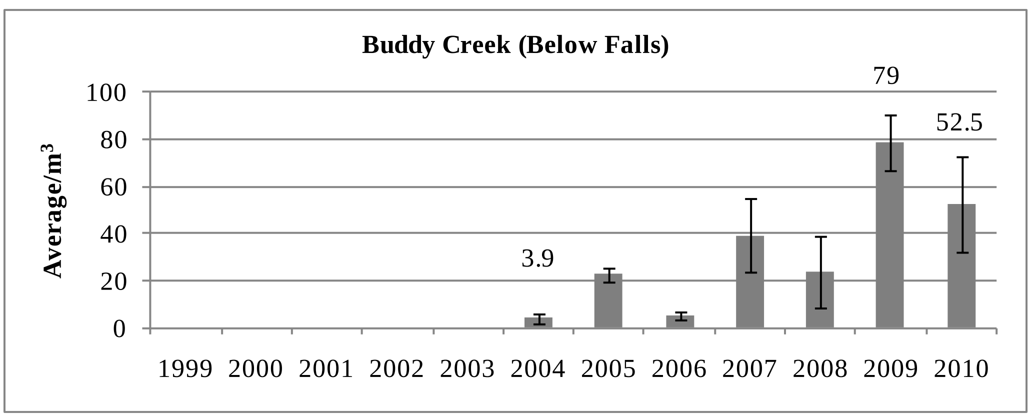

Figure 27. Buddy Creek aquatic invertebrate densities (average plus and minus one SD). Selected average values shown.

The percent Ephemeroptera, Plecoptera, and Trichoptera (EPT) and the percent Chironomidae for all sample sites in 2010 are presented in Figure 28. All sites were dominated by Chironomidae in 2010. Trichoptera are not common in our samples and are not a substantial contributor to EPT. The aquatic systems in the Red Dog Mine area are dominated by Chironomidae which is one of the primary food items of the fish species using these creeks.

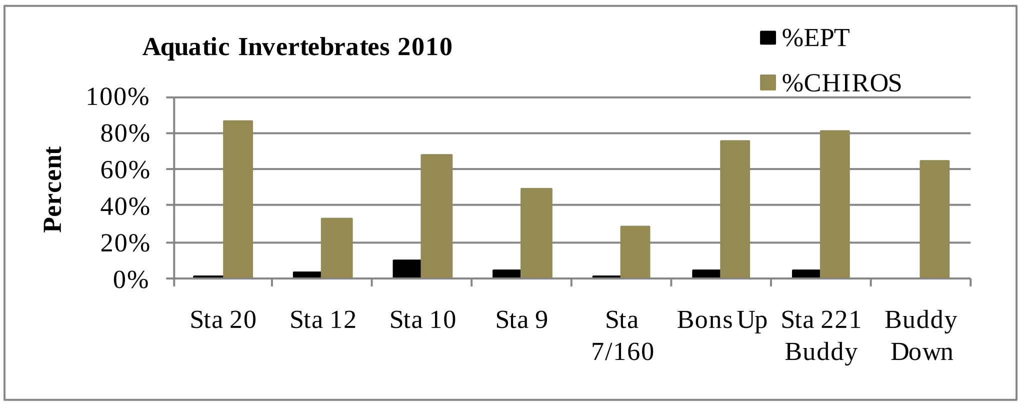

Figure 28. Percent Chironomidae and EPT in the aquatic invertebrate sample sites in July 2010.

The percent EPT in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks since 2004 is presented in Figure 29. There appears to be a trend for a decrease in the percent EPT. The trend exists at all the sample sites so it reflects an area wide shift in the aquatic invertebrate community. We calculated the density of EPT in Mainstem Red Dog, North Fork Red Dog, and Buddy creeks (below falls) to determine if there has been an actual decrease in the numbers of EPT (Figure 30). Densities of EPT generally are higher in North Fork Red Dog Creek than in Mainstem Red Dog Creek and they are highly variable in Buddy Creek (below falls). The highest densities seen in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks were 2.45, 0.48, and 2.39/m^3, respectively. We conclude that there is no downward trend in EPT, but rather an increase in Chironomidae.

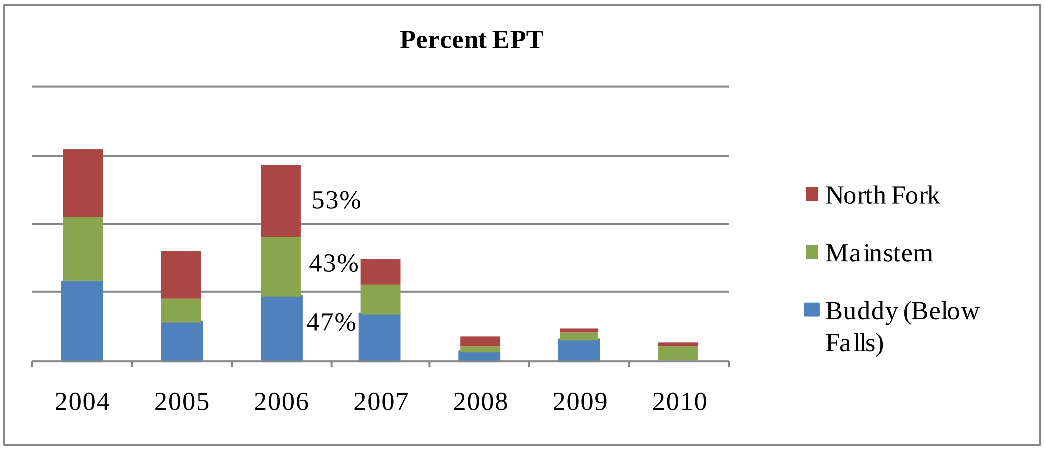

Figure 29. Percent EPT from 2004 to 2010. Values shown for 2006.

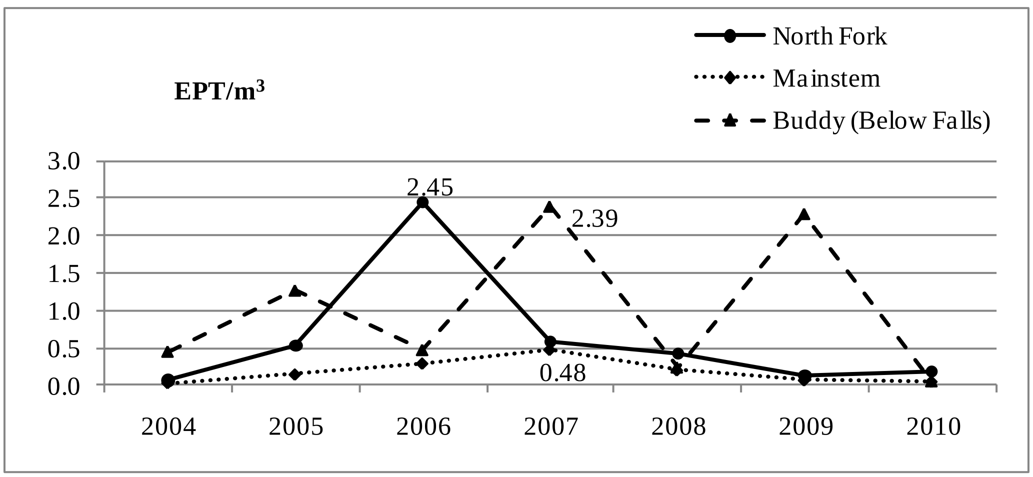

Figure 30. EPT/m3 in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks (selected peak densities for each sample site shown).

We looked at the percent EPT versus Chironomidae from 2004 to 2010 in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks to confirm the trend for increasing percent Chironomidae. Since 2004, with some minor deviations, the percent Chironomidae in all three creeks has been increasing with some of the highest percentages seen in 2010 (Figures 31, 32, and 33).

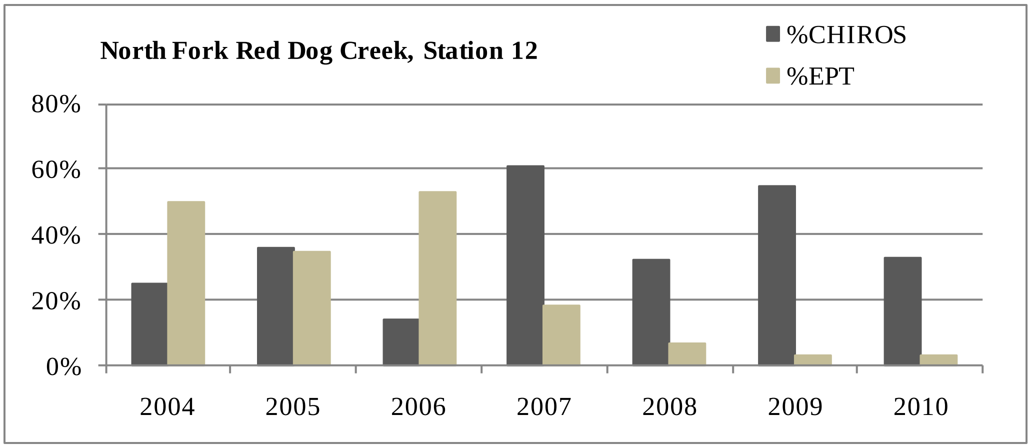

Figure 31. Percent Chironomidae and EPT in North Fork Red Dog Creek.

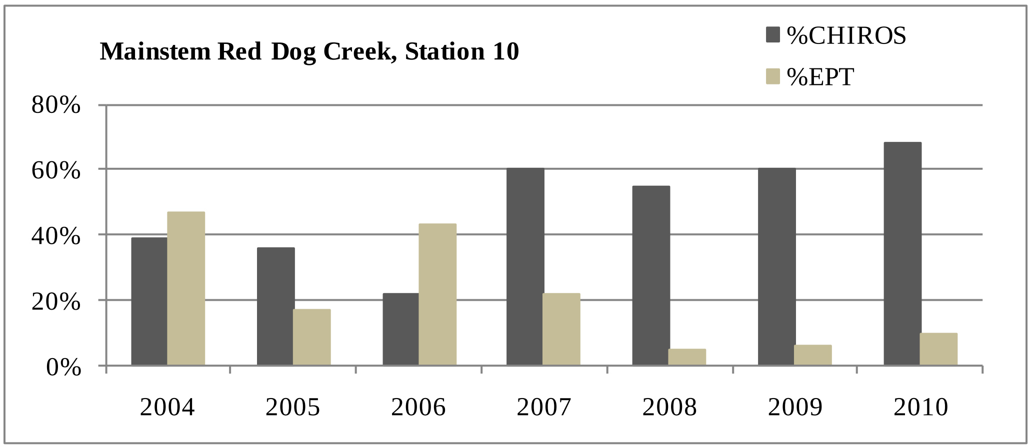

Figure 32. Percent Chironomidae and EPT in Mainstem Red Dog Creek.

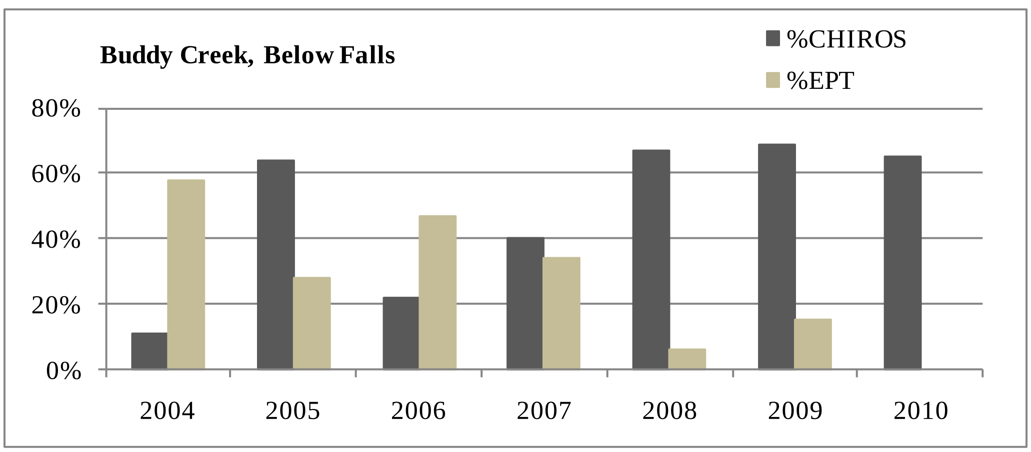

Figure 33. Percent Chironomidae and EPT in Buddy Creek.

Finally, we compared taxa richness for the three same sites (Figure 34). Taxa richness peaked in 2007 but was nearly identical in 2008. Richness varies among sample years and among sample sites. Overall, taxa richness is similar in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks.

Figure 34. Aquatic invertebrate taxa richness in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks.

Metals Concentrations in Juvenile Dolly Varden and Arctic Grayling

Under the new aquatic biomonitoring plan, we are sampling juvenile Dolly Varden and Arctic grayling to determine whole body concentrations of selected metals. The purposes of this effort are: (1) to determine if differences exist in metals concentrations in fish among the sample sites that can be linked with background water quality; and (2) to track change over time. Juvenile Dolly Varden were selected as the target species because of their wide distribution in the Red Dog area streams, their presence in Mainstem Red Dog Creek, their residence in freshwater for 2 to 4 years before smolting, and their rearing in the sample sites only during the ice-free season. Juvenile Arctic grayling were added for monitoring after we successfully established a self-sustaining population in Bons Pond. Arctic grayling captured in Bons Pond have been in the pond upstream of the freshwater dam their entire life and therefore serve as a good indicator of year round water quality conditions and change over time.

Ott and Morris (2004) found no relationship between fish length and whole body concentrations of selected metals for pre-smolt sized Dolly Varden. To minimize age-related variability, we targeted juvenile Dolly Varden from 90 to 140 mm (likely 2 and 3 year old fish), and collected all samples in August after fish have likely spent most of the summer in the sample reach. Fish larger than 140 mm are excluded because they could be resident fish and may be much older than the fish from 90 to 140 mm long. In prior years, we selected juvenile Arctic grayling that were between 140 and 220 mm long to minimize age variability. In 2010, we refined the sample effort to include only fish between 150 and 200 mm long. Our preferred sample size for Dolly Varden and Arctic grayling is 15 each year, recognizing that in some years we do not achieve this goal. Whole body metal concentrations for Dolly Varden and Arctic grayling collected in 2010 are presented in Appendix 4. Metals data for prior years are presented in Appendix 7 (Ott and Morris 2010).

Whole body Cd concentrations (median value) were consistently higher in fish collected from Mainstem Red Dog Creek and consistently lowest in Anxiety Ridge Creek (Figure 35). No trends of increasing or decreasing Cd concentrations have been seen from 2005 to 2010 other than a period of decrease from 2006 to 2009 for Mainstem Red Dog Creek caught juvenile Dolly Varden.

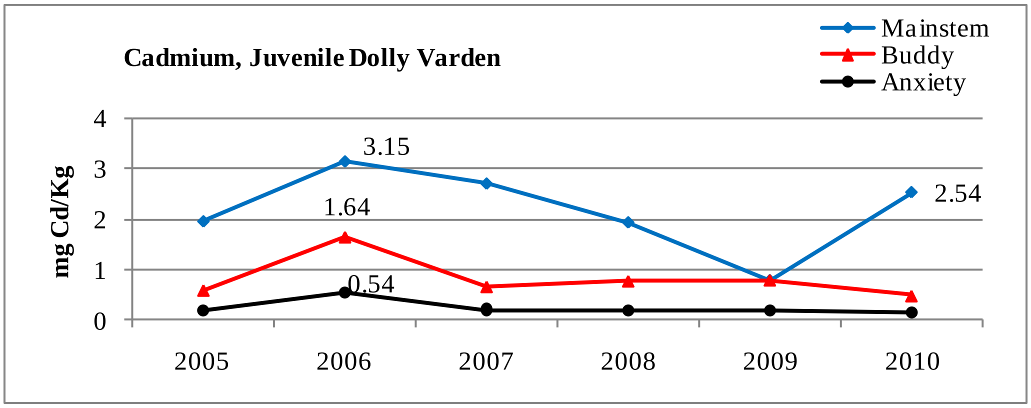

Figure 35. Median Cd whole body concentrations in juvenile Dolly Varden from 2005 to 2010.

Whole body Pb concentrations (median value) also were highest in Mainstem Red Dog Creek, but similar in Anxiety and Buddy creeks (Figure 36). Again, there does not appear to be any trend in Pb concentrations over time.

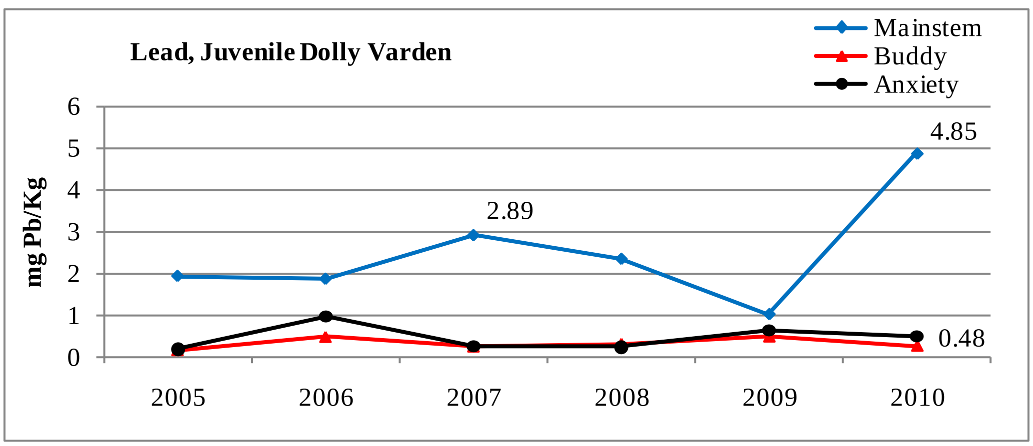

Figure 36. Median Pb whole body concentrations in juvenile Dolly Varden from 2005 to 2010.

Median whole body Se concentrations in Buddy Creek are higher than in Anxiety Ridge Creek and they track closely with each other (Figure 37).

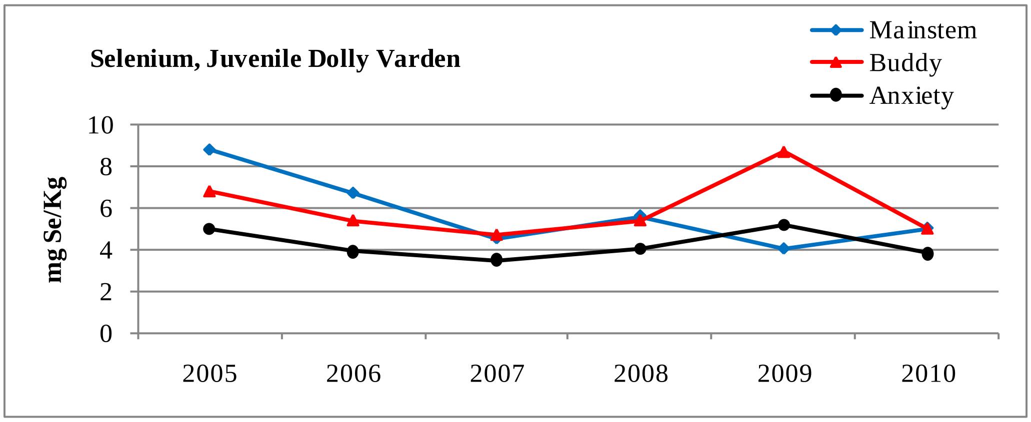

Figure 37. Median Se whole body concentrations in juvenile Dolly Varden from 2005 to 2010.

Zn whole body concentrations (median value) are highest in Mainstem Red Dog Creek (Figure 38). Concentrations of Zn generally are higher in Buddy Creek than in Anxiety Ridge Creek. There is no apparent trend with time for Zn except for a decreasing trend for Dolly Varden caught in Mainstem Red Dog Creek.

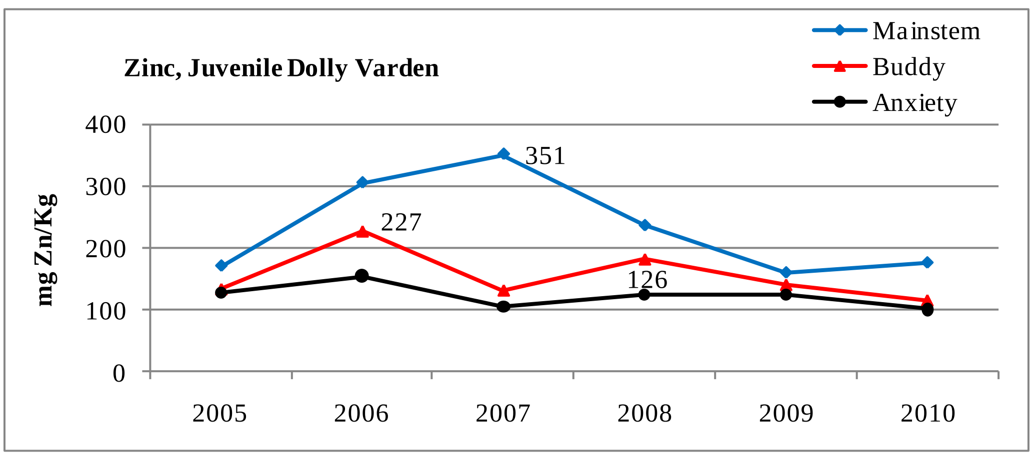

Figure 38. Median Zn whole body concentrations in juvenile Dolly Varden from 2005 to 2010.

Median whole body Hg concentrations generally are low and in many instances at the detection limit of 0.02 mg/Kg. However, in contrast with whole body Cd, Pb, and Zn concentrations which are highest in Mainstem Red Dog Creek, Hg is highest every year in Anxiety Ridge Creek (Figure 39).

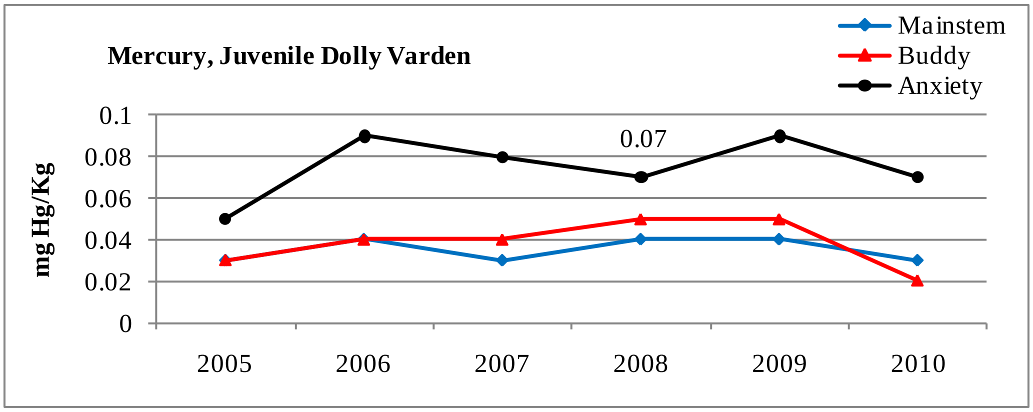

Figure 39. Median Hg whole body concentrations in juvenile Dolly Varden from 2005 to 2010.

In summary, whole body metals concentrations in juvenile Dolly Varden seem to have their own unique signature at each sample site/creek. Cd, Pb, and Zn median concentrations are highest in Mainstem Red Dog Creek. Se is similar at all three sites. Hg concentrations consistently are higher in Anxiety Ridge Creek. Finally, Cd and Zn are higher in Dolly Varden caught in Buddy Creek than they are in Dolly Varden caught in Anxiety Ridge Creek.

Cd and Pb concentrations (median value) in Bons Pond Arctic grayling have remained unchanged over time (Figure 40). Median Se concentrations have not changed, but there appears to have been an increase in Zn concentrations between 2004 and 2007 (Figure 41). Median Hg concentrations are not much higher than the detection limit of 0.02 mg/Kg, but they have increased in 2007 and 2010 as compared with 2004 (Figure 42). Zn concentrations in Bons Pond during the ice free season were reviewed and there are no indications of any change from 2004 to 2010.

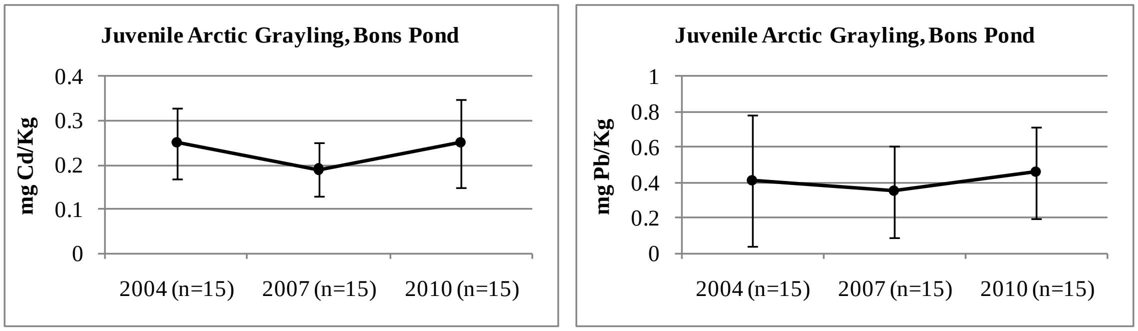

Figure 40. Median Cd and Pb whole body concentrations in juvenile Arctic grayling in 2004, 2007, and 2010.

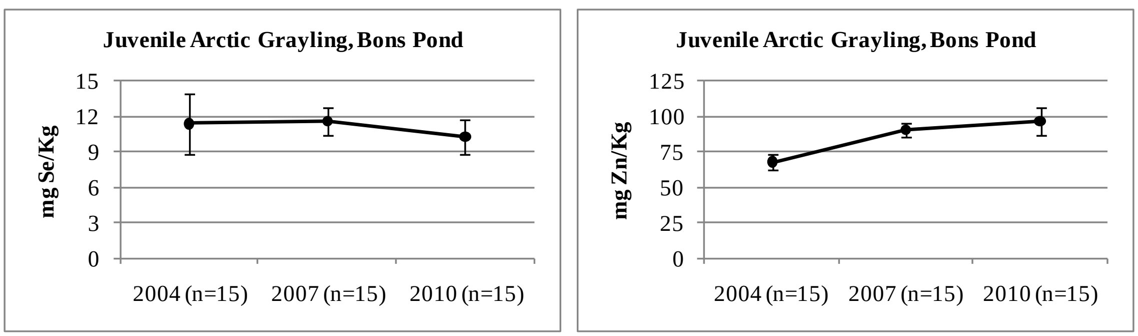

Figure 41. Median Se and Zn whole body concentrations in juvenile Arctic grayling in 2004, 2007, and 2010.

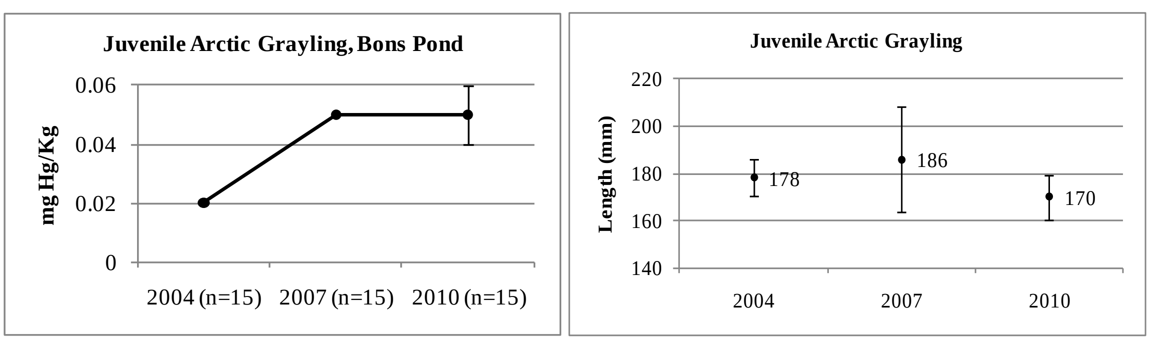

Figure 42. Median Hg whole body concentrations in juvenile Arctic grayling in 2004, 2007, and 2010. Average (plus and minus 1 SD) length of juvenile Arctic grayling.

Metals Concentrations in Adult Dolly Varden

Since 1990, we have sampled adult Dolly Varden from the Wulik River (Station 2) near Tutak Creek for metals concentrations (Al, Cd, Cu, Pb, and Zn) in gill, kidney, liver, and muscle tissue (Weber Scannell et al. 2000). In 1997, we added Se and in 1998 we started sampling reproductive tissue, when available. In 2003, we added Hg and Ca to the analytes being tested. From 2004 through 2009, Dolly Varden tissues were analyzed for Al, Cd, Cu, Pb, Se, Zn, and Hg. In 2010, we made several modifications based on previous results, including deleting Al from the analytes and eliminating gill tissue. The extremely high variability of Al in gill tissue was the reason for the change. The sample size for each spring and fall sample period has been 6 fish, except for the fall 2002 sample, when only 5 fish were retained.

The purpose of sampling adult Dolly Varden for metals concentrations is to monitor the long-term condition of fish over the life of the mine, to identify changes in tissue metals concentrations that may be related to mine activities, and to provide a data base for use by other professionals. The most likely benefits of this sampling program are long-term monitoring and use of these data by other professionals. It is highly unlikely that tissue metals concentrations or changes in adult fish could be related to events at the Red Dog Mine since Dolly Varden attain their growth in the marine environment. All laboratory work has been done with Level III Quality Assurance. Metals data for 2010 are presented in Appendix 5.

Metals are known to concentrate preferentially in certain organs; however, the relationship of organ concentration to ambient environmental concentrations is unknown. Concentrations of metals vary with season, age, size, weight, and feeding habits of fish (Jenkins 1980) and in the case of anadromous Dolly Varden, the metals concentrations vary with exposure to freshwater and marine environments. None of the analytes we measure concentrate in muscle tissue. Analyte concentration in various tissues is summarized below and in Figures 43 through 54: Two figures are presented for each analyte – one for all fish handled from 1999 to 2010 and the second for fish caught in spring and fall, 2010.

●Cd concentrates in kidney tissue (Figures 43 and 44)
●Cu concentrates in liver tissue and eggs (Figure 45 and 46);
●Pb does not concentrate in any specific tissue (Figures 47 and 48);
●Se concentrates in kidney and eggs (Figures 49 and 50);
●Zn concentrates in eggs (Figures 51 and 52); and
●Hg concentrates in kidney tissue (Figures 53 and 54).

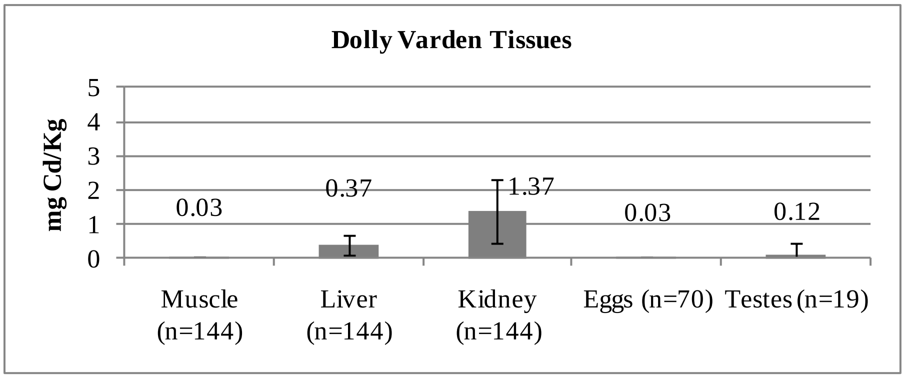

Figure 43. Average Cd concentrations (plus and minus 1 SD) in Dolly Varden (1999-2010).

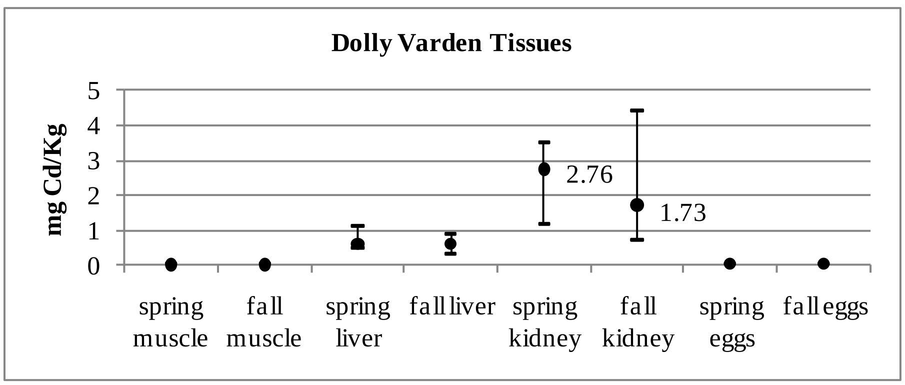

Figure 44. Median, maximum, and minimum Cd concentrations in Dolly Varden caught in spring and fall, 2010.

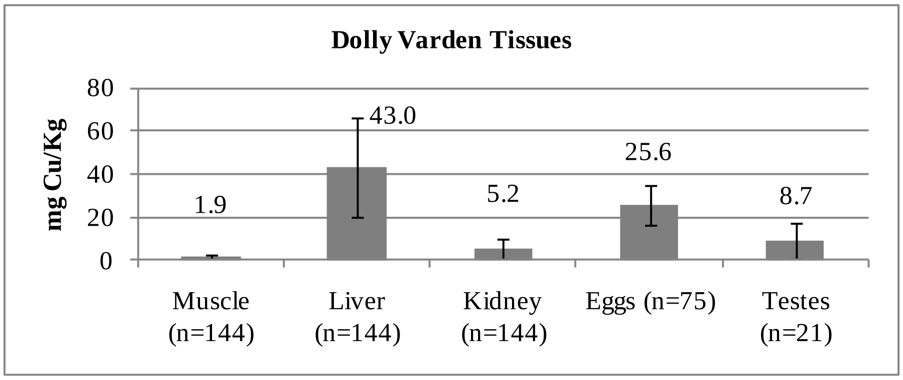

Figure 45. Average Cu concentrations (plus and minus 1 SD) in Dolly Varden (1999-2010).

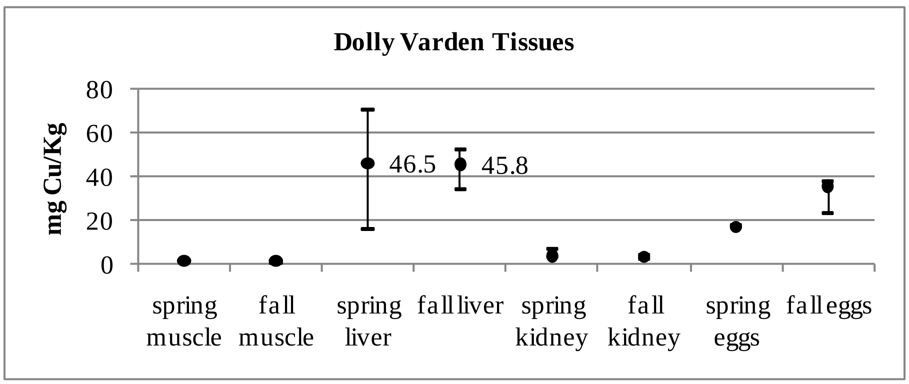

Figure 46. Median, maximum, and minimum Cu concentrations in Dolly Varden caught in spring and fall, 2010.

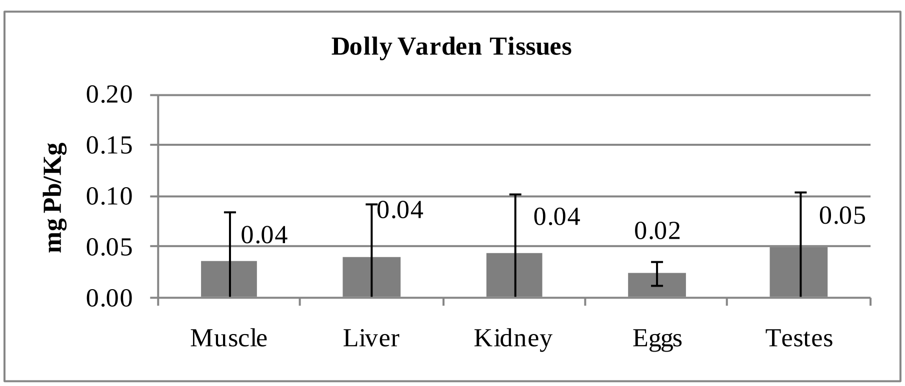

Figure 47. Average Pb concentrations (plus and minus 1 SD) in Dolly Varden (1999-2010). Note, average concentrations are only slightly higher than the detection limit (0.02 mg/Kg).

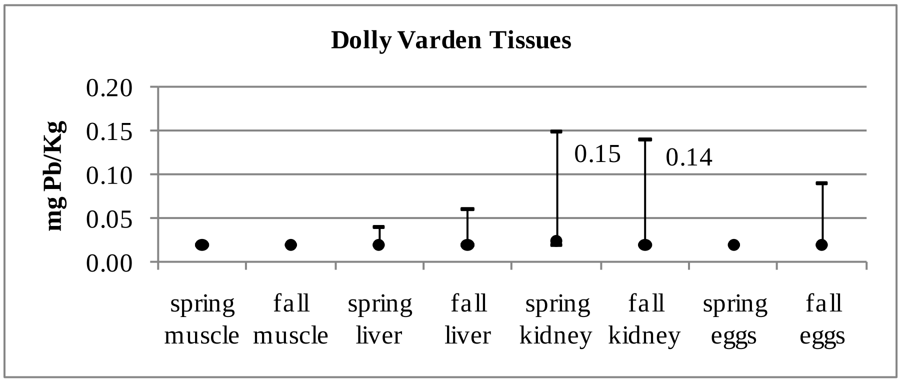

Figure 48. Median, maximum, and minimum Pb concentrations in Dolly Varden caught in spring and fall, 2010.

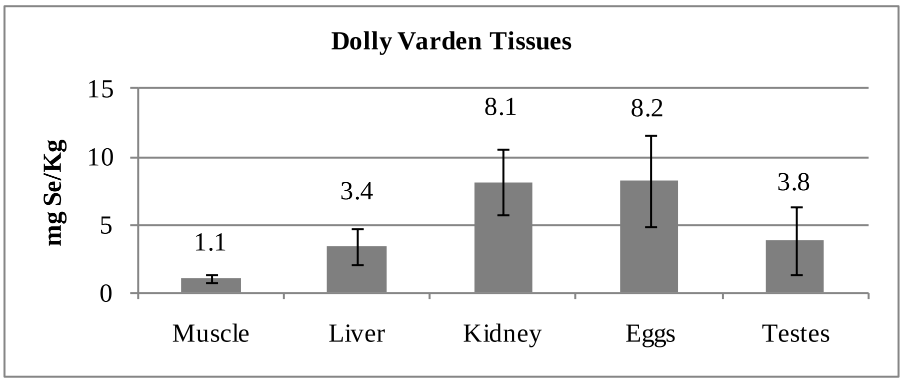

Figure 49. Average Se concentrations (plus and minus 1 SD) in Dolly Varden (1999-2010).

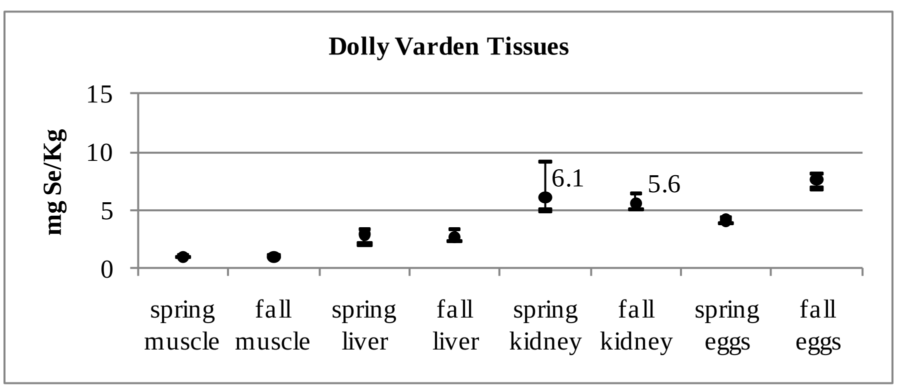

Figure 50. Median, maximum, and minimum Se concentrations in Dolly Varden caught in spring and fall, 2010.

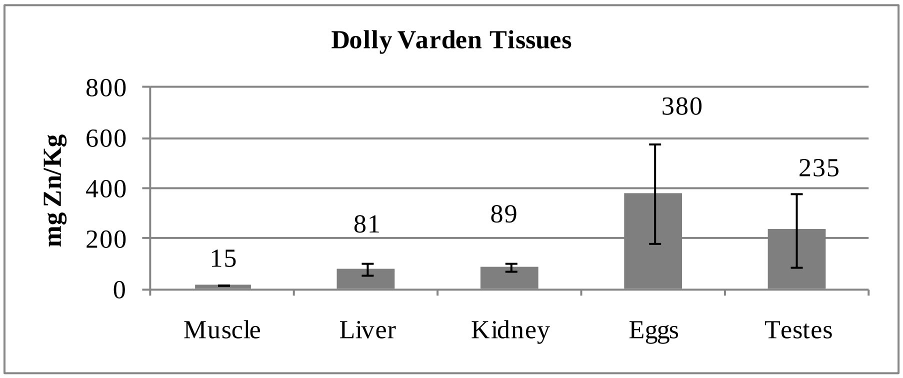

Figure 51. Average Zn concentrations (plus and minus 1 SD) in Dolly Varden (1999-2010).

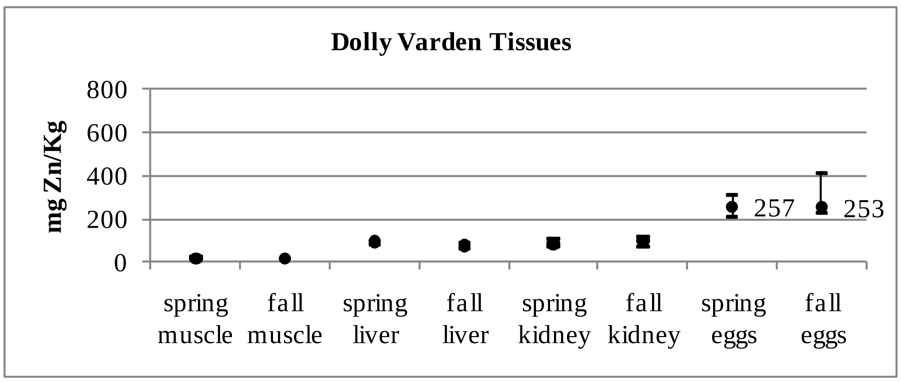

Figure 52. Median, maximum, and minimum Zn concentrations in Dolly Varden caught in spring and fall, 2010.

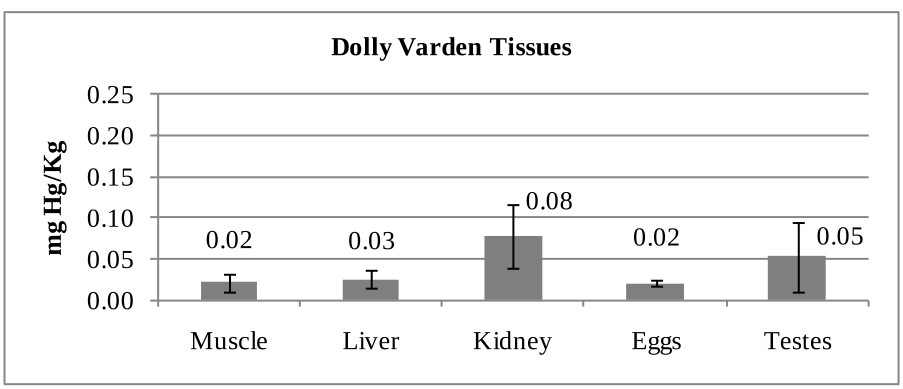

Figure 53. Average Hg concentrations (plus and minus 1 SD) in Dolly Varden (1999-2010). Note, average concentrations for kidney are slightly higher than the detection limit (0.02 mg/Kg).

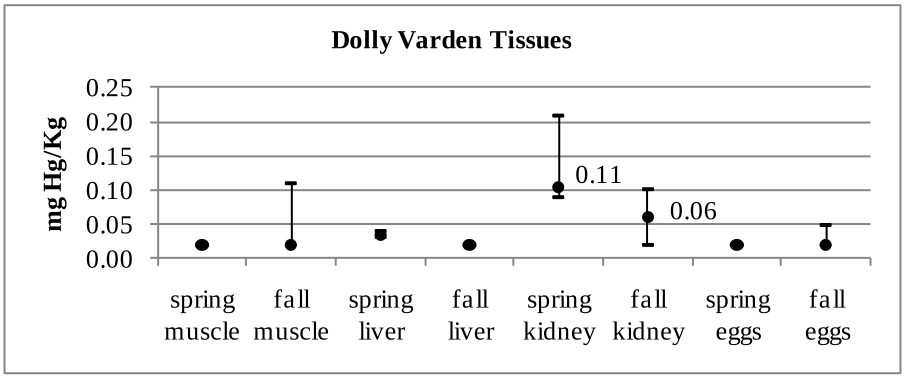

Figure 54. Median, maximum, and minimum Hg concentrations in Dolly Varden caught in spring and fall, 2010.

None of the analytes sampled concentrate in the muscle tissue of the Dolly Varden (Figure 55). Cd, Pb, Se, and Hg are at or very near the detection limit and many of the individual sample points are less than the detection limit.

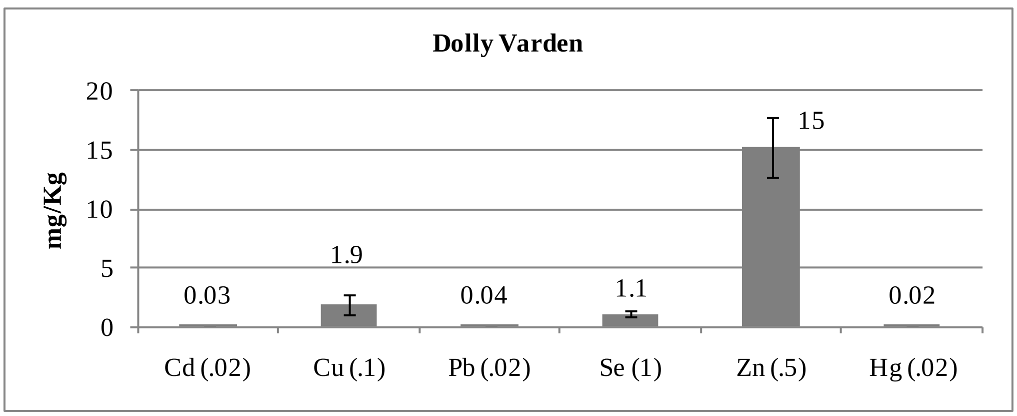

Figure 55. Average concentrations (plus and minus 1 SD) in Dolly Varden muscle (1999-2010). Note, detection limits shown in parenthesis.

Dolly Varden, Overwintering

An aerial survey to estimate the number of overwintering Dolly Varden in the Wulik River was flown on September 24, 2010, with a R-44 helicopter provided by Teck (DeCicco 2010). The weather was clear and wind was light out of the east; overall, conditions were ideal. The tundra slump several km downstream of Driver's Camp was adding substantial turbidity to the Wulik River affecting water color downstream for about 3 km. Counts began about 1.6 km upstream of Kivalina Lagoon. Fish were distributed nearly to the lagoon and were likely still entering from the sea. Overall the count was lower than in the past, continuing the trend downward (Figure 56 and Appendices 6 and 7). Similar to the past several years, very few small fish were present. The smaller Dolly Varden (1st year migrants 250 to 325 mm long) often enter freshwater late in the migration and they may have not yet entered from the sea or the low numbers of first year migrants may indicate reduced production in recent years.

The number of Dolly Varden estimated in the fall in the Wulik River varies annually. Survey results in 2010 found that over 99% of the fish seen were downstream of the mouth of Ikalukrok Creek. Only in 2004 has the percentage of fish below Ikalukrok Creek been less than 90%. Continued use of this section of the Wulik River by the majority of overwintering Dolly Varden suggests that conditions have not changed to alter the distribution of these fish.

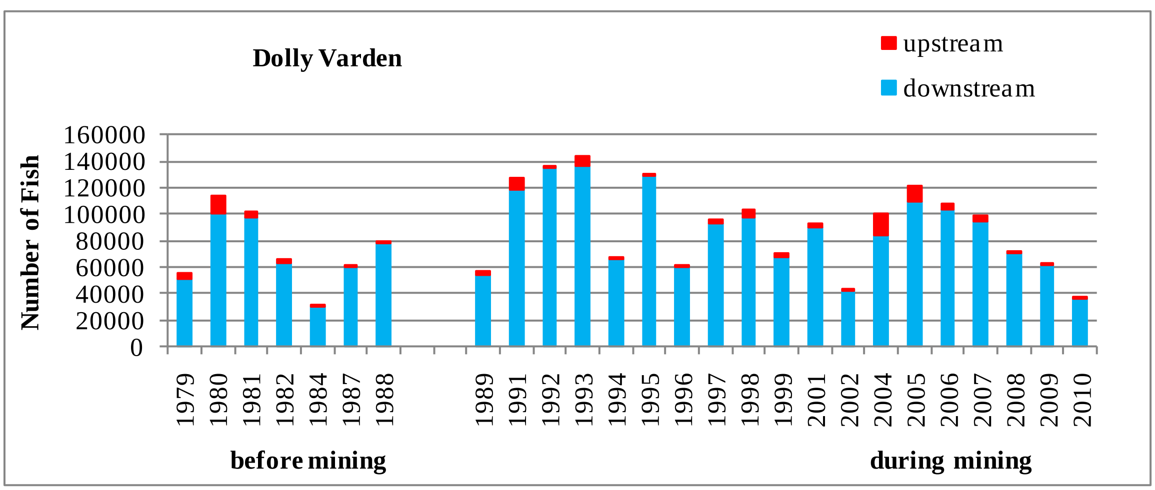

Figure 56. Estimated Dolly Varden in the Wulik River just prior to freezeup.

Chum Salmon, Spawning

ADF&G conducts annual aerial surveys to assess the distribution of adult chum salmon in Ikalukrok Creek from its confluence with the Wulik River upstream to Dudd Creek (Table 3 and Appendix 7). In fall 2010, we flew two surveys using a R-44 helicopter. Survey conditions on August 17, 2010, were poor and no estimate of chum salmon was made, but about 10 chum carcasses were seen on gravel bars in lower Ikalukrok Creek. On September 24, 2010, under near ideal conditions, DeCicco (2010) counted 1,358 chum salmon (live plus carcasses). The survey was conducted late in the spawning cycle and we assume numbers would have been higher in mid to late August.

Our estimated chum salmon return to Ikalukrok Creek in 2010 was at least 1,358 fish. We have seen good returns of chum salmon for the last five years. Our highest count since mining began at Red Dog Mine was in 2006, when we counted 4,185 fish.

All chum salmon observed were below Station 160 on Ikalukrok Creek, the downstream limit of the effluent discharge mixing zone. Counts of chum salmon in Ikalukrok Creek in 1990 and 1991 (mine discharge began in 1989) were lower than reported in baseline studies. Surveys began again in 1995, with the highest count made in fall 2006. Large returns of chum salmon in recent years are a good indication that the population has recovered from the early 1990s.

Table 3. Number of chum salmon adults in Ikalukrok Creek.

Survey Date	Number of Chum Salmon	Reference
September 1981	3,520 to 6,960	Houghton and Hilgert 1983
August September 1982	353 to 1,400	Houghton and Hilgert 1983
August 1984	994	DeCicco 1990c
August 1986	1,985	DeCicco 1990c
August 1990	<70	Ott et al. 1992
August 1991	<70	Ott et al. 1992
August 16, 1995	49	Townsend and Lunderstadt 1995
August 1995	300 to 400	DeCicco 1995
August 11, 1996	180	Townsend and Hemming 1996
August 12, 1997	730 to 780	Ott and Simpers 1997
1998	no survey	
August 9, 1999	75	Ott and Morris 1999
2000	no survey	
August 7, 2001	850	Morris and Ott 2001
August 28, 2001	2,250	DeCicco 2001b
August 29, 2001	1,836	DeCicco 2001b
September 23, 2001	500	DeCicco 2001c
October 8, 2001	232	DeCicco 2001a
August 5, 2002	890	Ott and Townsend 2002
August 11, 2003	218	Townsend and Ingalls 2003
August 26, 2004	405	Townsend and Conley 2004
August 29, 2005	350	Thompson 2005
August 14, 2006	4,185	Ott and Timothy 2006
August 11, 2007	1,408 and 1,998	Ott and Townsend 2007
August 6, 2008	3,820	Ott and Jacobs 2008
July 31, 2009	100	Ott and Benkert 2009
September 25, 2009	2,051	DeCicco 2009
September 24, 2010	1,358	DeCicco 2010

Dolly Varden, Juveniles

Limited pre-mining juvenile Dolly Varden distribution and use data are available for streams in the Red Dog Mine area. Houghton and Hilgert (1983) identified Anxiety Ridge Creek as the most productive system in the project area. They also reported finding only one Dolly Varden in the North Fork Red Dog Creek drainage and presumed that it was a resident fish. Surveys along Mainstem Red Dog Creek reported either few fish or no fish, and in some cases mortalities of small juvenile Dolly Varden and Arctic grayling fry (EVS Consultants Ltd and Ott Water Engineers 1983, Ward and Olson 1980).

We have targeted juvenile Dolly Varden in streams in the Red Dog Mine area since 1990. We added new sample sites and increased the number of minnow traps (10) per sample reach in 1992. Under the new program that began in 2010, we sample 8 sites, as listed in Table 4 (and Appendix 8), with 10 minnow traps per sample reach and a fishing effort of about 24 hr in early-to-mid August. Seven of these sites are unchanged since they were started and the new Station 160 corresponds to Station 7 – instead of being immediately downstream of Dudd Creek, it is now located about 7 km downstream.

Table 4. Location of juvenile Dolly Varden sample sites.

Site Name	Station No.	Year Sampling Started
Evaingiknuk Creek		1990
Anxiety Ridge Creek		1990
Buddy Creek		1996
North Fork Red Dog Creek	12	1993
Mainstem Red Dog Creek	151	1995
Mainstem Red Dog Creek	10	1996
Ikalukrok Creek above Mainstem	9	1996
Ikalukrok Creek below Dudd	7/160	1990

Minnow traps are the preferred sampling gear for juvenile Dolly Varden because they are very effective for this species and the age classes present, the gear is suitable for sample areas in large to small streams, the effort is uniform across sample sites, variability due to sampler-induced bias is reduced, and there is virtually no fish mortality. Juvenile Dolly Varden generally are the most numerous fish species present and are distributed most widely in the sample area. Our objective is to assess numbers of fish using streams over time and to sample juvenile Dolly Varden for whole body metal analyses from selected streams. Data relevant to whole body metal analyses of juvenile Dolly Varden were presented in a previous section of this report.

Dolly Varden Catches and Metrics

The relative abundance of juvenile Dolly Varden varies considerably among sample years (Figure 57 and Appendix 9); however, the relative catches among the sample sites follow similar patterns. Natural environmental conditions such as the duration of breakup, patterns and magnitude of rainfall, ambient air temperatures, and the strength of the age 1 cohort affect distribution of juveniles and relative abundance. We believe that the most important factor is the strength of the age 1 cohort which is directly related to numbers of spawners, spawning success, and survival the previous winter.

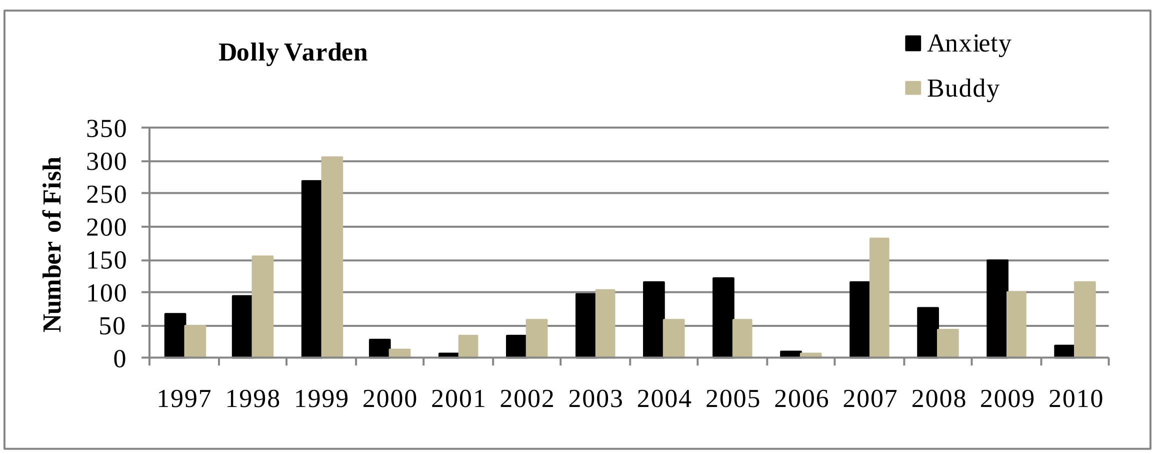

Figure 57. Catch of juvenile Dolly Varden in Anxiety Ridge and Buddy creeks in late July to early August.

With almost 20 years of sampling for juvenile Dolly Varden in streams near the Red Dog Mine, we have developed the following conclusions: abundance is higher in the upper reaches of each sample stream; peak use occurs from late July to late August; and although catches vary annually, juvenile Dolly Varden are most abundant in Anxiety Ridge and Buddy creeks. In 2010, catches of juvenile Dolly Varden were highest in Buddy Creek, but lower in Anxiety Ridge Creek than we would expect (Figure 58). In 2007, 2008, and 2009 catches were highest in Buddy and Anxiety Ridge creeks (Figure 58). A beaver dam (abandoned) exists in Anxiety Ridge Creek downstream of our sample reach, and with the extremely low flows in summer 2010 this may have been a partial barrier to movement of juvenile Dolly Varden. As far as we know, most of juvenile Dolly Varden leave our sample reaches in the fall prior to freeze-up and therefore, they have to move upstream the next summer to these rearing areas.

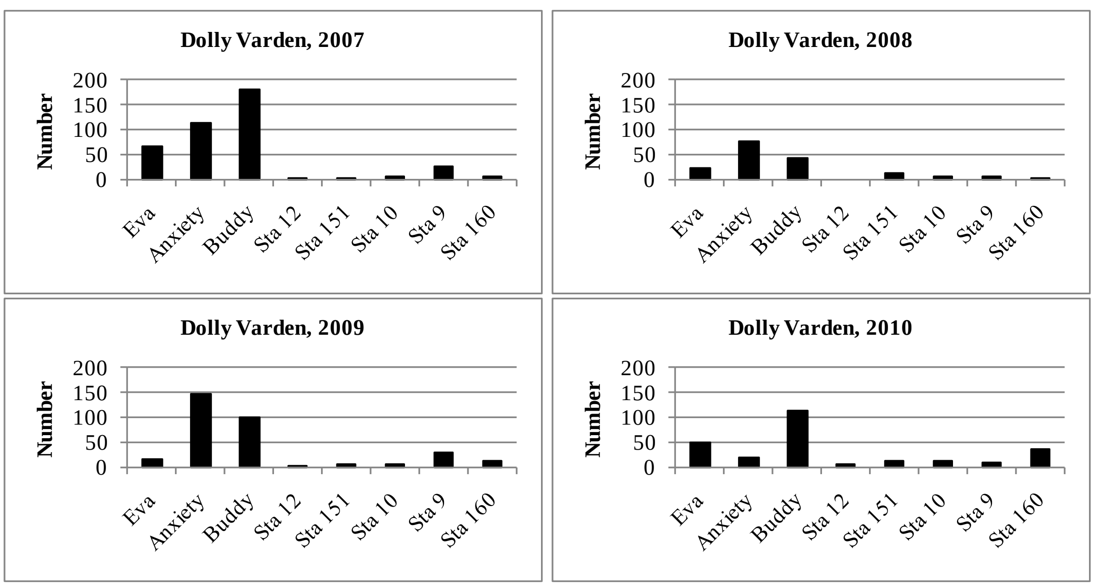

Figure 58. Catch of juvenile Dolly Varden in Evaingiknuk, Anxiety Ridge, Buddy, North Fork Red Dog Creek (Station 12) Mainstem Red Dog (Stations 151 and 10), and Ikalukrok (Station 9 and 160) creeks.

Catches of juvenile Dolly Varden from 1997 through 2010 in Mainstem Red Dog Creek (late July to mid August) are shown in Figure 59. The catch per unit of effort (CPUE where the catch is number of fish per trap per 24 hr) has varied from a low of 0.1 in 2004 to a high of 7.6 in 1999. The higher catches in 1998 and 1999 in Mainstem Red Dog Creek also were reflected in some of the larger catches in Anxiety Ridge and Buddy creeks in those same years. Catches from 2000 to 2010 have been fairly consistent and reflect use by rearing Dolly Varden.

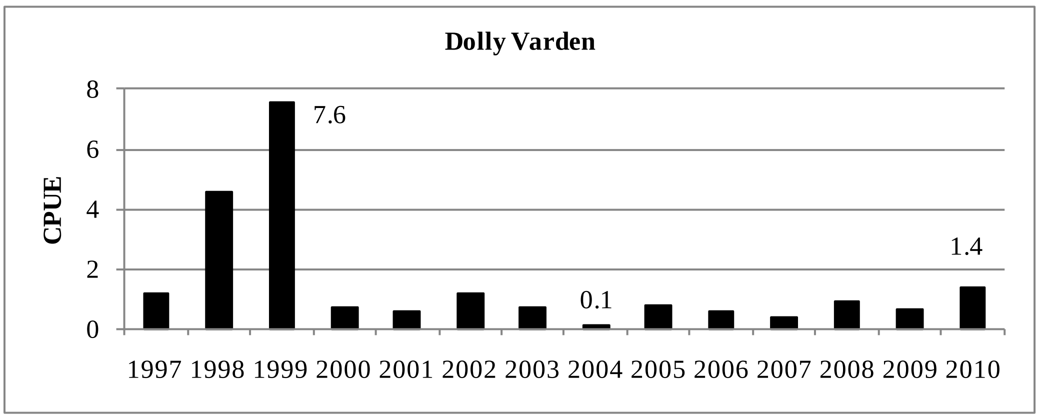

Figure 59. CPUE for juvenile Dolly Varden in Mainstem Red Dog Creek (two sample reaches) from 1997 to 2010.

Each spring during breakup we fish fyke nets in North Fork Red Dog Creek to capture Arctic grayling, but we also catch resident Dolly Varden. In spring 2010, we caught 22 Dolly Varden that averaged 140 mm long (Figure 60). Most of these fish were presumed to be stream resident (non-anadromous) fish due to size (larger than smolts), obvious parr marks, and distinct orange/pink dots (Figure 61). It is unknown whether this consistent change in fish use compared with baseline data is related to water quality improvements in Mainstem Red Dog Creek or simply due to increased sampling effort and the use of fyke nets.

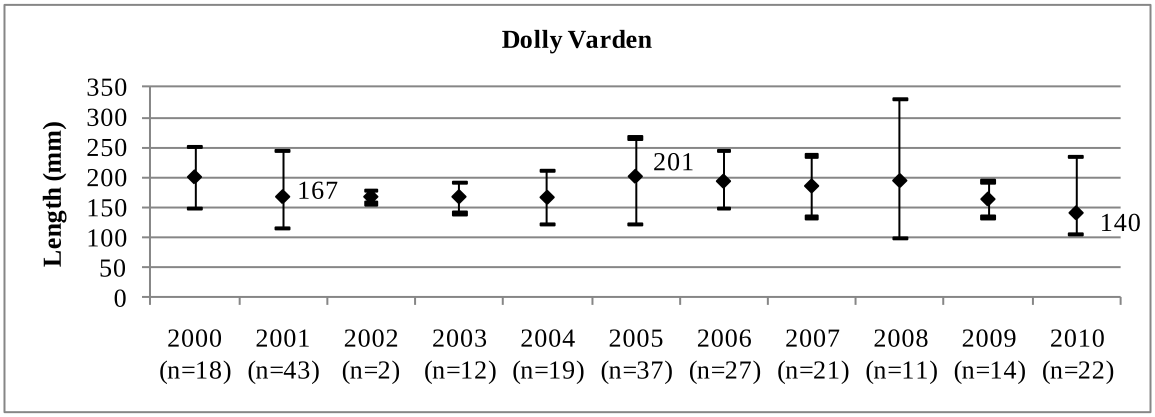

Figure 60. Dolly Varden caught in fyke nets fished in North Fork Red Dog Creek in spring during the Arctic grayling spawning run (selected averages shown).

Figure 61. Resident Dolly Varden from spring sample in North Fork Red Dog Creek.

The length frequency distribution of juvenile Dolly Varden, especially the presence of fry, indicates successful reproduction and survival. Dolly Varden less than 60 mm long in late July to mid-August probably are age 0 fry (Houghton and Hilgert 1983, DeCicco 1985). Fry caught in drift nets in Wulik River tributaries in early July were less than 30 mm long. Smolting can occur as early as age 2, but more commonly at age 3 (DeCicco 1990a). Our catch in mid August 2010 from the 7 sample reaches in the Ikalukrok Creek drainage was 213 fish. Length frequency distributions for 2007 through 2010 are shown in Figure 62. Potential recruitment of age 1 Dolly Varden is strongest in 2007 with some in both 2009 and 2010.

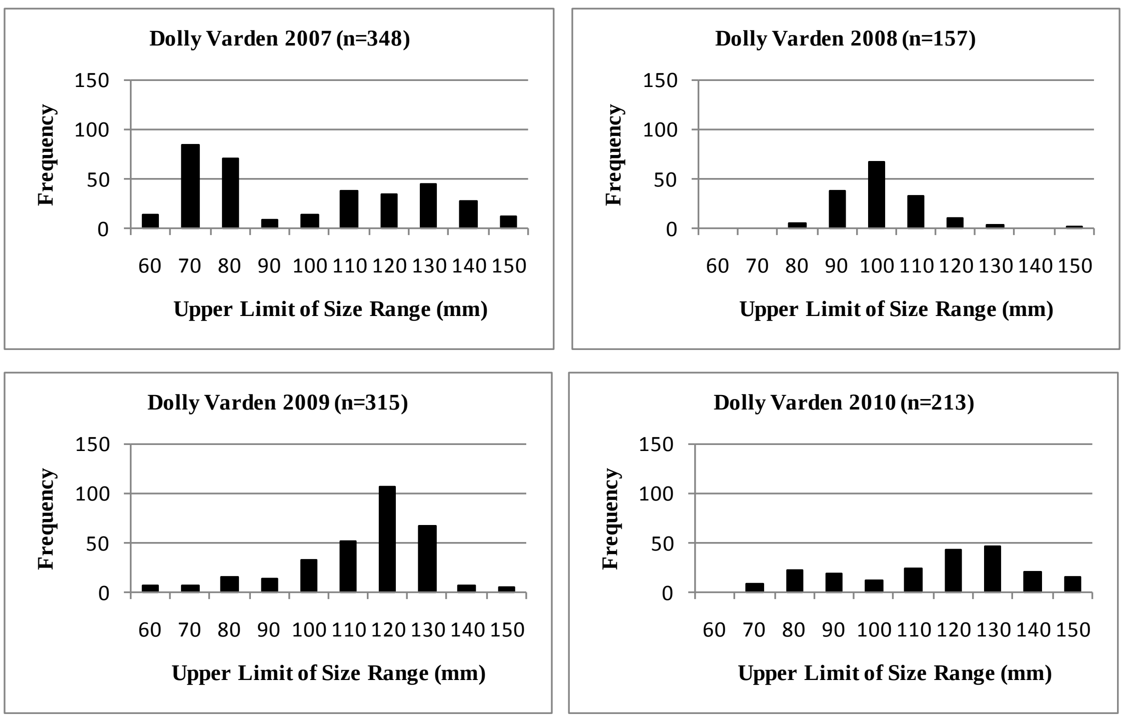

Figure 62. Length frequency distribution of Dolly Varden caught in minnow traps in the Ikalukrok Creek drainage.

Arctic Grayling, Red Dog Creek Drainage

Before mine development, Arctic grayling adults migrated through Mainstem Red Dog Creek in spring when flows were high and metals concentrations were low (Ward and Olsen 1980, EVS and Ott Water Engineers 1983, and Houghton and Hilgert 1983). Arctic grayling moved through Mainstem Red Dog Creek to spawn in North Fork Red Dog Creek. None of these reports stated or indicated that Arctic grayling spawned in Mainstem Red Dog Creek. Arctic grayling fry reared in North Fork Red Dog Creek and were displaced downstream by high-water events or outmigrated as water temperatures cooled in the fall. Before Red Dog Mine operations, very few, if any, juvenile Arctic grayling were found rearing in North Fork Red Dog Creek. Fry mortalities were reported in Mainstem Red Dog Creek by EVS Consultants and Ott Water Engineers (1983) and Ward and Olsen (1980). Since 1994, we have consistently documented Arctic grayling use (migration, spawning, and rearing) in Mainstem Red Dog Creek (Appendix 10).

Arctic Grayling Spawning

We have monitored Arctic grayling spawning during spring in North Fork Red Dog and Mainstem Red Dog creeks since 2001. The purpose of this sampling effort is to document when spawning has been substantially completed in Mainstem Red Dog Creek. Water temperature is the most likely factor determining spawning time, emergence of fry, first year growth, and survival. High flows during or immediately following spawning have a substantial negative effect on fry survival (Clark 1991).

Discharge volume and quality from the wastewater treatment facility at Red Dog are regulated to meet permit conditions. From 2001 to 2007, TDS concentrations were regulated to be less than 500 mg/L at Station 151 (Station 10) during Arctic grayling spawning. During that time frame, monitoring of Arctic grayling spawning was performed to determine when spawning was substantially completed, thus allowing Teck to increase the TDS concentrations to 1,500 mg/L for the remainder of the ice-free season.

A TDS site-specific criterion (SSC) of 1,500 mg/L during Arctic grayling spawning was issued by ADEC and became effective on February 15, 2006. The US Environmental Protection Agency (EPA) approved the 1,500 mg/L TDS SSC on April 21, 2006. The SSC as developed by ADEC was based on field and laboratory studies conducted with Arctic grayling at the Red Dog Mine site (Brix and Grosell 2005). Teck regulates the wastewater discharge to ensure that TDS concentrations do not exceed the ADEC and EPA approved 1,500 mg/L at Station 151.

In 2010, fyke nets and angling were used to capture Arctic grayling moving into North Fork Red Dog Creek. Two fyke nets were set in North Fork Red Dog Creek on June 3 (Figure 63). Water levels were extremely low in 2010, and allowed the placement of two fyke nets. One net was facing downstream to capture fish moving upstream and one facing upstream to capture fish moving downstream; no weir structure was required. Nets were checked twice daily until the morning of June 9 when both nets were checked and removed. The nets were operated for a total combined effort of 12 net days. Between June 2 and 9, 9 hours of angling was conducted in North Fork Red Dog Creek to check fish spawning condition in the creek. Six hours of angling also was conducted in Ikalukrok Creek about 0.4 km downstream of Grayling Junior Creek. Twenty percent of the recaptured fish (previously tagged) identified in Ikalukrok Creek had been captured in North Fork Red Dog Creek the previous day.

During the entire sampling period, only one mature female Arctic grayling was judged to be ripe and all others were judged to be spent, with the exception of one female of undetermined spawning condition. The catch composition and presence of nearly all spent females indicates that spawning was already complete in Mainstem Red Dog Creek by June 3.

Figure 63. Fyke net weir and fyke nets set in North Fork Red Dog Creek, May/June 2007 (top) and June 2010 (bottom). 2010 water levels were extremely low.

Review of water temperature data from Mainstem Red Dog Creek shows that water temperatures had peaked above 4°C for 9 consecutive days and had peaked above 7°C for 4 consecutive days prior to June 3 (Figure 64). Water temperature on May 23 reached 4.3°C. Based on water temperatures, it is probable that spawning was substantially complete by the morning of May 29 after temperatures peaked at 7.9°C on May 28. Spawning in North Fork Red Dog Creek likely was complete later. Catches of spent females leaving North Fork Red Dog Creek dropped substantially and numbers of mature males leaving the creek increased on the morning of June 5, suggesting that even males were now initiating their post spawning outmigration.

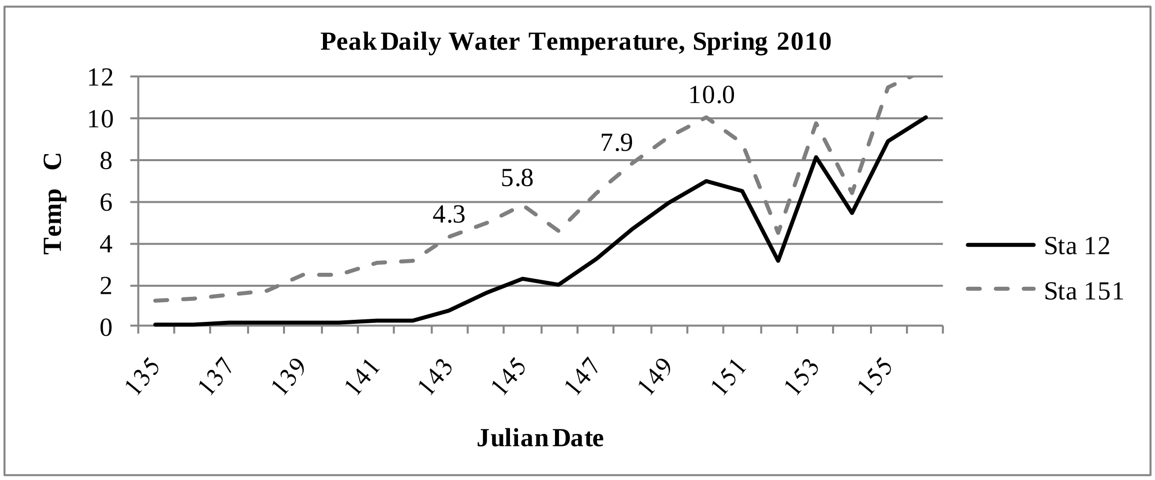

Figure 64. Peak water temperature in North Fork Red Dog Creek (Station 12) and Mainstem Red Dog Creek (Station 151) in spring 2010.

A summary of Arctic grayling spawning in Mainstem Red Dog Creek is presented in Table 5. The earliest spawning was judged to be substantially complete was May 29 in 2010. In both 2001 and 2006, spawning was not completed until June 15. Limited spawning could start at 3°C, but most likely does not start until temperatures reach 4°C. Data collected at Ft. Knox in spring 2010 did confirm that some Arctic grayling spawned in the wetland complex before peak temperatures reached 4°C (Ott and Morris 2010).

Table 5. Summary of Arctic grayling spawning in Mainstem Red Dog Creek.

Year	Date When Limited Spawning Started (3°C)	Date When Spawning Complete (Condition of Females)	Number of Days Peak Temperatures Exceeded 4°C[1]
2001	June 6	June 15	6
2002	May 29	June 8	8
2003	June 7	June 14	6
2004	May 25	May 31	4
2005	May 27	June 6	9
2006	May 30	June 15	10
2007	May 26	June 3	8
2008	June 1	June 9	9
2009	June 8	June 13	4
2010[2]	May 21	May 29	6

[1]Does not include the day spawning was judged to be complete since the fyke net is worked in the early morning prior to peak temperatures on that day.

[2]The date spawning was judged to be substantially complete was based solely on the water temperature data collected in spring 2010.

Arctic Grayling Fry

In 2010, spawning success in the Red Dog Creek drainage should have been very good as stream flows were low, water temperatures warmed quickly, and there were no major rainfall events until much later in the summer. In July, Arctic grayling fry were seen in North Fork Red Dog Creek (about 20 to 25 mm long) (Appendix 11). Fry were numerous and larger (25 to 30 mm long) in Mainstem Red Dog Creek. Arctic grayling fry also were abundant in Ikalukrok Creek upstream of Mainstem Red Dog Creek – this is the first time we have observed large numbers of fry in this reach of Ikalukrok Creek. Schools of Arctic grayling fry (5 to 20 fish) were distributed throughout the sample reach in Mainstem Red Dog Creek (Station 10). In mid August, we caught 9 Arctic grayling fry in minnow traps fished in Mainstem Red Dog and North Fork Red Dog creeks. Fry ranged in size from 58 to 77 mm long (average 64.2 mm, SD = 5.8). Catching these Arctic grayling in minnow traps, which are not effective for this species, provides a strong indication that there were a large number of this age class present this year.

Arctic Grayling Catches and Metrics

In spring 2010, excluding fish captured more than once, we handled a total of 347 Arctic grayling in North Fork Red Dog Creek, including 54 males, 32 females, and 261 immature fish. The smallest mature male was 232 mm long and the smallest mature female was 323 mm long. Mature males are considerably bigger than the mature females; however they begin to mature at a smaller size than females (Figures 65 and 66).

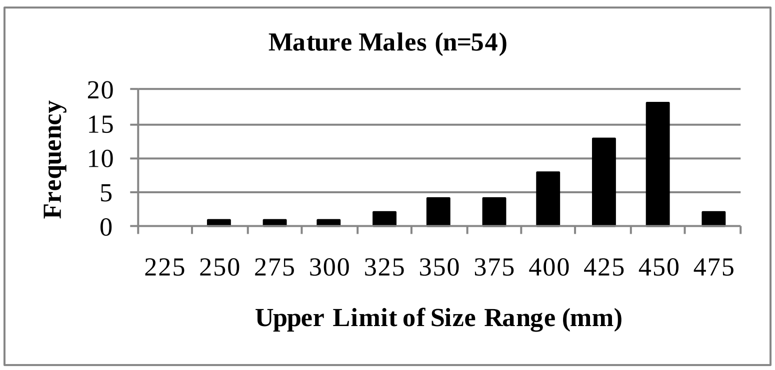

Figure 65. Length frequency distribution of Arctic grayling males in North Fork Red Dog Creek in spring 2010.

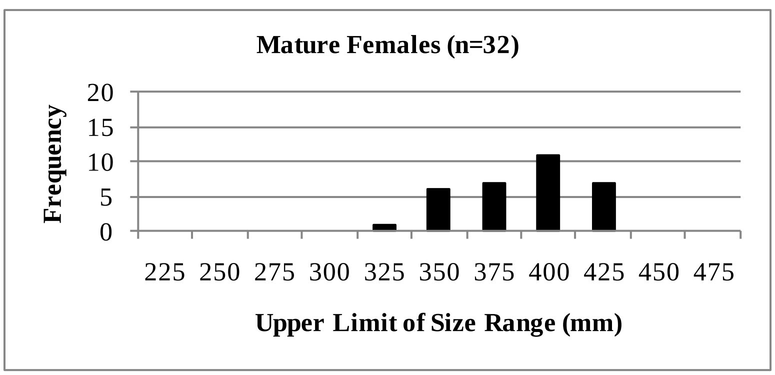

Figure 66. Length frequency distribution of Arctic grayling females in North Fork Red Dog Creek in spring 2010.

The potential for a substantial increase in the number of mature adults in North Fork Red Dog Creek can be seen in Figure 67. We caught 261 immature fish with 157 of these fish < 200 mm long. This is the fourth consecutive year (beginning in spring 2007) where large numbers of small, immature Arctic grayling have been caught.

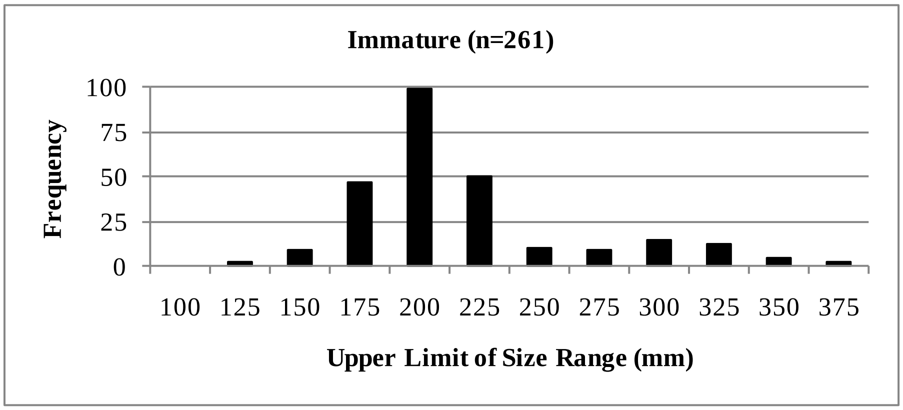

Figure 67. Length frequency distribution of immature Arctic grayling in North Fork Red Dog Creek in spring 2010.

A portion of this recruitment is attributable to Arctic grayling leaving Bons Pond, entering the Ikalukrok Creek drainage, and then returning to North Fork Red Dog Creek in the spring. The percentage of marked fish coming from Bons Pond in our North Fork Red Dog Creek sample has been 12, 18, 13, and 3 from 2007 to 2010, respectively.

Growth of Arctic grayling marked in spring 2009 and recaptured in spring 2010 is shown in Figure 68. As one would expect, growth rates are high for the immature fish and decrease substantially once the fish mature. Growth rates for large Arctic grayling (>350 mm long) generally are less than 10 mm per year. In spring 2009, we had more small fish in our sample and growth rates were as high as 48 mm over a one year time period. Growth rates were similar in both 2008 and 2009 although slightly higher in 2008.

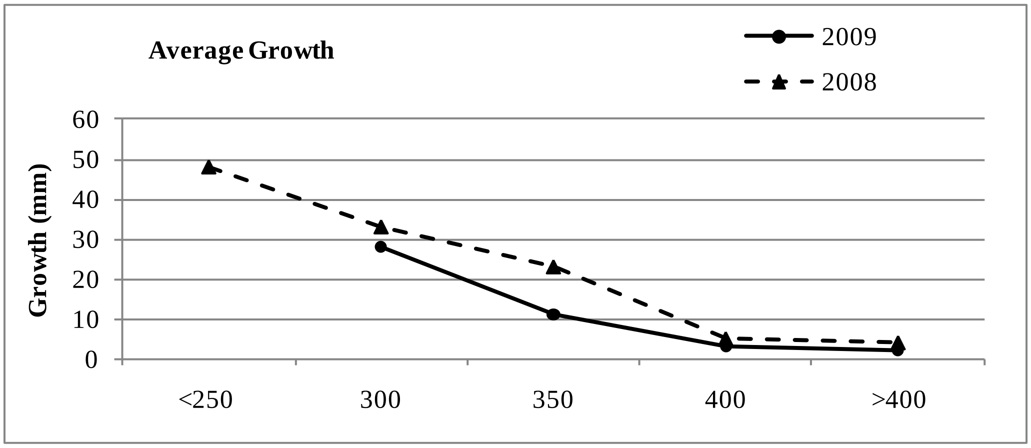

Figure 68. Average growth of Arctic grayling in 2008 and 2009 caught in North Fork Red Dog Creek each spring.

In 2009, we marked 222 Arctic grayling $\geq$ 200 mm long of which 28 were recaptured in spring 2010. Of all the fish captured in 2010, many were smaller than 240 mm long. Based on a comparison of the 2009 and 2010 length frequency distributions we determined that fish < 240 mm in 2010 would not have been large enough to mark in spring 2009. Considering only fish $\geq$ 240 mm, a total of 177 fish were captured for the purpose of estimating the 2009 population. Based on a 2009 mark of 222 fish, our adjusted sample size of 177 fish for 2010, and the 28 fish tagged in 2009 and recaptured in 2010, the estimated 2009 North Fork Red Dog Creek Arctic grayling population was 1,368 fish (SD = 418) (Figure 69). The 95% confidence intervals for the 2008 and 2009 estimates are tighter than for the 2003 and 2004 estimates. The population of Arctic grayling in North Fork Red Dog Creek, pre-mining, is not known.

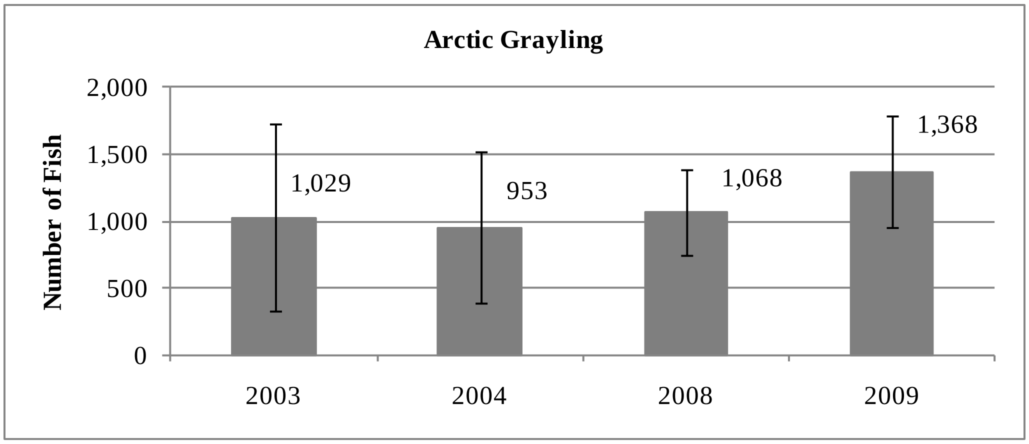

Figure 69. The estimated Arctic grayling population (± SD) in North Fork Red Dog Creek for fish ≥ 200 mm long.

Arctic Grayling, Bons Pond

Bons Pond, is an impoundment created by construction of an earthen dam. The dam was built in 1987/1988 to provide potable and make-up water for operational activities. Prior to construction of the dam, there were no fish present in Bons Creek due to a series of impassable waterfalls and chutes in bedrock about 1 km downstream of the dam.

The Arctic grayling population in Bons Pond is the result of a fish transplant conducted in 1994 and 1995 (Ott and Townsend 2003). The 1994 transplant fish from North Fork Red Dog Creek ranged in size from 158 to 325 mm long (n=102, average 235, SD = 34) and included 5 large Arctic grayling from Ikalukrok Creek (350 to 425 mm long, average 376, SD =32). In 1995, about 200 fry were caught in North Fork Red Dog Creek and transported to Bons Pond. Bons Creek flows out of the pond via a channel excavated in bedrock. Bons Creek flows over a 20 m high falls into the creek – there is no upstream fish passage (Figure 70).

Figure 70. Outlet of Bons Pond into Bons Creek – Arctic grayling leaving Bons Pond go over the falls and into Bons Creek and many of these fish are recaptured in North Fork Red Dog Creek during the spring sample event.

Sampling conducted in 1996 and 1997 indicated that the transplant probably was not successful as we were unable to catch or observe any fish in Bons Pond. In summers 1995 to 1997, 12 of the marked Arctic grayling from Bons Pond were recaptured in North Fork Red Dog Creek. However, in 2001 and 2002, Arctic grayling juveniles were observed in Bons Creek immediately downstream of the blast road. In summer 2003, fish sampling was reinitiated in Bons Pond to determine the extent of fish use. The estimated Arctic grayling population in 2003 was 6,773 fish $\geq$ 200 mm long (Ott and Townsend 2003).

Since 2003, we have sampled Bons Pond and Bons Creek in the spring, with additional sampling later in the ice-free season to increase our number of marked fish. Spawning has been observed in Bons Creek and in the outlet of Bons Pond. Our current program in Bons Pond includes a mark/recapture study to estimate the population size and the collection of 15 juvenile Arctic grayling for whole body metals analyses. Data on whole body metals was presented in a previous section of this report.

Bons Creek, upstream of Bons Pond, is about 1 to 2 m wide with depths from 0.3 to 1 m. In our sample reach, located about 200 m upstream of Bons Pond, the substrate consists of gravel in riffles, with fine sediments and organics in the pools. Bons Creek is incised with streambanks vegetated with willows and sedges. Thermal hydraulic erosion downstream of the diversion ditch placed to bypass non-mining impacted surface waters around the west side of the backdam on the tailing impoundment and around a waste rock stockpile contributes seasonally to the sediment and organic load in the creek. Most of the drainage area upstream of our sample site is in ice-rich permafrost with thermal erosion and sediment/organic input varying with seasonal conditions. Generally, there is a high input of sediments and organics to Bons Creek, particularly during rainfall events.

In spring 2010, we set a fyke net in Bons Creek, about 200 m upstream of Bons Pond (Figure 71). The fyke net was fished from June 3 to 9 and was checked periodically during the sample event. We caught 334 Arctic grayling in Bons Creek and Bons Pond. Most of the Arctic grayling (246) were caught in the fyke net – the remaining 88 were caught by angling. The length frequency distribution for mature Arctic grayling is presented in Figure 72. Most Arctic grayling ≥ 250 mm in Bons Pond are mature. In contrast, Arctic grayling from North Fork Red Dog Creek are not mature until 350 mm.

Figure 71. Fyke net in Bons Creek in spring 2010. The off color water seen is indicative of the sediment and organic material in the water column.

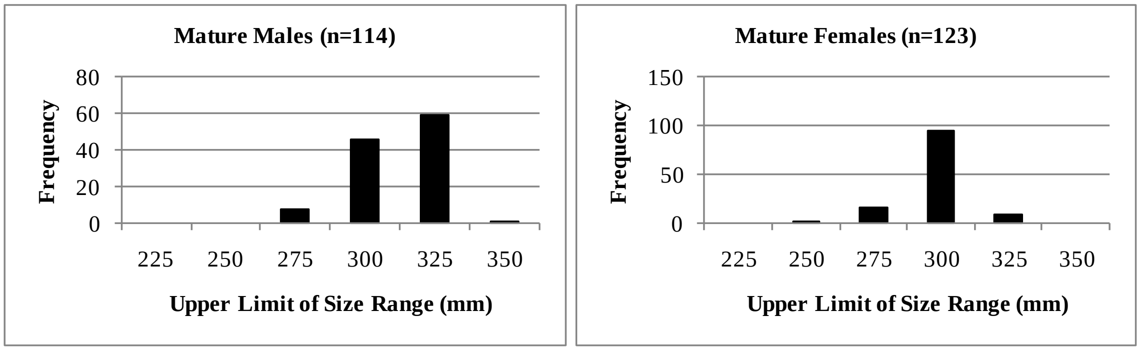

Figure 72. Length frequency distribution of mature Arctic grayling in Bons Pond in spring 2010.

Length frequency distribution of all Arctic grayling caught in spring 2010 is presented in Figure 73. The population consists of mature fish with limited numbers of juveniles suggesting limited spawning success and minimal recruitment. Population trend suggests this is the case and that recruitment has been less than mortality and emigration since 2004.

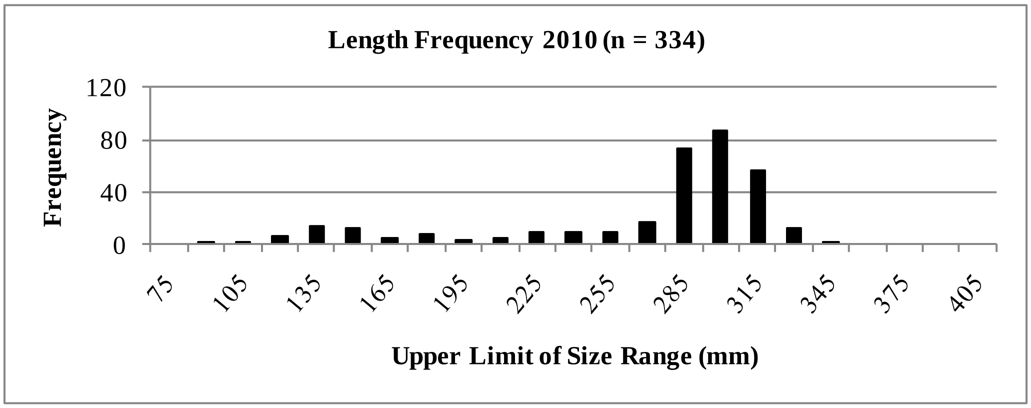

Figure 73. Length frequency distribution of all Arctic grayling in Bons Pond and Bons Creek in spring 2010.

Average growth (spring to spring) of individual Arctic grayling by size class in Bons Pond is presented in Figure 74. Growth rates were low and even the smallest fish did not exceed 18 mm annual growth (n=1). As has been seen in previous years, growth rates for fish from Bons Pond are much less than for comparable sized fish from North Fork Red Dog Creek.

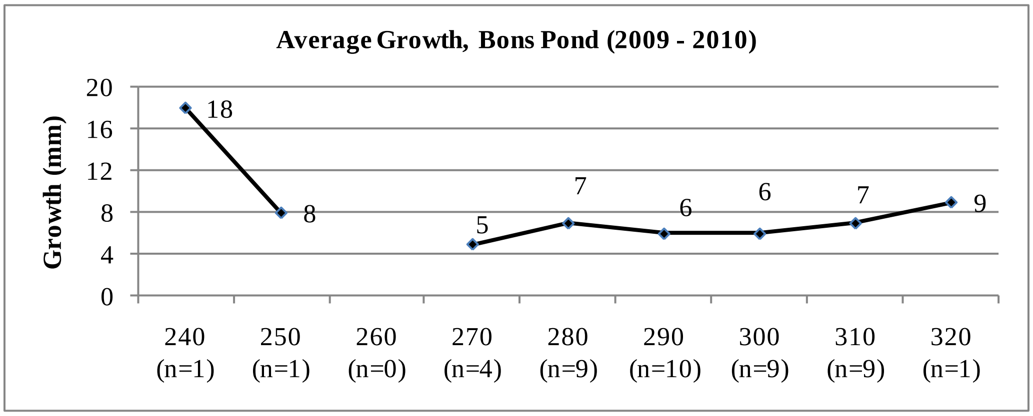

Figure 74. Individual growth of Arctic grayling from spring 2009 to spring 2010 in Bons Pond.

We estimated the Arctic grayling population in Bons Pond using 2009 as the mark event and spring 2010 as the recapture event. We had 347 marked fish seen in summer 2009. In spring 2010, we caught 281 Arctic grayling of which 44 were recaptures (fish seen in summer 2009). Our estimated Arctic grayling population is 2,180 fish $\geq$ 200 mm long (SD = 539 fish). The population estimates show a strong decreasing trend since the 2004 peak of 6,189 fish (Figure 75). However, estimates for 2008 and 2009 are the same, perhaps indicating the population may have stabilized or reached its low point somewhere around 2,000 individuals $\geq$200 mm.

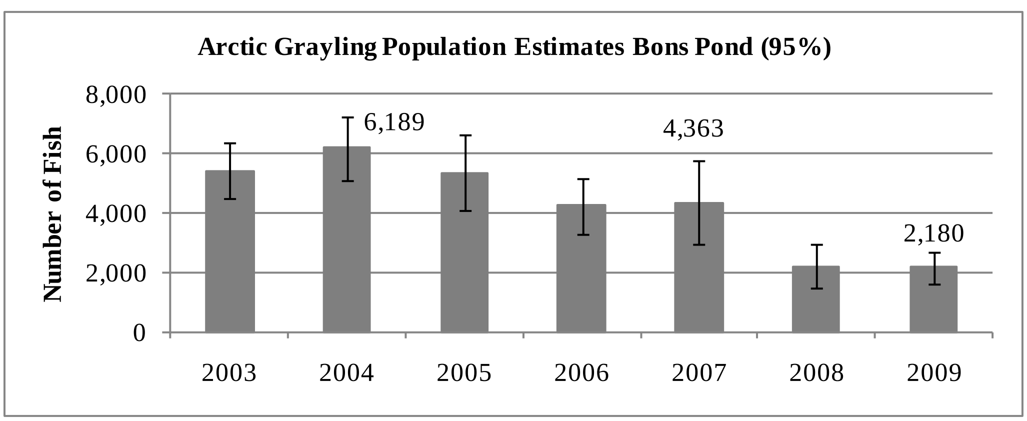

Figure 75. Estimated Arctic grayling population in Bons Pond.

Slimy Sculpin

Houghton and Hilgert (1983) found slimy sculpin in Ikalukrok Creek and Dudd Creeks, but none were seen or caught in the Red Dog Creek drainage. In 1995, we caught slimy sculpin in Mainstem Red Dog and North Fork Red Dog creeks (Weber Scannell and Ott 1998). Slimy sculpin are infrequently caught in the Red Dog Creek drainage; however, we did catch 3 large slimy sculpin (133, 129, and 132 mm) in spring 2008 and 4 large slimy sculpin (132, 134, 136, and 142 mm) in spring 2009 in the North Fork Red Dog Creek fyke net. In spring 2010, we caught one slimy sculpin (88 mm) in North Fork Red Dog Creek.

The minnow trap catch per unit of effort (CPUE is for 10 traps for one sample period) since 1997 is presented in Figure 76. The overall trend appears to be for an increasing number of slimy sculpin in Mainstem Red Dog Creek; however, we did not catch any in August 2010.

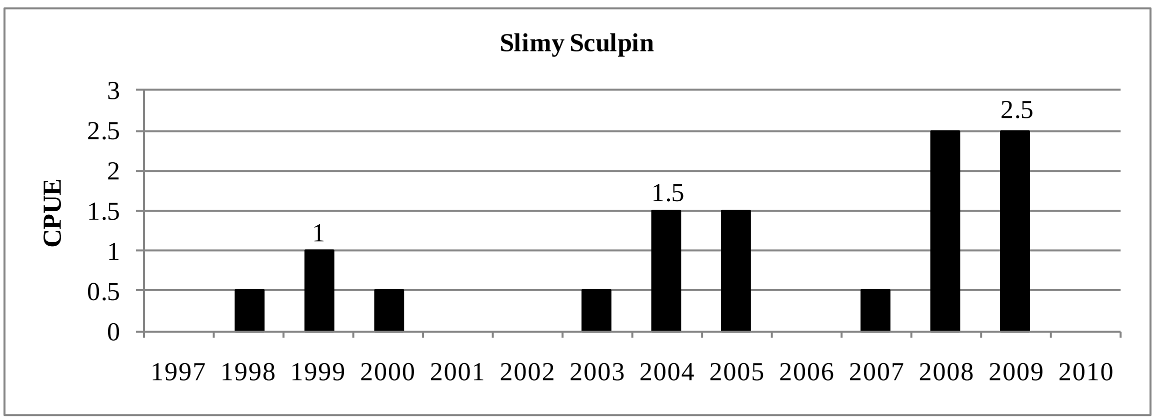

Figure 76. Slimy sculpin caught in Mainstem Red Dog Creek at two sample reaches – one just downstream of North Fork Red Dog Creek and the second in the vicinity of Station 10 near the mouth of Mainstem Red Dog Creek.

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Appendix 1. Summary of Mine Development and Operations

1982

●Baseline studies initiated, Cominco agreement with NANA finalized

1983

●EIS process initiated, alternatives for mine and road to port site identified

1984

●Stream surveys conducted along proposed road by private consultant

1985

●Permit applications prepared for regulatory agencies
●Implementation of wastewater treatment plant deferred to ADEC by ADF&G
●Wastewater discharge limited to summer
●Potential for acid rock drainage and metals mobilization not recognized

1986

●ADEC solid waste permit and bonding not required
●ADEC permit preceded solid waste regulations
●AIDEA bonds to build road and port site issued

1987

●Construction of road began, budget request to AIDEA prepared by ADF&G
●Reimbursement agreement for logistics with ADF&G to monitor construction made by AIDEA

1988

●Ore body developed
●Road and port site construction began
●Notice of Violation issued to AIDEA by ADF&G for failed road crossing bypasses
●Uniform Summons and Complaint issued for illegal water removal
●AIDEA provided funding to ADF&G for monitoring
●Rehabilitation plans for streams developed and implemented

Appendix 1 (continued)

1989

- ●Agreement to close-out old solid waste site finalized with Cominco
- ●Civil work on ore body and surface water drainage control begun
- ●Complaints about water quality in Ikalukrok Creek received
- ●Tailing dam becomes full, Cominco's request to siphon untreated water over the dam denied by State
- ●Elevated metals concentrations identified by red precipitation, were observed in Ikalukrok Creek below the mine
- ●Winter discharge of treated water authorized by State
- ●State regulatory agencies and Cominco in disagreement over whether metals exceeded background conditions

1990

- ●Biomonitoring of fish populations proposed and initiated by ADF&G
- ●Dead fish from the Wulik River were discovered by the public
- ●ADF&G sampling indicated very few fish remaining in Ikalukrok Creek
- ●Installation of sumps and pumps by Cominco prevented metals-laden water from entering Red Dog Creek
- ●Baseline and current water quality data reviewed by ADF&G
- ●Clean water bypass system requested by ADF&G
- ●Zinc levels in Ikalukrok Creek exceeded 40 mg/L
- ●State regulatory agencies and Cominco in disagreement over cause and extent of water quality problems
- ●Compliance Order by Consent for water quality violations affecting anadromous fish issued by ADEC
- ●Notice of Violation for water quality violations affecting anadromous fish issued by ADF&G
- ●Cominco directed to design and construct a clean water bypass system
- ●Perceived impairment to the subsistence fishery initiated involvement by the community of Kivalina

1991

- ●Clean water bypass system designed by Cominco, approved by state agencies
- ●ADF&G fisheries study funded by Cominco
- ●Clean water bypass system built
- ●Clean water bypass system repaired
- ●Improvements to water quality were documented

Appendix 1 (continued)

1992

- ●Fish study continued
- ●Water quality improvements to downstream receiving water continued
- ●Increasing water volume in tailing impoundment continued
- ●Water from dirty water collection system entering tailing impoundment increased volume
- ●Water treatment plant modifications made

1993

- ●Fish study continued
- ●Sand filters to remove particulate zinc installed

1994

- ●Fish study continued
- ●Use attainability studies of several streams initiated for reclassification
- ●Water treatment capacity increased by thickening tank conversion
- ●Wastewater discharge increased from 7.5 cfs to 23 cfs
- ●Ore processing capability expanded by Cominco
- ●107 juvenile and adult Arctic grayling transplanted from North Fork Red Dog Creek to Bons Pond in late June
- ●79 juvenile Dolly Varden transplanted from Anxiety Ridge Creek to Bons Pond in late June

1995

- ●Fish study expanded to include other aquatic biota
- ●Work on stream reclassification and site-specific criteria continued by ADF&G
- ●Metals concentrations in the clean water bypass system increased; contributing sources were identified: Hilltop Creek (Zn), Shelly Creek (Cd), and Rachel Creek (Al)
- ●Clean water bypass system extended to collect water from Hilltop Creek
- ●Reserves were doubled after exploration drilling located more ore
- ●Possible metals contamination in Bons Creek identified by ADF&G
- ●About 200 Arctic grayling fry (40 to 45 mm) were moved from North Fork Red Dog Creek to Bons Pond in August

1996

- ●Public notice for stream reclassification sent out
- ●Bons Creek water samples from above and below the Kivalina shale dump collected
- ●Fish and aquatic biota study continued

Appendix 1 (continued)

1997

●Stream reclassification incorporated into regulation (18 AAC 70.50)
●Fish barrier constructed across Middle Fork Red Dog Creek
●Water bypass around the Kivalina shale dump and interceptor trench at the head of the tailing impoundment built
●Gray-white precipitate observed in Middle Fork Red Dog Creek
●Heavy red staining and precipitate seen in Ikalukrok Creek; originated from seep near headwaters of Ikalukrok Creek, located upstream of mining activity
●Laboratory experiments of TDS on egg fertilization and early egg development initiated
●Fish and aquatic biota studies continue
●US EPA brings enforcement action for water quality violations; Cominco initiates Supplemental Environmental Projects
●Two-year aquatic community study in upper Ikalukrok Creek, above and below the Red Dog Mine discharge initiated by ADF&G
●Ground water monitoring wells installed and monitored below tailing dam by Cominco

1998

●Wet fertilization studies to test effects of TDS on fish embryos continued
●Draft 401 certification for a new NPDES permit prepared by ADEC and reviewed by ADF&G
●Discussed extension of the clean water bypass system up Shelly and Connie Creeks to ensure bypass of clean water and collection of seepage water from newly disturbed areas
●Heavy red staining in headwaters of Ikalukrok Creek, originating from seep in headwaters of Ikalukrok Creek, upstream of mining activity, staining extends downstream about 30 km
●Site-specific criteria for Zn in Mainstem Red Dog and Ikalukrok Creeks approved by EPA
●Heavy rains cause an unanticipated release of water into Bons Creek from the Kivalina stockpile
●Plans to increase port site capacity for direct loading of ships released to public
●NPDES permit (AK-003865-2) issued by US EPA became effective August 28, 1998 and was certified by ADEC (Certificate of Reasonable Assurance)
●Two-year aquatic community study completed
●Biomonitoring, including studies of fish and aquatic biota, required under 1998 NPDES permit

Appendix 1 (continued)

1999

- ●Two-year drilling program (Shelly and Connie Creeks) proposed
- ●New station 7 on Ikalukrok Creek established by Cominco, USGS, and ADF&G
- ●Fish and aquatic biota study expanded to upper North Fork Red Dog, Ikalukrok, and Ferric creeks
- ●Biomonitoring and USGS gauging work proposals submitted to Cominco
- ●Study of periphyton communities exposed to different concentrations of TDS in Mainstem Red Dog Creek done by ADF&G and Cominco Alaska Inc.
- ●Request to increase TDS for periphyton colonization experiment not approved
- ●Effects to Ikalukrok Creek from Alvinella Creek seepage water continued to below Dudd Creek mouth
- ●Arctic grayling females in ripe spawning condition collected from North Fork Red Dog Creek for selenium analysis of livers and ovaries

2000

- ●Effects to Ikalukrok Creek from Cub Creek seep continued; red stain and precipitate observed several km below mouth of Mainstem Red Dog Creek
- ●North Fork Red Dog Creek silty at breakup, previously not observed
- ●Minimal precipitate in Middle Fork Red Dog Creek below effluent outfall observed
- ●Civil work performed in Connie Creek to isolate surface from subsurface flows and bypass flow through disturbed areas
- ●Effectiveness of pump back system at the Kivalina rock dump verified by presence of juvenile Arctic grayling in creek immediately south of dump
- ●Site-specific criteria for TDS requested by Cominco
- ●Biomonitoring study continued
- ●Baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect begun

Appendix 1 (continued)

2001

●Effects to Ikalukrok Creek from Cub Creek seep continued, red stain and precipitate observed in Ikalukrok Creek to Station 8 below Mainstem Red Dog Creek, affects minor near mouth of Dudd Creek

●North Fork Red Dog Creek, siltation (natural) less than in summer 2000

●Minimal precipitate in Middle Fork Red Dog Creek below effluent outfall

●Water quality was monitored in Shelley, Rachel, Connie, and Middle Fork Red Dog creeks upstream and downstream of surface disturbance, catch-box and pipeline (about 430 m) placed in Shelley Creek to move water pass disturbance

●Juvenile Arctic grayling observed in Bons Creek just south of the Kivalina rock dump, pump-back system working based on fish use

●Fish weir repairs made during 2000, no problems observed in 2001

●Stream survey of cross drainage structures made along the Delong Mountains Transportation System, some minor work at some crossings identified

●Site-specific criteria for TDS still being worked, data on Arctic grayling spawning/water temperature collected in North Fork Red Dog and Mainstem Red Dog creeks, supplemental data gathered at the Ft. Knox mine

●Studies expanded to include the Delong Mountains Transportation System based on a National Park Service report that metals concentrations adjacent to road were elevated, water sites established upstream and downstream of road and sampled by Teck Cominco, juvenile Dolly Varden samples collected in Omikviorok River and Aufeis Creek, vegetation sampling started by Teck Cominco

●New haul trucks brought on site, hard-covered trucks to minimize loss of zinc and lead concentrates during transport

●Exploratory drilling (ore and shallow gas) continued, focus on North Fork Red Dog Creek and Wulik River basins near Anarraaq and Lik, including west of the Wulik River, another ore prospect found northwest of Anarraaq, shallow gas results promising

●State and Teck Cominco agree to start the state's large mine team to work on issues, key issue identified was development of a solid waste permit with bonding for the tailing dam, other issues include site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)

●Biomonitoring study continued, baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect continued for the second field season, four new sites added (tributaries on west side of Wulik in the area of the Lik Deposit and potential shallow gas development)

Appendix 1 (continued)

2002

●Effects to Ikalukrok Creek from Cub Creek seep continued, red stain and precipitate observed in Ikalukrok Creek to Station 8 below Mainstem Red Dog Creek, affects minor near mouth of Dudd Creek

●North Fork Red Dog Creek, siltation minor during summer 2002

●Minor precipitate in Middle Fork Red Dog Creek below effluent outfall

●Fish weir operating as designed

●Data on Arctic grayling spawning/water temperature collected in North Fork Red Dog Creek, supplemental data gathered at Ft. Knox

●Pit expansion continues to the north of the clean-water bypass system, road crossing added for access

●A bypass was installed for Connie Creek during winter 2001/2002. The bypass captures the upstream creek and carries the water in a pipe to the clean-water bypass system

●The bypass system for Shelly Creek was modified during summer 2002 to correct an overflow problem that occurred during breakup (the overflow water was captured in the pit and did not affect downstream waters). The modification involved adding a lined ditch to contain overflowing clean water and direct the water to the clean-water bypass system

●Juvenile Dolly Varden collected at eight sites located upstream and downstream of the Delong Mountains Regional Transportation System, whole body metals analyses for Cd, Pb, Se, and Zn

●Site-specific criteria for total dissolved solids is still being worked

●State and Teck Cominco continue to work on key issues, e.g., solid waste permit with bonding for the tailing dam, site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)

●Biomonitoring study continued, baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect and shallow gas exploration

●Arctic grayling adults remained in North Fork Red Dog Creek through early August, only the second time since 1992 that most of the adults stayed in the creek during summer, most years adults outmigrate shortly after spawning in spring

●Arctic grayling adults present in Buddy Creek just below the falls, about 50 adult fish in sample reach (0.3 km) in early July, all gone by early August

●About 50 to 60 adult Dolly Varden in Ikalukrok Creek at mouth of Dudd Creek from early July through late August

●Effluent discharge ceased on October 5, 2002, to allow time to winterize the water treatment plant

Appendix 1 (continued)

2003

●Effects to Ikalukrok Creek from Cub Creek seep continued but were much less than seen in the last two to three years

●North Fork Red Dog Creek, natural siltation throughout most of the summer was minor in summer 2003

●Minor precipitate in Middle Fork Red Dog Creek below effluent outfall

●Fish weir operating as designed

●Data on Arctic grayling spawning/water temperature collected in North Fork Red Dog Creek, supplemental data gathered at Ft. Knox

●Site-specific criteria for total dissolved solids was finalized

●USEPA modified the NPDES effective August 22, 2003, to incorporate the ADEC Site Specific Criteria and mixing zones for total dissolved solids in Mainstem Red Dog and Ikalukrok creeks with conditions that ensure total dissolved solids are at or below 500 mg/L during Arctic grayling spawning in Mainstem Red Dog Creek and during chum salmon and Dolly Varden spawning in Ikalukrok Creek, the modified permit was appealed by the Kivalina Relocation Planning Committee

●State and Teck Cominco continue to work on key issues, e.g., solid waste permit with financial assurance for the tailing dam, site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)

●Arctic grayling adult returns to North Fork Red Dog Creek were low, number of adult Arctic grayling seen in the Ikalukrok Creek drainage was the lowest seen since aerial surveys were begun in the late 1990s

●Arctic grayling population estimate was completed for Bons Pond the site of a fish transplant made in 1994 and 1995, estimated population in the reservoir was 6,773

●Modification to Shelly Creek bypass ditch completed, a better designed and constructed lined ditch was built and commissioned in August, 2003

●A permanent lined ditch was constructed parallel to the Connie Creek diversion pipeline to avoid spring freeze-up issues

●A permanent monitoring station was established at the end of the mixing zone in Mainstem Red Dog Creek, the location designation is Station 151, and is fitted with real time total dissolved solids and flow determination equipment and telemetry to link the station directly into the mill process control system

●Station 150, at the end of the mixing zone in Ikalukrok Creek, was fitted with real time total dissolved solids and flow determination equipment and telemetry to link the station directly into the mill process control system

Appendix 1 (continued)

2004

●Wastewater discharge began on May 20, ended on September 26, total discharge about one billion gallons
●Effects to Ikalukrok Creek from Cub Creek seep continued but were minor
●North Fork Red Dog Creek, natural siltation minor during ice-free season
●Minor precipitate in Middle Fork Red Dog Creek below effluent outfall
●Fish weir operating as designed
●Arctic grayling spawning/water temperature data collected, Arctic grayling from North Fork Red Dog Creek used for TDS fertilization experiment
●State and Teck Cominco continued to work on key issues associated with the solid waste permit and closure plan for the mine
●Arctic grayling adult returns to North Fork Red Dog Creek were low, number of adults seen in Ikalukrok Creek drainage remained low as in summer 2003
●Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2003 was 6,773 and for summer 2004 was 5,739
●Chinook salmon juveniles were documented for the first time in Ikalukrok Creek, near Dudd Creek, and in Anxiety Ridge Creek
●Age-1 Arctic grayling were caught in minnow traps fished in Ikalukrok, Mainstem, and Buddy creeks, since age-1 fish are seldom captured in minnow traps this may indicate good survival of fry spawned in spring 2003
●Red Dog Creek diversion (clean water ditch) was realigned to the west side of the pit. Realigned configuration is a combination of large diameter culvert and open lined ditch

2005

●Wastewater discharge began on May 10, 2005, ended on October 6, 2005, total discharge about 1.501 billion gallons
●Major precipitate observed on streambed in Middle Fork Red Dog Creek below effluent outfall in July and August, precipitates (gray colored) evident for at least 1 km downstream of effluent outfall
●Fish weir operating as designed
●Effects to Ikalukrok Creek from Cub Creek seep substantially greater than seen for past several years, water opaque and streambed coated with red precipitate at confluence with Mainstem Red Dog Creek, TCAK water sample from Cub Creek seep with a pH of 3.3
●Arctic grayling spawning/water temperature data collected, Arctic grayling from North Fork Red Dog Creek used for TDS fertilization experiment
●Attended and participated in a NPDES permit renewal meeting in Seattle with EPA, TCAK, and NANA, identified and discussed key issues

Appendix 1 (continued)

2005

●Red Dog Creek diversion (clean water ditch) mine engineering drawings (r4) were provided by TCAK showing the culverts and lined ditch that carry water from tributaries and Middle Fork Red Dog Creek through the pit area

●Recommendations for changes to the Red Dog biomonitoring program based on field data collection and analyses since 1999 were made for possible incorporation into the renewed NPDES permit or ADEC's solid waste permit for the tailing impoundment

●TCAK distributed the 2005 draft report on Arctic grayling fertilization studies that concluded TDS concentrations at or below 1,500 mg/L at Station 10 in Mainstem Red Dog Creek would provide for proper protection of Arctic grayling in the Red Dog Creek drainage, OHMP supported these findings in a letter to Pete McGee (ADEC) dated August 17, 2005

●Dr. Weber Scannell prepared comments on fish tissue data (Dolly Varden from Wulik and Kivalina rivers) collected by Maniilaq Association and compared these data with existing information from other sources in both Alaska and nationwide

●OHMP prepared a summary report (letter to Jim Kulas dated August 23, 2005) on temperature/spawning data collected for Arctic grayling in Mainstem Red Dog and North Fork Red Dog creeks from 2001 through 2005, a recommendation for determining start and completion of spawning based on temperature was developed for Mainstem Red Dog Creek

●State and TCAK continued to work on key issues associated with the solid waste permit and closure plan for the mine ADEC

●Wastewater Treatment Plant (WTP) #3 began operations in late summer 2005 to treat mine sump water and drainage from waste rock dumps prior to placement of these waters into the tailing impoundment; purpose is to improve water quality in tailing impoundment over time

●Exploratory drilling and flow testing for gas in North Fork Red Dog Creek basin was conducted, access road and pads inspected, corrugated pipes installed to provide cross drainage, no evidence of erosion noted along road to and connecting the drill pads

●A road was constructed to Station 151 (end of mixing zone in Mainstem Red Dog Creek

●Work to expand and relocate the water treatment plant sand filters was initiated

●Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2003 was 6,773 - for summer 2004 was 5,739 – and for summer 2005 was 5,356

Appendix 1 (continued)

2006

●ADEC amended the site-specific criteria (SSC) for TDS in Mainstem Red Dog Creek, the 500 mg/L limit during Arctic grayling spawning was removed and replaced with a 1,500 mg/L limit on February 15, 2006, and EPA approved the new SSC in April 2006

●North Fork Red Dog Creek, extensive areas of aufeis existed, turbidity and organic debris high due to erosion and thermal degradation, in several reaches flow was not in stream channel due to aufeis

●Arctic grayling spawning/water temperature data collected, early spring warming followed by cold weather, adult Arctic grayling entered North Fork Red Dog Creek in late May and due to cold water temperatures abandoned spawning and outmigrated from the creek in mid-June

●Four Arctic grayling captured in North Fork Red Dog Creek in spring 2006 were fish that had been marked in Bons Pond

●Review of ADEC's draft 401 certification to the renewal of the NPDES was completed and we provided a letter of support (March 10, 2006) to ADEC, including our concurrence with ADEC's decision to not require Whole Effluent Toxicity (WET) limits

●Effects to Ikalukrok Creek from Cub Creek seep continued, but were minor

●Major precipitate observed on streambed in Middle Fork Red Dog Creek below effluent outfall in August, precipitates (orange colored) evident for at least 1 km downstream of effluent outfall and precipitates continued upstream through the clean water bypass to Connie and Rachel creeks

●Fish weir operating as designed

●Work continued on the design for the Red Dog tailing backdam, the dam will be located on the south side of the tailing pond and will be constructed of earth fill with a concrete/soil aggregate/bentonite cutoff wall, the dam will be constructed to a final height of 986 ft., construction anticipated during 2006 and 2007

●In July, windrows of dead capelin were documented at the Port Site, die off after spawning is normal, only a small percentage survive spawning

●Total count of chum salmon in Ikalukrok Creek on August 16 was 4,185, the highest number reported since 1990

●In 2006, slightly elevated Zn concentrations persisted and TCAK initiated a field investigation comprised of sampling along the clean water bypass, although not definitive, results indicated that the Mine Sump might have been the source of increased Zn concentrations, modifications were made in operational procedures to ensure containment of contaminated waters in the Mine Sump

●Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2006 was 4,249

Appendix 1 (continued)

2007

●ADEC issued the Certificate of Reasonable Assurance for NPDES Permit AK-003865-2 on February 12, 2007. EPA issued the proposed NPDES permit for the Red Dog Mine discharge on March 7, 2007. Both actions were appealed and on September 28, 2007, EPA signed the NPDES Permit withdrawal. EPA intends to reissue the NPDES Permit upon completion of the Supplemental EIS for Aqqaluk Extension. In the interim, TCAK will operate under the 1998 NPDES Permit

●OHMP completed Technical Report No. 07-04 which summarized aquatic biomonitoring in Bons and Buddy creeks from 2004 to 2006. OHMP recommended that aquatic biomonitoring at four sites in Bons and Buddy Creeks and field work to estimate the Arctic grayling population in Bons Pond continue

●On May 17, 2007, ADNR issued the Certificate of Approval to Construct a Dam Red Dog Back Dam (AK00303)

●On May 24, we notified EPA that open flow existed in North Fork and Mainstem Red Dog creeks. TCAK received written permission from EPA to begin discharge from Outfall 001 and discharge was initiated on May 25

●Two fyke nets were fished in North Fork Red Dog Creek in spring 2007 to determine when Arctic grayling spawning was finished. Based on net catches, observed spawning activity in Mainstem Red Dog Creek, outmigration of mature fish from Mainstem Red Dog Creek as observed on June 3, and the lack of any spawning activity in Mainstem Red Dog Creek on June 3, OHMP determined that spawning was completed on June 2

●On June 6, EPA notified TCAK that the TDS load in Mainstem Red Dog Creek could be increased to 1,500 mg/L due to the fact that Arctic grayling spawning was complete

●Seven Arctic grayling captured in North Fork Red Dog Creek in spring 2007 were fish that had been marked in Bons Pond. Recruitment of Arctic grayling to North Fork Red Dog Creek from the Bons Pond population is occurring

●Fish weir, on Middle Fork Red Dog Creek, is operating as designed

●Arctic grayling spawning success, as determined by presence of fry, was very good in 2007 due to early spawning, low water following spawning for most of the summer, and warm water temperatures. Numerous fry were seen in North Fork Red Dog, Mainstem Red Dog, Ikalukrok, and Bons creeks. Arctic grayling fry in mid-August average 64 mm long (n = 26, 58 to 71 mm, SD = 3.1)

●Middle Fork Red Dog Creek contained an orange, tan colored precipitate that extended both above and below the waste water discharge point and was visible downstream to the fish weir

Appendix 1 (continued)

2007

- ●Our two estimates for adult chum salmon in Ikalukrok Creek (downstream of Station 160) were 1,408 and 1,998 along with about 100 adult Dolly Varden and 8 Chinook salmon
- ●Work on a Supplemental EIS for the Aqqaluk Extension project began with a draft scoping document in August, public meetings in early October, and draft alternatives scoping in December
- ●TCAK continued to make improvements to the mine's clean water bypass system. In October, galvanized culvert was installed replacing sections of HDPE lined ditch in Middle Fork Red Dog Creek upstream of Shelly Creek and continued upstream to the Rachel Creek confluence. In addition, the section of HDPE lined ditch in Connie Creek was converted to culvert as well

Appendix 1 (continued)

2008

●Work on the SEIS for the Aqqaluk Extension continued during 2008. Input via the State's LMPT coordinator was made periodically with emphasis on the alternatives being considered, the aquatic biology background section, and the monitoring plan for both the Red Dog and Bons/Buddy Creek drainages
●On May 5, 2008, we distributed copies of our technical report titled "Aquatic biomonitoring at Red Dog Mine, 2007 National Pollution Discharge Elimination System Permit No. AK-003865-2" covering work done in summer 2007
●On May 13, 2008, we notified ADEC that based on information provided by TCAK that open water flow existed in North Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks and that wastewater discharge could commence under the conditions of state and federal permits
●On May 28, 2008, TCAK reported to EPA that TDS on May 16 exceeded the permit limits in effect at the time of the discharge
●In spring 2008, Kivalina residents and NANA collected a number of adult Dolly Varden in the Wulik River and planned to have the fish analyzed for metals by Columbia Analytical Lab. Input regarding sampling protocol for adult Dolly Varden was provided to TCAK and NANA on June 6
●June 24, 2008, we reported to TCAK the successful completion of spring work on Arctic grayling in North Fork Red Dog and Mainstem Red Dog creeks and Bons Creek/Bons Pond. In spring 2008, we had at least three age classes of immature fish present in our North Fork Red Dog Creek sample and 18% of these recaptures were fish originally marked in Bons Pond. Our estimated population of Arctic grayling in Bons Pond for summer 2007 was 4,363 fish ≥ 200 mm
●On July 9, 2008, we participated in a teleconference with TCAK and Tetra Tech (contractor for the Aqqaluk SEIS) to discuss the potential impacts to Mainstem Red Dog Creek if the wastewater discharge was moved to the ocean. A short narrative describing possible changes to Mainstem Red Dog Creek was prepared and distributed
●On July 16, 2008, ADF&G sent a letter to TCAK that summarized results of our early July field work when we sampled periphyton, aquatic invertebrates, and fish at the NPDES and ADEC sample sites
●In early August, 2008, ADF&G Commissioner Denby Lloyd spent several days at Red Dog that included a briefing, tour of mine facilities, and an overflight of the project area including Ikalukrok Creek, Wulik River, Port Site, and the haul road from the port to the mine

Appendix 1 (continued)

2008

●On August 13, 2008, ADF&G sent to TCAK a summary of fish work done in early August. Using a helicopter, we estimated 3,820 chum salmon in Ikalukrok Creek on August 6 – one of our highest counts since surveys began in 1990
●On August 21, 2008, ADF&G sent to TCAK a summary of Arctic grayling spawning in Mainstem Red Dog and North Fork Red Dog creeks that covered from 2001 to 2008. The report includes a temperature-based criterion for determining when the majority of Arctic grayling spawning in Mainstem Red Dog Creek is substantially complete
●On September 3, 2008, a settlement was reached between all five plaintiffs residents of Kivalina and TECK on a lawsuit that alleged violations of the mine's NPDES permit. On October 23, 2008, a Consent Decree was entered with the Department of Justice as required under a CWA lawsuit. Principle to the agreement was a commitment (barring certain requirements) by TECK to design, permit and construct a pipeline to carry treated mine effluent to the ocean
●TCAK prepared and submitted on August 26, 2008, a draft Fugitive Dust Risk Management Plan
●On October 3, 2008, ADF&G sent by letter to TCAK results of the fall Dolly Varden overwintering survey in the Wulik River. Overall the count of Dolly Varden was lower than in the recent past; however, it was noted that very few small fish (first year migrants) were present. More chum salmon (16,215) were seen from Sivu to Driver's Camp – more chum salmon than have been seen before
●TCAK prepared and submitted a draft monitoring plan for state agency review in early November 2008. The objective is to develop one comprehensive monitoring plan for all state and federal permits pertaining to the mine site as defined by the ambient air boundary. In November and December, we provided input to the States LMPT on the monitoring plan which when completed will be incorporated by reference into the 401 Certification and the ADEC Waste Management Permit
●Adult Dolly Varden and juvenile Dolly Varden for selected metals analyses were prepared and sent to Columbia Analytical Laboratory in mid-November
●November 24, 2008, the SEIS for Red Dog Aqqaluk Extension was released by EPA for public review
●On December 22, 2008, we received a CD for the Red Dog Mine Closure and Reclamation Plan – the final draft for agency review. The closure and reclamation plan are the result of over six years of work by TCAK in consultation with state and federal agencies and the public

Appendix 1 (continued)

2009

●Continued to review and provide comments on the SEIS for the Red Dog Aqqaluk Extension project with emphasis on the monitoring plan prepared by Teck that covers both the Bons/Buddy Creek and Red Dog Creek drainages
●During 2009, Teck continued construction of the back dam/cutoff wall and the next raise of the main dam
●On February 10, 2009, the National Park Service issued a news release that they had released a report titled "Assessment of Metals Exposure and Sub-Lethal Effects in Voles and Small Birds Captured Near the Delong Mountain Regional Transportation System Road, Cape Krusenstern National Monument, Alaska, 2006"
●On February 12, 2009, we received notification that the legal company name for Red Dog was now changed to Teck Alaska Incorporated and in simple form will be known as Teck
●On May 1, 2009, ADF&G distributed copies of the report titled "Aquatic Biomonitoring at Red Dog Mine, 2008 National Pollution Discharge Elimination System Permit No. AK-003865-2"
●On May 5, 2009, ADF&G by email stated that we have no objection to Teck beginning the discharge of treated water to Middle Fork Red Dog Creek
●On May 6, 2009, ADF&G provided written input to ADEC on Teck's Monitoring Plan
●Several field inspections of the fish weir on Middle Fork Red Dog Creek were made by ADF&G - the weir was operating in compliance with the Fish Habitat Permit
●In early June, ADF&G monitored the Arctic grayling spawning run in Mainstem Red Dog and North Fork Red Dog creeks. Six adult Dolly Varden were collected in the Wulik River near Tutak Creek by Teck
●In early July we successfully completed collection of periphyton, aquatic invertebrates and fish at all NPDES required sample sites as well as 4 sites located in the Bons/Buddy Creek drainages
●Due to extremely low flows, Teck ceased the discharge at Outfall 001 from July 22 around 0600 hr to August 2 around 1400 hr. In our sample reach at Station 151 in Mainstem Red Dog Creek, we observed hundreds of Arctic grayling fry and caught 7 juvenile Dolly Varden in minnow traps. At Station 10 in Mainstem Red Dog Creek we observed several Arctic grayling fry and two adults and caught 6 juvenile Dolly Varden and 5 slimy sculpin. The Arctic grayling fry observed were actively feeding and showed no sign of stress. These results were obtained from July 29 to 31, 2009, and represent conditions in the creek without water from the wastewater discharge

Appendix 1 (continued)

2009

●On August 19, 2009, we reported to Teck the successful completion of spring work on Arctic grayling in North Fork Red Dog and Mainstem Red Dog creeks and Bons Creek/Bons Pond. In spring 2009, we again saw strong recruitment of Arctic grayling to North Fork Red Dog Creek and 13% of these recaptures were fish originally marked in Bons Pond. Our estimated population of Arctic grayling in Bons Pond for summer 2008 was 2,216 ≥200 mm – a fairly substantial decrease from the summer 2007 estimate of 4,363
●Provided to Teck via email on September 3 the protocols that should be used to handle a fish for pathological work
●On September 25, 2009, Mr. Fred DeCicco (Fisheries Services and Supplies) and Mr. Brendon Scanlon (ADF&G) conducted aerial surveys for Dolly Varden in the Wulik River and chum salmon in Ikalukrok Creek
●On November 24, 2009, ADF&G transmitted to Teck by letter a summary of Arctic grayling spawning in Mainstem Red Dog and North Fork Red Dog creeks (2001 through 2009)
●On December 2, 2009, ADNR issued the Reclamation Plan Approval for the Red Dog Mine and ADEC issued Waste Management Permit No. 0132-BA002 for the Red Dog Mine. Both actions are subject to appeal by third parties
●On December 15, 2009, the ADEC issued the Certificate of Reasonable Assurance for the NPDES Permit AK-003865-2 to regulate the discharge of treated wastewater and stormwater from Red Dog Mine

Appendix 1 (continued)

2010

●On January 8, 2010, the EPA issued NPDES Permit No. AK-003865-2. The permit shall become effective on March 1, 2010
●On January 14, 2010, two nonprofit law firms, representing local tribes and environmental groups, filed an appeal of the state's 401 certification, asserting that certain provisions do not comply with the Clean Water Act
●On February 15, 2010, the same two nonprofit law firms filed a petition for review of the EPA permit with the Environmental Appeals Board. In a letter dated February 26, 2010, EPA stayed several contested conditions of NPDES Permit No. AK-003865-2
●On March 11, 2010, the US Department of the Army issued permit POA-1984-12-M45 to Teck which would authorize development of the Aqqaluk Pit at the Red Dog Mine
●On March 17, 2010, EPA Region 10 withdrew conditions from the 2010 NPDES Permit No. AK-003865-2, including: Part IA.1, Table 1 effluent limits for lead (monthly average limit), selenium (daily maximum limit), zinc, and weak acid dissociable (WAD) cyanide, and; Part IA.7.a – effluent limitations for Total Dissolved Solids (TDS). Those permit conditions not withdrawn, which include the entire permit except the conditions identified above, became fully effective and enforceable on March 31, 2010. As a result of this withdrawal, the following conditions in the 1998 NPDES Permit No. AK003865-2 remain in effect until further agency action: Part IA.1 – effluent limitations for lead (monthly average limit), selenium (daily maximum limit), zinc, TDS, and total cyanide
●On May 20, 2010, Teck announced plans to proceed with development of Aqqaluk
●In early June, ADF&G monitored the Arctic grayling spring spawning migration in the Red Dog Creek drainage and in Bons Pond – strong recruitment of immature Arctic grayling was seen in North Fork Red Dog Creek
●On June 14, 2010, ADNR responded to a Legislative Research Services request for information on what happened at Red Dog during the past – ADF&G provided input on the request including a copy of Appendix 1 (chronology of events)
●In early July, we collected periphyton and aquatic invertebrate samples at all sites, except Bons Creek where there was no surface flow present
●On July 12, 2010, ADF&G sent a letter to Teck that included a document titled "Comparison of adult Dolly Varden (*Salvelinus malma*) tissue metals concentrations from fish caught in 2008 in the Wulik River Kivalina, Alaska." The document compares metals concentrations between fish collected by Kivalina and those collected by ADF&G
●We estimated the Arctic grayling population (fish $\geq$200 mm) in North Fork Red Dog Creek in spring 2009 at 1,368 fish (SD = 418) based on the 2010 recapture event

Appendix 1 (continued)

2010

●We estimated the Arctic grayling population (fish ≥200 mm) in Bons Pond in spring 2009 at 2,180 (SD = 539) based on the 2010 recapture event
●On September 24, 2010, Mr. Fred DeCicco (Fisheries Services and Supplies) and Mr. Brendon Scanlon (ADF&G) conducted aerial surveys for Dolly Varden in the Wulik River and chum salmon in Ikalukrok Creek – they also estimated 548 adult Dolly Varden in Ikalukrok Creek
●An Arctic grayling tagged in North Fork Red Dog Creek was recaptured by an sport fisherman in the Wulik River due west of the mine and near the Lik Deposit on August 15, 2010
●Seasonal discharge from Outfall 001 was initiated on May 6 and terminated on September 22, 2010

Appendix 2. Periphyton Standing Crop

2010 Chloro Results - Red Dog			Detection Limits - Instrument = 0.06 Vial Chla - Method = 0.02 Vial Chla -								
								Phaeo Corrected			
			Date	Date	Vial	Chl a	Below Instrument	Chl a	664/665	Chl b	Chl c
Daily	Site/Volume (liters)	Station /Site	Collected	Analyzed	Chl a	mg/m2	Detection Limit	mg/m2	Ratio	mg/m2	mg/m2
Vial #							(0.06 Vial Chl a)				
							OR				
							Above Linear Check				
							(21.19 Vial Chl a)				
1	BLANK	BLANK	11/30/10	11/30/10	0.00	**0.00**	**Below Detection**				
2	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.64	2.58		**2.46**	1.68	0.34	0.00
3	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.77	3.08		**2.78**	1.62	0.32	0.12
4	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.91	3.63		**3.31**	1.63	0.24	0.64
5	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.90	3.60		**3.31**	1.65	0.08	0.05
6	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	1.92	7.68		**7.37**	1.68	0.94	0.11
7	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.56	2.23		**2.14**	1.69	0.02	0.13
8	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.58	2.33		**2.24**	1.70	0.00	0.21
9	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	1.49	5.94		**5.66**	1.68	0.42	0.30
10	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.74	2.97		**2.88**	1.71	0.00	0.10
11	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2010	11/30/10	0.96	3.82		**3.63**	1.68	0.12	0.15
12	Ik us Red Dog	STA 9	July 2010	11/30/10	0.80	3.20		**2.99**	1.67	0.00	0.26
13	Ik us Red Dog	STA 9	July 2010	11/30/10	0.82	3.29		**3.10**	1.67	0.00	0.31
14	Ik us Red Dog	STA 9	July 2010	11/30/10	0.90	3.61		**3.42**	1.68	0.00	0.21
15	Ik us Red Dog	STA 9	July 2010	11/30/10	0.95	3.79		**3.63**	1.69	0.00	0.32
16	Ik us Red Dog	STA 9	July 2010	11/30/10	0.56	2.24		**2.14**	1.69	0.00	0.16
17	Ik us Red Dog	STA 9	July 2010	11/30/10	0.40	1.60		**1.50**	1.67	0.00	0.08
18	Ik us Red Dog	STA 9	July 2010	11/30/10	0.73	2.92		**2.88**	1.73	0.00	0.30
19	Ik us Red Dog	STA 9	July 2010	11/30/10	0.92	3.70		**3.63**	1.72	0.00	0.26
20	Ik us Red Dog	STA 9	July 2010	11/30/10	0.54	2.15		**2.03**	1.68	0.00	0.20
21	Ik us Red Dog	STA 9	July 2010	11/30/10	0.95	3.79		**3.74**	1.73	0.00	0.32
22	Mainstem Red Dog	STA 10	July 2010	11/30/10	0.49	1.95		**1.92**	1.72	0.16	0.07
23	Mainstem Red Dog	STA 10	July 2010	11/30/10	0.80	3.21		**2.99**	1.65	0.41	0.14
24	Mainstem Red Dog	STA 10	July 2010	11/30/10	0.69	2.75		**2.67**	1.69	0.40	0.10
25	Mainstem Red Dog	STA 10	July 2010	11/30/10	1.40	5.59		**5.34**	1.68	0.93	0.03
26	Mainstem Red Dog	STA 10	July 2010	11/30/10	0.44	1.77		**1.82**	1.77	0.16	0.13
27	Mainstem Red Dog	STA 10	July 2010	11/30/10	2.60	10.40		**9.40**	1.61	2.39	0.01
28	Mainstem Red Dog	STA 10	July 2010	11/30/10	1.35	5.41		**5.02**	1.64	0.85	0.12
29	Mainstem Red Dog	STA 10	July 2010	11/30/10	1.10	4.39		**4.17**	1.67	0.47	0.21
30	Mainstem Red Dog	STA 10	July 2010	11/30/10	1.02	4.08		**4.06**	1.73	0.30	0.18
31	Mainstem Red Dog	STA 10	July 2010	11/30/10	1.22	4.88		**4.59**	1.66	0.55	0.12
32	BLANK	BLANK	11/30/10	11/30/10	0.00	0.00	**Below Detection**				
4 Double	Lwr Bons blw WRD DBL	Lwr Bons blw WRD DBL	July 2010	11/30/10	0.89	3.58		**3.10**	1.58	0.26	0.64
1	BLANK	BLANK	12/1/10	12/01/10	**0.01**	0.04	**Below Detection**				
2	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	2.44	9.76		**9.08**	1.65	0.62	0.42
3	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	3.35	13.40		**12.18**	1.62	2.47	0.53
4	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	2.95	11.79		**11.32**	1.70	0.00	0.69
5	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	2.24	8.97		**8.65**	1.70	0.10	0.78
6	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	2.10	8.40		**7.80**	1.66	0.00	0.88
7	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	1.18	4.73		**4.38**	1.65	0.14	0.32
8	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	2.40	9.58		**9.08**	1.67	0.56	0.31
9	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	3.66	14.66		**14.10**	1.70	0.00	1.29
10	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	1.61	6.44		**6.30**	1.72	0.00	0.55
11	Buddy blw falls	Buddy blw falls	July 2010	12/01/10	3.66	14.63		**13.88**	1.68	0.00	0.77

Appendix 2 (concluded)

								Phaeo Corrected			
			Date	Date	Vial	Chl a	Below Instrument	Chl a	664/665	Chl b	Chl c
Daily	Site/Volume (liters)	Station /Site	Collected	Analyzed	Chl a	mg/m2	Detection Limit	mg/m2	Ratio	mg/m2	mg/m2
Vial #							(0.06 Vial Chl a)				
							OR				
							Above Linear Check				
							(21.19 Vial Chl a)				
12	Ik ds Dudd	STA 160	July 2010	12/01/10	0.98	3.91		**3.74**	1.69	0.13	0.40
13	Ik ds Dudd	STA 160	July 2010	12/01/10	1.57	6.29		**5.98**	1.68	0.08	0.51
14	Ik ds Dudd	STA 160	July 2010	12/01/10	1.23	4.91		**4.70**	1.69	0.21	0.34
15	Ik ds Dudd	STA 160	July 2010	12/01/10	1.17	4.69		**4.49**	1.69	0.07	0.36
16	Ik ds Dudd	STA 160	July 2010	12/01/10	0.87	3.46		**3.20**	1.65	0.03	0.39
17	Ik ds Dudd	STA 160	July 2010	12/01/10	0.89	3.56		**3.31**	1.66	0.00	0.31
18	Ik ds Dudd	STA 160	July 2010	12/01/10	1.99	7.96		**7.69**	1.71	0.00	0.61
19	Ik ds Dudd	STA 160	July 2010	12/01/10	1.02	4.07		**3.84**	1.68	0.00	0.34
20	Ik ds Dudd	STA 160	July 2010	12/01/10	1.81	7.24		**6.84**	1.67	0.08	0.68
21	Ik ds Dudd	STA 160	July 2010	12/01/10	0.87	3.46		**3.20**	1.65	0.03	0.39
22	North Fork Red Dog	STA 12	July 2010	12/01/10	3.12	12.48		**11.64**	1.66	0.14	1.62
23	North Fork Red Dog	STA 12	July 2010	12/01/10	0.48	1.92		**1.82**	1.68	0.00	0.07
24	North Fork Red Dog	STA 12	July 2010	12/01/10	0.42	1.69		**1.60**	1.68	0.00	0.04
25	North Fork Red Dog	STA 12	July 2010	12/01/10	1.46	5.83		**5.23**	1.61	0.71	0.32
26	North Fork Red Dog	STA 12	July 2010	12/01/10	1.29	5.17		**4.59**	1.61	0.36	0.66
27	North Fork Red Dog	STA 12	July 2010	12/01/10	1.35	5.40		**4.70**	1.59	0.35	0.50
28	North Fork Red Dog	STA 12	July 2010	12/01/10	1.26	5.04		**4.70**	1.65	0.87	0.13
29	North Fork Red Dog	STA 12	July 2010	12/01/10	0.48	1.91		**1.82**	1.68	0.01	0.14
30	North Fork Red Dog	STA 12	July 2010	12/01/10	0.45	1.78		**1.82**	1.77	0.00	0.12
31	North Fork Red Dog	STA 12	July 2010	12/01/10	0.55	2.19		**2.14**	1.71	0.00	0.07
32	BLANK	BLANK	12/1/10	12/01/10	0.00	0.00	**Below Detection**				
26 Double	North Fork Red Dog	STA 12	July 2010	12/01/10	1.56	6.25		**5.77**	1.64	0.45	0.85
1	BLANK	BLANK	12/2/10	12/02/10	0.00	0.00	**Below Detection**				
2	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.09	0.36		**0.43**	2.00	0.06	0.05
3	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.10	0.41		**0.32**	1.50	0.04	0.04
4	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.15	0.58		**0.53**	1.63	0.11	0.06
5	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.04	0.18	**Below Detection**				
6	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.12	0.50		**0.53**	1.83	0.07	0.10
7	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.79	3.17		**2.88**	1.63	0.28	0.11
8	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.84	3.38		**3.20**	1.67	0.57	0.12
9	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.12	0.50		**0.43**	1.57	0.07	0.10
10	Mid Fork Red Dog	STA 20	July 2010	12/02/10	1.15	4.62		**4.38**	1.66	1.07	0.09
21	Mid Fork Red Dog	STA 20	July 2010	12/02/10	0.26	1.04		**0.96**	1.64	0.12	0.09
11	Buddy us Road	STA 221	July 2010	12/02/10	1.72	6.88		**6.51**	1.68	0.10	0.60
12	Buddy us Road	STA 221	July 2010	12/02/10	3.65	14.60		**13.67**	1.66	0.52	1.09
13	Buddy us Road	STA 221	July 2010	12/02/10	3.80	15.21		**14.52**	1.69	0.22	1.10
14	Buddy us Road	STA 221	July 2010	12/02/10	3.06	12.25		**11.21**	1.63	1.46	0.53
15	Buddy us Road	STA 221	July 2010	12/02/10	6.40	25.61		**24.56**	1.70	0.00	1.82
16	Buddy us Road	STA 221	July 2010	12/02/10	1.17	4.70		**4.49**	1.69	0.00	0.49
17	Buddy us Road	STA 221	July 2010	12/02/10	2.35	9.40		**8.97**	1.68	0.46	0.59
18	Buddy us Road	STA 221	July 2010	12/02/10	1.65	6.61		**5.98**	1.63	0.02	0.34
19	Buddy us Road	STA 221	July 2010	12/02/10	0.84	4.05		**3.97**	1.70	0.67	0.26
20	Buddy us Road	STA 221	July 2010	12/02/10	2.91	11.65		**11.11**	1.66	3.42	0.15
22	BLANK	BLANK	12/2/10	12/02/10	0.00	0.00	**Below Detection**				
10 double	Mid Fork Red Dog	STA 20	July 2010	12/02/10	1.16	4.66		**4.49**	1.68	1.11	0.25

Appendix 3. Aquatic Invertebrate Drift Samples

Middle Fork Red Dog Creek, Station 20, Drift Samples Invertebrates												
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total aquatic taxa	15	15	19	15	28	23	20	16	26	25	15	15
												\
Tot. Ephemeroptera	9	0	17	4	6	44	41	7	23	29	16	1
Tot. Plecoptera	3	5	43	20	34	38	28	9	11	13	4	0
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	1	1	0
Total Aq. Diptera	104	40	153	121	449	28	92	6	80	72	45	103
Misc.Aq.sp	9	17	73	17	55	46	177	5	82	52	38	10
% Ephemeroptera	8%	0%	6%	2%	1%	28%	12%	26%	12%	17%	15%	1%
% Plecoptera	3%	7%	15%	13%	7%	24%	8%	35%	6%	8%	4%	0%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
% Aq. Diptera	83%	64%	53%	75%	83%	18%	27%	22%	41%	43%	43%	90%
% other	7%	28%	26%	10%	10%	29%	52%	18%	42%	31%	37%	9%
% EPT	10%	8%	21%	15%	7%	52%	21%	60%	18%	25%	20%	1%
% Chironomidae	80%	36%	51%	73%	73%	16%	24%	15%	35%	39%	38%	86%
% Dominant Aquatic Taxon	46%	36%	31%	43%	48%	30%	42%	37%	22%	22%	37%	75%
Volume of water (m3)	378	551	933	310	702	880	302	296	384	249	285	78
average water/net	76	110	187	62	140	176	60	59	77	50	57	16
StDev of water volume	24	26	89	14	38	91	26	9	52	8	11	9
Estimated total inverts/m3 water	2.92	0.6	1.7	6.2	6.6	1.1	19.4	0.6	7.4	16.2	23.2	10.1
Estimated aquatic inverts/m3 wa	1.7	0.6	1.5	2.6	3.9	0.9	5.6	0.4	2.6	3.4	1.8	7.3
average inv/m3	3.2	0.6	1.8	6.1	6.4	1.2	19.5	0.6	10.5	16.3	24.1	11.7
average aq. Invertebrates/m3 wa	1.8	0.57	1.64	2.59	3.74	0.95	5.33	0.45	3.53	3.39	1.8	8.2
Stdev of aq. Inv. Den.	1.3	0.21	0.38	0.58	1.07	0.27	0.97	0.21	1.86	0.7	0.25	3.2
Total aquatic invertebrates	627	309	1431	810	2719	783	1694	133	980	835	523	573
Total. terrestrial invertebrates	477	10	185	1115	1889	170	4158	59	1875	3210	6096	218
Total invertebrates	1104	319	1616	1925	4608	953	5852	192	2855	4045	6619	791
% Sample aquatic	57%	97%	89%	42%	59%	82%	29%	69%	34%	21%	8%	72%
% Sample terrestrial	43%	3%	11%	58%	41%	18%	71%	31%	66%	79%	92%	28%
Average # aquatic inverts / net	125	62	286	162	544	157	339	27	196	167	105	115
stdev aq inv/net	59	20	111	56	242	69	178	11	20	35	30	51
Average # terr. inverts / net	95	2	37	223	378	34	832	12	375	642	1219	44
Average # inverts / net	221	64	323	385	922	191	1170	38	571	809	1324	158
stdev inv/net	68	21	127	156	376	85	532	13	55	191	259	74
Total Larval Arctic Grayling/site	0	0	0	0	0	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3 (continued)

North Fork Red Dog Creek, Station 12, Drift Samples Invertebrates												
Date:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total aquatic taxa	13	13	18	16	26	20	21	15	21	23	19	17
Tot. Ephemeroptera	67	14	20	170	194	38	198	882	163	57	66	26
Tot. Plecoptera	23	94	117	40	64	5	5	19	11	77	18	4
Tot. Trichoptera	4	6	6	0	4	0	0	0	1	4	1	3
Total Aq. Diptera	700	314	1134	116	716	27	333	755	641	1574	2113	1092
Misc.Aq.sp	30	69	226	43	188	17	39	32	135	320	251	140
% Ephemeroptera	8%	3%	1%	46%	16%	44%	34%	52%	17%	3%	3%	2%
% Plecoptera	3%	19%	8%	11%	6%	5%	1%	1%	1%	4%	1%	0%
% Trichoptera	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	85%	63%	75%	31%	62%	31%	58%	45%	67%	77%	86%	86%
% other	4%	14%	15%	12%	16%	19%	7%	2%	14%	16%	10%	11%
% EPT	11%	23%	9%	57%	23%	50%	35%	53%	18%	7%	3%	3%
% Chironomidae	54%	36%	57%	22%	27%	25%	36%	14%	61%	32%	55%	33%
% Dominant Aquatic Taxon	45%	32%	43%	46%	35%	48%	34%	44%	36%	45%	43%	54%
Volume of water (m^3)	559	221	747	226	672	672	380	368	297	329	681	187
average water/net	112	44	149	45	134	134	76	74	59	66	136	37
StDev of water volume	80	12	54	23	37	64	54	10	24	20	45	22
Estimated total inverts/m^3 water	9.2	11.8	10.2	13.5	9.3	0.9	12.4	23.6	18.3	33.2	28	37.4
Estimated aquatic inverts/m^3 wat	7.4	11.2	10.0	8.1	8.7	0.6	7.6	23.0	16.0	30.9	18	33.8
average inv/m^3	14.2	11.5	10.2	15.0	10.0	0.8	16.3	23.5	19.9	33.5	28.1	35.3
average aq. Invertebrates/m^3 wa	11.4	10.9	10.0	9.1	9.4	0.6	11.8	22.8	17.5	31.1	18.4	31.3
Stdev of aq. Inv. Den.	8.3	5.7	1.5	5.3	5.2	0.2	9.4	3.9	6.6	7.8	2.83	11.6
Total aquatic invertebrates	4120	2486	7509	1839	5827	435	2875	8442	4750	10159	12242	6324
Total. terrestrial invertebrates	1044	129	117	1211	426	159	1833	248	670	745	6843	677
Total invertebrates	5164	2615	7626	3050	6254	594	4708	8691	5420	10904	19085	7000
% Sample aquatic	80%	95%	98%	60%	93%	73%	61%	97%	88%	93%	64%	90%
% Sample terrestrial	20%	5%	2%	40%	7%	27%	39%	3%	12%	7%	36%	10%
Average # aquatic inverts / net	824	497	1502	368	1165	87	575	1688	950	2032	2448	1265
stdev aq inv/net	138	352	545	161	409	60	278	448	265	802	764	977
Average # terr. inverts / net	209	26	23	242	85	32	367	50	134	149	1369	135
Average # inverts / net	1033	523	1525	610	1251	119	942	1738	1084	2181	3817	1400
stdev inv/net	274	339	560	188	434	97	587	447	308	848	1480	1048
Total Larval Arctic Grayling/site	1	3	1	0	0	0	0	0	9	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3 (continued)

Mainstem Red Dog Creek, Station 10, Drift Samples Invertebrates												
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total aquatic taxa	11	7	19	12	21	17	15	20	22	24	17	15
Tot. Ephemeroptera	2	0	6	14	313	24	54	77	56	25	10	1
Tot. Plecoptera	35	16	34	30	292	16	36	45	144	50	15	6
Tot. Trichoptera	0	1	3	0	1	0	7	0	1	3	1	0
Total Aq. Diptera	182	20	676	129	438	37	396	87	558	1301	347	57
Misc.Aq.sp	3	2	82	8	58	9	82	73	141	106	49	10
% Ephemeroptera	1%	1%	1%	8%	28%	28%	9%	27%	6%	2%	2%	2%
% Plecoptera	16%	41%	4%	17%	27%	18%	6%	16%	16%	3%	4%	8%
% Trichoptera	0%	3%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
% Aq. Diptera	82%	52%	84%	71%	40%	43%	69%	31%	62%	88%	82%	76%
% other	1%	4%	10%	4%	5%	11%	14%	26%	16%	7%	12%	14%
% EPT	17%	44%	5%	25%	55%	47%	17%	43%	22%	5%	6%	10%
% Chironomidae	69%	25%	79%	62%	24%	39%	36%	22%	60%	55%	60%	68%
% Dominant Aquatic Taxon	61%	42%	64%	52%	29%	30%	33%	23%	42%	52%	43%	55%
Volume of water (m3)	869	356	1323	255	688	1239	665	417	422	384	378	139
average water/net	174	71	265	51	138	248	133	83	84	77	76	28
StDev of water volume	122	27	56	15	39	54	65	13	20	10	24	16
Estimated total inverts/m3 water	1.4	0.6	3.1	3.8	8.2	0.5	7.5	4.8	13.5	22.6	9.2	4.1
Estimated aquatic inverts/m3 wa	1.3	0.5	3.0	3.6	8.0	0.3	4.3	3.4	10.7	19.4	5.6	2.7
average inv/m3	1.9	0.7	3.2	4.2	8.6	0.5	8.2	5.0	14.0	22.8	8.8	3.2
average aq. inverts/m3 water	1.8	0.6	3.1	4.0	8.4	0.4	4.6	3.5	11.1	19.5	5.3	2.1
Stdev of aq. Inv. Den.	1.3	0.3	0.8	2.1	1.9	0.0	1.6	1.4	2.3	3.6	1.4	1.4
Total aquatic invertebrates	1111	192	4003	910	5503	427	2875	1410	4497	7427	2109	370
Total. terrestrial invertebrates	136	21	121	49	121	173	2119	609	1218	1252	1351	205
Total invertebrates	1247	213	4123	959	5624	600	4993	2018	5715	8679	3461	575
% Sample aquatic	89%	90%	97%	95%	98%	71%	58%	70%	79%	86%	61%	64%
% Sample terrestrial	11%	10%	3%	5%	2%	29%	42%	30%	21%	14%	39%	36%
Average # aquatic inverts / net	222	38	801	182	1101	85	575	282	899	1485	422	74
stdev aq inv/net	126	25	182	47	152	16	311	66	83	227	242	76
Average # terr. inverts / net	27	4	24	10	24	35	424	122	244	250	270	41
Average # inverts / net	249	43	825	192	1125	120	999	404	1143	1736	692	115
stdev inv/net	153	27	171	51	152	25	529	69	111	218	358	116
Total Larval Arctic Grayling/site	5	5	0	2	1	0	0	0	0	45	2	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3 (continued)

Ikalukrok Creek, Station 9, Drift Samples Invertebrates												
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total aquatic taxa	8	9	15	13	21	16	13	18	20	20	24	14
Tot. Ephemeroptera	11	63	267	213	138	208	571	67	225	122	151	4
Tot. Plecoptera	17	13	159	24	54	30	189	57	98	64	21	4
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	0	0	0
Total Aq. Diptera	10	58	1252	285	485	196	185	56	217	193	370	167
Misc.Aq.sp	9	8	56	5	23	23	23	25	24	162	125	10
% Ephemeroptera	24%	44%	15%	40%	19%	45%	59%	33%	40%	23%	23%	2%
% Plecoptera	36%	9%	9%	5%	8%	7%	19%	28%	17%	12%	3%	2%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	22%	41%	72%	54%	70%	43%	19%	27%	39%	36%	56%	90%
% other	19%	6%	3%	1%	3%	5%	2%	12%	4%	30%	19%	5%
% EPT	60%	54%	25%	45%	27%	52%	79%	60%	57%	34%	26%	4%
% Chironomidae	21%	39%	69%	52%	65%	25%	15%	18%	35%	28%	31%	49%
% Dominant Aquatic Taxon	32%	45%	65%	44%	57%	36%	37%	24%	35%	20%	24%	44%
Volume of water (m^3)	260	478	833	575	450	2772	555	352	382	390	601	265
average water/net	52	96	167	115	90	554	111	70	76	78	120	53
StDev of water volume	25	16	106	29	23	161	12	16	23	22	46	19
Estimated total inverts/m^3 water	1.5	1.6	10.7	4.9	8.7	1.4	11.4	3.8	9.0	11.3	8.4	3.8
Estimated aquatic inverts/m^3 wat	0.9	1.5	10.4	4.6	7.8	0.8	8.7	2.9	7.4	6.9	5.5	3.5
average inv/m^3	1.6	1.6	12	5	8.9	1.4	11.4	3.9	9.5	13.7	8.4	4.0
average aq inverts/m^3 water	1.0	1.5	11.7	4.7	7.9	0.9	8.7	3.0	7.9	8.3	5.5	3.7
Stdev of aq. inv. Den.	0.6	0.3	4.6	0.8	1.0	0.1	1.7	1.2	2.5	6.2	1.3	0.8
Total aquatic invertebrates	232	714	8668	2635	3497	2288	4848	1028	2822	2707	3330	926
Total. terrestrial invertebrates	159	66	220	168	403	1507	1482	325	606	1704	1741	92
Total invertebrates	391	780	8888	2803	3900	3795	6330	1353	3427	4410	5071	1018
% Sample aquatic	59%	92%	98%	94%	90%	60%	77%	76%	82%	61%	66%	91%
% Sample terrestrial	41%	8%	2%	6%	10%	40%	23%	24%	18%	39%	34%	9%
Average # aquatic inverts / net	46	143	1734	527	699	458	970	206	564	541	666	185
stdev aq inv/net	26	46	822	102	115	90	255	81	120	266	347	63
Average # terr. inverts / net	32	13	44	34	81	301	296	65	121	341	348	18
Average # inverts / net	78	156	1778	561	780	759	1266	271	685	882	1014	204
stdev inv/net	51	50	849	99	110	158	296	94	173	424	491	65
Total Larval Arctic Grayling/site	1	1	0	0	0	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	1	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3 (continued)

Ikalukrok Creek below Dudd Creek Station 7, and Station 160 starting in 2010 under new permit												
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total aquatic taxa	10	12	18	9	18	24	18	22	18	24	19	14
Tot. Ephemeroptera	1	4	138	12	59	23	152	114	126	17	33	4
Tot. Plecoptera	9	102	43	12	37	8	4	29	21	21	8	2
Tot. Trichoptera	0	1	1	0	1	2	0	2	1	1	0	0
Total Aq. Diptera	38	319	262	111	1054	95	529	323	1356	1335	1558	371
Misc.Aq.sp	3	105	22	2	36	44	8	83	187	119	28	92
% Ephemeroptera	1%	1%	30%	8%	5%	13%	22%	21%	7%	1%	2%	1%
% Plecoptera	17%	19%	9%	8%	3%	4%	1%	5%	1%	1%	1%	0%
% Trichoptera	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	75%	60%	56%	81%	89%	55%	76%	59%	80%	89%	96%	79%
% other	7%	20%	5%	1%	3%	26%	1%	15%	11%	8%	2%	20%
% EPT	18%	20%	39%	17%	8%	19%	22%	26%	9%	3%	3%	1%
% Chironomidae	66%	39%	51%	36%	22%	43%	59%	43%	68%	18%	14%	29%
% Dominant Aquatic Taxon	63%	39%	46%	46%	67%	31%	38%	27%	58%	71%	82%	50%
Volume of water (m^3)	190	513	617	359	866	1182	303	617	502	491	659	1236
average water/net	38	103	123	72	173	236	61	123	100	98	132	247
StDev of water volume	23	54	40	23	19	114	14	35	33	56	46	101
Estimated total inverts/m^3 water	1.8	5.7	3.9	2.2	7.2	1.0	15.3	5.2	23.1	17.7	13.6	2.4
Estimated aquatic inverts/m^3 wat	1.3	5.2	3.8	1.9	6.9	0.7	11.4	4.5	16.9	15.2	12.3	1.9
average inv/m^3	2.5	6.0	4.1	2.3	7.3	1.0	15.4	5.6	26.1	17.9	14.1	2.3
average aq inverts/m^3 water	1.7	5.4	4.0	2.0	7.0	0.8	11.4	4.9	18.8	15.6	13	1.8
StDev of aq. Inv. Density	1.0	1.3	1.0	0.8	1.5	0.1	3.4	2.0	7.6	1.8	2.7	0.6
Total aquatic invertebrates	253	2657	2335	684	5940	857	3465	2759	8455	7466	8136	2347
Total. terrestrial invertebrates	90	291	54	114	291	279	1181	428	3112	1224	791	574
Total invertebrates	343	2948	2389	798	6232	1136	4646	3187	11567	8689	8927	2920
% Sample aquatic	74%	90%	98%	86%	95%	75%	75%	87%	73%	86%	91%	80%
% Sample terrestrial	26%	10%	2%	14%	5%	25%	25%	13%	27%	14%	9%	20%
Average # aquatic inverts / net	51	531	467	137	1188	171	693	552	1691	1493	1627	469
stdev aq inv/net	27	309	64	56	167	63	292	111	209	842	421	308
Average # terr. inverts / net	18	58	11	23	58	56	236	86	622	245	158	115
Average # inverts / net	69	590	478	160	1246	227	929	637	2313	1738	1785	584
stdev inv/net	29	328	66	53	167	84	352	130	276	1012	487	386
Total Larval Arctic Grayling/site	0	2	0	14	1	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	1	0	0	1	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	7	0	0	0	0	0	0

Appendix 3 (continued)

Bons Creek below Blast Road, upstream of Bons Pond							
Year Sampled	2004	2005	2006	2007	2008	2009	2010
Total aquatic taxa	17	23	16	14	19	14	11
Tot. Ephemeroptera	3	15	7	6	6	9	3
Tot. Plecoptera	1	1	1	1	3	1	0
Tot. Trichoptera	0	0	0	0	0	0	0
Total Aq. Diptera	39	82	23	367	347	251	46
Misc.Aq.sp	7	66	10	56	114	17	8
% Ephemeroptera	6%	9%	17%	1%	1%	6%	5%
% Plecoptera	2%	1%	2%	0%	1%	3%	0%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	77%	50%	56%	86%	74%	0%	81%
% other	14%	40%	25%	13%	24%	90%	14%
% EPT	8%	10%	19%	2%	2%	4%	5%
% Chironomidae	68%	27%	43%	72%	20%	81%	75%
% Dominant Aquatic Taxon	60%	38%	38%	50%	53.0%	76%	61%
Volume of water (m^3)	349	104	68	86	79	87	16
average water/net	70	21	14	17	16	17	3
StDev of water volume	10	11	3	3	8	12	1
Estimated total inverts/m^3 water	1.3	23.0	4.6	31.5	55.4	25.7	21.8
Estimated aquatic inverts/m^3 wat	0.7	7.9	3.1	24.8	29.9	16.1	17.9
average inv/m^3	1.3	23.0	4.6	31.5	57.6	31.8	20.2
average aq inverts/m^3 water	0.7	9.6	3.2	25.0	30.4	19	16.1
StDev of aq. Inv. Density	0.5	4.9	1.3	8.4	4.6	8.5	9.5
Total aquatic invertebrates	251	823	208	2147	2354	1392	283
Total. terrestrial invertebrates	209	1564	105	574	2012	834	63
Total invertebrates	460	2387	313	2721	4365	2226	346
% Sample aquatic	55%	34%	66%	79%	54%	63%	82%
% Sample terrestrial	45%	66%	34%	21%	46%	37%	18%
Average # aquatic inverts / net	50	165	42	429	471	278	57
stdev aq inv/net	40	58	14	154	218	135	43
Average # terr. inverts / net	42	313	21	115	402	167	13
Average # inverts / net	92	477	63	544	873	445	69
stdev inv/net	79	336	17	207	428	169	48
Total Larval Arctic Grayling/site	0	10	0	78	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0

Appendix 3 (continued)

Buddy Creek (Station 221), upstream of haul road							
Year Sampled	2004	2005	2006	2007	2008	2009	2010
Total aquatic taxa	20	20	19	23	22	17	17
Tot. Ephemeroptera	2042	232	515	385	110	18	25
Tot. Plecoptera	20	18	28	130	86	30	3
Tot. Trichoptera	0	1	0	1	0	1	2
Total Aq. Diptera	195	423	476	965	1632	489	654
Misc.Aq.sp	25	47	84	98	204	73	69
% Ephemeroptera	89%	32%	47%	24%	5%	3%	3%
% Plecoptera	1%	3%	3%	8%	4%	5%	0%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	9%	59%	43%	61%	80%	80%	87%
% other	1%	32%	8%	6%	10%	12%	9%
% EPT	90%	35%	49%	33%	10%	8%	4%
% Chironomidae	5%	38%	25%	43%	39%	39%	81%
% Dominant Aquatic Taxon	89%	28%	44%	24%	41%	41%	62%
Volume of water (m^3)	771	235	600	242	489	318	183
average water/net	154	47	120	48	98	64	37
StDev of water volume	146	18	65	30	18	34	16
Estimated total inverts/m^3 water	16.2	22.0	11.5	39.7	24.6	19	31
Estimated aquatic inverts/m^3 water	14.8	15.3	9.2	32.7	20.8	9.6	20.6
average inv/m^3	20.1	22.0	11.5	47.0	25.0	22.3	35.4
average aq inverts/m^3 water	18.1	17.2	9.3	38.9	21.0	11.1	25.1
StDev of aq. Inv. Density	10.1	7.5	2.1	16.1	4.2	4.7	16.8
Total aquatic invertebrates	11414	3607	5515	7892	10161	3050	3767
Total. terrestrial invertebrates	1074	1572	1404	1698	1900	2971	1897
Total invertebrates	12488	5179	6918	9590	12061	6021	5664
% Sample aquatic	91%	70%	80%	82%	84%	51%	67%
% Sample terrestrial	9%	30%	20%	18%	16%	49%	33%
Average # aquatic inverts / net	2283	721	1103	1578	2032	610	753
stdev aq inv/net	1459	176	575	555	391	144	410
Average # terr. inverts / net	215	314	281	340	380	594	379
Average # inverts / net	2498	1036	1384	1918	2412	1204	1133
stdev inv/net	1540	323	752	683	394	380	852
Total Larval Arctic Grayling/site	0	0	0	1	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0

Appendix 3 (continued)

Bons Creek (Station 220), just upstream of confluence with Buddy Creek									
Year Sampled	2004	2005	2006a	2006b	2007a	2007b	2008a	2008b	2009
Total aquatic taxa	20	18	17	19	16	17	19	20	19
Tot. Ephemeroptera	7	51	17	17	95	95	63	63	130
Tot. Plecoptera	3	5	8	8	8	8	29	29	7
Tot. Trichoptera	1	1	0	0	4	4	4	4	0
Total Aq. Diptera	48	63	122	122	1391	1391	2112	2112	1044
Misc.Aq.sp	3	8	241	5255	34	1590	134	1322	95
% Ephemeroptera	11%	40%	4%	0%	6%	3%	3%	2%	10%
% Plecoptera	5%	4%	2%	0%	1%	0%	1%	1%	1%
% Trichoptera	2%	1%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	77%	50%	31%	2%	91%	45%	90%	60%	82%
% other	5%	40%	62%	97%	2%	51%	6%	37%	7%
% EPT	18%	44%	7%	0%	7%	3%	4%	3%	11%
% Chironomidae	46%	43%	30%	2%	35%	17%	72%	48%	50%
% Dominant Aquatic Taxon	45%	43%	53%	89%	56%	50%	67%	48%	45%
Volume of water (m^3)	698	76	612	612	150	150	317	317	216
average water/net	140	15	122	122	30	30	63	63	43
StDev of water volume	59	7	44	44	21	21	20	20	12
Estimated total inverts/m^3 water	0.8	11.2	5.0	46.0	63.7	115.6	41.7	60.5	36.2
Estimated aquatic inverts/m^3 water	0.4	8.4	3.2	44.2	51.1	103.0	37.0	55.8	29.6
average inv/m^3	0.9	11.2	5.0	46.0	130.0	222.4	42.3	61.4	35.2
average aq inverts/m^3 water	0.4	8.1	3.3	46.4	107.4	199.8	37.8	56.8	28.6
StDev of aq. Inv. Density	0.2	2.2	0.8	21.5	136.8	232.8	11.0	11.0	12.4
Total aquatic invertebrates	312	636	1943	27013	7654	15436	11706	17648	6375
Total. terrestrial invertebrates	273	217	1143	1143	1892	1892	1494	1494	1427
Total invertebrates	585	853	3086	28156	9546	17328	13200	19142	7802
% Sample aquatic	53%	75%	63%	96%	80%	89%	89%	92%	82%
% Sample terrestrial	47%	25%	37%	4%	20%	11%	11%	8%	18%
Average # aquatic inverts / net	62	127	389	5403	1531	3087	2341	3530	1275
stdev aq inv/net	56	66	108	2101	854	2008	766	993	833
Average # terr. inverts / net	55	43	229	229	378	378	299	299	285
Average # inverts / net	117	171	617	5631	1909	3466	2640	3828	1560
stdev inv/net	59	88	239	2183	1108	2288	872	1098	992
Total Larval Arctic Grayling/site	0	0	0	0	1	1	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0
2006a is without Daphniids and 2006b is with Daphniids									
2007a is without Ostracods and 2007b is with Ostracods									
2008a is without Ostracods and 2008b is with Ostracods									

Appendix 3 (continued)

Buddy Creek (Station 221), upstream of haul road						
Year Sampled	2004	2005	2006	2007	2008	2009
Total aquatic taxa	20	20	19	23	22	17
Tot. Ephemeroptera	2042	232	515	385	110	18
Tot. Plecoptera	20	18	28	130	86	30
Tot. Trichoptera	0	1	0	1	0	1
Total Aq. Diptera	195	423	476	965	1632	489
Misc.Aq.sp	25	47	84	98	204	73
% Ephemeroptera	89%	32%	47%	24%	5%	3%
% Plecoptera	1%	3%	3%	8%	4%	5%
% Trichoptera	0%	0%	0%	0%	0%	0%
% Aq. Diptera	9%	59%	43%	61%	80%	80%
% other	1%	32%	8%	6%	10%	12%
% EPT	90%	35%	49%	33%	10%	8%
% Chironomidae	5%	38%	25%	43%	39%	39%
% Dominant Aquatic Taxon	89%	28%	44%	24%	41%	41%
Volume of water (m^3)	771	235	600	242	489	318
average water/net	154	47	120	48	98	64
StDev of water volume	146	18	65	30	18	34
Estimated total inverts/m^3 water	16.2	22.0	11.5	39.7	24.6	19
Estimated aquatic inverts/m^3 water	14.8	15.3	9.2	32.7	20.8	9.6
average inv/m^3	20.1	22.0	11.5	47.0	25.0	22.3
average aq inverts/m^3 water	18.1	17.2	9.3	38.9	21.0	11.1
StDev of aq. Inv. Density	10.1	7.5	2.1	16.1	4.2	4.7
Total aquatic invertebrates	11414	3607	5515	7892	10161	3050
Total. terrestrial invertebrates	1074	1572	1404	1698	1900	2971
Total invertebrates	12488	5179	6918	9590	12061	6021
% Sample aquatic	91%	70%	80%	82%	84%	51%
% Sample terrestrial	9%	30%	20%	18%	16%	49%
Average # aquatic inverts / net	2283	721	1103	1578	2032	610
stdev aq inv/net	1459	176	575	555	391	144
Average # terr. inverts / net	215	314	281	340	380	594
Average # inverts / net	2498	1036	1384	1918	2412	1204
stdev inv/net	1540	323	752	683	394	380
Total Larval Arctic Grayling/site	0	0	0	1	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0

Appendix 3 (concluded)

Buddy Creek (below falls), downstream of the canyon and haul road								
Year Sampled	2004	2005	2006a	2006b	2007	2008	2009	2010
Total aquatic taxa	18	19	16	18	25	20	13	14
Tot. Ephemeroptera	578	328	253	253	1316	124	776	6
Tot. Plecoptera	9	12	32	32	92	21	18	0
Tot. Trichoptera	1	2	0	0	7	2	0	0
Total Aq. Diptera	363	855	199	199	2284	2011	4424	1478
Misc.Aq.sp	71	19	125	2461	444	206	153	56
% Ephemeroptera	57%	27%	42%	9%	32%	5%	14%	0%
% Plecoptera	1%	1%	5%	1%	2%	1%	0%	0%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	35%	70%	33%	7%	55%	85%	82%	96%
% other	7%	2%	21%	84%	11%	9%	3%	4%
% EPT	58%	28%	47%	10%	34%	6%	15%	0%
% Chironomidae	11%	64%	22%	4%	40%	67%	69%	65%
% Dominant Aquatic Taxon	56%	43%	33%	69%	30%	46%	50%	50%
Volume of water (m^3)	1326	271	612	612	593	633	347	128
average water/net	265	54	122	122	119	127	69	26
StDev of water volume	160	12	29	29	63	57	19	15
Estimated total inverts/m^3 water	4.5	35.9	7.3	26.4	42.4	20.8	81.5	87.5
Estimated aquatic inverts/m^3 water	3.9	22.5	5.0	24.1	34.9	18.7	77.4	60.3
average inv/m^3	4.4	35.9	7.3	26.4	47.5	26.4	83.4	73.3
average aq inverts/m^3 water	3.9	22.6	5.0	24.8	39.4	23.6	79	52.5
StDev of aq. Inv. Density	2.2	3.3	1.6	9.7	16.0	15.3	11.9	20.6
Total aquatic invertebrates	5109	6085	3041	14723	20713	11820	26860	7706
Total. terrestrial invertebrates	876	3645	1400	1400	4439	1320	1431	3479
Total invertebrates	5985	9730	4441	16123	25152	13140	28291	11185
% Sample aquatic	85%	63%	68%	91%	82%	90%	95%	69%
% Sample terrestrial	15%	37%	32%	9%	18%	10%	5%	31%
Average # aquatic inverts / net	1022	1217	608	2945	4143	2364	5372	1541
stdev aq inv/net	744	279	222	1201	1812	352	1247	1322
Average # terr. inverts / net	175	729	280	280	888	264	286	696
Average # inverts / net	1197	1946	888	3225	5030	2628	5658	2237
stdev inv/net	893	494	322	1224	2337	432	1244	2327
Total Larval Arctic Grayling/site	0	0	0	0	1	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	1	0	0	0	0	0	0
2006a is without Daphniids and 2006b is with Daphniids								

Appendix 4. Juvenile Dolly Varden and Arctic Grayling Whole Body Metal Concentrations, 2010

								Method	200.8	200.8		7471A	7740.0	200.8	
								analyte	Cd	Pb		Hg	Se	Zn	
Collector	Sample			Date	Fish	Length	Weight		total	total		total	total	total	%
	Number	Stream	Site	Collected	Spp	(mm)	(g)	MRL	0.05	0.02		0.02	1.0	0.5	Solids
ADF&G	081610MSRDDVJ01	Red Dog	Mainstem	8/16/2010	DV	119	10.25	Juvenile	7.14	21.7		0.03	6.2	330	26
ADF&G	081610MSRDDVJ02	Red Dog	Mainstem	8/16/2010	DV	128	14.5	Juvenile	2.85	7.61		0.03	5.9	175	25.6
ADF&G	081610MSRDDVJ03	Red Dog	Mainstem	8/16/2010	DV	110	14.25	Juvenile	2.40	6.34		0.03	5.0	176	25.2
ADF&G	081610MSRDDVJ04	Red Dog	Mainstem	8/16/2010	DV	127	20.25	Juvenile	2.50	2.72		0.04	6.8	225	24.5
ADF&G	081610MSRDDVJ05	Red Dog	Mainstem	8/16/2010	DV	106	19.75	Juvenile	1.88	0.89		0.03	4.6	121	25.1
ADF&G	081610MSRDDVJ06	Red Dog	Mainstem	8/16/2010	DV	122	19	Juvenile	2.42	3.55		0.03	5.7	186	25.7
ADF&G	081610MSRDDVJ07	Red Dog	Mainstem	8/16/2010	DV	105	16.5	Juvenile	1.76	1.25	<	0.02	5.1	141	24.2
ADF&G	081610MSRDDVJ08	Red Dog	Mainstem	8/16/2010	DV	124	18.25	Juvenile	1.63	4.26		0.02	5.0	197	26
ADF&G	081610MSRDDVJ09	Red Dog	Mainstem	8/16/2010	DV	112	21.25	Juvenile	3.91	12.5		0.06	6.1	218	24.4
ADF&G	081610MSRDDVJ10	Red Dog	Mainstem	8/16/2010	DV	101	15.25	Juvenile	2.08	4.85		0.02	4.8	155	24.7
ADF&G	081610MSRDDVJ11	Red Dog	Mainstem	8/16/2010	DV	141	19.5	Juvenile	2.54	1.26		0.03	5.0	163	24
ADF&G	081610MSRDDVJ12	Red Dog	Mainstem	8/16/2010	DV	114	13.25	Juvenile	3.57	5.37		0.03	5.6	196	24.9
ADF&G	081610MSRDDVJ13	Red Dog	Mainstem	8/16/2010	DV	125	17.25	Juvenile	3.65	12.6		0.04	3.9	173	25
ADF&G	081610MSRDDVJ14	Red Dog	Mainstem	8/16/2010	DV	121	22	Juvenile	2.81	0.90		0.03	4.0	144	25
ADF&G	081610MSRDDVJ15	Red Dog	Mainstem	8/16/2010	DV	119	15.75	Juvenile	3.66	5.40		0.03	4.5	201	25
ADF&G	081610AXDVJ01	Anxiety Ridge	at Haul Road	8/16/2010	DV	133	22.5	Juvenile	0.23	0.98		0.08	4.1	127	25.2
ADF&G	081610AXDVJ02	Anxiety Ridge	at Haul Road	8/16/2010	DV	107	12.25	Juvenile	0.21	0.83		0.05	4.0	108	25.3
ADF&G	081610AXDVJ03	Anxiety Ridge	at Haul Road	8/16/2010	DV	116	15.5	Juvenile	0.12	1.64		0.08	4.6	104	24.6
ADF&G	081610AXDVJ04	Anxiety Ridge	at Haul Road	8/16/2010	DV	122	17	Juvenile	0.17	0.42		0.08	4.3	97.9	24.7
ADF&G	081610AXDVJ05	Anxiety Ridge	at Haul Road	8/16/2010	DV	121	18	Juvenile	0.22	0.34		0.07	3.1	89.8	25.9
ADF&G	081610AXDVJ06	Anxiety Ridge	at Haul Road	8/16/2010	DV	120	17.25	Juvenile	0.05	0.12		0.05	3.4	83.3	26
ADF&G	081610AXDVJ07	Anxiety Ridge	at Haul Road	8/16/2010	DV	123	19	Juvenile	0.10	0.18		0.06	3.4	115	26
ADF&G	081610AXDVJ08	Anxiety Ridge	at Haul Road	8/16/2010	DV	122	15.75	Juvenile	0.12	0.54		0.07	3.2	114	24.8
ADF&G	081610AXDVJ09	Anxiety Ridge	at Haul Road	8/16/2010	DV	97	8.25	Juvenile	0.17	0.19		0.04	3.6	97.3	25.3
ADF&G	081610AXDVJ10	Anxiety Ridge	at Haul Road	8/16/2010	DV	141	24.25	Juvenile	0.13	0.56		0.07	4.0	88.8	25.3
ADF&G	081610BUDVJ01	Buddy	D/S Road	8/16/2010	DV	105	10.25	Juvenile	0.83	0.56		0.02	5.3	119	25.1
ADF&G	081610BUDVJ02	Buddy	D/S Road	8/16/2010	DV	115	14.5	Juvenile	0.38	0.13	<	0.02	4.5	116	26.2
ADF&G	081610BUDVJ03	Buddy	D/S Road	8/16/2010	DV	116	14.25	Juvenile	0.39	0.25		0.03	5.7	130	26.4
ADF&G	081610BUDVJ04	Buddy	D/S Road	8/16/2010	DV	128	20.25	Juvenile	0.54	0.10	<	0.02	3.9	97.0	27
ADF&G	081610BUDVJ05	Buddy	D/S Road	8/16/2010	DV	125	19.75	Juvenile	0.48	0.17	<	0.02	5.0	108	27
ADF&G	081610BUDVJ06	Buddy	D/S Road	8/16/2010	DV	128	19	Juvenile	0.35	0.41		0.02	5.2	120	26.6
ADF&G	081610BUDVJ07	Buddy	D/S Road	8/16/2010	DV	121	16.5	Juvenile	0.60	0.60	<	0.02	3.7	141	24.2
ADF&G	081610BUDVJ08	Buddy	D/S Road	8/16/2010	DV	125	18.25	Juvenile	0.27	0.44	<	0.02	4.3	107	25.4
ADF&G	081610BUDVJ09	Buddy	D/S Road	8/16/2010	DV	133	21.25	Juvenile	1.02	0.33		0.03	6.3	131	24.2
ADF&G	081610BUDVJ10	Buddy	D/S Road	8/16/2010	DV	127	15.25	Juvenile	0.49	0.20		0.04	4.1	107	25.7
ADF&G	081610BUDVJ11	Buddy	D/S Road	8/16/2010	DV	128	19.5	Juvenile	0.18	0.09	<	0.02	6.6	113	26
ADF&G	081610BUDVJ12	Buddy	D/S Road	8/16/2010	DV	113	13.25	Juvenile	0.66	0.13	<	0.02	5.2	124	26.7
ADF&G	081610BUDVJ13	Buddy	D/S Road	8/16/2010	DV	122	17.25	Juvenile	0.22	0.57		0.04	5.2	113	24.3
ADF&G	081610BUDVJ14	Buddy	D/S Road	8/16/2010	DV	130	22	Juvenile	0.95	0.21		0.02	3.7	114	27.6
ADF&G	081610BUDVJ15	Buddy	D/S Road	8/16/2010	DV	117	15.75	Juvenile	1.14	0.29		0.02	4.7	133	26.8
ADF&G	060710BPAGJ01	Bons Pond	Bons Creek	6/7/2010	GR	158	40	Juvenile	0.19	0.43		0.05	9.8	96.1	24.3
ADF&G	060710BPAGJ02	Bons Pond	Bons Creek	6/7/2010	GR	177	55	Juvenile	0.21	0.33		0.05	9.5	89.9	24
ADF&G	060710BPAGJ03	Bons Pond	Bons Creek	6/7/2010	GR	154	38.5	Juvenile	0.13	0.30		0.07	8.1	99.2	23.8
ADF&G	060710BPAGJ04	Bons Pond	Bons Creek	6/7/2010	GR	180	69.5	Juvenile	0.27	0.40		0.05	13.3	82.9	24.4
ADF&G	060710BPAGJ05	Bons Pond	Bons Creek	6/7/2010	GR	167	50	Juvenile	0.31	0.64		0.05	9.7	87.5	24.2
ADF&G	060810BPAGJ06	Bons Pond	Bons Creek	6/8/2010	GR	163	44	Juvenile	0.11	0.15		0.03	10.3	90.2	23.9
ADF&G	060810BPAGJ07	Bons Pond	Bons Creek	6/8/2010	GR	179	56	Juvenile	0.28	0.25		0.04	12.0	110	22.9
ADF&G	060810BPAGJ08	Bons Pond	Bons Creek	6/8/2010	GR	165	47.5	Juvenile	0.16	0.41		0.03	9.2	79.5	24.5
ADF&G	060910BPAGJ09	Bons Pond	Bons Creek	6/9/2010	GR	168	50	Juvenile	0.42	0.79		0.06	10.9	103	23.8
ADF&G	060910BPAGJ10	Bons Pond	Bons Creek	6/9/2010	GR	172	57	Juvenile	0.22	0.28		0.06	13.0	95.1	23.5
ADF&G	060910BPAGJ11	Bons Pond	Bons Creek	6/9/2010	GR	169	47.5	Juvenile	0.29	0.45		0.02	10.2	116	24.4
ADF&G	060910BPAGJ12	Bons Pond	Bons Creek	6/9/2010	GR	159	43.5	Juvenile	0.18	0.47		0.05	10.4	98.0	24.9
ADF&G	060910BPAGJ13	Bons Pond	Bons Creek	6/9/2010	GR	184	57.5	Juvenile	0.45	1.21		0.07	8.4	109	24.1
ADF&G	060910BPAGJ14	Bons Pond	Bons Creek	6/9/2010	GR	178	57.5	Juvenile	0.23	0.27		0.04	9.8	91.2	24.1
ADF&G	060910BPAGJ15	Bons Pond	Bons Creek	6/9/2010	GR	184	64.5	Juvenile	0.37	0.58		0.04	10.0	101	23.5

Appendix 5. Dolly Varden metals data, 2010

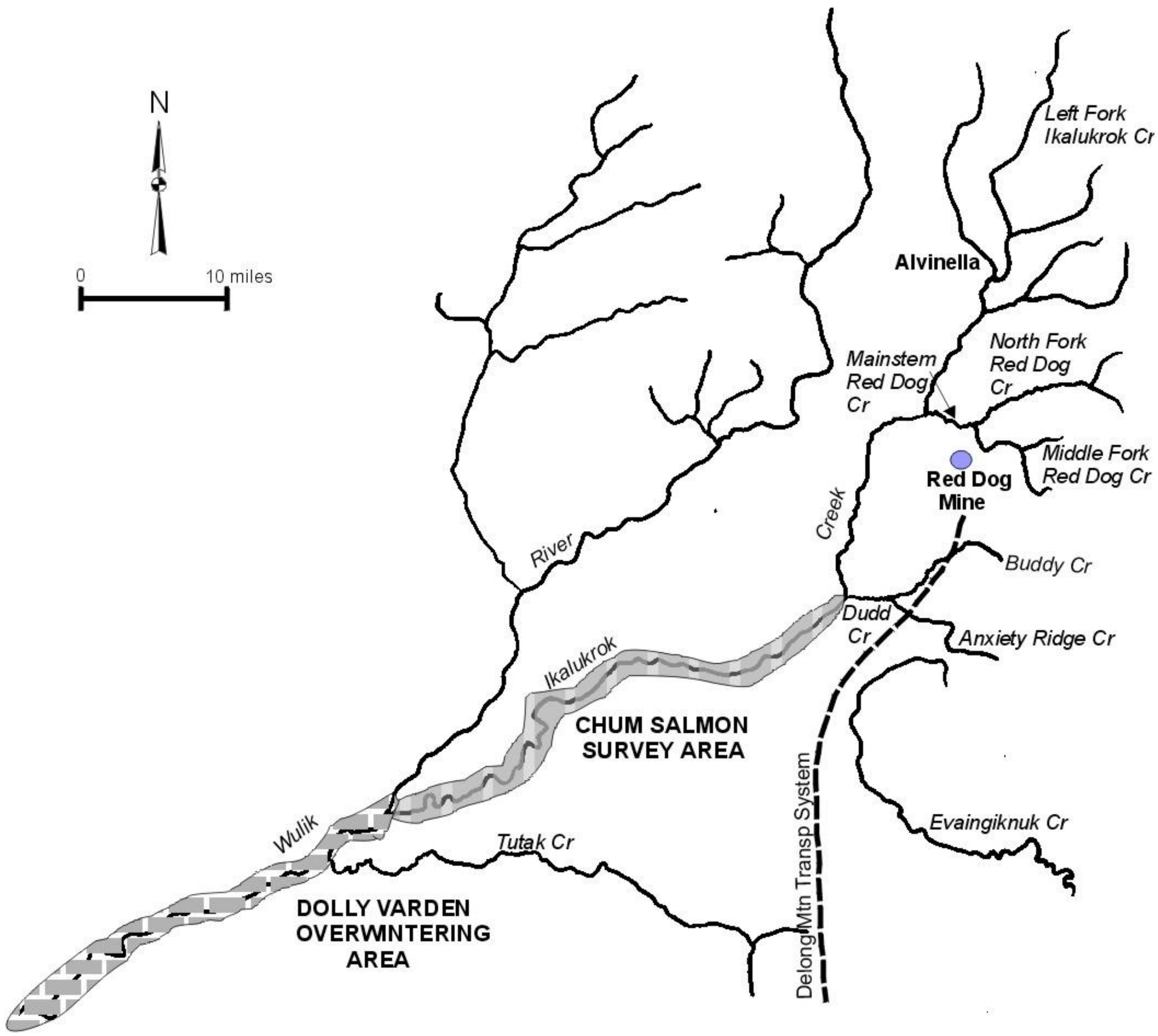
																						CAS
	Sample	Sex	Weight	Length	age	age	total		Al		Cd		Cu		Pb		Se		Zn		Hg	%
Tissue	Identification		grams	mm	fresh	salt	age		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	Solids
Kidney	060410WUDVA1	F	3217	632	3	5	8		3.7		3.54		7.3		0.07		9.2		87.1		0.15	20.2
Kidney	060410WUDVA2	F	2434	604	3	4	7	<	2		3.37		4.2	<	0.02		5.6		85.1		0.11	23.1
Kidney	060410WUDVA3	M	1181	475	3	2	5	<	2		1.20		3.1		0.03		6.1		68.9		0.10	22.7
Kidney	060410WUDVA4	M	2766	592			7	<	2		1.65		3.6	<	0.02		6.3		100		0.21	18.6
Kidney	060410WUDVA5	M	3461	630	2	6	8		6.4		2.30		3.5		0.15		6.0		83.6		0.10	23.8
Kidney	060410WUDVA6	M	3133	640			9	<	2		3.21		4.6	<	0.02		5.0		112		0.09	20.4
Kidney			Duplicate of Fish #2					<	2		2.15		3.5		0.11		5.3		94.9		0.14	24.7
Kidney	092410WUDVA1	F	1390	517	3	2	5	<	2		1.97		4.4		0.02		6.5		91.7		0.06	23.9
Kidney	092410WUDVA2	F	1174	488			5	<	2		2.71		3.4	<	0.02		5.7		94.7		0.06	22.7
Kidney	092410WUDVA3	M	1642	522	3	4	7	<	2		4.44		4.3	<	0.02		6.5		106		0.08	23.4
Kidney	092410WUDVA4	M	1392	526	3	4	7	<	2		1.48		3.4		0.07		5.3		116	<	0.02	23.3
Kidney	092410WUDVA5	F	1126	464	3	3	6	<	2		0.71		2.7	<	0.02		5.4		70.7	<	0.05	28.7
Kidney	092410WUDVA6	F	1707	535	3	5	8	<	2		0.85		3.3		0.14		5.1		96.9		0.10	27.5
Kidney			Duplicate of Fish #6					<	2		1.82		4.2	<	0.02		6.1		81.9		0.08	24
Liver	060410WUDVA1	F	3217	632	3	5	8	<	2		0.67		49.3		0.04		3.4		93.6		0.03	36.6
Liver	060410WUDVA2	F	2434	604	3	4	7	<	2		1.11		16.4	<	0.02		2.5		93.2		0.03	31.7
Liver	060410WUDVA3	M	1181	475	3	2	5	<	2		0.65		43.6	<	0.02		3.3		95.6		0.04	28.8
Liver	060410WUDVA4	M	2766	592			7	<	2		0.52		70.6	<	0.02		2.7		98.5		0.04	41
Liver	060410WUDVA5	M	3461	630	2	6	8	<	2		0.57		64.2	<	0.02		3.2		91.6		0.04	31.8
Liver	060410WUDVA6	M	3133	640			9	<	2		0.47		42.6	<	0.02		2.1		78.8		0.03	42.4
Liver			Duplicate of Fish #2					<	2		1.04		15.7	<	0.02		2.4		89.8		0.03	31.4
Liver	092410WUDVA1	F	1390	517	3	2	5	<	2		0.66		49.0	<	0.02		3.3		80.6		0.02	40.8
Liver	092410WUDVA2	F	1174	488			5	<	2		0.55		43.3	<	0.02		2.7		93.6		0.02	45
Liver	092410WUDVA3	M	1642	522	3	4	7	<	2		0.79		52.3	<	0.02		2.3		59.3	<	0.02	50.8
Liver	092410WUDVA4	M	1392	526	3	4	7	<	2		0.87		39.1		0.03		2.6		79.9		0.02	38
Liver	092410WUDVA5	F	1126	464	3	3	6	<	2		0.31		34.0	<	0.02		3.3		62.6	<	0.02	44.7
Liver	092410WUDVA6	F	1707	535	3	5	8	<	2		0.52		48.3		0.06		2.3		73.9	<	0.02	48
Liver			Duplicate of Fish #6					<	2		0.52		39.7	<	0.02		1.8		62.4		0.02	47.4
Muscle	060410WUDVA1	F	3217	632	3	5	8	<	2	<	0.02		1.3	<	0.02	<	1.0		14.2		0.02	27.2
Muscle	060410WUDVA2	F	2434	604	3	4	7	<	2	<	0.02		1.2	<	0.02	<	1.0		14.7		0.02	27.5
Muscle	060410WUDVA3	M	1181	475	3	2	5	<	2	<	0.02		1.9	<	0.02	<	1.0		22.2	<	0.02	27.1
Muscle	060410WUDVA4	M	2766	592			7	<	2	<	0.02		1.4	<	0.02		1.0		15.5	<	0.02	34.1
Muscle	060410WUDVA5	M	3461	630	2	6	8	<	2	<	0.02		1.4	<	0.02		1.2		15.0	<	0.02	28.5
Muscle	060410WUDVA6	M	3133	640			9	<	2	<	0.02		1.3	<	0.02	<	1.0		17.4	<	0.02	31.4
Muscle			Duplicate of Fish #2					<	2	<	0.02		1.4		0.11	<	1.0		16.9		0.04	28.3
Muscle	092410WUDVA1	F	1390	517	3	2	5	<	2	<	0.02		1.3	<	0.02		1.0		16.6	<	0.02	30.7
Muscle	092410WUDVA2	F	1174	488			5	<	2	<	0.02		1.4	<	0.02		1.2		16.6	<	0.02	27.2
Muscle	092410WUDVA3	M	1642	522	3	4	7	<	2	<	0.02		1.1	<	0.02	<	1.0		13.9		0.11	28.9
Muscle	092410WUDVA4	M	1392	526	3	4	7	<	2	<	0.02		1.3	<	0.02		1.0		16.8		0.02	28.2
Muscle	092410WUDVA5	F	1126	464	3	3	6	<	2	<	0.02		1.2	<	0.02	<	1.0		18.9	<	0.02	28.8
Muscle	092410WUDVA6	F	1707	535	3	5	8	<	2	<	0.02		1.5	<	0.02	<	1.0		13.7	<	0.02	32.7
Muscle			Duplicate of Fish #6					<	2	<	0.02		1.4	<	0.02	<	1.0		15.0	<	0.02	31.6
Reproductive	060410WUDVA1	F	3217	632	3	5	8	<	2		0.03		16.9	<	0.02		4.4		307	<	0.02	31.7
Reproductive	060410WUDVA2	F	2434	604	3	4	7	<	2	<	0.02		17.8	<	0.02		3.9		206	<	0.02	32.9
Reproductive	060410WUDVA4	M	2766	592			7	<	2		0.04		3.0	<	0.02		1.4		143	<	0.02	21.4
Reproductive	060410WUDVA6	M	3133	640			9	<	2		0.12		3.6	<	0.02		1.9		210	<	0.02	18.8
Reproductive			Duplicate of Fish #6					<	2	<	0.02		17.0	<	0.02		3.9		195	<	0.02	33.4
Reproductive	092410WUDVA1	F	1390	517	3	2	5		3.1		0.05		35.9		0.09		6.9		227	<	0.02	21.8
Reproductive	092410WUDVA5	F	1126	464	3	3	6	<	2		0.03		23.6	<	0.02		8.1		413	<	0.05	19.3
Reproductive	092410WUDVA6	F	1707	535	3	5	8	<	2		0.03		38.3	<	0.02		7.7		253	<	0.02	23
Reproductive			Duplicate of Fish #6					<	2		0.03		39.3		0.07		7.4		255	<	0.02	24.9

Appendix 6. Dolly Varden Aerial Surveys

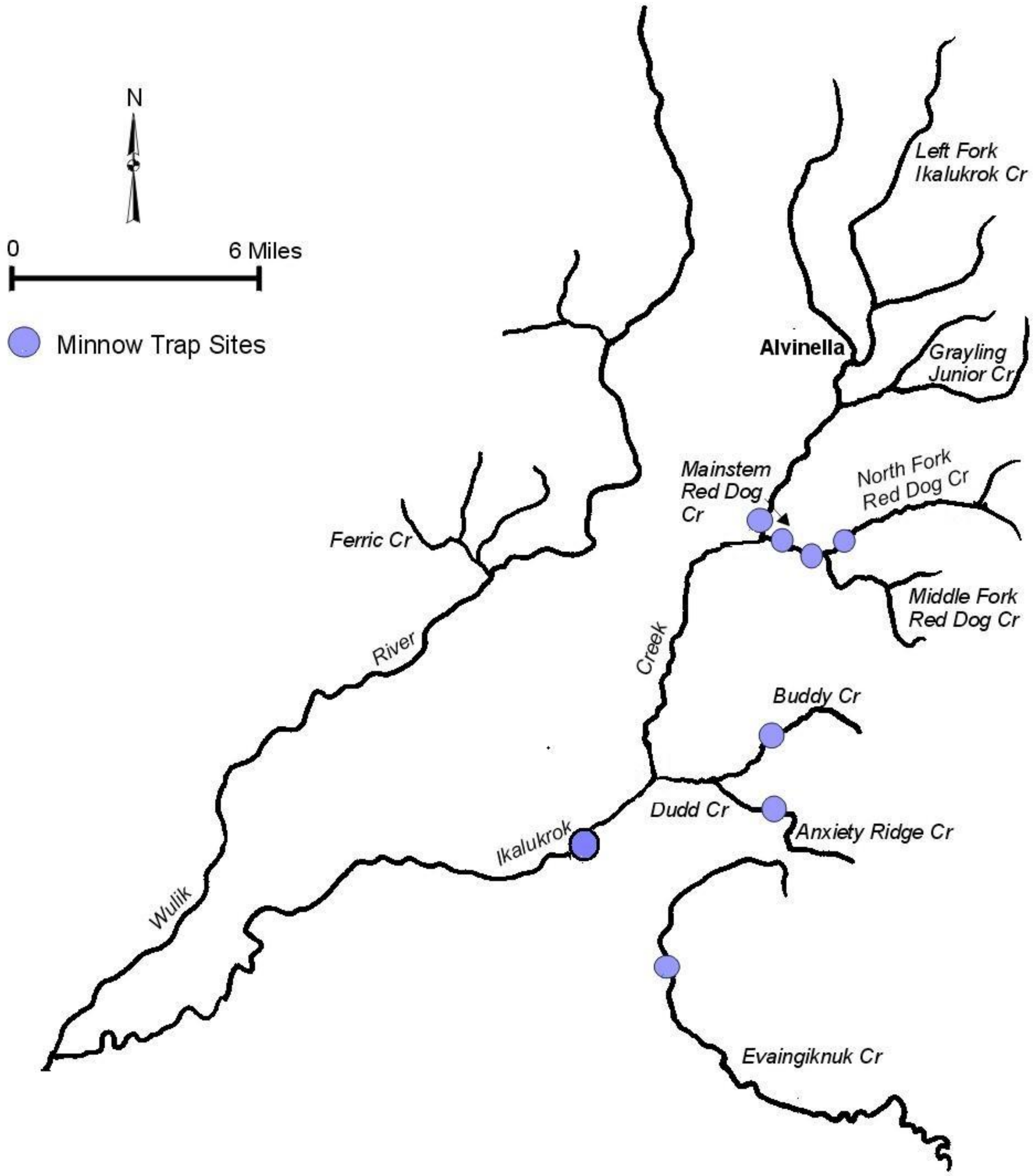
Estimated number of overwintering Dolly Varden in the Wulik River before freezeup. Surveys conducted by ADF&G (DeCicco 1989, 1991-1999, 2001-2002, and 2004-2010.

Year	Wulik River upstream of Ikalukrok Creek	Wulik River downstream of Ikalukrok Creek	Total Fish	Percent of Fish downstream of Ikalukrok Creek
Before Mining				
1979	3,305	51,725	55,030	94
1980	12,486	101,067	113,553	89
1981	4,125	97,136	101,261	96
1982	2,300	63,197	65,497	97
1984	370	30,483	30,853	99
1987	893	60,397	61,290	99
1988	1,500	78,644	80,144	98
During Mining				
1989	2,110	54,274	56,384	96
1991	7,930	119,055	126,985	94
1992	750	134,385	135,135	99
1993	7,650	136,488	144,138	95
1994	415	66,337	66,752	99
1995	240	128,465	128,705	99
1996	1,010	59,995	61,005	98
1997	2,295	93,117	95,412	98
1998	6,350	97,693	104,043	94
1999	2,750	67,954	70,704	96
2001	2,020	90,594	92,614	98
2002	1,675	42,582	44,257	96
2004	16,486	84,320	100,806	84
2005	10,645	110,203	120,848	91
2006	4,758	103,594	108,352	96
2007	5,503	93,808	99,311	94
2008	271	71,222	71,493	99
2009	122	60,876	60,998	99
2010	70	36,248	36,318	99
The population estimate (mark/recapture) for winter 1988/1989 for fish >400 mm				
was 76,892 (DeCicco 1990b)				
The population estimate (mark/recapture) for winter 1994/1995 for fish >400 mm				
was 361,599 (DeCicco 1996c)				
Fall 2000 aerial survey was not made due to weather.				
Fall 2003 aerial survey was not made due to weather.				

Appendix 7. Dolly Varden and Chum Salmon Survey Areas



Appendix 8. Juvenile Dolly Varden Sampling Sites



Appendix 9. Juvenile Dolly Varden Catches

Number of Dolly Varden Caught in Late-July/Early August with ten minnow traps per sample site														
Sample Site Description	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Evaingiknuk (Noatak Tributary)	54	27	38	2	7	20	64	71	29	4	67	21	16	48
Anxiety Ridge	68	94	271	27	6	33	98	116	121	8	115	75	147	18
Buddy	48	154	306	11	34	57	104	59	59	5	183	43	100	115
North Fork Red Dog Creek (Sta 12)	0	12	17	1	1	1	0	1	8	0	1	0	3	6
Mainstem (below North Fork) (Sta 151)	14	70	86	13	9	12	2	2	6	8	2	13	7	13
Mainstem (Station 10)	10	21	66	1	3	12	12	0	10	3	6	5	6	14
Ikalukrok Creek (below Dudd)(Sta 7/160)	13	51	55	31	6	17	17	27	36	2	25	7	30	10
Ikalukrok Creek (above Mainstem)(Sta 9)	3	44	41	5	2	18	3	12	0	5	7	3	11	37
Total Catch Dolly Varden	210	473	880	91	68	170	300	288	269	35	406	167	320	261

Appendix 10. Arctic Grayling, Mainstem Red Dog Creek

Observations and catches of Arctic grayling in Mainstem Red Dog Creek below the confluence of North Fork Red Dog and Middle Fork Red Dog creeks since 1994.

7/27/94 – visual, two adults just below North Fork

6/29/95 – angling, one adult just below North Fork
7/17/95 – angling, two adults near rock bluff 0.8 km below North Fork
7/20/95 – visual, one adult near rock bluff 0.8 km below North Fork
8/11/95 – visual, fry (about 30) below North Fork
8/14/95 – angling, 11 adults marked and released, rock bluff 0.8 km below North Fork

6/19/96 – visual, one adult near Station 10
7/15/96 – angling, seven adults marked and released near Station 10
8/11/96 – visual, fry in shallow eddies at mouth of Mainstem
8/12/96 – visual, fry near rock bluff 0.8 km below North Fork

6/25/97 – visual, two adults at rock bluff 0.8 km below North Fork
6/25/97 – drift net, fry caught at Station 10, 13-15 mm long
6/26/97 – angling, 15 adults marked and released near Station 10
6/27/97 – visual, fry numerous at Station 10
8/10/97 – visual, fry in backwaters
9/29/97 – minnow traps, seven fry caught near Station 10

6/10/98 – visual, no fish seen between North Fork mouth and rock bluff 0.8 km downstream
6/28/98 – visual, one adult feeding at rock bluff (0.8 km below North Fork)

5/29/99 – angling, three adults caught just below North Fork mouth
5/30/99 – fyke net, 32 adults caught about 100 m below North Fork mouth
7/8-9/99 – angling, two adults captured, marked, and released near Station 10
7/8-9/99 – visual, 12 adults and some fry near Station 10
7/8-9/99 – visual, two adults at rock bluff (0.8 km below North Fork)
8/9-10/99 – visual, numerous fry in backwaters and along stream margins

Appendix 10 (continued)

6/11-12/00 – fyke net, adults captured, marked, and released 7/28/00 – visual, several fry in backwaters and along stream margins, not numerous
7/5/00 – visual, two adults feeding at rock bluff (0.8 km below North Fork), juvenile observed
7/6/00 – visual, walked most of creek, tagged three adults near Station 10, most pools held one to three adults

6/15-18/01 – visual, walked creek to check for spawners in proposed mixing zone, none observed, one adult seen feeding at rock bluff (about 0.8 km below North Fork)
6/17/01 – angling, 11 adults marked and released near Station 10, all females spent
7/29-31/01 – visual, very few fry seen (about 20 mm), late breakup, cold temperatures resulted in late spawning

5/31/02 – fyke net, seven adults marked and released near Station 10
6/1/02 – fyke net, 31 adults marked and released near Station 10
6/2/02 – fyke net, eight adults marked and released near Station 10
6/3/02 – fyke net, three adults marked and released near Station 10
6/4/02 – fyke net, three adults and three juveniles marked and released near Station 10
6/7/02 – angling, 10 adults and three juveniles marked and released near Station 10, most of the females were spent
7/27/02 – visual, few fry (<10) seen
7/28/02 – visual, adults present near Station 10, three to four per pool

6/11/03 – aerial, 48 adults, two spawning pairs seen
6/12/03 – visual, ten adults, three active spawning pairs observed near Station 10
6/14/03 – angling, eight adults, one spent male near Station 10
7/7/03 – visual, fry in backwaters near Station 10, one group of 30
7/8/03 – visual, ten adults near Station 10
9/7/03 – visual, two adults and five fry near Station 151

5/25/04 – visual, two adult males near Station 10
5/26/04 – fyke net, four adults near Station 10
7/7/04 – visual, fry common near Station 151
7/7/04 – angling, two adults (333, 325 mm) near Station 151
7/8/04 – visual, fry in all backwaters near Station 10
7/8/04 – angling, three adults (373, 297, 356 mm) near Station 10

Appendix 10 (continued)

6/5/05 – aerial, observed 30 adult Arctic grayling, only two sets paired
6/25 and 26/05 – Houghton reported catching about 60 fish in Mainstem between mouth and North Fork Red Dog Creek
7/4/05 – visual, 8 adults and fry (about 70) observed near Station 10
7/28/05 – visual, small numbers of fry in backwaters near Station 10

6/13/06 – visual, five adult Arctic grayling seen in Mainstem near Station 10
6/16/06 – angling, caught 8 Arctic grayling (260 – 355 mm long) in Mainstem just below mouth of North Fork

6/1/07 – visual, several adult male and female Arctic grayling seen near Station 151
6/2/07 – visual, numerous Arctic grayling spawning at 3rd bend downstream of Station 151 in area of cobbles to gravelly sand
6/3/07 – visual, groups of 4 to 5 adults moving downstream in Station 10 area, caught several spent females, fish obviously moving out of Mainstem
7/1/07 – visual, observed large number of fry in side channels and backwaters near Station 10 and three adult Arctic grayling feeding on drift
7/3/07 – visual, observed one adult Arctic grayling at Station 151 and several fry along stream margins
8/9/07 – visual, observed two adult Arctic grayling at Station 151 and saw 35 fry along stream margins, one group of about 25
8/10/07 – visual, observed quite of few Arctic grayling fry in vicinity of Station 10 and caught fry in minnow traps (n = 10, 59 to 68 mm, average 64.1, SD = 2.8)

6/608 – visual, observed one Arctic grayling near Station 151
6/9/08 – visual and angling, walked Station 151 downstream for about 1.6 km and caught one Arctic grayling (363 mm)
6/10/08 – visual and angling, caught 5 Arctic grayling (325 – 425 mm long) just upstream of Station 10, four males and one partially spent female – saw about six fish that we did not catch
7/3/08 – visual, saw one adult Arctic grayling near Station 10
7/4/08 – visual, fry common along stream margins near Station 10, very small (about 15 mm long)
7/4/08 – minnow traps, caught one 67 mm Arctic grayling near Station 151
8/3/08 – minnow traps, caught one 82 mm Arctic grayling near Station 151

Appendix 10 (concluded)

6/13/09 – caught one 408 mm Arctic grayling in Mainstem Red Dog Creek at first rock bluff below North Fork Red Dog Creek
7/2/09 – observed one adult Arctic grayling near Station 151
7/3/09 – observed 8 adult Arctic grayling in pools just upstream of Station 10
7/29/09 – saw large numbers of Arctic grayling fry virtually everywhere in our sample reach in Mainstem Red Dog Creek upstream of Station 151
7/30/09 – observed a few Arctic grayling fry in Mainstem Red Dog Creek near Station 10

7/3/10 – observed fry at Station 10, fry numerous and schools of 5 to 20 seen everywhere we looked
8/15/10 – observed moderate numbers of Arctic grayling fry just upstream of Station 151
8/15/10 – saw two adult Arctic grayling just upstream of Station 10
8/15/10 – observed moderate numbers of Arctic grayling fry upstream and downstream of Station 10

Appendix 11. Arctic Grayling Fry, North Fork Red Dog Creek

Year	Relative Abundance of Fry	Comments
1992	high	100's of fry, late July
1993	low	Few fry in early August, high water
1994	low	High water after spawning probably displaced fry
1995	low	Fry small (<25 mm) in mid-July
1996	high	Schools of 50 to 200 fry common
1997	high	Average size of fry was 10 mm greater than in 1996
1998	low	Cold water, late breakup, high water after spawning
1999	high	Low flows, warm water after spawning, schools of 50 to 100 fry common
2000	low	Cold water, late breakup, spawning 90% done June 13/14, fry small (<25 mm) and rare in mid-July
2001	low	Cold water, late breakup, spawning 90% done June 19, fry small (<25 mm) and rare in mid-July
2002	low	High flows, spawning 90% done June 8, fry small (<35 mm) in early August and rare, more fry seen in Ikalukrok Creek in early July, probably displaced by high water
2003	low	Cold water, late breakup, spawning 90% done June 14, fry small (<25 mm) and rare in early August
2004	low	Early breakup, spawning 90% done by May 31, fry (<30 mm) on July 10
2005	low	Spawning 90% done by June 7, fry present in early July, several groups of 25 to 30 observed to high water
2006	low	Spawning partially abandoned due to cold water temperatures, no fry observed in early August, July surveys not possible due to high water
2007	high	Spawning 90% done by June 3, followed by low water with very little rainfall until mid-August, fry numerous, hundreds seen in shallow water along stream margin, fry averaged 64 mm in early August

Appendix 11 (concluded)

Year	Relative Abundance of Fry	Comments
2008	low	Spawning 90% done by June 9, most fish probably spawned in Mainstem Red Dog Creek, no fry seen along stream margins
2009	low	Most fish probably spawned in Mainstem Red Dog Creek, breakup late, very few fry seen in July or August, fry observed in the reach just upstream of Station 151 indicate some spawning success in North Fork Red Dog Creek
2010	moderate	breakup early, water flows low, moderate numbers of fry seen in North Fork Red Dog Creek in July, grayling fry caught in minnow buckets on August 16