Technical Report No. 15-01

Aquatic Biomonitoring at Red Dog Mine, 2014
Alaska Pollution Discharge Elimination System
Permit No. AK-0038652 (Modification #1)

by Alvin G. Ott and William A. Morris

North Fork Red Dog Creek Fyke Net, June 12, 2014
Photograph by William A. Morris

March 2015

Alaska Department of Fish and Game
Division of Habitat

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Anthony R. DeGange
Director
Division of Habitat
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Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in reports by the Divisions of Habitat, Sport Fish and of Commercial Fisheries. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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Acknowledgements

We thank Teck for their financial and logistical support for the 2014 aquatic biomonitoring work. We specifically acknowledge the assistance provided by Mr. Jeff Clark, Mr. Wayne Hall, Mr. Chris Eckert, Mr. Andy Willman, Mr. Joseph Diehl III, Mr. Dennis Sheldon, Mr. Chris Menefee, Ms. Karen Conitz, and Mr. Robert Napier.

Ms. Laura Jacobs and Mr. Brad Wendling with the Division of Habitat, Alaska Department of Fish and Game (ADF&G) and Mr. Brendan Scanlon with Sport Fish Division (ADF&G) provided assistance with laboratory work. Mr. Fred DeCicco (Fisheries Services and Supplies) conducted the fall Dolly Varden (*Salvelinus malma*) and chum salmon (*Oncorhynchus keta*) aerial surveys and collected the fall sample of adult Dolly Varden from the Wulik River. Ms. Laura Jacobs and Mr. Todd Nichols (ADF&G) participated in 2014 field sampling events.

Dr. Phyllis Weber Scannell (Scannell Technical Services) updated our long-term water quality data base with 2014 data. Ms. Nora Foster (NRF Taxonomic Services) was responsible for sorting and identification of aquatic invertebrates. Mr. Parker Bradley (ADF&G), Ms. Heather Scannell (ADF&G), 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. The pH and total dissolved solids (TDS) in Mainstem Red Dog Creek are higher than pre-mining. Median concentrations of Cd, Pb, and Zn are consistently higher in Mainstem Red Dog Creek as compared with Buddy and North Fork Red Dog creeks and Bons Pond. Teck continued to maintain the clean water bypass system. Median Pb concentrations in Mainstem Red Dog Creek, which had increased from 2011 to 2013, decreased in 2014.

●Algal biomass, as estimated by chlorophyll-a concentration, is determined each year at Red Dog. Chlorophyll-a concentrations in 2014 were highest in Buddy Creek below the falls and lowest in Middle Fork Red Dog Creek. Average chlorophyll-a concentrations were higher in Mainstem Red Dog and North Fork Red Dog creeks as compared with Middle Fork Red Dog Creek. Periphyton standing crop tracks closely with elevated Zn and Cd in Ikalukrok Creek at Station 9. The major source of Cd and Zn at Station 9 is the Cub Creek natural seep.

●Aquatic invertebrate densities are used as an index of stream productivity and health. In 2014, aquatic invertebrate density was low at all sites except for the two Buddy Creek sites. All sites, except for Buddy Creek above the road and Ikalukrok Creek upstream of Red Dog Creek, contained a higher percentage of Chironomidae than EPT (Ephemoptera Plecoptera Tricoptera). The percent Chironomidae in North Fork Red Dog and Mainstem Red Dog Creeks has increased since 2007. Taxa richness was highest in 2014 and was the lowest in 2010. Taxa richness is similar in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks.

●Juvenile Arctic grayling have been analyzed for selected whole body metals in 2004, 2007, 2010, and 2014. Cadmium concentrations in Arctic grayling have not changed. Mean Pb and Se concentrations were highest in 2014. Selenium concentrations in 2014 are significantly higher than the other three sample periods. Zinc concentrations were variable among sample events. All of the Hg concentrations are either at or very near the detection limit (.02 or .04 mg/kg).

●Median whole body concentrations of Cd, Pb, and Zn are consistently higher in Mainstem Red Dog Creek than in Buddy and Anxiety Ridge creeks. Cadmium and Zn water quality data track with whole body concentrations, but Pb does not. Median whole body Se concentrations in juvenile Dolly Varden generally are lowest in fish from Anxiety Ridge Creek, but Hg concentrations are highest. Each of our sample sites seems to have its own unique relationship with whole body concentrations of Cd, Pb, Se, Zn, and Hg.

●Kidney, liver, ovary, testes, and muscle from adult Dolly Varden captured in the Wulik River during spring and fall 2014 were sampled for Cd, Cu, Pb, Se, Zn, and Hg. None of the analytes measured appear to concentrate in muscle. Various metals do concentrate in specific tissues: Cd in kidney, Cu in liver, Se in kidney and ovary, Zn in ovary, and Hg in kidney.

Executive Summary (concluded)

●The number of overwintering Dolly Varden is estimated each fall in the Wulik River. The number of fish overwintering in the Wulik River has exhibited a decreasing trend since 2006 reaching a low of 21,084 in 2012, but in 2011 and 2014 over 63,000 fish were estimated. Aerial surveys prior to mine development found that over 90% of overwintering Dolly Varden in the Wulik River were located below the mouth of Ikalukrok Creek. Surveys post mining demonstrate the same distribution. Adult Dolly Varden were radio-tagged in fall 2014 and will be monitored during the spring 2015 outmigration.

●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. Post-mining, the highest estimated number of chum salmon was 4,185 in 2006. In fall 2014, the estimated chum salmon return to Ikalukrok Creek was at least 2,406 fish. Returns of chum salmon to Ikalukrok Creek have been strong the last nine years.

●Juvenile Dolly Varden sampling was conducted in late summer 2014. A few resident Dolly Varden (n = 4) were collected with fyke nets in North Fork Red Dog Creek in spring. Total number of juvenile Dolly Varden captured in late July was low (65), with the highest catches occurring in Evaingiknuk, Buddy, and lower Mainstem Red Dog creeks. Catches of juvenile Dolly Varden in lower Mainstem Red Dog Creek have been relatively consistent from 1997 to 2014.

●The Arctic grayling spawning migration into North Fork Red Dog Creek was monitored in spring 2014. On June 12, 2014, four spent females were captured. It appears that spawning was substantially complete in Mainstem Red Dog Creek by June 11. Spawning success in North Fork Red Dog Creek was low, but fry were present along stream margins in late July. Recruitment of immature fish to North Fork Red Dog Creek has been strong since 2007.

●The population of Arctic grayling ($\geq$ 200 mm) in Bons Pond in 2012 was an estimated 715 fish. The population estimates show a continuous decrease in starting in 2005 (population was 6,189 in 2004). Sampling in 2012 and 2014 however, consisted of high numbers of juvenile fish (< 200 mm) suggesting that the population is likely to increase. Arctic grayling spawning was observed in Bons Creek and in the outlet channel from Bons Pond in spring 2014.

●Pre-mining slimy sculpin (*Cottus cognatus*) abundance is unknown. Baseline reports indicated that this species was numerous in the Ikalukrok Creek drainage, but uncommon in the Red Dog Creek drainage. Post-mining, slimy sculpin commonly are captured in Mainstem Red Dog Creek, but highest catches consistently occur in Ikalukrok Creek downstream of the mouth of Dudd 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.

Aquatic biomonitoring has occurred annually since 1995 and has included periphyton, aquatic invertebrate, and fish sampling, including tissue and whole body metals analyses for Dolly Varden (*Salvelinus malma*) and spawning season monitoring for Arctic grayling (*Thymallus arcticus*). The Alaska Department of Environmental Conservation (ADEC) Alaska Pollution Discharge Elimination System Permit No. AK-0038652 (APDES Permit) to Teck Alaska Incorporated (Teck) to allow discharge of up to 2.418 billion gallons of treated effluent per year became effective March 1, 2010. The APDES 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 APDES 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

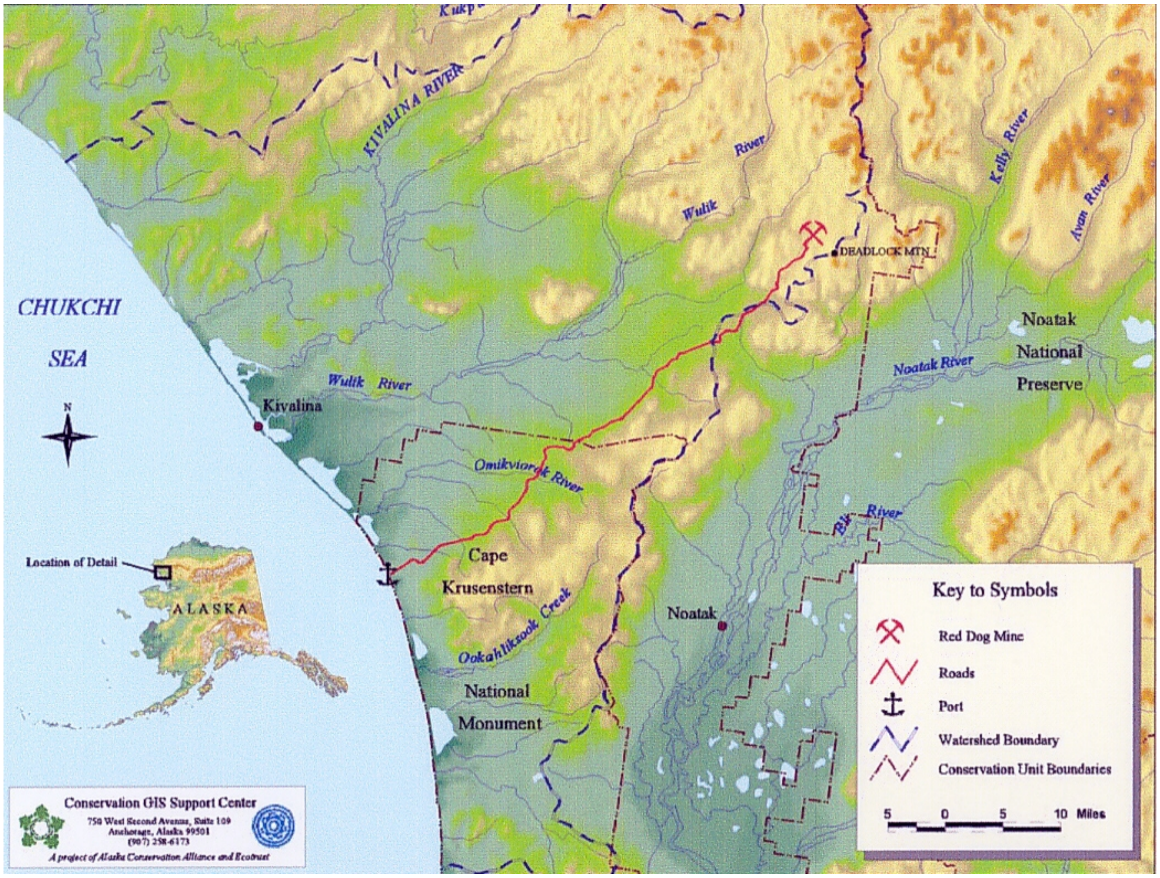


Figure 1. Location of the Red Dog Mine in northwestern Alaska. Map used with permission of Conservation GIS Support Center, Anchorage, Alaska.

On December 2, 2009, the 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. In April 2010 to satisfy conditions in the EPA and ADEC permits, 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)". Teck's May 2009 monitoring plan includes sample sites, sampling frequency, and parameters for all aquatic sites, including those required by the APDES Permit (Tables 2 and 3).

Table 2. Location of Sample Sites and Factors Measured.

Location	APDES/ADEC	Location Description	Sampling 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	APDES/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	1/year	Periphyton (as chlorophyll-a concentrations)
			1/year	Aquatic invertebrates (monitored for taxonomic richness, abundance, and density)
Station 10	APDES/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	APDES/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

Table 3. Location of sample sites for Red Dog aquatic biomonitoring study.

Site Type	Water Body	Site ID	Longitude	Latitude
Invert Sites	Bons Creek ds Bons Pond	Station 220	-162.9395	68.0183
Invert Sites	Bons Creek	Bons Creek us Bons Pond	-162.9149	68.0317
Invert Sites	Buddy Creek ds road	Buddy Creek	-162.9628	68.0062
Invert Sites	Buddy Creek us road	Station 221	-162.9362	68.0189
Invert Sites	Ikalukrok Creek	Station 160 (upstream)	-163.0915	67.9856
Invert Sites	Ikalukrok Creek	Station 9 (upstream)	-162.9410	68.0993
Invert Sites	Mainstem Red Dog Creek	Station 10	-162.9433	68.0889
Invert Sites	Middle Fork Red Dog Cre	Station 20	-162.8837	68.0820
Invert Sites	North Fork Red Dog Creel	Station 12	-162.8852	68.0835
Trap Sites	Anxiety Ridge Creek	Anxiety Ridge ds Trap	-162.9589	67.9940
Trap Sites	Anxiety Ridge Creek	Anxiety Ridge us Trap	-162.9509	67.9935
Trap Sites	Buddy Creek ds road	Buddy ds Trap	-162.9629	68.0062
Trap Sites	Buddy Creek ds road	Buddy us Trap	-162.9548	68.0074
Trap Sites	Evaingiknuk Creek	Evaingiknuk Creek ds Tra	-163.00945	67.9655
Trap Sites	Evaingiknuk Creek	Evaingiknuk Creek us Tra	-163.0020	67.9674
Trap Sites	Ikalukrok Creek	Station 160 ds Trap	-163.0921	67.9846
Trap Sites	Ikalukrok Creek	Station 160 us Trap	-163.0895	67.9871
Trap Sites	Ikalukrok Creek	Station 9 ds Trap	-162.9430	68.0971
Trap Sites	Ikalukrok Creek	Station 9 us Trap	-162.9413	68.1008
Trap Sites	Mainstem Red Dog Creek	Station 10 ds Trap	-162.9458	68.0890
Trap Sites	Mainstem Red Dog Creek	Station 10 us Trap	-162.9343	68.0900
Trap Sites	Mainstem Red Dog Creek	Station 151 ds Trap	-162.8999	68.0827
Trap Sites	Mainstem Red Dog Creek	Station 151 us Trap	-162.8921	68.0842
Trap Sites	North Fork Red Dog Creel	Station 12 ds Trap	-162.8833	68.0835
Trap Sites	North Fork Red Dog Creel	Station 12 us Trap	-162.8774	68.0839

ds – represents the location of the most downstream minnow trap
us - represents the location of the most upstream minnow trap

The reinstated limits for total dissolved solids became effective on April 1, 2013, in the APDES Permit. Modification #1 of the APDES Permit which authorizes a mixing zone for selenium (Mixing Zone 2) and adjusts Outfall 001 effluent limits for selenium, came into effect on May 8, 2014.

Teck's monitoring plan is incorporated by reference into the Alaska Department of Natural Resources (ADNR) 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. Active mining in the Aqqaluk Pit occurred during 2012. In addition to mine drainage, certain waste rock from Aqqaluk and treated water were placed in the mined out main pit. Our report presents data collected during summer 2014 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 and Arctic grayling 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 APDES Permit No. AK-0038652 (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 are located in the Red Dog Creek drainage, Ikalukrok Creek, Bons and Buddy Creek drainage, Anxiety Ridge Creek, and Evaingiknuk Creek.

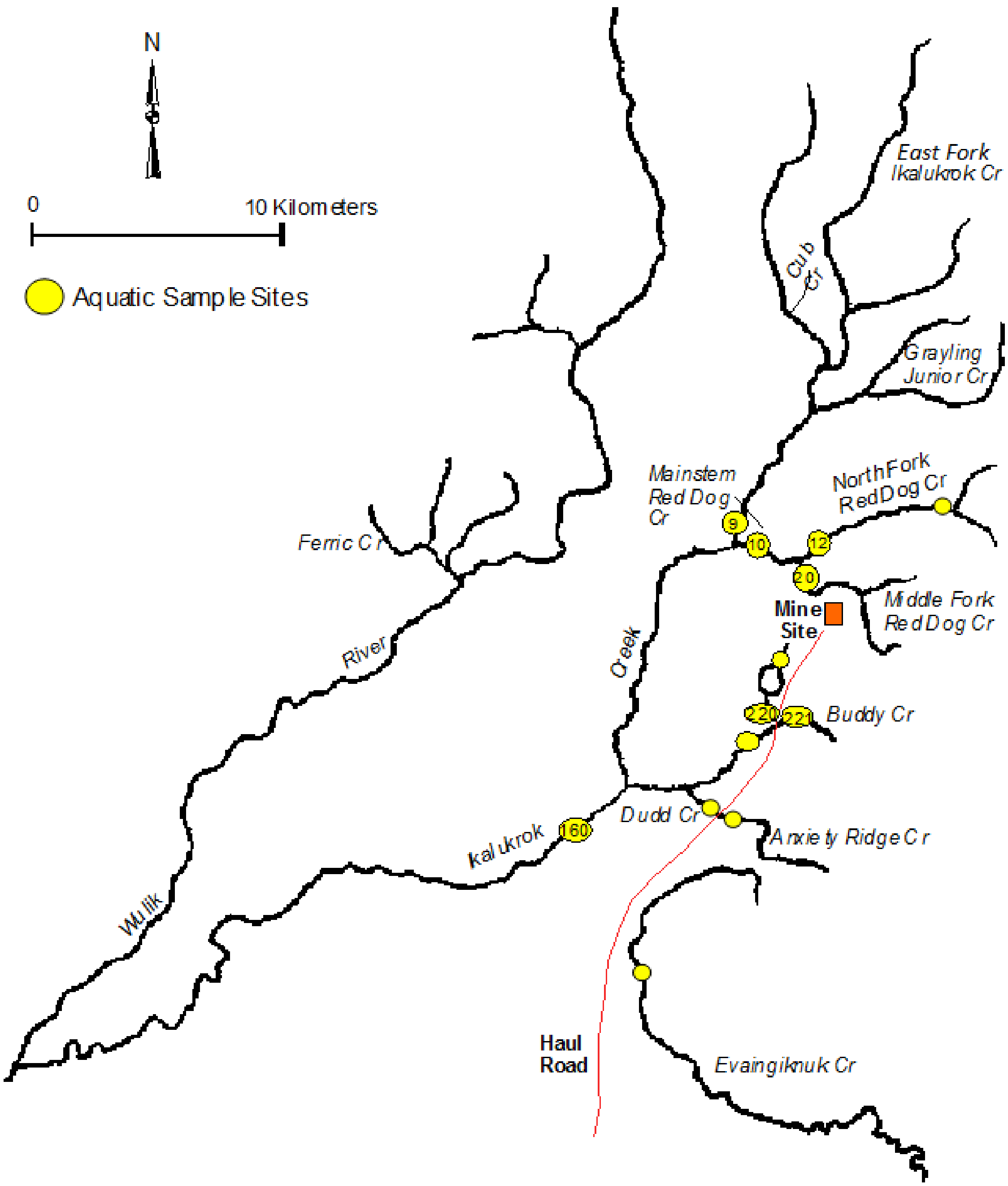


Figure 2. Location of sample sites (some have a Station #) in the Ikalukrok and Evaingiknuk Creek (a tributary of the Noatak River) drainages.

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), lead (Pb), and selenium (Se) was 50, 20, and 50 µg/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 µg/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 per site. Baseline water quality pre-mining presented in the report were collected from 1979 to 1982.

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):

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

95% C.I. for the population estimate was calculated as

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

Results and Discussion

Water Quality

Water quality data collected in Mainstem Red Dog Creek prior to 2010 are from Station 10, located near the mouth of the creek. Data from 2010 to 2014 were collected at Station 151 located about 2 km upstream from Station 10. Station 151 is at the downstream end of the mixing zone in Mainstem Red Dog Creek (Figure 3). There are no defined drainages entering Mainstem Red Dog Creek between these two water quality stations. Station 151 replaced Station 10 effective spring 2010. Mainstem Red Dog Creek is directly affected by the mine wastewater effluent and by water from the clean water bypass. North Fork Red Dog Creek is a reference site with no direct effects from the mine. We continue to evaluate water quality data collected in Mainstem Red Dog Creek as part of the ongoing aquatic biomonitoring program.

Figure 3. Downstream end of mixing zone in Mainstem Red Dog Creek in late July 2013 (Station 151).

Teck continued to maintain the mine's clean water bypass system which picks up non-mining impacted water from Sulfur, Shelly, Connie, Rachel, and Upper Middle Fork Red Dog creeks (Figure 4). This water is moved through the mine pit area, including by the currently active Aqqaluk pit, to its original channel via a combination of culverts and lined open ditch. These bypass conveyance structures serve to isolate the clean water from contact with areas disturbed by mining activities.

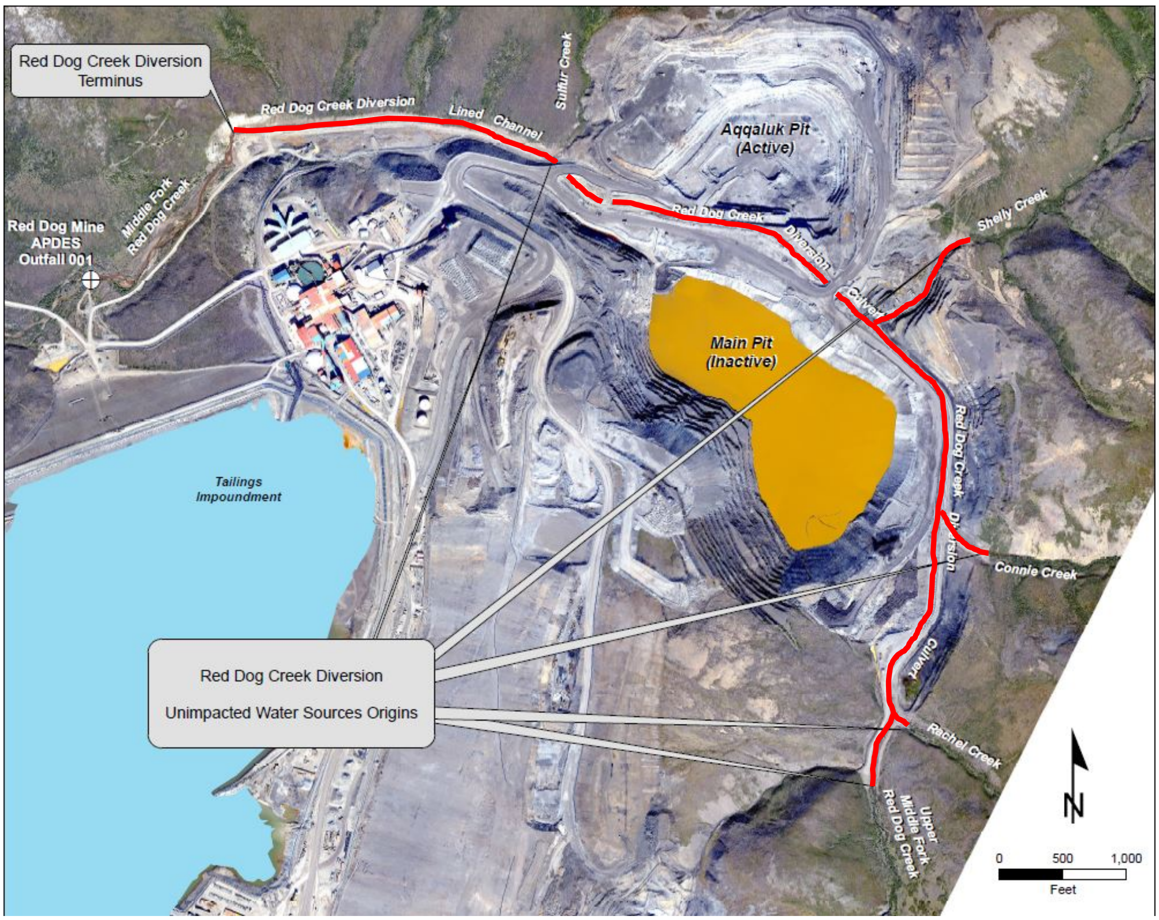


Figure 4. Clean water bypass system at the Red Dog Mine. The Red Dog Creek Diversion structure (delineated by labels in the photograph and shown in red) picks up non-mining impacted waters from upstream tributaries and moves them between the Aqqaluk pit and the main pit back to the original Middle Fork Red Dog Creek streambed (flow is from right to left). Figure provided by Teck with modifications made by ADF&G.

Pb and Zn concentrations at Station 151/10, 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 (Figures 5 and 6). Median lead concentrations, which had increased from 2011 to 2013, decreased to 4.5 µg/L 2014. Median zinc concentration in 2014 was 460 µg/L as compared with a baseline median concentration of 3,700 µg/L.

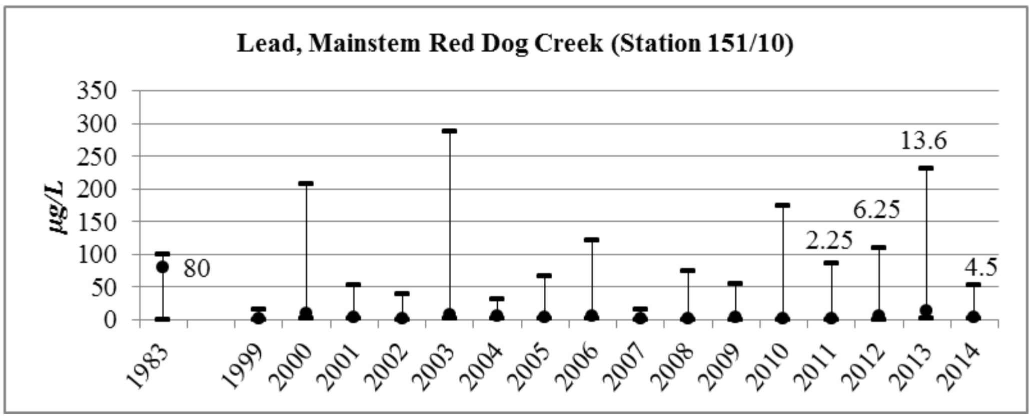


Figure 5. Median, maximum, and minimum Pb concentrations at Station 151/10 (selected median values shown).

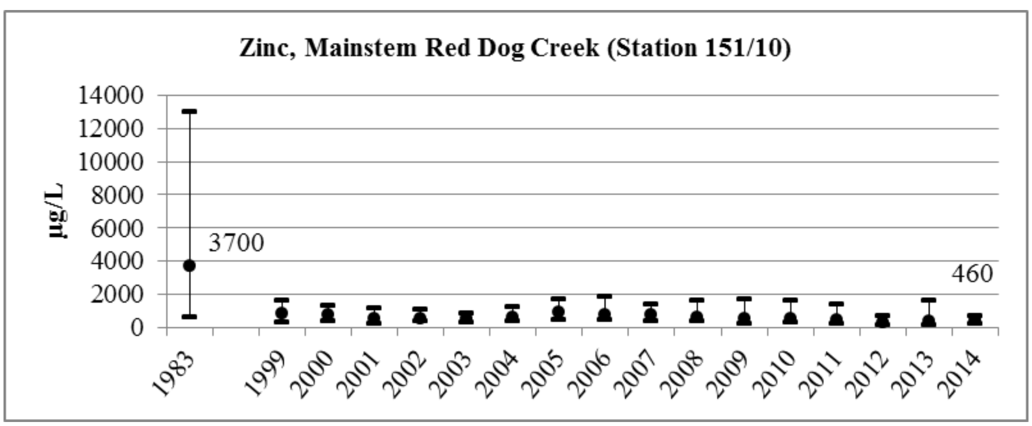


Figure 6. Median, maximum, and minimum Zn concentrations at Station 151/10 (selected median values shown).

In 2014, the major sources of Pb were Middle Fork Red Dog Creek (Station 145) upstream of the clean water bypass and Sulfur and Rachel Creeks (tributaries to the clean water bypass). Sulfur Creek had the highest median Pb concentration, but this drainage is small compared to the other tributaries to the clean water bypass (Figure 7). Sulfur Creek may eventually be incorporated into the Aqqaluk Pit. Overall, the median Pb concentrations in 2014 were lower than those reported in 2013 (Ott and Morris 2014). The median Pb concentration in Sulfur Creek was 362 µg/L in 2013 and 122.4 µg/L in 2014.

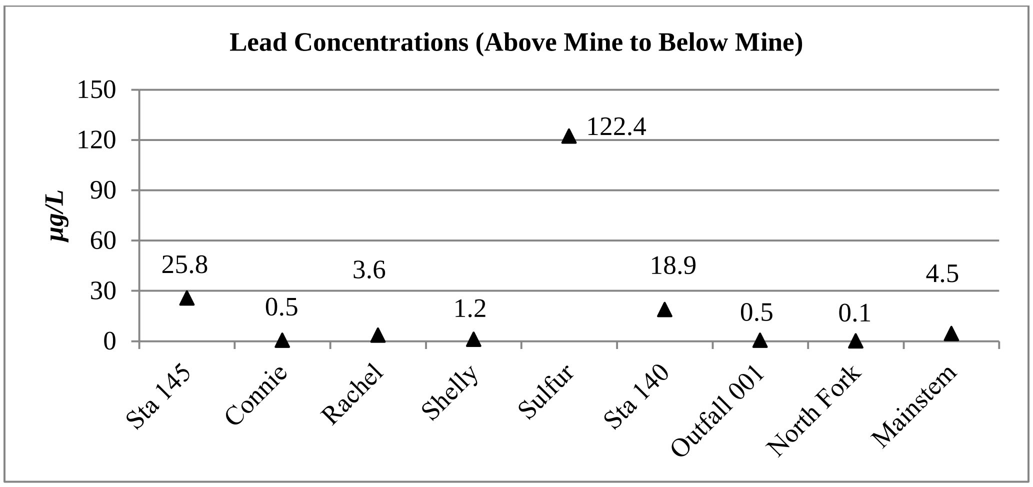


Figure 7. Median Pb concentrations in 2014 from upstream (Station 145) of the clean water bypass, including tributaries to the clean water bypass (Connie, Rachel, Shelly, and Sulfur), and Station 140 (above the Outfall 001), Outfall 001, and North Fork Red Dog and Mainstem Red Dog Creeks.

Median Al concentrations at Station 10/151 continue to be lower than pre-mining (Figure 8). Cd concentrations are lower than pre-mining conditions (Figure 9). The median Cd concentration in 1983 was 28 µg/L and in summer 2014 it was 3.2 µg/L. In most years (1999 to 2014), the maximum Cd concentration is lower than the 1983 median value.

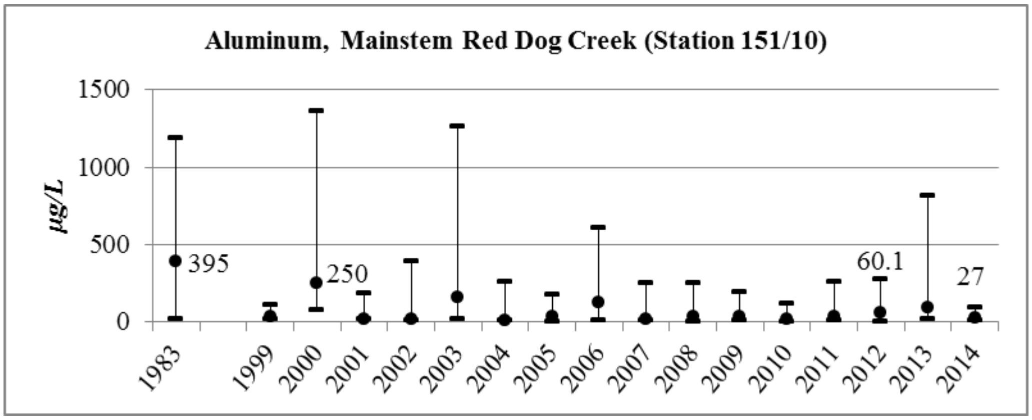


Figure 8. Median, maximum, and minimum Al concentrations at Station 151/10 (selected median values shown).

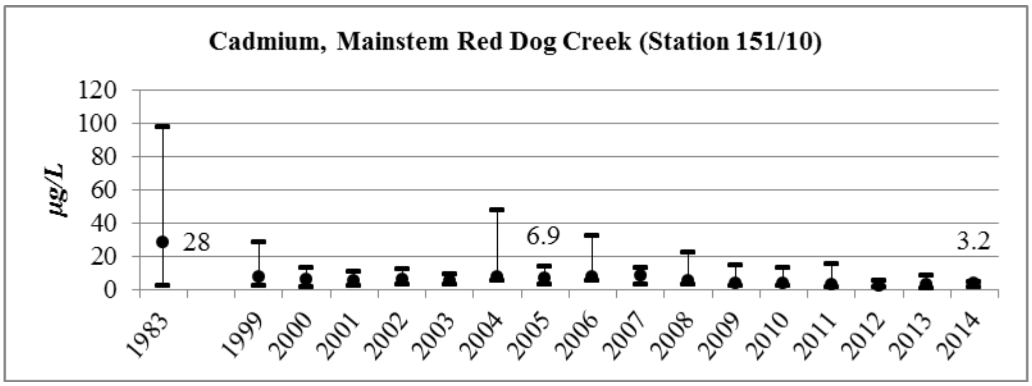


Figure 9. Median, maximum, and minimum Cd concentrations at Station 151/10 (selected median values shown).

Pre-mining data for Se are not available. Median Se concentrations in Mainstem Red Dog Creek remained similar from 2001 to 2007, but then increased reaching a high of 2.75 µg/L in 2011 (Figure 10). In 2012, discharge of treated water was stopped on June 8 and was not resumed the entire open water season due to elevated Se. Treated water was discharged to the main pit for the remainder of the 2012 open water period. Discharge was discontinued to allow Teck time to work on ways to reduce the Se in the treated water discharge and to obtain a mixing zone in Mainstem Red Dog Creek. Discharge resumed in 2013 and by summer 2014, the median Se concentration in Mainstem Red Dog Creek was 1.7 µg/L.

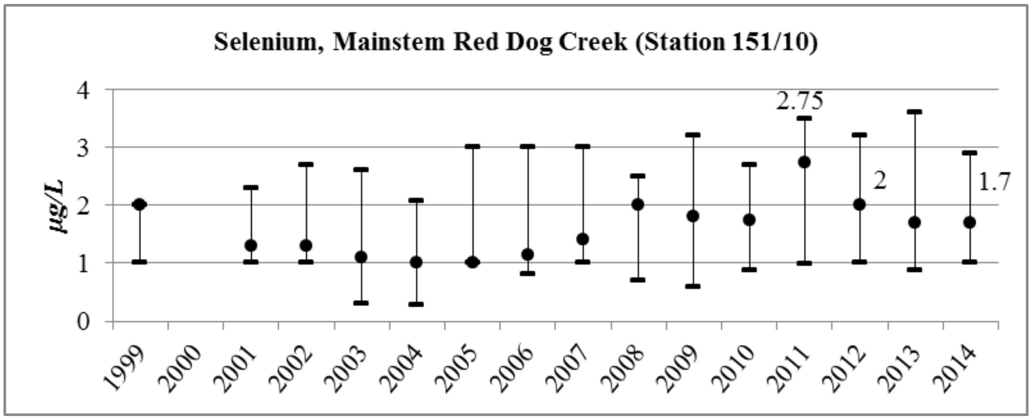


Figure 10. Median, maximum, and minimum Se concentrations at Station 151/10 (selected median values shown).

Pre-mining data for Ni are not available. Median Ni concentrations at Station 151/10 were highest in 2006 and 2007 (Figure 11). Higher median Ni concentrations were observed first in 2006. The primary source of Ni to the clean water bypass system has been Rachael Creek (Ott and Morris 2010). Median Ni concentrations in Mainstem Red Dog Creek were 10.1 µg/L in 2014.

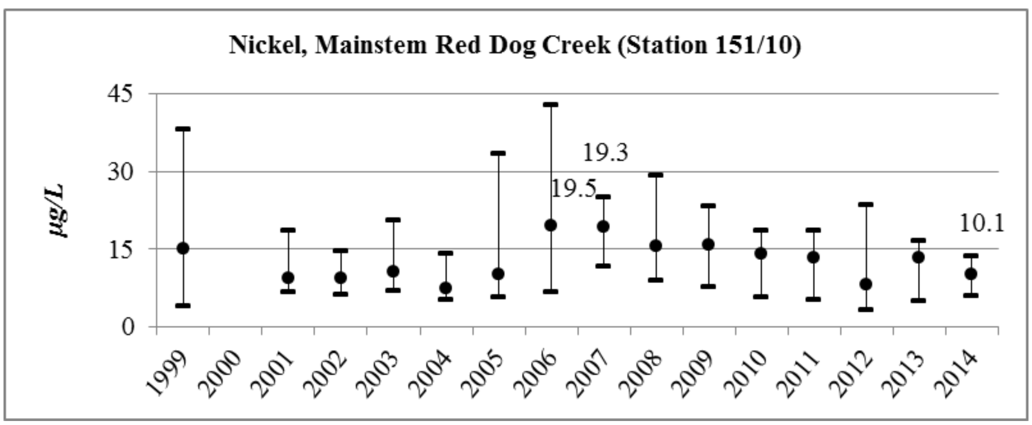


Figure 11. Median, maximum, and minimum Ni concentrations at Station 151/10 (selected median values shown).

The pH at Station 151/10 is higher than pre-mining (Figure 12). The pH is slightly more basic and has only dropped below 6 once, in 2011. The 1990 data set is during mining, but prior to construction of the clean water bypass system. The clean water bypass system was built and operational prior to spring breakup in 1991.

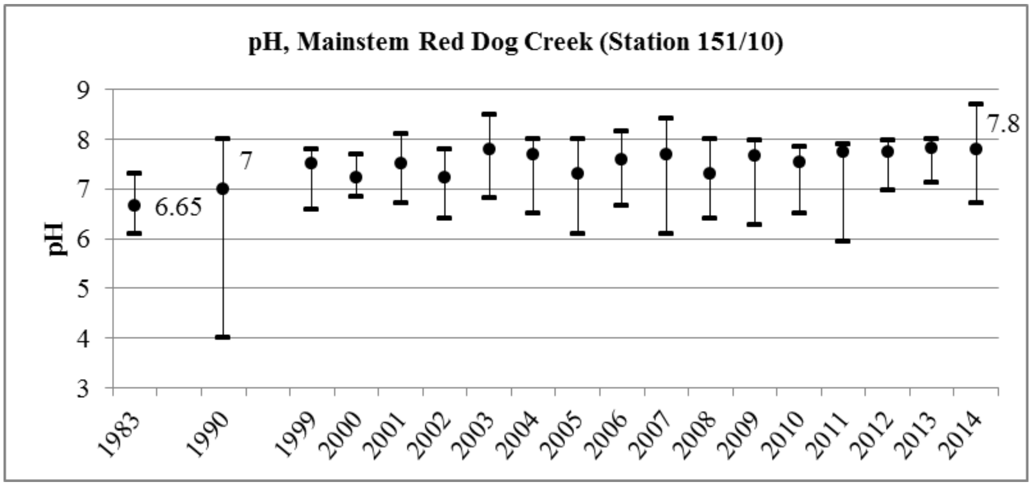


Figure 12. Median, maximum, and minimum pH values at Station 151/10 (selected median values shown).

Total dissolved solids (TDS) in Mainstem Red Dog Creek are higher than pre-mining (Figure 13). TDS is directly related to high concentrations in the treated wastewater discharge at Outfall 001. Calcium hydroxide $Ca(OH)_2$ is added to precipitate and collect metals from the tailing water as metal hydroxides prior to discharge. Sulfates released in this process along with the Ca result in the elevated TDS concentrations. TDS concentrations in Mainstem Red Dog Creek in summer 2014 exceeded the 1,500 mg/L standard applied at Station 151 one time – on May 5, 2014. A second grab sample was taken later that same day and the TDS concentration was 1,084 mg/L. The TDS exceedance was attributed to cooling air temperatures which contributed to near freezing conditions in the stream and the formation of ice/slush around the in-situ probe. The presence of ice/slush around the probe may have interfered with its performance and resulted in transmission of incorrect TDS data to water treatment plant personnel. To prevent such incidents from happening in the future, a standard operating procedure will be developed and implemented to ensure that the conductance probe is regularly checked and, as necessary, cleared of accumulated ice/slush during early and late season operations when episodic freezing conditions can occur.

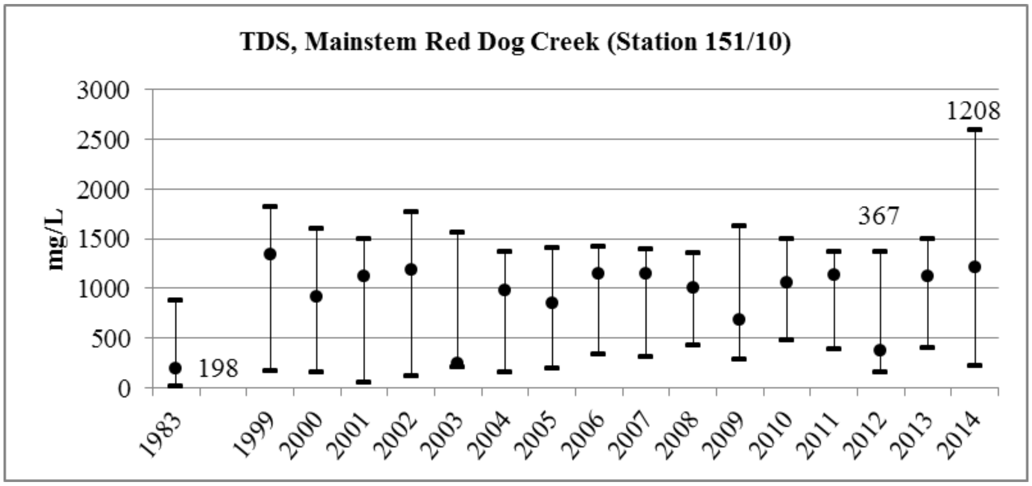
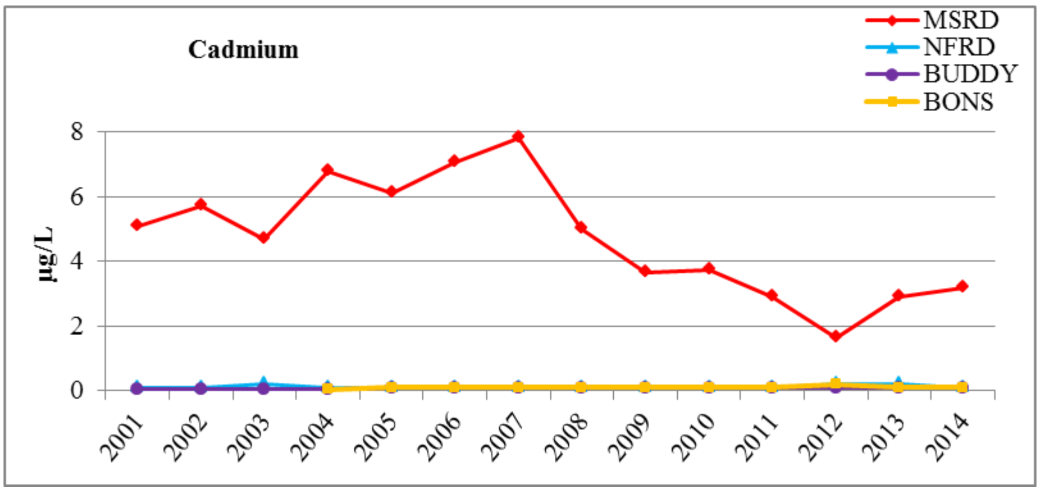


Figure 13. Median, maximum, and minimum TDS concentrations at Station 151/10 (selected median values shown).

Cadmium, Pb, Zn, and Se concentrations in Mainstem Red Dog Creek (Station 151/10) were compared with those found in North Fork Red Dog Creek, Buddy Creek (below the confluence of Bons and Buddy creeks), and Bons Pond (Figures 14 to 17). Sites in North Fork Red Dog and Buddy creeks and Bons Pond were selected because they are reference sites with no direct effects from the mine process or discharge. Mainstem Red Dog Creek is directly downstream of the mine clean water bypass and wastewater effluent discharge at Outfall 001. Buddy Creek and Bons Pond are reference sites, but with the potential to be affected by the road, airport, waste rock dump, and they are down gradient from the tailing backdam. Cadmium, Pb, Se, and Zn were selected for comparison because these elements are analyzed for whole body concentrations in juvenile Arctic grayling from Bons Pond and Dolly Varden from Mainstem Red Dog, Anxiety Ridge, and Buddy creeks.

Cadmium, Pb, and Zn median concentrations are highest in Mainstem Red Dog Creek. (Note: Two graphs are presented for Cd, Pb, and Zn so the differences in North Fork Red Dog and Buddy creeks and Bons Pond can be seen). In the three reference sites, Cd and Zn concentrations are stable over the sampling period from 2001 to 2014. Pb concentrations demonstrate more variability, but still are consistently lower in North Fork Red Dog and Buddy creeks and Bons Pond.



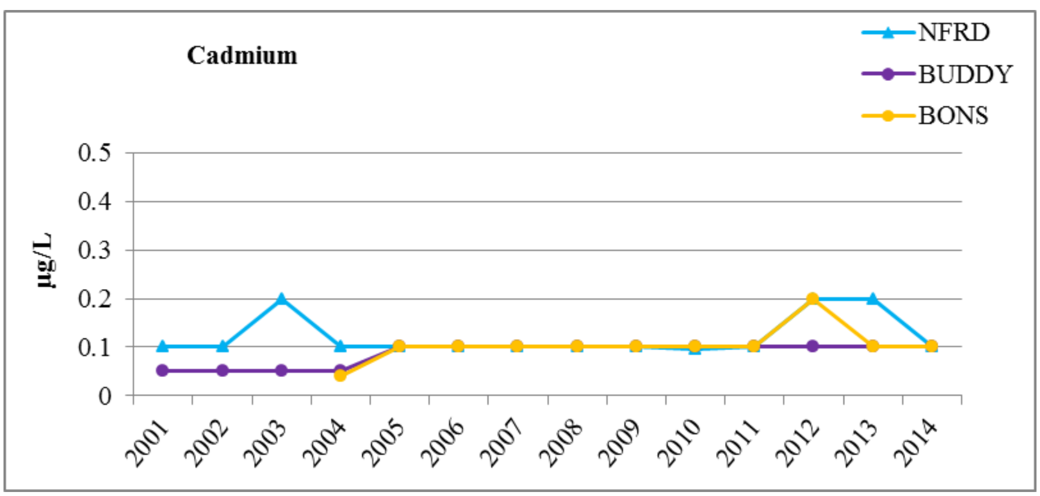
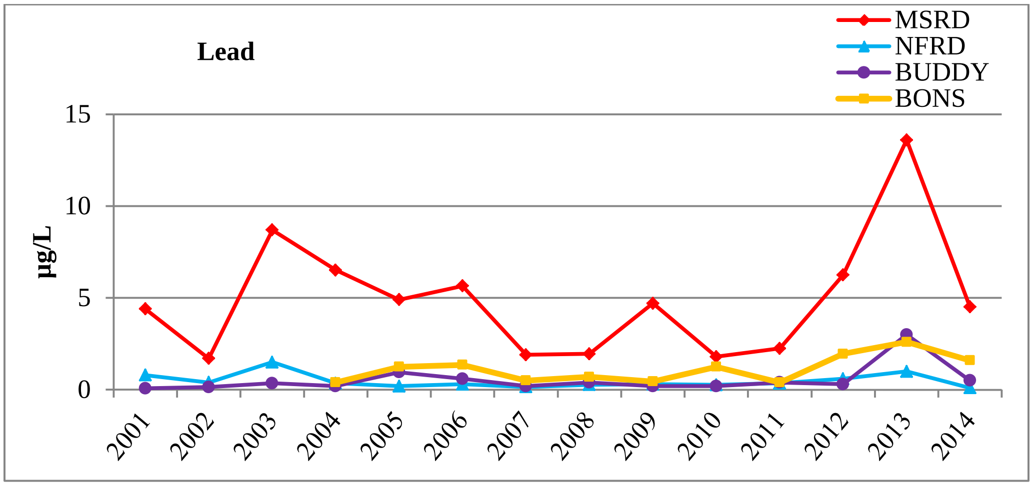


Figure 14. Median Cd concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy Creeks and Bons Pond (2001 to 2014). Two graphs are presented, the bottom graph does not include Mainstem Red Dog Creek.



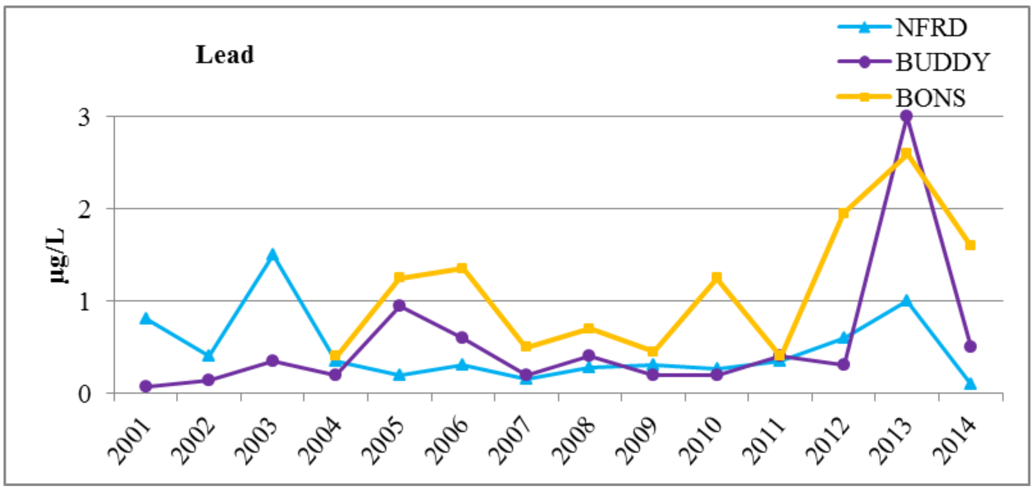


Figure 15. Median Pb concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy Creeks and Bons Pond (2001 to 2014).). Two graphs are presented, the bottom graph does not include Mainstem Red Dog Creek.

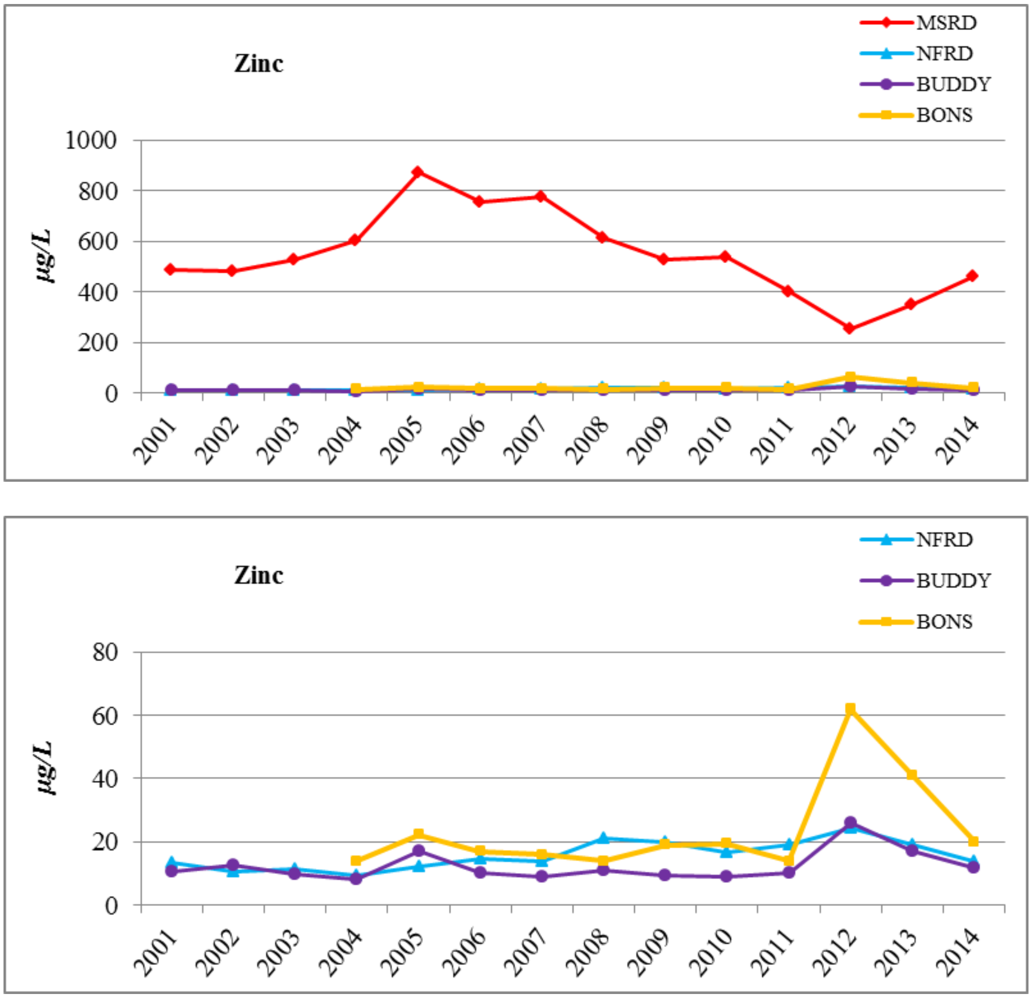


Figure 16. Median Zn concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy Creeks and Bons Pond (2001 to 2014). Two graphs are presented, the bottom graph does not include Mainstem Red Dog Creek.

Differences in Se among these sites are not substantial (Figure 17). Most of the Se concentrations range from 1 µg/L (the detection limit) to 3.0 µg/L.

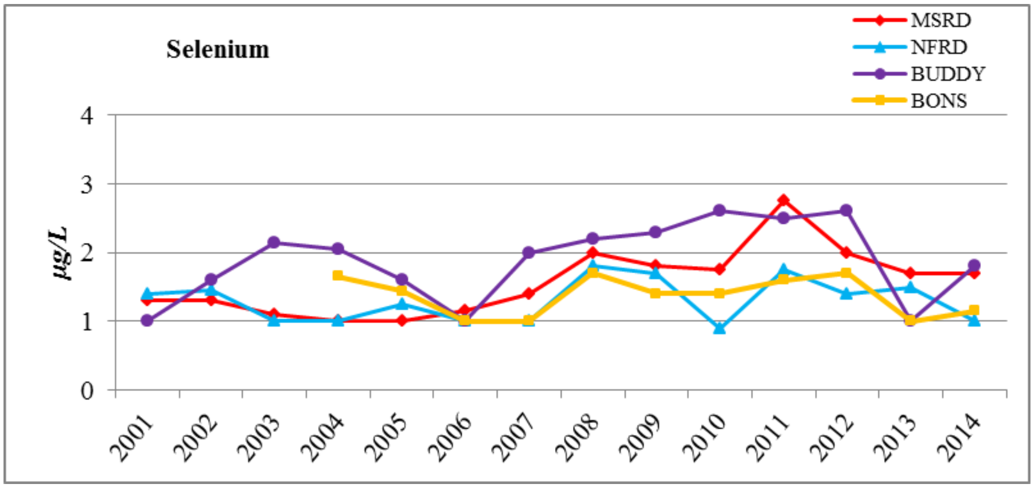


Figure 17. Median Se concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy Creeks and Bons Pond (2001 to 2014).

Periphyton Standing Crop

Periphyton attached microalgae biomass samples are collected each year (2014 data, Appendix 2). Under the new program initiated in 2010, sampling occurred at nine sites (Table 2). In 2014, samples were collected at all sites. Periphyton samples are processed in the laboratory and standing crop determined as mg/m^2 chlorophyll-a.

Chlorophyll-a concentrations in 2014 were highest in Buddy Creek (12.3 mg/m^2) below the falls and lowest in Middle Fork Red Dog Creek (0.3 mg/m^2) (Figure 18). Periphyton standing crops also were high in Bons Creek (10.1 mg/m^2) below Bons Pond.

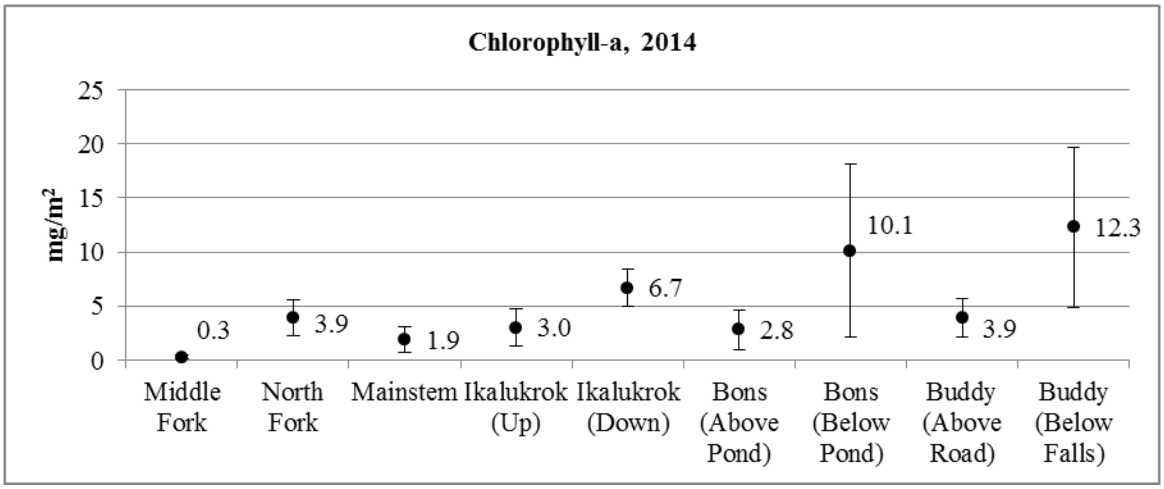


Figure 18. Average concentration of chlorophyll-a (± 1SD).

Average chlorophyll-a concentrations in Middle Fork Red Dog, Mainstem Red Dog, and North Fork Red Dog creeks (below falls) are presented in Figure 19. Generally, average chlorophyll-a concentrations are higher in Mainstem Red Dog and North Fork Red Dog creeks as compared with Middle Fork Red Dog Creek. Low chlorophyll-a concentrations in Middle Fork Red Dog Creek probably are directly related to higher metals concentrations in the creek.

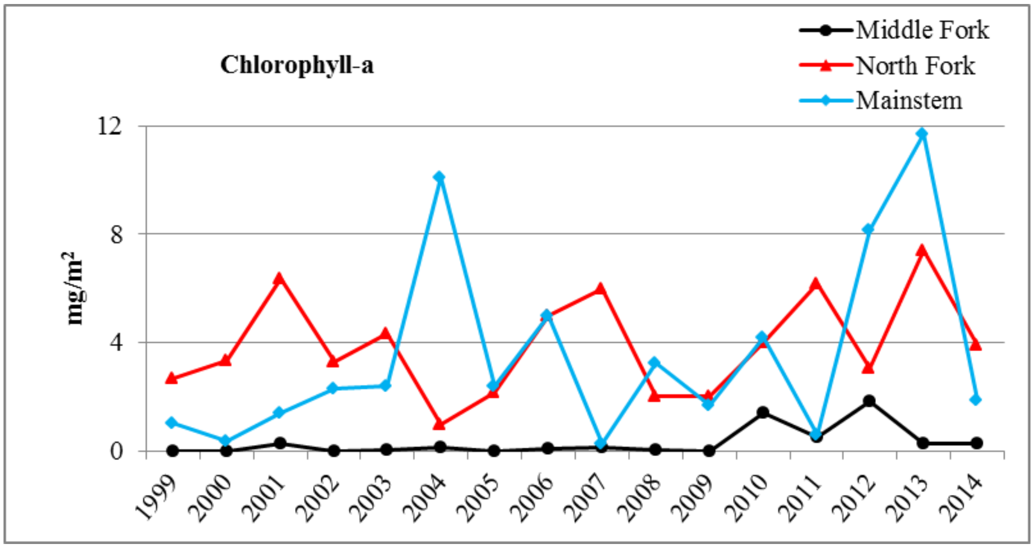


Figure 19. Average concentration of chlorophyll-a.

Periphyton standing crop tracks closely with elevated Zn and Cd in Ikalukrok Creek at Station 9 which is just upstream of the mouth of Mainstem Red Dog Creek. Water quality at this site 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 20 and 21). The variability seen from 2002 to 2014 may be natural as both Cd and Zn concentrations remained low and consistent during this time frame. The major source of Zn and Cd to Ikalukrok Creek is the Cub Creek seep (Figure 22).

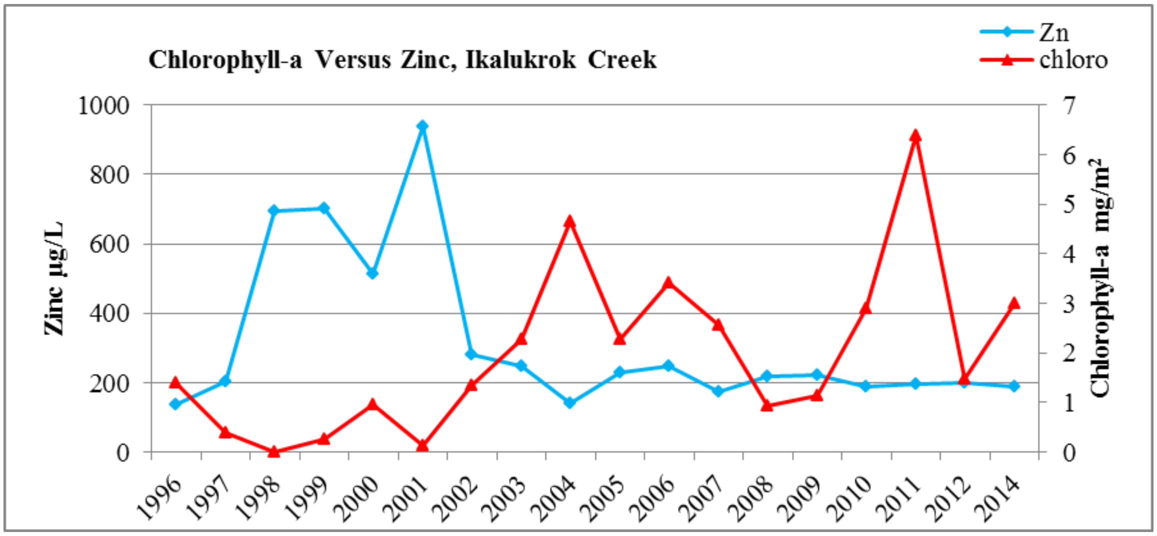


Figure 20. Average chlorophyll-a concentrations versus Zn in Ikalukrok Creek (red line is chlorophyll and blue line is zinc).

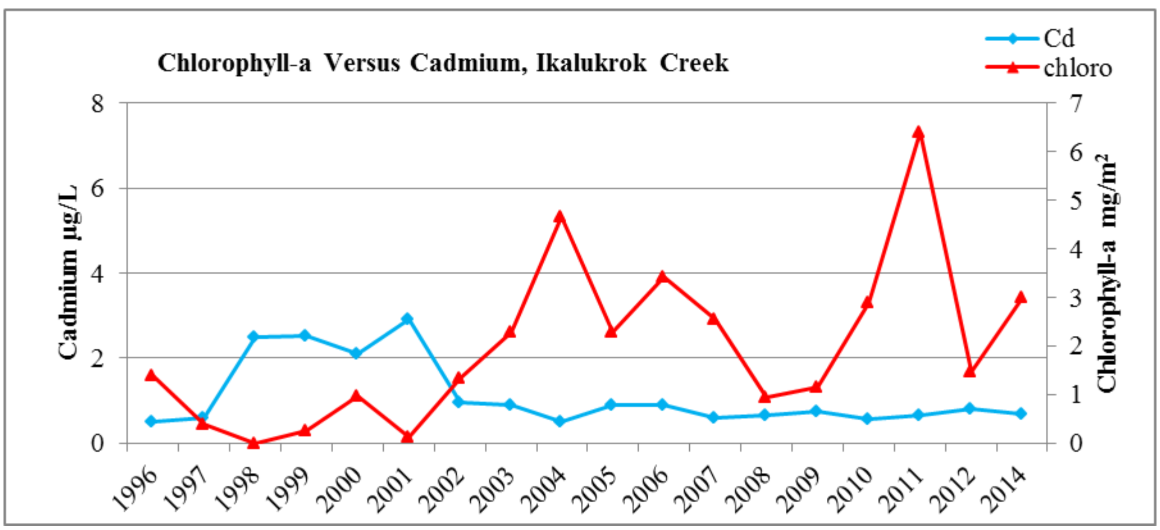


Figure 21. Average chlorophyll-a concentrations versus Cd in Ikalukrok Creek (red line is chlorophyll and blue line is cadmium).

Figure 22. Ikalukrok Creek at the Cub Creek seep about 10 km upstream of the mouth of Mainstem Red Dog Creek – note iron staining in and along the edge of Cub Creek. Photograph by W. Morris, ADF&G, spring 2012.

Aquatic Invertebrates

Aquatic invertebrate samples are collected annually using drift nets (Appendix 3). In 2014, nine sites were sampled July 27 to 31. Flows were high with water covering stream side grasses, sedges, and equisetum.

In 2014, densities were low at all sites except for the two Buddy Creek sites. The density of aquatic invertebrates was highest (14.9/m^3) in Buddy Creek upstream of the road and was lowest (1.3/m^3) in Ikalukrok Creek at Station 160 (Figure 23) (Appendix 3).

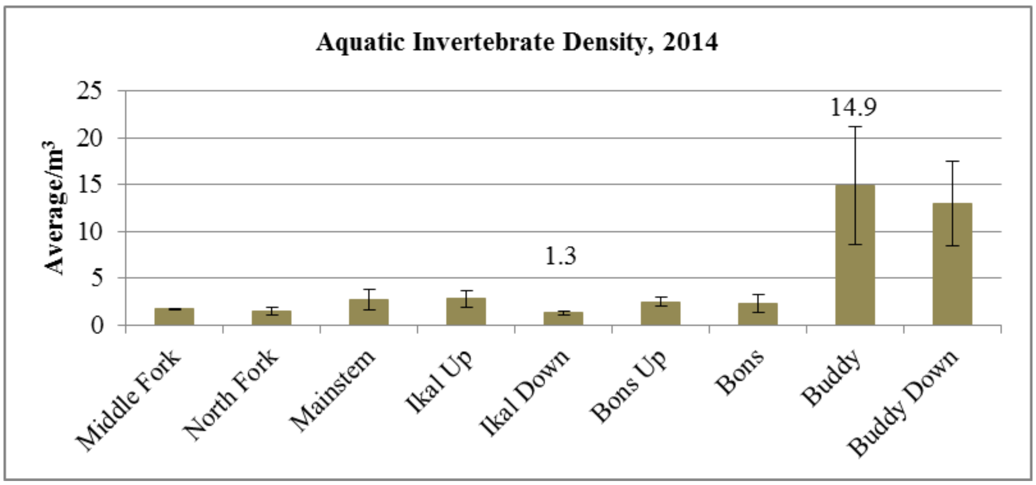


Figure 23. Average aquatic invertebrate densities (± 1SD) in all sample sites in late July 2014. Selected average values shown.

Average aquatic invertebrate densities vary among sample years. Densities in North Fork Red Dog Creek generally are higher than in Mainstem Red Dog Creek (Figures 24 and 25). In most years, the highest densities are found in Buddy Creek upstream of the Haul Road (Figure 26). There appears to be an increase in aquatic invertebrate densities from 2006 to 2010 in North Fork Red Dog Creek and a decrease from 2011 to 2014. We have noted fairly substantial physical changes (channel changes and increased turbidity) in North Fork Red Dog Creek in recent years.

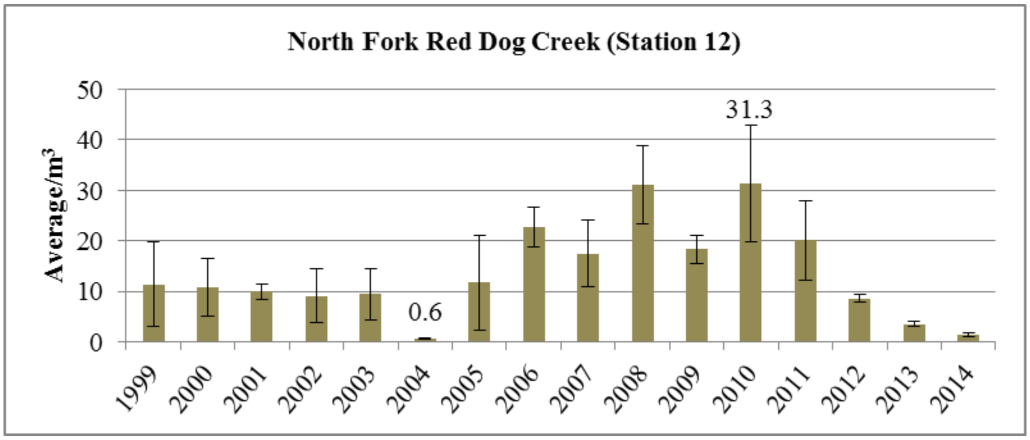


Figure 24. Average aquatic invertebrate densities (+ 1SD) in North Fork Red Dog Creek. Selected average values shown.

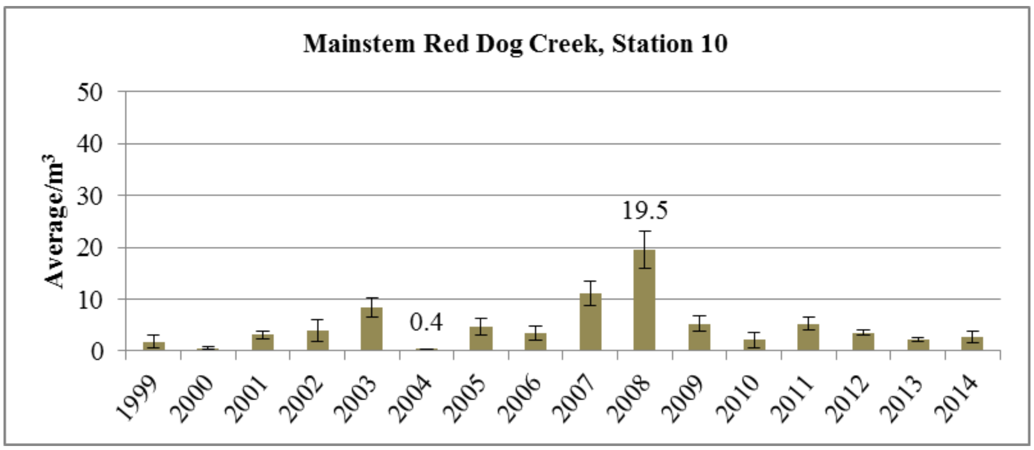


Figure 25. Average aquatic invertebrate densities (+ 1SD) in Mainstem Red Dog Creek. Selected average values shown.

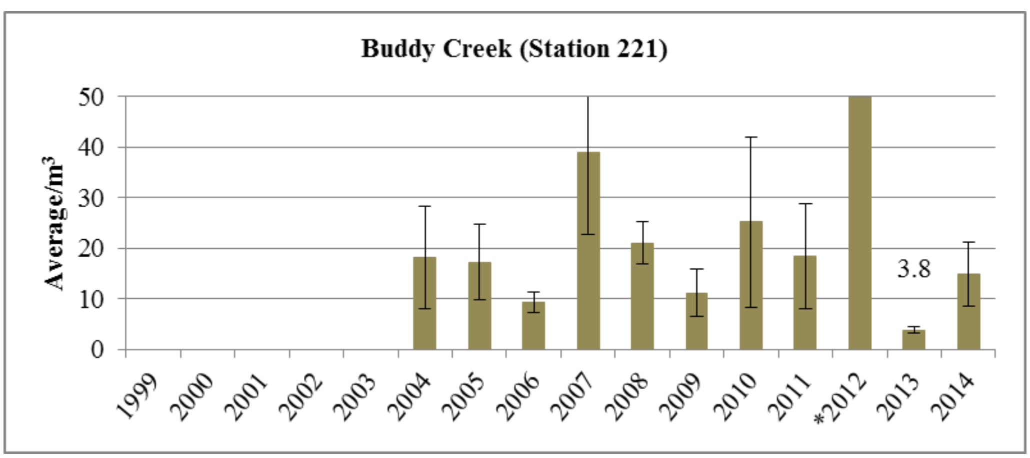


Figure 26. Average aquatic invertebrate densities (+ 1SD) in Buddy Creek. Selected average values shown. *The average density in 2012 was 164.5/m^3.

The percent Ephemeroptera, Plecoptera, and Trichoptera (EPT) and the percent Chironomidae for sample sites in 2014 are presented in Figure 27. All sites, except for Buddy Creek above the road and Ikalukrok Creek upstream of Red Dog Creek, contained a higher percentage of Chironomidae in 2014. Trichoptera are not common in our samples and are not a substantial contributor to EPT. Generally, 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 (e.g. Arctic grayling and Dolly Varden) using these creeks.

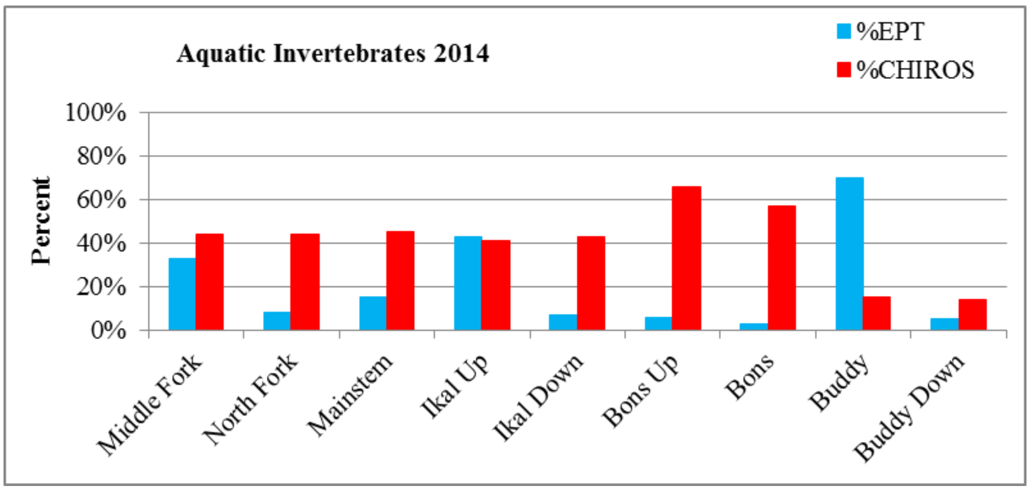


Figure 27. Percent EPT and Chironomidae in the aquatic invertebrate sample sites in late July 2014.

The percent EPT in North Fork Red Dog and Mainstem Red Dog creeks was low in 2001 and from 2008 to 2011 (Figures 28 and 29). The percent EPT in Mainstem Red Dog Creek has been higher than North Fork Red Dog Creek since 2009. Buddy Creek in certain years (2004, 2011, 2012, and 2014) had a much higher percentage of EPT than either North Fork Red Dog or Mainstem Red Dog creeks (Figure 30). In most years since 2007, the percent Chironomidae in North Fork Red Dog and Mainstem Red Dog Creeks has been higher than the percent EPT. Increased percent Chironomidae in the Red Dog Creek drainage may be related to increased sediment input due to aufeis, channel changes, and sediment input from tundra habitats.

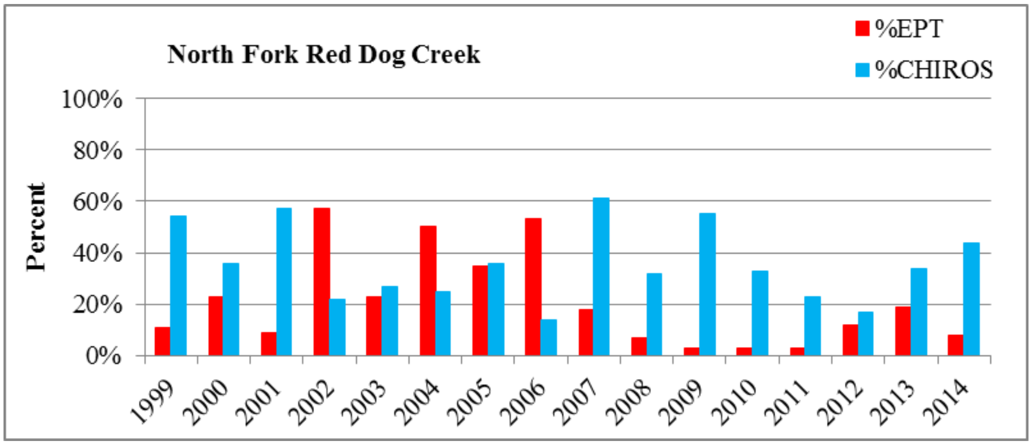


Figure 28. Percent EPT and Chironomidae in North Fork Red Dog Creek.

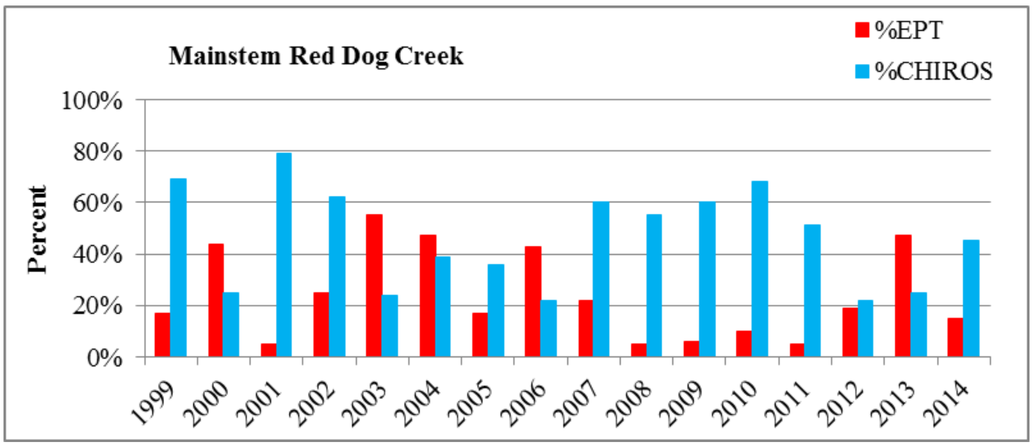


Figure 29. Percent EPT and Chironomidae in Mainstem Red Dog Creek.

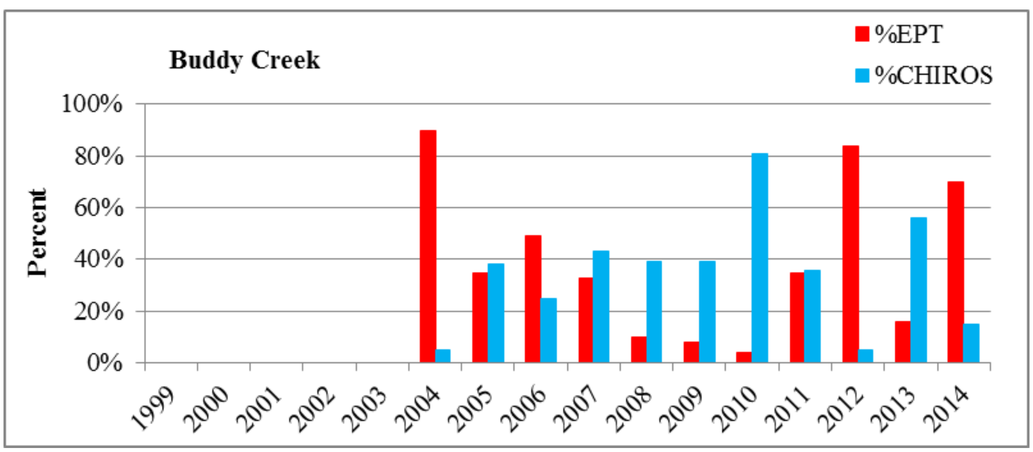


Figure 30. Percent EPT and Chironomidae in Buddy Creek.

The actual density of EPT (average number of organisms per m^3 of water) in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks is variable (Figure 31). Generally, EPT densities are lowest in Mainstem Red Dog Creek and highest in Buddy Creek. The variability in the density of EPT in Buddy Creek is the highest, ranging from 0.58 to 134.7 organisms per m^3.

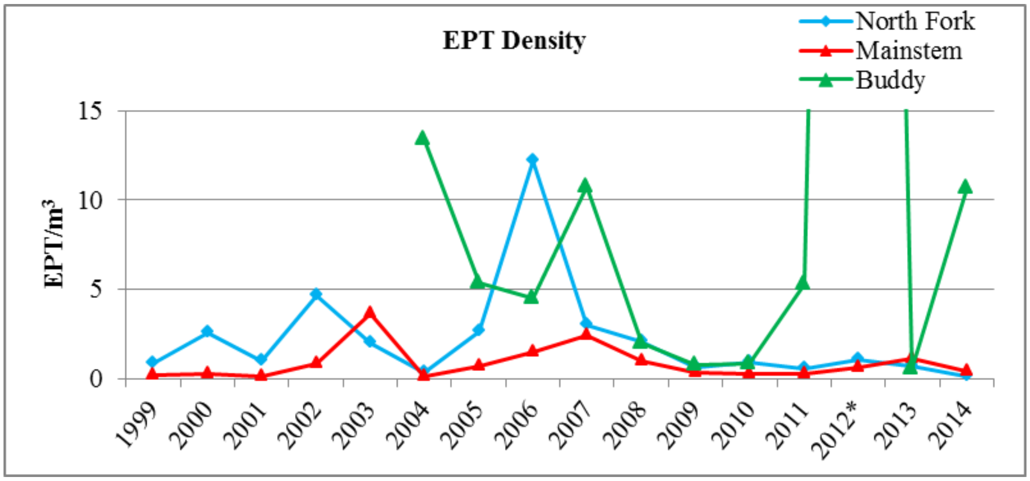


Figure 31. EPT density in North Fork Red Dog and Mainstem Red Dog creeks from 1999 to 2014 and Buddy Creek from 2004 to 2014. *The density in 2012 was 134.7.

We compared taxa richness for the three sample sites in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks (Figure 32). Taxa richness was highest in 2014 and was the lowest in 2010. Overall taxa richness is similar in North Fork Red Dog (1999-2014), Mainstem Red Dog (1999-2014), and Buddy creeks (2004-2014).

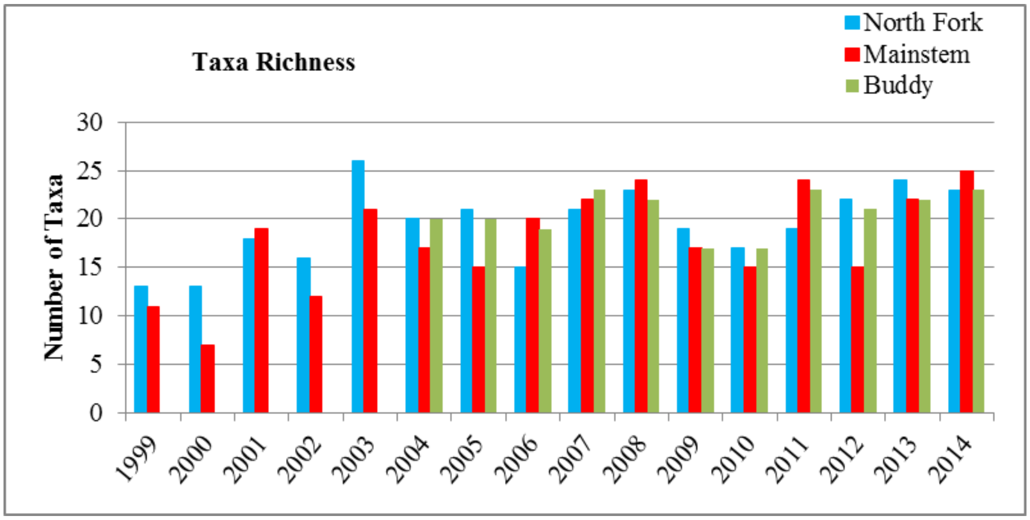


Figure 32. Aquatic invertebrate taxa richness in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks.

Metals Concentrations in Juvenile Arctic Grayling and Dolly Varden

We sample juvenile Arctic grayling and Dolly Varden to determine whole body concentrations of selected metals. The purpose of this effort is: (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 Arctic grayling were selected for long-term monitoring after we had successfully established a self-sustaining population in Bons Pond. Arctic grayling captured in Bons Pond have been in the pond system, including tributaries for their entire life. Arctic grayling that leave Bons Pond must go over a waterfall that prohibits upstream/return movement of fish. Therefore, these Arctic grayling serve as an indicator of change over time in Bons Pond. We selected juvenile Arctic grayling that were between 140 and 220 mm long to minimize variability due to age. In 2010, we refined the sample effort to include only Arctic grayling between 150 and 200 mm long. Our preferred sample size for Arctic grayling is 15 each year, recognizing that in some years we do not achieve this goal. Fish samples were collected during the spring sample event when fish are moving from Bons Pond into Bons Creek.

Juvenile Dolly Varden were selected as a target species because of their wide distribution in the Red Dog area streams, their residence in freshwater for two to four years before smolting, and their rearing in the selected sample sites only during the ice-free season. Juvenile Dolly Varden are collected opportunistically from Mainstem Red Dog, Anxiety Ridge, and Buddy creeks during the minnow trap sample event each fall. 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 were excluded because they could be resident fish and may be much older than the fish from 90 to 140 mm long. Our preferred sample size for juvenile Dolly Varden is 15 each year.

In spring 2014, we collected 15 Arctic grayling from Bons Creek just upstream of Bons Pond (Appendix 4). The average length of these fish was 173±5 mm (1SD). Cadmium concentrations in Bons Pond juvenile Arctic grayling have not significantly changed since 2004 as there are no significant differences among sample years (Figure 33).

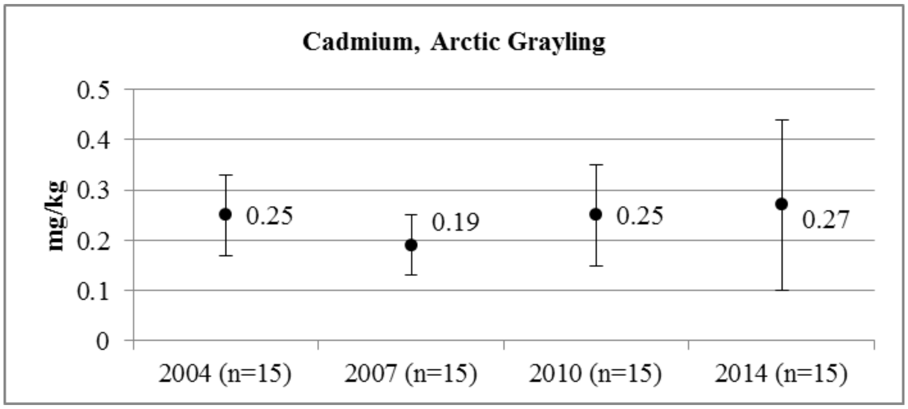


Figure 33. Average Cd concentrations (± 1SD) in juvenile Arctic grayling collected in the Bons Pond drainage (dry weight).

The average Pb concentration in juvenile Arctic grayling from Bons Pond generally were similar among sample events, except for 2014 which had a higher average Pb concentration than in 2007 (KW Stat = 10.62, p = 0.01).

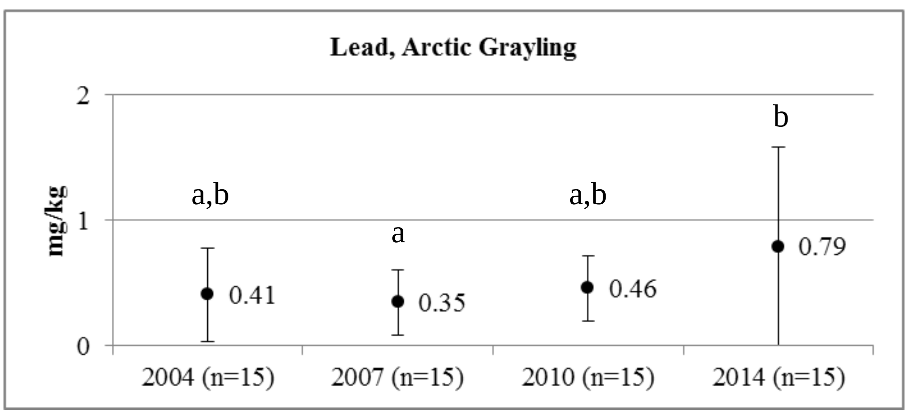


Figure 34. Average Pb concentrations (± 1SD) in juvenile Arctic grayling collected in the Bons Pond drainage (dry weight). Different lower case letters represent averages that are statistically different.

The average Se concentration for whole body Arctic grayling was highest in spring 2014 (Figure 35). Selenium concentrations in 2014 are significantly higher than the other three samples from 2004, 2007, and 2010 (KW Stat = 23.59, $p = 0.001$).

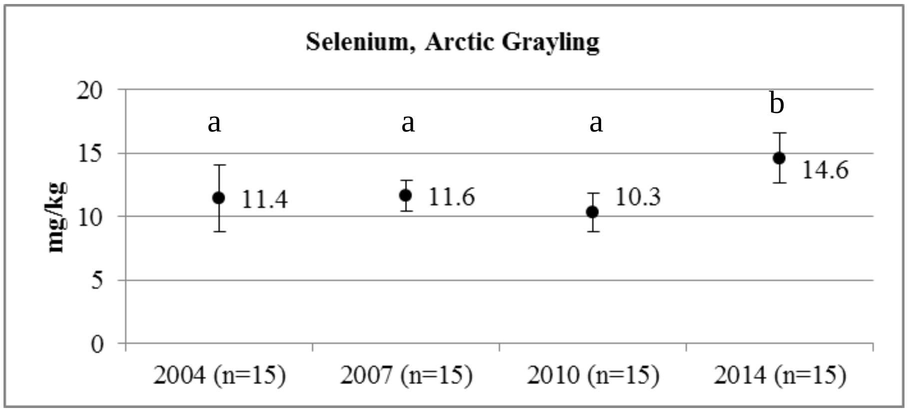


Figure 35. Average Se concentrations (+ 1SD) in juvenile Arctic grayling collected in the Bons Pond drainage (dry weight). Different lower case letters represent averages that are statistically different.

The average Zn concentration in Arctic grayling in Bons Pond has varied from a high of 97 mg/kg to a low of 68 mg/kg (Figure 36). The averages of the fish in 2007 and 2010 are significantly higher than the fish in the 2004 and 2014 sample (KW Stat = 42.38, $p < 0.001$).

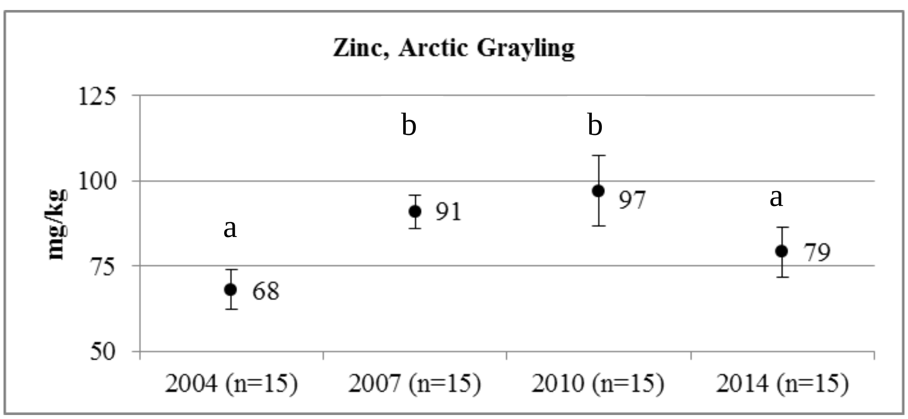


Figure 36. Average Zn concentrations (+ 1SD) in juvenile Arctic grayling collected in the Bons Pond drainage (dry weight). Different lower case letters represent averages that are statistically different.

Average Hg concentrations in juvenile Arctic grayling varied from 0.02 mg/kg (the detection limit) to 0.05 mg/kg (Figure 37). Average Hg concentrations from the 2007 and 2010 sample are not statistically different. Fish from the 2004 and 2014 samples had average Hg concentrations that were below the detection limit of 0.02 mg/kg and are statistically different than the 2007 and 2010 samples (KW Stat = 48.37, p = 0.001).

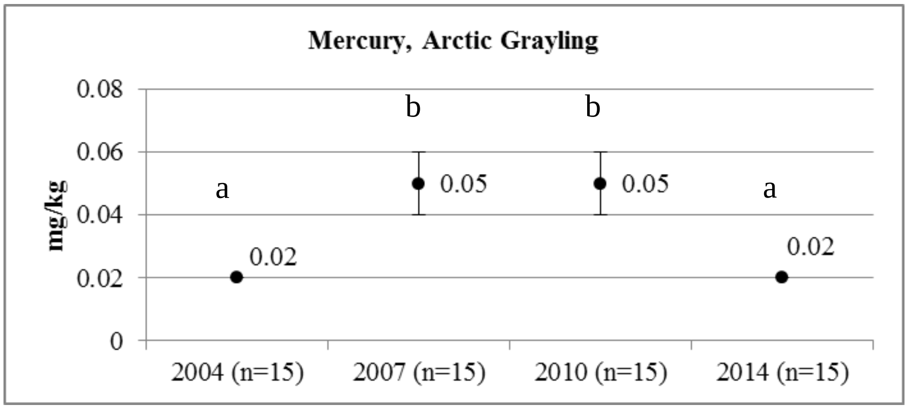


Figure 37. Average Hg concentrations (± 1SD) in juvenile Arctic grayling collected in the Bons Pond drainage. Different lower case letters represent averages that are statistically different.

In the fall of 2014, we collected juvenile Dolly Varden for whole body metals analysis from Mainstem Red Dog (n=15), Buddy (n=15), and Anxiety Ridge creeks (n=7) (Appendix 5). Since water quality concentrations of Cd, Pb, and Zn are highest in Mainstem Red Dog Creek, we expect to see higher concentrations of these metals in whole body samples of juvenile Dolly Varden.

Whole body Cd concentrations (median value) were higher in juvenile Dolly Varden collected from Mainstem Red Dog Creek and consistently lowest in Anxiety Ridge Creek (Figure 38). Highest median Cd concentrations occurred at all three sites in 2006. Median Cd concentrations have been below 1 mg/kg in fish from Buddy Creek since 2007 and Anxiety Ridge Creek since 2005. Cd median concentrations have steadily decreased in Mainstem Red Dog juvenile Dolly Varden from 2006 to 2009, but then increased in 2010 and have decreased in 2011 and 2014. These changes in whole body Cd concentrations seem to track closely with the water quality data for Mainstem Red Dog Creek (Figure 39).

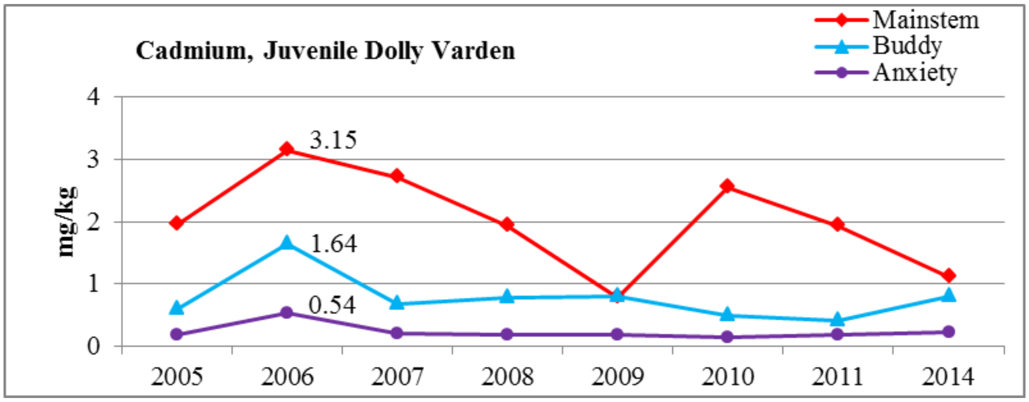


Figure 38. Median Cd whole body concentrations in juvenile Dolly Varden from 2005 to 2014.

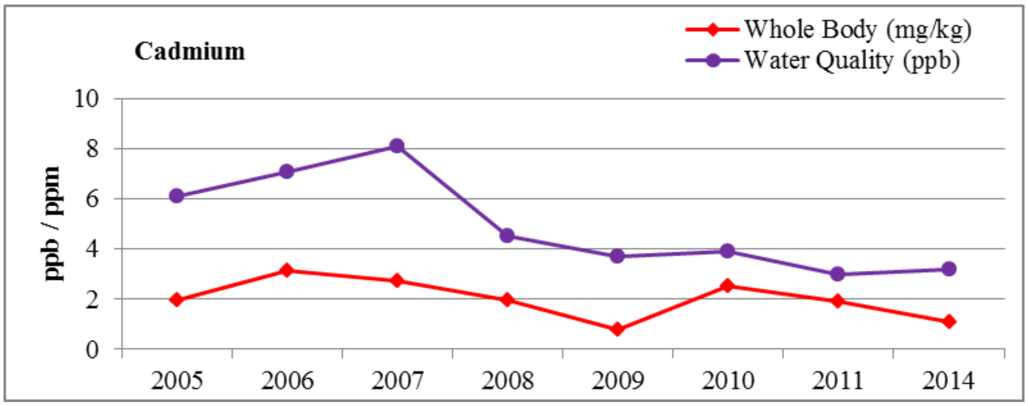


Figure 39. Median whole body Cd concentrations and median Cd water quality data for Mainstem Red Dog Creek.

Median whole body Pb concentrations in juvenile Dolly Varden are consistently higher in Mainstem Red Dog Creek than in Buddy and Anxiety Ridge creeks, which have similar Pb concentrations (Figure 40). Lead concentrations in the water of Mainstem Red Dog Creek have been increasing since 2007; however, this pattern does not appear to correspond well with whole body lead concentrations in the juvenile fish (Figure 41). Median Pb concentrations in the water in 2012 and 2013 were 6.25 and 13.6 µg/L.

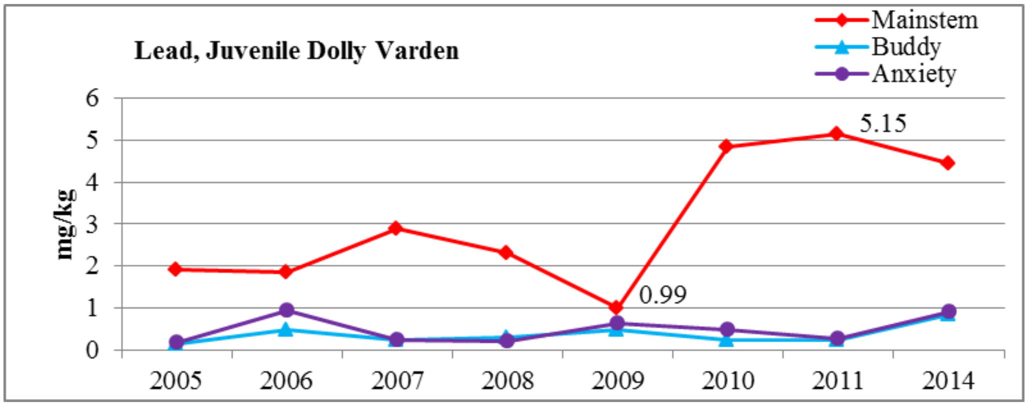


Figure 40. Median Pb whole body concentrations in juvenile Dolly Varden from 2005 to 2014.

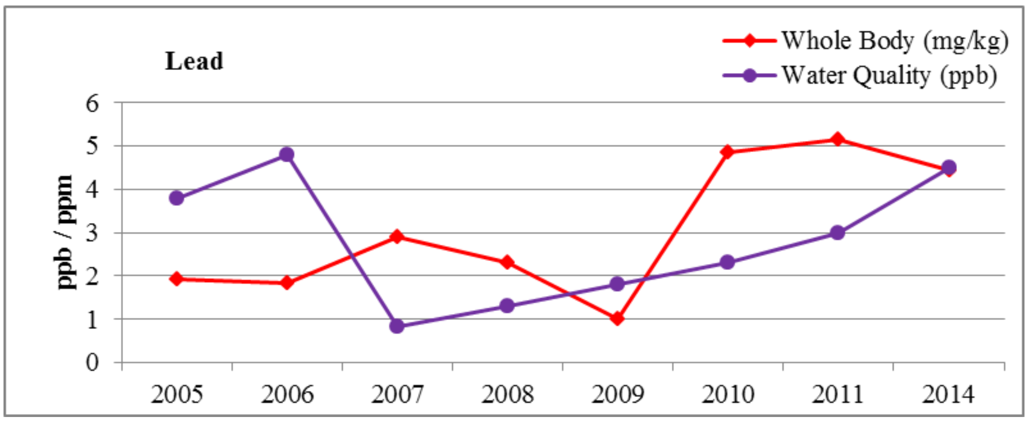


Figure 41. Median whole body Pb concentrations and median Pb water quality data for Mainstem Red Dog Creek.

Median whole body Se concentrations in juvenile Dolly Varden generally are lowest in fish from Anxiety Ridge Creek (Figure 42). Median Se concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek and Buddy Creek generally are similar. There doesn't seem to be any relationship between Se in the water and the quantity of Se in whole body juvenile Dolly Varden (Figure 43). In 2012 and 2013 when juvenile Dolly Varden samples were not obtained, median Se water quality concentrations in Mainstem Red Dog Creek were 2.0 and 1.7 µg/L.

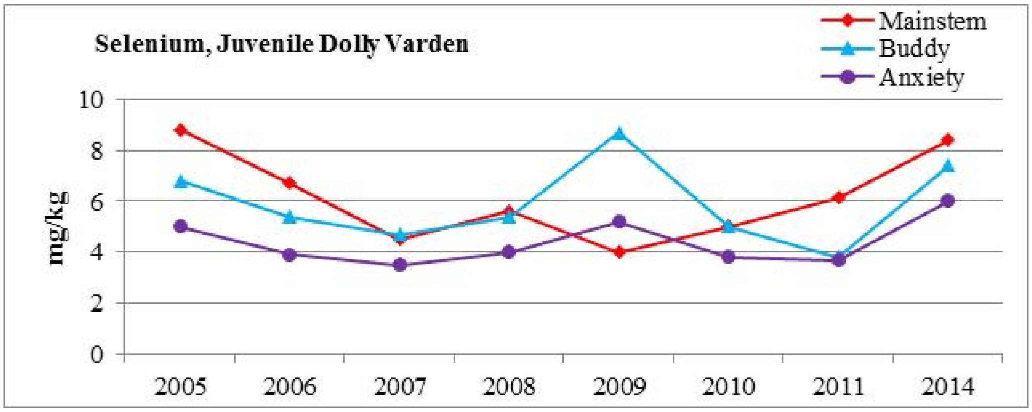


Figure 42. Median Se whole body concentrations in juvenile Dolly Varden from 2005 to 2014.

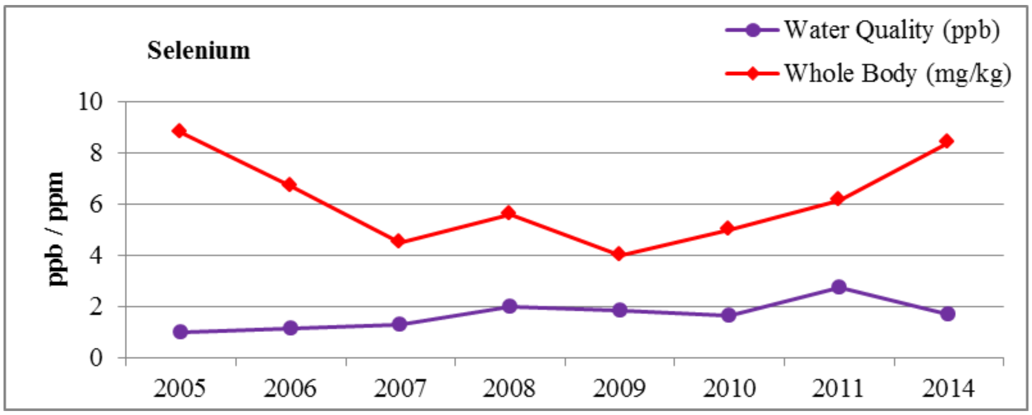


Figure 43. Median whole body Se concentrations and median Se water quality data for Mainstem Red Dog Creek.

Median Zn whole body concentrations are highest in fish from Mainstem Red Dog Creek and lowest in fish from Anxiety Ridge Creek (Figure 44). Zinc whole body concentrations have decreased from a high of 351 mg/kg in 2007 to a low of 160 mg/kg in 2009 in Mainstem Red Dog Creek. Minor changes in Zn whole body concentrations have occurred since 2009. Generally, as Zn concentrations in the water have decreased so have whole body Zn concentrations (Figure 45). Median Zn concentrations in the water in 2012 and 2013 were 254.5 and 350.5 *u*g/L.

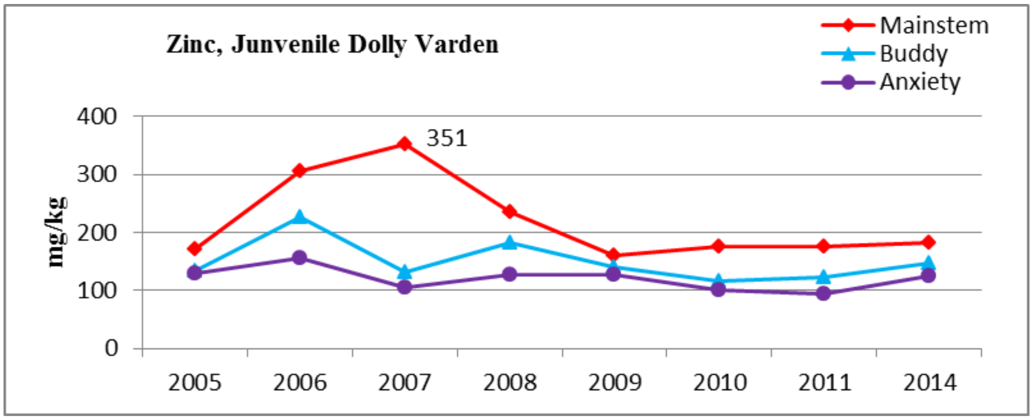


Figure 44. Median Zn whole body concentrations in juvenile Dolly Varden from 2005 to 2014.

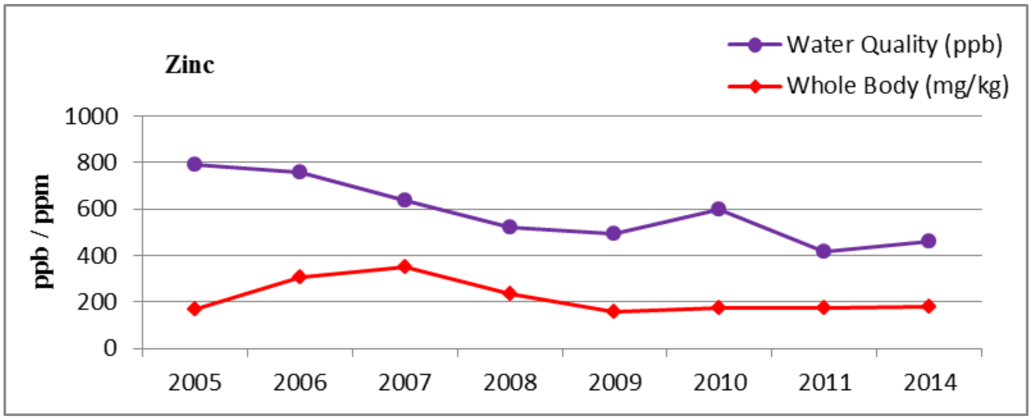


Figure 45. Median whole body Zn concentrations and median Zn water quality data for Mainstem Red Dog Creek.

Median Hg concentrations in juvenile Dolly Varden are consistently higher in Anxiety Ridge Creek and very similar between Buddy and Mainstem Red Dog creeks (Figure 46).

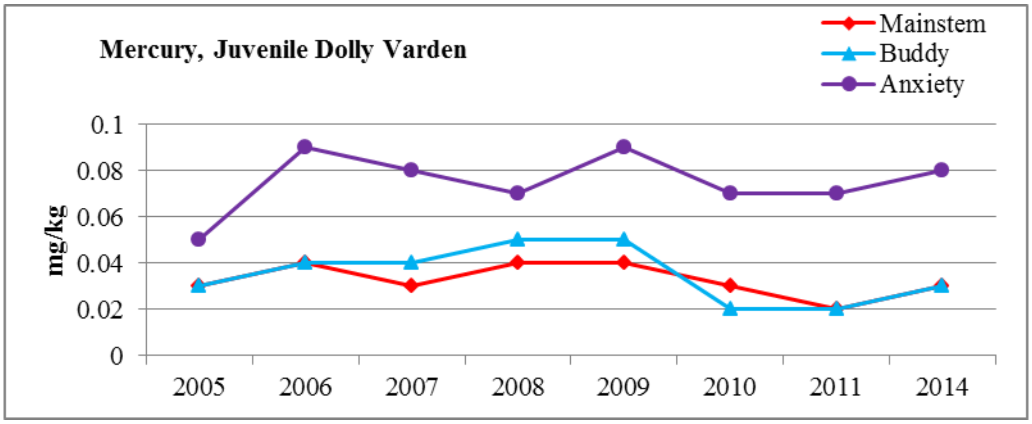


Figure 46. Median Hg whole body concentrations in juvenile Dolly Varden from 2005 to 2014.

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). Station 2 is located on the Wulik River about 2 km downstream from the mouth of Ikalukrok Creek.

In 1997, we added Se and in 1998 we started sampling reproductive tissue, when available in adequate mass. 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 extreme variability of Al in gill tissue and the potential for gill sample contamination during sampling were the reasons for this change. The sample size for each spring and fall sample period has been six fish, except for the fall 2002 sample, when only five fish were caught.

The purpose of sampling adult Dolly Varden for metals concentrations is to monitor changes in tissue metals concentrations and to provide a database for use by other professionals. It is unlikely that tissue metals concentrations in adult fish could be related to events at the Red Dog Mine, since Dolly Varden attain the majority of their growth while in the marine environment. All laboratory work has been done with Level III Quality Assurance. Metals data for 2014 are presented in Appendix 6.

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 appear to concentrate in muscle tissue.

Analyte concentration in various tissues is summarized below and in Figures 47 through 52: One figure is presented for each analyte and contains data for all fish handled from 1999 to 2014.

- ●Cd concentrates in kidney tissue (Figure 47)
- ●Cu concentrates in liver tissue and eggs (Figure 48);
- ●Pb does not concentrate in any specific tissue (Figure 49);
- ●Se concentrates in kidney and eggs (Figure 50);
- ●Zn concentrates in eggs (Figure 51); and
- ●Hg concentrates in kidney tissue (Figure 52).

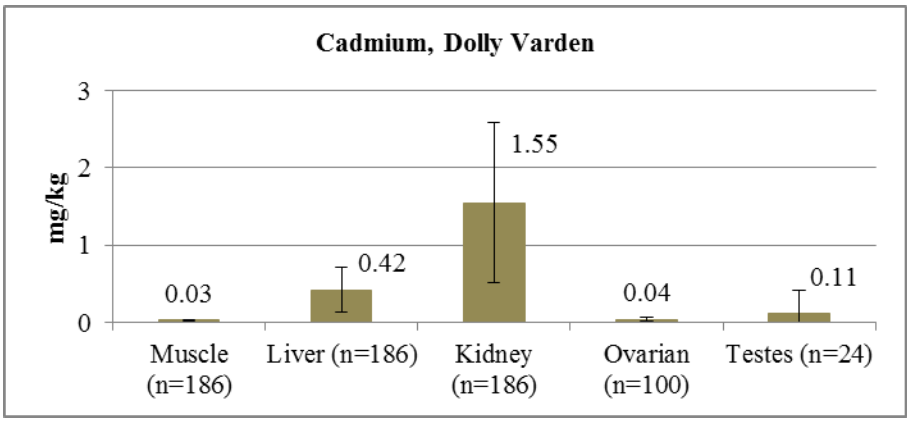


Figure 47. Average Cd concentration (dry weight ± 1SD) in Dolly Varden (1999-2014).

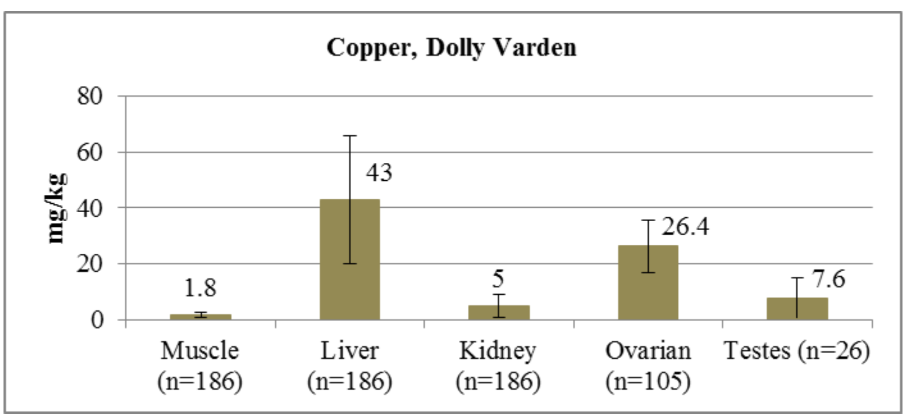


Figure 48. Average Cu concentration (dry weight ± 1SD) in Dolly Varden (1999-2014).

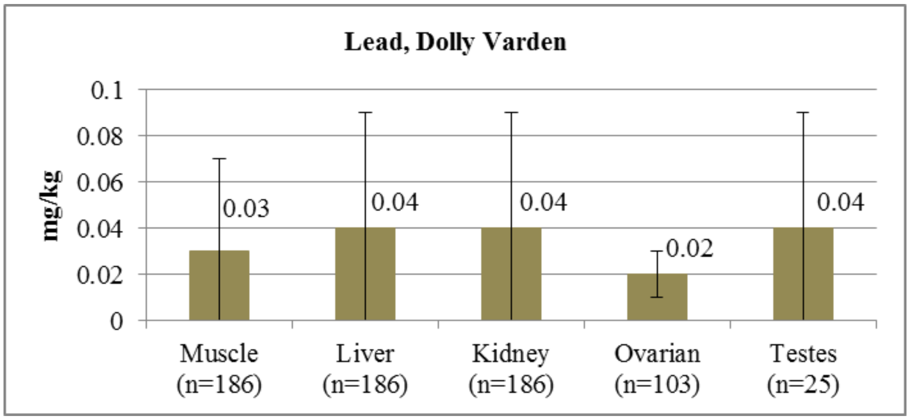


Figure 49. Average Pb concentration (dry weight + 1SD) in Dolly Varden (1999-2014).

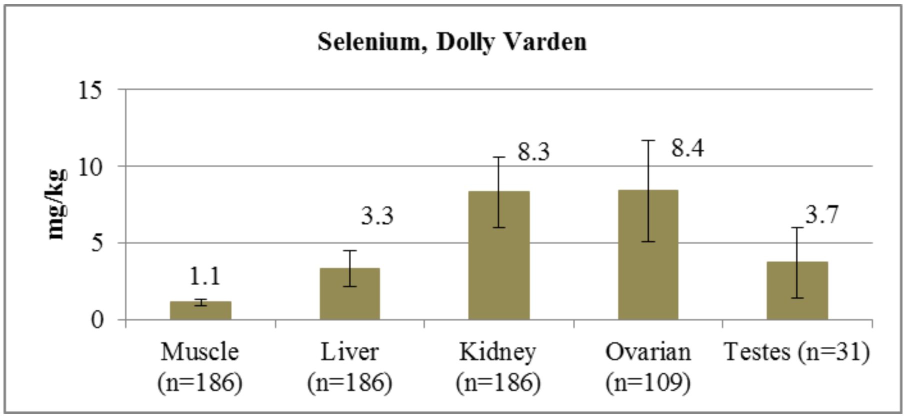


Figure 50. Average Se concentration (dry weight + 1SD) in Dolly Varden (1999-2014).

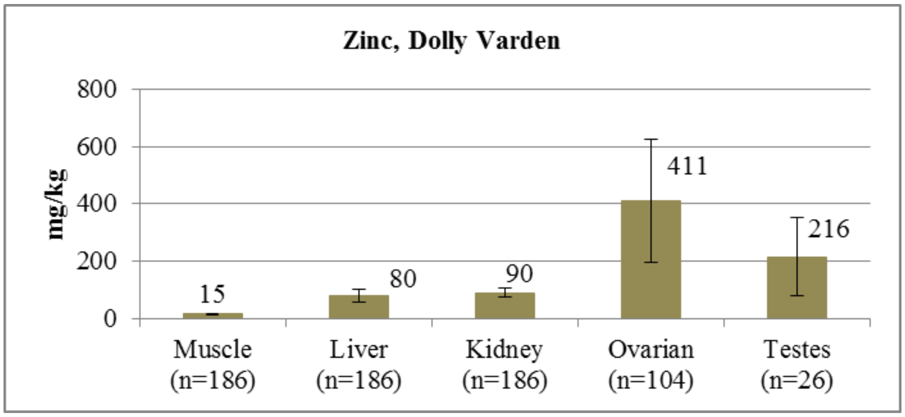


Figure 51. Average Zn concentration (dry weight + 1SD) in Dolly Varden (1999-2014).

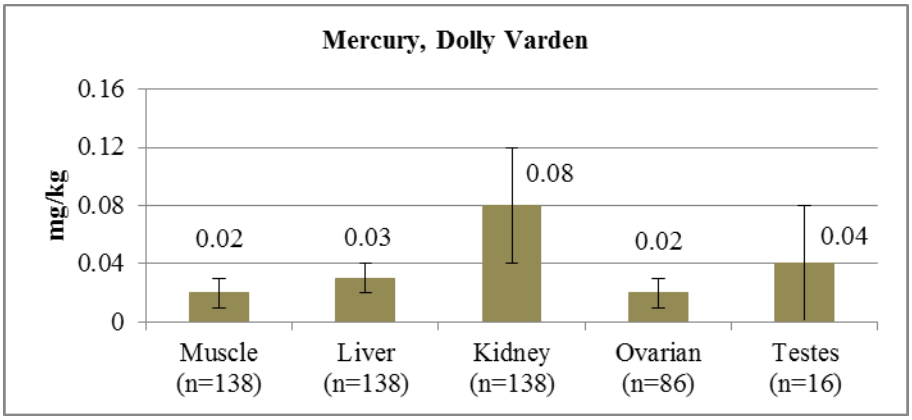


Figure 52. Average Hg concentration (dry weight ± 1SD) in Dolly Varden (1999-2014).

Dolly Varden, Overwintering

Two aerial surveys to estimate the number of overwintering Dolly Varden in the Wulik River were conducted in 2014, September 21 and October 7. Surveys were conducted with an R-44 helicopter provided by Teck (DeCicco 2014). The October 7 survey yielded the highest counts and was conducted under excellent conditions except for slight overcast during the last part of the survey. The permafrost slump located downstream of Driver's camp was not a factor during either survey. In fact, the river had changed and now flows around the slump. Counts began slightly upstream of Kivalina Lagoon.

Late September estimates of Dolly Varden have decreased annually since 2005, reached their lowest (21,084) number in 2012, but then increased in fall 2014 (63,951) (Figure 53, Table 4, and Appendix 7). We hypothesized that, similar to some recent salmon migrations in the Arctic, Dolly Varden may be delaying their migration until later in the fall and that the aerial survey may need to be conducted later in the season.

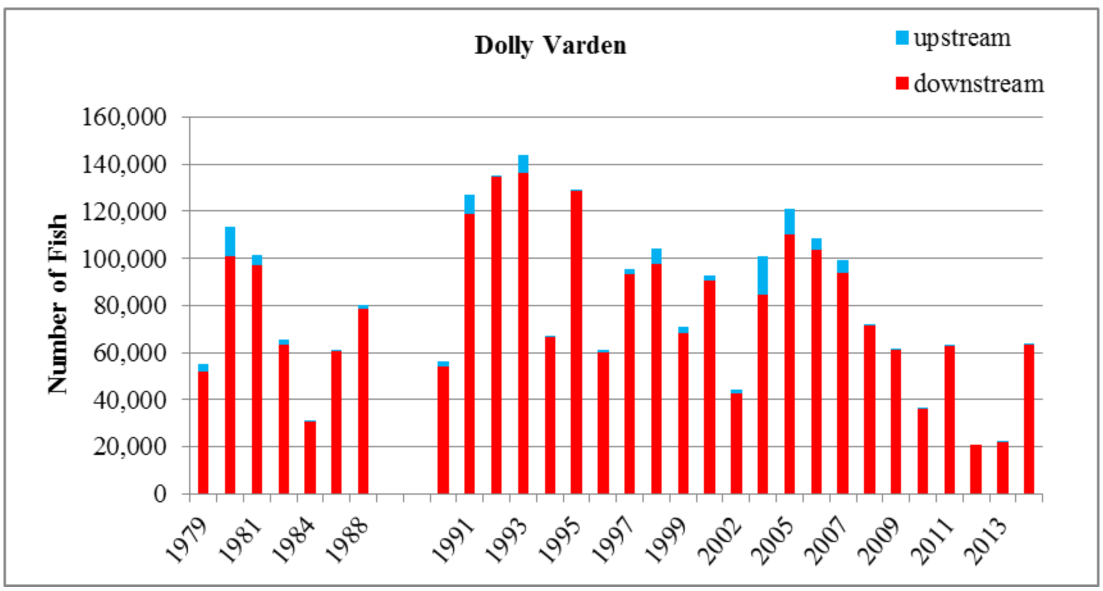


Figure 53. Aerial survey estimate of the number of Dolly Varden in the Wulik River just prior to freezeup.

We will continue to attempt these later surveys, but results will be largely dependent upon weather and survey conditions. The ADF&G Sport Fish Division deployed a DIDSON® (Dual frequency Identification SONar) side-scanning sonar in the Wulik River in spring 2014 to estimate the number of Dolly Varden leaving the Wulik River to feed in marine waters (Scanlon and Savereide 2014). The sonar operated from the evening of May 30 through the morning of June 6. Installation of the sonar went well and it was calibrated correctly. The sonar counted 229 fish moving downstream and 52 fish moving upstream. Generally, Dolly Varden in the Wulik River begin to move downstream after the freshet in spring melt water has passed and the water begins to clear. During our sample period, the water stayed high and turbid and the majority of Dolly Varden probably left the Wulik River after the sonar was removed. In the fall of 2014, 16 adult Dolly Varden were caught in the Wulik River upstream of Ikalukrok Creek and fitted with radio-tags. The radio-tagged fish will be monitored during the spring outmigration when Sport Fish Division deploys the side scanning sonar in the Wulik River.

The number of Dolly Varden estimated in the fall in the Wulik River varies annually. Survey results in 2014 found that 99% of the fish observed were downstream of the mouth of Ikalukrok Creek. Only in 1980 and 2004 has the percentage of fish below Ikalukrok Creek been less than 90% (Table 4). 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.

Table 4. Estimated number of Dolly Varden in the Wulik River.

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
2011	637	62,612	63,249	99
2012	0	21,084	21,084	100
2013	114	21,945	22,059	99
2014	610	63,341	63,951	99

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 5 and Appendix 8). In fall 2014, we flew a survey using an R-44 helicopter. An estimated 2,406 chum salmon (live and dead) were observed in Ikalukrok Creek on September 21 (DeCicco 2014). The weather was clear with a slight wind from the northeast. All chum salmon observed were below Station 160 on Ikalukrok Creek, the furthest downstream location at which the instream TDS limits apply (from July 25 through the end of the discharge season). Our highest count of chum salmon since mining began at Red Dog was in 2006, when we estimated 4,185 chum salmon in Ikalukrok Creek.

Counts of chum salmon in Ikalukrok Creek in 1990 and 1991 (mine discharge began in 1989) were lower than reported in baseline studies in 1981 and 1982. It should be noted that the reported number of chum salmon in 1981 was an extrapolation based on aerial photographs and, therefore are not comparable to other datasets.

Annual aerial surveys, post-mining, were initiated in 1990. Based on the number of chum salmon counted in the Ikalukrok Creek drainage during 1981 and 1982 and recognizing that the 1981 estimate was an extrapolation, data collected suggest that the chum salmon population may have recovered to pre-mining numbers by the mid-1990s and at the latest by the early 2000s.

Table 5. Number of chum salmon adults in Ikalukrok Creek.

Survey Date	Number of Chum Salmon	Reference
September 1981	3,520 to 6,960[1]	Houghton and Hilgert 1983
August September 1982	353 to 1,400	Houghton and Hilgert 1983
August 1984	994	DeCicco 1990
August 1986	1,985	DeCicco 1990
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[2]	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
September 26, 2011	1,507	DeCicco 2011
September 29, 2012	1,198	DeCicco 2012
September 19, 2013	1,480	DeCicco 2013
September 21, 2014	2,406	DeCicco 2014

[1]Chum salmon count was an estimation based on extrapolation from aerial photographs
[2]Counts were made independently by Ott and Townsend

Dolly Varden, Juveniles

Limited pre-mining juvenile Dolly Varden distribution 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 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 sampled for juvenile Dolly Varden in streams within 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 modified program that began in 2010, we sample eight sites with 10 minnow traps per sample reach with about 24 hrs of effort in early-to-mid August (Table 6, Appendix 9). Seven of these sites are unchanged in location 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 6. 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 the species and 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 very low fish mortality. Mortalities do occur and these are associated with flow increases or a large juvenile (> 150 mm) becoming gilled in the entrance to the minnow trap. 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 (Appendix 10); however, the catches among the sample sites follow similar patterns. Generally, the CPUE (total number of fish for ten traps fished for 24 hr) in Anxiety and Buddy creeks is higher than at the other sample reaches. In 2014, the CPUE was highest in Evaingiknuk Creek (17.0) and lowest in North Fork Red Dog Creek (0) (Figure 54).

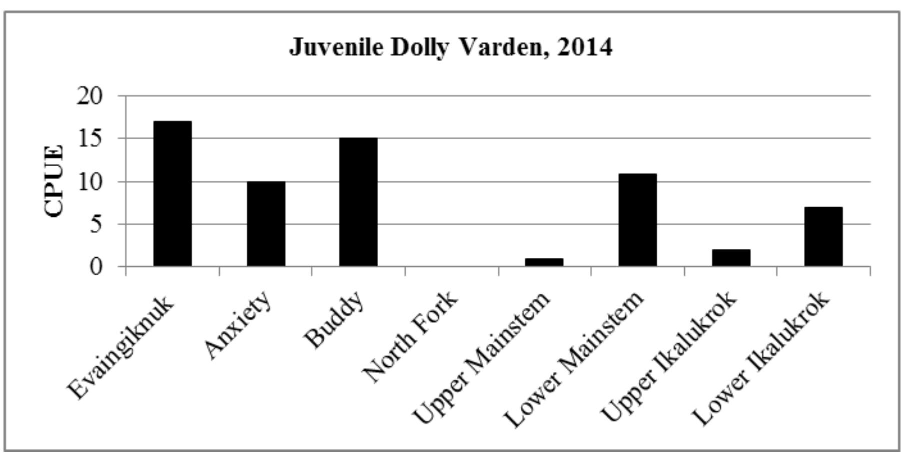


Figure 54. CPUE for juvenile Dolly Varden in the Red Dog Mine sample reaches in 2014.

Natural environmental conditions such as 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. Probably the most important factor is the strength of the age 1 cohort which is directly related to number of spawners, spawning success, and survival the previous winter. The CPUE for juvenile Dolly Varden in Anxiety Ridge and Buddy creeks from 1997 to 2014 reflects the high degree of variability among sample years (Figures 55 and 56). The CPUE follows a similar pattern between Anxiety Ridge Creek and Buddy Creek.

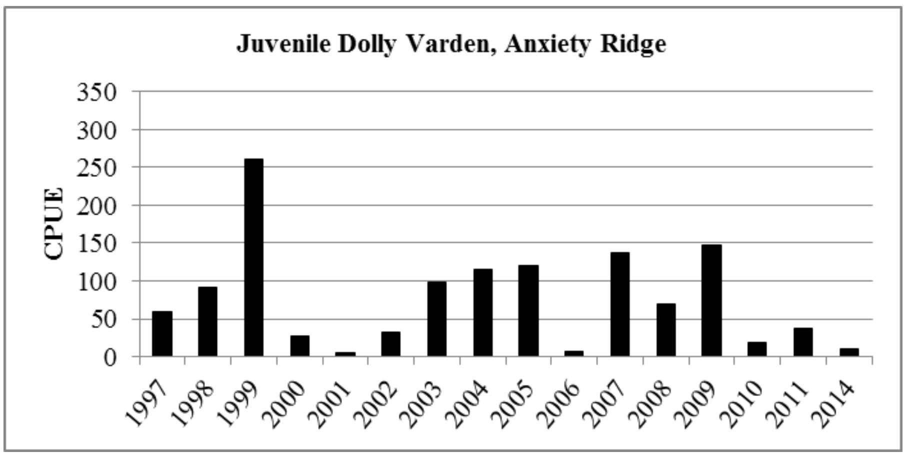


Figure 55. CPUE of juvenile Dolly Varden in Anxiety Ridge Creek.

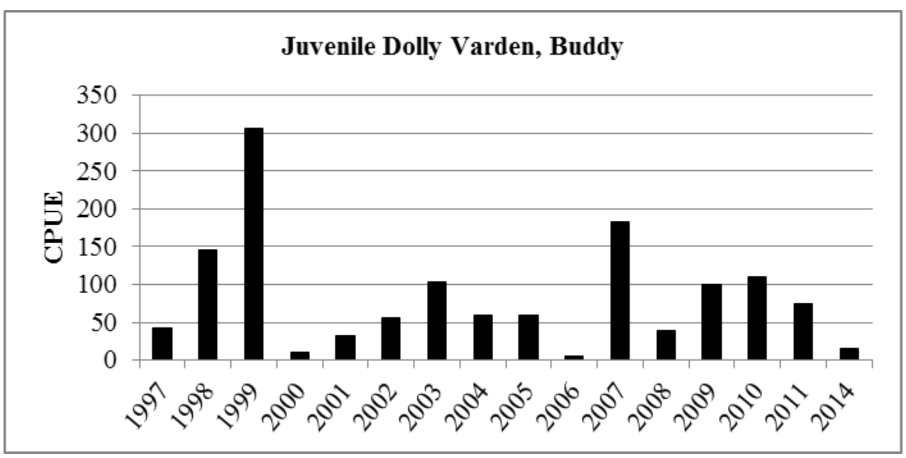


Figure 56. CPUE of juvenile Dolly Varden in Buddy Creek.

The CPUE for lower Mainstem Red Dog Creek from 1997 to 2014 is presented in Figure 57. The CPUE ranged from a low of 2.5 in 2006 to a high of 73.3 in 1999. A similar pattern was found for Anxiety Ridge and Buddy creeks. Catches since 2000 in lower Mainstem Red Dog Creek have remained low, but relatively consistent. Only in 2004 did we not catch any juvenile Dolly Varden in lower Mainstem Red Dog Creek. Use of lower Mainstem Red Dog Creek by juvenile Dolly Varden is substantially greater than what was found by Houghton and Hilgert (1983) during baseline studies.

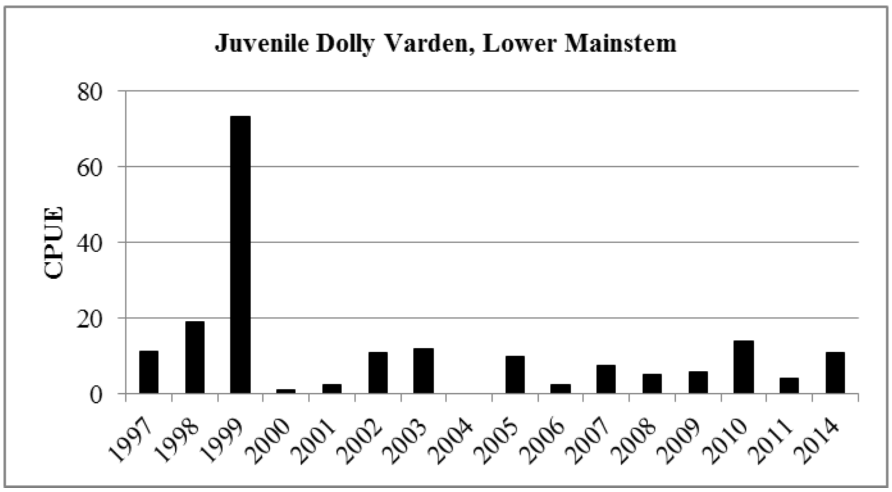


Figure 57. CPUE for juvenile Dolly Varden in lower Mainstem Red Dog Creek.

Anadromous Dolly Varden spend at least one year in freshwater before their migration to the marine environment (DeCicco 1990). Adult Dolly Varden collected from the Wulik River had an average freshwater residency of 3.1$\pm$1.1 years (1 SD, n = 192). Based on length frequency distributions for juvenile Dolly Varden captured in 2014, it is likely all fish were age 1+ (Figure 58). Small Dolly Varden (< 70 mm) captured in late July and August likely are age 0, which were not present in 2014, but were present in 2011 (Figure 59). In previous sample years (1997 to 2014 – excluding 2012 and 2013 when minnow traps were not fished due to high water), age-0 fish were present in our catches in 12 out of 16 years.

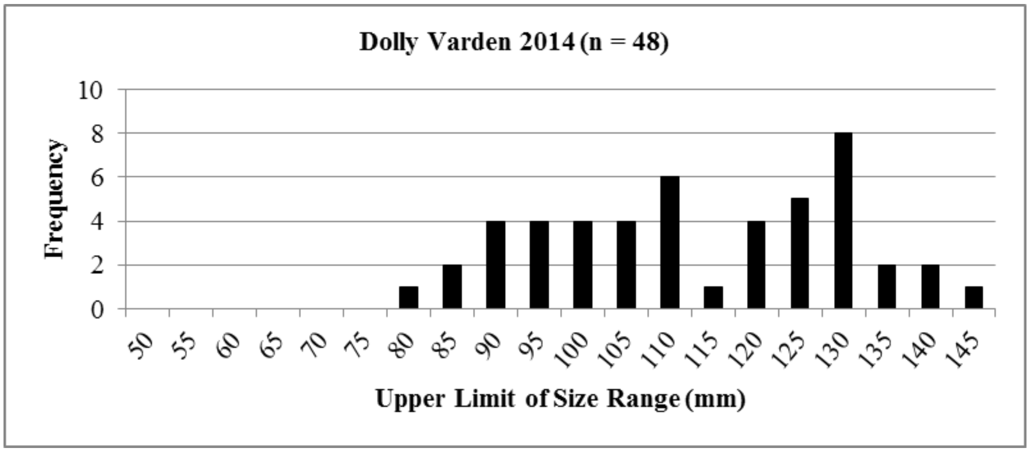


Figure 58. Length frequency distribution of Dolly Varden in the Ikalukrok Creek drainage in fall 2014.

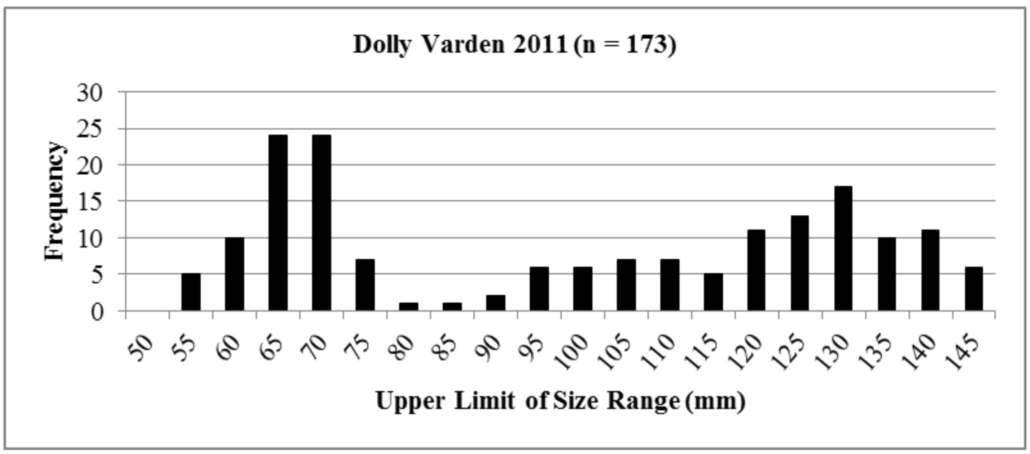


Figure 59. Length frequency distribution of Dolly Varden in the Ikalukrok Creek drainage in fall 2011.

In our catches of Dolly Varden in the Ikalukrok Creek drainage we capture some fish that are > 145 mm. Some of these fish are resident and have not been to the marine environment. These resident fish are identified by their coloration (orange dots and white edges on the pelvic fins) and sexual condition (milt observed). During spring each year, fyke net(s) are fished in North Fork Red Dog Creek for the primary purpose of catching Arctic grayling. However, Dolly Varden also are caught in the fyke nets and generally these fish are larger than those caught later in the summer in minnow traps. In spring

2014, we caught four Dolly Varden that averaged 128 mm long (Figure 60). Many of the Dolly Varden caught in North Fork Red Dog Creek are freshwater resident (non-anadromous) fish due to size (larger than smolts), obvious parr marks, and distinct orange/pink dots.

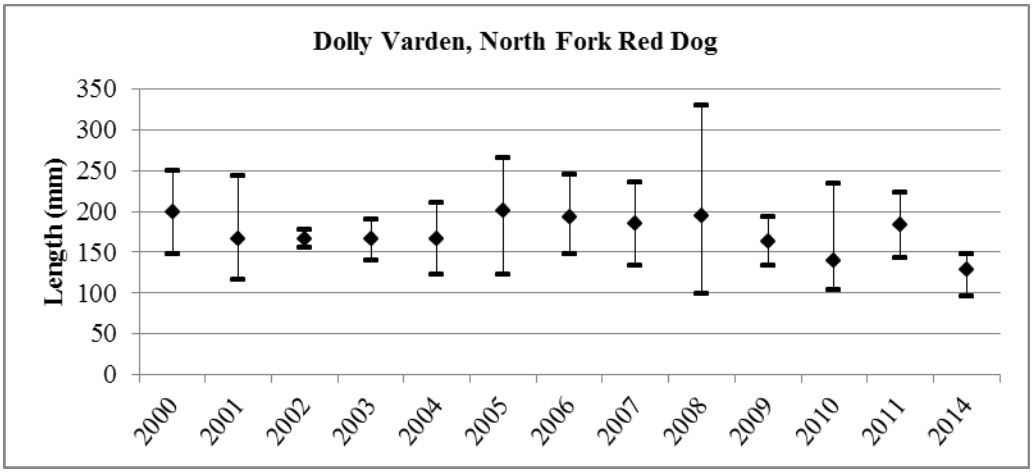


Figure 60. Dolly Varden caught in fyke nets fished in North Fork Red Dog Creek in spring during the Arctic grayling spawning run. Average, maximum, and minimum lengths are shown for each sample year.

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 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. A few juvenile Arctic grayling were collected in North Fork Red Dog Creek prior to mine development. Dolly Varden and Arctic grayling fry mortality was reported in Mainstem Red Dog Creek by EVS Consultants and Ott Water Engineers (1983) and Ward and Olsen (1980). Since 1994, we have documented Arctic grayling use of Mainstem Red Dog Creek and have not observed any fish mortalities (Appendix 11).

Arctic Grayling Spawning

We have monitored Arctic grayling spawning during the spring in North Fork Red Dog and Mainstem Red Dog creeks since 2001. The purposes of this sampling effort are to document when spawning has been substantially completed in Mainstem Red Dog Creek and to assess the return of Arctic grayling to North Fork Red Dog Creek. Spring water temperatures and timing of warming appear to be the key variables determining spawning success, spawning time, fry emergence, first year growth, and likely survival. High flows during or immediately following spawning can have a negative effect on fry survival (Clark 1992).

Discharge volume and quality from the wastewater treatment facility at the Red Dog Mine 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 rest 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 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 TDS limit of 1,500 mg/L at Station 151.

We used a fyke net to capture Arctic grayling in North Fork Red Dog Creek from June 9 to 14, 2014 (Figure 61). On June 9 flows peaked at 300 cfs at 0910 hours, delaying the deployment of the fyke net; however, by June 11 discharge had dropped to 180 cfs. This decrease in discharge allowed us to deploy the net fyke net and allow it to fish for about three days.

Figure 61. Looking downstream at the fyke net in North Fork Red Dog Creek, June 2014.

We caught a total of 37 Arctic grayling in North Fork Red Dog Creek in June 2014. The CPUE peaked on June 12 (Figure 62). All of the Arctic grayling captured were juvenile fish, except for four spent females on June 12. Most of the large mature Arctic grayling had already moved into North Fork Red Dog Creek before the fyke net was set.

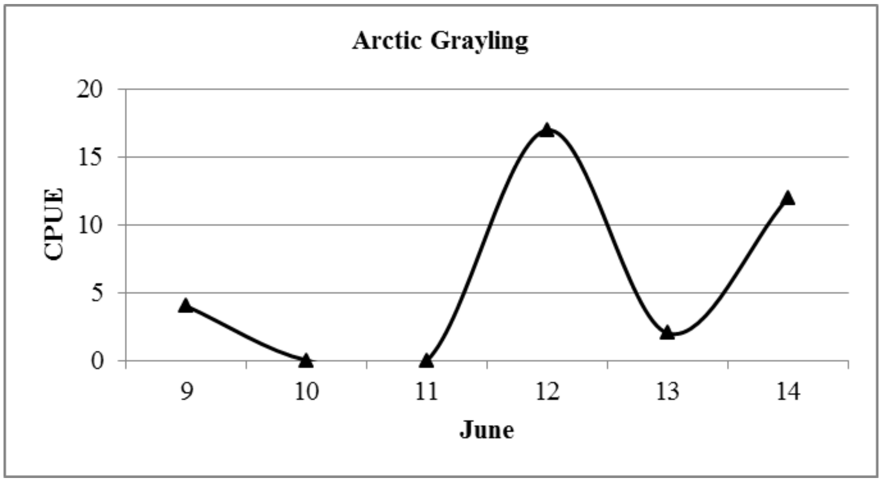


Figure 62. CPUE (fish/day) in North Fork Red Dog Creek in June 2014.

Limited spawning could have started on June 5 when the water temperature exceeded 3.0°C (Figure 63). Based on these data, it appears that spawning was substantially complete in Mainstem Red Dog Creek by June 11 (Table 7). Water temperatures were consistently higher in Mainstem Red Dog Creek than in North Fork Red Dog Creek.

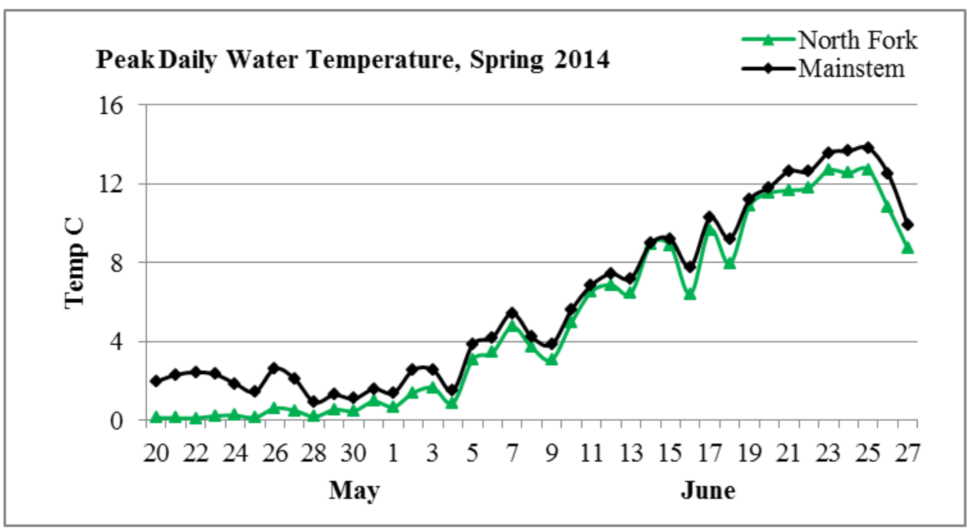


Figure 63. Peak daily water temperatures in North Fork Red Dog (Station 12) and Mainstem Red Dog (Station 151) Creeks.

Table 7. 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
2011	June 6	June 9	4
2012	May 27	June 4	7
2013[3]			
2014	June 5	June 11	4

[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.

[3]Arctic grayling sampling was not conducted in spring 2013 due to extremely high water throughout the spring sampling period.

Arctic Grayling Fry

Since 1992, we have estimated the relative abundance of Arctic grayling age-0 fish in North Fork Red Dog Creek (Appendix 12). Estimates are made in early July of each year after the eggs have hatched and the fry have absorbed the yolk sac. In 2014, spawning success in North Fork Red Dog Creek probably was low due to high water during spawning. However, Arctic grayling fry were present along the stream margins and one group of 20 to 30 was observed in the vicinity of Station 151 (just downstream of North Fork Red Dog Creek).

Arctic Grayling Catches and Metrics

In spring 2014, we handled 37 Arctic grayling in North Fork Red Dog Creek caught with fyke nets (Figure 64). Thirty three of these fish were immature. Recruitment of immature fish to North Fork Red Dog Creek has been strong since 2007 and may be due in part to juvenile fish leaving Bons Pond and returning to North Fork Red Dog Creek (Figure 65).

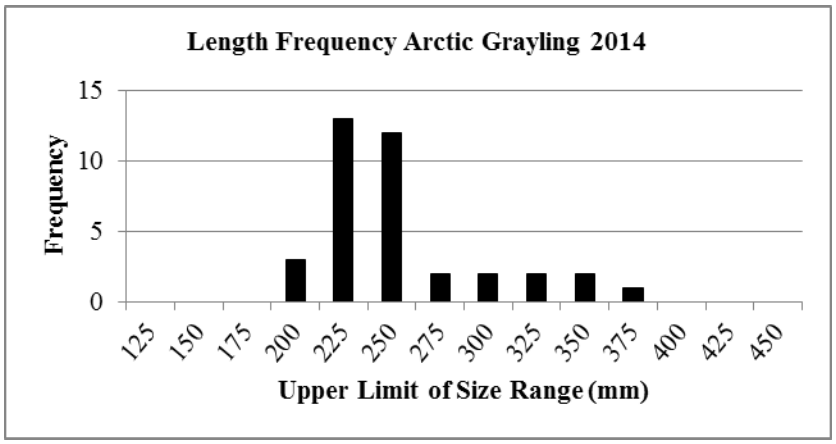


Figure 64. Length frequency distribution of Arctic grayling in June 2014.

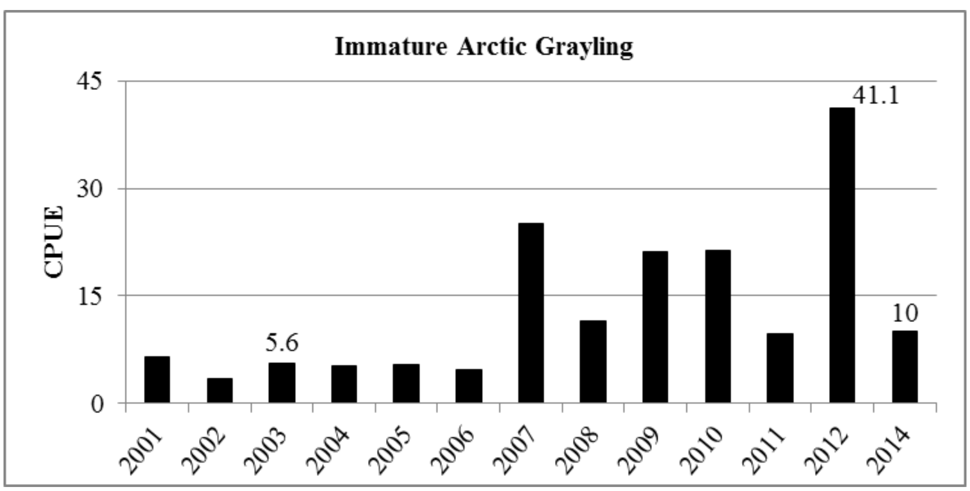


Figure 65. Average CPUE (fish/day) of immature Arctic grayling in North Fork Red Dog Creek from spring 2001 to spring 2014. No sampling was done due to high water in spring 2013.

Catches of mature Arctic grayling in North Fork Red Dog Creek have remained stable since 2001 (Figure 66). Our highest CPUE was 37.6 fish/day in 2007 and our lowest was 1.3 fish/day in 2014. Most of the variability in the catches is related to temporal variability in spring breakup, warming water temperatures, and sampling efficiency. Sampling events are limited to times of lower discharge ($\leq$ 100 cfs) when fyke nets can be set and fished effectively.

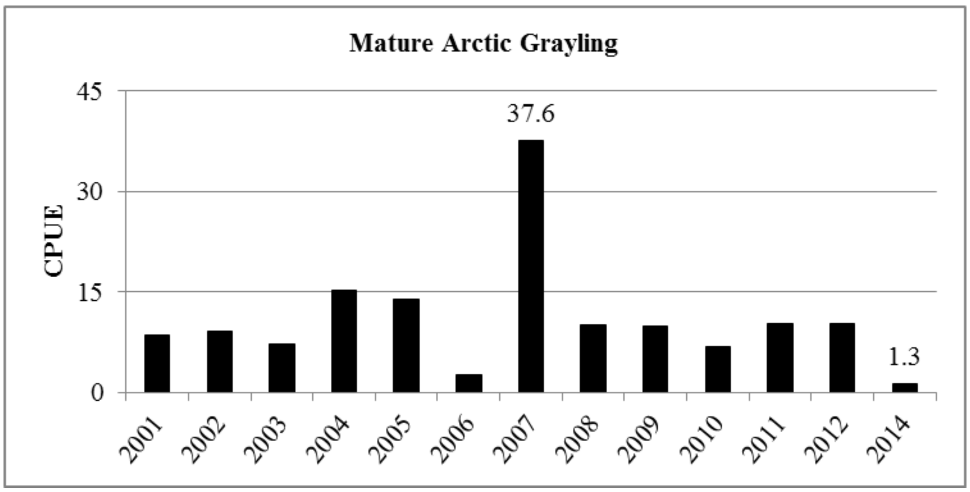


Figure 66. Average CPUE (fish/day) of mature Arctic grayling in North Fork Red Dog Creek from spring 2001 to spring 2014. No sampling was done due to high water in spring 2013.

Some of the Arctic grayling caught in the North Fork Red Dog Creek are fish that were marked in Bons Pond. The percentage of marked fish coming from Bons Pond in our 2014 sample was 0% (Figure 67). Since 2008, we have observed a decrease in the percentage of Bons Pond Arctic grayling being captured in North Fork Red Dog Creek. This decrease is due to the fact that the number of fish $\geq$ 200 mm in Bons Pond also has been declining since 2007.

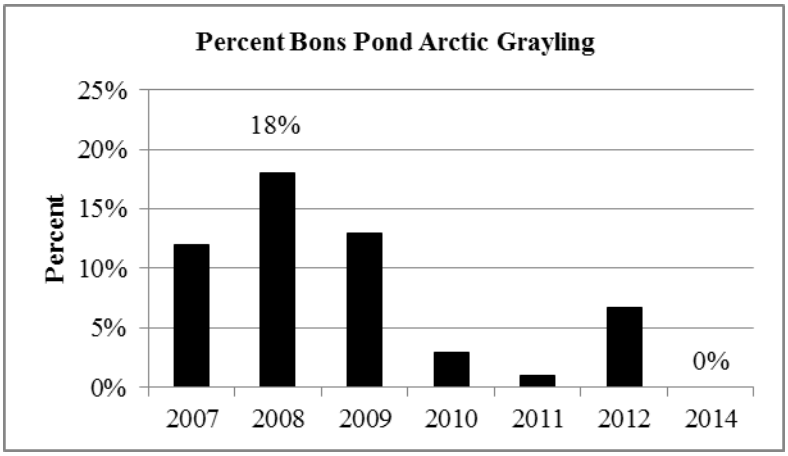


Figure 67. Percent of marked fish caught in North Fork Red Dog Creek that were marked in Bons Pond.

The average growth rate (mm/year) for Arctic grayling between 250 and 300 mm long when marked and at large for about one year is presented in Figure 68. Fish growth data includes only those fish marked the previous year and recaptured the following spring. Recapture numbers in any given year are low (1 to 7 fish per year).

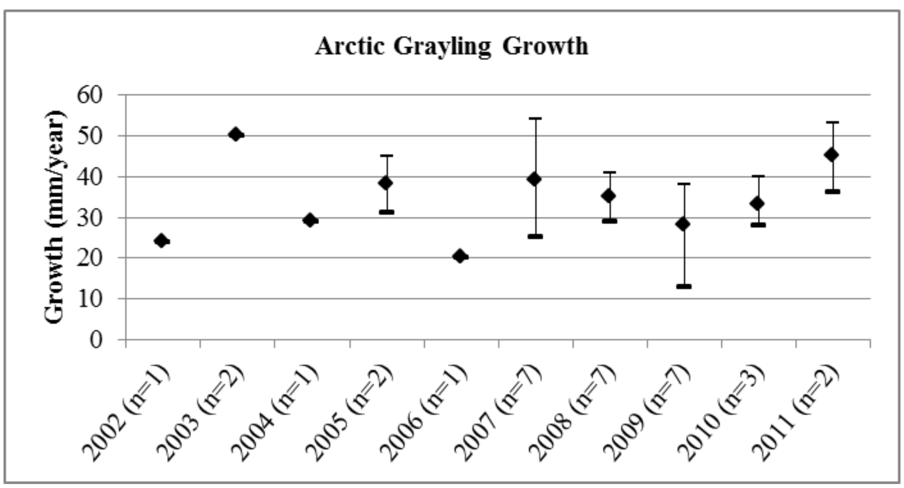


Figure 68. Average, maximum, and minimum annual growth of Arctic grayling in North Fork Red Dog Creek for fish between 250 and 300 mm long when marked.

The population of Arctic grayling in North Fork Red Dog Creek, pre-mining, is not known. We attempt to make population estimates each year, but in some years the number of recaptures is not adequate to make the estimate with any level of confidence. The highest population estimate was 1,422 in 2010 and the lowest estimate was 942 in 2011 (Figure 69). The 2011 population estimate based on the 2012 recapture event was the last year where we had adequate marks and recaptures for an estimate of the population. The confidence limits overlap for all of the population estimates suggesting that there are no significant differences among years.

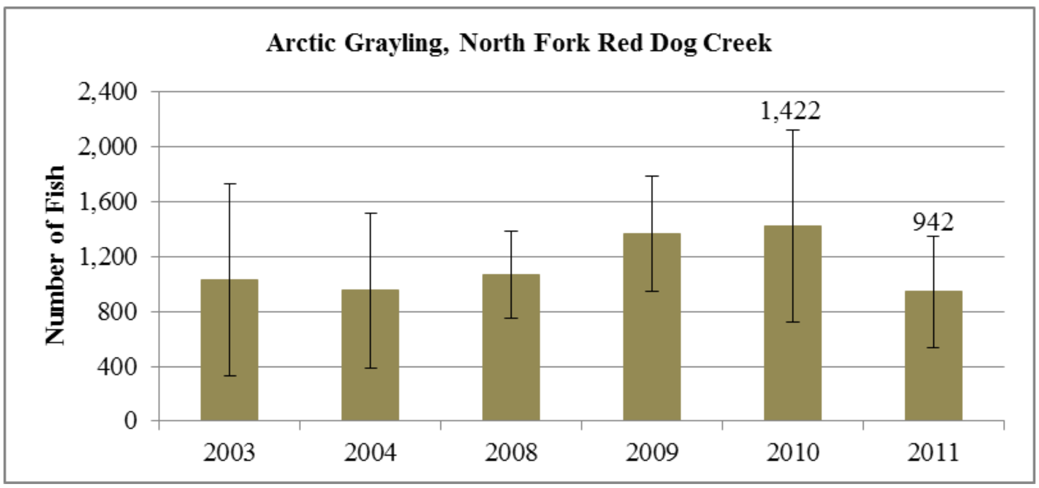


Figure 69. The estimated Arctic grayling population (95% CI) in North Fork Red Dog Creek for fish ≥ 200 mm long.

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 (Figure 70). Bons Creek flows into Buddy Creek and eventually into Ikalukrok Creek.

Figure 70. Outlet of Bons Pond – Arctic grayling leaving Bons Pond go over the falls and into Bons Creek.

The Arctic grayling population in Bons Pond is the result of a fish transplant conducted in 1994 and 1995 (Ott and Townsend 2003). In 1994, fish from North Fork Red Dog Creek that 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) were transplanted to Bons Pond. In 1995, about 200 fry were caught in North Fork Red Dog Creek and moved to Bons Pond.

In 1996 and 1997 visual observations and fyke net sampling in Bons Pond were conducted and no fish were caught or observed. In summers 1995 to 1997, 12 of the marked Arctic grayling transplanted to Bons Pond were recaptured in North Fork Red Dog Creek. Initially, it was believed that the fish transplant was unsuccessful. 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 conducted in Bons Pond to determine fish use and the estimated Arctic grayling population 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 the 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 analysis.

Bons Creek, upstream of Bons Pond, is incised with streambanks vegetated with willows and sedges, and measures 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.

A diversion ditch was constructed to carry surface water around the waste rock stockpile. Thermal and hydraulic erosion in the diversion ditch contributes seasonally to the sediment and organic load in Bons Creek. Most of the Bons Creek drainage area is in ice-rich permafrost with thermal erosion and sediment/organic input that varies with seasonal conditions. Generally, there is a high input of sediments and organics to Bons Creek, particularly during rainfall events.

Arctic Grayling Fry

Drift nets, which have been used to sample aquatic invertebrates in Bons Creek upstream of Bons Pond since 2004, are also effective in catching Arctic grayling fry. Each year in the summer (usually the first week of July), five drift nets are set for a duration of one hour and the contents placed in a container for later analyses (Figure 71). In five of 11 years of sampling, catches of Arctic grayling fry have been zero. The highest number of Arctic grayling fry caught was 78 in five drift nets in 2007 (Figure 72).

Figure 71. Looking upstream at drift nets in Bons Creek upstream of Bons Pond in 2014.

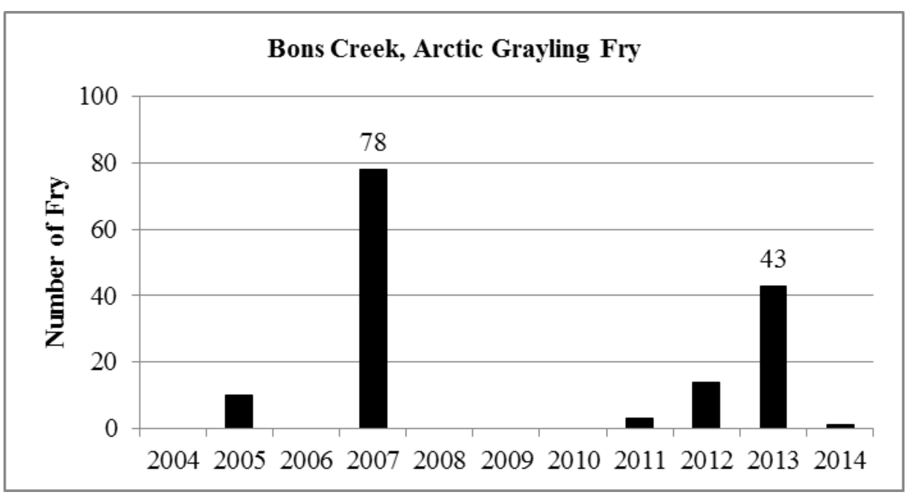


Figure 72. Number of Arctic grayling fry caught in drift nets.

Arctic Grayling Catches and Metrics

We fished a fyke net in Bons Creek from June 9 to June 14, 2014, and caught 266 Arctic grayling. Most of the Arctic grayling were caught in the fyke net (n = 261); however, some fish (n = 5) were captured by angling in the outlet of Bons Pond. Our mean CPUE (#fish/day) for the fyke net in 2014 was 52 (Figure 73). The CPUE for Arctic grayling < 200 mm has ranged from 1 to 38 since 2006 (Figure 74). Catch rates in 2012 and 2014 are some of the highest, with the exception of 2006.

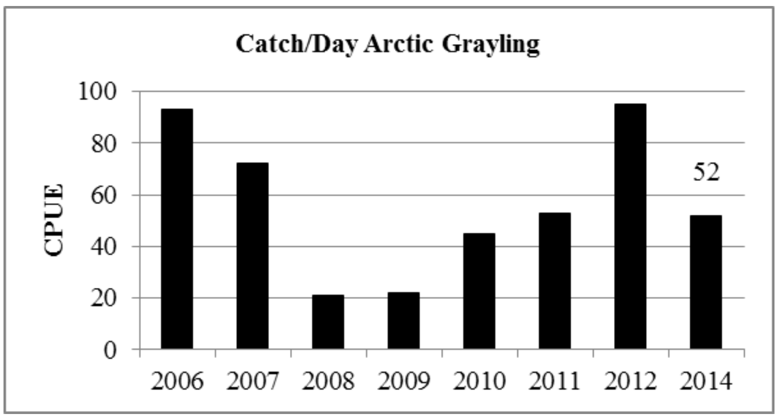


Figure 73. CPUE for all Arctic grayling in Bons Creek.

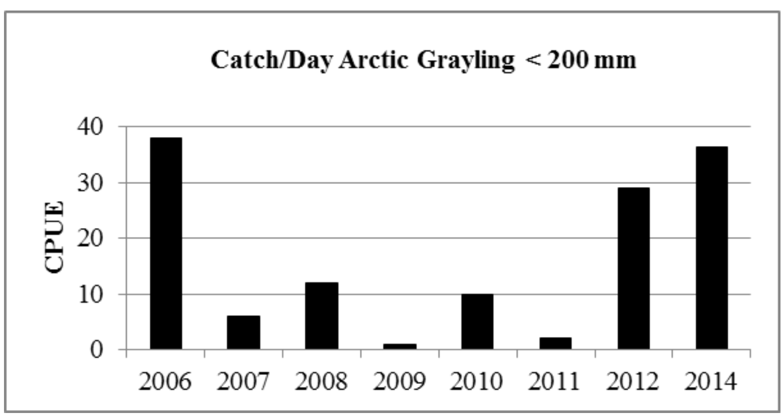


Figure 74. CPUE for Arctic grayling < 200 mm in Bons Creek.

The length frequency distribution for Arctic grayling caught in fyke nets and by angling in spring 2010, 2011, 2012, and 2014 is presented in Figure 75. The current population in Bons Pond consists of a small number of mature fish with a large number of juvenile fish suggesting that the population (≥ 200 mm) is likely to increase.

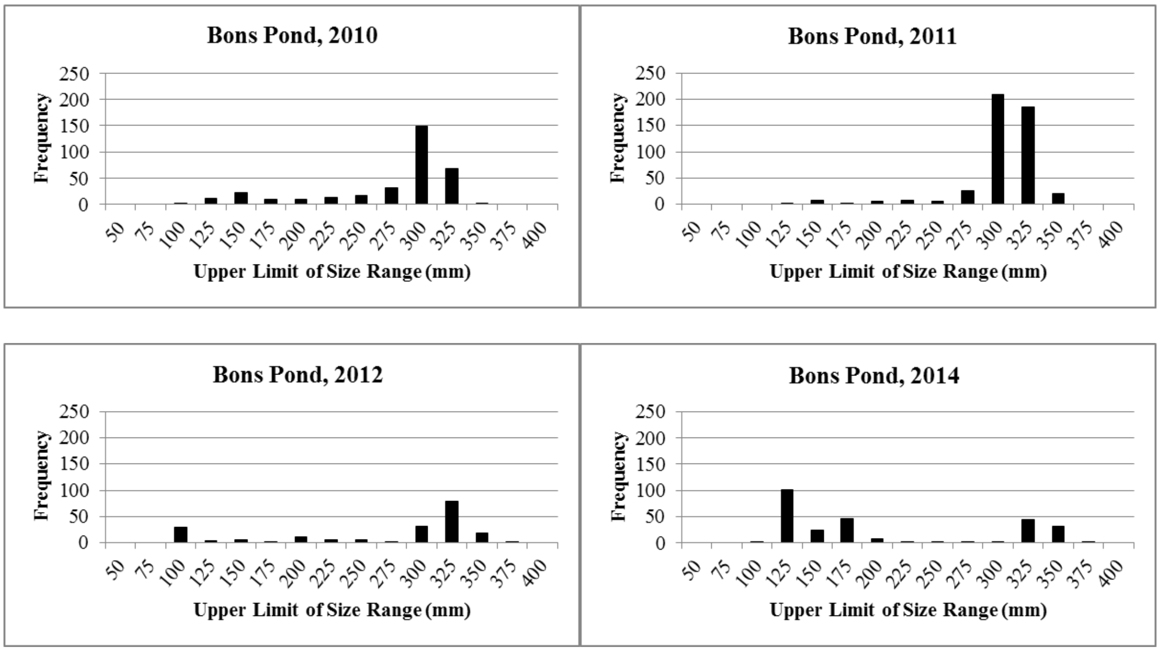


Figure 75. Length frequency distribution of Arctic grayling in Bons Pond in spring 2010, 2011, 2012, and 2014.

Growth rates for Arctic grayling from Bons Pond are much less than for comparable sized fish from North Fork Red Dog Creek. Growth data were not obtained for 2012 and 2013 because of high water and a lack of recaptures. Growth rates by size group (< 250 mm and ≥ 250 mm at marking) are presented in Figures 76 and 77. The number of recaptured Arctic grayling that were less than 250 at marking was relatively high in 2003 and 2004 and had average growth rates of 20 mm and 37 mm, respectively. Annual growth rates for larger fish (≥ 250 mm) generally were less than 10 mm except for 2011 when the average growth was 15 mm.

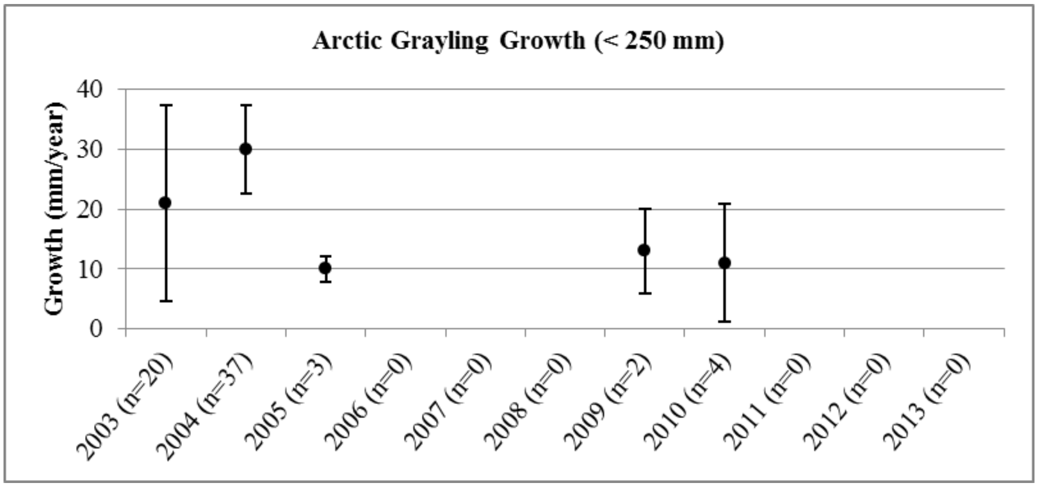


Figure 76. Average annual growth (± 1SD) of Arctic grayling < 250 mm at time of marking.

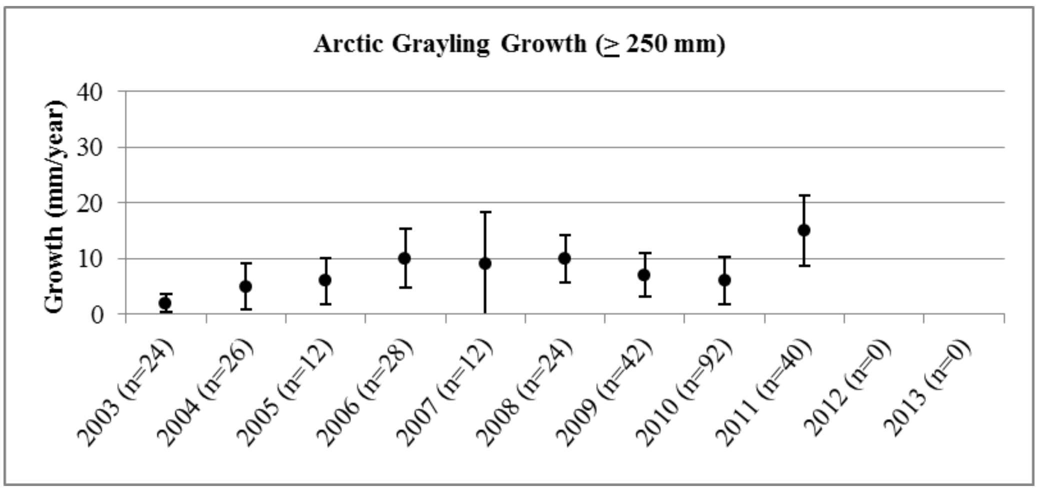


Figure 77. Average annual growth (± 1SD) of Arctic grayling ≥ 250 mm at time of marking.

We estimated the 2012 Arctic grayling population in Bons Pond using 2012 as the mark event and spring 2014 as the recapture event. We had 144 marked fish in summer 2012 that were either recaptures or new marks. In spring 2014, we caught 83 Arctic grayling of which 16 were recaptures from the spring 2012 mark event. Based on these values, our estimated Arctic grayling population for 2012 is 715 fish±277 (95% CI) ≥ 200 mm long. The population estimates show a continuous decrease in the population beginning in 2005 (Figure 78).

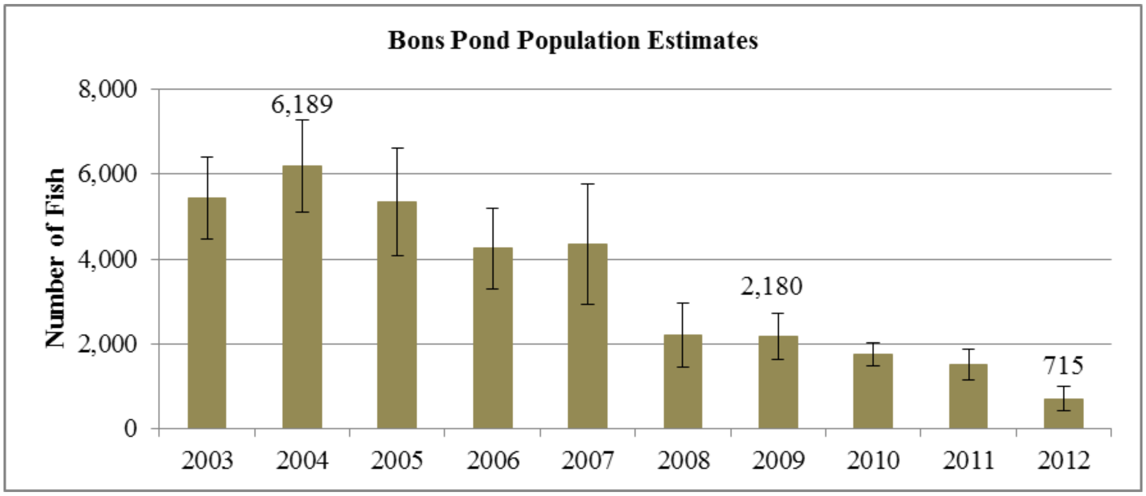


Figure 78. Estimated Arctic grayling population (95% CI) in Bons Pond for fish ≥ 200 mm long.

Slimy Sculpin

Houghton and Hilgert (1983) found slimy sculpin in Ikalukrok and Dudd creeks, but none were observed or caught in the Red Dog Creek drainage. However, in 1995, slimy sculpin were captured in both Mainstem Red Dog and North Fork Red Dog creeks (Weber Scannell and Ott 1998). They were captured again during the spring Arctic grayling sampling event in 2008 and 2009 ranging in size from 129 to 142 mm total length.

Minnow trap data (CPUE is for 10 minnow traps fished for 24 hr) since 1997 for lower Mainstem Red Dog Creek is presented in Figure 79. There is no apparent trend with CPUE varying from 0 to a high of five in fall, 2009.

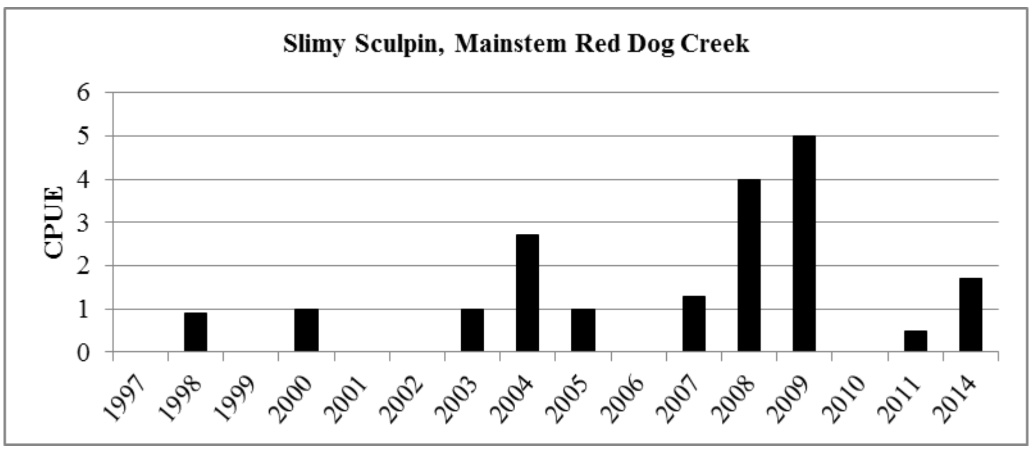


Figure 79. CPUE of slimy sculpin caught in Mainstem Red Dog Creek at the sample reach in the vicinity of Station 10 near the mouth of the creek.

In 2010, we moved our minnow trap sample reach from Station 7 on Ikalukrok Creek to a new site on the same system, upstream of Station 160. The new sample reach in Ikalukrok Creek is similar to Station 7 in that there are multiple channels. The CPUE has varied from a low of 0 to a high of 24 in 2004 (Figure 80). Catches of slimy sculpin generally are higher in Ikalukrok Creek than in the other sample reaches located in North Fork Red Dog, Mainstem Red Dog, upper Ikalukrok (Station 9), Buddy, Anxiety, and Evaingiknuk creeks. These data are consistent with findings by Houghton and Hilgert

(1983) in the early 1980s prior to development of the Red Dog Mine when they reported slimy sculpin to be numerous in Ikalukrok Creek, but different in that we now find slimy sculpin in the Red Dog Creek drainage.

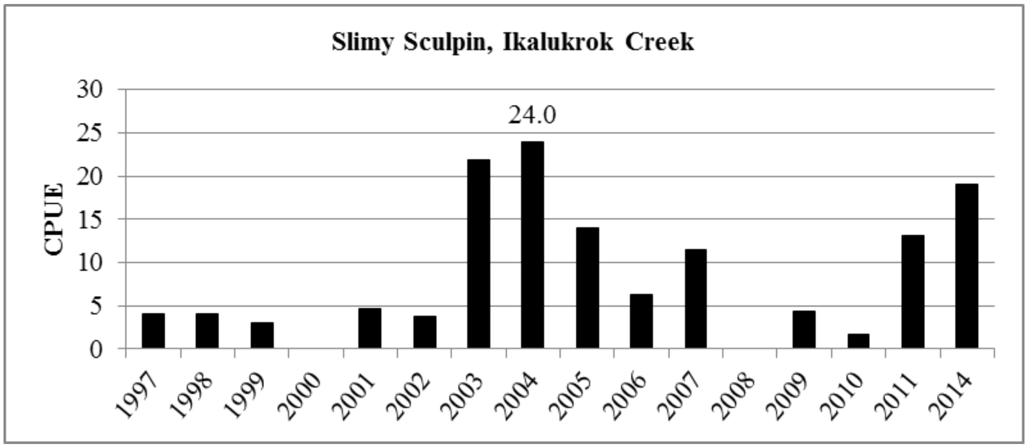


Figure 80. CPUE of slimy sculpin caught in Ikalukrok Creek at Station 7 (1997 to 2009) and Station 160 (2010, 2011, and 2014).

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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

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

Appendix 1 (continued)

2008

●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

●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

Appendix 1 (continued)

2008

●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

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

Appendix 1 (continued)

2009

- ●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
- ●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

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

Appendix 1 (continued)

2010

●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
●We estimated the Arctic grayling population (fish $\geq$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

Appendix 1 (continued)

2010

●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

2011

●Technical Report No. 11-01 titled "Aquatic biomonitoring at Red Dog Mine, 2010 National Pollution Discharge Elimination System Permit (NPDES) No. AK-003865-2" was submitted to EPA and ADEC on February 2, 2011

●In mid-February, Teck approved funding to support a radio telemetry project on Arctic grayling in North Fork Red Dog Creek

●On March 11, 2011, ADNR approved modifications (fertilizer rates and composition, use of wild native seeds) to the Reclamation Plan

●On March 30, 2011, ADNR approved modifications to the waste rock segregation criteria as submitted by Teck

●Reports were received from hunters in April of a foul odor up the Wulik River and Teck responded by sending out an inspection crew – they went to Jakes seep along Ikalukrok Creek – the seep was active with a fair amount of gas being released and the odor was very noticeable downwind

●On May 8, 2011, Teck notified EPA (by letter) of plans to utilize Waste Treatment Plant (WTP1) in parallel with WTP2 in order to facilitate more efficient treatment of tailings impoundment (reclaim) water

●On May 15, 2011, Teck notified EPA (by letter) that the discharge through Outfall 001 was initiated at about 0830 – seasonal discharge was terminated on September 24, 2011

●On June 6, 2011, Teck sent a letter to ADF&G summarizing work conducted to clear bridges and culverts of snow and ice along the Port Road prior

●On June 13, 2011, Teck notified EPA by letter of an exceedance in TDS collected at Outfall 001 on May 17 – Teck also indicated that they continue to be in compliance with TDS at Station 151

●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 2, 7 adult Dolly Varden were captured and retained for metals analyses of selected tissues

●15 mature Arctic grayling were surgically implanted with radio transmitters between June 5 and 11 – all fish were caught and tagged in North Fork Red Dog Creek

Appendix 1 (continued)

2011

●Arctic grayling with radio transmitters were radio-located in July, September, October and November – initially they distributed throughout the Ikalukrok Creek drainage but by fall most were in lower Ikalukrok Creek in a reach used by chum salmon for spawning – on the last survey in early November most of the fish were in the Wulik River between the mouth of Ikalukrok Creek to a location several km downstream of the mouth of Tutak Creek
●In mid-July, periphyton and aquatic invertebrate samples were collected at all the NPDES and ADEC sites
●In late August, 2011, juvenile Dolly Varden sampling was conducted and 42 fish were retained for whole body metals analyses
●On September 27, 7 adult Dolly Varden were captured and retained for metals analyses of selected tissues and an aerial survey of chum salmon spawners in Ikalukrok Creek was conducted on September 25 – 1,507 chum salmon (live and dead) were counted
●Two aerial surveys of Dolly Varden in the Wulik River were flown (September 26 and October 6). The first survey found 16,916 Dolly Varden, but on October 6 DeCicco estimated 64,499 Dolly Varden – a substantial increase from the earlier survey
●seasonal discharge from Outfall 001 was terminated on September 24, 2011
●on November 5, an aerial tracking survey to relocate 14 radio tagged Arctic grayling was conducted finding 9 in the Wulik River, 2 in lower Ikalukrok Creek, 2 in North Fork Red Dog Creek, and 1 in Grayling Junior Creek – the fish in North Fork Red Dog and Grayling Junior creeks had not moved and are presumed to be dead

2012

●Technical Report No. 12-02 titled “Aquatic biomonitoring at Red Dog Mine, 2010 National Pollution Discharge Elimination System Permit (NPDES) No. AK-003865-2” was submitted to EPA and ADEC on March 1, 2012
●Discharge through Outfall 01 to Red Dog Creek began on May 8 and was postponed on June 8 with treated discharge water then routed to either the main pit or back to the tailings impoundment for the remainder of the 2012 discharge season. Discharge to Red Dog Creek was postponed to facilitate repairs to the water treatment plant and was not resumed due to elevated Se concentrations
●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 in 2012 (recruitment has been strong the last 6 years)

Appendix 1 (continued)

2012

●In early June, radio tagged Arctic grayling were radio-located. Analysis of relocation sites for each fish indicated a 64% mortality rate from 2011 to spring 2012

●On June 3 and 4, adult Dolly Varden were captured and retained for metals analyses of selected tissues – these fish were caught by angling in the Wulik River near Station 2

●In early June, Arctic grayling were captured in Bons Creek and Bons Pond. Growth rates for summer 2011 increased compared with previous years and fish appeared to be more robust and in better condition

●In June, Teck made required notifications to EPA and the State that TDS at Outfall 001 exceeded the end-of-pipe limitation, but TDS did not exceed the applicable state water quality standard at Station 151 in Mainstem Red Dog Creek

●In June, Teck made required notifications to EPA and the State that Se analytical results for Outfall 001 potentially exceeded the limitation set in the 1998 NPDES permit. Currently, Teck is not discharging to Red Dog Creek.

●In early July, periphyton and aquatic invertebrate samples were collected in accordance with permit requirements

●In August, Teck made required notifications to EPA and the State that the diversion structure along the western perimeter of the Aqqaluk Pit had over-topped as a result of a major precipitation event (over three inches of precipitation during a 24-hr period). A temporary repair of the diversion structure was made immediately

●Our mid-August field trip (August 11 to 19) to Red Dog to sample juvenile Dolly Varden was made, but due to extremely high rainfall actual sampling could not be done

●Three aerial surveys of Dolly Varden in the Wulik River were flown (September 27 and 29 and October 10). The second survey (best conditions) found 21,084 Dolly Varden in the Wulik River

2013

●Teck continued to mine ore from the Aqqaluk Pit

●Technical Report No. 13-01 titled "Aquatic biomonitoring at Red Dog Mine, 2012 National Pollution Discharge Elimination System Permit (NPDES) No. AK-003865-2" was submitted to EPA and ADEC on February 28, 2013

●Discharge through Outfall 001 to Middle Fork Red Dog Creek began on May 26, 2013 and ended on September 20, 2013

●An environmental audit of the Red Dog Mine operation was initiated. The scope of the audit does not include the road or Port Facility. The audit is required by the Waste Management Plan and Closure Plan Approval

Appendix 1 (continued)

2013

●The State of Alaska (ADEC) and Teck entered into a Compliance Order by Consent for Se in the waste water discharge. Se concentrations exceeded the permit limits at Outfall 001 on several occasions, but did not exceed the Fresh Water Aquatic Life Criterion of 5.0 *u*g/L at Station 151 (the end of mixing zone in Mainstem Red Dog Creek). Teck continues its effort to obtain State authorization of a mixing zone for Se in Mainstem Red Dog Creek

●On June 13, fyke nets were set in North Fork Red Dog and Bons creeks and due to high water and rain, the nets were pulled on July 15 – only one Arctic grayling was captured

●In late July, periphyton and aquatic invertebrate samples were collected at six of the nine sites in accordance with permit requirements

●In late July, Arctic grayling fry were present in Bons Creek upstream of Bons Pond, but none were observed in North Fork Red Dog or Mainstem Red Dog creeks

●Our mid-August field trip to Red Dog to sample juvenile Dolly Varden was not made due to repeated high rainfall events during the entire month

●Two aerial surveys of Dolly Varden in the Wulik River were flown (September 19 and October 4). A chum salmon survey in Ikalukrok Creek also was done on September 19

●On October 11, ADF&G sent a letter to Teck regarding increased winter water use from Bons Pond to support lime slaking. We recommended that Teck monitor water use during winter and document surface water elevation in spring prior to breakup

2014

●Technical Report No. 14-02 titled "Aquatic biomonitoring at Red Dog Mine, 2013 National Pollution Discharge Elimination System Permit (NPDES) No. AK-003865-2" was submitted to EPA and ADEC on February 28, 2014

●On April 8, 2014, ADEC issued Modification #1 to the APDES Permit (AK0038652) which authorized a mixing zone for selenium and adjusts Outfall 001 effluent limits for selenium. The modification became effective on May 8, 2014

●Discharge through Outfall 001 to Middle Fork Red Dog Creek began on May 1, 2014 and ended on September 20, 2014

●On May 5, 2014, TDS concentrations at Station 151 as measured with a conductance probe exceeded the TDS limit of 1,500 mg/L – measures will be implemented (during episodic freezing conditions conductance probes will be removed and washed and checks will be made with calibrated, hand-held instruments)

Appendix 1 (concluded)

2014

- ●On May 28, 2014, ice buildup in the clean water bypass culvert caused water to overflow. The water was collected and pumped back into the creek for about 24 hr until it was determined that it may have mixed with mine contact water. Pumping was then diverted to the mine water drainage containment system. Water quality changes downstream during this 24 hr period were undetectable at monitoring stations
- ●A DIDSON® side-scanning sonar was operated in the lower Wulik River from May 30 to June 6 – over this time period 229 fish moved downstream and 52 moved upstream – water remained high and turbid during the entire sample period
- ●On June 5, 2014, Teck filed a court report stating that it was exercising their option not to build a pipeline to the coast
- ●The spring spawning migration of Arctic grayling in Bons Pond/Bons Creek and North Fork Red Dog Creek was sampled from June 7 to 16. Adult Dolly Varden were collected for metals analyses in tissues and adult Arctic grayling were retained from Bons Creek for selenium analysis of ovaries
- ●In the July 26 to August 2, 2014, field trip, periphyton, aquatic invertebrate, and juvenile fish sampling was done at all nine sites in accordance with permit requirements. In addition, aquatic biomonitoring was conducted in Volcano, Competition, Sourdock, and Upper North Fork Red Dog creeks
- ●Two aerial surveys of Dolly Varden in the Wulik River were flown (September 21 and October 7, 2014). The chum salmon survey in Ikalukrok Creek also was done on September 21. Radio-tags were placed in 15 adult Dolly Varden in the Wulik River – these fish will be monitored next year during the spring outmigration
- ●On December 1, 2014, DNR administratively extended the Final Reclamation Plan approval (F20099958) to July 2, 2015

2015

- ●On January 6, 2015, ADF&G by email indicated that we would be willing to assume regulatory oversight over Teck's maintenance of the fish weir on Middle Fork Red Dog Creek
- ●On January 22, 2015, ADF&G by letter reported a summary of Se data (ovaries and livers) collected on Arctic grayling females at the Red Dog Mine, Fort Knox Mine, and from the Chena River near Fairbanks
- ●On February 10, 2015, Habitat (Parker Bradley) gave a presentation at the Alaska Center for the Environment Forum in Anchorage on biomonitoring at Red Dog, Fort Knox, and Greens Creek

Appendix 2. Periphyton Standing Crop

2014 Chloro Results - Red Dog		IDL = 0.03	Linear Check Maximum = 20.18mg/m^2								
		EDL = 0.12 mg/m^2						Phaeo Corrected			
			Date	Date	Vial	Chl a	Below Estimated	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 #							(0.12 mg/m^2)				
							OR				
							Above Linear Check				
							(20.18 mg/m^2)				
Blank 1				01/30/15	0.00	0.00	Below Detection Limit	0.00	0.00	0.00	0.00
2	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.01	0.05	Below Detection Limit	0.11	0.00	0.00	0.00
3	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.06	0.23		0.11	1.25	0.00	0.00
4	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.16	0.64		0.53	1.56	0.01	0.00
5	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.00	0.00	Below Detection Limit	0.00	0.00	0.00	0.00
7	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.08	0.32		0.32	1.75	0.01	0.00
6	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.16	0.63		0.53	1.56	0.08	0.05
8	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.01	0.05	Below Detection Limit	0.11	0.00	0.00	0.00
9	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.01	0.05	Below Detection Limit	0.11	0.00	0.00	0.00
10	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.05	0.18		0.43	0.00	0.00	0.04
11	Mid Fk Red Dog Cr	20	7/27/2014	01/30/15	0.09	0.37		0.32	1.60	0.00	0.00
12	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	3.89	15.55		14.20	1.62	3.04	0.19
13	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	7.72	30.90		28.41	1.63	7.57	0.53
14	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	2.68	10.70		9.83	1.64	0.81	0.33
15	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	1.37	5.49		3.74	1.40	0.97	0.04
16	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	0.36	1.43		0.53	1.45	0.33	0.00
16 duplicate	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	1.15	4.58		3.42	1.46	0.93	0.16
17	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	1.30	5.20		2.19	1.55	1.26	0.12
18	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	2.60	10.39		9.40	1.63	0.05	0.82
19	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	2.06	8.24		7.90	1.67	2.08	0.16
20	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	3.48	13.93		10.57	1.47	3.33	0.31
21	Bons u/s of confl w/ buddy	220	7/29/2014	01/30/15	4.24	16.95		14.20	1.54	3.69	0.99
32	North Fk	12	7/27/2014	02/03/15	1.10	4.41		3.95	1.62	0.14	0.24
33	North Fk	12	7/27/2014	02/03/15	0.74	2.98		2.67	1.61	0.45	0.10
34	North Fk	12	7/27/2014	02/03/15	0.76	3.02		2.78	1.65	0.00	0.12
35	North Fk	12	7/27/2014	02/03/15	1.08	4.30		4.17	1.71	0.00	0.21
36	North Fk	12	7/27/2014	02/03/15	1.17	4.66		4.49	1.70	0.00	0.26
37	North Fk	12	7/27/2014	02/03/15	0.52	2.10		2.03	1.70	0.01	0.08
38	North Fk	12	7/27/2014	02/03/15	1.02	4.07		3.74	1.65	0.00	0.34
39	North Fk	12	7/27/2014	02/03/15	0.62	2.47		2.24	1.64	0.00	0.10
40	North Fk	12	7/27/2014	02/03/15	2.09	8.37		7.90	1.67	0.27	0.43
41	North Fk	12	7/27/2014	02/03/15	1.30	5.19		4.70	1.63	0.16	0.26
42	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.51	2.06		2.03	1.73	0.00	0.12
43	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.37	1.47		1.39	1.68	0.00	0.13
44	Bons Creek us of Bons Pond		7/27/2014	02/03/15	1.88	7.53		7.64	1.65	0.00	0.54
45	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.66	2.65		2.46	1.66	0.00	0.14
46	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.58	2.33		2.24	1.70	0.00	0.15
47	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.59	2.38		2.35	1.73	0.00	0.11
48	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.55	2.19		2.03	1.66	0.00	0.17
48 duplicate	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.55	2.19		2.14	1.71	0.00	0.26
49	Bons Creek us of Bons Pond		7/27/2014	02/03/15	1.07	4.28		4.17	1.71	0.06	0.12
50	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.57	2.29		2.14	1.67	0.00	0.15
51	Bons Creek us of Bons Pond		7/27/2014	02/03/15	0.45	1.78		1.71	1.70	0.00	0.12

Appendix 2 (concluded)

2014 Chloro Results - Red Dog		IDL = 0.03	Linear Check Maximum = 20.18mg/m^2								
		EDL = 0.12 mg/m^2						Phaeo Corrected			
			Date	Date	Vial	**Chl a**	**Below Estimated**	**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 #							**(0.12 mg/m^2)**				
							OR				
							Above Linear Check				
							(20.18 mg/m^2)				
2	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.26	1.05		1.07	1.77	0.04	0.12
3	Main stem Red Dog Cr	10	7/28/2014	02/04/15	1.01	4.03		3.63	1.61	0.89	0.73
4	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.47	1.87		1.71	1.64	0.03	0.15
5	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.95	3.80		3.52	1.65	0.32	0.55
6	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.78	3.12		2.88	1.64	0.36	0.28
7	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.32	1.28		1.28	1.75	0.00	0.19
8	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.45	1.78		1.71	1.70	0.00	0.12
9	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.30	1.18		1.17	1.73	0.06	0.07
10	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.46	1.85		1.71	1.64	0.19	0.18
11	Main stem Red Dog Cr	10	7/28/2014	02/04/15	0.26	1.05		1.07	1.77	0.00	0.06
12	Buddy u/s of Road	221	7/28/2014	02/04/15	0.97	3.88		3.74	1.70	0.00	0.30
13	Buddy u/s of Road	221	7/28/2014	02/04/15	1.03	4.12		3.95	1.70	0.00	0.37
14	Buddy u/s of Road	221	7/28/2014	02/04/15	1.38	5.53		5.34	1.70	0.00	0.47
15	Buddy u/s of Road	221	7/28/2014	02/04/15	0.93	3.73		3.63	1.71	0.08	0.19
16	Buddy u/s of Road	221	7/28/2014	02/04/15	1.12	4.48		4.27	1.69	0.00	0.32
17	Buddy u/s of Road	221	7/28/2014	02/04/15	0.84	3.35		3.20	1.68	0.34	0.22
18	Buddy u/s of Road	221	7/28/2014	02/04/15	1.07	4.28		4.17	1.71	0.04	0.32
19	Buddy u/s of Road	221	7/28/2014	02/04/15	0.95	3.79		0.00	0.98	0.00	0.25
20	Buddy u/s of Road	221	7/28/2014	02/04/15	0.87	3.46		3.42	1.73	0.04	0.29
21	Buddy u/s of Road	221	7/28/2014	02/04/15	1.85	7.41		7.26	1.72	0.00	0.58
22	Buddy Cr below falls		7/28/2014	02/04/15	1.60	6.41		6.19	1.71	0.00	0.62
23	Buddy Cr below falls		7/28/2014	02/04/15	4.39	17.54		16.77	1.69	0.00	1.27
24	Buddy Cr below falls		7/28/2014	02/04/15	7.30	29.21		27.87	1.67	4.63	0.60
24 double	Buddy Cr below falls		7/28/2014	02/04/15	7.27	29.07		27.55	1.67	4.61	0.65
25	Buddy Cr below falls		7/28/2014	02/04/15	3.12	12.48		11.85	1.69	0.00	0.99
26	Buddy Cr below falls		7/28/2014	02/04/15	3.35	13.40		12.92	1.70	0.00	1.19
27	Buddy Cr below falls		7/28/2014	02/04/15	2.15	8.59		8.01	1.66	0.00	0.82
28	Buddy Cr below falls		7/28/2014	02/04/15	4.84	19.35		17.94	1.66	0.00	1.65
29	Buddy Cr below falls		7/28/2014	02/04/15	1.52	6.09		5.87	1.71	0.00	0.53
30	Buddy Cr below falls		7/28/2014	02/04/15	0.67	2.69		2.56	1.69	0.02	0.27
31	Buddy Cr below falls		7/28/2014	02/04/15	3.61	14.42		13.24	1.64	0.98	1.15
Blank 32				02/04/15	0.00	0.00	**Below Detection Limit**	0.00	0.00	0.00	0.00
Blank 1				02/06/15	0.00	0.00	**Below Detection Limit**	0.00	0.00	0.00	0.00
2	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.50	6.00		5.87	1.72	0.00	0.48
3	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	2.25	9.02		8.76	1.71	0.00	0.69
4	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.66	6.64		6.41	1.71	0.00	0.55
5	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.85	7.41		7.05	1.69	0.00	0.58
6	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.03	4.12		3.84	1.67	0.00	0.37
7	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.59	6.37		6.09	1.70	0.00	0.46
8	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.35	5.40		5.13	1.69	0.00	0.36
9	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	2.58	10.34		9.72	1.67	0.00	0.42
10	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.90	7.59		7.26	1.69	0.00	0.62
11	Ikalukrok Cr d/s of Dudd	160	7/31/2014	02/06/15	1.87	7.46		7.16	1.70	0.00	0.51
12	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	02/06/15	0.42	1.69		1.60	1.68	0.00	0.14
13	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	02/06/15	0.47	1.87		1.82	1.71	0.00	0.08
14	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	1.61	6.45		6.19	1.70	0.00	0.51
15	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	1.13	4.53		4.38	1.71	0.00	0.34
16	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	0.92	3.66		3.63	1.74	0.00	0.23
16 double	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	0.93	3.71		3.63	1.72	0.00	0.29
17	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	0.06	0.22		0.53	0.00	0.05	0.00
18	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	0.81	3.24		3.10	1.69	0.00	0.32
19	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	0.43	1.74		1.71	1.73	0.00	0.13
20	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	0.80	3.20		3.20	1.75	0.00	0.26
21	Ikalukrok Cr u/s of Red Dog	9	7/31/2014	2/6/2015	1.09	4.35		4.06	1.67	0.00	0.40
Blank 43	Red Dog			2/6/2015	0.00	0.00	**Below Detection Limit**	0.00	0.00	0.00	0.00

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	2011	2012	2013	2014
Total aquatic taxa	15	15	19	15	28	23	20	16	26	25	15	15	25	16	28	28
												\				
Tot. Ephemeroptera	9	0	17	4	6	44	41	7	23	29	16	1	30	2	2	7
Tot. Plecoptera	3	5	43	20	34	38	28	9	11	13	4	0	20	5	61	60
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0
Total Aq. Diptera	104	40	153	121	449	28	92	6	80	72	45	103	197	18	105	103
Misc.Aq.sp	9	17	73	17	55	46	177	5	82	52	38	10	181	3	84	33
% Ephemeroptera	8%	0%	6%	2%	1%	28%	12%	26%	12%	17%	15%	1%	7%	7%	1%	3%
% Plecoptera	3%	7%	15%	13%	7%	24%	8%	35%	6%	8%	4%	0%	5%	17%	24%	30%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	0%
% Aq. Diptera	83%	64%	53%	75%	83%	18%	27%	22%	41%	43%	43%	90%	46%	64%	42%	51%
% other	7%	28%	26%	10%	10%	29%	52%	18%	42%	31%	37%	9%	42%	11%	33%	16%
% EPT	10%	8%	21%	15%	7%	52%	21%	60%	18%	25%	20%	1%	12%	25%	25%	33%
% Chironomidae	80%	36%	51%	73%	73%	16%	24%	15%	35%	39%	38%	86%	44%	51%	37%	44%
% Dominant Aquatic Taxon	46%	36%	31%	43%	48%	30%	42%	37%	22%	22%	37%	75%	28%	38%	21%	30%
Volume of water (m3)	378	551	933	310	702	880	302	296	384	249	285	78	733	72	246	601
average water/net	76	110	187	62	140	176	60	59	77	50	57	16	147	14	49	120
StDev of water volume	24	26	89	14	38	91	26	9	52	8	11	9	28	3	22	27
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	4.7	3.1	10	2.4
Estimated aquatic inverts/m3 water	1.7	0.6	1.5	2.6	3.9	0.9	5.6	0.4	2.6	3.4	1.8	7.3	2.9	2.0	5.1	1.7
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	4.7	3.3	11.6	2.4
average aq. Invertebrates/m3 water	1.8	0.57	1.64	2.59	3.74	0.95	5.33	0.45	3.53	3.39	1.8	8.2	3	2.1	5.94	1.69
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	0.4	1.7	2.53	0.08
Total aquatic invertebrates	627	309	1431	810	2719	783	1694	133	980	835	523	573	2145	144	1263	1019
Total. terrestrial invertebrates	477	10	185	1115	1889	170	4158	59	1875	3210	6096	218	1290	82	1194	441
Total invertebrates	1104	319	1616	1925	4608	953	5852	192	2855	4045	6619	791	3435	226	2457	1460
% Sample aquatic	57%	97%	89%	42%	59%	82%	29%	69%	34%	21%	8%	72%	62%	64%	51%	70%
% Sample terrestrial	43%	3%	11%	58%	41%	18%	71%	31%	66%	79%	92%	28%	38%	36%	49%	30%
Average # aquatic inverts / net	125	62	286	162	544	157	339	27	196	167	105	115	429	29	253	204
stdev aq inv/net	59	20	111	56	242	69	178	11	20	35	30	51	86	22	58	49
Average # terr. inverts / net	95	2	37	223	378	34	832	12	375	642	1219	44	258	16	239	88
Average # inverts / net	221	64	323	385	922	191	1170	38	571	809	1324	158	687	45	491	292
stdev inv/net	68	21	127	156	376	85	532	13	55	191	259	74	206	49	110	65
Total Larval Arctic Grayling/site	0	0	0	0	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	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	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	2011	2012	2013	2014
Total aquatic taxa	13	13	18	16	26	20	21	15	21	23	19	17	19	22	24	23
Tot. Ephemeroptera	67	14	20	170	194	38	198	882	163	57	66	26	79	33	36	7
Tot. Plecoptera	23	94	117	40	64	5	5	19	11	77	18	4	22	26	38	11
Tot. Trichoptera	4	6	6	0	4	0	0	0	1	4	1	3	11	1	3	0
Total Aq. Diptera	700	314	1134	116	716	27	333	755	641	1574	2113	1092	3245	203	170	116
Misc.Aq.sp	30	69	226	43	188	17	39	32	135	320	251	140	536	221	151	90
% Ephemeroptera	8%	3%	1%	46%	16%	44%	34%	52%	17%	3%	3%	2%	2%	7%	9%	3%
% Plecoptera	3%	19%	8%	11%	6%	5%	1%	1%	1%	4%	1%	0%	1%	5%	10%	5%
% Trichoptera	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
% Aq. Diptera	85%	63%	75%	31%	62%	31%	58%	45%	67%	77%	86%	86%	83%	42%	43%	52%
% other	4%	14%	15%	12%	16%	19%	7%	2%	14%	16%	10%	11%	14%	46%	38%	40%
% EPT	11%	23%	9%	57%	23%	50%	35%	53%	18%	7%	3%	3%	3%	12%	19%	8%
% Chironomidae	54%	36%	57%	22%	27%	25%	36%	14%	61%	32%	55%	33%	23%	17%	34%	44%
% Dominant Aquatic Taxon	45%	32%	43%	46%	35%	48%	34%	44%	36%	45%	43%	54%	61%	25%	25%	28%
Volume of water (m3)	559	221	747	226	672	672	380	368	297	329	681	187	1015	287	567	800
average water/net	112	44	149	45	134	134	76	74	59	66	136	37	203	57	113	160
StDev of water volume	80	12	54	23	37	64	54	10	24	20	45	22	49	22	27	26
Estimated total inverts/m3 water	9.2	11.8	10.2	13.5	9.3	0.9	12.4	23.6	18.3	33.2	28	37.4	20.2	9.8	4.6	2
Estimated aquatic inverts/m3 water	7.4	11.2	10	8.1	8.7	0.6	7.6	23	16	30.9	18	33.8	19.2	8.4	3.5	1.4
average inv/m3	14.2	11.5	10.2	15	10	0.8	16.3	23.5	19.9	33.5	28.1	35.3	21.2	10.1	4.6	2.1
average aq. Invertebrates/m3 water	11.4	10.9	10	9.1	9.4	0.6	11.8	22.8	17.5	31.1	18.4	31.3	20.1	8.6	3.52	1.45
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	7.9	0.7	0.46	0.41
Total aquatic invertebrates	4120	2486	7509	1839	5827	435	2875	8442	4750	10159	12242	6324	19465	2417	1988	1126
Total. terrestrial invertebrates	1044	129	117	1211	426	159	1833	248	670	745	6843	677	1070	395	625	500
Total invertebrates	5164	2615	7626	3050	6254	594	4708	8691	5420	10904	19085	7000	20535	2812	2612	1626
% Sample aquatic	80%	95%	98%	60%	93%	73%	61%	97%	88%	93%	64%	90%	95%	86%	76%	69%
% Sample terrestrial	20%	5%	2%	40%	7%	27%	39%	3%	12%	7%	36%	10%	5%	14%	24%	31%
Average # aquatic inverts / net	824	497	1502	368	1165	87	575	1688	950	2032	2448	1265	3893	483	398	225
stdev aq inv/net	138	352	545	161	409	60	278	448	265	802	764	977	1286	174	104	49
Average # terr. inverts / net	209	26	23	242	85	32	367	50	134	149	1369	135	214	79	125	100
Average # inverts / net	1033	523	1525	610	1251	119	942	1738	1084	2181	3817	1400	4107	562	522	325
stdev inv/net	274	339	560	188	434	97	587	447	308	848	1480	1048	1378	188	164	76
Total Larval Arctic Grayling/site	1	3	1	0	0	0	0	0	9	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	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	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	2011	2012	2013	2014
Total aquatic taxa	11	7	19	12	21	17	15	20	22	24	17	15	24	15	22	25
Tot. Ephemeroptera	2	0	6	14	313	24	54	77	56	25	10	1	16	3	2	6
Tot. Plecoptera	35	16	34	30	292	16	36	45	144	50	15	6	27	36	162	52
Tot. Trichoptera	0	1	3	0	1	0	7	0	1	3	1	0	4	0	1	1
Total Aq. Diptera	182	20	676	129	438	37	396	87	558	1301	347	57	708	102	96	188
Misc.Aq.sp	3	2	82	8	58	9	82	73	141	106	49	10	271	68	88	140
% Ephemeroptera	1%	1%	1%	8%	28%	28%	9%	27%	6%	2%	2%	2%	2%	1%	1%	1%
% Plecoptera	16%	41%	4%	17%	27%	18%	6%	16%	16%	3%	4%	8%	3%	17%	46%	14%
% Trichoptera	0%	3%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	82%	52%	84%	71%	40%	43%	69%	31%	62%	88%	82%	76%	69%	49%	28%	49%
% other	1%	4%	10%	4%	5%	11%	14%	26%	16%	7%	12%	14%	26%	32%	25%	36%
% EPT	17%	44%	5%	25%	55%	47%	17%	43%	22%	5%	6%	10%	5%	19%	47%	15%
% Chironomidae	69%	25%	79%	62%	24%	39%	36%	22%	60%	55%	60%	68%	51%	22%	25%	45%
% Dominant Aquatic Taxon	61%	42%	64%	52%	29%	30%	33%	23%	42%	52%	43%	55%	38%	30%	46%	30%
Volume of water (m3)	869	356	1323	255	688	1239	665	417	422	384	378	139	966	311	781	704
average water/net	174	71	265	51	138	248	133	83	84	77	76	28	193	62	156	141
StDev of water volume	122	27	56	15	39	54	65	13	20	10	24	16	17	20	50	38
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	6.7	4.4	2.4	6.3
Estimated aquatic inverts/m3 water	1.3	0.5	3	3.6	8	0.3	4.3	3.4	10.7	19.4	5.6	2.7	5.3	3.4	2.2	2.7
average inv/m3	1.9	0.7	3.2	4.2	8.6	0.5	8.2	5	14	22.8	8.8	3.2	6.6	4.5	2.5	6
average aq. inverts/m3 water	1.8	0.6	3.1	4	8.4	0.4	4.6	3.5	11.1	19.5	5.3	2.1	5.3	3.5	2.33	2.67
Stdev of aq. Inv. Den.	1.3	0.3	0.8	2.1	1.9	0	1.6	1.4	2.3	3.6	1.4	1.4	1.3	0.5	0.43	1.13
Total aquatic invertebrates	1111	192	4003	910	5503	427	2875	1410	4497	7427	2109	370	5125	1048	1745	1932
Total. terrestrial invertebrates	136	21	121	49	121	173	2119	609	1218	1252	1351	205	1311	311	113	2526
Total invertebrates	1247	213	4123	959	5624	600	4993	2018	5715	8679	3461	575	6437	1359	1858	4457
% Sample aquatic	89%	90%	97%	95%	98%	71%	58%	70%	79%	86%	61%	64%	80%	77%	94%	43%
% Sample terrestrial	11%	10%	3%	5%	2%	29%	42%	30%	21%	14%	39%	36%	20%	23%	6%	57%
Average # aquatic inverts / net	222	38	801	182	1101	85	575	282	899	1485	422	74	1025	210	349	386
stdev aq inv/net	126	25	182	47	152	16	311	66	83	227	242	76	315	52	59	246
Average # terr. inverts / net	27	4	24	10	24	35	424	122	244	250	270	41	262	62	23	505
Average # inverts / net	249	43	825	192	1125	120	999	404	1143	1736	692	115	1287	272	372	891
stdev inv/net	153	27	171	51	152	25	529	69	111	218	358	116	355	63	67	700
Total Larval Arctic Grayling/site	5	5	0	2	1	0	0	0	0	45	2	0	1	0	1	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3 (continued)

Ikalukrok Creek, Station 9, Drift Samples Invertebrates (samples not collected in 2013 due to high water)															
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014
Total aquatic taxa	8	9	15	13	21	16	13	18	20	20	24	14	19	22	23
Tot. Ephemeroptera	11	63	267	213	138	208	571	67	225	122	151	4	129	109	247
Tot. Plecoptera	17	13	159	24	54	30	189	57	98	64	21	4	62	28	124
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	0	0	0	3	0	0
Total Aq. Diptera	10	58	1252	285	485	196	185	56	217	193	370	167	1625	416	414
Misc.Aq.sp	9	8	56	5	23	23	23	25	24	162	125	10	113	26	74
% Ephemeroptera	24%	44%	15%	40%	19%	45%	59%	33%	40%	23%	23%	2%	7%	19%	29%
% Plecoptera	36%	9%	9%	5%	8%	7%	19%	28%	17%	12%	3%	2%	3%	5%	14%
% Trichoptera	0%	0%	0%	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%	84%	72%	48%
% other	19%	6%	3%	1%	3%	5%	2%	12%	4%	30%	19%	5%	6%	4%	9%
% EPT	60%	54%	25%	45%	27%	52%	79%	60%	57%	34%	26%	4%	10%	24%	43%
% Chironomidae	21%	39%	69%	52%	65%	25%	15%	18%	35%	28%	31%	49%	76%	46%	41%
% Dominant Aquatic Taxon	32%	45%	65%	44%	57%	36%	37%	24%	35%	20%	24%	44%	63%	29%	34%
Volume of water (m3)	260	478	833	575	450	2772	555	352	382	390	601	265	792	540	1519
average water/net	52	96	167	115	90	554	111	70	76	78	120	53	158	108	304
StDev of water volume	25	16	106	29	23	161	12	16	23	22	46	19	28	41	31
Estimated total inverts/m3 water	1.5	1.6	10.7	4.9	8.7	1.4	11.4	3.8	9	11.3	8.4	3.8	13.9	9.7	3.8
Estimated aquatic inverts/m3 water	0.9	1.5	10.4	4.6	7.8	0.8	8.7	2.9	7.4	6.9	5.5	3.5	12.2	5.4	2.8
average inv/m3	1.6	1.6	12	5	8.9	1.4	11.4	3.9	9.5	13.7	8.4	4	14.3	11.7	3.8
average aq inverts/m3 water	1	1.5	11.7	4.7	7.9	0.9	8.7	3	7.9	8.3	5.5	3.7	12.6	6.4	2.8
Stdev of aq. inv. Den.	0.6	0.3	4.6	0.8	1	0.1	1.7	1.2	2.5	6.2	1.3	0.8	4	4.06	0.9
Total aquatic invertebrates	232	714	8668	2635	3497	2288	4848	1028	2822	2707	3330	926	9662	2890	4295
Total. terrestrial invertebrates	159	66	220	168	403	1507	1482	325	606	1704	1741	92	1377	2375	1415
Total invertebrates	391	780	8888	2803	3900	3795	6330	1353	3427	4410	5071	1018	11039	5264	5711
% Sample aquatic	59%	92%	98%	94%	90%	60%	77%	76%	82%	61%	66%	91%	88%	55%	75%
% Sample terrestrial	41%	8%	2%	6%	10%	40%	23%	24%	18%	39%	34%	9%	12%	45%	25%
Average # aquatic inverts / net	46	143	1734	527	699	458	970	206	564	541	666	185	1932	578	859
stdev aq inv/net	26	46	822	102	115	90	255	81	120	266	347	63	516	278	265
Average # terr. inverts / net	32	13	44	34	81	301	296	65	121	341	348	18	275	475	283
Average # inverts / net	78	156	1778	561	780	759	1266	271	685	882	1014	204	2208	1053	1142
stdev inv/net	51	50	849	99	110	158	296	94	173	424	491	65	581	585	309
Total Larval Arctic Grayling/site	1	1	0	0	0	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	0	1	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3 (continued)

Ikalukrok Creek below Dudd Creek Station 7/160 starting in 2010 under new permit (samples not collected in 2013 due to high water)															
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014
Total aquatic taxa	10	12	18	9	18	24	18	22	18	24	19	14	19	24	22
Tot. Ephemeroptera	1	4	138	12	59	23	152	114	126	17	33	4	38	31	11
Tot. Plecoptera	9	102	43	12	37	8	4	29	21	21	8	2	6	2	5
Tot. Trichoptera	0	1	1	0	1	2	0	2	1	1	0	0	0	1	0
Total Aq. Diptera	38	319	262	111	1054	95	529	323	1356	1335	1558	371	867	181	165
Misc.Aq.sp	3	105	22	2	36	44	8	83	187	119	28	92	61	64	64
% Ephemeroptera	1%	1%	30%	8%	5%	13%	22%	21%	7%	1%	2%	1%	4%	11%	4%
% Plecoptera	17%	19%	9%	8%	3%	4%	1%	5%	1%	1%	1%	0%	1%	1%	2%
% Trichoptera	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	75%	60%	56%	81%	89%	55%	76%	59%	80%	89%	96%	79%	89%	65%	67%
% other	7%	20%	5%	1%	3%	26%	1%	15%	11%	8%	2%	20%	6%	23%	26%
% EPT	18%	20%	39%	17%	8%	19%	22%	26%	9%	3%	3%	1%	5%	12%	7%
% Chironomidae	66%	39%	51%	36%	22%	43%	59%	43%	68%	18%	14%	29%	55%	35%	43%
% Dominant Aquatic Taxon	63%	39%	46%	46%	67%	31%	38%	27%	58%	71%	82%	50%	36%	32%	31%
Volume of water (m3)	190	513	617	359	866	1182	303	617	502	491	659	1236	801	550	954
average water/net	38	103	123	72	173	236	61	123	100	98	132	247	160	110	191
StDev of water volume	23	54	40	23	19	114	14	35	33	56	46	101	29	21	99
Estimated total inverts/m3 water	1.8	5.7	3.9	2.2	7.2	1	15.3	5.2	23.1	17.7	13.6	2.4	6.4	3.0	1.4
Estimated aquatic inverts/m3 water	1.3	5.2	3.8	1.9	6.9	0.7	11.4	4.5	16.9	15.2	12.3	1.9	6.1	2.5	1.3
average inv/m3	2.5	6	4.1	2.3	7.3	1	15.4	5.6	26.1	17.9	14.1	2.3	6.4	3.1	1.5
average aq inverts/m3 water	1.7	5.4	4	2	7	0.8	11.4	4.9	18.8	15.6	13	1.8	6	2.7	1.3
StDev of aq. Inv. Density	1	1.3	1	0.8	1.5	0.1	3.4	2	7.6	1.8	2.7	0.6	2.9	1.0	0.2
Total aquatic invertebrates	253	2657	2335	684	5940	857	3465	2759	8455	7466	8136	2347	4860	1397	1228
Total. terrestrial invertebrates	90	291	54	114	291	279	1181	428	3112	1224	791	574	252	249	133
Total invertebrates	343	2948	2389	798	6232	1136	4646	3187	11567	8689	8927	2920	5112	1646	1361
% Sample aquatic	74%	90%	98%	86%	95%	75%	75%	87%	73%	86%	91%	80%	95%	85%	90%
% Sample terrestrial	26%	10%	2%	14%	5%	25%	25%	13%	27%	14%	9%	20%	5%	15%	10%
Average # aquatic inverts / net	51	531	467	137	1188	171	693	552	1691	1493	1627	469	972	279	246
stdev aq inv/net	27	309	64	56	167	63	292	111	209	842	421	308	502	53	128
Average # terr. inverts / net	18	58	11	23	58	56	236	86	622	245	158	115	50	50	27
Average # inverts / net	69	590	478	160	1246	227	929	637	2313	1738	1785	584	1022	329	272
stdev inv/net	29	328	66	53	167	84	352	130	276	1012	487	386	533	64	136
Total Larval Arctic Grayling/site	0	2	0	14	1	0	0	0	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	1	0	0	1	0	0	0	0	0	0	13
Total Larval Dolly Varden/site	0	0	0	0	0	7	0	0	0	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	2011	2012	2013	2014
Total aquatic taxa	17	23	16	14	19	14	11	20	15	20	15
Tot. Ephemeroptera	3	15	7	6	6	9	3	67	13	47	3
Tot. Plecoptera	1	1	1	1	3	1	0	1	0	2	5
Tot. Trichoptera	0	0	0	0	0	0	0	0	0	0	0
Total Aq. Diptera	39	82	23	367	347	251	46	507	37	121	81
Misc.Aq.sp	7	66	10	56	114	17	8	86	20	15	30
% Ephemeroptera	6%	9%	17%	1%	1%	6%	5%	10%	18%	26%	2%
% Plecoptera	2%	1%	2%	0%	1%	3%	0%	0%	1%	1%	4%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	77%	50%	56%	86%	74%	0%	81%	77%	53%	66%	68%
% other	14%	40%	25%	13%	24%	90%	14%	13%	29%	8%	26%
% EPT	8%	10%	19%	2%	2%	4%	5%	10%	18%	26%	6%
% Chironomidae	68%	27%	43%	72%	20%	81%	75%	70%	46%	53%	66%
% Dominant Aquatic Taxon	60%	38%	38%	50%	53%	76%	61%	48%	46%	33%	57%
Volume of water (m3)	349	104	68	86	79	87	16	176	53	418	236
average water/net	70	21	14	17	16	17	3	35	11	84	47
StDev of water volume	10	11	3	3	8	12	1	7	5	24	10
Estimated total inverts/m3 water	1.3	23	4.6	31.5	55.4	25.7	21.8	21.3	9.5	2.5	2.8
Estimated aquatic inverts/m3 water	0.7	7.9	3.1	24.8	29.9	16.1	17.9	18.8	6.7	2.2	2.5
average inv/m3	1.3	23	4.6	31.5	57.6	31.8	20.2	21.5	12.5	2.8	2.8
average aq inverts/m3 water	0.7	9.6	3.2	25	30.4	19	16.1	19.1	8.37	2.42	2.5
StDev of aq. Inv. Density	0.5	4.9	1.3	8.4	4.6	8.5	9.5	3.9	5.07	1.16	0.5
Total aquatic invertebrates	251	823	208	2147	2354	1392	283	3302	353	925	591
Total. terrestrial invertebrates	209	1564	105	574	2012	834	63	450	147	134	75
Total invertebrates	460	2387	313	2721	4365	2226	346	3752	500	1059	666
% Sample aquatic	55%	34%	66%	79%	54%	63%	82%	88%	71%	87%	89%
% Sample terrestrial	45%	66%	34%	21%	46%	37%	18%	12%	29%	13%	11%
Average # aquatic inverts / net	50	165	42	429	471	278	57	660	71	185	118
stdev aq inv/net	40	58	14	154	218	135	43	141	25	45	43
Average # terr. inverts / net	42	313	21	115	402	167	13	90	29	27	15
Average # inverts / net	92	477	63	544	873	445	69	750	100	212	133
stdev inv/net	79	336	17	207	428	169	48	187	43	50	42
Total Larval Arctic Grayling/site	0	10	0	78	0	0	0	3	14	43	1
Total Larval Slimy Sculpin/site	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

Appendix 3 (continued)

Bons Creek (Station 220), just upstream of confluence with Buddy Creek (2010 and 2012 no surface flow)														
Year Sampled	2004	2005	2006a	2006b	2007a	2007b	2008a	2008b	2009	2011	2013a	2013b	2014a	2014b
Total aquatic taxa	20	18	17	19	16	17	19	20	19	27	21	24	24	29
Tot. Ephemeroptera	7	51	17	17	95	95	63	63	130	12	6	6	2	2
Tot. Plecoptera	3	5	8	8	8	8	29	29	7	14	1	1	1	1
Tot. Trichoptera	1	1	0	0	4	4	4	4	0	2	0	0	2	2
Total Aq. Diptera	48	63	122	122	1391	1391	2112	2112	1044	260	133	133	101	101
Misc.Aq.sp	3	8	241	5255	34	1590	134	1322	95	191	39	602	25	856
% Ephemeroptera	11%	40%	4%	0%	6%	3%	3%	2%	10%	2%	3%	1%	2%	0%
% Plecoptera	5%	4%	2%	0%	1%	0%	1%	1%	1%	3%	0%	0%	1%	0%
% Trichoptera	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
% Aq. Diptera	77%	50%	31%	2%	91%	45%	90%	60%	82%	54%	74%	18%	77%	11%
% other	5%	40%	62%	97%	2%	51%	6%	37%	7%	40%	22%	81%	19%	89%
% EPT	18%	44%	7%	0%	7%	3%	4%	3%	11%	6%	4%	1%	3%	0%
% Chironomidae	46%	43%	30%	2%	35%	17%	72%	48%	50%	25%	72%	18%	57%	8%
% Dominant Aquatic Taxon	45%	43%	53%	89%	56%	50%	67%	48%	45%	29%	45%	39%	42%	49%
Volume of water (m^3)	698	76	612	612	150	150	317	317	216	409	573	573	296	296
average water/net	140	15	122	122	30	30	63	63	43	82	115	115	59	59
StDev of water volume	59	7	44	44	21	21	20	20	12	47	45	45	20	20
Estimated total inverts/m^3 water	0.8	11.2	5.0	46.0	63.7	115.6	41.7	60.5	36.2	6.3	1.9	6.8	3.2	17.3
Estimated aquatic inverts/m^3 water	0.4	8.4	3.2	44.2	51.1	103.0	37.0	55.8	29.6	5.9	1.6	6.5	2.2	16.3
average inv/m^3	0.9	11.2	5.0	46.0	130.0	222.4	42.3	61.4	35.2	7.6	1.9	7	3.5	17.3
average aq inverts/m^3 water	0.4	8.1	3.3	46.4	107.4	199.8	37.8	56.8	28.6	7	1.6	6.7	2.3	16.1
StDev of aq. Inv. Density	0.2	2.2	0.8	21.5	136.8	232.8	11.0	11.0	12.4	3	0.2	1.5	1	2.3
Total aquatic invertebrates	312	636	1943	27013	7654	15436	11706	17648	6375	2393	898	3712	654	4809
Total. terrestrial invertebrates	273	217	1143	1143	1892	1892	1494	1494	1427	198	196	196	302	302
Total invertebrates	585	853	3086	28156	9546	17328	13200	19142	7802	2591	1094	3908	956	5111
% Sample aquatic	53%	75%	63%	96%	80%	89%	89%	92%	82%	92%	82%	95%	68%	94%
% Sample terrestrial	47%	25%	37%	4%	20%	11%	11%	8%	18%	8%	18%	5%	32%	6%
Average # aquatic inverts / net	62	127	389	5403	1531	3087	2341	3530	1275	479	180	742	131	962
stdev aq inv/net	56	66	108	2101	854	2008	766	993	833	188	62	242	43	358
Average # terr. inverts / net	55	43	229	229	378	378	299	299	285	40	39	39	60	60
Average # inverts / net	117	171	617	5631	1909	3466	2640	3828	1560	518	219	782	191	1022
stdev inv/net	59	88	239	2183	1108	2288	872	1098	992	197	87	263	72	353
Total Larval Arctic Grayling/site	0	0	0	0	1	1	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	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006a is without Cladocerans and 2006b is with Cladocerans														
2007a is without Ostracods and 2007b is with Ostracods														
2008a is without Ostracods and 2008b is with Ostracods														
2013a is without Ostracods, Cladocerans, and Copepods and 2013b is with Ostracods, Cladocerans, and Copepods														
2014a is without Ostracods, Cladocerans, and Copepods and 2014b is with Ostracods, Cladocerans, and Copepods														

Appendix 3 (continued)

Buddy Creek (Station 221), upstream of haul road											
Year Sampled	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total aquatic taxa	20	20	19	23	22	17	17	23	21	22	23
Tot. Ephemeroptera	2042	232	515	385	110	18	25	409	1878	39	1473
Tot. Plecoptera	20	18	28	130	86	30	3	48	8	19	36
Tot. Trichoptera	0	1	0	1	0	1	2	1	0	0	0
Total Aq. Diptera	195	423	476	965	1632	489	654	715	334	260	527
Misc.Aq.sp	25	47	84	98	204	73	69	147	36	60	119
% Ephemeroptera	89%	32%	47%	24%	5%	3%	3%	31%	83%	10%	68%
% Plecoptera	1%	3%	3%	8%	4%	5%	0%	4%	0%	5%	2%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	9%	59%	43%	61%	80%	80%	87%	54%	15%	69%	24%
% other	1%	32%	8%	6%	10%	12%	9%	11%	2%	16%	6%
% EPT	90%	35%	49%	33%	10%	8%	4%	35%	84%	16%	70%
% Chironomidae	5%	38%	25%	43%	39%	39%	81%	36%	5%	56%	15%
% Dominant Aquatic Taxon	89%	28%	44%	24%	41%	41%	62%	32%	83%	36%	67%
Volume of water (m3)	771	235	600	242	489	318	183	437	71	495	783
average water/net	154	47	120	48	98	64	37	87	14	99	157
StDev of water volume	146	18	65	30	18	34	16	46	3	26	99
Estimated total inverts/m3 water	16.2	22	11.5	39.7	24.6	19	31	15.7	160.6	4.6	15.9
Estimated aquatic inverts/m3 water	14.8	15.3	9.2	32.7	20.8	9.6	20.6	15.1	159.3	3.8	13.8
average inv/m3	20.1	22	11.5	47	25	22.3	35.4	19.2	165.8	4.5	16.5
average aq inverts/m3 water	18.1	17.2	9.3	38.9	21	11.1	25.1	18.4	164.5	3.8	14.9
StDev of aq. Inv. Density	10.1	7.5	2.1	16.1	4.2	4.7	16.8	10.3	84.4	0.7	6.3
Total aquatic invertebrates	11414	3607	5515	7892	10161	3050	3767	6593	11276	1894	10783
Total. terrestrial invertebrates	1074	1572	1404	1698	1900	2971	1897	289	90	364	1683
Total invertebrates	12488	5179	6918	9590	12061	6021	5664	6882	11366	2257	12466
% Sample aquatic	91%	70%	80%	82%	84%	51%	67%	96%	99%	84%	87%
% Sample terrestrial	9%	30%	20%	18%	16%	49%	33%	4%	1%	16%	13%
Average # aquatic inverts / net	2283	721	1103	1578	2032	610	753	1319	2255	379	2157
stdev aq inv/net	1459	176	575	555	391	144	410	642	1016	111	1682
Average # terr. inverts / net	215	314	281	340	380	594	379	58	18	73	337
Average # inverts / net	2498	1036	1384	1918	2412	1204	1133	1376	2273	451	2493
stdev inv/net	1540	323	752	683	394	380	852	670	1014	143	2010
Total Larval Arctic Grayling/site	0	0	0	1	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	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

Appendix 3 (concluded)

Buddy Creek (below falls), not sampled in 2013 due to high water												
Year Sampled	2004	2005	2006a	2006b	2007	2008	2009	2010	2011a	2011b	2012	2014
Total aquatic taxa	18	19	16	18	25	20	13	14	28	29	19	26
Tot. Ephemeroptera	578	328	253	253	1316	124	776	6	139	139	112	108
Tot. Plecoptera	9	12	32	32	92	21	18	0	30	30	4	18
Tot. Trichoptera	1	2	0	0	7	2	0	0	3	3	0	2
Total Aq. Diptera	363	855	199	199	2284	2011	4424	1478	1525	1525	187	1788
Misc.Aq.sp	71	19	125	2461	444	206	153	56	230	1773	37	445
% Ephemeroptera	57%	27%	42%	9%	32%	5%	14%	0%	7%	4%	33%	5%
% Plecoptera	1%	1%	5%	1%	2%	1%	0%	0%	2%	1%	1%	1%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	35%	70%	33%	7%	55%	85%	82%	96%	79%	44%	55%	76%
% other	7%	2%	21%	84%	11%	9%	3%	4%	12%	51%	11%	19%
% EPT	58%	28%	47%	10%	34%	6%	15%	0%	9%	5%	34%	5%
% Chironomidae	11%	64%	22%	4%	40%	67%	69%	65%	57%	32%	38%	14%
% Dominant Aquatic Taxon	56%	43%	33%	69%	30%	46%	50%	50%	44%	44%	31%	61%
Volume of water (m3)	1326	271	612	612	593	633	347	128	741	741	120	1043
average water/net	265	54	122	122	119	127	69	26	148	148	24	209
StDev of water volume	160	12	29	29	63	57	19	15	23	23	6	111
Estimated total inverts/m3 water	4.5	35.9	7.3	26.4	42.4	20.8	81.5	87.5	15.8	26.2	14.4	12.5
Estimated aquatic inverts/m3 water	3.9	22.5	5	24.1	34.9	18.7	77.4	60.3	13	23.4	14.1	11.3
average inv/m3	4.4	35.9	7.3	26.4	47.5	26.4	83.4	73.3	15.9	26.4	14.5	14.3
average aq inverts/m3 water	3.9	22.6	5	24.8	39.4	23.6	79	52.5	13	25.5	14.2	13
StDev of aq. Inv. Density	2.2	3.3	1.6	9.7	16	15.3	11.9	20.6	3.3	4.9	3.1	4.5
Total aquatic invertebrates	5109	6085	3041	14723	20713	11820	26860	7706	9639	17358	1698	11808
Total. terrestrial invertebrates	876	3645	1400	1400	4439	1320	1431	3479	2091	2091	35	1200
Total invertebrates	5985	9730	4441	16123	25152	13140	28291	11185	11730	19448	1733	13008
% Sample aquatic	85%	63%	68%	91%	82%	90%	95%	69%	82%	89%	98%	91%
% Sample terrestrial	15%	37%	32%	9%	18%	10%	5%	31%	18%	11%	2%	9%
Average # aquatic inverts / net	1022	1217	608	2945	4143	2364	5372	1541	1928	3472	340	2362
stdev aq inv/net	744	279	222	1201	1812	352	1247	1322	567	787	105	1007
Average # terr. inverts / net	175	729	280	280	888	264	286	696	418	418	7	240
Average # inverts / net	1197	1946	888	3225	5030	2628	5658	2237	2346	3890	347	2602
stdev inv/net	893	494	322	1224	2337	432	1244	2327	761	922	108	1100
Total Larval Arctic Grayling/site	0	0	0	0	1	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	1	0	0	0	0	0	0	0	0	0	0
2006a is without Cladocerans and 2006b is with Cladocerans												
2011a is without Ostracods and 2011b is with Ostracods												

Appendix 4. Juvenile Arctic Grayling from Bons Creek, Whole Body Metal Concentrations, 2014

					Method	200.8	200.8		7471A	7740	200.8	
					analyte	Cadmium	Lead		Mercury	Selenium	Zinc	
Sample	Date	Length	Weight	Units								
Number	Collected	(mm)	(g)	dry weight	MRL	0.02	0.02		0.02	1	0.5	% Solids
061014BPAGJ01	6/10/2014	170	51	mg/Kg		0.25	1.14		0.03	16.2	82.0	25.0
061114BPAGJ02	6/11/2014	174	51	mg/Kg		0.15	0.35	<	0.02	14.9	78.7	27.4
061114BPAGJ03	6/11/2014	172	49	mg/Kg		0.19	0.47		0.03	11.9	78.4	24.9
061214BPAGJ04	6/12/2014	163	39	mg/Kg		0.34	0.36	<	0.02	15.9	86.3	26.7
061314BPAGJ05	6/13/2014	173	50	mg/Kg		0.37	0.24	<	0.02	14.9	67.8	25.8
061414BPAGJ06	6/14/2014	180	56	mg/Kg		0.40	0.23		0.02	15.2	84.0	26.0
061414BPAGJ07	6/14/2014	170	45	mg/Kg		0.78	0.48	<	0.02	11.9	74.8	27.3
061414BPAGJ08	6/14/2014	178	54	mg/Kg		0.21	1.37		0.02	16.2	73.7	25.6
061414BPAGJ09	6/14/2014	168	42	mg/Kg		0.14	0.28	<	0.02	14.3	74.5	26.1
061414BPAGJ10	6/14/2014	180	58	mg/Kg		0.23	3.36		0.02	15.2	96.5	25.2
061414BPAGJ11	6/14/2014	179	51	mg/Kg		0.31	1.10		0.02	15.9	79.5	25.2
061414BPAGJ12	6/14/2014	170	49	mg/Kg		0.32	0.59		0.02	13.6	88.4	26.7
061414BPAGJ13	6/14/2014	172	47	mg/Kg		0.14	0.80		0.03	16.6	72.2	26.4
061414BPAGJ14	6/14/2014	167	42	mg/Kg		0.13	0.44	<	0.02	16.3	77.6	25.7
061414BPAGJ15	6/14/2014	174	49	mg/Kg		0.14	0.58		0.02	9.8	71.4	28.2

Appendix 5. Juvenile Dolly Varden from Anxiety Ridge, Buddy, and Mainstem Red Dog Creeks, Whole Body Metal Concentrations, 2014

					Method	200.8	200.8		7471A	7740	200.8	
					analyte	Cadmium	Lead		Mercury	Selenium	Zinc	
Sample	Date	Length	Weight	Units								
Number	Collected	(mm)	(g)	dry weight	MRL	0.02	0.02		0.02	1	0.5	% Solids
080214AXDVJ01	8/2/2014	87	7.5	mg/kg		0.83	1.20		0.05	6.0	127	26.6
080214AXDVJ02	8/2/2014	110	12.5	mg/kg		0.18	0.91		0.09	6.0	97.3	24.4
080214AXDVJ03	8/2/2014	94	7	mg/kg		0.18	0.63		0.04	6.3	126	22.2
080214AXDVJ04	8/2/2014	125	18	mg/kg		0.22	1.18		0.10	5.1	125	24.1
080214AXDVJ05	8/2/2014	109	13	mg/kg		0.70	0.43		0.04	5.7	128	25.2
080214AXDVJ06	8/2/2014	93	9	mg/kg		0.32	0.25		0.08	6.3	111	24.7
080214AXDVJ07	8/2/2014	128	17.5	mg/kg		0.20	1.01		0.08	5.5	112	23.5
072914BUDVJ01	7/29/2014	126	20.5	mg/kg		1.28	0.90		0.02	8.3	128	27.2
072914BUDVJ02	7/29/2014	107	12	mg/kg		0.81	0.83		0.03	7.4	142	25.9
072914BUDVJ03	7/29/2014	120	16.5	mg/kg		0.63	0.73		0.02	6.7	132	25.9
072914BUDVJ04	7/29/2014	136	23	mg/kg		1.12	0.74		0.03	8.2	142	26.4
072914BUDVJ05	7/29/2014	126	18	mg/kg		0.79	1.50		0.02	8.1	175	26.2
072914BUDVJ06	7/29/2014	135	22	mg/kg		0.49	0.85		0.03	6.9	147	22.8
072914BUDVJ07	7/29/2014	123	17.5	mg/kg		0.54	0.49		0.06	6.7	138	23.3
072914BUDVJ08	7/29/2014	126	18.5	mg/kg		1.39	2.06		0.04	6.8	214	23.8
072914BUDVJ09	7/29/2014	122	15.5	mg/kg		1.47	1.42		0.03	8.3	195	24.1
072914BUDVJ10	7/29/2014	127	17	mg/kg		0.49	0.40		0.03	7.1	165	23.0
072914BUDVJ11	7/29/2014	144	25	mg/kg		0.35	0.55		0.03	7.9	136	23.4
072914BUDVJ12	7/29/2014	106	10	mg/kg		0.57	0.64		0.03	8.8	236	18.6
072914BUDVJ13	7/29/2014	105	10	mg/kg		1.32	1.00	<	0.02	8.7	173	24.6
072914BUDVJ14	7/29/2014	103	10.5	mg/kg		1.65	2.74		0.02	7.2	175	25.0
072914BUDVJ15	7/29/2014	100	8.5	mg/kg		1.03	9.45		0.03	5.6	131	24.7
072814MSRDDVJ01	7/28/2014	140	24	mg/kg		2.31	6.01		0.04	9.2	159	23.5
072914MSRDDVJ02	7/29/2014	130	19	mg/kg		1.10	7.09		0.03	6.3	182	23.2
072914MSRDDVJ03	7/29/2014	130	18.5	mg/kg		1.47	3.33		0.03	7.9	182	21.1
072914MSRDDVJ04	7/29/2014	134	20	mg/kg		1.26	3.21		0.04	7.9	209	22.5
072914MSRDDVJ05	7/29/2014	127	19	mg/kg		1.07	15.3		0.03	9.7	160	22.1
072914MSRDDVJ06	7/29/2014	119	16	mg/kg		0.83	2.12		0.02	7.6	139	25.1
072914MSRDDVJ07	7/29/2014	125	18.5	mg/kg		0.88	5.96		0.03	7.3	152	22.6
072914MSRDDVJ08	7/29/2014	113	12.5	mg/kg		0.98	4.81		0.03	8.4	194	21.3
072914MSRDDVJ09	7/29/2014	89	6	mg/kg		1.04	1.10		0.03	7.3	220	21.1
072914MSRDDVJ10	7/29/2014	120	17	mg/kg		2.17	4.43		0.03	8.8	211	22.6
072914MSRDDVJ11	7/29/2014	94	8	mg/kg		1.36	8.80		0.03	8.9	166	22.3
072914MSRDDVJ12	7/29/2014	125	18	mg/kg		0.99	1.63		0.03	9.1	183	21.2
072914MSRDDVJ13	7/29/2014	117	14	mg/kg		1.59	3.13		0.07	7.7	183	21.1
073014MSRDDVJ14	7/30/2014	128	20.5	mg/kg		1.01	3.59		0.04	10.1	175	23.5
073014MSRDDVJ15	7/30/2014	117	15	mg/kg		2.58	6.13		0.07	9.4	232	22.7

Appendix 6. Dolly Varden Metals Data, Wulik River 2014

Tissue	Sample Identification	Fish Species	Sex	Weight (grams)	Length (mm)	Cadmium mg/kg	Copper mg/kg	Lead mg/kg	Selenium mg/kg	Zinc mg/kg	Mercury mg/kg	Percent Solids
Kidney	061214WUDVA1	Dolly	Female	1125	463	1.07	2.8	< 0.02	9.1	65.8	0.08	25.9
Kidney	061214WUDVA2	Dolly	Male	1082	480	1.02	2.0	< 0.02	8.0	75.7	0.05	30.4
Kidney	061214WUDVA3	Dolly	Female	1340	491	1.15	3.1	< 0.02	8.5	61.0	0.06	24.0
Kidney	061214WUDVA4	Dolly	Female	1216	465	1.37	4.7	< 0.02	9.6	76.9	0.06	22.9
Kidney	061214WUDVA5	Dolly	Female	1640	511	1.83	4.8	< 0.02	9.5	72.2	0.06	24.1
Kidney	061214WUDVA6	Dolly	Male	4776	730	4.66	8.2	< 0.02	10.6	128	0.14	20.4
duplicate of Fish #6						7.58	11.9	< 0.02	12.3	130	0.16	21.1
Liver	061214WUDVA1	Dolly	Female	1125	463	0.32	25.1	< 0.02	2.1	62.3	< 0.02	43.4
Liver	061214WUDVA2	Dolly	Male	1082	480	0.62	68.6	< 0.02	3.9	99.4	0.03	37.4
Liver	061214WUDVA3	Dolly	Female	1340	491	0.35	33.9	< 0.02	2.5	76.1	< 0.02	35.8
Liver	061214WUDVA4	Dolly	Female	1216	465	0.47	61.3	< 0.02	3.3	93.4	0.02	31.0
Liver	061214WUDVA5	Dolly	Female	1640	511	0.35	26.8	< 0.02	5.1	85.7	< 0.02	28.8
Liver	061214WUDVA6	Dolly	Male	4776	730	1.43	94.7	< 0.02	3.1	97.0	0.04	37.9
duplicate of Fish #6						1.48	81.9	< 0.02	3.6	96.3	0.04	39.1
Muscle	061214WUDVA1	Dolly	Female	1125	463	< 0.02	1.3	< 0.02	< 1.0	13.5	< 0.02	28.0
Muscle	061214WUDVA2	Dolly	Male	1082	480	< 0.02	1.1	< 0.02	< 1.0	12.5	< 0.02	31.6
Muscle	061214WUDVA3	Dolly	Female	1340	491	< 0.02	1.5	< 0.02	< 1.0	13.1	< 0.02	30.1
Muscle	061214WUDVA4	Dolly	Female	1216	465	< 0.02	1.0	< 0.02	< 1.0	14.1	0.02	26.7
Muscle	061214WUDVA5	Dolly	Female	1640	511	< 0.02	1.5	< 0.02	< 1.0	13.9	< 0.02	31.4
Muscle	061214WUDVA6	Dolly	Male	4776	730	< 0.02	1.4	< 0.02	< 1.0	12.3	< 0.02	35.1
duplicate of Fish #6						< 0.02	1.7	< 0.02	< 1.0	12.4	< 0.02	34.0
Reproductive	061214WUDVA1	Dolly	Female	1125	463	< 0.02	19.0	< 0.02	5.8	186	< 0.02	28.0
Reproductive	061214WUDVA2	Dolly	Male	1082	480	< 0.02	2.7	< 0.02	2.4	106	< 0.02	18.1
Reproductive	061214WUDVA3	Dolly	Female	1340	491	< 0.02	21.5	< 0.02	5.5	310	< 0.02	26.2
Reproductive	061214WUDVA4	Dolly	Female	1216	465	< 0.02	16.0	< 0.02	5.4	139	< 0.02	32.5
Reproductive	061214WUDVA5	Dolly	Female	1640	511	< 0.02	13.8	< 0.02	8.6	140	< 0.02	31.7
Reproductive	061214WUDVA6	Dolly	Male	4776	730	0.06	4.1	< 0.02	2.8	119	< 0.02	19.4
duplicate of Fish #6						< 0.02	1.8	< 0.02	2.6	116	< 0.02	18.6

Appendix 6 (concluded)

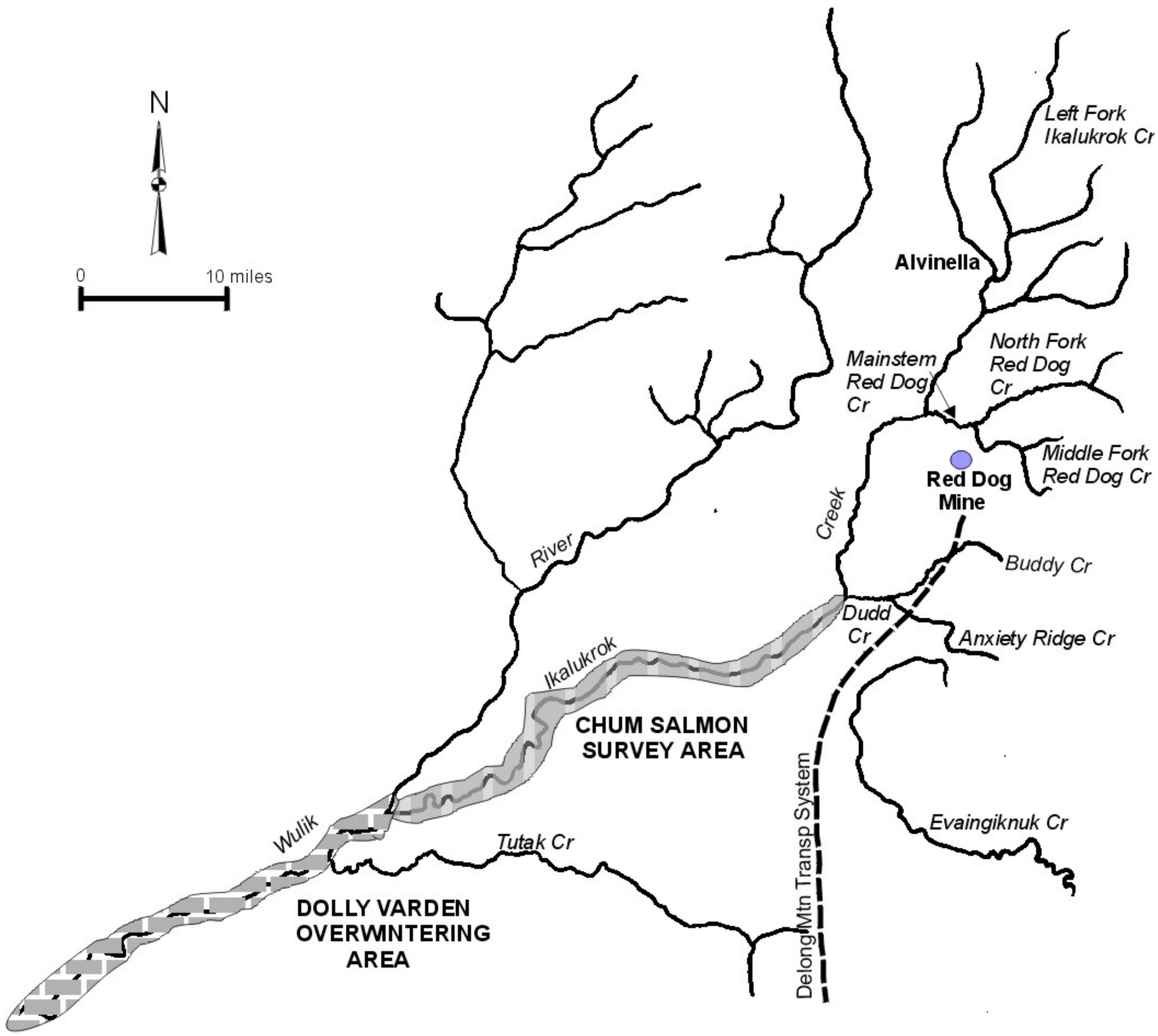
Tissue	Sample Identification	Fish Species	Sex	Weight (grams)	Length (mm)	Cadmium mg/kg	Copper mg/kg	Lead mg/kg	Selenium mg/kg	Zinc mg/kg	Mercury mg/kg	Percent Solids
Kidney	092114WUDVA1	Dolly	Male	1792	524	1.25	3.1	0.02	8.2	80.1	0.06	22.5
Kidney	092114WUDVA2	Dolly	Female	2369	570	2.28	5.9	0.02	8.1	113	0.13	21.6
Kidney	092114WUDVA3	Dolly	Female	3103	650	2.90	4.6	0.02	12.5	115	0.22	22.9
Kidney	092114WUDVA4	Dolly	Female	1337	496	1.63	3.2	0.02	6.0	77.9	0.07	23.9
Kidney	092114WUDVA5	Dolly	Female	2179	566	1.32	3.8	0.02	7.2	86.7	0.08	23.1
Kidney	092114WUDVA6	Dolly	Male	2680	603	2.38	7.9	0.02	9.4	99.7	0.14	22.9
	duplicate of Fish #3					6.41	5.9	0.02	11.7	126	0.17	22.5
Liver	092114WUDVA1	Dolly	Male	1792	524	0.358	27.7	0.02	3.4	65.7	0.03	37.5
Liver	092114WUDVA2	Dolly	Female	2369	570	0.464	32.1	0.02	2.5	54.9	0.02	46.5
Liver	092114WUDVA3	Dolly	Female	3103	650	0.502	32.6	0.02	3.1	52.7	0.03	54.9
Liver	092114WUDVA4	Dolly	Female	1337	496	0.511	24.7	0.02	3.3	72.9	0.02	36.5
Liver	092114WUDVA5	Dolly	Female	2179	566	0.331	15.9	0.02	2.3	47.5	0.02	13.2
Liver	092114WUDVA6	Dolly	Male	2680	603	0.321	26.0	0.02	3.7	58.8	0.02	48.3
	duplicate of Fish #3					0.626	42.8	0.02	4.2	72.3	0.04	46.8
Muscle	092114WUDVA1	Dolly	Male	1792	524	0.02	1.5	0.02	1.0	13.2	0.02	31.9
Muscle	092114WUDVA2	Dolly	Female	2369	570	0.02	3.1	0.02	1.1	12.1	0.02	31.4
Muscle	092114WUDVA3	Dolly	Female	3103	650	0.02	0.97	0.02	1.0	12.3	0.03	31.1
Muscle	092114WUDVA4	Dolly	Female	1337	496	0.02	1.3	0.02	1.0	12.4	0.02	29.8
Muscle	092114WUDVA5	Dolly	Female	2179	566	0.02	1.4	0.02	1.0	11.0	0.02	34.9
Muscle	092114WUDVA6	Dolly	Male	2680	603	0.02	1.3	0.02	1.0	10.6	0.02	38.1
	duplicate of Fish #3					0.02	2.6	0.02	1.0	12.5	0.03	32.1
Reproductive	092114WUDVA2	Dolly	Female	2369	570	0.068	34.7	0.02	9.9	204	0.02	21.3
Reproductive	092114WUDVA3	Dolly	Female	3103	650	0.087	35.4	0.02	10.0	827	0.02	23.4
Reproductive	092114WUDVA4	Dolly	Female	1337	496	0.045	15.9	0.02	8.4	670	0.02	18.5
Reproductive	092114WUDVA5	Dolly	Female	2179	566	0.039	34.4	0.02	9.3	568	0.02	27.4
	duplicate of Fish #3					0.088	34.2	0.02	10.1	826	0.02	23.6

Appendix 7. Dolly Varden Aerial Surveys

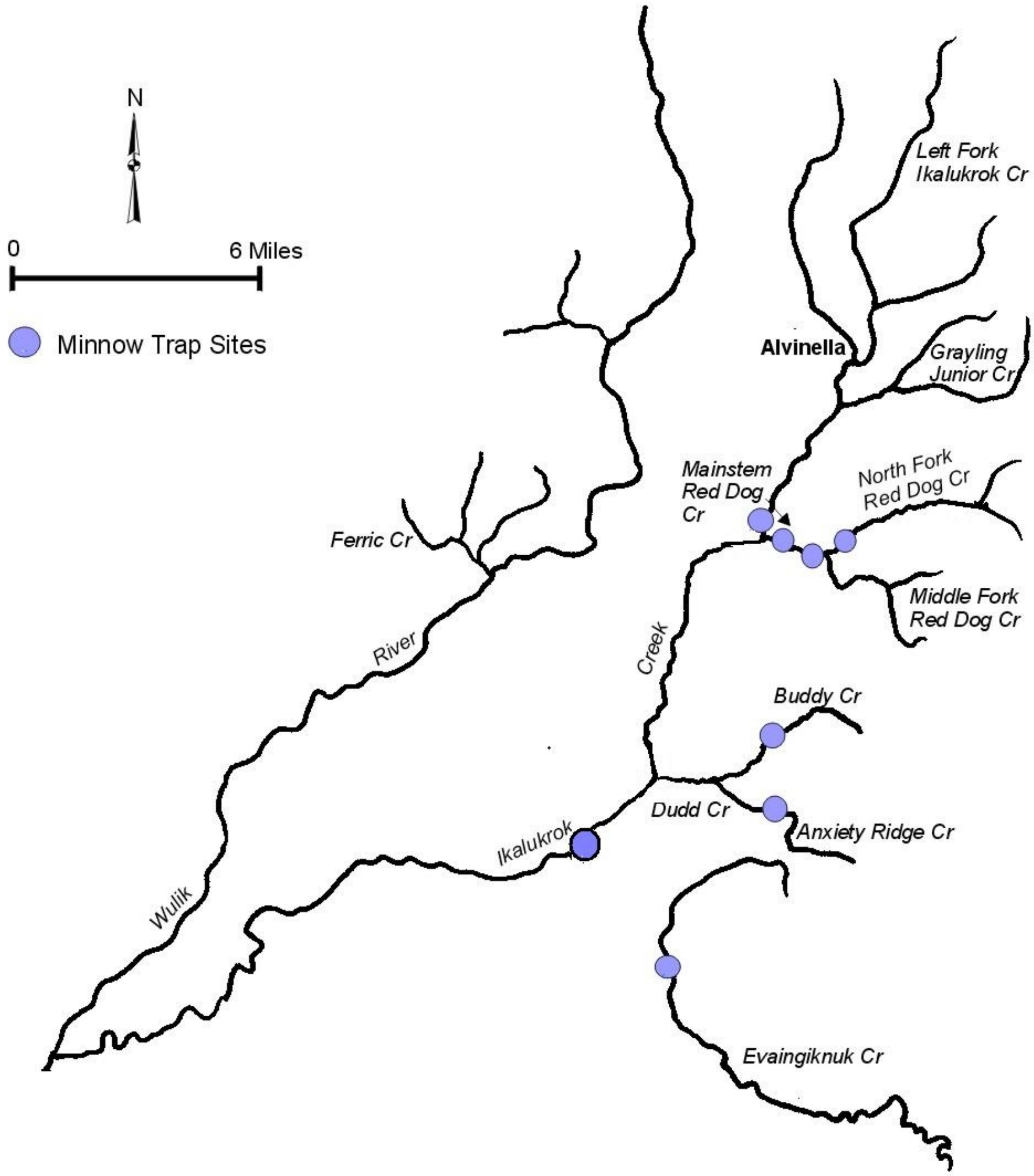
Estimated number of overwintering Dolly Varden in the Wulik River before freezeup. Surveys conducted by ADF&G (DeCicco 1989, 1991-1999, 2001-2002, and 2004-2014).

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
2011	637	62,612	63,249	99
2012	0	21,084	21,084	100
2013	114	21,945	22,059	99
2014	610	63,341	63,951	99
The population estimate (mark/recapture) for winter 1988/1989 for fish				
>400 mm was 76,892 (DeCicco 1990a)				
The population estimate (mark/recapture) for winter 1994/1995 for fish				
>400 mm was 361,599 (DeCicco 1996b)				
Fall 2000 and 2003 aerial surveys were not made due to weather.				

Appendix 8. Dolly Varden and Chum Salmon Survey Areas



Appendix 9. Juvenile Dolly Varden Sampling Sites



Appendix 10. 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	2011	2014
Evaingiknuk (Noatak Tributary)	54	27	38	2	7	20	64	71	29	4	67	21	16	48	36	17
Anxiety Ridge	68	94	271	27	6	33	98	116	121	8	115	75	147	18	43	7
Buddy	48	154	306	11	34	57	104	59	59	5	183	43	100	115	77	18
North Fork Red Dog Creek (Sta 12)	0	12	17	1	1	1	0	1	8	0	1	0	3	6	2	0
Mainstem (below North Fork) (Sta 151)	14	70	86	13	9	12	2	2	6	8	2	13	7	13	7	1
Mainstem (Station 10)	10	21	66	1	3	12	12	0	10	3	6	5	6	14	8	13
Ikalukrok Creek (below Dudd)(Sta 7/160)	13	51	55	31	6	17	17	27	36	2	25	7	30	10	32	7
Ikalukrok Creek (above Mainstem)(Sta 9)	3	44	41	5	2	18	3	12	0	5	7	3	11	37	12	2
Total Catch Dolly Varden	210	473	880	91	68	170	300	288	269	35	406	167	320	261	217	65

Appendix 11. 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 11 (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 11 (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 11 (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

6/7/2011 – one male Arctic grayling (Code #49 – radiotag) radio-located in Mainstem Red Dog Creek along with many other adult Arctic grayling near first bluff below Station 151
6/10/2011 – caught 6 Arctic grayling in Mainstem Red Dog Creek between the mouth of North Fork Red Dog Creek and Station 151
6/11/2011 – two male Arctic grayling (Code 50 and 54 – radiotag) radio-located in Mainstem Red Dog Creek downstream of Station 151
7/17/2011 – aerial survey to relocate radio-tagged Arctic grayling, 13 of 15 fish found – none were in Mainstem Red Dog Creek
8/28/2011 – observed several Arctic grayling fry in Mainstem Red Dog Creek just upstream of Station 151, fry were in backwaters and in a side channel

7/8/2012 – observed Arctic grayling fry near Station 10, broad distribution in vicinity of drift nets, several small schools of 15 to 20 fry

7/30/2013 – Arctic grayling fry were not observed near Station 10

7/28/2014 – one Arctic grayling fry observed near Station 10, about 40 mm long, several 300 mm Arctic grayling observed moving upstream, smaller Arctic grayling (200 to 300 mm) common (five to seven is backwaters and pools throughout the minnow bucket sample reach)

Appendix 12. 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 12 (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
2011	low	Spawning probably began on June 9, 2011 – no fry were seen in July and in late August a few fry (less than 5) were observed in backwaters
2012	low	Observed small numbers (2 to 3) of fry along stream margins and in several pools
2013		No observations made due to extremely high water
2014	low	Arctic grayling fry observed in most back waters, about 20 mm