Technical Report No. 14-08

Arctic Grayling and Burbot Studies at the Fort Knox Mine, 2014

by Alvin G. Ott, William A. Morris, Heather L. Scannell, and Parker T. Bradley

Fyke Net in Pond F Outlet, April 29, 2014
Photograph by William A. Morris

October 2014

Alaska Department of Fish and Game
Division of Habitat

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ARCTIC GRAYLING AND BURBOT STUDIES AT THE FORT KNOX MINE, 2014

By

Alvin G. Ott, William A. Morris, Heather L. Scannell, and Parker T. Bradley

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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	$\geq$
harvest per unit effort	HPUE
less than	$<$
less than or equal to	$\leq$
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 Fairbanks Gold Mining Inc. (FGMI) (Delbert Parr, Mark Huffington, and Dave Stewart) for their continued support of our work to monitor fish and wildlife resources in the Water Supply Reservoir, tributaries, and developed wetlands. Bartly Kleven, Mark Huffington, and Dave Stewart (FGMI) provided constructive review of our report.

Executive Summary

Water Quality

●Winter dissolved oxygen was not collected in April due to unsafe ice conditions associated with water removal from the Water Supply Reservoir (page 4)

Arctic Grayling Stilling Basin

●Forty-three Arctic grayling were caught in the stilling basin. Two of these fish had been marked in the Water Supply Reservoir (pages 8 and 9)

Arctic Grayling Water Supply Reservoir

●Arctic grayling spawning was early in the wetland complex due to minimal aufeis and warm weather – spawning probably began on May 12 and was substantially complete by May 23. Arctic grayling spawned throughout the wetland complex but not in the upper 100 m of Channel C because of a beaver dam that blocked upstream passage (pages 10 and 11)

●The spring 2013 population estimate for Arctic grayling $\geq$ 200 mm long was 6,675 fish (95% CI 6,217-7,333) (page 13)

●Recruitment of Arctic grayling was observed in spring 2014 – 301 new fish between 200 and 240 mm in length were captured and marked (page 13)

●Average annual growth of Arctic grayling in the WSR decreased from 2010 to 2013 as compared with 2009, as the population increased (page 16)

Burbot Water Supply Reservoir

●We caught 98 burbot in the WSR and developed wetlands that ranged from 135 to 850 mm long - 25 of those fish were larger than 400 mm and 7 had been seen in spring 2013 (pages 18 and 19)

●The estimated population of large burbot ($\geq$ 400 mm) in the WSR was 80 (95% CI 44-117) for spring 2013 and is a substantial decrease in the population from 2012 (page 19)

Introduction

Fairbanks Gold Mining Incorporated (FGMI) began construction of the Fort Knox hard-rock gold mine in March 1995. The mine is located in the headwaters of the Fish Creek drainage about 25 km northeast of Fairbanks, Alaska (Figure 1). The project included an open-pit mine, mill, tailing impoundment, water supply reservoir (WSR), and related facilities. Construction of the WSR dam and spillway was completed in July 1996. In 2007, permits were issued for the construction, operation, and closure of a valley fill heap leach facility located in Walter Creek upstream of the tailing pond. Ore was processed through the mill as well as through the Walter Creek valley fill heap leach in 2014. Exploration drilling continued at the Gil Prospect located 13 km east of Fort Knox.

Figure 1. Aerial photograph of the Fort Knox Gold Mine water supply reservoir, tailing facility, and pit – water supply reservoir in lower part of photo and the tailing dam and impoundment in the upper Fish Creek valley, photograph provided by FGMI.

A chronology of events for 2011, 2012, 2013, and 2014 with emphasis on biological factors, is presented in Appendix 1. The chronology for previous years (1992 to 2010) can be found in Technical Report No. 10-5 titled "Arctic grayling and burbot studies at the Fort Knox Mine, 2010" (Ott and Morris, 2010).

Rehabilitation, to the extent practicable, has been concurrent with mining activities and natural revegetation of some disturbed habitats has been rapid. Wetland construction between the tailing dam and WSR began in summer 1998. A channel connecting Pond D and E was built in summer 2001 (Figure 2).

Figure 2. Channel from Pond D to E in the wetlands in 2001 (top photo) and in 2010 (bottom photo). Arctic grayling spawned in this channel in spring 2014.

In-channel excavation, drainage rock placement, and channel reconstruction work to mitigate aufeis in Last Chance Creek was conducted in fall 2001 and again in fall 2008. Repair work on dikes separating Ponds D and E and the channel connecting the ponds was completed in summer 2002. Buell and Moody (2005) provided recommendations for additional work to enhance fish and wildlife habitats between the tailing dam and WSR.

Fish research prior to construction of the Fort Knox mine and related facilities began in 1992 and water quality sampling started in summer 1997. Technical Reports (Weber Scannell and Ott 1993, Weber Scannell and Ott 1994, Ott et al. 1995, Ott and Weber Scannell 1996, Ott and Townsend 1997, Ott and Weber Scannell 1998, Ott and Morris 1999, Ott and Morris 2000, Ott and Morris 2001, Ott and Morris 2002a, b, Ott and Morris 2003, Ott and Morris 2005a, b, Ott and Morris 2006, Ott and Morris 2007, Ott and Morris 2009a, b, Ott and Morris 2010, Ott and Morris 2011, Ott et al. 2012, Ott et al. 2013) summarizing field work can be found on the Alaska Department of Fish and Game, Division of Habitat's Web Page:

http://www.adfg.alaska.gov/index.cfm?adfg=habitat_publications.main.

Populations of Arctic grayling (*Thymallus arcticus*) and burbot (*Lota lota*) exist in the WSR, and both Arctic grayling and burbot inhabit the stilling basin below the WSR. Arctic grayling spawning occurs predominantly in the wetland complex between the WSR and the tailing dam. Burbot spawning as documented by using radio telemetry likely occurs in Solo Bay where Solo Creek enters the WSR. Recruitment of Arctic grayling to the stilling basin is from the WSR, but no tagged burbot from the WSR have been caught in the stilling basin. Our report summarizes fish and water quality data collected during 2014 and discusses these findings in relation to previous work.

Methods

Water Quality

In 2014, water quality sampling was not conducted in late April when the WSR was ice covered. Conditions of ice were considered unsafe as winter water removal had caused the ice to fall creating large cracks and a steep gradient from the shoreline. Water from Last Chance, Solo, and Fish creeks had overflowed on top of the ice. A temperature probe was placed in the Pond F outlet channel on April 22, 2014 to monitor water temperature; the probe was removed on May 22, 2014 and replaced with a new probe that was removed on September 26, 2014.

Fish

Fish sampling methods included visual observations, fyke nets, angling, and hoop traps. One fyke net sampling site in the developed wetlands located just upstream of the WSR was used in spring 2014 (Figure 3). The fyke net was set in Channel #5 on April 29, 2014 and was fished until May 9. The fyke net was pulled on May 9 and reset at the same location on May 12 and fished until May 15 when it was pulled. Water levels in the WSR had risen and on May 12 water was flowing over the spillway. Arctic grayling were sampled by angling in the stilling basin and burbot were captured in the WSR using baited hoop traps.

Arctic grayling were measured to fork length (nearest mm), inspected for tags and spawning condition, and released. Burbot were measured (total length), inspected for tags, and released. Arctic grayling and burbot $\geq$ 200 mm were marked with a numbered Floy® T-bar internal anchor tag. Arctic grayling and burbot abundance was estimated using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951) and variance was estimated (Seber 1982).

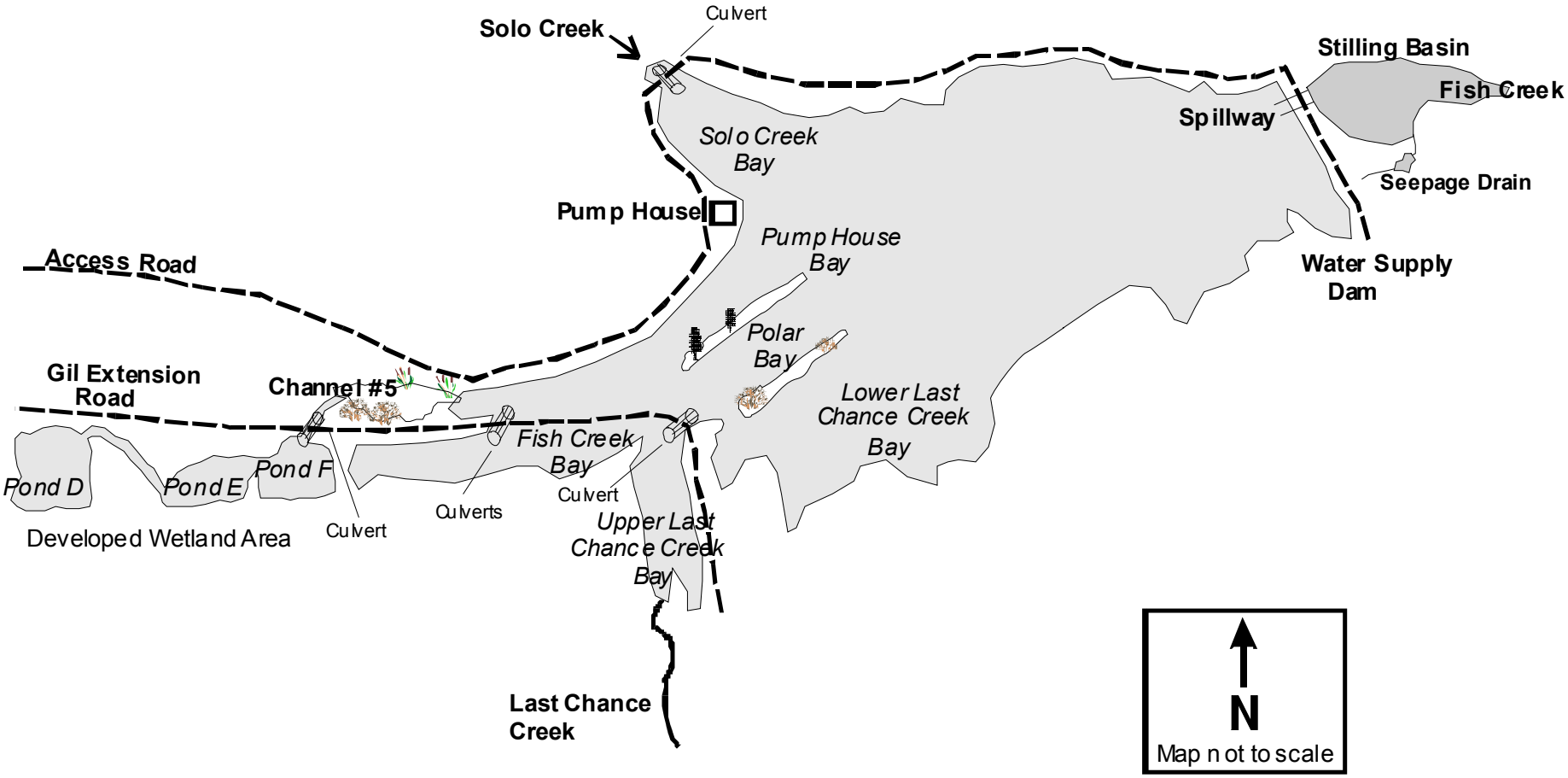

Figure 3. Sample areas in the Fort Knox WSR, stilling basin, and developed wetlands.

Results and Discussion

Water Supply Reservoir, Water Quality

Ponding of water for the WSR began in November 1995. Water surface elevation varied in 1996 and 1997 due to water use and winter seepage below the freshwater dam. The WSR reached the projected maximum water surface elevation of 1,021 feet on September 29, 1998, after a major rainfall event. When full, the WSR contains about 3,363 acre-feet (1.1 billion gallons) of water.

Water levels have remained fairly constant since 1998, except in the winter in certain years when large amounts were removed (Table 1). In late April 2014 there was no surface flow over the spillway, but by May 12, 2014, water was flowing in the low flow channel of the spillway. Winter water use in 2013/2014 was 1,399 acre-feet (about 42% of the water available) not counting winter input from tributaries feeding the WSR.

Table 1. Winter water use from the WSR, 1997 to 2014 (October 1 to April 30).

Year	Acre-Feet of Water Removed
1997/1998	660
1998/1999	605
1999/2000	577
2000/2001	1,464
2001/2002	320
2002/2003	337
2003/2004	279
2004/2005	716
2005/2006	659
2006/2007	299
2007/2008	1,176
2008/2009	817
2009/2010	1,167
2010/2011	187
2011/2012	59
2012/2013	1,837
2013/2014	1,399

Flashboards were placed in the low flow channel of the spillway during summer 2014 to maintain water levels about 15 cm (6 inches) higher in the WSR. Based on discussions with FGMI, anticipated winter water use (2014 – 2015) will be high because of water needs for the valley heap leach.

Stilling Basin, Arctic Grayling and Burbot

The stilling basin, located immediately downstream of the WSR spillway, is fed by groundwater, seepage flow, and surface flow (Figure 4). A narrow notch in the spillway was designed to accommodate surface water discharge from the WSR during winter without forming aufeis. Aufeis in the spillway has never been observed since it was constructed. In spring 2014, water was not flowing over the spillway.

Figure 4. Stilling basin located immediately below the spillway, looking northeast, water elevation increased by at least one meter due to beaver dam at outlet, spring 2014.

Arctic Grayling

Limited Arctic grayling sampling using angling was conducted in spring 2014. We fished for 60 min on April 29 and for 60 min on May 1, catching 43 Arctic grayling ranging from 160 to 294 mm fork length. Two recaptures were caught and these fish had been tagged in the WSR in 2012 and 2013. The length frequency distribution for Arctic

grayling caught in the stilling basin is presented in Figure 5. Multiple age classes are present in the stilling basin.

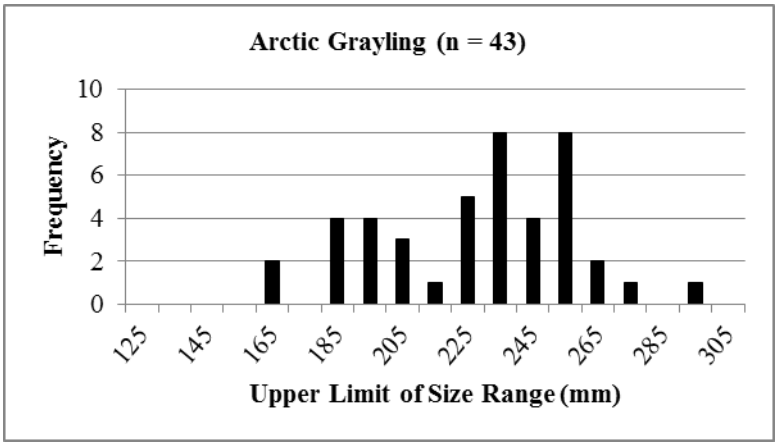

Figure 5. Length frequency distribution of Arctic grayling in the stilling basin in spring 2014.

Water Supply Reservoir, Arctic Grayling

Arctic grayling were found throughout the Fish Creek drainage prior to construction of the WSR. However, fish were concentrated in flooded mine cuts in Last Chance Creek. The population appeared stunted: fish larger than 220 mm were rare; average annual growth was 9 mm; and size at maturity was small (148 mm for males, 165 mm for females). Successful spawning was limited to inlets and outlets of the flooded mine cuts and upper Last Chance Creek. Flooding of the WSR inundated the inlets and outlets of mine cuts, thus eliminating this spawning habitat. Since flooding of the WSR, aufeis in Last Chance Creek has been substantial. Since 1998, we have only observed successful spawning by Arctic grayling in Last Chance Creek in 2004 and 2005.

Very few fry were captured or observed from 1996 through 1998 in the WSR and Last Chance Creek (less than 10 were observed). In spring 1999, FGMI constructed an outlet channel (Channel #5) to connect the developed wetland complex with the WSR (Figure 3). Channel #5 was constructed to bypass a perched pipe and provide fish access to potential spawning and rearing habitat in the wetland complex. Arctic grayling have successfully spawned in the wetland complex every year since 1999. However, substantial aufeis and resultant cold water temperatures in the wetland complex, in addition to beaver dams, substantially limited availability of, and access to, spawning habitats in 2002, 2006, and 2007.

Arctic Grayling Spawning (Timing, Temperature, and Fry Presence)

In spring 2014, we fished one fyke net in the developed wetlands just upstream of the WSR. The fyke net was set on April 29 and was fished until May 9 and then again from May 12 to 15. Beaver dams removed from the wetlands in fall 2013 had not been rebuilt in the wetland complex, except for one near the head of Channel C. Aufeis was minimal downstream of Pond D and Arctic grayling had access to most of the wetland complex.

In spring 2014, Arctic grayling spawning probably began around May 8 and by May 13 nearly all female Arctic grayling were ripe and sampling ceased on May 14. Handling of Arctic grayling once they reach this stage of maturity results in the loss of many, if not

most, of their eggs. In 2014, Arctic grayling spawning probably began on May 12 when water temperatures peaked at 4.2°C (Figure 6). Active spawning by Arctic grayling in the wetland complex was observed through May 23, but by May 28 no evidence of spawning was seen.

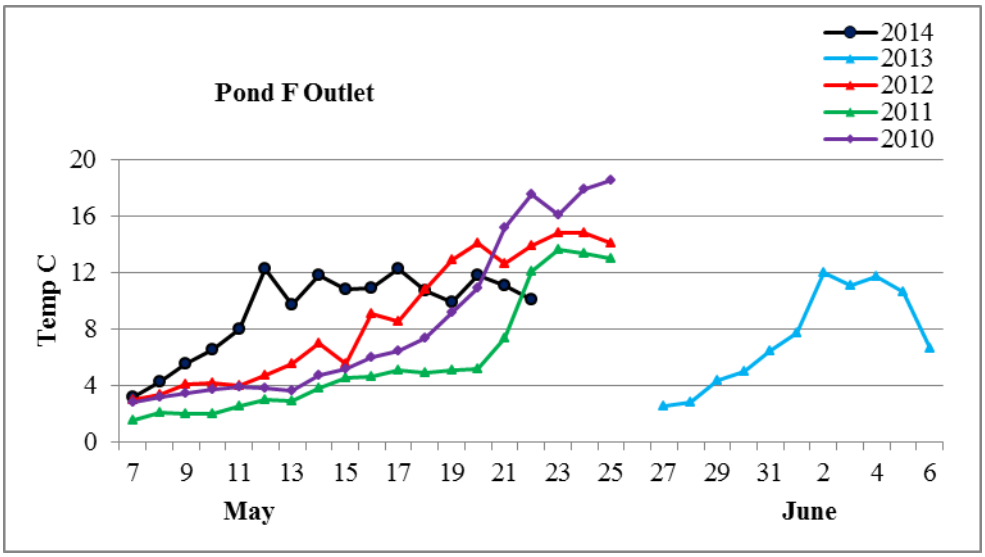

Figure 6. Peak daily water temperatures in Pond F outlet channel.

Visual surveys for Arctic grayling fry were conducted on September 26, 2014. Ponds in the wetland complex were partially ice covered and only one fry was observed. Most of the fry probably had already left the wetland complex and entered the WSR. The water temperature in Pond F outlet was 3.4°C.

Arctic Grayling Catches and Metrics

The fyke net was set before fish began entering the wetland complex. This was the only open water area present that was large enough to allow the net to be set (Figure 7). We captured three Arctic grayling from April 29 to May 1, but on May 2, 2014, we caught 275 Arctic grayling (Figure 8). The catch per trap day peaked on May 8 when we caught 559 Arctic grayling.

Figure 7. Fyke net was placed in this pool/run on April 29, 2014, when the WSR was still ice covered.

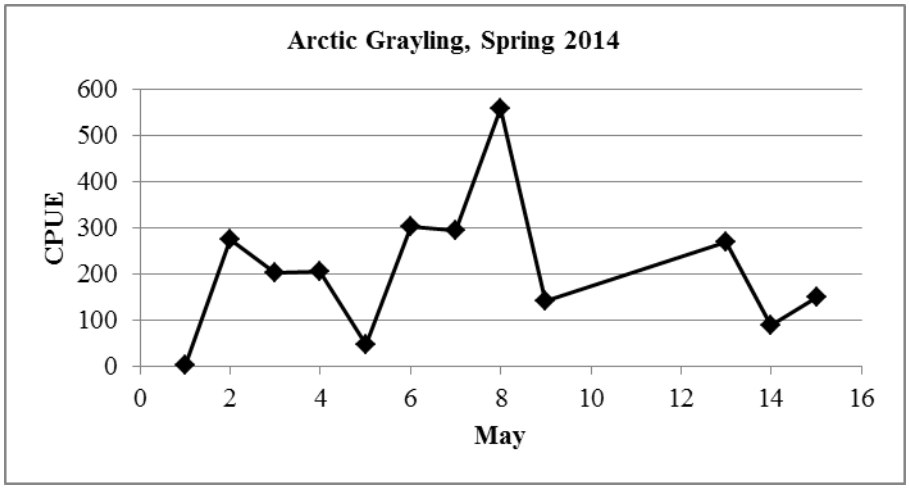

Figure 8. Catch per unit of effort (fish per net day) for Arctic grayling in spring 2013 in the wetland complex.

The abundance of Arctic grayling was estimated in the WSR using spring 2013 as the mark event and spring 2014 as the recapture event. In spring 2013, there were 1,599 marks when newly tagged and recaptured fish were combined. In spring 2014, 1,380 Arctic grayling $\geq$ 240 mm were captured, and of those, 330 were recaptures. For the 2013 estimated Arctic grayling population, length frequency distributions from 2013 and 2014 were compared to eliminate those fish handled in 2014 that would have been too

small (< 200 mm) to mark in spring 2013. We reduced the total number of fish handled in spring 2014 by 310 fish that were < 240 mm long.

The spring 2013 population estimate for Arctic grayling ≥ 200 mm long was 6,675 fish (95% CI 6,117 to 7,232) (Figure 9 and Appendix 2). There was no substantial change in the Arctic grayling population from 2011 to 2013.

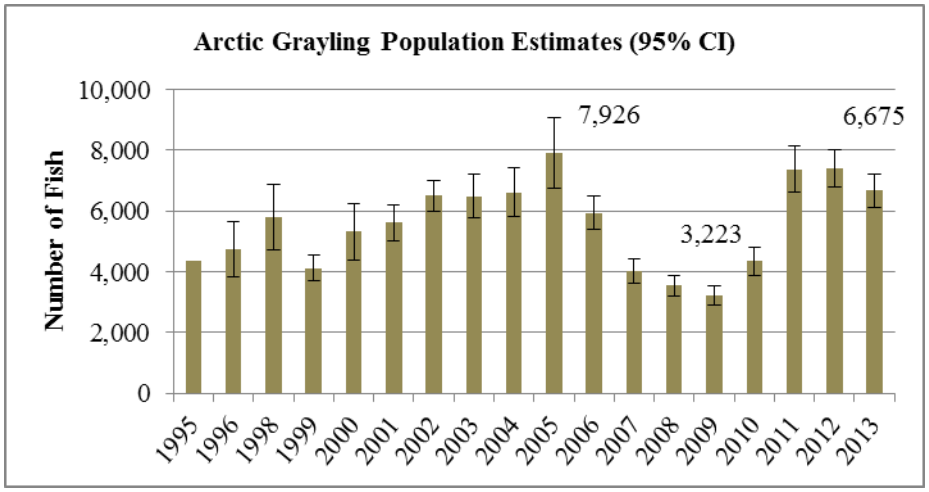

Figure 9. Estimates of the Arctic grayling population in the WSR.

Substantial recruitment, defined as fish encountered during a recapture sampling event that were not available for tagging based on size during the mark sampling event (typically fish between 200 and 240 mm) was observed in springs 2004, 2010, and 2014 (Figure 10). We captured 310 fish between 200 and 240 mm long that we marked in spring 2014 that would have been less than 200 mm long in spring 2013. The structure of the population is similar in 2012, 2013, and 2014. The length frequency distribution of all Arctic grayling captured in spring 2014 is presented in Figure 11.

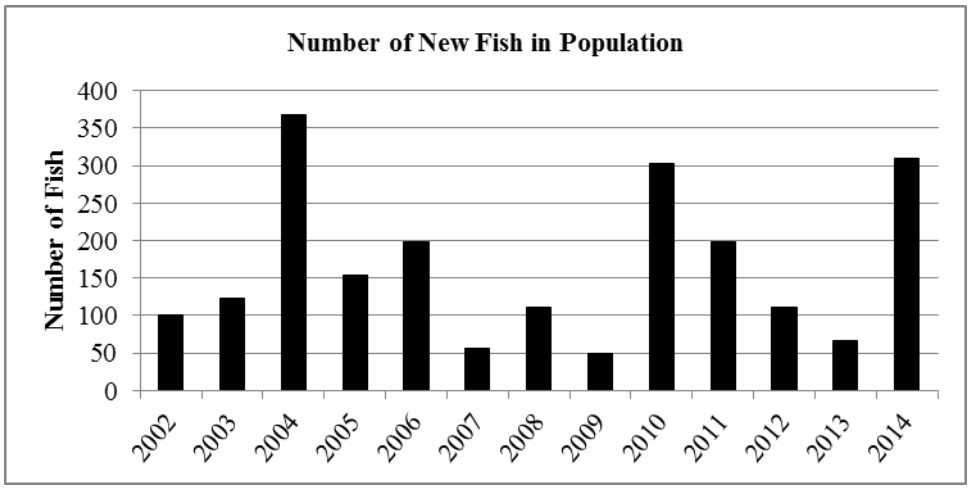

Figure 10. Number of new fish ≥ 200 mm that entered the population but would have been too small to mark in the previous year (based on growth of marked fish).

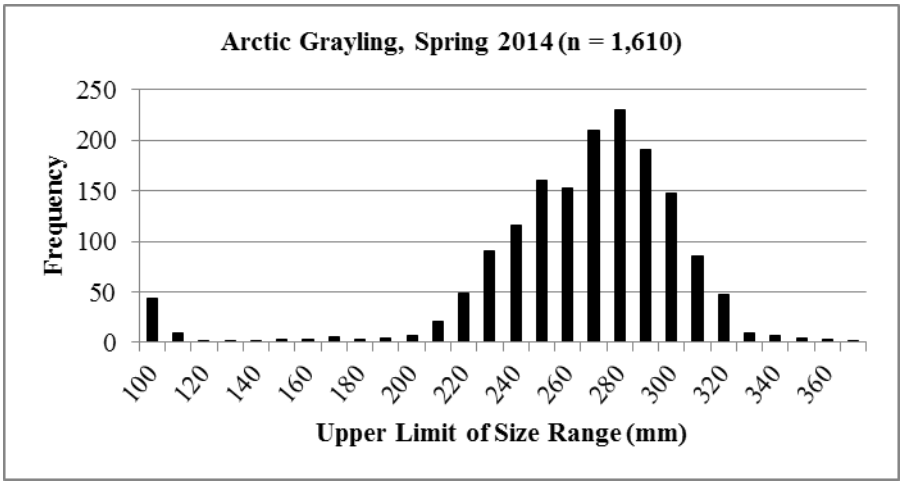

Figure 11. Length frequency distribution of Arctic grayling in wetlands in spring 2014 (n = 1,610).

The length frequency distribution for Arctic grayling in 1995 and 2014 is presented in Figure 12. The 1995 data set were obtained prior to construction of the freshwater dam and reflects the stunted condition of the population at that time. Twenty years later, the current population is composed of much larger fish as well as consistent numbers of juvenile fish from annual recruitment. The population structure is likely to remain that

way provided the wetland complex remains open for fish to access and use the wetlands for spawning, rearing, and outmigration to overwintering habitats in the WSR.

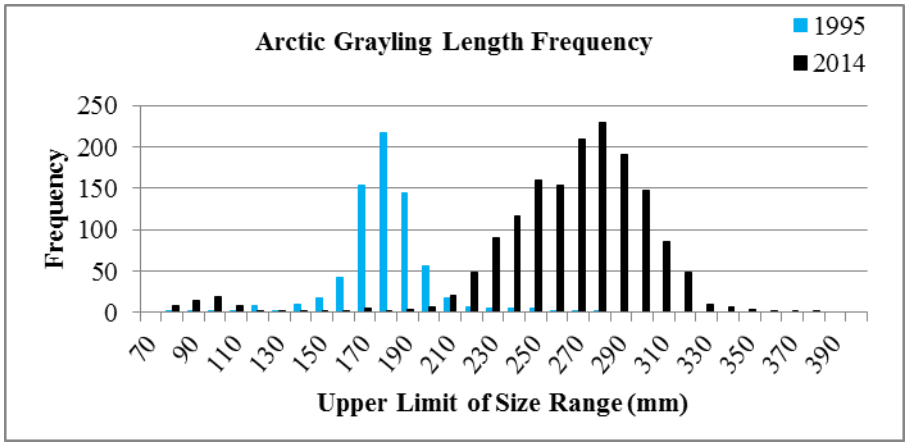

Figure 12. Length frequency distribution of Arctic grayling in 1995 (prior to the flooding of the WSR) and in 2014, 20 years after the freshwater dam was constructed.

Average growth of Arctic grayling prior to development of the WSR ranged from 3 to 17 mm per year (Figure 13 and Appendix 3). After the WSR was flooded in 1995, annual growth for fish increased substantially. Average growth in summer 2013 was substantially higher than in 1994, when compared by size class.

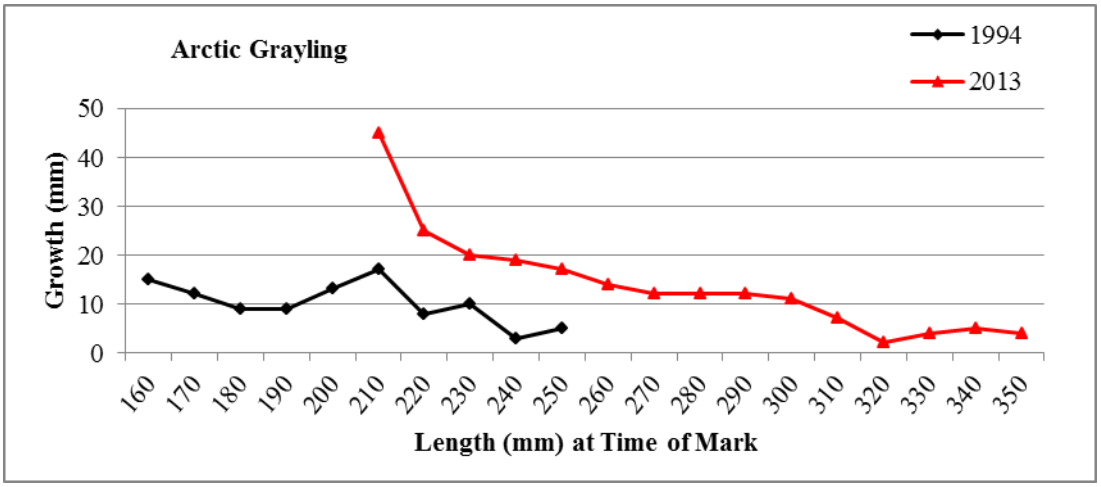

Figure 13. Growth of marked Arctic grayling before the WSR and in 2013.

Annual growth rates of marked fish peaked in 2001, and then decreased slowly each year through 2004. Growth rates were increasing as the fish population was decreasing in the WSR. Growth rates of individual fish increased after 2004, with highest growth seen in summer 2008, as the population continued to decrease. However, growth rates in summer 2009 dropped slightly and probably reflect the large increase in recruitment of new fish to the population. Growth rates in 2010, 2011, 2012, and 2013 continued to be lower than in summer 2009 (Figure 14).

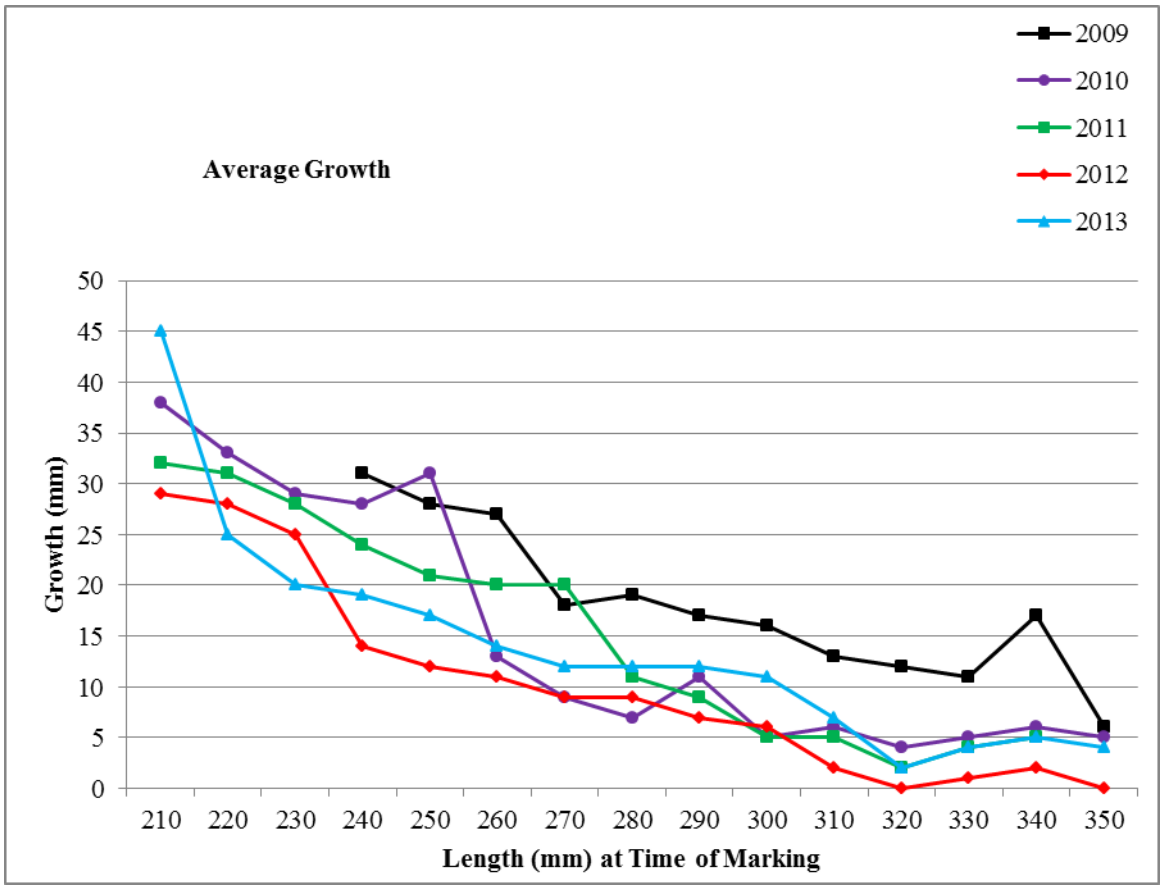

Figure 14. Average growth (mm) of Arctic grayling from 2009 to 2013 in the WSR.

Water Supply Reservoir, Burbot

Only a few burbot (135, 165, and 252 mm) were captured in spring 2014 in the fyke net fished in the developed wetlands. Most of the burbot (95) were captured in hoop traps fished from May 23 to 30, 2014 in the WSR. Burbot ranged in size from 135 to 850 mm, and 25 of the burbot were ≥ 400 mm (Figure 15).

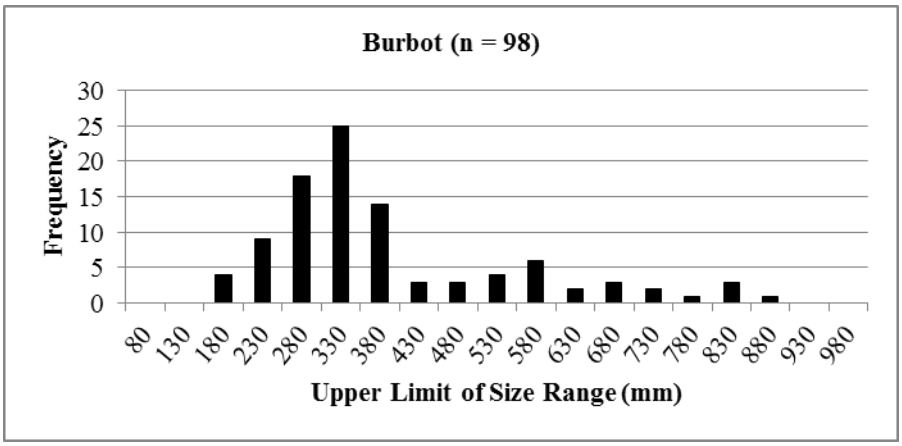

Figure 15. Length frequency of burbot in the developed wetlands and WSR in spring 2014.

The catch per unit of effort for hoop traps (number of burbot per hoop trap/24 hrs) fished in the WSR remains low as compared with higher catches that occurred following the flooding of the reservoir (Figure 16). Catches of smaller burbot were highest in 1998 (7.2 fish/day), but decreased quickly and have remained low since 2002.

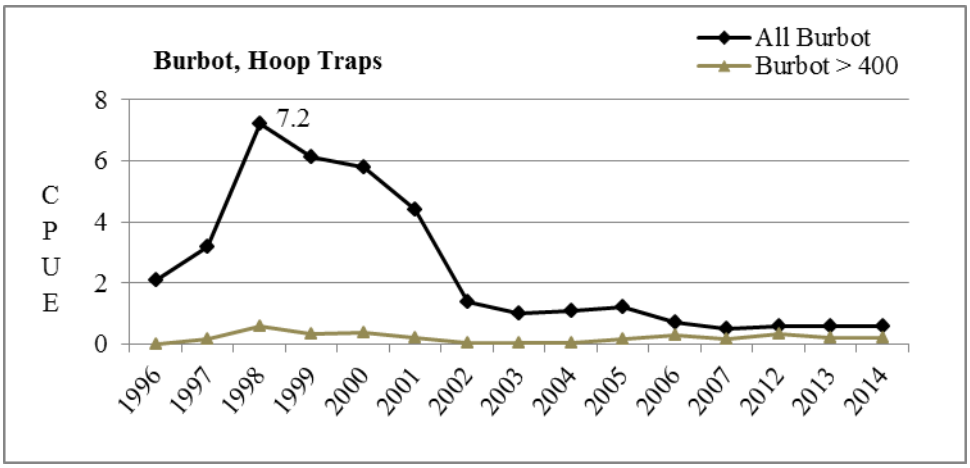

Figure 16. Catch per unit of effort (fish/trap day) of burbot in the WSR from 1996 to 2014.

In spring 2013, we marked or recaptured 24 burbot ≥ 400 mm. We caught 25 burbot ≥ 400 mm in spring 2014 with only seven recaptured fish from spring 2013. Our estimated population of large burbot for spring 2013 was 80 (95% CI 44-117) (Figure 17, Appendix 4). Growth rates of the seven large burbot averaged 25 mm per year but were highly variable and ranged from 8 to 40 mm.

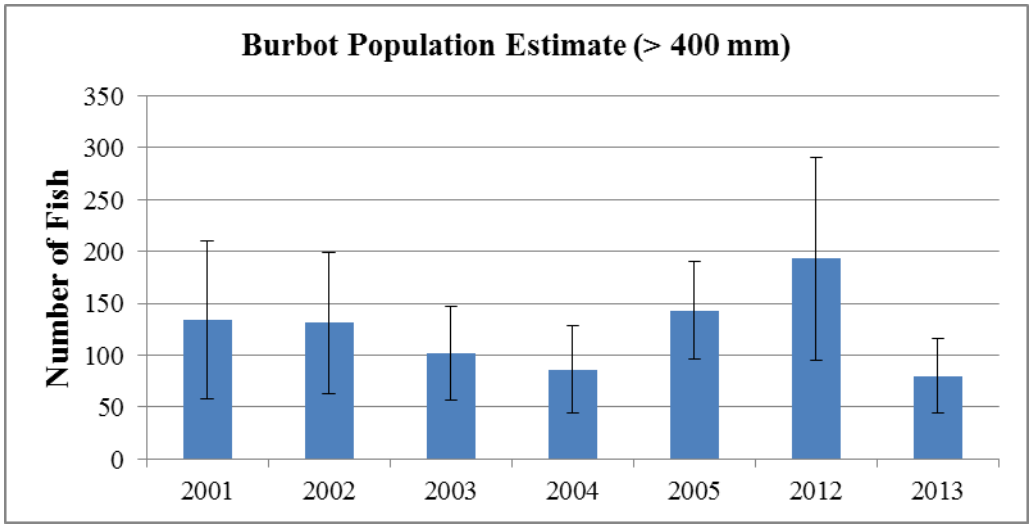

Figure 17. Burbot population estimates in the WSR.

Conclusion

Populations of Arctic grayling and burbot have been established in the Fort Knox WSR. The post-mining goal for the Arctic grayling population was set at 800 to 1,600 fish ≥ 200 mm (FGMI 1993). Our spring 2013 estimated population for Arctic grayling ≥ 200 mm was 6,675 fish which is a slight decrease from the estimated 2012 population. A goal for the burbot population was not set prior to construction, but a small population of fish larger than 400 mm exists.

We plan to continue to work cooperatively with FGMI to collect data on fish resources and water quality in the WSR and to implement rehabilitation projects designed to increase fish and aquatic habitat values and terrestrial habitats. Active management of beaver populations within the developed wetlands and WSR appears to remain a critical component to the productive capacity of the wetland complex for Arctic grayling.

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Appendix 1. A Summary of Mine Development with Emphasis on Biological Factors

2011

●on February 9, 2011, ADF&G provided input to ADNR on the environmental audit to be conducted in summer 2011. We identified several possible fish and wildlife enhancement projects originally recommended by Buell and Moody (2005).

●on March 4, 2011, the ACOE issued a permit (POA-1992-574-M19) authorizing construction of the modified dam raise and expansion of the Tailing Storage Facility (TSF).

●in April and May several Plan of Operations amendments were issued by ADNR for work associated with the TSF, waste rock dumps, powerline, topsoil storage, and dewatering.

●on May 2, 2011, ADF&G provided input to ADNR on the reclamation and closure plan for Fort Knox. Emphasis was on maintaining the existing developed wetland complex downstream of the TSF.

●our spring sample event for Arctic grayling and burbot ran from May 9 to 24. We caught 1,194 Arctic grayling and 117 burbot in a fyke net set in the WSR.

●the estimated spring 2010 Arctic grayling population was 4,346 fish > 200 mm long and was an increase from the 2009 estimate of 3,223. Recruitment of new fish in spring 2011 was strong with 198 new fish < 230 mm marked.

●Arctic grayling spawned in the wetland complex from Pond D downstream. Beavers had not rebuilt the dams in the wetland complex.

●a constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring 2011 – one chick was seen in August. An active raven nest was observed on the rock cut near the freshwater dam.

●water began flowing over the spillway on May 27, water had not reached the spillway since winter 2009/2010.

●on June 2, 2011, ADF&G provided written comments on the Ft. Knox and True North environmental audit proposals.

●on July 19, 2011, FGMI pumped about 10,440 gallons of water from the "801 Pond" downstream – environmental staff were notified and pumping was immediately stopped – water from the "801 Pond" is supposed to be pumped back into sump below the TSF

●on August 4, 2011, ADNR informed us of planned changes at Fort Knox including expansion of the heap leach facility from 160 to 300 million tons, the need for a ADEC permit to discharge non-contact water, and the long-term need for a permit and water treatment plant for closure.

Appendix 1 (continued).

2011

●on September 13, 2011, ADNR approved the drilling of two monitoring wells in the headwaters of Victoria Creek. The purpose of these monitoring wells is to ensure water in Victoria Creek is not impacted by the increased elevation of tailings in the Pearl Creek drainage.

●on September 28, 2011, we met with FGMI to discuss plans to discharge non-contact water from the Fort Knox pit to the WSR.

2012

●our spring sample event (Arctic grayling and burbot) began on May 7 and ended on May 30. The estimated spring 2011 Arctic grayling population was 7,378 fish $\geq$ 200 mm long which was an increase of 3,032 from the 2010 estimate. Recruitment of new fish in spring 2012 was strong with 111 new fish < 230 mm marked.

●we caught 140 burbot (175 to 950 mm long) in spring 2012 in hoop traps and fyke nets.

●Arctic grayling spawned throughout the wetland complex, including the upper portion of Channel C, in spring 2012. Beavers had not rebuilt the dams in the wetland complex.

●a constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring 2012.

●water was flowing over the spillway when we began sampling in the spring of 2012 – water was still overflowing in late October.

●on July 13, 2012, ADF&G provided input to ADEC on the APDES draft permit for discharge of non-contact water. The discharge point has been changed to the old Fish Creek channel just downstream of Ponds A and B. The ADEC permit was issued on August 15, 2012.

●on September 27, 2012, ADF&G confirmed that a culvert in the road down the Fish Creek valley had been removed. In our trip report to FGMI, we recommended some additional civil work to ensure that the discharge water stays on the north side of the valley.

2013

●on February 20, 2013, FGMI received a Notice of Violation from the ACOE for the unauthorized discharge of fill material into 0.28 acres of wetlands

●on March 1, 2013, ADF&G informed FGMI that their 2012 Annual Report was extremely well done and FGMI's report was distributed to all habitat offices in the state

●on March 11, 2013, the ACOE issued an After-the-Fact authorization covering the 0.28 acres of wetland fill

Appendix 1 (continued).

2013

●on April 25, 2013, water quality data (temperature, dissolved oxygen, etc.) were collected in the WSR under ice cover
●on May 4, 2013, the ADNR transmitted comments on the December 2012 reclamation and closure plan
●our spring sample event (Arctic grayling and burbot) began on May 20 and ended on June 10. The estimated spring 2012 Arctic grayling population was 7,404 fish ≥200 mm long. Recruitment of new fish in spring 2013 was strong with 114 new fish <230 mm marked
●we caught 96 burbot (89 to 697 mm long) in spring 2013 in hoop traps and fyke nets
●Arctic grayling spawned throughout the wetland complex, including the upper portion of Channel C, in spring 2013. Beavers had rebuilt the dams in the wetland complex, but the dams were notched to allow fish passage
●a constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring 2013
●water was not flowing over the spillway when we began sampling, but by May 27 water had begun to flow out of the WSR and over the spillway
●on June 25, 2013, we observed Arctic grayling fry (numerous) in the upper portion of Channel C, very few fry were observed in Pond F and the Pond F outlet
●on October 14, 2013, ADF&G submitted comments on the Fort Knox 2013 reclamation plan – eight recommendations were made
●on November 27, 2013, ADF&G distributed the Fork Knox technical report for work done in 2013

2014

●in early April emails were exchanged to determine when Fish Creek was removed from the list of impaired waterbodies – it was listed on the 1992 list but was removed from the 1994 listing because FGMI had bought out all the existing placer operations and was planning on building the freshwater dam
●in mid-April, 2014, the decision was made to not collect winter water quality due to unsafe ice conditions and overflow
●in spring 2014, we fished a fyke net in the developed wetlands just upstream of the WSR from April 29 until May 9 and then again from May 12 to 15. Arctic grayling spawned throughout the wetland complex in spring 2014 –the only beaver dam present was in the upper end of C Channel
●Our estimated population of Arctic grayling (> 200 mm) for spring 2013 was 6,675 – a slight reduction from the 2011 and 2012 estimates
●Our estimated population of large burbot (≥ 400 mm) for spring 2013 was 80 – a substantial reduction from the spring 2012 estimate of 193

Appendix 1 (concluded).

2014

- ●on September 29, 2014, FGMI notified state agencies that the new Environmental Superintendent was Bartly Kleven
- ●on September 4, 2014, we were notified that the road across Solo Creek had failed – FGMI will determine a proper fix – this is the second time the road has failed at the culvert crossing
- ●on September 26, 2014, the developed wetlands and lower Last Chance Creek were inspected, no beaver dams were observed in Ponds D and F and in lower Last Chance Creek (dams had been removed by FGMI during summer)
- ●in October FGMI and ADFG discussed a draft design for the Solo Creek culvert replacement, conducted a field inspection, and are continuing discussions to decide what remedial work will be done

Appendix 2. Arctic Grayling Population Estimates in the WSR.

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
1995[1]	150	4,358	
1996[2]	150	4,748	3,824-5,672
1996[3]	150	3,475	2,552-4,398
1998[4]	200	5,800	4,705-6,895
1999[4]	200	4,123	3,698-4,548
2000[4]	200	5,326	4,400-6,253
2001[4]	200	5,623	5,030-6,217
2002[4]	200	6,503	6,001-7,005
2003[4]	200	6,495	5,760-7,231
2004[4]	200	6,614	5,808-7,420
2005[4]	200	7,926	6,759-9,094
2006[4]	200	5,930	5,382-6,478
2007[4]	200	4,027	3,620-4,433
2008[4]	200	3,545	3,191-3,900
2009[4]	200	3,223	2,896-3,550
2010[4]	200	4,346	3,870-4,823
2011[4]	200	7,378	6,616-8,141
2012[4]	200	7,404	6,775-8,033
2013[4]	200	6,675	6,217-7,333

[1]We used estimates from the ponds and creeks for the Arctic grayling population; a confidence interval was not applicable to the data set.

[2]The 1996 estimate was made with a capture and recapture event in summer 1996.

[3]Gear type for the population estimate was a boat-mounted electroshocker with both capture and recapture events in fall 1996.

[4]The 1998 through 2013 population estimates were made using a mark event in spring of the year of the estimate, but the recapture event was in spring of the following year.

Appendix 3. Arctic Grayling Growth in the WSR.

	Avg Growth	Avg Growth	Avg Growth
Length at Mark	1994	2013	2009
160	15		
170	12		
180	9		
190	9		
200	13		
210	17	45	
220	8	25	
230	10	20	
240	3	19	31
250	5	17	28
260		14	27
270		12	18
280		12	19
290		12	17
300		11	16
310		7	13
320		2	12
330		4	11
340		5	17
350		4	6

Appendix 4. Burbot Population Estimates in the WSR.

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
2001	400	134	58-210
2002	400	131	63-199
2003	400	102	57-147
2004	400	86	44-128
2005	400	143	96-191
2012	400	193	95-290
2013	400	80	44-117