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Arctic Grayling and Burbot Studies at the Fort Knox Mine, 2010

by Alvin G. Ott
and William A. Morris

Developed Wetland Complex, June 2010
Photograph by William A. Morris

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Alaska Department of Fish and Game
Division of Habitat

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ARCTIC GRAYLING AND BURBOT STUDIES AT THE FORT KNOX MINE, 2010

By

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Acknowledgements

We thank Fairbanks Gold Mining Inc. (FGMI) (Lauren Roberts, Delbert Parr, 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. Jack Winters (Alaska Department of Fish and Game) and Delbert Parr and Dave Stewart (FGMI) provided constructive review of our report.

Executive Summary

Water Quality

●Dissolved oxygen (DO) concentrations in early April 2010 under ice cover were some of the lowest ever measured, with the highest DO being 1.68 mg/L (pages 7 to 9)

●The number and condition of multiple age classes of Arctic grayling and burbot in the WSR during spring sampling indicates that fish found suitable overwintering habitats in the WSR where DOs ranged from 0.15 to 1.68 mg/L (page 22)

Arctic Grayling Stilling Basin

●Our estimated summer 2009 Arctic grayling population was 1,159 (in season) and 1,199 (using spring 2010 as the recapture event) for fish ≥ 200 mm (Page 11)

●All Arctic grayling ≥ 250 mm were mature (page 12)

●Average growth rates of small Arctic grayling (≥ 200 and < 225 mm) range from 20 to 31 mm, but annual growth rates of fish ≥ 225 mm are low (in 2009 average growth was only 2.3 mm (page 13)

Arctic Grayling Water Supply Reservoir

●Last Chance Creek was inundated with aufeis, water temperature remained cold, and Arctic grayling did not spawn in the creek in spring 2010 (page 14)

●Arctic grayling spawning peaked from May 15 to 18 in the Pond F outlet channel, but did not peak in the Pond D outlet until much later (May 21 to 24) due to slower warming of the water from upstream aufeis (page 15)

●The first spent female was caught on May 14 in the Pond F outlet channel before peak daily water temperatures reached 4°C (page 16)

●Arctic grayling fry were observed in the Pond F outlet and these fry were larger than those seen in the Pond D to E outlet channel. Numerous fry were observed throughout the wetland complex indicating spawning success in 2010 (page 17)

●The spring 2009 population estimate for Arctic grayling ≥ 200 mm long was 3,223 fish (95% CI 2,896 to 3,550) (page 18)

●Strong recruitment of small Arctic grayling was seen in spring 2010 – we marked 302 new fish between 200 and 240 mm long (page 19)

●Annual growth rates of Arctic grayling in the WSR continue to be strong (pages 19 and 20)

Burbot Water Supply Reservoir

●We caught 46 burbot in the WSR that ranged from 95 to 680 mm long – 15 were larger than 400 mm. Fish smaller than 400 mm generally appeared to be in better condition than observed in the past (page 21)

Introduction

Fairbanks Gold Mining Inc. (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 (Figure 1). The project includes 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, state and federal 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. Work continued throughout 2010 on the Walter Creek valley fill heap leach facility. A chronology of events (1992 to 2010), with emphasis on biological factors, is presented in Appendix 1.

Figure 1. Aerial photograph provided by FGMI – water supply reservoir in lower part of photo and the tailing dam and impoundment in the upper Fish Creek valley.

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 wetlands along the south side of the valley was built in spring 1999. Civil work to mitigate aufeis in Last Chance Creek occurred 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. Some of their key recommendations are summarized below:

- Remove the culvert connecting the head of Pond C to the channel presently conveying high runoff (during breakup) on the north side of the road in the bottom of the Fish Creek valley to allow high runoff flows to remain in the north side drainage;
- Continue implementing wetland rehabilitation and restoration work in the Fish Creek valley between the tailing dam and WSR and continue to systematically document usage by wildlife and waterfowl until closure;
- Explore development of a "pilot" passive treatment constructed wetland for the purpose of removing arsenic, antimony, and any other "problem" elements from tailing seepage water that might reduce or eliminate long-term pump-back requirements;
- Start planning and designing future Fish Creek alignment from the tailing embankment to the small drainage on the north side of the Fish Creek valley bottom; and
- Develop a detailed plan and implementation schedule for the conversion of the existing causeway across the WSR into re-vegetated islands to increase habitat diversity and improve water exchange/circulation.

Fish research prior to construction of the Fort Knox mine and related facilities began in 1992 and water quality sampling started in summer 1997. Fish and water quality sampling has occurred each year. 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 summarizing each year of work can be found on the Division of Habitat's Web Page: http://www.habitat.adfg.alaska.gov/publications3.php. Viable populations of both Arctic grayling (*Thymallus arcticus*) and burbot (*Lota lota*) exist in the WSR today and both Arctic grayling and burbot inhabit the stilling basin below the WSR.

Our report summarizes fish and water quality data collected during 2010 and discusses these findings in relation to previous work.

Methods

Water Quality

Temperature (°C), dissolved oxygen (DO) concentration (mg/L), DO percent saturation (barometrically corrected), pH, specific conductance (*u* S/cm), oxidation reduction potential (ORP), and depth (m) were measured with a Hydrolab® Minisonde®5 water quality multiprobe connected to a Surveyor® 4 digital display unit. The multiprobe sensors were calibrated to suggested specifications prior to use. The LDO sensor was calibrated using a saturated air method. Conductivity, ORP, and pH sensors were calibrated with fresh standard solutions. Winter water quality measurements were made at 1 m depth intervals and near the bottom.

Fish

Fish sampling methods and gear included angling, visual observations, and fyke nets. Multiple fyke net sampling sites in the WSR and developed wetlands, including Last Chance Creek, have been used to capture Arctic grayling (Figure 2). Changes in fyke net locations are made to optimize catches and to account for water surface elevation changes in the WSR. The water surface in the WSR was at least 2 m lower than the low flow notch in the spillway and water was not flowing out of the reservoir. In spring 2010, fyke nets were fished in Pond F, in the Pond F outlet channel about 50 m upstream from its mouth, and in the WSR just upstream of the large culvert in the Gil Causeway. The fyke net in Pond F was fished for several days and then removed due to beaver activity. Captured Arctic grayling $\geq$200 mm were marked with a numbered Floy® T-bar internal anchor tag. Arctic grayling abundance was estimated using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951). Variance was calculated as given by Seber (1982).

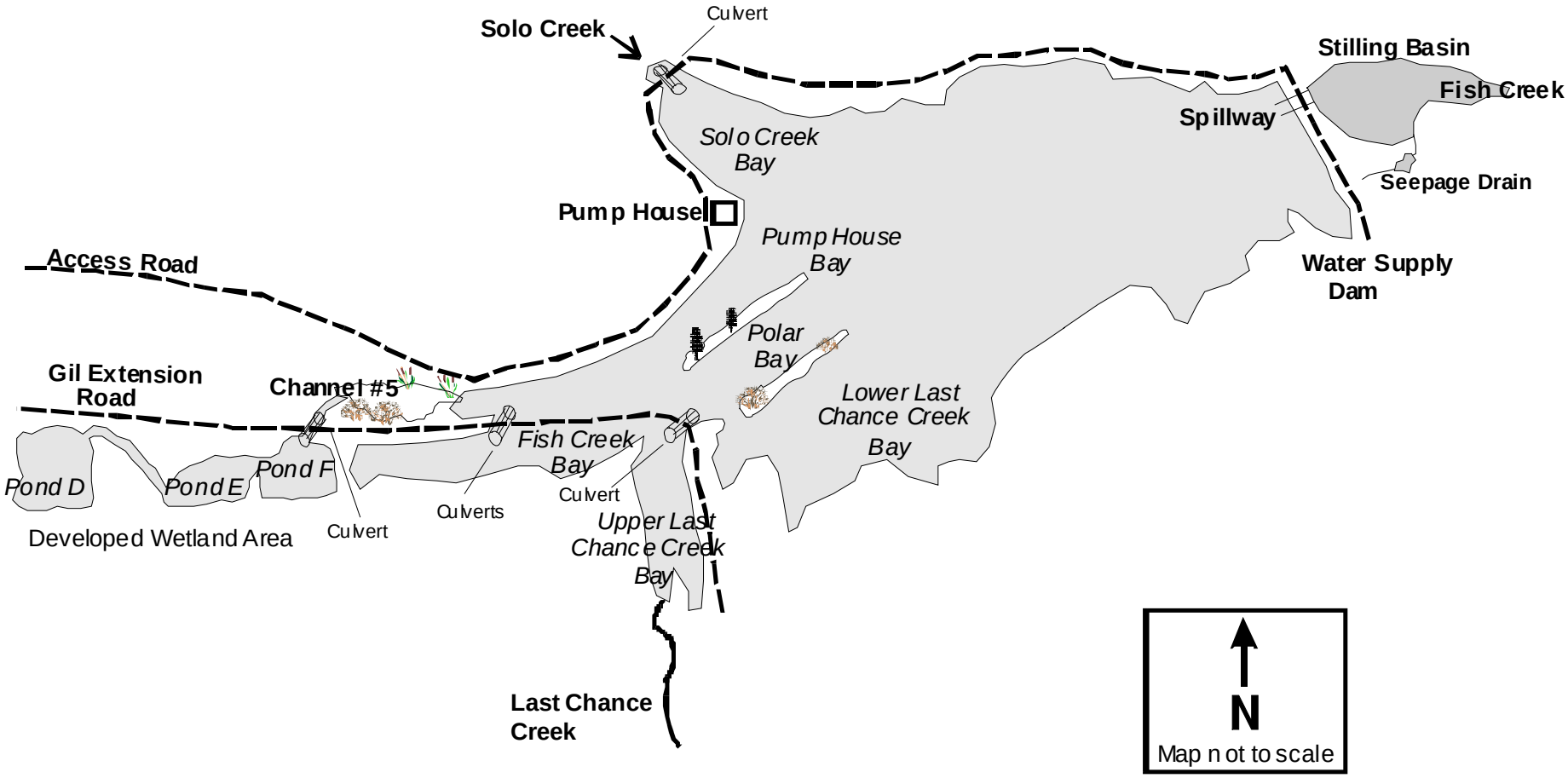

Figure 2. Sample areas in the Fort Knox WSR, stilling basin, and developed wetlands.

Results and Discussion

Water Supply Reservoir, Water Quality

Five water quality sites located in the main portion of the WSR have been sampled annually since 1997 (Solo Creek Bay, Lower Last Chance Bay, Polar Bay, one in the Middle of the WSR, and one about 100 m off the face of the freshwater dam). 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 winter 2000/2001 and again in winters 2007/2008 and 2009/2010. In 2009/2010, 1,167 acre-feet of water (380 million gallons) of water were pumped from the WSR (Table 1). Flow over the spillway ceased sometime in the fall of 2009 and flow did not reach the low flow channel in the spillway during the entire summer of 2010.

Table 1. Winter water use from the WSR, 1997 to 2009.

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

Seepage flow downstream of the WSR is monitored continuously by FGMI. Seepage flow has remained fairly constant for the last 12 years (Table 2).

Table 2. Seepage flow rates below the WSR dam.

Year	Rate of Flow (cfs)	Geometric Mean (cfs)
1999	1.16 to 1.82	1.47
2000	1.03 to 1.86	1.38
2001	1.03 to 1.78	1.31
2002	1.13 to 1.78	1.41
2003	1.13 to 1.78	1.36
2004	1.00 to 1.69	1.28
2005	0.97 to 2.35	1.49
2006	1.30 to 2.35	1.44
2007	1.13 to 1.78	1.32
2008	n/a	n/a
2009	1.06 to 3.55	1.53
2010	1.06 to 1.78	1.38

Water quality data were collected prior to breakup in April 2010 (Appendix 2). The average ice thickness on the WSR was about 1 m with the exception of Solo Bay where ice thickness was about 0.67 m. The water surface elevation was at least 2 m below the low flow channel in the spillway. Water temperature ranged from 0.39 to 2.46°C and generally increased with depth with minor cooling observed at depths deeper than 8 to 10 m. The pH ranged from 6.22 to 6.79. ORP ranged from a high of 377 to a low of 158. Generally, ORP values were lower in 2010 than in April 2009. The lowest ORP values were found at Site #1 where readings decreased with depth after reaching 10 m. Specific conductance increased with depth at all sites except Solo Bay and ranged from 132.6 to 273.6 *u* S/cm.

The most notable finding in spring 2010 was the extremely low percent saturation DO and DO concentrations at all sites. Percent saturation DO varied from 1.1 to a maximum of 12.3 and the DO ranged from 0.15 to 1.68 mg/L. DO concentrations at most of the sites were the lowest seen in late winter since we began sampling in 1998 (Figure 3). The highest DO concentrations found were at Site #2 which is located in the middle of the WSR near the freshwater dam (Figure 4). Even at this location, the highest DO concentration was 1.68 mg/L.

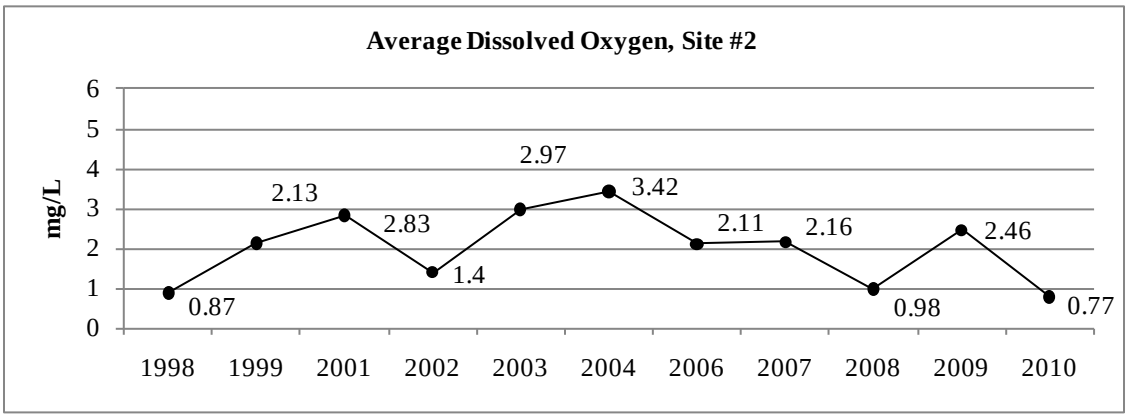

Figure 3. Average water column DO concentration at Site #2 from 1998 to 2010.

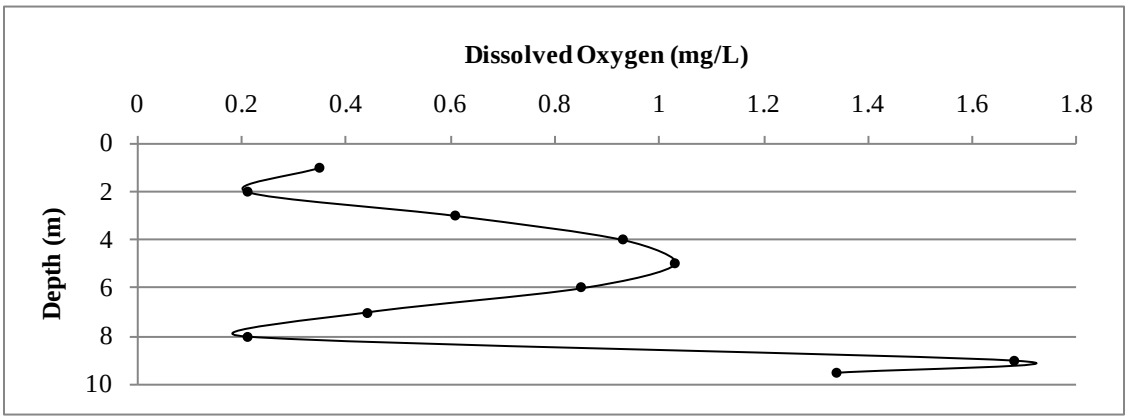

Figure 4. DO concentration at Site #2 on April 5, 2010.

Aufeis in the developed wetland complex was extensive from the uppermost reach of the channel all the way to the WSR. The only exceptions were Ponds E and F which contained very little aufeis. From our observations of aufeis in the wetland complex and the very low DO concentrations in the WSR, it appears that water flow and oxygen input

from Last Chance and Solo creeks and the wetland complex were greatly reduced during this past winter (Figures 5 and 6).

Figure 5. Aufeis in channel connecting Ponds D and E, early May 2010.

Figure 6. Aufeis in Last Chance Creek near its mouth, early May 2010.

Stilling Basin, Arctic Grayling

The stilling basin, located immediately downstream of the WSR spillway, is fed by groundwater, seepage flow, and surface flow (Figure 7). The narrow notch in the spillway was designed to accommodate surface water discharge from the WSR during winter without forming aufeis. No aufeis in the spillway has been observed since the dam was first overtopped in September, 1998.

Figure 7. Spillway, looking downstream, at Ft. Knox freshwater dam (October 2010).

Arctic Grayling Catches and Metrics

We sampled Arctic grayling in the stilling basin in spring 2010 using angling as the capture method. There was no flow in the low flow channel in the spillway throughout

the summer of 2010. Normally, fish are concentrated where the water from the low flow channel enters the stilling basin. We sampled four times in May and June, catching 94 Arctic grayling ranging in size from 140 to 316 mm – our catch per unit of effort varied from 3 to 15.3 fish per hour (Table 3).

Table 3. Catch of Arctic grayling in the stilling basin in 2010.

Date	Fishing Effort (hr)	Arctic Grayling	Catch/ Hr
5/3/10	4	30	7.5
5/5/10	3	15	5
5/7/10	1	3	3
6/25/10	3	46	15.3

In summer 2009, we made an in-season Arctic grayling population estimate of 1,159 fish $\geq$ 200 mm long (Ott and Morris 2009b). We then used our spring 2010 sample event to make a second estimate of the 2009 Arctic grayling population estimate. For the second estimate, we had 352 marked fish seen in summer 2009. In spring 2010, we caught 33 Arctic grayling with 9 recaptures. Our second population estimate was 1,199 fish $\geq$ 200 mm long (95% CI 612 – 1,787) (Figure 8 and Appendix 3).

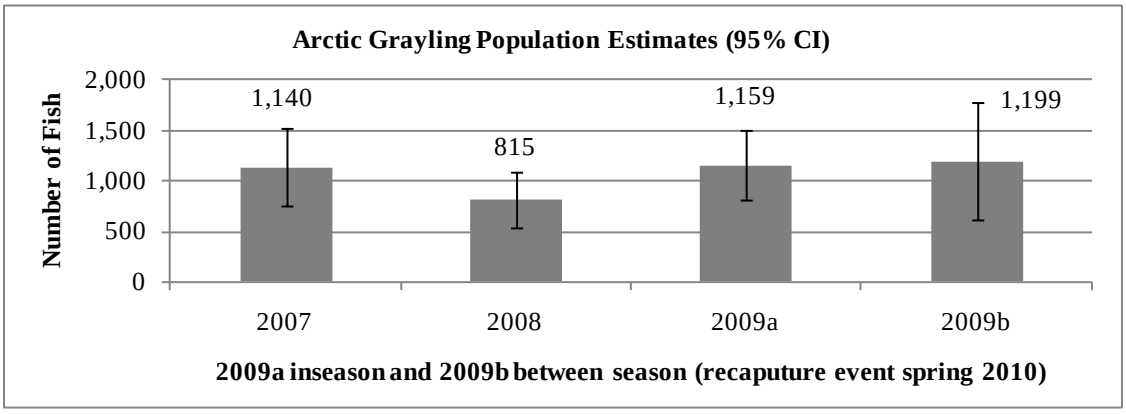

Figure 8. Estimates of the Arctic grayling population in the stilling basin.

Length-frequency distributions of mature versus immature Arctic grayling captured in spring 2010 are shown in Figure 9. All of the Arctic grayling handled that were > 250 mm long were mature.

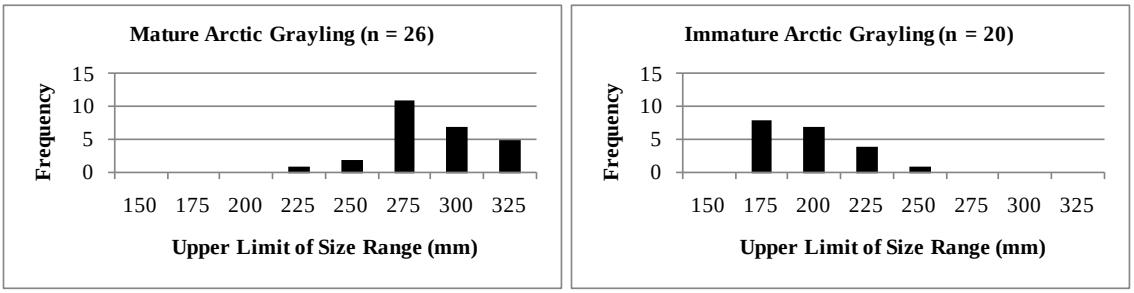

Figure 9. Mature versus immature Arctic grayling in spring in the stilling basin, 2010.

Length frequency distributions for all Arctic grayling caught from 2007 to 2010 are presented in Figure 10. There appears to be slight increase in the size of Arctic grayling in 2008 and 2009, but an increase in the number of smaller fish in 2010. These smaller fish did not enter the stilling basin in 2010 because there was no surface flow connection with the WSR.

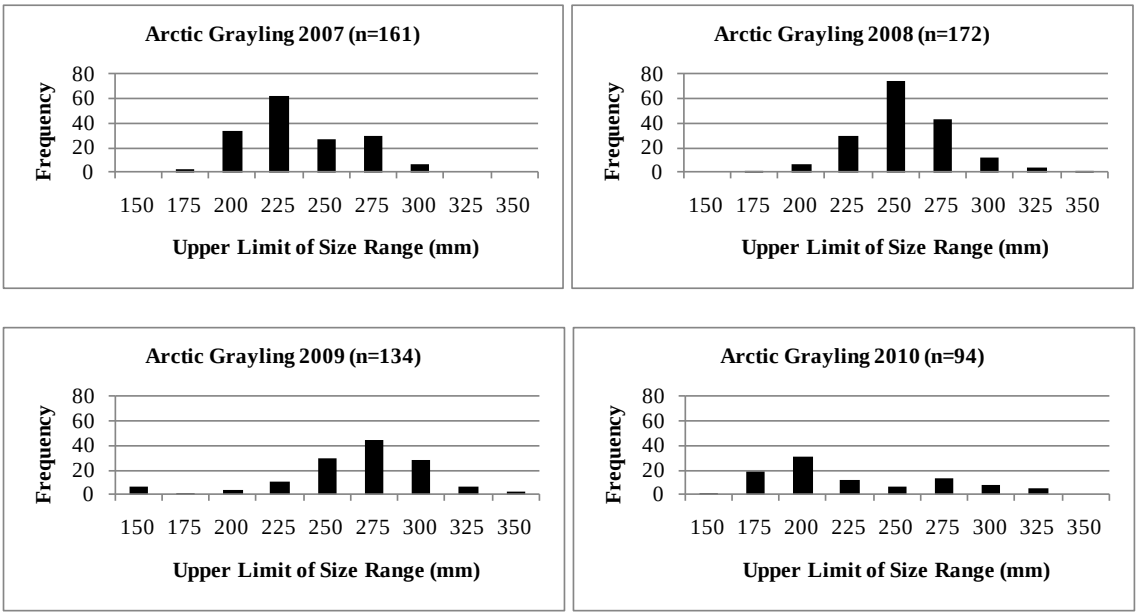

Figure 10. Length frequency distribution of Arctic grayling in the stilling basin (2007 to 2010).

Growth of Arctic grayling between 200 and 225 mm averaged 20 mm in 2007 (n = 7) and 31 mm in 2008 (n = 4). We only had one recapture in spring 2010 and that fish grew 26 mm. Growth rates decrease substantially for fish $\geq$ 225 mm. Average growth for 9 Arctic grayling caught in spring 2010 that were $\geq$ 225 mm when marked was only 2.3 mm.

Water Supply Reservoir, Arctic Grayling

Arctic grayling were found throughout the Fish Creek drainage prior to construction of the WSR. Fish were concentrated in flooded mine cuts in Last Chance Creek. The population appeared stunted: fish larger than 220 mm were rare; annual growth rate 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. Flooding of the WSR, while increasing overall habitat availability, eliminated most of the spawning habitat.

Fish sampling from 1996 through 1998 in the WSR and Last Chance Creek found very few fry. In spring 1999, FGMI constructed an outlet channel (Channel #5) to connect the developed wetland complex with the WSR (Figure 3). Channel #5 bypassed a perched pipe and provided fish access to spawning and rearing habitat in the wetland complex.

Arctic grayling have successfully spawned in the wetland complex every year since 1999 and have used most of the wetland complex in the majority of years. However, substantial aufeis and resultant cold water temperatures in the wetland complex and beaver dams limited availability of, and access to, spawning habitats in 2002, 2006, and 2007. Since field work began in 1992, only in 2004 and 2005 have Arctic grayling successfully spawned in Last Chance Creek. Lack of spawning in Last Chance Creek was due directly to cold water temperatures caused by extensive aufeis that lasted beyond the Arctic grayling spring spawning period.

Arctic Grayling Spawning (Temperature, Timing, Fry Presence)

In spring 2010, we fished fyke nets in Pond F, the outlet channel from Pond F, and in the WSR immediately upstream from the Gil Causeway. Low water conditions allowed for setting the Gil Causeway fyke net. Last Chance Creek was inundated with aufeis and there were no locations to set a fyke net. Aufeis was extensive in the wetland complex from Pond D upstream and in the Pond F outlet channel. Aufeis was in excess of 2 m thick in Channel C and it is unlikely that any fish moved into this reach for spawning in

2010. Beaver dams had been removed and there were no barriers to fish movement. Beavers did construct a new dam inside the Pond F culvert, but this dam was breached to allow fish passage and several of the beavers were removed. Thus, Arctic grayling had access to spawning habitat in the wetland complex in spring 2010 up to and including Pond D.

We fished a fyke net in Pond F from May 3 through 12 and then removed it due to beaver activity. We set a second fyke net in the outlet channel, just upstream of the WSR, on May 7 and fished that net until May 24. We set a third fyke net in the WSR just upstream of the Gil Causeway on May 12 and fished it until May 28. Peak water temperature first exceeded 4.0°C on May 14 when it reached 4.7°C. We first observed spawning in the Pond F outlet channel on May 15. Spawning continued through May 18 when numbers of spawning fish decreased. The peak water temperature ranged from 5.2°C to 7.3°C (Figure 11) during peak spawning. We also observed active spawning in the channel connecting Ponds D and E from May 21 to 24. Spawning was later in the Pond D outlet channel due to colder water temperatures from aufeis that extended from Pond D upstream to the head of Channel C.

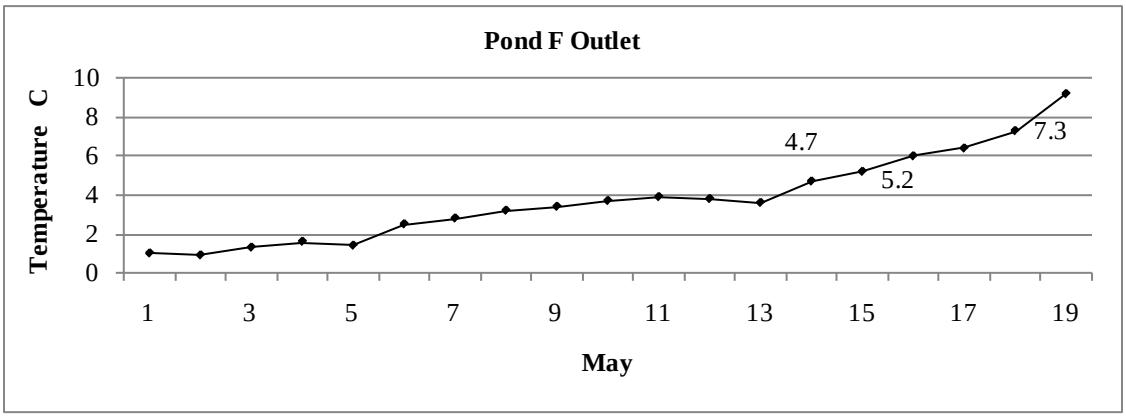

Figure 11. Peak daily water temperatures in Pond F outlet channel.

We first captured Arctic grayling on May 5 in Pond F. Catches of Arctic grayling peaked on May 15, 2010 (Julian Date 135) (Figure 12). Peak catches occurred on the same day that spawning activity substantially increased in the developed wetlands. Catches probably would have been much higher on May 17 (Julian Date 137), but the fyke net

was damaged by wildlife and most of the fish escaped. Ripe (ready to spawn) female Arctic grayling continued to move into the wetland complex well after peak spawning. We were still catching ripe females in the developed wetlands on May 24, 2010, when the net was pulled.

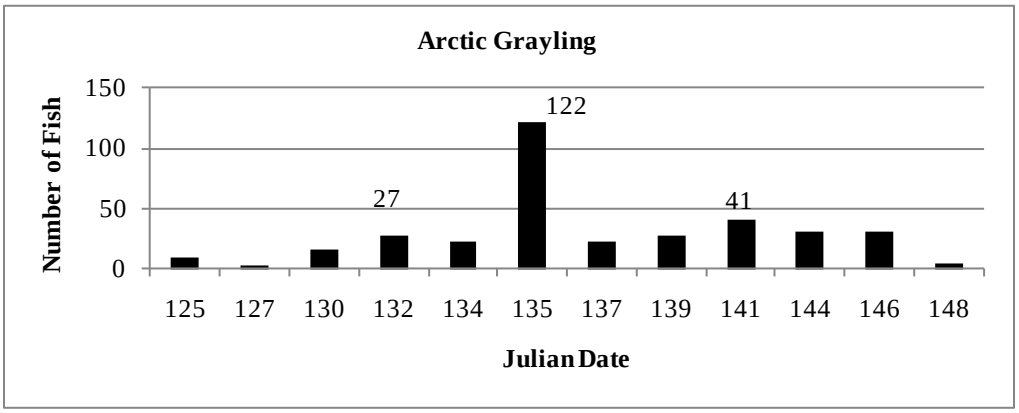

Figure 12. Catch per unit of effort (grayling/day/fyke net) for Arctic grayling in spring 2010 in the wetland complex.

Two partially spent females were caught early in the morning on May 14 (Julian Date 134), one day before we saw substantial spawning activity in the outlet channel from Pond F (Figure 13). A slight decrease in percent ripe females seen on May 15 and 17 coincided with increased catches as new fish were moving into the developed wetlands from the WSR. On May 24, all females were either ripe or spent. These data indicate that some spawning occurred prior to peak temperatures reaching 4°C.

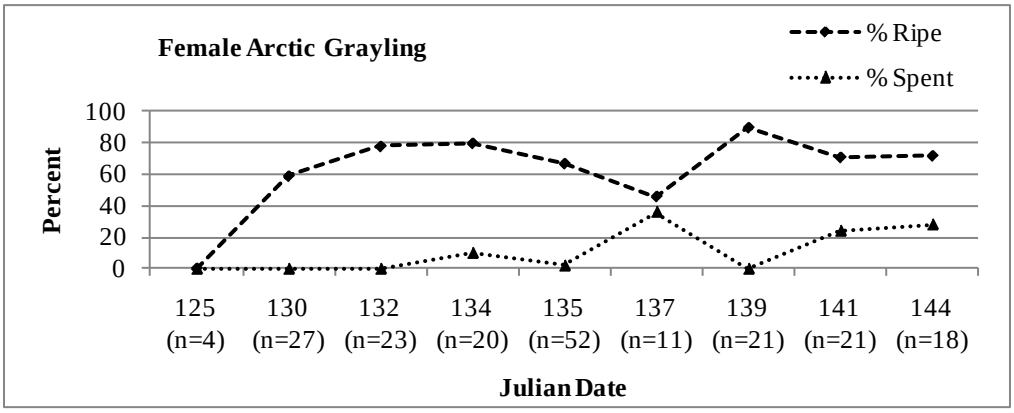

Figure 13. The percent ripe and spent female Arctic grayling in the developed wetlands. Sample size includes females judged not to be ripe.

Observations of Arctic grayling spawning activity, ice conditions, and distribution of fish in the developed wetland complex are presented in Table 4.

Table 4. Spawning activity, ice conditions, and distribution of Arctic grayling in spring 2010.

Date	Pond F Outlet Channel	Ponds E and F	Pond D Outlet Channel	Pond D	Channel C
5/3/2010	set fyke net in Pond F outlet	90% ice covered, only outlet of Pond F open	ice covered, flow on channel bottom	100% ice cover	100% aufeis entire length of channel
5/5/2010	caught Arctic grayling in fyke net	still 90% ice cover	ice covered, flow on channel bottom	100% ice cover	100% aufeis
5/7/2010	set fyke net in wetlands below Pond F	still 90% ice cover	ice cover decreasing	100% ice cover	100% aufeis
5/12/2010	catching Arctic grayling in fyke net	still 90% ice cover	ice cover decreasing	100% ice cover	100% aufeis but has melted some
5/14/2010	male Arctic grayling in channel	still 90% ice cover	ice cover decreasing	100% ice cover	not much change
5/15/2010	quite a few Arctic grayling , spawning observed	about 60% ice cover	not much change	90% ice cover, outlet is open	not much change
5/16/2010	active spawning seen	about 50% ice cover	Arctic grayling seen in channel	90% ice cover, outlet is open	still melting, but slowly, flow appears to be subsurface
5/18/2010	active spawning seen	ice free	Arctic grayling (about 8) in channel, active spawning seen	still 90% ice covered	melting slowly
5/21/2010	active spawning but not as many fish	ice free	active spawning observed	still 70% ice covered	melting slowly
5/24/2010	not many fish, still some spawning, pulled fyke net in wetlands	ice free	active spawning observed	almost ice free	not much change, water from channel turbid appears to be subsurface
5/26/2010	not much activity, a few fish still around	ice free	not much activity	ice fee	no change, water still very turbid

On June 25, we made visual inspections for Arctic grayling in the developed wetlands. Fry, although not numerous, were observed in the outlet channel below Pond F. These fry were already over 30 mm long. Arctic grayling fry were numerous in the channel connecting Ponds D and E, but these fish were smaller (< 25 mm long).

Arctic Grayling Catches and Metrics

The abundance of Arctic grayling was estimated in the WSR using spring 2009 as the mark event and spring 2010 as the recapture event. In spring 2009, there were 1,145 marks when newly tagged and recaptured fish were combined. In spring 2010, 556 Arctic grayling ≥ 240 mm were captured, and of those, 197 were recaptures. The spring 2009 population estimate for Arctic grayling ≥ 200 mm long was 3,223 fish (95% CI 2,896 to 3,550) (Figure 14 and Appendix 4).

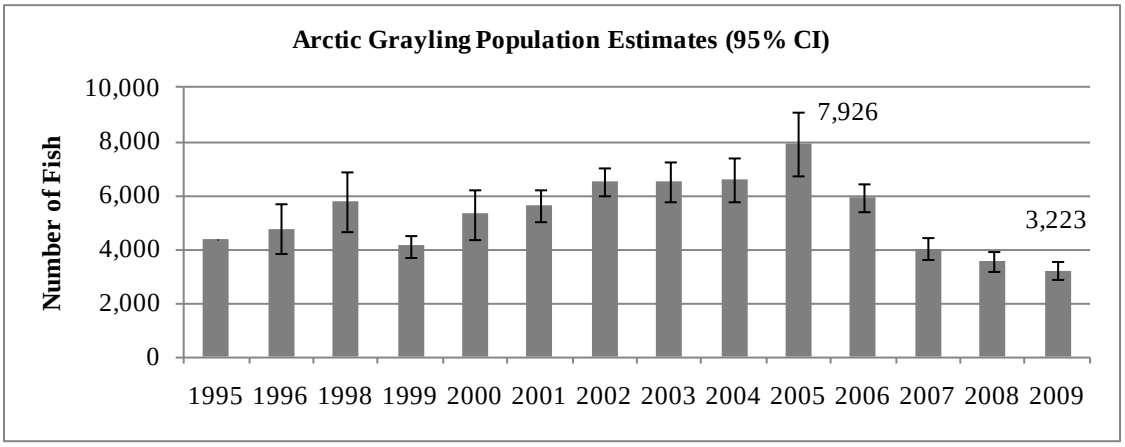

Figure 14. Estimates of the Arctic grayling population in the WSR.

For the 2009 estimated Arctic grayling population, length frequency distributions were compared for fish marked in spring 2009 with those recaptured in spring 2010 to eliminate those fish handled in 2010 that would have been too small (< 200 mm) to mark in spring 2009. The gradual decrease in the total population of fish ≥ 200 mm from 2005 to 2009 is attributed to a lack of recruitment because of reduced availability and quality of spawning habitat in the developed wetland complex. However, spawning in 2008 extended throughout the wetland complex and in both 2009 and 2010 spawning occurred from Pond D downstream. Increased spawning success in 2008, 2009, and 2010 was due to improved access to spawning habitat by removal of beaver dams.

Substantial recruitment of fish ≥ 200 mm was seen in spring 2010 (Figure 15). We had 302 new fish between 200 and 240 mm long that we marked in spring 2010. Recruitment observed this spring is likely fry produced in 2008, the first year of beaver management. Fry from 2009 should be observed in the population of Arctic grayling ≥ 200 mm in spring 2011 or 2012. Substantial recruitment of fish is expected to continue for the next several years. In comparison, there were essentially very few new fish caught in spring 2009 (Figure 16).

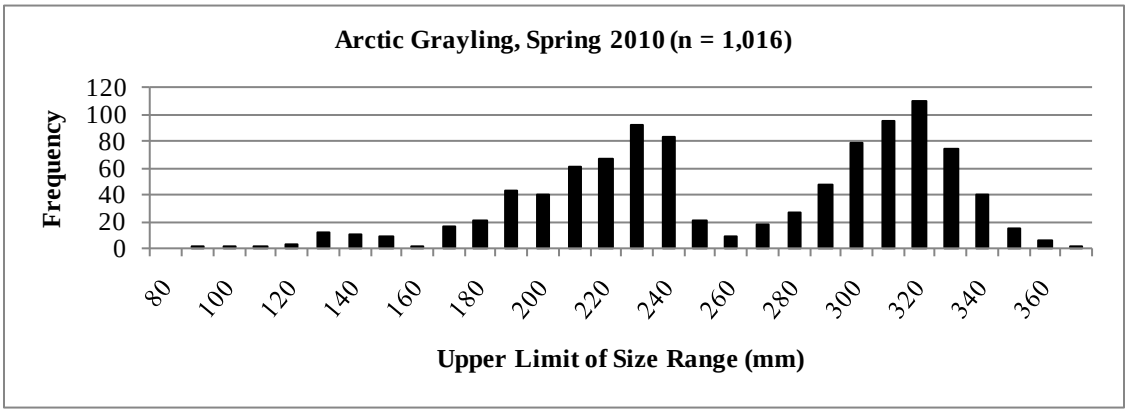

Figure 15. Length frequency of Arctic grayling in the WSR and developed wetlands in spring 2010.

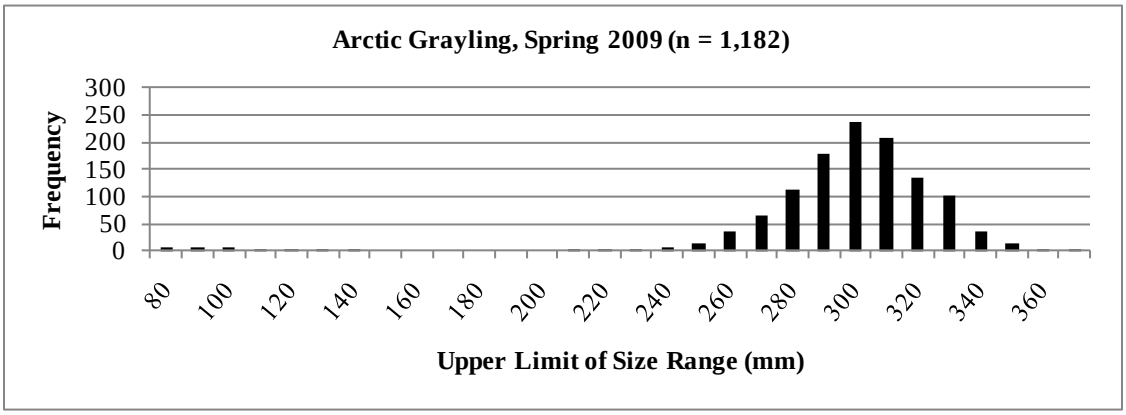

Figure 16. Length frequency of Arctic grayling in the WSR and developed wetlands in spring 2009.

On May 21 and 24, 2010, we caught 190 Arctic grayling in the WSR fyke net that were less than 250 mm long. Of these 190 fish, 78 were ripe males, 9 were ripe females, and 103 were judged to be immature. The smallest ripe male was 195 mm long while the smallest ripe female was 206 mm long. 89% of the mature small fish were males and 11% were females. Length frequency distributions mature and immature Arctic grayling are presented in Figure 17. All Arctic grayling > 250 mm were mature.

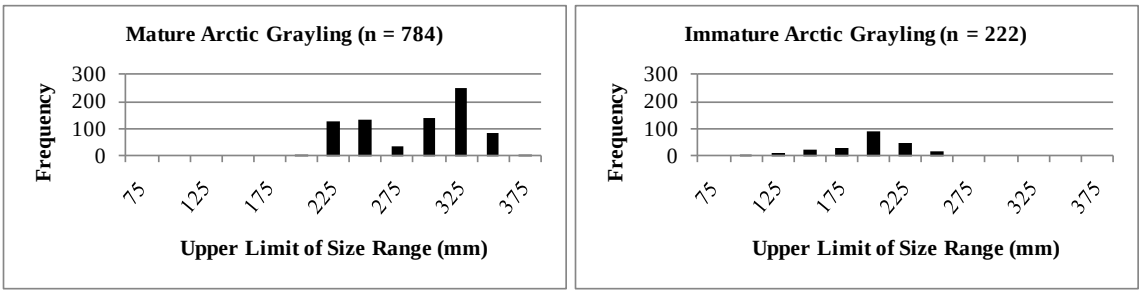

Figure 17. Mature versus immature Arctic grayling in spring 2010.

Average growth of Arctic grayling prior to development of the WSR ranged from 3 to 17 mm per year (Appendix 5). Once the WSR was flooded, annual growth rates for marked fish increased substantially (Figure 18). By 1998, most of the fish in the population were larger and growth rates exceeded those seen prior to construction of the freshwater dam in 1995 (Appendix 5).

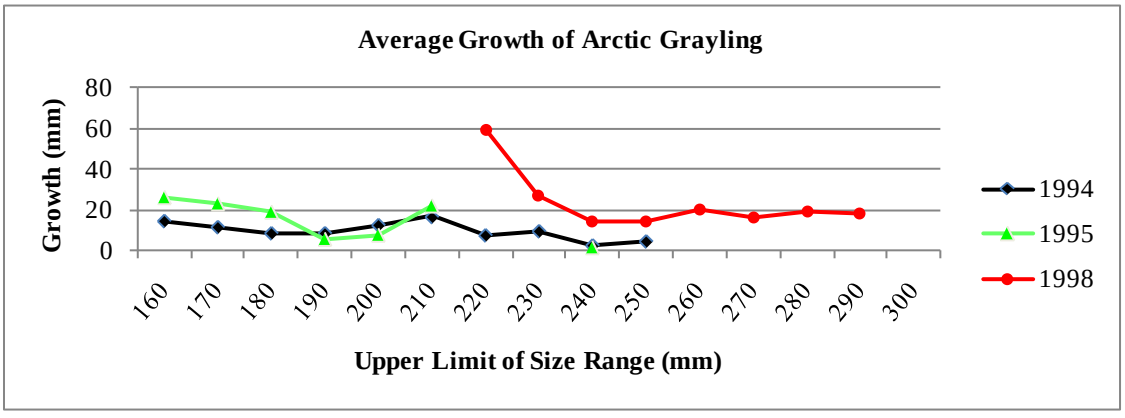

Figure 18. Growth of marked Arctic grayling in the WSR in 1994, 1995, and 1998.

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. Since 2004, growth rates of individual fish have increased, with highest growth seen in summer 2008, as the population has 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.

Average growth of Arctic grayling for fish $\leq$ 250 mm and for fish >250 mm for all sample years where population estimates were made is presented in Figure 19. We selected 250 mm as the break point because almost all the fish >250 are sexually mature and typically growth decreases for these fish. The pattern of growth for both the smaller and larger fish is higher when the population is lower. One possible explanation for the increased growth might be the fact that with a lower overall population there is an increase in available food for the fish present. These data would indicate that at the higher populations there is not adequate food to maintain the higher growth rates. Further, these data suggest that maintaining the population of fish over 200 mm at around 3,000 to 4,000 individuals might be ideal to produce more larger fish and to help stabilize the population.

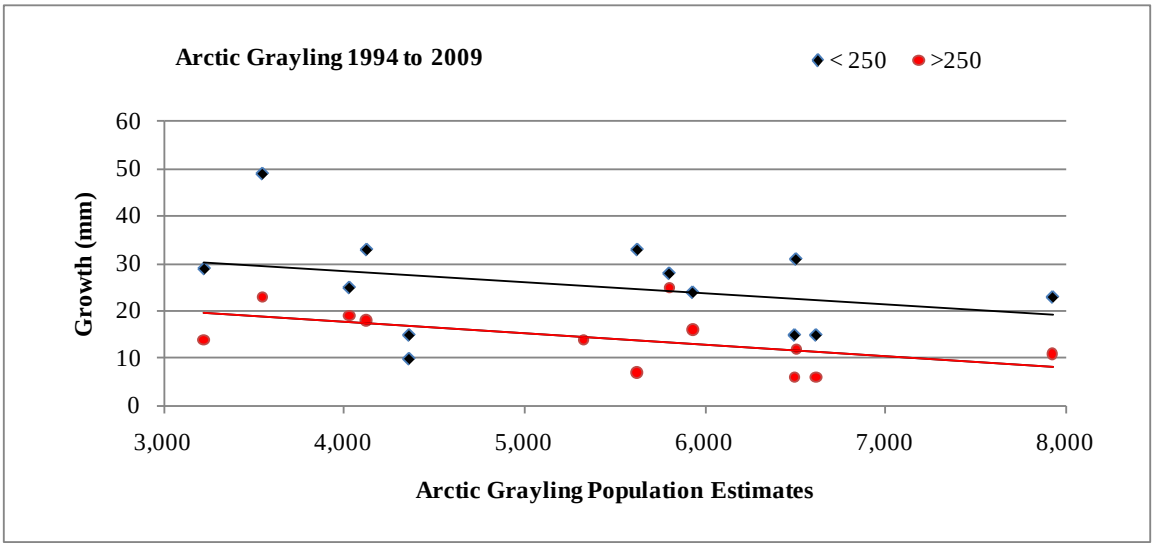

Figure 19. Growth of marked Arctic grayling in the WSR versus the estimated population of fish. Linear trendlines are shown for each group of fish.

Water Supply Reservoir, Burbot

Burbot were captured in spring 2010 in a fyke net fished in the WSR just upstream of the Gil Causeway. The fyke net fished for 16 days catching 46 burbot that ranged from 95 to 680 mm long. Fifteen of the burbot were larger than 400 mm. Evidence of recruitment by the catches of smaller burbot indicates the large burbot are still present in the WSR and are spawning successfully (Figure 20).

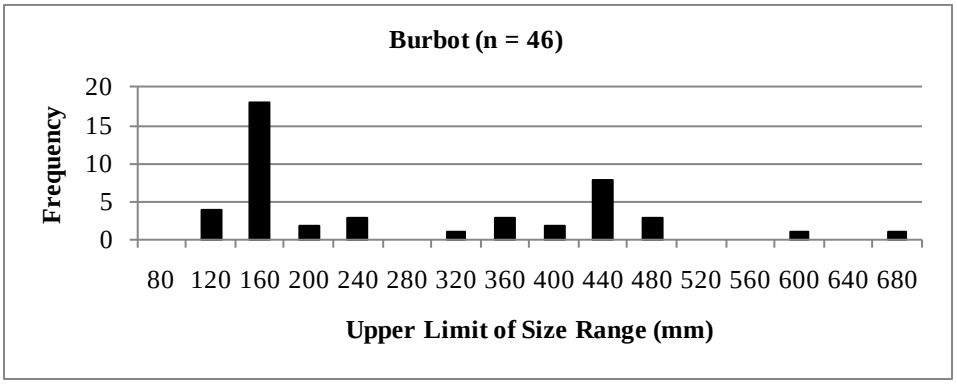

Figure 20. Length frequency of burbot in the WSR in spring 2010.

One of the burbot captured in spring 2010 had originally been tagged in the WSR on June 6, 2002 (Table 6). This burbot was 405 mm long when tagged and had grown 166 mm in 8 years.

Table 5. Mark-Recapture History for Burbot #27085.

Tag Number	Tag Color	Length (mm)	Date Captured	Location	Date Recaptured	Location	Length (mm)
27085	Gray	405	6/6/2002	WSR	5/29/2003	WSR	405
					10/2/2003	WSR	426
					5/24/2004	WSR	435
					5/23/2005	WSR	470
					6/5/2006	WSR	485
					6/19/2007	WSR	515
					5/19/2010	WSR	571

Conclusion

Self-sustaining 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. Our spring 2009 estimated population for Arctic grayling ≥ 200 mm was 3,223 fish. A goal for the burbot population was not set prior to construction, but a self-sustaining population currently exists.

We plan to continue to work cooperatively with FGMI to gather data on fish resources and water quality in the WSR and to implement rehabilitation projects designed to increase fish and aquatic habitat values. Options under consideration include development of a second wetland complex along the north side of the Fish Creek valley, conversion of the existing Gil causeway into re-vegetated islands, civil work in Last Chance Creek to mitigate aufeis, rehabilitation of the road down the valley between the tailing dam and freshwater reservoir, construction of a passive water treatment wetlands below the tailing dam, and removal of beaver dams to maintain Arctic grayling spawning habitat in the developed wetlands.

The number and condition of Arctic grayling and burbot in the WSR during spring sampling indicates that fish found suitable overwintering habitats even with the very low winter DOs measured in April. Either fish found areas in the WSR with higher DOs or these two species and multiple age classes have a high tolerance for DOs that ranged from 0.15 to 1.68 mg/L.

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

1992

- on March 16, 1992, we received notification from GVEA of their proposed plans to provide electrical service to the Fort Knox mine and we responded in writing on March 21, 1992
- ADNR began work with FGMI to develop a reimbursable services agreement that would cover state agency costs in the review of the proposed Fort Knox project. The agreement was voluntary on the part of FGMI and was prepared to expedite project review, to not interfere with individual agency permit decisions, and to not prejudge any regulatory decisions for the project
- FGMI's contractor requested aerial moose survey data on April 1, 1992, and this information was provided by Wildlife Conservation Division via memorandum on April 15, 1992
- on June 3, 1992, the ADF&G provided input to ADNR regarding the preliminary project description for the development of the Fort Knox mine. Major topics regarding potential affects to fish and wildlife and habitat identified included the following: water rights in Upper Fish Creek drainage; Fishway Act for the freshwater dam; rehabilitation plan; heavy metals; fugitive dust; blasting; solid waste management; biomonitoring; and cyanide heap leach process
- in summer 1992, we began work to collect basic aquatic habitat information for the Fort Knox mine. Our work scope focused on upper and lower Fish, Last Chance, and Solo creeks and was sent to FGMI by letter dated June 5, 1992. Sample areas were established within the area to be disturbed as well as upstream and downstream to assess aquatic habitats and fish use. This work was funded by FGMI
- during 1992, beginning in July the State's Large Mine Project Team (LMPT) began holding agency meetings with FGMI with invited participation by federal agencies, local government, and environmental groups. We continued throughout the remainder of 1992 to provide comments on draft documents (e.g., freshwater dam, Solo Creek causeway, reclamation plan, wetland construction) as requested by FGMI
- FGMI arranged for state agencies to travel to Nevada in late July, 1992, for the purpose of observing several existing and operating large hard rock mines and to provide an opportunity for state agencies to meet with their counterparts in Nevada
- on October 6, 1992, ADF&G notified FGMI via the State's LMPT coordinator of the requirements for evaluating a permit application to construct the freshwater dam. Included was a request to describe how fish passage would be provided or alternatively, what would be done to mitigate for the creation of a barrier to upstream fish movement

Appendix 1 (continued)

1992

- ●on October 6, 1992, ADEC provided ADNR (and the applicant) a written description of the various ADEC permits and their respective requirements
- ●on October 27, 1992, ADF&G provided FGMI with a summary of information pertinent to wildlife harvest in the Fort Knox project area
- ●on November 19, 1992, ADF&G in a memorandum to the Division of Water requested technical information regarding the pending applications of FGMI for water use in the Fish Creek drainage
- ●on November 23, 1992, ADF&G in a memorandum to the State's LMPT coordinator identified several topics that require attention including the following: the need to identify the point of compliance for ADEC's water quality standards; fate of the freshwater dam (temporary versus permanent); and the reclamation plan for the whole project
- ●on December 1, 1992, the State's LMPT coordinator sent a letter to FGMI asking what the cost differences would be between design of a permanent freshwater dam as opposed to the rehabilitation costs associated with rehabilitation of the flooded habitat (including Last Chance, Solo, and Fish creeks) upon completion of mining
- ●on December 2, 1992, FGMI applied to ADNR for two surface leases for the proposed Fort Knox project
- ●on December 18, 1992, EPA sent a letter to FGMI identifying several areas of concern, but stating that as long as the operation does not have a discharge to waters of the United States, it is determined that FGMI will not need a NPDES permit
- ●in Early December 1992, the State's LMPT coordinator specifically requested that the State's Dam Safety Engineer look into and resolve the question of whether the freshwater dam is to be a temporary or permanent structure
- ●on December 30, 1992, ADF&G submitted comments to ADNR on the Fort Knox draft EA

1993

- ●throughout 1993, the ADF&G worked with the State's LMPT to review and provide input on various design aspects of the Fort Knox project. Data gathered in 1992 was provided and used in the preparation of the Environmental Assessment for the proposed project. Substantial input was made on the design of the freshwater dam, the Solo Creek culvert, developed wetlands between the tailing dam and freshwater reservoir, and the reclamation plan for the overall project

Appendix 1 (continued)

1993

●during 1993, both winter and summer, the ADF&G continued to sample fish in areas potentially affected by the upcoming construction of the Ft. Knox mine. Sampling focused on Last Chance Creek above and below the eventual WSR, Solo Creek, Bear Creek, and Fish Creek upstream and downstream of the freshwater dam site

●on January 5, 1993, ADF&G by memorandum provided comments to ADNR regarding the ADL 414960 (lease for tailing impoundment and dam, freshwater reservoir and dam, and related infrastructure) and ADL 414961 (lease for mill site). Topics that needed to be addressed in stipulations for the leases included the reclamation plan, tailing impoundment and dam, freshwater impoundment and dam, wildlife mortality, biological and water quality monitoring, and project changes

●on January 20, 1993, ADF&G submitted copies of Technical Report 93-4 titled "Aquatic habitat study, upper Fish Creek drainage, with emphasis on Arctic grayling (*Thymallus arcticus*): baseline studies 1992" summarizing fisheries habitat information collected. Also included in this report was a summary of expected changes to stream habitats from development of the Fort Knox mine

●on February 5, 1993, the ACOE notified FGMI of the need to submit a revised version of the reclamation plan with more complete information. The ACOE also informed FGMI that they had not made a determination as to whether the project would need an Environmental Impact Statement

●on February 12, 1993, the state provided comments to FGMI on the Fort Knox draft Environmental Assessment document

●on March 23, 1993, the ACOE public noticed the Fort Knox project (Fish Creek 23, 4-920574) which included a description of project related facilities and included a mitigation, general reclamation procedures, and performance standards document prepared by FGMI. Substantial input by state agencies had already been made and incorporated by FGMI into their COE permit application package

●on April 13, 1993, ADEC by letter to FGMI requested that preapplication meetings be held with state agencies prior to submittal of the ADEC permit package with emphasis on development of the monitoring plan

●on April 23, 1993, we submitted our proposed scope of work for continuing the aquatic habitat study in the upper Fish Creek drainage. FGMI agreed to provide funding to support the field work and technical report preparation

●in early May 1993, the cooperative agreement between ADNR and FGMI was signed and the terms of the agreement to reimburse state agencies was from July 1, 1992 to June 30, 1993, unless further extended by agreement

●on May 24, 1993, ADNR and ADF&G notified the ACOE by letter that the state intends to provide federal agencies the opportunity to review and comment on state authorizations being adjudicated for the Fort Knox project

Appendix 1 (continued)

1993

- on August 5, 1993, ADNR received the FGMI reclamation plan for formal review under 11 AAC 97.300
- in August 1993, the ADF&G collected 24 Arctic grayling from the Last Chance Creek pond complex and these fish were analyzed for whole body metal concentrations (Al, As, Cd, Pb, and Hg)
- on October 6, 1993, ADEC issued the Certificate of Reasonable Assurance for the proposed discharge of about 4,526,140 cubic yards of fill material into about 102.7 acres of waters of the US, including wetlands, in conjunction with impoundments, diversions, staging areas, and culverted road crossings
- on October 10, 1993, ADNR sent a letter to FGMI indicating their intent to hire Andy Robertson for QA, QC during construction and operation of the tailing dam
- on September 28, 1993, the cooperative agreement between ADNR and FGMI was extended through June 30, 1994, subject to resolution of additional funding requested by ADEC
- on November 24, 1993, the ADF&G sampled the Last Chance Creek pond complex for overwintering fish. Both ponds were ice covered, DO concentrations were between 6 and 7 mg/L, and Arctic grayling captured by angling had been actively feeding
- on November 26, 1993, the ADF&G provided input to ADEC on the proposed draft solid waste permit for the tailing dam and impoundment. Overall the ADF&G concurred with the draft permit. The major issues of concern to ADF&G were that the tailing impoundment be non-toxic to wildlife during the operational phase, that the concept of a closed treatment system (zero discharge) be assured during operations, and that the tailing impoundment be closed following mining and surface and subsurface waters meet the water quality standards for protection of aquatic life
- on December 9, 1993, ADNR by letter distributed a draft proposed upland mining lease for the Fort Knox project. Review and comments were requested from agencies and FGMI
- on December 10, 1993, the ADF&G commented on the FGMI Trust Agreement being developed for long-term management of the Fort Knox impoundments and wetland complex
- on December 13, 1993, FGMI submitted to ADNR a list of plans that were being developed as part of the Fort Knox Project Environmental Management System (e.g., reclamation, monitoring, and water resources)

Appendix 1 (continued)

1993

●on December 23, 1993, the ADF&G identified several potential design options for the freshwater dam that would mitigate potential effects on fish. The ADF&G concerns were related to fish entrapment and entrainment in the stilling basin at the end of the concrete spillway. Options included designing the outlet channel as a V-notch and grouting the bottom of the channel to prevent fish entrainment during low or no flows

●on December 28, 1993, the ADF&G provided input to ADNR regarding material site rehabilitation and construction monitoring. The ADF&G request focused on the potential for incorporating material sites into the design of the freshwater reservoir. Secondly, the ADF&G recommended that the state develop a mechanism/plan to address monitoring of construction

1994

●on February 2, 1994, ADF&G submitted a proposed work scope to FGMI for continuation of our aquatic habitat study in the upper Fish Creek drainage. Emphasis in 1994 was placed on gathering fisheries data in areas directly affected by construction activities. Multiple trips were made sampling fish in Last Chance Creek, the Last Chance Creek pond complex, Bear Creek, and Fish Creek

●on February 7, 1994, ADEC issued the Solid Waste Disposal Permit for mine tailing to FGMI with an effective date of February 15, 1994

●ADF&G fish habitat permits were issued under AS 16.05.840 and AS 16.05.870 for the freshwater dam. The Solo Creek culvert and wetland construction were issued under AS 16.05.840. All permits were issued to FGMI on February 14, 1994

●on February 15, 1994, the Agreement for Funding Post Reclamation Obligations was signed by the state and FGMI

●FGMI conveyed the fee simple land to the state, but retained the water rights and FGMI agreed to take over the mitigation obligation for Polar Mining

●Arctic grayling were collected by the ADF&G from the Last Chance Pond complex from March 29 to 31 to establish baseline conditions (e.g., length, age, growth, and maturity)

●on May 5, 1994, the ACOE issued Fish Creek 23, 4-920574 to FGMI

●construction activities were monitored during 1994. In October, work began at the freshwater dam site (i.e., construction of diversion ditch to bypass water through the construction zone). Brush and tree clearing in the area to be flooded by the freshwater dam was nearly complete by mid-November

●on November 30, 1994, the USFWS forwarded a copy of the report titled “A preliminary assessment of bird use of revegetated habitats affected by placer mining, Fish Creek drainage, Alaska”. Breeding bird censuses were conducted by two observers in the Fish Creek drainage on June 8, 1994. Results are indicative of the importance of revegetation in restoring habitat values

Appendix 1 (continued)

1994

- in a memorandum dated December 21, 1994, the ADF&G summarized turbidity data collected in Fish Creek just upstream of Fairbanks Creek. Turbidity consistently dropped from 1992 to 1994 (0 to 3,000 NTU in 1992, 0 to 300 NTU in 1993, and 0 to 30 in 1994). The decreased turbidity is attributable in part to the cessation of placer mine activities in the valley and projections are that decreases will continue once the freshwater dam is built and the developed wetland complex has been rehabilitated
- December 22, 1994, ADF&G sent a memorandum to ADNR that identified a number of issues (e.g., use of motorized vehicles, access to pit and freshwater reservoir, commercial development, trapping cabins, wildlife viewing, timber harvest, mining, fire suppression, trails, hunting, fishing, trapping, garbage and refuse, responsible management entity)

1995

- ADEC issued a short term variance on January 26, 1995, to cover dewatering and construction excavation at the Water Dam Spillway. FGMI was to use best management practices to ensure that settleable solids did not exceed the 0.2 mg/L standard with a waiver of the turbidity standard
- monitoring of the Fort Knox construction phase of the project occurred frequently and throughout calendar year 1995. A complete description of construction activities and actions taken by ADF&G to monitor the freshwater dam, constructed wetlands, and our Fish Habitat Permits is contained in Technical Report No. 96-5
- on March 1, 1995, in a memorandum the ADF&G notified the ADNR of our checklist of items that required further review, permitting, and field monitoring. These included final design plans for the wetland complex, final design plans for the Solo Creek culvert, final design plans for the water intake system, temporary stream crossings for access, temporary diversion of Fish Creek at the freshwater dam, and material sites
- in summer 1995, as construction on the freshwater dam was proceeding; the ADF&G continued to sample burbot and Arctic grayling. Arctic grayling successfully spawned in the outlet of Polar Ponds #1 and #2. A burbot population estimate was made for Polar Ponds #1 and #2. The ADF&G also collected an additional 24 Arctic grayling from the Last Chance Creek pond complex for whole body analyses for Pb
- on December 11, 1995, the State Dam Safety Engineer informed FGMI by letter of approval to impound water to elevation 1012 subject to completion of punch list items identified by Knight Piesold
- December 19, 1995, most of the work at the freshwater reservoir had been completed – only minor items remain

Appendix 1 (continued)

1996

- the ADF&G made multiple site inspections from early January through June 1996 to observe construction activities at the freshwater dam site and to provide input to FGMI on minimizing sediments being introduced to Fish Creek. The ADF&G Technical Report transmitted on June 24, 1996, was titled "Baseline fish and aquatic habitat data for Fort Knox Mine 1992 to 1995". This report includes a section describing construction activities at the freshwater dam. Also presented are baseline data on fish, benthic macroinvertebrates, heavy metal concentrations in Arctic grayling, water quality, and an estimate of the fish population prior to dam construction and flooding
- on May 9, 1996, the ADF&G made an inspection of construction activities at the mine. A 72-inch culvert was set at the upper end of Polar Pond #3. The pipe was set at elevation 1028 to ensure that it would be perched above the freshwater pond surface. Work continued on the freshwater dam spillway
- in a letter dated May 24, 1996, the ADF&G reported that an Arctic grayling tagged in Bear Creek in 1994 was captured by Sport Fish Division in Badger Slough near Pedee Road
- in late May, 1996, aufeis still 3 to 4 m thick covered Last Chance Creek and the creek was flowing on top of the ice
- in late May, 1996, Sport Fish Division sampled the WSR specifically to recapture burbot that had been injected with oxytetracycline about one year prior. Length frequency distributions indicate that burbot caught in spring 1996 were, on the average, larger than those caught in 1995
- on June 11, 1996, the ADF&G noted that Last Chance Creek was flowing at about 25 to 30 cfs and was extremely muddy. The total flow of Last Chance Creek about 1.5 km upstream of the mouth was going subsurface through an old abandoned pond. Large amounts of sediment and organic material were being carried into the WSR
- in early and late June, the ADF&G sampled fish by angling and fyke nets collecting Arctic grayling and burbot in the WSR. Sampling was conducted to determine catch/unit effort to assess the number of fyke nets needed for estimating the Arctic grayling population. Water elevation in the WSR was at 1015 ft. Maximum pool elevation is at 1021
- on July 25, 1996, the ADF&G conducted a site inspection of the Fort Knox project. Water levels had dropped about 3 m in the WSR as freshwater input was not exceeding the water withdrawal of about 15 acre-feet
- on July 31, 1996, the ADF&G conducted a site inspection of the WSR and dam, including the stilling basin. Grading of the construction zone downstream of the WSR dam had been completed. The entire WSR was clear, but stained. Waters have cleared since ADF&G's last site inspection on July 25

Appendix 1 (continued)

1996

- ●on July 11, 1996, the ADF&G electrofished Last Chance Creek and found no fish. Arctic grayling use of Last Chance Creek during 1996 was greatly reduced due to aufeis, high water, and high suspended solids
- ●in early and late August, the ADF&G fished fyke nets in the WSR. Preliminary analysis of the Arctic grayling and burbot data suggested that growth rates have increased from those found prior to flooding of the WSR.
- ●on September 26, 1996, the margins of the WSR were electrofished by the ADF&G. Small Arctic grayling (≤ 150 mm) were not numerous, but small burbot were abundant with concentrations of small burbot seen in Solo Bay
- ●by letter dated November 5, 1996, the ADF&G transmitted to FGMI a copy Chapter 3 titled "Fort Knox burbot investigations" of Fishery Data Series No. 96-30 by Mr. Evenson (ADF&G) that summarizes burbot collections and marking with oxytetracycline
- ●in November of 1996, FGMI began operation of the crusher and mill facilities. Tailing deposition commenced on November 14, 1996.

1997

- ●on February 14, 1997, by letter to FGMI the ADF&G identified our proposed continuation of fisheries work with an emphasis on Arctic grayling (mark/recapture for growth and population estimate) and burbot (mark/recapture for growth and population estimate and recapture of fish injected with oxytetracycline)
- ●on March 19, 1997, the ADF&G conducted a field tour at Fort Knox to observe ongoing construction activities.
- ●on March 31, 1997, the ADF&G inspected the constructed wetland area with FGMI and arrived at a conceptual plan to maximize the wetted area, minimize push/haul distance, and best use of materials. Diverting flow from one side of the valley to the other should maximize wetted area and three locations for diversion were identified
- ●on April 29, 1997, the ADF&G inspected the constructed wetland area with FGMI and discussed upcoming civil work planned for summer (e.g., grading of disturbed areas, seeding of cut slopes, maintenance of the main access road down the valley)
- ●on May 8, 1997, the ADF&G inspected a potential road alignment to access exploratory sites south of Fish Creek. Agreement was reached on a possible route, but later investigations resulted in abandonment of the project due to thaw unstable soils

Appendix 1 (continued)

1997

●on May 15, 1997, ADF&G sent a letter to FGMI summarizing the recent events of moose mortality in the spillway of the freshwater dam. During the winter of 1996/1997, there were two cases where adult moose fell into the freshwater dam spillway and died. Tracks indicated that both moose were walking normally and did not appear to recognize the vertical drop of about 3+ m. As a result, FGMI worked with ADF&G and in March/April 1997 they constructed an 8-ft high cyclone fence to keep moose from walking into the spillway. FGMI promptly notified ADF&G of the moose mortalities, took action to salvage the meat, and implemented the fencing project to mitigate the cause.

●in late May, ADF&G Habitat and Sport Fish Division sampled fish in the WSR. Our target species was burbot. The ADF&G estimated the burbot population for fish ≥ 200 mm at 622. The ADF&G caught about 500 Arctic grayling in two fyke nets fished along the edge of the WSR

●on July 13, 1997, FGMI notified ADEC by letter that they had collected soil samples from cleanup areas where process solution spills have occurred. Process solution spills commenced in mid-November 1996. Results of soil samples following cleanup at all spill sites demonstrated that cleanup levels are far below the threshold limit of 10 mg/Kg WAD cyanide

●on July 14, 1997, FGMI notified ADEC by letter of their plans to expand the secondary containment area and paving between the mill and leach tanks to contain spillage from the leach tanks. FGMI planned to complete this work by the third quarter 1997

●on July 22, 1997, the ADF&G conducted a joint field trip with the ACOE to discuss the proposed reclamation in the Fish Creek valley downstream of the TSF. The plan was to move water from south to north across the valley, to construct two dikes to intercept and pond water, and to maintain access down the middle of the valley

●on July 25, 1997, the ADF&G conducted a visual survey by boat along the margins of the WSR and did not see any Arctic grayling fry; however, we did observe numerous Arctic grayling juveniles feeding on the surface in the Upper Last Chance pond area

●on August 21, 1997, the ADF&G conducted a site inspection noting that natural revegetation of the Solo Creek waste dump had continued to increase and the area below the spillway had revegetated with native species and grasses. Beavers had constructed a dam in Fish Creek below the outlet of the spillway. Staging areas used for construction had been cleared of materials and regraded

●on September 6 and 7, the ADF&G worked with UAF professors and students to sample fish in the WSR

●on September 17, 1997, the ADF&G sampled two locations in the WSR for zooplankton. Zooplankton were numerous and consisted entirely of Heterocope Copepods

Appendix 1 (continued)

1997

●on November 7, 1997, the ADF&G summarized in a letter to FGMI our recent Fort Knox annual meeting. Road construction across the upper portion of the WSR is anticipated to access an exploratory site. A conceptual plan was developed for wetland construction during summer 1997 and work will continue in 1998. We agreed to put together a work scope for the upcoming environmental audit

1998

●on March 18, ADF&G measured water quality at six locations in the WSR. DO concentrations were measured at 1 m depth intervals and results indicated that the WSR was likely unsuitable for fish. The maximum DO concentration found was 2.1 mg/L – in most locations DOs were depressed with depth with some concentrations in the main part of WSR between 1.0 and 1.8 mg/L

●FG98-III-0109 was issued on May 6, 1998, to place additional fill on the Gil Causeway to provide access to the Gil Prospect. By condition of the permit, FGMI is responsible for the preparation of a restoration plan which will include removal of all culverts to provide for improved water circulation in the WSR

●ADF&G conducted field work during the last two weeks of May and reported in a letter dated June 14 that active Arctic grayling spawning was seen in three areas: shallow rocky zone near the spillway; in Upper Last Chance Bay at the road crossing; and in a recently flooded outlet channel connecting Upper Last Chance and Fish bays

●ADNR by letter dated July 24, 1998, approved FGMIs request to use Barnes Creek as a waste rock dump and low-grade stockpile

●ADF&G by letter dated July 31, 1998, reported that about 30% of the work in the developed wetland complex was done including three diversion channels and grading and slope work along the old placer mine cuts

●ADNR conducted an inspection at Fort Knox on August 6 and summarized their findings in a report. Findings made included the following: the 1998 tailing dam lift is complete; floating vegetative mats need to be monitored especially in the entrance to the spillway; the Last Chance Causeway is complete; about 45% of the reconstructed wetlands has been done; work is needed to reduce tailing spray from the lines

●on September 4, 1998, ADNR notified the LMPT of the upcoming requirement to conduct an environmental audit of the Fort Mine mine facilities

●ADNR conducted a facilities inspection on October 1, 1998, with an emphasis on top soil stockpiles and reclamation completed to date. Disturbed areas along the pipeline service road were seeded and fertilized in June and August of 1997 and there was adequate grass cover with annual mustards and other native plants, including woody species, to minimize erosion. About 70% of the “dirt work” had been completed in the re-constructed wetlands located between the tailing dam and WSR

Appendix 1 (continued)

1998

- ●on October 8, 1998, ADNR conducted an inspection of the tailing and WSR dams. The TSF was originally designed with a 12 year life to contain about 210 million tons. Operation of the facility now indicates that it could handle 230 million tons due to tailing being deposited at a higher density
- ●on September 12 and 13, ADF&G and UAF participated in a joint field sampling event using fyke nets, minnow traps, and an electrofishing boat to capture burbot and Arctic grayling. Temperature and DO profiles were made at several sites in the WSR
- ●on October 8, 1998, ADF&G collected water quality data in the WSR. The ADF&G noted in a letter to FGMI dated October 8, 1998, that by late September the WSR had filled with water and an estimated 2 to 3 cfs was flowing through the low flow outlet. The outflow was the first reported since the dam was constructed during the winter of 1995/1996
- ●in early November, 1998, the state LMPT met to discuss selection of the third party contractor to perform the environmental audit at Fort Knox. Agreement was reached to recommend that FGMI contract with TRC

1999

- ●on February 1, 1999, ADF&G by memorandum provided input to ADNR on the draft five-year environmental audit conducted by TRC. The audit concludes that FGMI is in overall compliance with applicable state and federal permits
- ●on March 16, 1999, ADEC by letter notified FGMI that the increase in TDS showing up in monitoring wells may indicate the pump back system is not completely working. FGMI has begun corrective action, but ADEC still needs a written copy of the corrective action plan
- ●ADNR in an internal memorandum (March 31 – LeFebvre to Loeffler) proposed that agencies meet to discuss how to handle permit modifications that would involve moving ore from other ore bodies to the Fort Knox mill for processing
- ●on April 1, 1999, FGMI in a letter to the ACOE notified them that they had reclaimed a total of 308 acres since the spring of 1996. FGMI requested an extension to Special Condition 9c of the ACOE permit to allow time to deposit enough tailing for test plots to be done and data incorporated into the reclamation plan. FGMI also discussed the subject of a dry versus wet closure emphasizing that water quality probably would drive that decision
- ●on April 26, 1999, the ADF&G field checked three proposed projects that involve improvements to cross drainage and fish passage in the WSR and the developed wetlands. A letter dated April 27 was sent to FGMI summarizing our field observations

Appendix 1 (continued)

1999

- on May 15, 1999, ADF&G issued Fish Habitat Permit FG99-III-0101 to FGMI to construct Channel #5 and to install a 78-inch diameter pipe located at the lower end of Pond F. FGMI constructed Channel #5 to connect the existing wetland complex with the WSR with this work completed on May 16. Prior to this effort, flow exited the wetlands via a perched culvert that was permitted – this new channel should provide access for Arctic grayling to the wetland complex
- during the week of May 17 to 21, 1999, the ADF&G sampled the wetland complex with fyke nets. Mature Arctic grayling were caught and active spawning was observed in the newly constructed channel
- the ADF&G 1998 Arctic grayling population estimate for fish $\geq$ 200 mm was 5,800 fish
- on June 2, the ADF&G collected water quality data in the WSR and found higher DO concentrations in Solo Bay and Polar Bays where surface water input was greatest. At most sites, DO concentrations remain depressed with depth
- the ADF&G fished hoop traps for burbot in the WSR from June 3 to 8, 1999, catching 626 burbot – most burbot were caught along the north and east sides of the WSR in those areas where DO concentrations were highest
- on September 1, 1999, the ADF&G removed a fyke net set in Pond E that caught 19 burbot and 37 Arctic grayling. All, except for one of the Arctic grayling, were judged to be young of the year and provided clear evidence of successful spawning in the wetland complex in spring 1999
- December 1, 1999, the ADF&G attended the Fort Knox annual meeting and in a memorandum dated January 4, 2000, the ADF&G summarized general recommendations for Fort Knox, True North, and Gil

2000

- on January 26, 2000, FGMI notified ADEC that they had completed drilling and construction of two additional interceptor wells below the TSF (IW-5 and IW-6) and requested clarification on Section 1.2.3 of the ADEC permit regarding cyanide limits on monthly average and daily maximum limit
- on February 28, 2000, ADF&G sent a letter to ADNR summarizing our participation in the February 18, 2000, meeting to discuss the draft Fort Knox reclamation plan dated December 1999. The ADF&G recommended, from a biological viewpoint, that the two existing large stockpiles (Solo Creek, Fish Creek just below the TSF) of soils/organics be left in place as they have revegetated naturally and are already providing productive wildlife habitat. If additional soils/organics are needed (e.g., to cover tailing or rock dumps), the ADF&G believes converting the largely climax, undisturbed areas to earlier successional stages, would be preferred provided sufficient soils/organics remain for natural revegetation

Appendix 1 (continued)

2000

- on March 1, 2000, FGMI sent their Guaranty of Kinross Gold Corporation to ADNR to meet its obligations under the Fort Knox Mine Millsite Permit
- on March 9, ADNR administratively extended the Fort Knox Reclamation Plan to September 1, 2000, to allow for site inspections during the snow-free season
- FGMI submitted their 1999 Annual Reclamation Report for True North exploratory work on March 9
- the ADF&G 1999 burbot population estimate for fish ≥ 200 mm was 4,136 fish
- the ADF&G 1999 Arctic grayling population estimate for fish ≥ 200 mm was 4,123 fish
- in spring (early May to early June), the ADF&G documented the presence of Arctic grayling juveniles (age 1+) in Pond E and based on fall catches in 1999 we are fairly certain that Arctic grayling successfully spawned in the wetland complex in spring 1999 just after FGMI constructed a channel to connect the wetlands with the WSR
- on May 30 and 31, 2000, the ADF&G conducted field inspections along the Gil Causeway where fill material had been placed raising the road grade. This activity was permitted by ADF&G on May 6, 1998 (FG98-III-0109). The new fill probably plugged existing culverts and thus the water surface elevation upstream of the causeway was rising. On May 30, a field decision was made to excavate a portion of the road near the northern end and to place two 48-inch pipes to reduce water levels. Work was completed on the two pipes between June 6 and 8
- on June 23, 2000, ADF&G along with state and federal agencies conducted a site inspection with emphasis on reclamation alternatives. The ADF&G recommended that the failed dike at the bottom end of Pond C not be fixed and that we allow a stream to develop over time. A fluvial system in this location would be ideal habitat for Arctic grayling spawning and adjacent areas should revegetate naturally and quickly. ADF&G also recommended that the area north of Fish Creek be considered for construction of a series of ponds that would be fed with water from the TSF at closure and that this system be separated from the existing wetland complex along the south side of the valley
- an August 8 field trip was made to discuss reclamation options and preliminary agreement was reached to leave the stockpile below the TSF in place, to remediate the Yellow Pup waste dump leaving 25% open rock and 75% with topsoil added. We also agreed to allow FGMI to remove topsoil (about 50%) upslope from the final tailing elevation and to spread this material over the tails to promote natural revegetation. Finally, we will continue to evaluate development of a wetland complex on the north side of Fish Creek
- on August 10, the ADF&G inspected the Gil Causeway and documented that a 10-foot diameter pipe had been installed near the south end of the causeway

Appendix 1 (continued)

2000

- during the last week of August, the ADF&G fished fyke nets in Upper Last Chance Bay, Pond F outlet, Pond E, and the boat ramp in the WSR. Arctic grayling juveniles and fry were actively feeding on the surface and appeared abundant at all sample sites
- on October 11, 2000, ADF&G nominated FGMI for the ADNR reclamation award for reclamation in the Fish Creek valley downstream of the TSF. Reclamation has occurred concurrently with mining activities. Wetland and aquatic habitats have been constructed and use by waterfowl, raptors, wolves, moose, beaver, and fish is occurring. Work continues to improve the value of these habitats to fish and wildlife and plans for developing more wetlands are under active consideration

2001

- on January 25, 2001, ADEC approved FGMI's request to dispose of True North ore process tailing at the Fort Knox TSF subject to the terms and conditions of the solid waste permit 0031-BA008
- on February 21, the ADF&G conducted a field inspection and noticed at the WSR spillway where a cow moose with calf had approached the spillway from the upstream side headed east. The moose went around the north end of the fence where it abuts against the toe of the rock bluff. The opening at this location is from one to at most 3 feet. The ADF&G recommended that FGMI block this small area with some additional fencing
- FGMI informed ADF&G by email dated February 26 that they had completed fence modifications at the WSR spillway. A panel of fence was added on the upper and lower end of the spillway to prohibit moose access to the spillway
- on April 4, 2001, ADF&G issued amendment #5 to Fish Habitat Permit FG98-III-0109 which approved the restoration plan as submitted by FGMI by letter dated March 29, 2001
- on April 10 and 13, the ADF&G collected phytoplankton and zooplankton samples in the WSR. Zooplankton densities in April 2001 were similar to August 2000; however communities in April were dominated by copepods, whereas August communities were dominated by daphniids
- ADEC approved a change in Section 1.2.1 of the Solid Waste Permit 0031-BA008 that will now limit waste materials to 50,000 tons per day as a monthly average
- FGMI informed the ADNR Dam Safety Engineer of their intent to raised the tailing impoundment embankment to the 1407 elevation by letter dated July 20, 2001

Appendix 1 (continued)

2001

- ●the ADF&G 2001 burbot population estimate for fish ≥ 200 mm was 3,391 fish with the mark event done in early June and the recapture event done in late June
- ●the ADF&G 2000 Arctic grayling population estimate for fish ≥ 200 mm was 5,326 fish
- ●on August 20, 2001, state agencies conducted an inspection at the Fort Knox Mine. Overall, FGMI appeared to be operating consistent with the Plan of Operations. We looked at the north side of the Fish Creek valley below the TSF where FGMI is considering development of a pond complex that would be fed by water from Fish Creek at closure. We also drove to Last Chance Creek where FGMI and ADF&G are working on a plan to mitigate aufeis in the creek
- ●in early October, the ADF&G caught about 20 large burbot (> 500 mm) in the WSR using hoop traps and surgically implanted three fish with radiotags with the objective of determining both movement and spawning areas in February/March
- ●on November 7, 2001, the ACOE notified FGMI that no further approval was needed to proceed with restoration work (civil work) on Last Chance Creek designed to keep the creek in its existing channel thus reducing aufeis formation. Civil work was completed by FGMI in two reaches by grading material to confine flows to the existing channel.
- ●on November 28, 2001, ADEC approved FGMIs request to use lead nitrate as a reagent in the milling process. Reference was made that FGMI had agreed to conduct weekly monitoring for As, Sb, Se, and Pb in the tailing decant, tailing filtrate, and tailing seepage
- ●November 30, 2001, ADNR distributed by email a draft reclamation plan specific to the development of the public recreation area. The draft plan included the list of issues as distributed to the public in 1995

2002

- ●on January 30 and March 31, 2002, the ADF&G attempted to relocate three radiotagged burbot marked in October 2001 and released near the dam. In late January two of the three burbot were found in Solo Bay and in late March only one fish was found and it was in Solo Bay immediately upstream of the culvert. The ADF&G hypothesized that the adult burbot would go to Solo Bay to spawn because of the freshwater input from Solo Creek
- ●on April 4, 2002, ADEC approved FGMIs request to install a thickener. The environmental benefits of the new thickener include: overall addition of less CN to the milling process and lower levels of ammonia, nitrates, sulfate, copper, and TDS in the tailing effluent

Appendix 1 (continued)

2002

●on April 18, 2002, the ADF&G collected water quality data in the WSR. DO concentrations were higher than in previous years and the increased DO was attributed to removal of 1464 acre-feet of water from the bottom of the WSR where DO concentrations are the lowest. The ADF&G found very high DO concentrations in Solo Bay and believe that input water from Solo Creek is the key factor in allowing burbot and Arctic grayling to successfully overwinter in the WSR

●on June 12, 2002, ADNR distributed a letter announcing two decisions that enable FGMI to expand its mining operations at True North. The Remand Decision reaffirmed ADNRs decision to approve the True North Mine and haul road as made in December 2000. ADNR also approved FGMIs request to expand the True North Mine and extend the life of the mine by about one year

●on July 19, 2002, the ADF&G visually surveyed the wetland complex and Last Chance Creek finding Arctic grayling fry numerous in the wetland complex and absent from Last Chance Creek

●on August 22, 2002, the ADF&G sampled Arctic grayling fry in the wetland complex finding about 10% of the fish with spinal deformities

●in early October (2002), the ADF&G caught one of three burbot that had been radiotagged in October 2001. The incision area and where the antenna exits the abdomen had completely healed, scar tissue was minimal, there was only a slight reddish color around the antenna at the body surface, and the fish was in excellent condition

●the ADF&G estimated burbot population for fish ≥ 200 mm for summer 2002 (spring mark, fall recapture) was 1,763 fish

●the ADF&G 2001 Arctic grayling population estimate for fish ≥ 200 mm was 5,623 fish

●the ADNR Dam Safety Engineer in a letter dated December 23, 2002, approved the 2002 expansion which raised the seal zone of the tailing dam to elevation 1428

●the ADNR on December 20, 2002, issued a conditional approval to FGMI for the reclamation plan under AS 27.19 until February 11, 2004. The state still consider a “dry closure” to be the preferred approach

2003

●on January 8, 2003, ADF&G reported minimal aufeis in the wetland complex with water flow under ice/snow cover and predicted that if aufeis remains minor that we expect Arctic grayling to use the entire wetland complex for spawning this spring. Otter sign was seen in the stilling basin below the freshwater dam

Appendix 1 (continued)

2003

●on January 28, 2003, ADEC authorized FGMI to change the monitoring frequency for As, Sb, Se, and Pb from weekly to monthly. The purpose of this monitoring is to closely track the increasing As and Sb concentrations since FGMI began processing ore from True North and Pb concentrations as a result of use of $PbNO_3$ in the mill

●at the February 13, 2003, annual meeting ADF&G presented a summary of fish work conducted in the WSR. Successful spawning of Arctic grayling in the wetland complex has now been documented each year since 1999 when FGMI constructed a channel to connect the wetlands with the WSR

●on February 13, 2003, the ADF&G attended the FGMI annual meeting. At this meeting, agencies were in agreement that the best option for closure of the TSF was as a "dry closure"

●in spring 2003, the ADF&G discovered where the floating mats of vegetation have been coming from in the WSR. Along the south side of the WSR, substantial thermal degradation (melting of massive ice lenses) is occurring leaving black spruce wetlands perched above the water with extensive undercutting. Eventually, chunks of black spruce wetland break off and float around the WSR. The surface area of the WSR is actually increasing and the ADF&G notified FGMI security of the situation. The thermal degradation also is a primary source of organics and detritus to the WSR

●the ADF&G spring 2003 sampling work was conducted from May 5 to June 2. Extensive aufeis in Last Chance Creek with water temperatures remaining below 2°C resulted in catching only a few Arctic grayling. Over 1,500 Arctic grayling were tagged in the developed wetland complex

●on June 25, 2003, the Office of Habitat Management and Permitting (OHMP) conducted visual surveys in Last Chance Creek and found no evidence of any Arctic grayling fry as expected due to extensive aufeis in the spring

●on August 19, 2003, the OHMP sampled Arctic grayling fry in the developed wetlands catching 65 fry (average 72 mm long, range 58 to 113 mm)

●on September 29, 2003, the OHMP submitted written comments to ADNR on the Draft Five-Year Environmental Audit. Increases in antimony, arsenic, copper, cyanide, nitrate, phosphate, and selenium have been seen since addition of True North ore and the OHMP recommended further discussion regarding whether these increases are temporary

●OHMP conducted a site visit of the constructed wetlands on November 20 and reported minimal aufeis, active flow under ice cover, and observed 8 moose in the valley

●on December 3, 2003, the ADNR submitted, by letter, comments to FGMI on the Draft Five-Year Environmental Audit for the Fort Knox and True North Mines

Appendix 1 (continued)

2004

- on February 6, 2004, ADNR issued an administrative extension to the reclamation plan until January 1, 2005
- on March 4, 2004, the Fort Knox and True North Mine annual meeting was held at the mine. True North will be in temporary suspension for 3 to 7 months. Revegetation test plots have been done on tailing material and we recommended that additional test plots be done with topsoil on the tailing material. The FGMI environmental audit has been completed and the closure plan along with the revised reclamation plan will be submitted by August 1, 2004.
- on March 11, 2004, the ACOE extended Permit N-920574 to allow FGMI additional time to revise the reclamation plan and develop a closure plan while addressing chemical stabilization, water quality, water treatment, acid rock drainage, mill site characterization, and tailing consolidation (both plans are to be submitted to the ACOE by August 1, 2004
- on April 7, 2004, the OHMP collected water quality data in the Fort Knox WSR – all five sites were sampled. Generally it appears as though input from Solo Creek is beneficial to overall DO concentrations. A major difference seen this winter was higher DO concentrations in Polar Bay and these increases probably are related to more flow from Last Chance Creek where aufeis development had been minimal
- on April 7, 2004, the ACOE issued POA 1992-0574-N (Fish Creek 23) to extend the time limit by about one year for completion of the final reclamation plan
- on April 14, 2004, FGMI sent a letter to ADNR (State Dam Safety Engineer) indicating their intent to raise the tailing impoundment embankment during the 2004 construction season
- the state's LMPT met with FGMI, Mental Health Trust Office, and the ACOE to discuss the Fort Knox Mine reclamation plan on April 15, 2004. Agreement appeared to be reached on the following: keep open water away from the TSF dam; the TSF may very well be a jurisdictional dam in perpetuity; the 425 acres of water as required by the COE is not set in stone but would need a public process to change; need to start defining the recreation area and what roads, etc. will remain and what their operating costs are; address the option of the north side of Fish Creek wetland complex; and monitor thermal degradation along the south shore of the WSR
- the Arctic grayling population estimate for fish $\geq$ 200 m for spring 2003 was 6,495 fish, the population has remained stable since 2002

Appendix 1 (continued)

2004

●the OHMP sampled Arctic grayling from May 5 to 28, and summarized our findings in a trip report sent to FGMI on June 23. Minimal aufeis was present in lower Last Chance Creek, water temperatures warmed, and Arctic grayling spawned in the creek (first time since 1995). Arctic grayling were captured in Pond F outlet and moved upstream of a beaver dam at this location with spawning documented throughout the wetland complex.

●on July 14, 2004, the State's Dam Safety Engineer in ADNR conducted a site inspection of the TSF dam and in the trip report he identified the critical importance of the abutments

●on August 11, 2004, OHMP sent a letter to FGMI summarizing field inspections made on August 10, including the following: large numbers of Arctic grayling fry in Last Chance Creek (first time we have seen this since construction of the freshwater dam); and fry numbers in the wetland complex were low

●September 30, 2004, a letter to FGMI from OHMP identified the following action items: a beaver dam at Pond F outlet channel should be removed; and surface disturbance related to access by another mining company in the stilling basin area needs to be stabilized

2005

●January 12, 2005, ADNR administratively extended the reclamation plan approval and requested that FGMI submit a revised plan by November 1, 2005, that addressed a number of items including reclamation costs, long-term post-reclamation maintenance costs, development of a wetland complex along the north side of the Fish Creek valley, and closure issues necessary to revise the US ACOE permit

●in early February, FGMI inquired about the feasibility and permitting of a cyanide heap leach pad at Ft. Knox

●the OHMP applied for and obtained a Fish Transport Permit to collect Arctic grayling gametes in the developed wetland complex to be used in a laboratory experiment testing effects of total dissolved solids on egg fertilization and early development

●aufeis in both the wetland complex and Last Chance Creek were minimal and Arctic grayling spawned successfully in both systems in spring 2005

●the Arctic grayling population estimate for fish $\geq$ 200 mm for spring 2004 was 6,393 fish, the population has remained stable since 2002

●the burbot population for fish $\geq$ 400 mm was 86 for spring 2004

Appendix 1 (continued)

2005

- July 28, 2005, ADEC approved the disposal of water from the dewatering of the Fish Creek causeway to the TSF (ADEC Waste Disposal Permit 0031-BA008
- August 8, 2005, the OHMP collected Arctic grayling fry in Last Chance Creek and in the wetland complex, fry were larger in Ponds E and F than in Last Chance Creek and Channel C
- the beaver dam at the outlet of Pond F appeared to be unchanged from spring 2005, but another new dam had been built in the outlet of Pond D
- October 25, 2005, ADNR administratively extended the reclamation plan approval to June 1, 2006, and reiterated the items that need to be addressed including incorporation of the heap leach facility
- November 2005, the OHMP attended a meeting with FGMI to discuss the proposed valley heap leach pad in Walter Creek, there are still a number of questions including potential effects of this project on closure of the TSF
- December 12, 2005, ADEC administratively extended Permit #0031-BA008 with the understanding the FGMI will submit a Final Closure Plan for the Ft. Knox facility, an updated Reclamation Plan, a design and operating plan for the Walter Creek Heap Leach Facility, and an updated Financial Assurance estimate for closure and post-closure monitoring for the Ft. Knox TSF by January 6, 2006

2006

- on April 7, 2006, the OHMP gathered water quality data at 5 sites in the WSR, DO concentrations varied among sample sites with the higher DOs seen in the main portion of the WSR
- aufeis was extensive in Last Chance Creek and in the wetland complex and Arctic grayling spawning probably was limited to Ponds E and F and the Pond F outlet channel
- in May, the OHMP noted aufeis in the excavated channel immediately downstream of the monitoring wells and upstream of Ponds A and B and because we had not seen aufeis in previous years we had requested that FGMI collect samples
- the Arctic grayling population estimate for fish $\geq$ 200 m for spring 2005 was 7,926 – a substantial increase from the 2004 estimate
- the burbot population estimate for fish $\geq$ 400 for spring 2005 was 143, due to low recaptures an estimate of small burbot could not be made
- the state's review of the FGMI request to use the pit lake as a treatment facility was begun

Appendix 1 (continued)

2006

- in early August 2006, the OHMP observed large numbers of Arctic grayling concentrated at the mouth of Solo and Last Chance creeks and in the stilling basin where seepage water enters. The OHMP estimated over 1,000 Arctic grayling at the mouth of Last Chance Creek. Fish appeared to be concentrated in these areas due to cold water input as the WSR had a surface temperature of >17°C, whereas Last Chance Creek water was about 7°C
- on August 18, 2006, ADEC notified FGMI that an investigation should be conducted to determine the cause of TDS water quality exceedances in MW-5 and MW-6 and if exceedances have resulted from the seepage capture system not functioning property to implement a corrective action plan
- on September 15, 2006, FGMI responded to the ADEC letter dated August 18 and included a report prepared by Water Management Consultants. The Water Management Consultants report concluded that the seepage capture system was working as designed
- the OHMP provided comments to ADNR on the report titled "Addendum to reassessment of functions and values for wetlands and aquatic features associated with the Fort Knox Gold Mine" prepared by Moody and Buell. The addendum was completed to reflect the proposed addition of a heap leach facility in the headwaters of Walter Creek
- a Ft. Knox LMPT meeting was held on 12/15/06 to discuss the proposed heap leach facility, use of the pit lake for treatment and disposal of TSF decant water and seepage, and use of the constructed wetlands between the TSF and the freshwater reservoir
- ADEC conducted a site inspection with FGMI on December 19, 2006, immediately downstream of the TSF. Three areas of aufeis were observed and ADEC was verbally notified that the source of the aufeis is TSF decant water based on TDS, Sb, and CN
- ADEC and ADNR made two joint TSF site inspections on December 18 and 22, 2006.
- COE issued POA-1992-574-U (Fish Creek) on December 31, 2006, for land clearing and excavation in conjunction with construction of the heap leach pad in the upper portion of Walter Creek
- December 26, 2006, ADEC sends certified letter to FGMI regarding correction actions associated with seepage below the TSF dam. ADEC had been notified by FGMI on December 16, 2006, that seepage water analyses indicated exceedances of Alaska Water Quality Standards and on December 18, 2006, ADEC met with FGMI on site. The ADEC December 26, 2006, letter contained a number of actions items to be completed by FGMI

Appendix 1 (continued)

2006

- December 28, 2006, the ADNR distributed a trip report summarizing a December 22 field inspection to the Ft. Knox TSF. The trip report contained a number of action items requested by dam safety

2007

- January 9, 2007, the OHMP participated in a site inspection of the TSF and seepage areas and corrective measures (pumping water back to the TSF, newly constructed drainage ditch connecting several pump back sites) that had been implemented and identified additional wetland sample sites down the valley
- ADEC conducted several site inspections in early 2007 concerning seepage water at the TSF south abutment and FGMI implemented a number of measures to capture and pump seepage water back to the TSF and they implemented a water quality monitoring program at the seep and sites down gradient
- on April 3, 2007, the ADNR by letter to FGMI stated that surface seepage on the south abutment of the tailing dam did not constitute a structural stability problem as long as seepage remained constant and clear. ADNR identified a number of action items to be completed by FGMI
- on April 6, 2007, water quality data were collected in the WSR with DO concentrations generally above 4 mg/L for the first six m of water in the main part of the reservoir, but lower in Solo, Last Chance, and Polar Bays and generally decreased with depth at all sites
- on April 20, 2007, the OHMP drilled two holes in Pond F and using an underwater camera determined that no fish were present; however, one dead Arctic grayling was found on the upper side of a beaver dam at the Pond F outlet channel. Previous water quality measurements indicated anoxic conditions in Pond F – likely the cause of mortality was zero dissolved oxygen in Pond F
- Arctic grayling spawning did not occur in Last Chance Creek due to extensive aufeis (cold water) that persisted beyond the Arctic grayling spawning period
- in spring 2007, Arctic grayling spawning was limited to the Pond F outlet channel due to extensive aufeis and beaver dams upstream of Pond E and F
- the Arctic grayling population estimate for fish $\geq$ 200 m for spring 2006 was 5,930 fish, this estimate represents a decrease from the number of fish estimated for spring 2005
- the burbot population estimate for fish $\geq$ 400 for spring 2006 was 128, the number of large burbot in the WSR has remained stable for the last 6 years
- June 4, 2007 the ADEC notified the US ACOE that FGMI had satisfactorily completed work or they have committed in writing to perform all tasks necessary to resolve the seepage issue at the tailing dam

Appendix 1 (continued)

2007

- ●June 5, 2007, OHMP reported finding Arctic grayling in the small pond complex in Channel C and that these fish must have overwintered in this pond. Since this pond is the closest aquatic habitat supporting fish to the TSF, it provides additional data suggesting that tailing water did not reach these habitats
- ●June 8, 2007, the ADNR also sent a letter to the US ACOE stating that they consider the seepage issue resolved, but reconfirmed that state agencies will continue to diligently monitor the activities still underway relating to the tailing storage facility
- ●July 3, 2007 the ADNR issued the Final Plan of Operations Amendment for construction of the Walter Creek Valley Fill Heap Leach Facility
- ●July 5, 2007, the ADNR issued the Certificate of Approval to Construct a Dam for the Walter Creek Valley Fill Heap Leach Facility
- ●field visit on 9/26 confirmed that beaver activity in the wetland complex was high with multiple dams effectively blocking access to spawning and rearing habitat
- ●October 11, 2007, the ADNR issued a letter authorizing pushbacks for "Phase 7" of the Ft. Knox pit that includes NOAA property currently authorized by BLM
- ●October 31, 2007, the COE issued permit POA-1992-574-S authorizing the placement of fill into 57.6 acres of waters of the US for the construction, operation, and closure of a valley heap leach facility with the ADEC certificate of assurance that was issued on July 12

2008

- ●FGMI mechanically removed all the beaver dams along the developed wetland complex on the south side of the valley to provide for Arctic grayling passage and spawning in spring 2008
- ●at the March annual meeting, FGMI informed the state that the tailing facility does not have the capacity to handle tailing throughout the projected mine life
- ●the possibility of discharging water from pit dewatering was discussed, if deemed to be feasible and permittable, the discharged water could be used to feed a newly constructed wetland complex along the north side of the valley
- ●winter water quality in the WSR exhibited very low dissolved oxygen (DO) concentrations (< 2 mg/L) at all sites and depths, only two sample points had DO concentrations > 2 mg/L
- ●Arctic grayling spawning did not occur in Last Chance Creek due to extensive aufeis (cold water) that persisted beyond the Arctic grayling spawning period

Appendix 1 (continued)

2008

- in spring 2008, Arctic grayling spawned throughout the wetland complex, in late June fry densities were highest in Channel D and in the Pond F outlet channel
- the Arctic grayling population estimate for fish ≥ 200 mm for spring 2007 was 4,027 fish, this estimate represents a decrease from the number of fish estimated for spring 2006, and is the second consecutive year of population decline
- the OHMP first estimate of the Arctic grayling population in the stilling basin was done in 2008 and estimated the number of Arctic grayling in spring 2007 was 1,139 fish ≥ 200 mm
- FGMI constructed an osprey nesting site immediately adjacent to the main pump house in the WSR; the osprey nest site was active with adults observed on the nest
- the Arctic grayling population decline is likely due to past beaver activity in the wetland complex that limited access to spawning and rearing habitat
- by early August the beaver dams had been rebuilt, but FGMI plans to remove these dams again during winter 2008/2009, the dam at the head of C Channel was removed in October
- clearing for the Walter Creek Heap Leach started in March, the heap leach pad should be functional by 2009 and is projected to be operational through 2019
- in September 2008, FGMI completed civil work in Last Chance Creek, four stream reaches about 30 m long were excavated and 9 to 30 cm granite was placed in the excavations as part of an aufeis abatement project designed to provide Arctic grayling access to spawning habitat in the spring, this project was required by the COE as mitigation for pit expansion and authorized by both the COE and ADF&G

2009

- February 11, 2009, ADNR sent a letter to FGMI regarding the Agreement for Funding Post-Reclamation Obligations and the need to update several exhibits to the Agreement
- April 3, 2009, FGMI presented a summary of their plans to increase the height of the tailing dam and to construct a back dam to protect the heap leach facility, the reclamation and closure plan will need to be updated and ADEC requested that close attention be paid to the fracture zone in the south abutment and that FGMI begin to monitor water quality in Victoria Creek
- April 13, 2009, ADF&G distributed Technical Report No. 09-01 summarizing biomonitoring work conducted during 2008
- April 16, 2009, winter water quality data were collected in the WSR, overall dissolved oxygen concentrations were slightly above the 10-year late winter average and considerably higher than in April 2008

Appendix 1 (continued)

2009

- in spring 2009, Arctic grayling spawned in the Pond F outlet and in the channel connecting Ponds D and E, spawning success was judged to be excellent with thousands of fry present and juvenile Arctic grayling observed in the WSR on May 19
- Arctic grayling spawning did not occur in Last Chance Creek due to extensive aufeis (cold water) that persisted beyond the Arctic grayling spawning period
- June 8, 2009, Last Chance Creek field inspection was conducted to assess aufeis mitigation, two of the four reconstructed crossings appear to have worked
- the Arctic grayling population estimate for fish ≥ 200 mm for spring 2008 was 3,545, this estimate represents a decrease from the number of fish estimated for spring 2007, and is the third consecutive year of population decline
- the Arctic grayling population decline is likely due to past beaver activity in the wetland complex that limited availability and access to spawning and rearing habitat
- ADF&G's estimate of the Arctic grayling population in the stilling basin for spring 2008 was 815, a 28% decrease from the spring 2007 estimate
- a constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring 2009 – two osprey chicks were seen on the nest in August
- September 11, 2009, the beaver dams had been rebuilt, but FGMI plans to remove these dams again during winter 2009/2010
- October 13, 2009, the ADNR issued a temporary Certificate of Approval to Operate a Dam at the Walter Creek Heap Leach Facility; work continued throughout the year on this facility; by October 15 FGMI had placed 2,050,000 tons of rock into the heap leach

2010

- on March 1, 2010, the COE issued POA-1992-574-M18 authorizing preliminary stages of reconstruction of the tailing dam in preparation for a future increase in the height of the dam to increase storage capacity
- attended the March 19 Ft. Knox annual meeting and Bill Morris presented a summary of our work on Arctic grayling and burbot
- on March 25, 2010, ADF&G sent a letter to Ft. Knox describing a plan to mitigate aufeis in Last Chance Creek
- on April 5, 2010, we collected water quality information finding some of the lowest late winter DOs that we have recorded (highest found was 1.68 mg/L
- there was no flow over the WSR spillway during winter and rainfall events were not enough to send water over the spillway during summer 2010
- a process water spill occurred within the ore processing facility on May 4, 2010; cleanup was initiated by FGMI

Appendix 1 (concluded)

2010

- ●beaver dams had been removed from the wetland complex, but beavers were still present in Pond F and removal of some of these beavers took place during early spring
- ●in spring 2010, Arctic grayling spawned in the Pond F outlet channel and in the channel connecting Ponds D and E, fry were not numerous in the Pond F outlet channel, but fry were numerous in the Pond D to E channel
- ●Arctic grayling did not spawn in Last Chance Creek due to extensive aufeis
- ●in spring 2010, we caught a large number (302) of Arctic grayling between 200 and 240 mm long, this represents the first major recruitment to the population since 2005
- ●the Arctic grayling population estimate for fish ≥ 200 mm for spring 2009 was 3,223; this estimate represents a decrease from the number of fish estimated for spring 2008, and is the fourth consecutive year of population decline
- ●substantial recruitment of Arctic grayling to the population was seen in spring 2010 (302 new fish 200 to 240 mm long were marked) and should be reflected in the population estimate made in 2011 for 2010
- ●ADF&G's estimate of the Arctic grayling population in the stilling basin for summer 2009 was 1,159 (in season estimate) and 1,199 (using 2010 as the recapture event)
- ●a constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring 2010 – one osprey chick was seen on the nest in late July
- ●46 burbot were caught in spring 2010 in a fyke net in the WSR; 15 were larger than 400 mm, and all appeared to be in robust condition
- ●the number and condition of Arctic grayling and burbot in the WSR during spring 2010 indicated that even with the very low winter DOs that fish were able to find suitable overwintering habitats somewhere in the WSR or suggests the two species are particularly tolerant of low DO conditions; an ability known for Arctic grayling, but not for burbot

Appendix 2. Water Quality, April 2010

Site 1 is located in the middle of Water Supply Reservoir								
				% Saturation	Dissolved			
Site		Depth	Temperature	Dissolved	Oxygen	Conductivity		ORP
Number	Date	(m)	(C)	Oxygen	(mg/L)	(*u* S/cm)	pH	(mv)
1	4/5/2010	1	0.80	6.6	0.91	136.6	6.72	377
		2	1.16	6.4	0.88	135.6	6.68	375
		3	1.34	5.0	0.69	134.2	6.79	375
		4	1.78	12.3	1.66	132.6	6.74	374
		5	1.88	9.9	1.33	133.3	6.64	374
		6	2.10	11.2	1.50	134.0	6.66	374
		7	2.30	8.7	1.15	137.5	6.79	374
		8	2.46	2.4	0.31	144.5	6.53	372
		9	2.44	1.5	0.19	155.0	6.48	302
		10	2.09	1.2	0.17	195.4	6.42	242
		11	2.04	1.2	0.16	223.8	6.46	189
		12	1.95	1.2	0.16	230.1	6.52	172
		13	2.21	1.1	0.15	232.0	6.58	158
Site 2 is located about 100 m upstream of the Water Supply Dam								
2	4/5/2010	1	0.51	2.6	0.35	137.1	6.29	264
		2	0.93	1.6	0.21	135.7	6.39	264
		3	1.27	4.5	0.61	134.5	6.36	268
		4	1.47	6.8	0.93	134.6	6.45	270
		5	1.66	7.6	1.03	135.1	6.49	272
		6	1.91	6.3	0.85	137.3	6.52	274
		7	1.91	3.3	0.44	143.4	6.53	276
		8	1.74	1.6	0.21	165.4	6.53	266
		9	1.44	12.3	1.68	188.4	6.51	250
		9.5	1.18	9.8	1.34	217.8	6.64	259
Site 3 is located in Solo Creek Bay								
3	4/5/2010	1	0.39	3.2	0.45	137.2	6.68	288
		2	0.79	2.1	0.29	136.1	6.64	287
		3	1.16	1.6	0.22	136.3	6.63	285
		4	1.34	1.5	0.21	138.5	6.64	286

Appendix 2 (concluded)

Site 11 is located in Polar Bay								
				% Saturation	Dissolved			
Site		Depth	Temperature	Dissolved	Oxygen	Conductivity		ORP
Number	Date	(m)	(C)	Oxygen	(mg/L)	(*u* S/cm)	pH	(mv)
11	4/5/2010	1	0.54	5.3	0.73	142.8	6.22	320
		2	0.51	5.3	0.75	149.2	6.44	320
		3	0.86	5.8	0.80	154.2	6.48	320
		4	0.74	5.3	0.73	171.9	6.50	322
		5	1.18	2.9	0.39	186.6	6.50	320
		6	2.33	1.6	0.21	273.6	6.42	230
Site 7 is located in Lower Last Chance Bay								
7	4/5/2010	1	0.54	4.4	0.61	144.5	6.74	292
		2	0.75	2.2	0.31	142.0	6.72	295
		3	1.06	1.8	0.25	140.7	6.67	296
		3.7	1.00	1.6	0.23	164.3	6.61	228

Appendix 3. Arctic Grayling Population Estimates in the stilling basin.

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
2007[1]	200	1,140	748-1,531
2008[1]	200	815	531-1,099
2009[2]	200	1,159	812-1,505
2009[1]	200	1,199	612-1,787

[1]The 2007 through 2009 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.

[2]This 2009 estimate was made capture (spring) and recapture (fall) event in summer 2009.

Appendix 4. 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

[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 2009 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 5. Arctic Grayling Growth in the WSR.

1994 to 1995 growth grayling (n=128)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
160 (n=17)	15	22	6
170 (n=31)	12	57	0
180 (n=39)	9	22	0
190 (n=21)	9	28	0
200 (n=5)	13	40	0
210 (n=4)	17	28	0
220 (n=3)	8	12	0
230 (n=4)	10	18	1
240 (n=1)	3	3	3
250 (n=3)	5	14	0

1995 to 1996 growth grayling (n=29)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
160 (n=7)	26	33	22
170 (n=7)	23	33	16
180 (n=7)	19	32	10
190 (n=2)	6	8	3
200 (n=3)	8	13	3
210 (n=2)	22	27	16
220 (n=0)			
230 (n=0)			
240 (n=1)	2	2	2
250 (n=0)			

1998 to 1999 growth grayling (n=31)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
220 (n=1)	59	59	59
230 (n=3)	27	47	13
240 (n=2)	15	21	8
250 (n=3)	15	30	4
260 (n=4)	20	48	3
270 (n=4)	16	39	1
280 (n=8)	19	32	3
290 (n=4)	18	36	4
300 (n=0)			
310 (n=2)	2	3	0
320 (n=0)			

1999 to 2000 growth grayling (n=141)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
240 (n=1)	62	62	62
250 (n=9)	30	58	10
260 (n=16)	26	63	1
270 (n=13)	31	67	6
280 (n=19)	20	44	0
290 (n=27)	17	34	0
300 (n=26)	13	34	0
310 (n=14)	11	27	0
320 (n=9)	11	17	0
330 (n=5)	7	17	0
340 (n=2)	10	11	9

2000 to 2001 growth grayling (n=47)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
240 (n=0)			
250 (n=0)			
260 (n=2)	17	21	13
270 (n=2)	19	21	16
280 (n=6)	17	31	0
290 (n=8)	9	27	0
300 (n=7)	15	20	8
310 (n=13)	13	26	4
320 (n=6)	13	20	4
330 (n=2)	18	23	12

2001 to 2002 growth grayling (n=296)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=23)	44	99	25
220 (n=30)	33	51	11
230 (n=34)	32	74	16
240 (n=42)	29	86	8
250 (n=25)	29	85	10
260 (n=12)	21	35	10
270 (n=15)	11	20	0
280 (n=11)	9	17	0
290 (n=12)	10	23	0
300 (n=92)	4	30	0

Appendix 5 (continued)

2002 to 2003 growth grayling (n=362)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=11)	34	83	20
220 (n=19)	24	46	6
230 (n=37)	23	36	5
240 (n=35)	21	43	10
250 (n=72)	17	39	0
260 (n=81)	16	32	0
270 (n=43)	13	31	0
280 (n=21)	10	21	0
290 (n=6)	7	18	0
300 (n=37)	3	20	0
310 (n=0)			
320 (n=0)			
330 (n=0)			
340 (n=0)			
350 (n=0)			

2003 to 2004 growth grayling (n=218)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=9)	28	45	7
220 (n=13)	25	52	5
230 (n=22)	17	43	11
240 (n=37)	14	26	6
250 (n=54)	10	20	0
260 (n=31)	8	23	0
270 (n=25)	5	15	0
280 (n=9)	6	16	1
290 (n=8)	6	14	0
300 (n=10)	2	6	0
310 (n=0)			
320 (n=0)			
330 (n=0)			
340 (n=0)			
350 (n=0)			

2004 to 2005 growth grayling (n=211)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=5)	15.8	20	12
220 (n=36)	16.7	33	0
230 (n=35)	16.3	36	7
240 (n=35)	14.9	38	3
250 (n=24)	12.3	21	2
260 (n=24)	7.2	19	0
270 (n=16)	6.1	16	0
280 (n=10)	5.2	13	2
290 (n=4)	6.3	10	3
300 (n=22)	6.2	15	0
310 (n=0)			
320 (n=0)			
330 (n=0)			
340 (n=0)			
350 (n=0)			

2005 to 2006 growth grayling (n=132)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=6)	35	49	27
220 (n=13)	26	41	8
230 (n=16)	25	39	7
240 (n=24)	21	33	9
250 (n=22)	18	36	5
260 (n=24)	15	26	7
270 (n=11)	11	17	0
280 (n=8)	10	16	5
290 (n=1)	12	12	12
300 (n=7)	1	5	0
310 (n=0)			
320 (n=0)			
330 (n=0)			
340 (n=0)			
350 (n=0)			

Appendix 5 (concluded)

2006 to 2007 growth grayling (n=274)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=11)	31	47	20
220 (n=18)	28	41	15
230 (n=31)	26	38	10
240 (n=44)	24	38	0
250 (n=40)	20	38	6
260 (n=51)	19	36	5
270 (n=32)	16	33	3
280 (n=24)	15	26	0
290 (n=19)	13	23	3
300 (n=4)	7	11	0
310 (n=0)			
320 (n=0)			
330 (n=0)			
340 (n=0)			
350 (n=0)			

2007 to 2008 growth grayling (n=205)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=1)	60	60	60
220 (n=0)	0	0	0
230 (n=3)	33	45	21
240 (n=8)	28	49	10
250 (n=15)	24	42	13
260 (n=41)	22	35	12
270 (n=41)	20	41	6
280 (n=39)	18	31	7
290 (n=31)	17	29	5
300 (n=19)	15	24	2
310 (n=7)	15	23	8
320 (n=0)			
330 (n=0)			
340 (n=0)			
350 (n=0)			

2008 to 2009 growth grayling (n=210)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=4)	54	63	40
220 (n=3)	59	71	44
230 (n=8)	59	72	50
240 (n=8)	45	64	31
250 (n=6)	35	48	15
260 (n=9)	29	44	16
270 (n=25)	25	36	12
280 (n=39)	25	43	8
290 (n=38)	23	43	11
300 (n=29)	20	35	10
310 (n=40)	19	30	0
320 (n=0)			
330 (n=0)			
340 (n=0)			
350 (n=0)			

2009 to 2010 growth grayling (n=192)			
Upper Limit (mm) and Sample Size	Average (mm)	Maximum (mm)	Minimum (mm)
210 (n=0)			
220 (n=0)			
230 (n=0)			
240 (n=1)	31	31	31
250 (n=4)	28	45	15
260 (n=4)	27	33	14
270 (n=9)	18	31	3
280 (n=25)	19	45	3
290 (n=31)	17	44	7
300 (n=43)	16	40	4
310 (n=32)	13	22	5
320 (n=24)	12	23	1
330 (n=18)	11	19	6
340 (n=4)	17	23	14
350 (n=1)	6	6	6