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Arctic Grayling and Burbot Studies at the Fort Knox Mine, 2005

by Alvin G. Ott
and William A. Morris

Pond D in Wetland Complex
Photograph by William A. Morris 2005

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Table of Contents

List of Tables

List of Figures

Executive Summary

Water Quality

- dissolved oxygen (DO) concentrations continue to be low in the Water Supply Reservoir (WSR) and decrease with depth in both summer and winter (pages 11 and 12)

Arctic Grayling

- Arctic grayling (*Thymallus arcticus*) successfully spawned in the wetland complex in spring 2005 with peak spawning activity occurring from May 9 to 11 when water temperatures exceeded 10°C (page 15)

- Arctic grayling successfully spawned in Last Chance Creek in spring 2005; this is the second year since construction of the WSR that Arctic grayling spawned in Last Chance Creek and the second consecutive year we have observed minimal aufeis in lower Last Chance Creek (pages 15 and 17)

- the estimated Arctic grayling population in spring 2004 was 6,614; the population has remained essentially unchanged from spring 2002 to spring 2004 (pages 19 and 20)

- growth rates of Arctic grayling >200 mm based on marked and recaptured fish indicate that with time the growth rate is decreasing in the WSR (pages 21 to 24)

Burbot

- the estimated burbot (*Lota lota*) population for fish >200 mm in spring 2004 was 2,100; a slight increase from spring 2003 after several years of declining numbers (page 24)

- the estimated number of large burbot (>400 mm) has slowly decreased from 2002 through 2004 (page 24)

- successful spawning of burbot (*Lota lota*) in the WSR and developed wetlands continues based on catches of small burbot in the WSR and in Ponds E and F in the wetland complex (page 25)

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 complete by July 1996.

Rehabilitation, to the extent practicable, has been concurrent with mining activities and natural revegetation of many disturbed habitats has been rapid. Wetland construction between the tailing dam and WSR began in summer 1998. A channel connecting wetlands to the WSR was built in May 1999. Civil work to minimize aufeis in Last Chance Creek was done in fall 2001. Repair work on the earthen dike separating Ponds D and E and the channel connecting the ponds was completed in summer 2002.

In summer 2004, FGMI conducted an assessment of functions and values for wetlands and aquatic features for the Fort Knox mine (Buell and Moody 2005). Recommendations were made for civil work (culvert removal, causeway removal and rehabilitation, construction of wetland/stream complex along north side of valley) that would further enhance fish and wildlife habitats between the tailing dam and the WSR.

Fish research began in 1992 and focused on streams in and downstream of the project area (Weber Scannell and Ott 1993). In 1993, sampling to assess if a population of fish was available to colonize the WSR continued (Weber Scannell and Ott 1994). Stream sampling continued in 1995 and we estimated the Arctic grayling and burbot populations that would be available to colonize the WSR (Ott et al. 1995). In 1995, the Arctic grayling population in Fish Creek, upstream of the proposed WSR dam site, was estimated at 1,700 fish <150 mm, and 4,350 fish >150 mm. The number of burbot, between 150 and 331 mm, in the upper Fish Creek drainage was estimated at 876 fish.

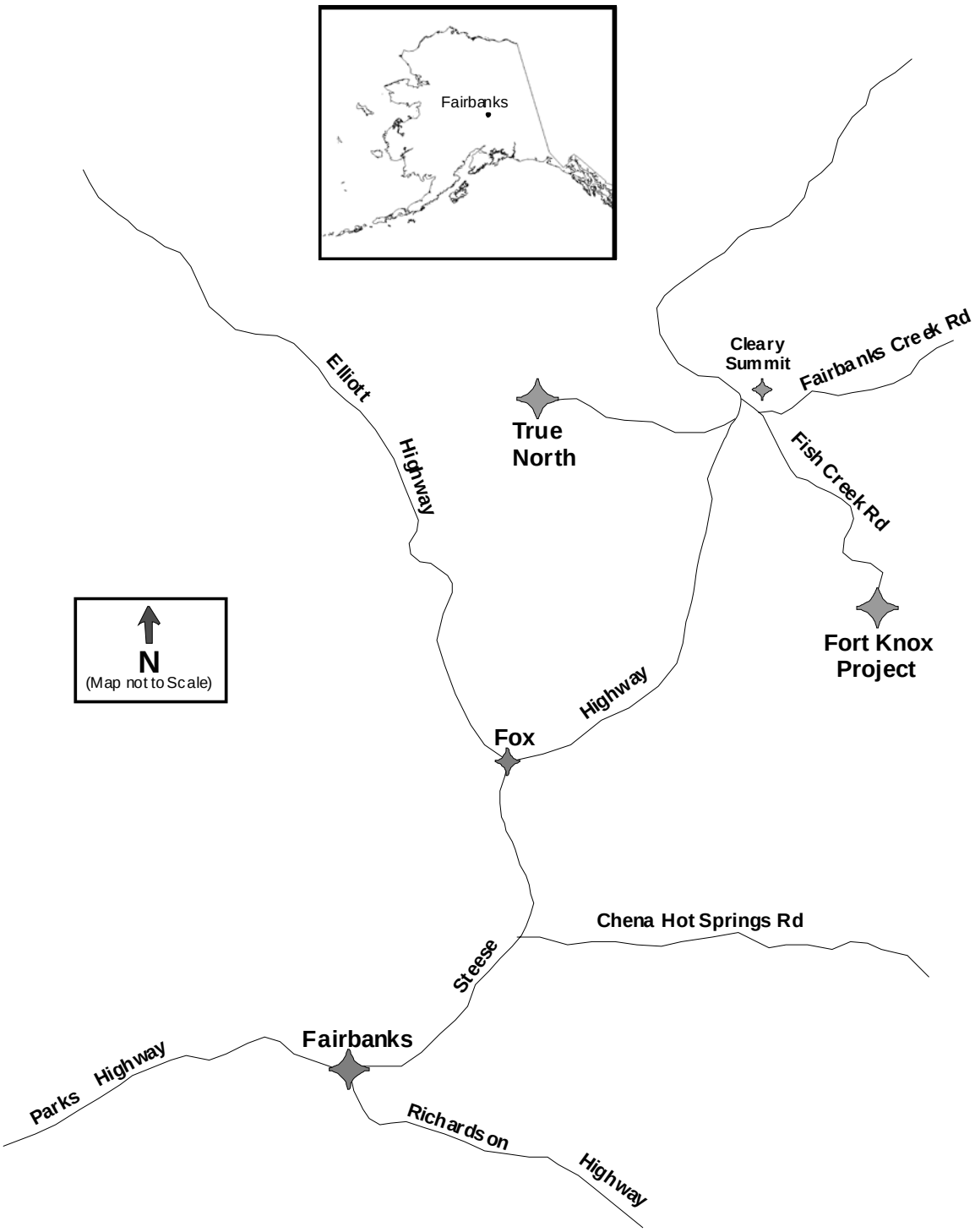

Figure 1. Fort Knox project location.

From 1996 to the present, we have continued to monitor Arctic grayling and burbot, including estimates of their populations (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, Ott and Morris 2002b, Ott and Morris 2003, Ott and Morris 2005). Water quality monitoring in the WSR began in 1997 and continues annually. Fisheries work was expanded in spring 1999 to sample the wetland complex. Channel construction in spring 1999 that connected the wetland complex with the WSR provided for fish passage. Fish sampling also was conducted from spring 2001 to spring 2004 in the stilling basin below the WSR. Our report summarizes fish and water quality data collected during 2005 and discusses these findings in relation to previous work.

Methods

Sampling Sites

Multiple fyke net sampling sites have been used (Figures 2 and 3) to capture Arctic grayling. Changes in fyke net locations have been made to optimize catches and to account for water surface changes in the WSR. Fyke net sites were added in the developed wetland complex after Channel #5 was built in spring 1999. In spring 2005, fyke nets were fished at four stations (#16, #18, #17, and #12). Sites in spring 2005 were not affected by water surface elevation in the WSR. Hoop traps targeting burbot were set throughout the WSR and in the wetland complex. Seining was used in early August to capture Arctic grayling fry in Last Chance Creek and the wetland complex.

Water Quality

Temperature (°C), dissolved oxygen (DO) concentration (mg/L), DO percent saturation (barometrically corrected), pH, specific conductance (u S/cm), and depth (m) were measured with a Hydrolab® Minisonde® water quality multiprobe connected to a Surveyor® 4 digital display unit. The meter was calibrated to suggested specifications prior to field use. The DO concentration was calibrated using the open-air method. Conductivity and pH were calibrated with standard solutions. Water quality measurements were made at the surface, at 1 m depth intervals, and near the bottom.

Fish

Fish sampling methods and gear included visual observations, fyke nets, seines, and hoop traps (Figure 4). Prior to settling burbot traps, DO profiles were run at selected sites in the WSR to ensure adequate DO concentrations were present to support trapped burbot. If DO concentrations were low (e.g., <3 mg/L) at the 5 m depth, all hoop traps were set in less than 4 m of water. Burbot and Arctic grayling >200 mm captured during May and June were marked with a numbered Floy® internal anchor tag.

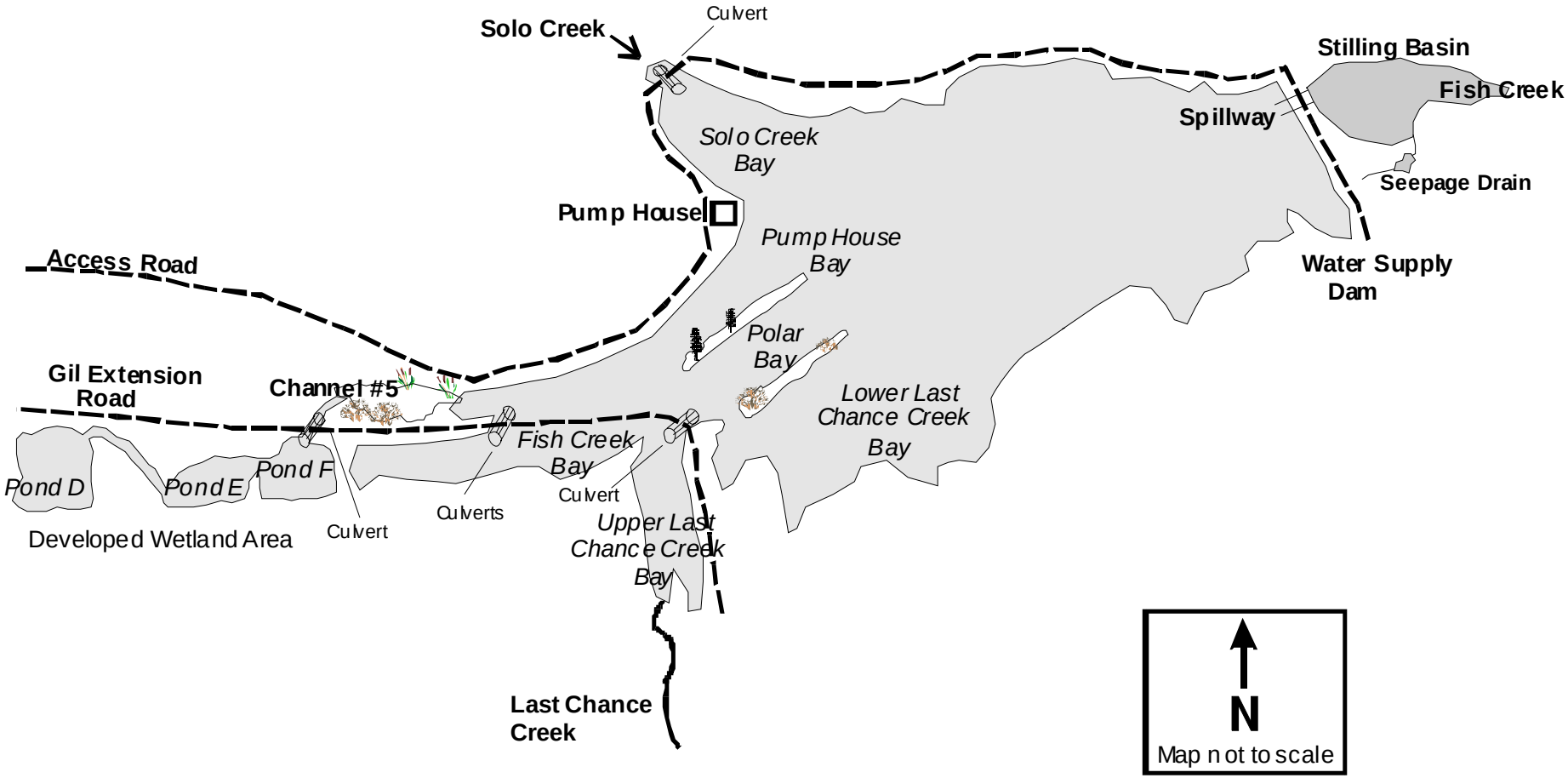

Figure 2. Sample areas in the Fort Knox WSR, stilling basin, and developed wetlands.

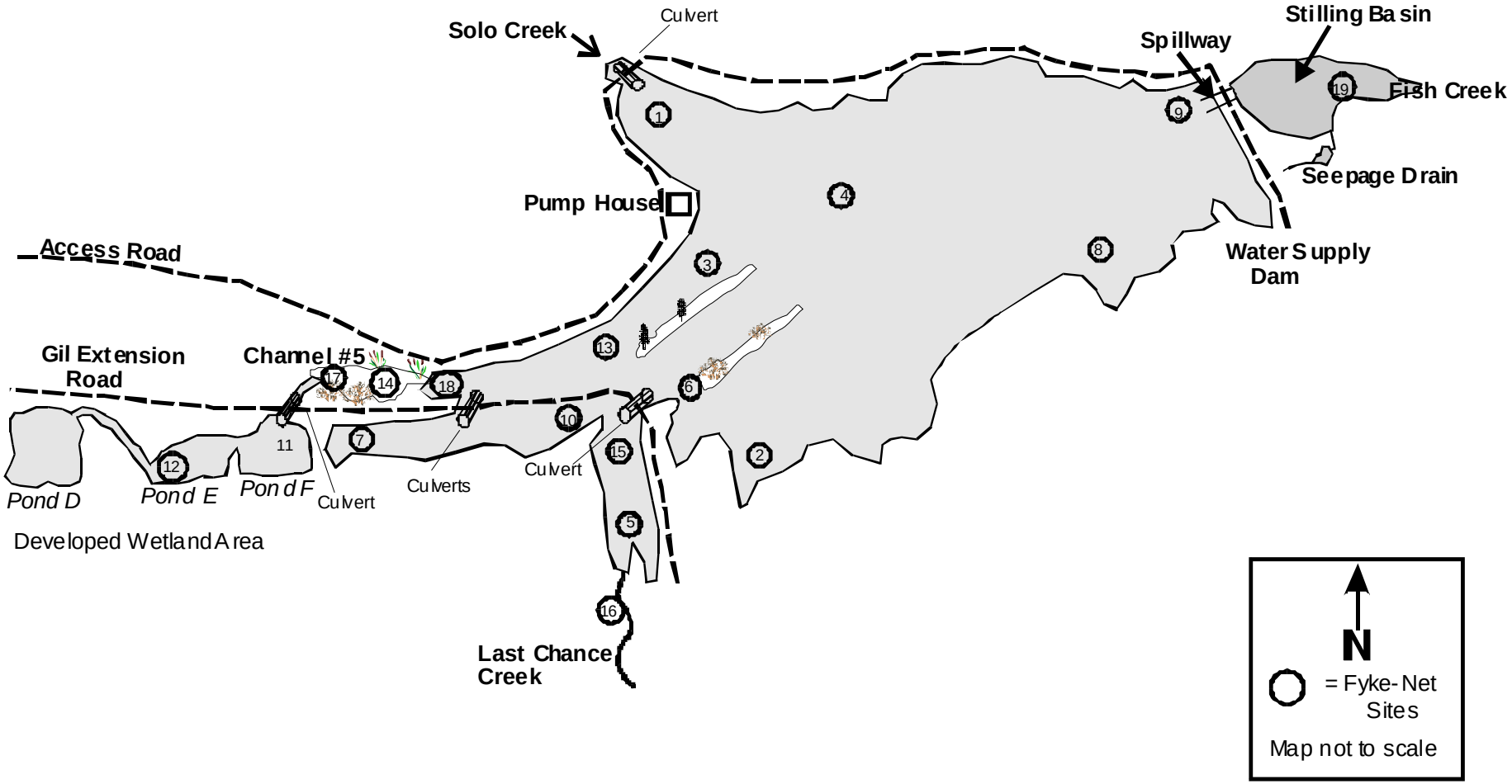

Figure 3. Fyke net sample sites in the Fort Knox WSR, stilling basin, and developed wetlands.

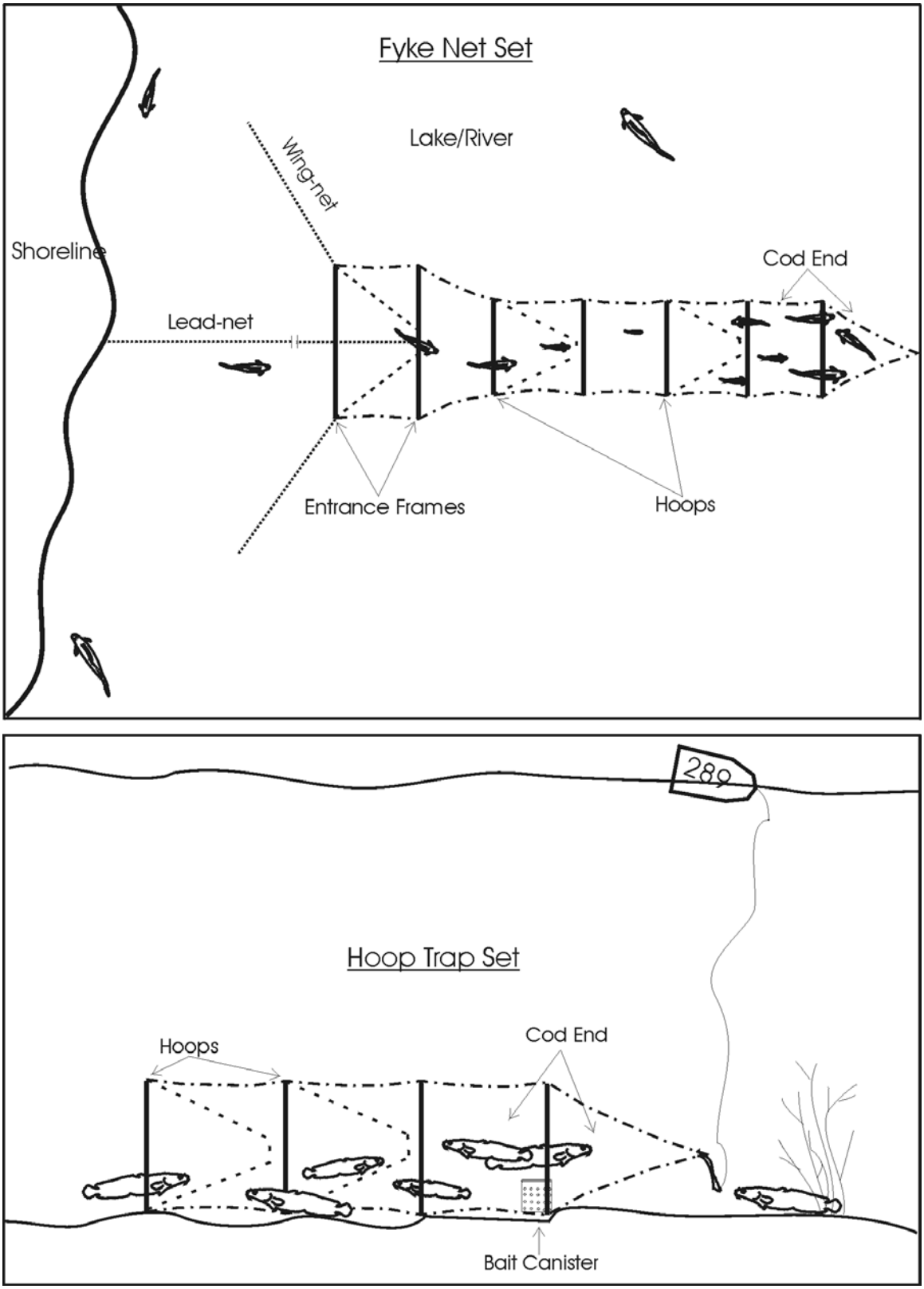

Figure 4. Diagram of fyke net and hoop trap sets.

Three sizes of fyke nets were used. All netting was 10 mm square mesh. Center leads varied from 7.6 m to 30.4 m and were deployed to the maximum extent needed without submerging the top of the entrance frame. Nets were set with the center lead perpendicular to or at an angle to the shore. Generally fyke nets were checked every 24 hours.

Hoop traps baited with whitefish were used to capture burbot. In 2005, traps were fished from 24 to 72 hours and were rebaited when reset. Hoop traps were 1.6 m long with 4 hoops 54 cm in diameter. Netting was 8.5 mm bar mesh. Traps were kept stretched and open with spreader bars. Each trap had two throats and a cod end that was tied shut. A 10 m long seine 0.9 m deep with 10 mm square mesh was used to sample small fish.

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

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

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

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

95% CI for the population estimate was calculated as

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

Results and Discussion

Water Supply Reservoir, Water Quality

Five water quality sites were established and sampled in the WSR beginning in fall 1997 (Figure 5). Two new sites were added in fall 2002 – both of these are located upstream of the Gil Extension Road.

Ponding of water in the WSR began in November 1995. Water levels varied greatly in 1996 and 1997, due to water use and winter seepage below the dam that exceeded freshwater input. The WSR reached the projected maximum surface elevation of 1,021 feet on September 29, 1998, following a period of high rainfall. The WSR contains 3,363 acre-feet (1.096 billion gallons) of water.

Water levels during summers 1999 and 2000 were fairly constant and flow through the low-flow channel in the spillway was present. In winter 2000/2001, about 1,464 acre-feet (477 million gallons) of water was pumped from the WSR to the tailing impoundment. In summer 2001, it took until mid-summer before the WSR recharged and water flowed over the spillway. Water use during the next four winters (October through April) was minimal and generally, there was a surface discharge to Fish Creek throughout the year.

Table 1. Winter water use from the WSR, 1997 through 2005.

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

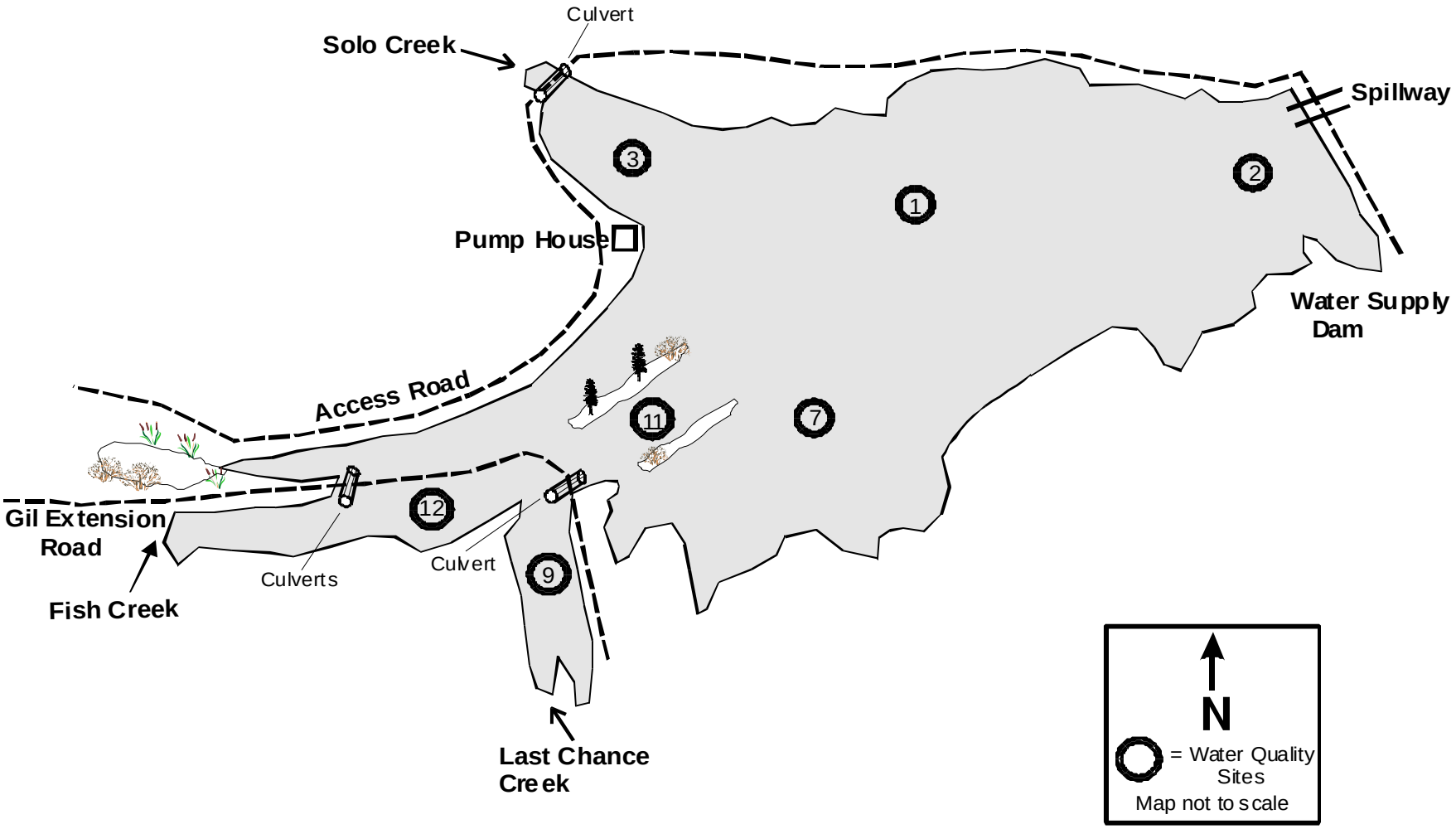

Figure 5. Water quality sample sites in the Fort Knox WSR.

Seepage flow below the WSR is monitored by FGMI. Seepage flow has remained fairly constant for the last six 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

In spring 2005, aufeis was minimal in Last Chance Creek and in the wetland complex. Civil work conducted in Last Chance Creek in fall 2001 and natural development of a stream channel over time in the wetland complex appears to have mitigated aufeis growth. Aufeis in spring 2005 and 2004 was nearly absent from the lower one km of Last Chance Creek and throughout the wetland complex. Decreased aufeis in these tributaries to the WSR will result in higher flow of oxygenated water during winter.

Winter water quality data were not collected in 2005 due to equipment failure. Sampling was done on May 19, 2005, after the WSR was ice-free. The dissolved oxygen (DO) profiles for all five sites in the WSR were similar. DO was highest at the surface and decreased with depth (Site 2, Figure 6). This pattern has been consistent since sampling began in 1997. Hoop traps for burbot in spring 2005 were set at depths less than 4 m to avoid low DO concentrations (i.e., < 4 mg/L).

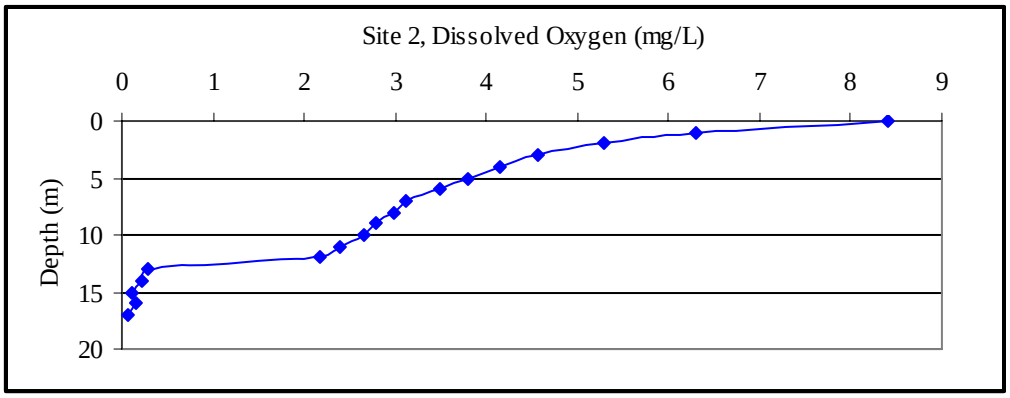

Figure 6. Dissolved oxygen concentration at Site #2 (deepest part of WSR next to dam) by depth on May 19, 2005.

Conductivity and pH in the WSR have varied slightly, but no definite trends have been observed. The pH at Site #2 in 1999 and in 2005 in spring after the WSR was ice-free follow a similar profile, with pH being slightly lower in 2005 (Figure 7).

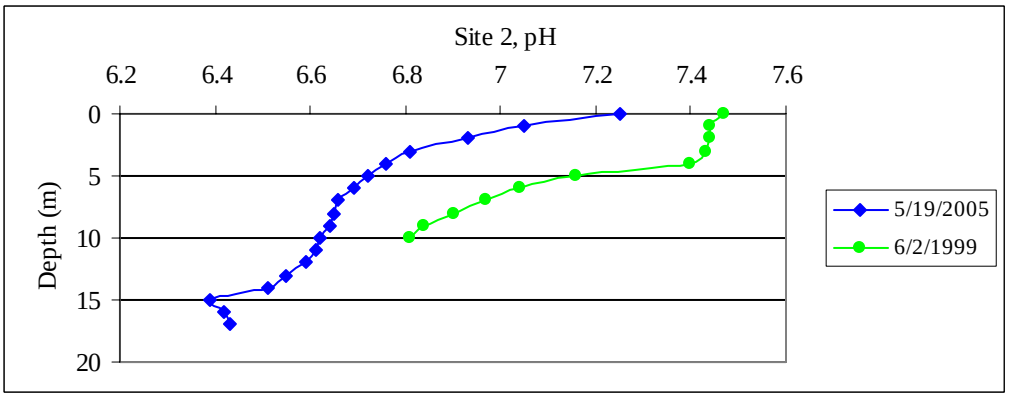

Figure 7. pH at Site #2 (deepest part of WSR next to dam) by depth in early spring 1999 and 2005.

Arctic Grayling and Burbot, Stilling Basin

The stilling basin, located immediately downstream of the WSR spillway, is fed by groundwater, seepage flow, and by surface flow (Figure 3). In spring 2005, we did not sample the stilling basin due to time constraints, an increased water level in the basin from beaver dams, and the high likelihood of having fyke nets damaged by beavers.

Arctic grayling, Last Chance Creek and Developed Wetlands

Arctic grayling were found throughout the Fish Creek drainage prior to construction of the WSR. Fish were most concentrated in Lower and Upper Last Chance Creek ponds and overwintered in flooded placer mine cuts. Arctic grayling in the Last Chance Creek pond complex were characterized as 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 occurred in outlets and inlets of ponds with minimal survival of fry in Last Chance Creek. Flooding of the WSR eliminated all pond inlets and outlets.

Fish sampling from 1996 through 1998 in the WSR and Last Chance Creek found very few Arctic grayling fry. In spring 1999, FGMI constructed an outlet channel to connect the wetland complex with the WSR (Channel #5, Figure 2). Channel #5 bypassed water from the wetland complex that had previously flowed out of Pond F via a perched culvert. The perched culvert was installed in 1995 in accordance with a Fish Habitat Permit to allow use of these wetlands for post-mining passive water treatment.

Construction of Channel #5 was done in early May 1999 and immediately upon completion, Arctic grayling entered the channel and associated wetland complex to spawn. Successful spawning by Arctic grayling in the wetland complex has occurred every year since spring 1999. Arctic grayling have used most of the wetland complex for spawning in all years except spring 2002 when spawning was limited to the lower portion (i.e., Channel #5 and Ponds E and F) by massive aufeis (about 4 m thick) upstream.

Due to extensive aufeis in Last Chance Creek, spawning by Arctic grayling was not documented until spring 2004. In years with massive aufeis, adult Arctic grayling entered Last Chance Creek, but did not ripen and outmigrated without spawning as water temperatures remained cold (< 3°C). Aufeis in the lower 1 km of Last Chance Creek was minimal in spring 2004, water temperatures warmed for spawning to commence, and fry were observed in late summer.

Arctic Grayling Spawning (Timing – Temperature)

In 2005, fyke nets were set in Last Chance Creek and the wetland complex on May 5 and 6. Arctic grayling were already present in the wetland complex and in Last Chance Creek.

A chronology of observations of Arctic grayling spawning in the wetland complex is presented in Table 3. Arctic grayling spawning was observed throughout the wetland complex, with highest use occurring in the channel connecting Ponds D and E in spring 2005. About 200 adult Arctic grayling were actively spawning in the Pond D to E channel on May 9 and 10. Spawning in the channel connecting Ponds D and E peaked from May 9 to 11 as water temperatures exceeded 10°C (Figure 8). Very little spawning activity was seen on May 12.

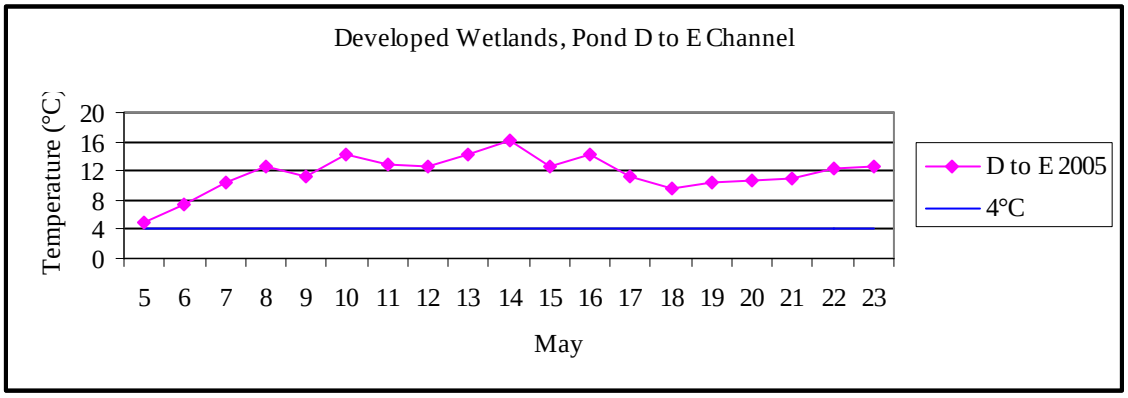

Figure 8. Peak daily water temperature in the channel connecting Ponds D and E in spring 2005.

A single fyke net blocking the entire Last Chance Creek channel was set on May 5, 2005. We visually inspected about 1 km of lower Last Chance Creek and found only minimal aufeis. This is the second consecutive year of minimal aufeis in lower Last Chance Creek since observations began in spring 1992.

Table 3. Chronology of Arctic grayling spawning in the wetland complex in spring 2005 at the Fort Knox Mine.

Date	Observations
May 4, 2005	Discharge about 3 cfs and stained but clear, water temperature 3°C, Ponds D, E, and F with 90% ice cover, Arctic grayling males distributed throughout wetland complex and appeared to be defending territories, seven ripe males and one not ripe female caught in Pond F
May 5, 2005	Water temperatures ranged from 4.5 to 5.0°C, Arctic grayling males defending territories and distributed throughout wetland complex
May 6, 2005	Water temperatures ranged from 5.0 to 6.0°C, channel between Ponds D and E full of fish (about 100), fyke nets caught 108 fish (20 females, one spent female)
May 9, 2005	Water temperatures ranged from 8.0 to 10.0°C, Ponds D, E, and F ice free, fyke nets caught 295 fish (91 females, 0 spent females), spawning activity very high in multiple locations
May 10, 2005	Water temperatures ranged from 8.0 to 12.0°C, fyke nets caught 81 fish (44 females, 1 spent female), spawning activity very high in Pond F outlet, in the channel between Ponds D and E, and in the headwaters of channel C
May 11, 2005	Water temperatures ranged from 9.0 to 13.0°C, fyke nets caught 61 fish (22 females, 4 spent females), very little spawning activity seen in the wetland complex
May 12, 2005	Water temperatures ranged from 10.0 to 14.5°C, fyke nets caught 68 fish (43 females, five spent), very little spawning activity seen in wetland complex
May 13, 2005	Water temperatures similar at all locations about 13°C, fyke nets caught 102 fish (67 females, 17 spent females), very little spawning activity seen in wetland complex
May 26, 2005	Arctic grayling fry (about 10 mm long) observed in channel between Ponds D and E and in Pond D

One Arctic grayling was caught in Last Chance Creek on May 6. Catches increased rapidly, peaked on May 11, and then decreased until the fyke net was pulled on May 16, 2005 (Table 4). About 40 Arctic grayling were in the fyke net on May 16. These fish were released immediately without checking the condition of females.

Table 4. Fyke net catches of Arctic grayling in Last Chance Creek in spring 2005.

Date	Temperature °C	Number of Fish	Number of Females	Number of Spent Females
5/6/05	4.0°C	1	0	0
5/9/05	5.2°C	97	31	3
5/10/05	4.0°C	74	35	0
5/11/05	5.0°C	155	89	10
5/12/05	5.5°C	132	86	12
5/13/05	5.0°C	80	50	7

Water temperatures warmed early in spring 2005 and as in spring 2004, these warmer temperatures reflected the minimal aufeis present in the channel compared with previous years (Figure 9). In 2002 and 2003 when water temperatures remained cold (< 4°C), Arctic grayling adults entered Last Chance Creek, but did not spawn.

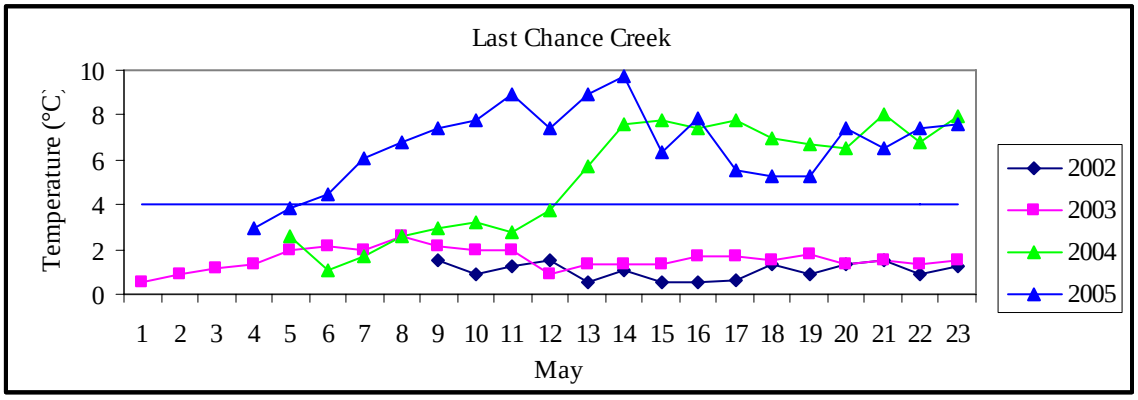

Figure 9. Peak daily water temperature in Last Chance Creek in spring 2002 through 2005.

In spring 2005, Arctic grayling spawned successfully in the wetland complex and in Last Chance Creek. Arctic grayling fry (about 10 mm long) were seen in the wetland complex on May 26, 2005. On August 8, 2005, fry were abundant in lower Last Chance Creek, in Ponds D and E in the wetland complex, and in Channel C located upstream of Pond D. Fry fish were captured on August 8, 2005 in Last Chance Creek and in the wetland complex. Fish caught in Ponds E and F (wetlands) were substantially larger than Arctic grayling fry in Last Chance Creek or in Channel C (i.e., the stream channel above Pond D) (Table 5). About 10% of the fry caught in the pond complex had spinal deformities whereas none were seen in fish collected from either Last Chance Creek or Channel C.

Table 5. Arctic grayling fry caught in the wetland complex and Last Chance Creek.

Sample Location	Date	Number of Fish	Average Length (mm)	Range (mm)	Standard Deviation
Wetlands	9/1/99	21	91	76-97	5.4
Wetlands	7/19/02	41	44	32-57	4.8
Wetlands	8/22/02	113	84	66-102	7.2
Wetlands	9/3/02	145	88	60-114	9.5
Wetlands	6/25/03	20	28	21-46	7.3
Wetlands	7/28/03	50	59	33-75	8.4
Wetlands	8/9/03	65	72	58-113	11.1
Wetlands	8/10/04	19	68	50-82	9.7
Last Chance	8/8/05	72	46	37-67	6.2
Wetlands	8/8/05	41	80	63-97	8.2
Channel C	8/8/05	70	56	44-68	4.3

The average size of Arctic grayling fry in the wetland complex ponds (80 mm) was much larger than in Last Chance Creek (46 mm) or in Channel C (56 mm) upstream of the ponds. Water temperatures in the wetland complex as measured at the outlet of Pond F were the highest (Figure 10). Temperatures in Channel C were slightly warmer than Last Chance Creek and size of fry was larger by an average of 10 mm. As stated previously, all Arctic grayling fry with spinal deformities came from the wetland complex where water temperatures were substantially higher.

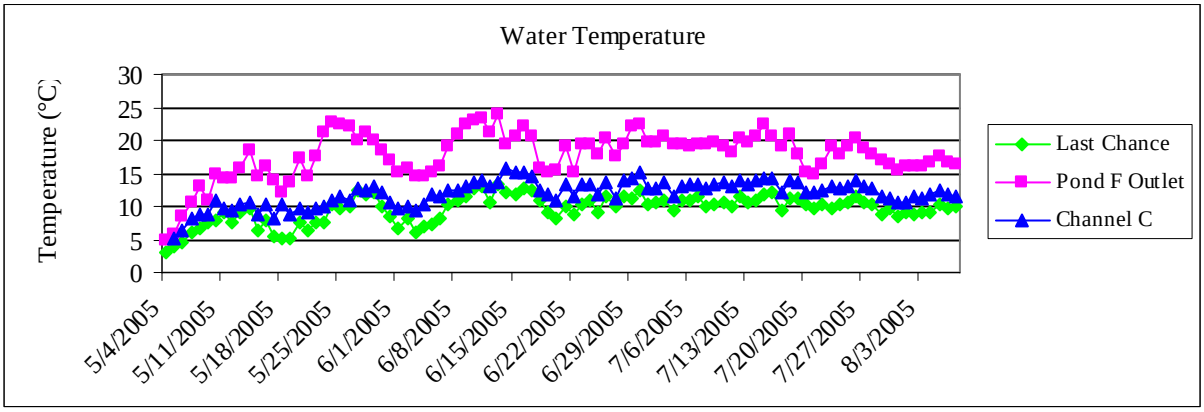

Figure 10. Peak daily water temperature in wetland complex, Channel C, and Last Chance Creek in summer 2005.

Arctic Grayling (Mark/Recapture, Population Estimate, and Growth)

We estimated the abundance of Arctic grayling in the WSR using spring 2004 as the mark event and spring 2005 as the recapture event. In spring 2005, we caught 957 Arctic grayling >220 mm, with 178 recaptures. Our spring 2004 estimated Arctic grayling population in the WSR for fish >200 mm was 6,614 (95% CI 5,808 to 7,420). The Arctic grayling population of fish >200 mm long in the Fort Knox WSR has remained stable over the past several years (Figure 11) (Appendix 1).

For our 2004 estimated Arctic grayling population, we did not include fish that had been marked prior to 2004 unless that individual fish was seen in spring 2004. We also compared length frequency distributions for fish marked in spring 2004 with those

recaptured in spring 2005 to eliminate those fish handled in 2005 that would have been too small (<200 mm) to mark in 2004. Our comparisons of length frequency diagrams indicated that fish ≤220 mm in spring 2005 should not be included in the population estimate (i.e., they would have been too small in 2004 to mark). Using this approach, we reduced the number of fish seen in 2005 by 153 individuals.

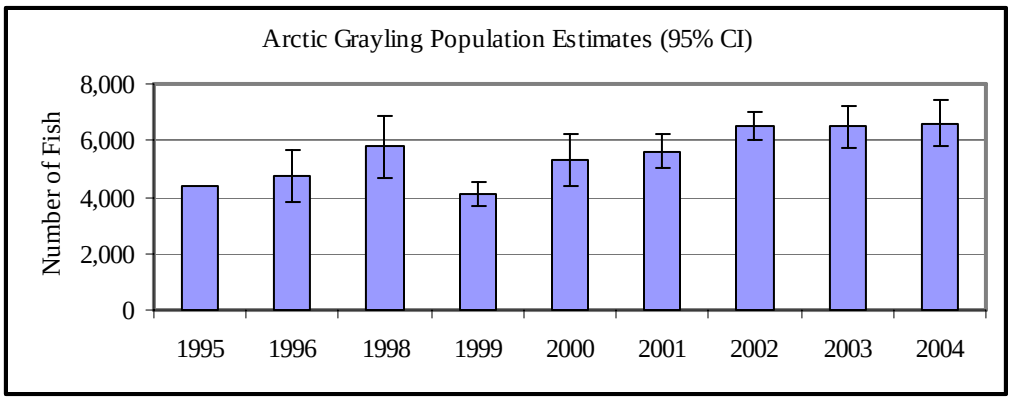

Figure 11. Estimates of the Arctic grayling population in the WSR at the Fort Knox Mine (1995-2004).

In spring 2002, 2003, 2004, and 2005 we had sufficient recaptures to show annual growth by individual fish by size (Table 6, Figure 12). Average growth prior to the WSR was 9 mm per year. Once the WSR was flooded, annual growth rates for all marked fish from 1996 through 1998 were 41, 38, and 39 mm (Ott and Morris 2002a). Generally, annual growth rates for small Arctic grayling are still greater than prior to flooding of the WSR, but the trend appears to be decreased growth with time.

Table 6. Annual growth of marked and recaptured Arctic grayling in the WSR.

Years	Upper Limit Size Range (mm)	Average Growth (mm)
2001 to 2002	210 mm	44
2001 to 2002	220 mm	33
2002 to 2003	210 mm	34
2002 to 2003	220 mm	24
2003 to 2004	210 mm	28
2003 to 2004	220 mm	25
2004 to 2005	210 mm	16
2004 to 2005	220 mm	17

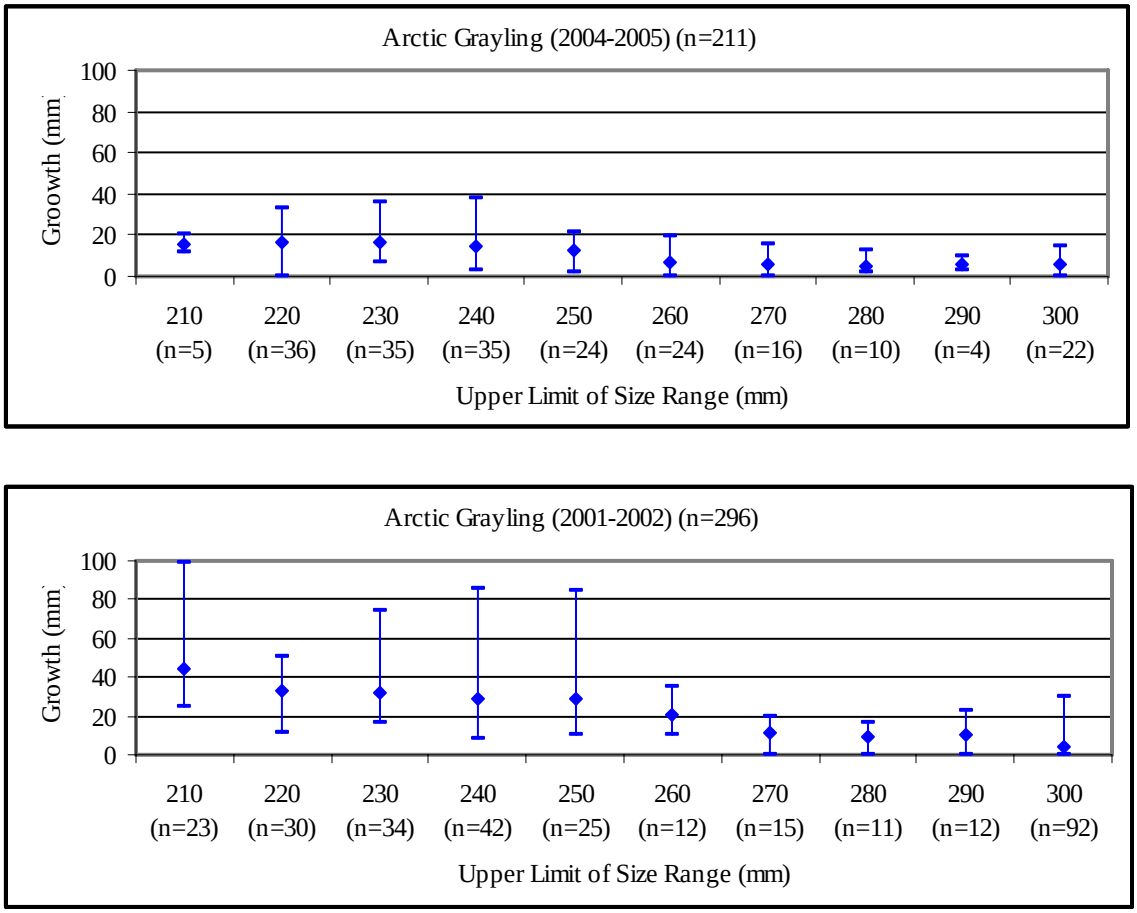

Figure 12. Maximum, minimum, and average growth (mm) for Arctic grayling >200 mm long for 2001/2002 and 2004/2005.

Length frequency distributions for Arctic grayling collected in previous years were presented by Ott and Morris (2002b). Through 1999, little or no recruitment of small fish was seen, but after construction of a channel connecting the wetlands with the WSR, substantial numbers of smaller Arctic grayling have been seen or captured. In spring 2005, small numbers of Arctic grayling <200 mm long were caught in fyke nets, but all age classes were represented (Figure 13).

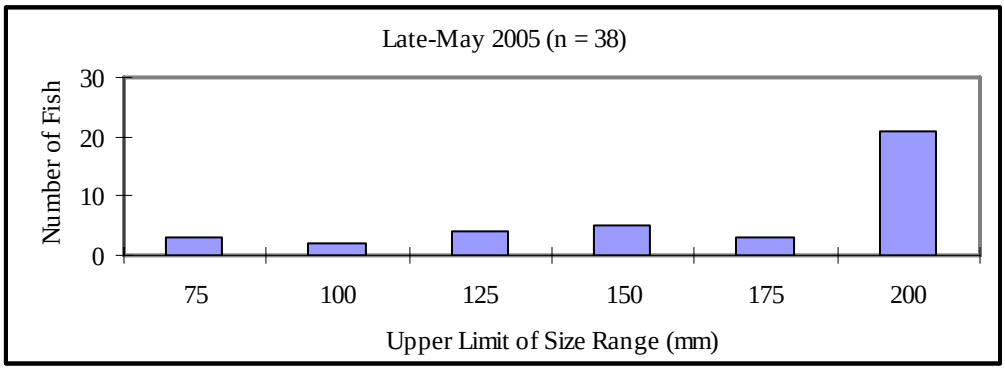

Figure 13. Length frequency distribution of Arctic grayling in the WSR, Last Chance Creek, and the developed wetlands in spring 2005.

Burbot, Water Supply Reservoir and Developed Wetlands

Burbot were found in Lower Last Chance Creek Pond and in Polar Ponds #1 and #2 prior to flooding of the WSR (Ott and Weber Scannell 1996). In May 1995, we conducted a mark/recapture effort and estimated the abundance of burbot (150 to 331 mm) to be 825 fish (Ott and Weber Scannell 1996). Flooding of the WSR inundated the areas where burbot had been found.

Estimates of the burbot population were made during the ice-free season following construction of the WSR (Figure 14, Appendix 2). The estimated burbot population for fish >200 mm long peaked in 1999, decreased substantially through 2003, and then increased to 2,100 (95% CI 1,242 to 2,957) in 2004. Our 2004 burbot estimate is based on a spring 2004 mark event and a spring 2005 recapture event.

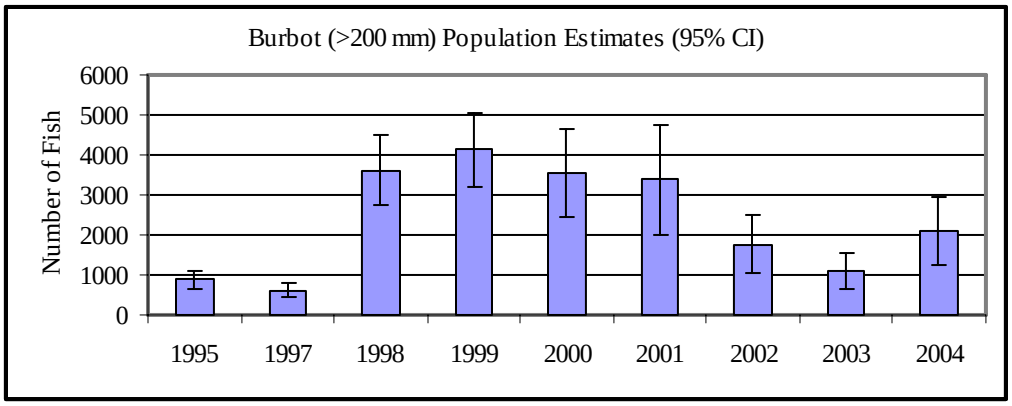

Figure 14. Estimates of the burbot population (>200 mm) in the WSR at the Fort Knox Mine (1995 to 2004).

We also estimated the number of large burbot (>400 mm) in the population from 2001 through 2004. The population of larger fish appeared to be stable from 2001 through 2003, but with the 2004 population estimate, it appears that the number of large fish in the population may be decreasing slowly (Figure 15, Appendix 2).

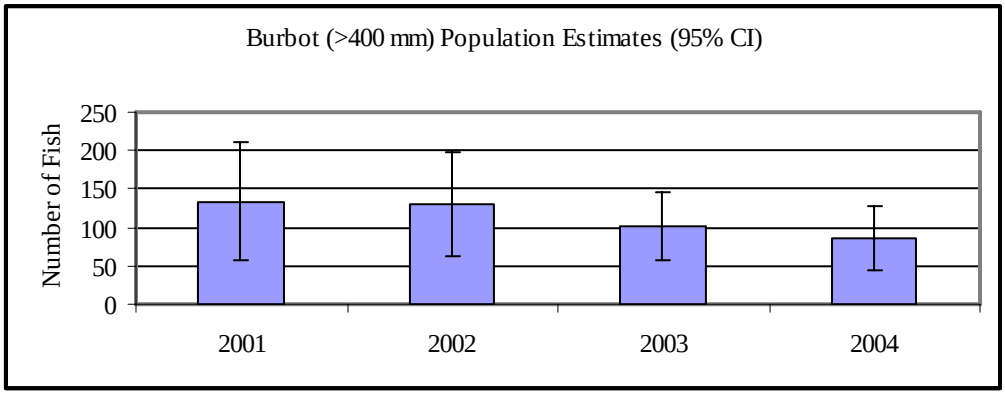

Figure 15. Estimates of the burbot population (>400 mm) in the WSR at the Fort Knox Mine (2001 to 2004).

Burbot were caught in the wetland complex (Pond E) during spring sampling with fyke nets for Arctic grayling. Length frequency distributions of burbot captured in the wetland complex and in the WSR are presented in Figure 16. Traps were used in the WSR and the catch of larger burbot present in the WSR decreases the number of small burbot observed because of predation in the trap. Burbot also were captured in the wetland complex (Ponds E and F) in August 2005 with a seine. Several of these burbot caught in August 2005 were fry (n = 9, 64 to 88 mm). Based on our 2005 sampling in the wetland complex and results from previous years, it is apparent that juvenile burbot and burbot fry are using the developed wetland complex.

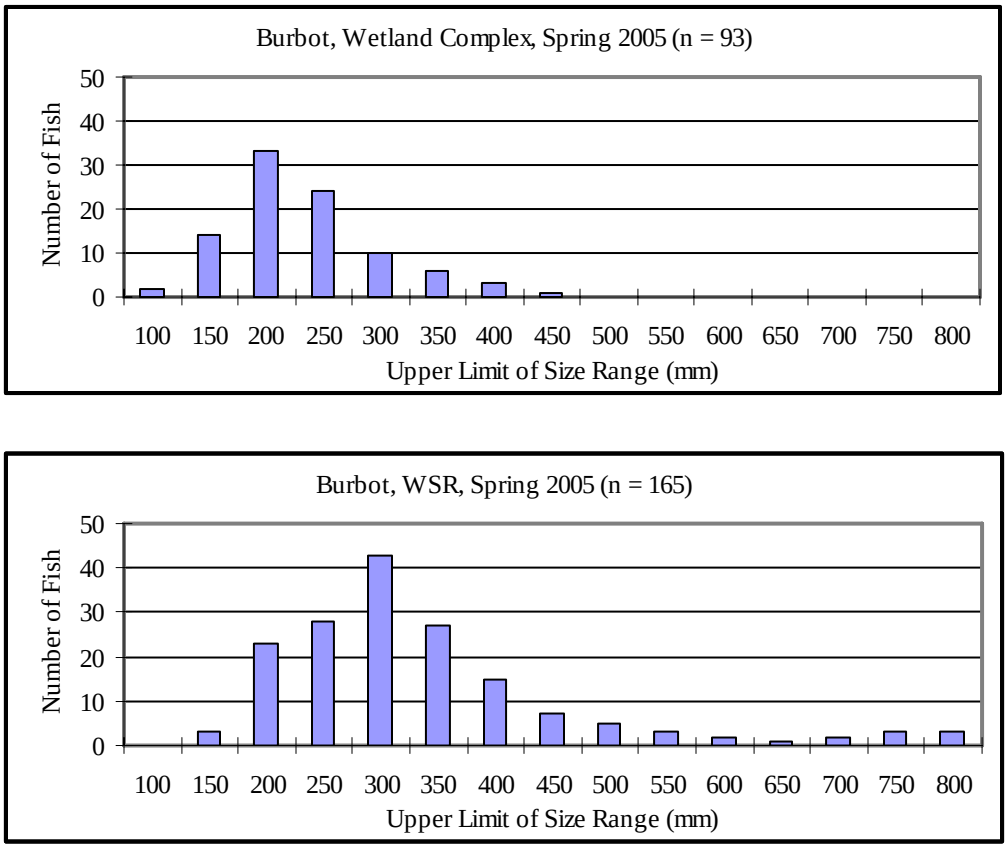

Figure 16. Length frequency distribution of burbot caught in wetlands (fyke net) and in the WSR (hoop traps) in spring 2005.

Conclusion

We predicted prior to construction of the WSR dam that opportunities existed to enhance fisheries resources, specifically Arctic grayling. Our goal was to reach a density of 10 to 20 Arctic grayling >200 mm per hectare of surface area (i.e., 800 to 1,600 fish >200 mm) in the WSR ten years after construction. The most significant civil work completed, from a biological viewpoint, was development of the wetland complex between the tailing dam and the WSR along with construction of Channel #5 in spring 1999 that connected the wetland complex with the WSR. Arctic grayling spawning success in Channel #5 and the wetland complex along the south side of the Fish Creek valley has been documented every year since 1999. Additionally, we now have data indicating use of the wetland complex by fry and juvenile burbot. We also identified another opportunity to enhance aquatic resources through the construction of a second wetland complex located along the north side of the Fish Creek valley that would be separated from the wetland complex on the south by a road (Figure 17).

A self-sustaining Arctic grayling population has been established in the WSR that exceeds our goal of 800 to 1,600 fish >200 mm. Our goal was reached by 1998 when the population was estimated at 5,800 fish >200 mm. Our population estimates for 2002, 2003, and 2004 exceeded 6,000 fish. Successful recruitment of Arctic grayling fry has occurred every year since 1999 in the wetland complex and in both 2004 and 2005 in Last Chance Creek.

Predictions on the burbot population response to the flooding of the WSR were not made. Following construction of the freshwater dam, the burbot population grew rapidly reaching a high of 4,136 fish >200 mm in 1999. From 2000 through 2003, the burbot population decreased reaching a low of 1,103 >200 mm in 2003, but increased in 2004 to an estimated 2,100 fish >200 mm. The estimated number of large burbot (>400 mm) has decreased slowly from 2001 (134) through 2004 (86). Successful spawning of burbot continues to be documented based on catches of fry and juveniles.

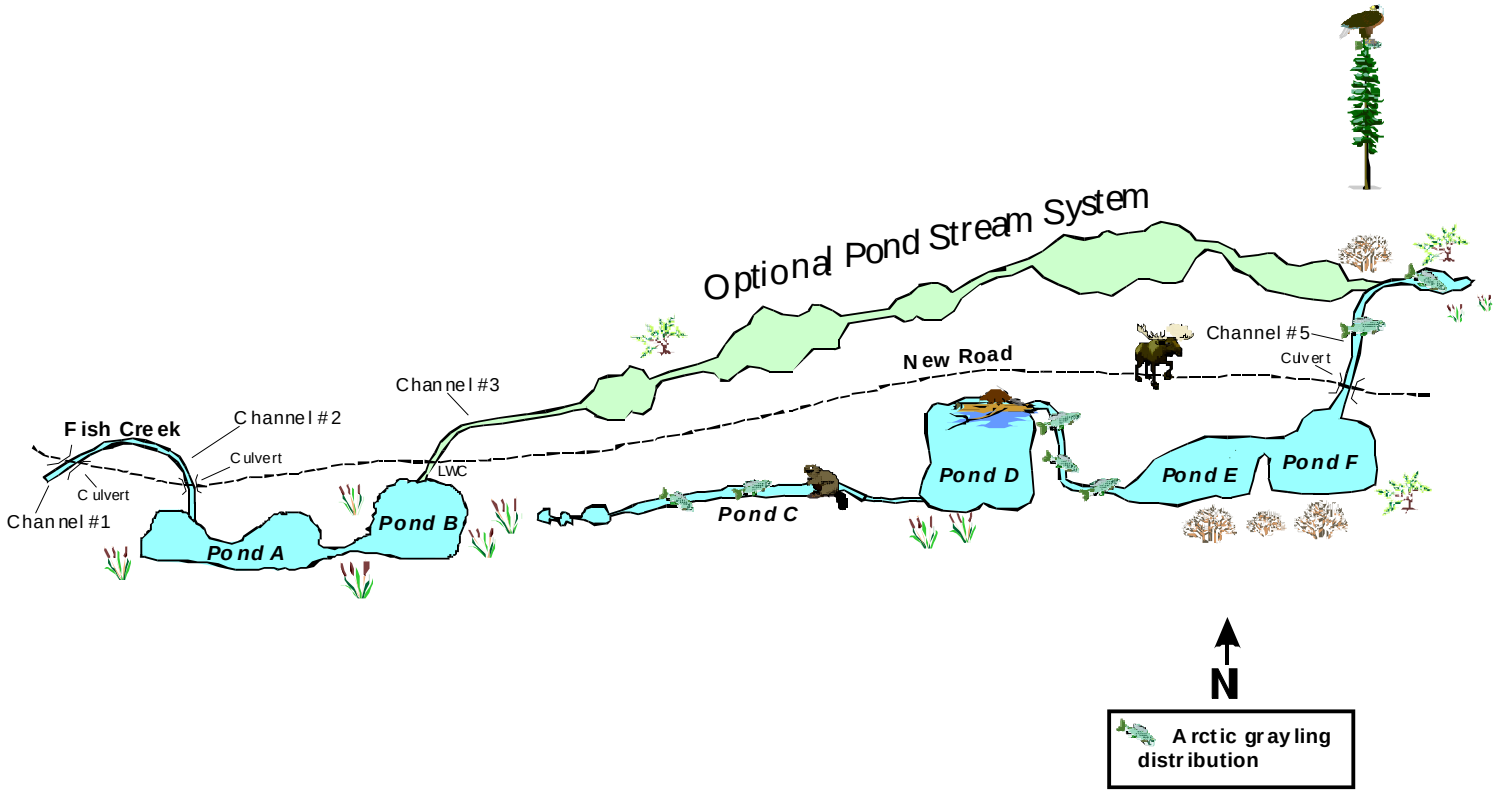

Figure 17. Optional pond/stream complex along north side of Fish Creek valley between tailing dam and WSR.

Water quality data collected in the WSR have shown that flooding of ice-rich permafrost materials has created a condition in which DO concentrations are depressed with depth in both winter and summer. It has been documented that freshwater input, particularly from Solo Creek and to a lesser extent Last Chance Creek, during winter has been essential to maintaining DO concentrations in portions of the WSR that have allowed successful overwintering of both Arctic grayling and burbot.

Wildlife use of the WSR and developed wetlands has increased since construction of the freshwater dam and with concurrent reclamation in the Fish Creek valley downstream of the tailing dam. Wildlife species and uses in the Fish Creek valley were summarized by Ott and Morris (2002b). In 2005, bald eagles (*Haliaeetus leucocephalus*), horned grebes (*Podiceps auritus*), common loons (*Gavia immer*), and osprey (*Pandian haliaetus*) were seen in the WSR area.

Future Plans

We will continue to work cooperatively with FGMI to gather data on fish resources, water quality, and wildlife use in the WSR and developed wetlands. We plan to continue our discussions with FGMI on development of a second wetland complex along the north side of the Fish Creek valley.

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Appendix 1. 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

[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 2004 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 2. Burbot Population Estimates in the WSR

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
1995[1]	150	876	666-1,087
1997[2]	250	622	462-782
1998[2]	300	703	499-907
1998[3]	200	3,609	2,731-4,485
1999[3]	200	4,136	3,215-5,057
2000[3]	200	3,536	2,444-4,629
2001[4]	200	3,391	2,017-4,764
2001	400	134	58-210
2002[4]	200	1,763	1,045-2,480
2002	400	131	62-199
2003[4]	200	1,103	671-1,535
2003	400	102	57-147
2004[5]	200	2,100	1,242-2,957
2004	400	86	44-128

[1]We used fyke nets in the Polar Pond complex to make the 1995 population estimate.
[2]The 1997 and 1998 estimates were made with a capture and recapture event in May of the same year.
[3]The 1998, 1999, and 2000 population estimates were made using a mark event in spring with the recapture event occurring one year later in the spring.
[4]The 2001, 2002, and 2003 population estimates were made with capture and recapture events in the same year.
[5]The 2004 population estimate was made using 2004 as the mark event in spring with the recapture event occurring in spring 2005.