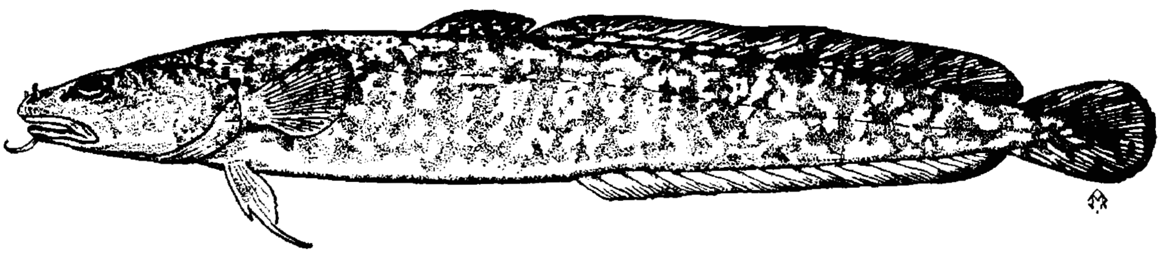
Technical Report No. 00-1

FISH USE OF THE FORT KNOX WATER SUPPLY RESERVOIR AND DEVELOPED WETLANDS

by Alvin G. Ott and William A. Morris



January 2000

Alaska Department of Fish and Game

Habitat and Restoration Division

FISH USE OF THE FORT KNOX WATER SUPPLY RESERVOIR AND DEVELOPED WETLANDS

by

Alvin G. Ott and William A. Morris

Kenton P. Taylor
Director
Habitat and Restoration Division
Alaska Department of Fish and Game

Table of Contents

List of Tables

List of Figures

Acknowledgments

Our thanks to Fairbanks Gold Mining Inc. (Steve Lang, Tom Irwin, Bill Jeffress, and Clyde Gillespie) for their cooperation and support of our project designed to monitor fish resources and water quality in the water supply reservoir and developed wetlands. Ms. Nancy Ihlenfeldt prepared maps and figures for the report and assisted with field data collection activities. Mr. Matt Evenson (Sport Fish Division, Alaska Department of Fish and Game), Mr. Jack Winters (Habitat Division, Alaska Department of Fish and Game) and Mr. Bill Jeffress and Mr. Clyde Gillespie provided constructive review of our report.

Executive Summary

This report summarizes data collected on Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), and water quality in the Fort Knox Gold Mine (FGMI) water supply reservoir (WSR) and developed wetlands in 1999. Arctic grayling and burbot population data from 1995 through 1999 and water quality information from 1997 through 1999 are presented and compared. After flow from three systems (Fish, Last Chance, and Solo creeks) was blocked by a freshwater dam in November 1995, the WSR began to fill. As water levels increased, there was a substantial increase in habitat, and potentially, an increase in invertebrate prey availability for resident populations of Arctic grayling and burbot. Low concentrations of dissolved oxygen were first found in fall 1997, and a water quality monitoring program was initiated.

Populations of Arctic grayling and burbot were assessed prior to flooding of the WSR in 1995. Data collected on Arctic grayling were indicative of a stunted population; fish larger than 220 mm fork length were rare, annual growth was 9 mm, and size at maturity was small (as small as 148 mm for males, and 165 mm for females) (Ott et al. 1995). In 1995, the burbot population consisted of small fish (generally < 300 mm) with most present in two settling ponds. Data gathered pointed to a young burbot population that recently colonized the settling ponds.

Monitoring of Arctic grayling and burbot, post-construction of the freshwater dam, began in summer 1996. Flooding produced a 66.8 ha (165 acre) lake with variable depth and irregular shoreline. After flooding, both the Arctic grayling and burbot populations changed dramatically.

Arctic grayling growth rates doubled for one year, doubled the following year, and then stabilized between about 30-40 mm/yr, nearly quadrupling pre-flood growth rates. However, from 1998 to 1999, annual growth rates decreased to 16 mm/yr. The population has continued to grow older with larger size classes most frequent; recruitment has been virtually non-existent. Length frequency distributions suggest the population of Arctic grayling will decline rapidly unless recruitment occurs. The Arctic grayling population in 1995 was estimated at 1,700 fish < 150 mm, and 4,350 individuals ≥ 150 mm. The Arctic grayling population in the WSR was estimated in 1996 and 1998

at 4,748 and 5,800 $\geq$ 150 mm with virtually no fish <150 mm. Based on 1996 and 1998 population estimates, survival of Arctic grayling has been excellent. Furthermore, construction of Channel #5 in spring 1999 provided Arctic grayling access to three of the developed wetland ponds for potential spawning. Fall 1999 sampling indicated substantial spawning success and excellent growth of young-of-the-year Arctic grayling.

The pre-WSR burbot population was estimated at 825 fish (most were < 300 mm long). In fall 1996 and 1997, young-of-the-year burbot were abundant in fyke-net catches. The burbot population was estimated at 622 fish $\geq$ 250 mm in May 1997 and 703 fish $\geq$ 300 mm in May 1998. During both 1997 and 1998 there were a number of small burbot caught and marked, but a near total absence of marked small burbot during recapture events. However, catch rates for small marked burbot increased in spring 1999 allowing us to estimate the spring 1998 population. We estimated the spring 1998 burbot population at 3,609 which includes all fish > 200 mm. Length frequency distributions for burbot show the most frequently captured size classes were 150 mm and 200 mm, with few large fish in 1998. However, in 1999 the most dominant size class was between 250 and 300 mm - this size class represents the recruitment of burbot to the population since flooding of the WSR. This distribution is indicative of a rapidly increasing population.

The Fort Knox WSR inundated an area containing vast amounts of organic material creating the potential for high biological and chemical oxygen demand. Water quality data collected led to some concern for fish survival within the reservoir. Dissolved oxygen levels measured in fall 1997 were becoming depressed at depth; surface dissolved oxygen also was low (about 6 mg/L). By March 1998, dissolved oxygen concentrations were depressed to nearly 0.0 mg/L in all areas sampled. Subsequent summer 1998 sampling revealed anomalously high levels in an area of the reservoir where pre-impoundment creek channels existed. In late winter 1999, dissolved oxygen still decreased with depth reaching concentrations of < 1 mg/L at the reservoir bottom. However, dissolved oxygen concentrations were generally higher in 1999 in the upper portion of the water column. During summer stratification in 1998 and 1999, the dissolved oxygen concentrations at Site #2 (main reservoir - deep portion near dam) decreased with depth, but again were higher in 1999. Fish survival through winter 1997/1998 appeared unlikely; however, summer 1998 sampling revealed strong populations of both Arctic grayling and burbot, with no evidence of a winter fish kill. Continued healthy populations of both Arctic grayling and burbot were seen in summer,

1999. It is hypothesized that an oxygenated upwelling is present in the middle portion of the reservoir that allowed for the strong fish survival observed over winter.

In summary, water quality - particularly dissolved oxygen concentration - appears to be improving with time. The burbot population is healthy and the length-frequency distribution is indicative of a rapidly increasing population. However, young-of-the-year burbot were not captured in fall of 1998; we did not sample in fall 1999. Recruitment of Arctic grayling has not been documented, but may change due to construction of Channel #5 providing fish access to wetlands for spawning. The larger, adult Arctic grayling population is stable and survival has been excellent.

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. During construction of the WSR we monitored activities in the field and summarized the various aspects of dam construction that included a stream bypass (Ott and Weber Scannell 1996, Ott and Townsend 1997). Construction of the WSR dam and spillway was complete by July 1996. Development of wetlands between the tailing dam and head of the WSR began in summer 1998 and continued in summer 1999.

Projected maximum water surface elevation in the WSR is 1021 feet. Water levels varied widely in 1996 and 1997, due to water use and winter seepage flow below the dam that exceeded freshwater input. The WSR reached the projected maximum water level on September 29, 1998, following substantial summer rainfall. Water levels during summer 1999 were fairly constant and flow through the low-flow channel in the spillway was still present in November 1999. Seepage flow below the dam remains fairly constant at a rate of about 1.16 to 1.82 cfs (geometric mean 1.47 cfs).

Fish research was initiated in 1992 and focused on streams in and downstream of the project area (Weber Scannell and Ott 1993). In 1993, stream sampling continued and we began to collect fish data in abandoned settling ponds and mine cuts that would be flooded by the WSR (Weber Scannell and Ott 1994). In 1994, we established and sampled stream reaches above and below the area to be flooded (Ott et al. 1995).

Stream sampling continued in 1995 and we estimated the size of the Arctic grayling (*Thymallus arcticus*) and burbot (*Lota lota*) populations that would be available to colonize the WSR (Ott and Weber Scannell 1996). The Arctic grayling population in Fish Creek, upstream of the freshwater dam was estimated at 1,700 individuals <150 mm, and 4,350 individuals ≥ 150 mm. The number of burbot (150 to 331 mm) in upper Fish Creek drainage was estimated at 825 fish.

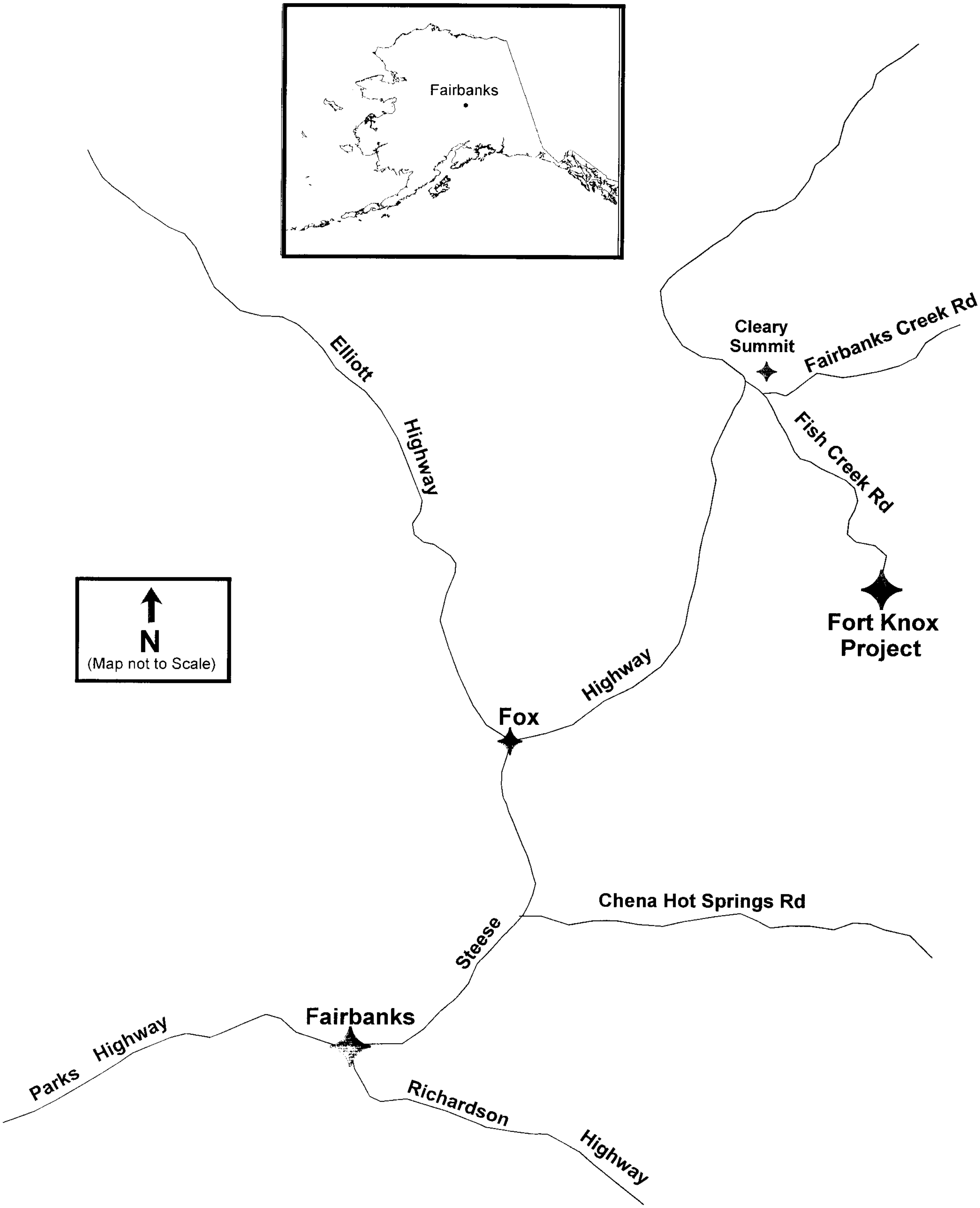


Figure 1. Fort Knox project location.

In 1996, we began to monitor the use of the WSR by Arctic grayling and burbot, gathering information on growth, recruitment of young-of-the-year, and catch per unit of effort (CPUE) (Ott and Weber Scannell 1996). The Arctic grayling population estimate for fish $\geq$150 mm in summer 1996 was 4,748 fish. Few young-of-the-year grayling were captured, however; young-of the-year burbot were abundant (Ott and Townsend 1997). In May 1997, we estimated the burbot population (fish $\geq$ 250 mm) at 622 fish. Young-of-the-year burbot were abundant in fall 1997, but young-of-the-year Arctic grayling were virtually absent (Ott and Weber Scannell 1998). In spring 1998, we conducted a mark/recapture experiment for burbot. Our population estimate in 1998 for burbot $\geq$300 mm was 703 (95% confidence interval 499 to 907) with an unknown number less than 300 mm (Ott and Morris 1999).

We began water quality monitoring in the WSR in September 1997 and found anaerobic conditions in the middle of the WSR (Ott and Weber Scannell 1998). Water quality conditions, specifically dissolved oxygen concentrations, improved in summer 1998 but were still depressed with depth (Ott and Morris 1999). This report summarizes fish and water quality data collected during 1999 and discusses these findings in relation to previous work.

Methods

Sampling Sites

Water quality sampling began in fall 1997 in the WSR and in summer 1999 in the developed wetlands. Fyke-net sampling sites in the WSR were established in 1996, two sites were added in 1998 (#9 and #10), and two new stations were set in the developed wetlands in 1999 (Figures 2 and 3). In summer 1999, fyke-nets were fished at four sites. The general area for each net site is fixed but location varies with water level. Fyke-nets have been fished at the following sites: Fyke-net #1 (Solo Creek Bay), #2 and #6 (Last Chance Bay), #3 (Pump House Bay), #4 (Polar Pond Bay), #5 and #10 (Upper Last Chance Bay), #7 (Fish Creek Bay), #8 (Main Reservoir), #9 (Spillway), #11 (Pond F), and #12 (Pond E) (Figure 3). Hoop traps were fished throughout the WSR east of the new road.

Water Quality

Temperature (°C), dissolved oxygen concentration (mg/L), dissolved oxygen percent saturation (temperature and barometrically corrected), pH, conductivity (u S/cm), and depth (m) were measured with a Hydrolab® Minisonde® water quality multiprobe connected to a Surveyor® 4 water quality display unit. The meter was calibrated to suggested specifications prior to use in the field. The dissolved oxygen 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 one-meter (m) depth intervals, and at the bottom. In the developed wetlands, measurements were made near the shoreline at a depth of about 0.5 m.

Fish

Fish sampling was conducted with passive, active and observational methods in summer 1999. Field sampling methods and gear included visual observations, fyke-nets, and hoop traps (Figure 4). Most of the burbot and Arctic grayling collected during May and June were measured and marked with a numbered floy-tag. Some of the burbot

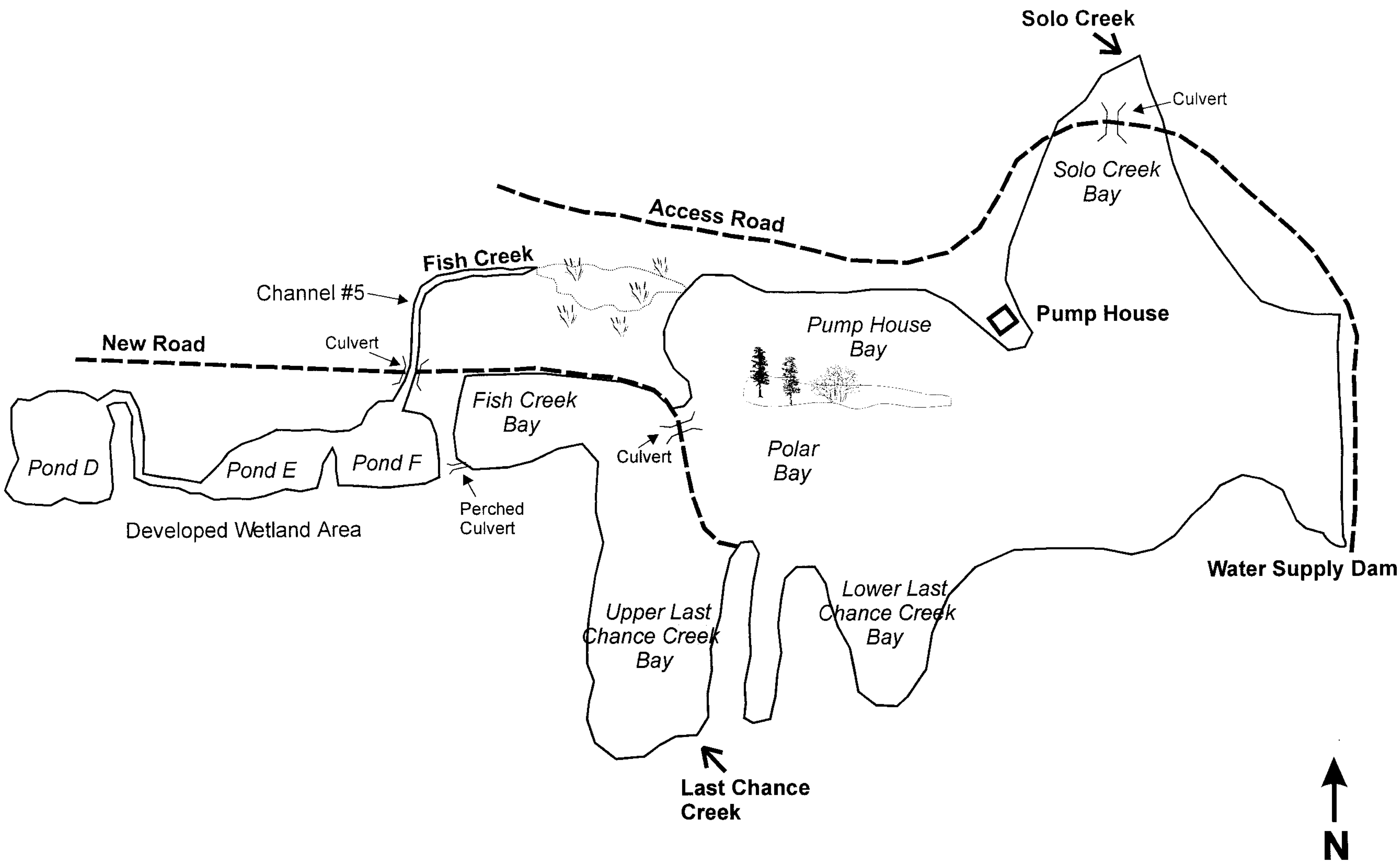


Figure 2. Sample areas in the Fort Knox water supply reservoir and developed wetlands.

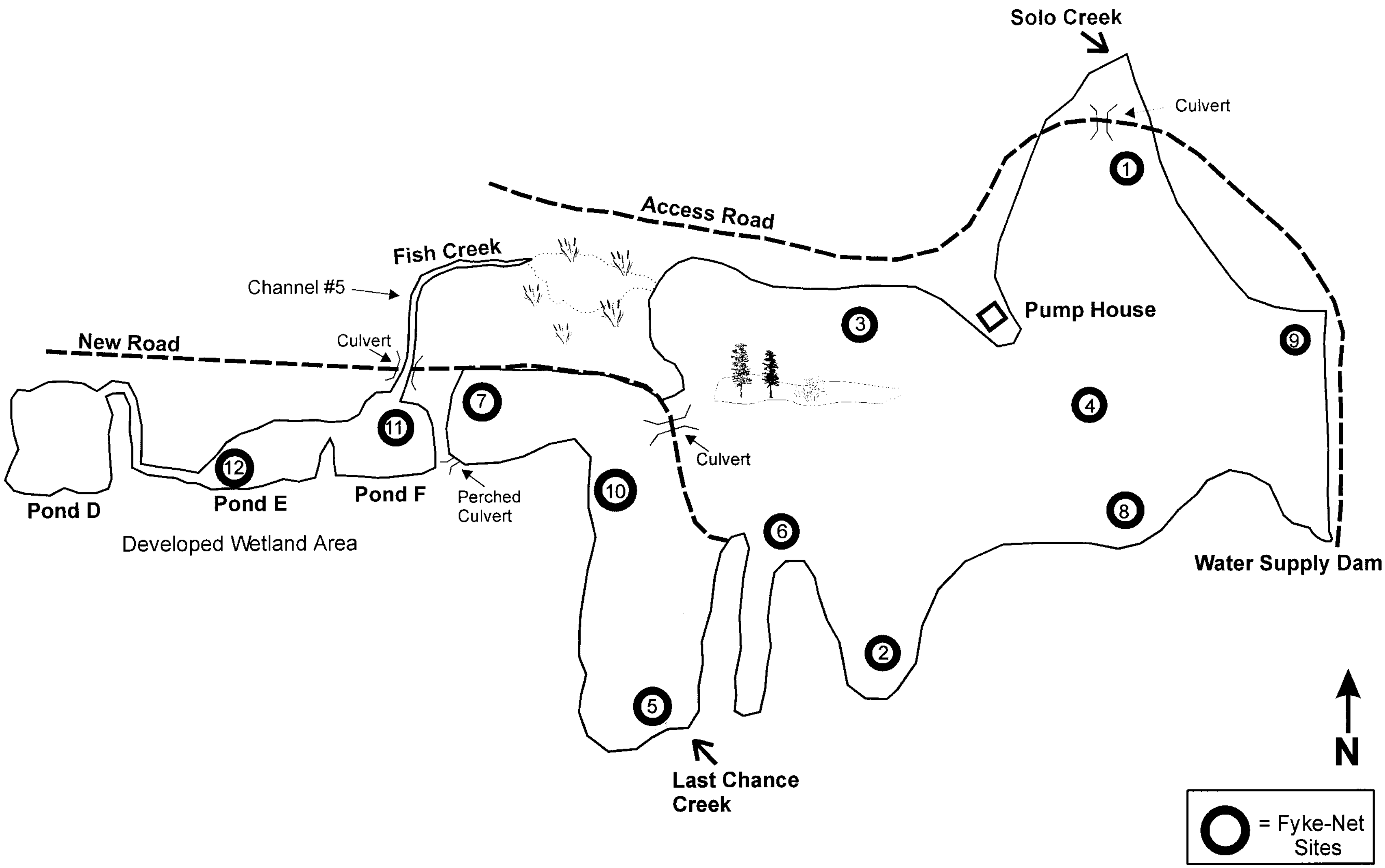
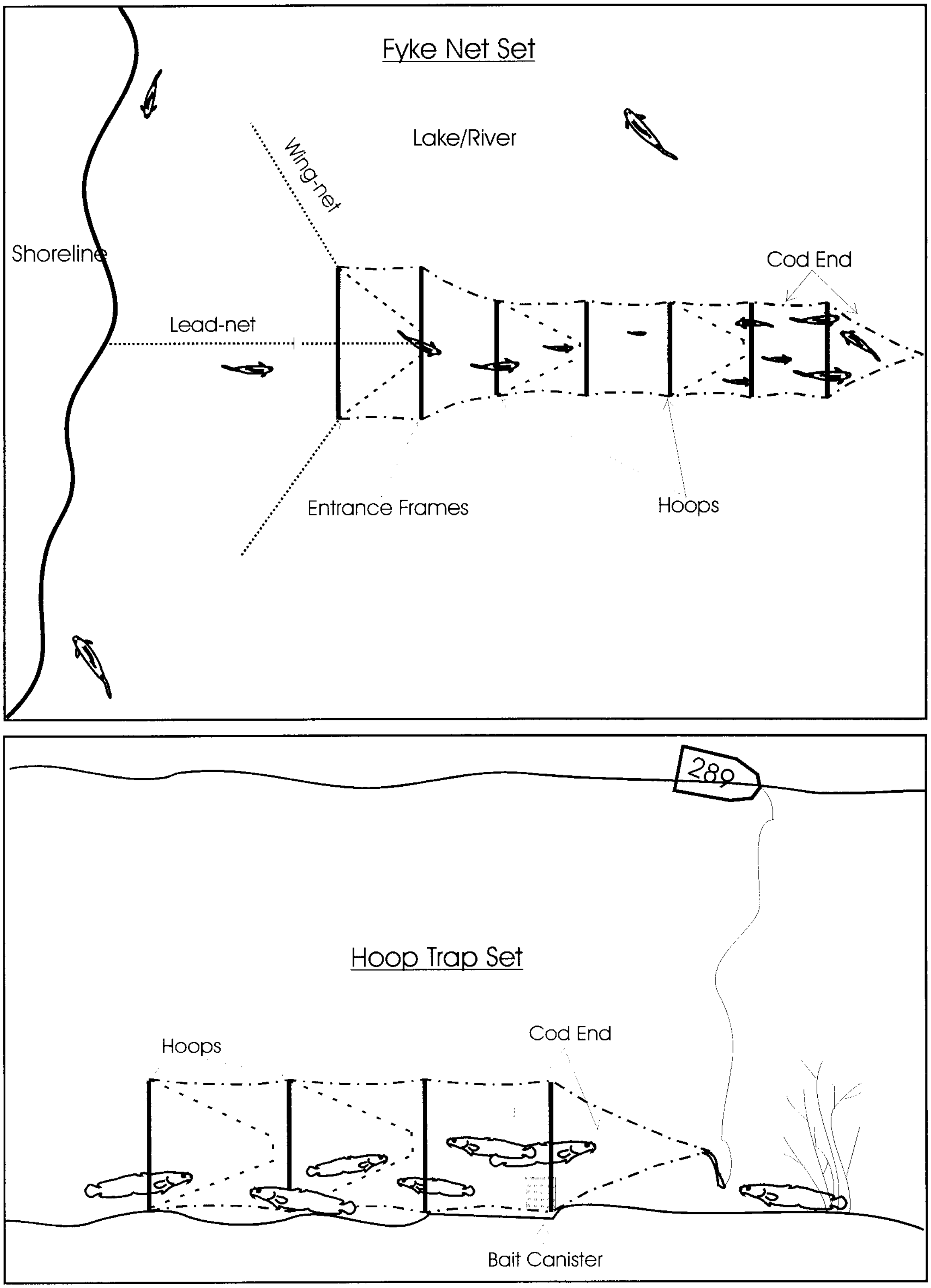


Figure 3. Fyke-net sample sites in the Fort Knox water supply reservoir and developed wetlands (1996-1999).

Figure 4. Fyke-net and hoop trap sets (diagram).



recaptured in 1999 had been marked and injected with oxytetracycline in 1995. Ten of these individuals were retained for age validation studies being conducted by Mr. Matt Evenson (Sport Fish Division, Alaska Department of Fish and Game).

Two sizes of fyke-net were used. General net specifications were the same (wings, mesh, and center leads), however; entrance frame size varied. Entrance frames were either 0.9 m^2 or 1.2 m^2. Fyke-nets were 3.7 m long, had five hoops, a 1.8 m cod end, and 0.9 m by 7.6 m net wings attached to the entrance frame. The center lead was 30.4 m and was deployed to the maximum extent possible without submerging the top of the entrance frame. Nets were set with the center lead either perpendicular to or at an angle to the shore, depending upon distance to deep water. Unbaited fyke-nets were fished 24 hr and either reset or removed (Figure 4).

We used hoop traps baited with salmon roe and fish to collect burbot in the WSR. Traps generally were fished 24 hr and rebaited if reset. Hoop traps were 1.6 m long with four hoops 54 cm in diameter. Netting was 8.5 mm bar mesh. All traps were kept stretched and open with spreader bars. Each trap had one throat and a cod end that was tied shut (Figure 4).

The Arctic grayling and burbot populations were estimated using Chapman's modification of the Lincoln-Petersen model (Chapman 1951),

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

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

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

95% confidence interval for the population estimate was calculated as

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

Results and Discussion

Fort Knox Water Supply Reservoir, Water Quality

Five standardized water quality sample sites (Figure 5) were established and sampled in the WSR beginning in fall 1997 (Ott and Weber Scannell 1998). Data collected at these five sites during all sample events are presented in Appendix 1. In 1999, water quality data were collected at Site #2 in April and at all five sites in June. Decreasing oxygen concentrations with depth were found in September 1997, but by fall 1998, oxygen concentrations had increased and were fairly constant with depth (Figure 6). In late winter 1998 and 1999, dissolved oxygen decreased with depth reaching concentrations of < 1 mg/L (Figure 7). However, dissolved oxygen concentrations were generally higher in 1999 in the upper portion of the water column (Figure 7). During summer stratification in 1998 and 1999, the dissolved oxygen concentrations at Site #2 decreased with depth, but again were higher in 1999 (Figure 8).

By late September 1998, the WSR had filled with water and an estimated 2 to 3 cfs was flowing out of the reservoir through the low-flow channel of the spillway. The outflow of surface water from the WSR was the first reported since the dam was constructed during winter 1995/1996. Water levels in the WSR dropped during winter 1998/1999, but the reservoir was nearly full following spring breakup. Outflow of water through the spillway began again in June 1999 and was intermittent until fall with flow still present in the spillway flow channel in November 1999. Freshwater input to the water supply reservoir in fall 1999 exceeded seepage through the dam. Early snow probably provided insulation to stream flows under ice cover. In the previous three winters, cold temperatures with little snow led to freezeback, aufeis and decreased stream flow.

The Fort Knox WSR inundated an area containing vast amounts of organic material creating the potential for high biological and chemical oxygen demand. Although dissolved oxygen concentrations have increased since 1997, concentrations are still depressed with depth, particularly during late winter. Water quality monitoring in the WSR will continue to document changes in water quality over time.

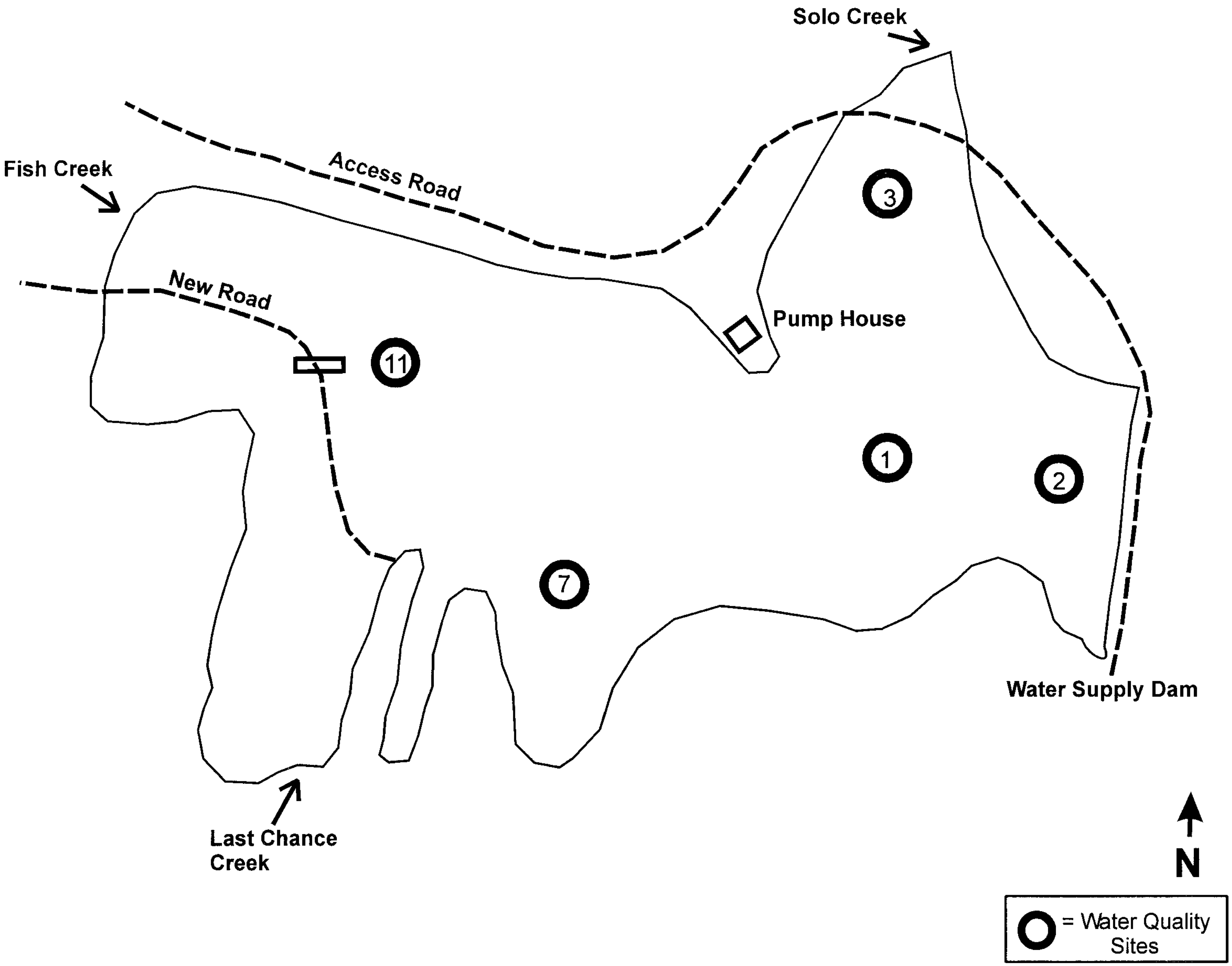
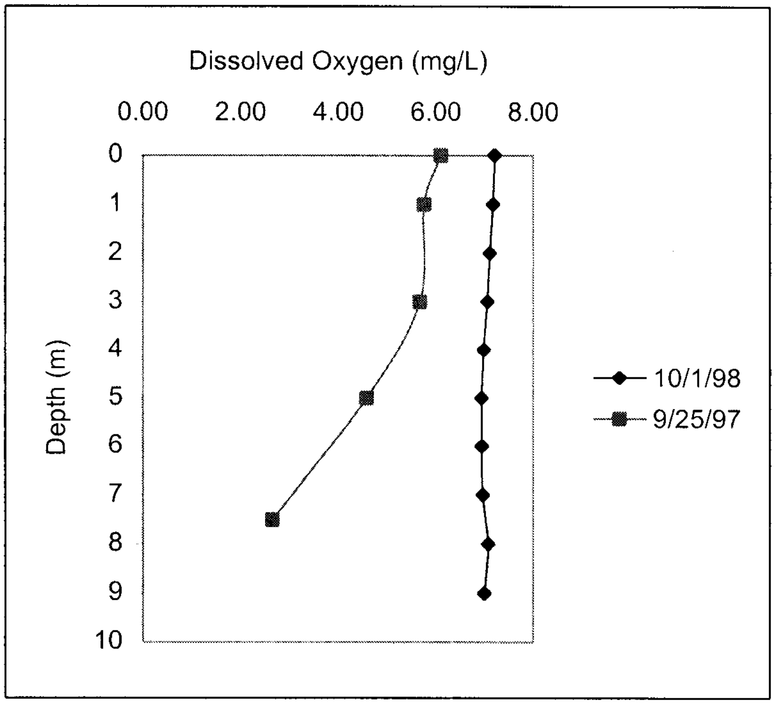


Figure 5. Water quality sample sites in the Fort Knox water supply reservoir.

Figure 6. Dissolved oxygen concentration and temperature at Site #2 by depth in the water supply reservoir in fall 1997 and 1998.



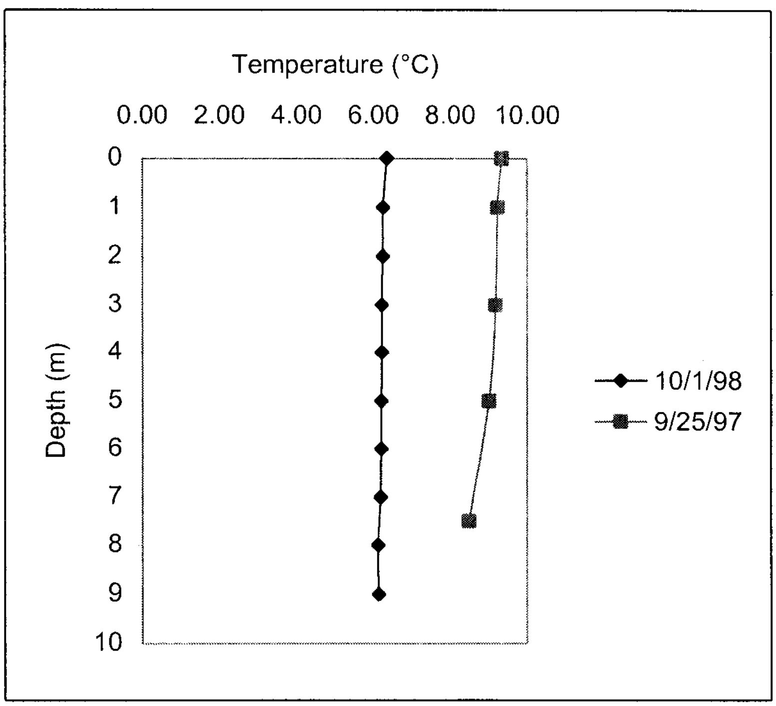
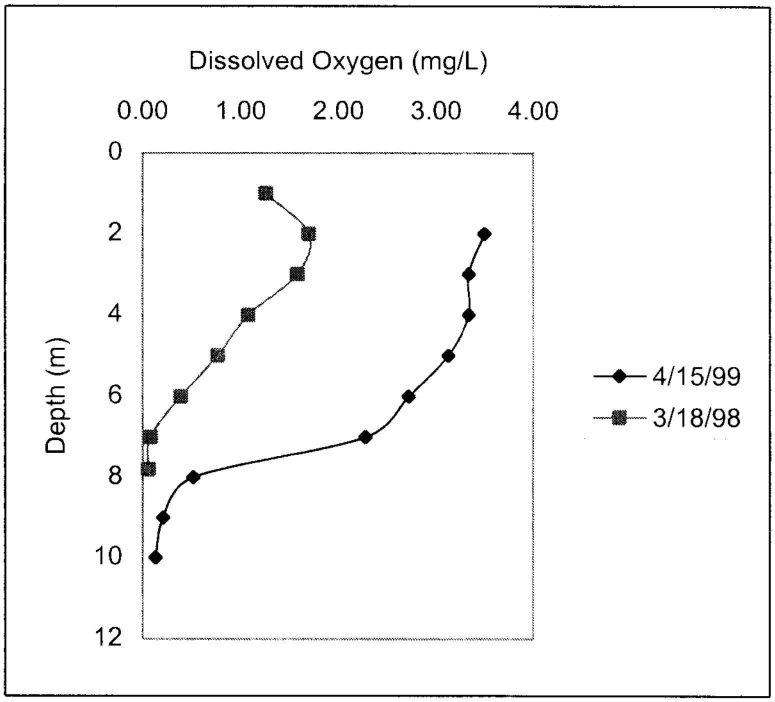


Figure 7. Dissolved oxygen concentration and temperature at Site #2 by depth in the water supply reservoir in late winter 1998 and 1999.



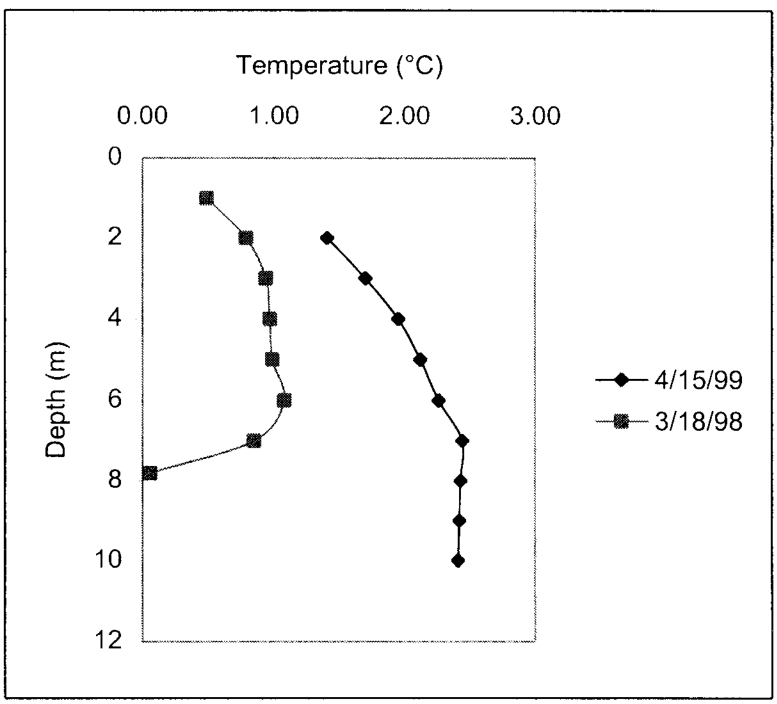
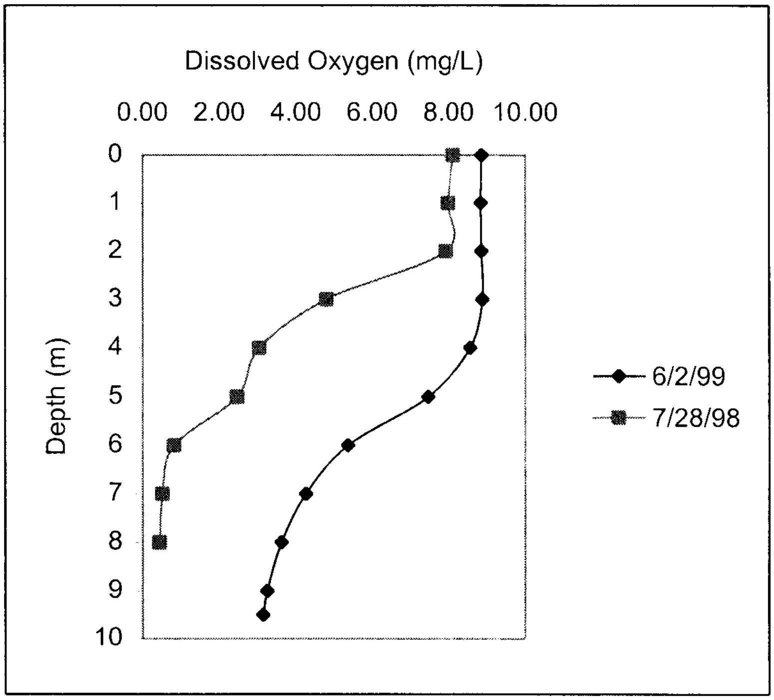
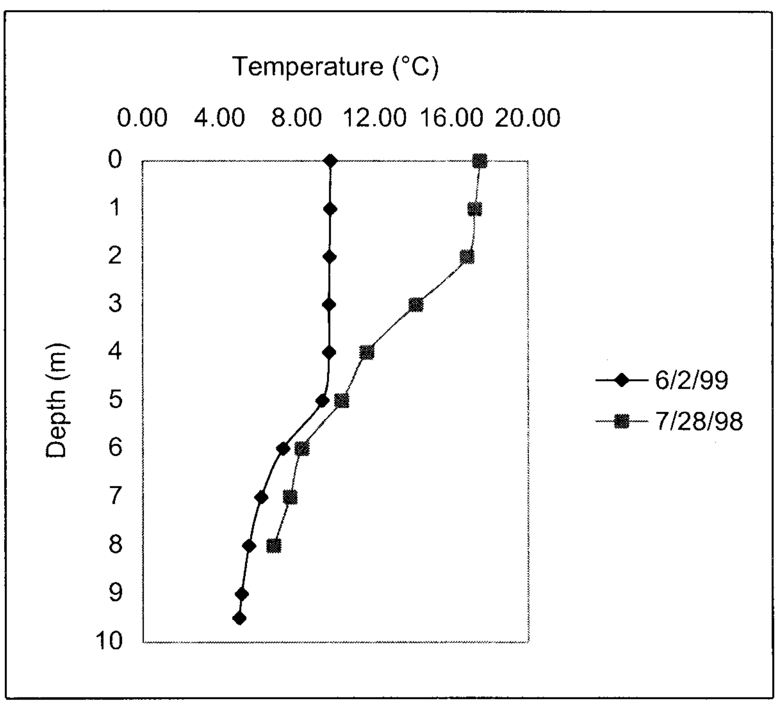


Figure 8. Dissolved oxygen concentration and temperature at Site #2 by depth in the water supply reservoir in summer 1998 and 1999.





Water quality data were collected in the six ponds (Ponds A, B, C, D, E, and F) in the developed wetlands in September 1999 (Figure 9) (Appendix 2). Conductivity ranged from 187.9 to 230.5 *u* S/cm, pH from 7.10 to 8.28, and dissolved oxygen from 5.61 to 9.16 mg/L. During spring breakup 1999, waters entering Pond A had a conductivity of 107.0 *u* S/cm, dissolved oxygen of 13.22 mg/L, and a pH of 6.30 (Figure 10). Conductivity in Pond F in spring 1999 was 217.6 *u* S/cm (Figure 11).

We plan to continue collecting water quality data in the six ponds in summer 2000. The program was initiated in response to water quality (e.g., total dissolved solids) data collected by FGMI that suggested tailing water was potentially bypassing the interceptor wells. FGMI began an active drilling program to assess movement of groundwater below the tailing dam, drilled a new monitoring well, and converted an existing monitoring well to an interceptor well. Based on results from the drilling program, FGMI developed a remedial action plan that included the addition of two new interceptor wells - one of the new interceptor wells is complete and drilling of the second is in progress.

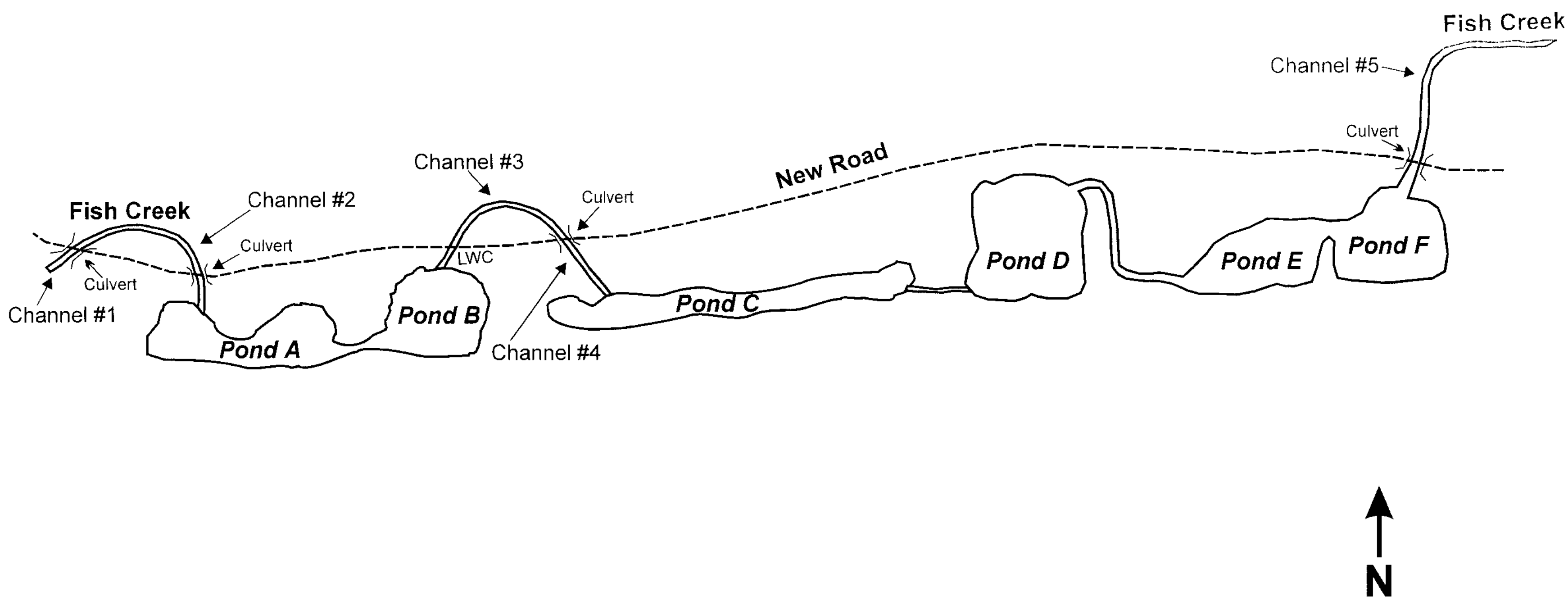


Figure 9. Fort Knox developed wetlands.

Figure 10. Pond A in Fish Creek, immediately below the tailing dam (photograph looking east down the valley).

Figure 11. Pond F in Fish Creek, just upstream of water supply reservoir (photograph looking west up the valley).

Fort Knox Water Supply Reservoir, Arctic Grayling

A perched culvert was installed in May 1996 during construction of the Fort Knox mine at the lower end of the developed wetlands (Pond F) (Figure 3). The perched pipe was placed to prevent fish movement into the developed wetlands during the active mine operation period. However, after construction Arctic grayling were observed upstream of the constructed fish barrier as far as Pond A. Monitoring of Arctic grayling in the WSR has been conducted annually since 1996. Recruitment of young-of-the-year Arctic grayling to the population has not been observed. Lack of recruitment was believed to be due to a lack of available spawning habitat and predation by burbot. Failure of Arctic grayling recruitment was discussed with Fairbanks Gold Mining Inc. and the decision was made to construct a bypass channel (Channel #5) from the lower end of the wetlands (Pond F) to a sedge grass meadow (Figure 3). The objective was to provide Arctic grayling access to the lower end of the developed wetlands for spawning, thus providing an opportunity for young-of-the-year hatching and rearing success.

Channel #5 was constructed in early May 1999. The channel is about 75 m long with a grade of about 0.5%. Water from Channel #5 enters the sedge grass meadow and flows about 330 m to the WSR. In the sedge grass meadow there were several small pools with water flowing through vegetation between the pools. Water depths in some of the vegetated areas were less than 50 mm. The estimated discharge on May 17, 1999, was 2 cfs.

During the week of May 17 to 21, we sampled the newly constructed Channel #5 in the lower end of the developed wetlands, Pond F, Pond E, and Upper Last Chance Creek Bay. Our objective was to document fish use of Channel #5 and Ponds F and E, and to mark with floy-tags 300 Arctic grayling $\geq$200 mm fork length.

Water temperatures in the developed wetlands were highly variable (2.8 to 8.9°C, 37 to 48°F) on May 17. Pond F was still partially ice covered, Pond E was completely ice free, and Upper Last Chance Creek Bay was about 50% ice covered.

Arctic grayling were observed moving through the sedge grass meadow from the WSR and in the channel between Pond D and E on May 17. A fyke-net was set across the upper end of Channel #5 with the cod end in Pond F. The fyke-net was set at 1330 hours and checked at 1500 hours. Ten Arctic grayling were captured, marked, and released upstream of the net. The same net was fished for 24-hours and checked on May 18, 1999. We caught 111 Arctic grayling on May 18. Fish ≥200 mm were marked and released upstream of the net (Table 1). The net was reset and on May 19, we caught 28 Arctic grayling (Table 1). We conducted a visual survey of Channel #5 and the sedge grass meadow complex and did not observe any fish on May 19. However, there were Arctic grayling immediately upstream of the fyke-net opening along the two leads. We pulled the net from Channel #5 and set another fyke-net blocking both upstream and downstream-moving fish in Pond E. We came back to Channel #5 about one hour after pulling the net and Arctic grayling were spread along the 75 m of newly constructed channel. Apparently the fish were trying to move downstream from the pond to the channel to spawn and were blocked by the net.

On May 19 we observed in Channel #5, Arctic grayling males holding in selected areas and defending these against other males. Active spawning was observed throughout Channel #5. After the act of spawning, females would drop down in the channel to the next resting area, and then would return to where the male(s) were holding. In some areas of the channel, water depth and slight turbidity reduced visibility, but we estimated over 50 Arctic grayling were using the channel on May 19, 1999. On May 20, 1999, the water temperature in Channel #5 was 6.7°C (44.1° F). Water temperature in the Upper Last Chance Bay was 6.1°C (43° F).

The total catch of Arctic grayling in Fyke Net 10 (set in Upper Last Chance Bay for 24 hours) on May 20, 1999, was 953 (Table 1) (Figures 12 and 13). On May 20, 1998, the fyke-net set in Upper Last Chance Bay captured 965 Arctic grayling (Table 1). Our highest catches in 1997 occurred on May 21 in two fyke-nets fished along the shoreline of the main reservoir. These high catches all occurred during early spring as adult Arctic grayling actively moved along the shoreline to find suitable spawning habitat. The number of juvenile Arctic grayling <150 mm remains extremely small in relationship to the larger fish (Table 1). In May 1999, we marked 497 Arctic grayling with floy-tags.

Length frequency distribution for Arctic grayling collected during spring 1995, 1996, 1998, and 1999 is presented in Figure 14. A few small Arctic grayling were seen, but the population was still dominated by large, older fish. We recaptured 73 marked Arctic grayling in spring 1999 that were handled during spring 1998. Average growth for these fish was 16 mm (Figure 15). Annual growth of Arctic grayling in the WSR since 1996, even though the average size of fish is increasing and few small fish have been

Table 1. Catch of Arctic grayling in fyke nets fished in the Fort Knox water supply reservoir and developed wetlands.

Sample Date	Number of Nets	Number of Grayling (<150 mm)	Number of Grayling (>150 mm)	CPUE (AG/trap/day)
6/26/96	2	6	57	31.5
6/27/96	2	6	85	45.5
6/28/96	2	9	104	56.5
8/6/96	4	17	201	54.5
8/7/96	5	17	123	28.0
8/8/96	5	6	140	29.2
8/27/96	5	16	150	33.2
8/28/96	5	18	109	25.4
8/29/96	5	11	145	31.2
8/30/96	5	9	110	23.8
5/21/97[1]	2			320.0
8/26/97	5	6	19	5.0
8/27/97	5	7	49	11.2
9/7/97	5	8	37	9.0
5/19/98	2	0	29	14.5
5/20/98	3	1	1002[2]	334.0
5/27/98	2	0	3	1.5
5/28/98	3	0	30	15.0
5/29/98	3	2	72	24.7
5/18/99	1	2	109	111.0
5/19/99	1	2	26	28.0
5/20/99	2	0	1135[3]	567.5
9/1/99	1	36	1[4]	37.0

[1]Arctic grayling were counted and released - measurements were not made due to the large number of fish. We did estimate that less than 10 of the 640 were small (i.e. <150 mm).

[2]One fyke-net fished in the flooded Upper Last Chance Creek pond caught 965 Arctic grayling.

[3]One fyke-net fished in the flooded Upper Last Chance Bay caught 953 Arctic grayling.

[4]The fyke-net fished in Pond E caught young-of-the-year Arctic grayling.

Figure 12. Fyke-net #10 in Upper Last Chance Bay where 953 Arctic grayling were caught in a 24-hour set.

Figure 13. Two adult Arctic grayling - male with large dorsal fin and ripe female - both fish are about 320 mm long.

Figure 14. Length-frequency distribution of Arctic grayling caught in the water supply reservoir (1995, 1996, 1998, and 1999).

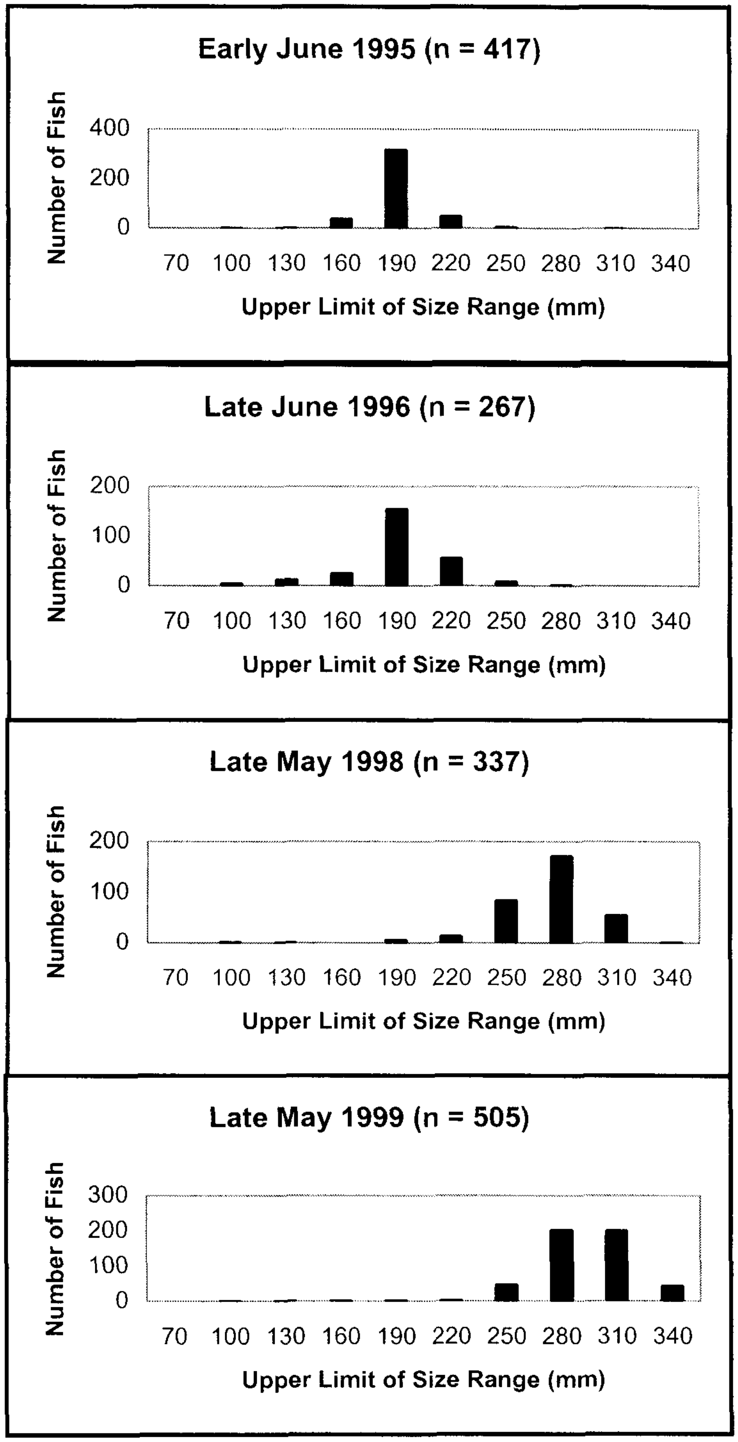
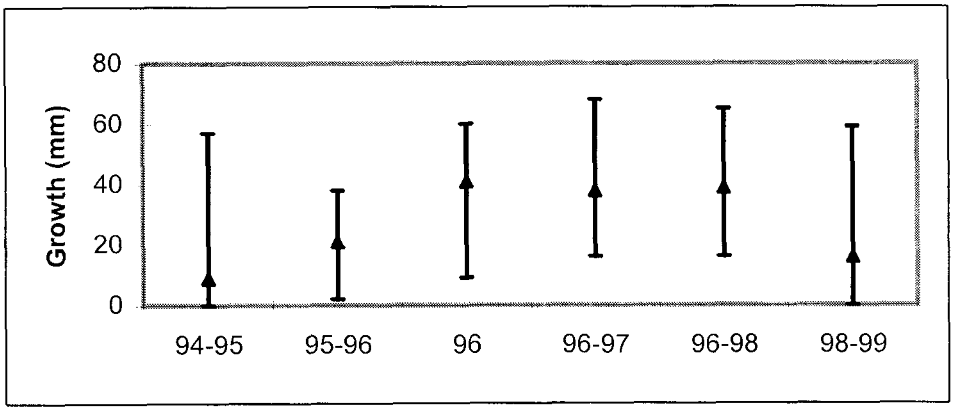


Figure 15. The minimum, maximum, and average annual growth of Arctic grayling in upper Fish Creek and the Fort Knox water supply reservoir from 1994 to 1999.

Year	Average	Maximum	Minimum	Number of Fish
94-95	9	57	0	208
95-96	21	38	2	30
96	41	60	9	42
96-97	38	68	16	7
96-98	39	65	16	121
98-99	16	59	0	73



observed, remained fairly constant for the first three years. Prior to construction of the freshwater dam, average annual growth for Arctic grayling collected in the Last Chance Creek pond complex was 9 mm. Average growth for fish in summer 1996 was 41 mm and from 1996 through 1998 the average growth was 39 mm. Average annual growth decreased to 16 mm for the spring 1998 to spring 1999 period. Decreased growth rates are to be expected as the population grows older, and most individuals reach sexual maturity and spend most of their energy reserves on reproduction rather than growth.

We estimated the Arctic grayling population in the WSR using spring 1998 as the mark event (n_1 = 355) and spring 1999 as the recapture event. In spring 1999, we caught 1,270 Arctic grayling (n_2 = 1,270) with 77 recaptures (m_2 = 77). Our spring 1998 estimated Arctic grayling population for fish > 200 mm was 5,800 (95% CI 4,705 - 6,895).

We set a fyke-net in Pond E on August 31, 1999, in the constructed wetland complex with the objective of determining whether Arctic grayling spawning was successful and young-of-the-year were present. We observed Arctic grayling fry in Ponds D, E, and F. Numerous young-of-the-year Arctic grayling were feeding on the surface on September 1, 1999. In the fyke-net, which fished about 24 hours, we caught 19 burbot and 37 Arctic grayling. All of the Arctic grayling caught in Pond E, except one 155 mm long fish, were judged to be young-of-the-year fish ranging in size from 76 to 97 mm (n = 21, average length = 91 mm, SD = 5.4). All burbot handled had full stomachs - one regurgitating a 102 mm Arctic grayling. The burbot ranged in size from 246 to 390 mm (n = 19, average length 301 mm, SD = 34.8).

We also observed a number of young-of-the-year Arctic grayling feeding on the surface in Solo Creek Bay. We conclude that Arctic grayling spawned successfully in the newly constructed channel from Pond F to the WSR and that young-of-the-year growth was excellent in the pond type habitats. We plan to continue monitoring the Arctic grayling population in 2000 to determine if the young-of-the-year fish produced in spring 1999 successfully recruit to the population. Recruitment of substantial numbers of Arctic grayling <150 mm has not been documented since the water supply dam was completed in winter 1995/1996.

Many of the Arctic grayling caught in spring 1999 had been marked during previous sample events in the area of the WSR, including fish tagged prior to construction of the freshwater dam. A summary of marks put out each year and the number of recaptures in May 1998 and 1999 is presented in Table 2.

Table 2. Number of Arctic grayling marked by year and the number of recaptures seen during the May 1998 and 1999 sample events. Arctic grayling > 200 mm handled in May 1998 and May 1999 were 1,140 and 1,275, respectively.

Year (Tag Color)	Number of Fish Tagged	Number of Recaptures May 1998	Number of Recaptures May 1999
93 (yellow)	413	4	4
94 (white)	800	5	8
95 (orange)	1315	39	14
96 (blue)	591	123	102
98 (orange)	181		34
99 (yellow)	497		

Fort Knox Water Supply Reservoir, Burbot

Use of the Lower Last Chance Creek Pond and Polar Ponds #1 and #2 by burbot was reported by Ott and Weber Scannell (1996). In May 1995, we conducted a mark/recapture experiment and estimated abundance of burbot (150 to 331 mm) to be 825 fish (Ott and Weber Scannell 1996). Flooding of the WSR began in November 1995, isolating burbot upstream of the dam.

Burbot estimates in the WSR for 1995, 1997, and 1998 were 825, 622, and 703 fish, respectively. The 1995 estimate included burbot >150 mm, the 1997 and 1998 estimates were for burbot ≥250 and ≥300 mm, respectively. Assuming the population sampled is the same group of fish, survival of these fish has been extremely high since the original population estimate was made in 1995.

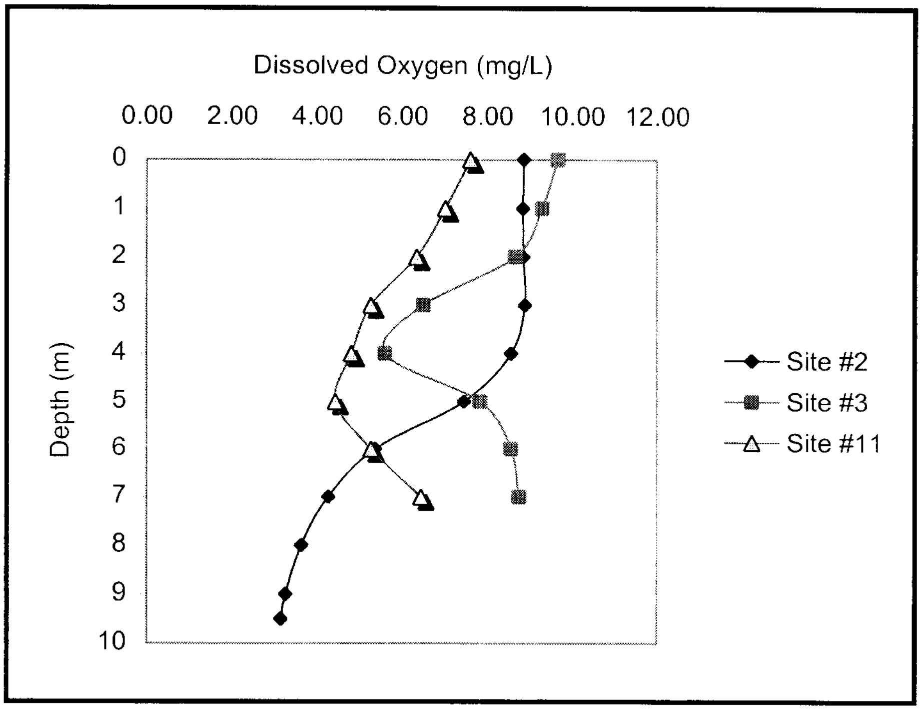
We fished baited hoop traps in the WSR from June 2 to 8, 1999 to capture and mark burbot. Seventeen hoop traps were placed throughout the WSR below the Gil Extension road crossing. Traps with low catches of burbot were moved throughout the sample event to new areas. Most of the burbot were caught in Solo, Pump House, Lower Last Chance, and Polar Bays and along the east side of the WSR (Figures 16 and 17). High catches of burbot occurred in those areas (Solo Creek and Polar Bays) of the WSR having the highest dissolved oxygen concentrations at the bottom (Figure 18). Higher dissolved oxygen concentrations in the two bays probably are from freshwater input from Solo, Last Chance, and Fish Creeks.

We also estimated the burbot population in the WSR using spring 1998 as a mark event (n_1 = 305) and spring 1999 as the recapture event. In spring 1999, we caught 577 burbot with 48 recaptures. Our spring 1998 estimate of abundance for burbot > 200 mm was 3,609 (95% CI 2,731 - 4,485). We checked the abundance estimate by calculating the proportion of our sample > 325 mm in 1999 and multiplying that by the total estimate. The number of burbot > 325 mm was similar to that estimated in 1998. The substantial increase in burbot numbers is due to recruitment of burbot less than 300 mm into the population.

Figure 16. Water supply reservoir with pump house (middle of photograph) and Solo Bay to the right and Pump House Bay to the left.

Figure 17. Two burbot caught in water supply reservoir using hoop traps.

Figure 18. Dissolved oxygen concentrations at Sites #2 (main reservoir), #3 (Solo Creek Bay), and #11 (Polar Bay) by depth in the water supply reservoir in spring 1999.



The total catch of burbot for the June 1999 sample event was 626. We marked 495 burbot with floy-tags. Catch per unit of effort for hoop traps fished in the WSR has been collected each year since 1996 (Table 3). Generally, catch rates have increased each year due to recruitment of small burbot. Catch rates in spring 1999 were similar to those in spring 1998. The catch was dominated by fish between 250 and 300 mm. Length frequency for burbot collected from May 1995 to May 1999 is shown in Figure 19. An estimate for the 1999 spring burbot population will be made based on the spring 2000 sample event.

Forty-three burbot caught in May 1998 were recaptured in June 1999. Burbot ranging in length from 300 to 400 mm when tagged exhibited slow growth (<11 mm) and many were in poor condition (Table 4). Fish greater than 400 mm when tagged showed higher growth rates (28 to 45 mm). General observations made during spring 1999 suggested small burbot (< 300 mm) and larger burbot (>400 mm) were in better condition. Similar findings were made during the spring 1998 sample event. We hypothesize that intermediate size burbot may be in poorer condition as a result from switching between prey types (invertebrate to fish).

Table 3. Catch of burbot in the water supply reservoir in 1996, 1997, 1998, and 1999 using hoop nets.

Sample Date	Gear Type	Number of Traps	Catch (Total)	Mean CPUE[1] (BB/trap/day)
May 22, 96	small hoop	11	36	3.3
May 22, 96	large hoop	4	6	1.5
May 23, 96	small hoop	11	19	1.7
May 23, 96	large hoop	4	2	0.5
May 20, 97	small hoop	11	58	5.3
May 20, 97	large hoop	13	24	1.8
May 21, 97	small hoop	11	61	5.5
May 21, 97	large hoop	17	56	3.3
May 28, 97	small hoop	11	45	4.1
May 28, 97	large hoop	19	42	2.2
May 29, 97	small hoop	11	32	2.9
May 29, 97	large hoop	20	39	2.0
May 20, 98	small hoop	7	87	12.4
May 21, 98	small hoop	9	61	6.8
May 21, 98	large hoop	3	20	6.7
May 22, 98	small hoop	9	57	6.3
May 27, 98	small hoop	9	61	6.8
May 28, 98	small hoop	9	67	7.4
May 29, 98	small hoop	9	44	4.9
June 3, 99	small hoop	17	135	7.9
June 4, 99	small hoop	17	124	7.3
June 5, 99	small hoop	17	136	8.0
June 7, 99	small hoop	17	142	4.2
June 8, 99	small hoop	17	89	5.2

[1]CPUE = catch per unit of effort

Figure 19. Length-frequency distribution of burbot caught in the water supply reservoir (1995-1999).

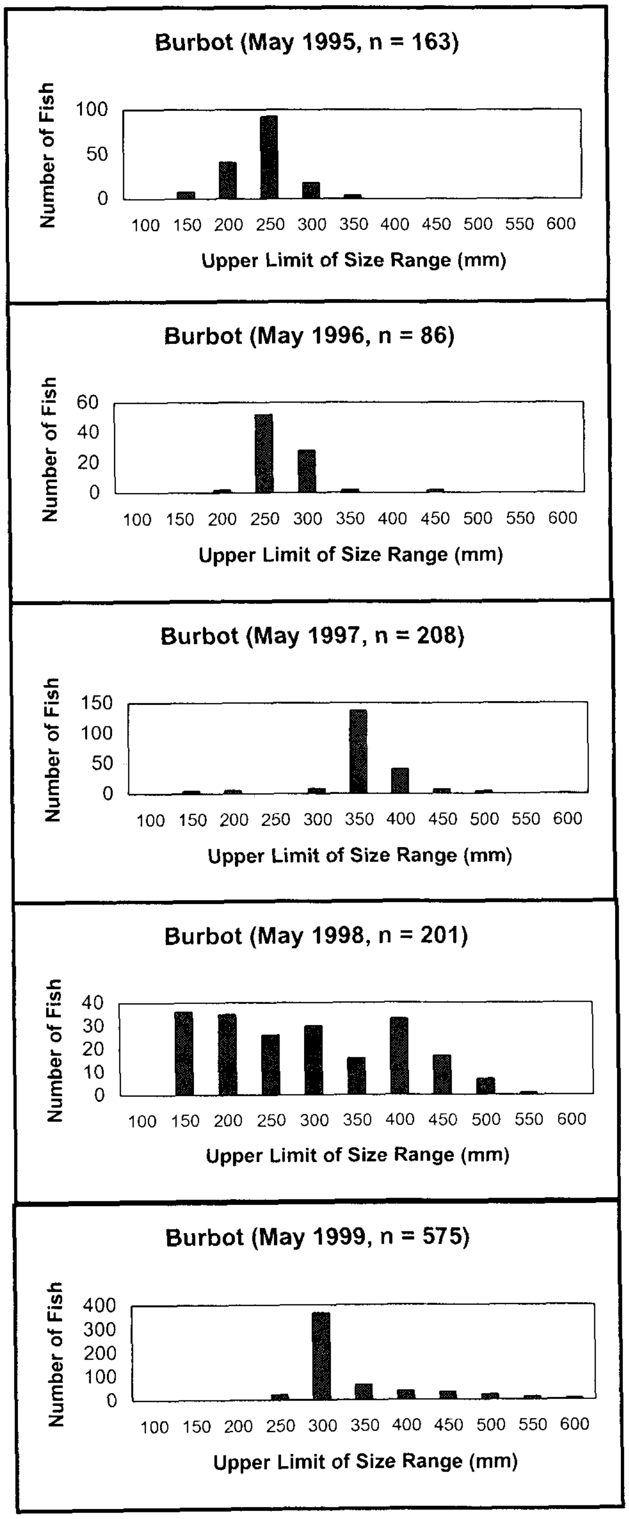


Table 4. Growth of burbot tagged in May 1998 and recaptured in June 1999 using hoop traps.

Length at Mark (mm)	Sample Size	Average Growth (mm)	Standard Deviation
225-249	2	32	-
250-274	0	-	-
275-299	0	-	-
300-324	0	-	-
325-349	3	8	1.7
350-374	6	11	6.2
375-399	11	11	9.3
400-424	5	29	14.2
425-449	5	34	24.5
450-474	4	45	25.0
475-499	2	41	-
500-524	0	-	-
525-549	1	33	-
550-574	3	41	4.6
575-599	1	28	-

Literature Cited

Chapman, D.G. 1951. Some practices of the hypergeometric distribution with applications to zoological censuses. University of California Publications in Statistics 1:131-60.

Ott, A.G. and W.A. Morris. 1999. Fish use of the Fort Knox water supply reservoir 1995-1998. Alaska Department of Fish and Game Tech. Rept. 99-2. Habitat and Restoration Division. Juneau. 28 pp.

Ott, A.G. and P. Weber Scannell. 1998. Fisheries use and water quality in the Fort Knox mine water supply reservoir. Alaska Department of Fish and Game Tech. Rept. 98-1. Habitat and Restoration Division. Juneau. 39 pp.

Ott, A.G. and A.H. Townsend. 1997. Fisheries use of the Fort Knox water supply reservoir 1996. Alaska Department of Fish and Game Tech. Rept. 97-2. Habitat and Restoration Division. Juneau. 69 pp.

Ott, A.G., P. Weber Scannell, and A.H. Townsend. 1995. Aquatic habitat and fisheries studies upper Fish Creek, 1992-1995. Alaska Department of Fish and Game Tech. Rept. 95-4. Habitat and Restoration Division. Juneau. 61 pp.

Ott, A.G. and P. Weber Scannell. 1996. Baseline fish and aquatic habitat data for Fort Knox mine 1992 to 1995. Alaska Department of Fish and Game Tech. Rept. 96-5. Habitat and Restoration Division. Juneau. 165 pp.

Seber, G.A.F. 1982. The estimation of animal abundance. Charles Griffin & Company LTD.

Weber Scannell, P. and A.G. Ott. 1994. Aquatic habitat of Fish Creek before development of the Fort Knox gold mine 1992-1993. Alaska Department of Fish and Game Tech. Rept. 94-5. Habitat and Restoration Division. Juneau. 79 pp.

Weber Scannell, P. and A.G. Ott. 1993. Aquatic habitat study, upper Fish Creek drainage, with an emphasis on Arctic grayling (*Thymallus arcticus*): baseline studies 1992. Alaska Department of Fish and Game Tech. Rept. 93-4. Habitat and Restoration Division. Juneau. 76 pp.

Appendix 1 - Water Quality: Water Supply Reservoir

Site Number	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (*u* S/cm)	pH
2	6/2/99	0	9.74	81.0	8.86	134.2	7.47
		1	9.72	80.5	8.84	134.4	7.44
		2	9.70	80.6	8.85	134.9	7.44
		3	9.66	80.9	8.88	134.8	7.43
		4	9.66	77.9	8.56	135.1	7.40
		5	9.31	67.7	7.45	133.9	7.16
		6	7.26	46.0	5.36	133.7	7.04
		7	6.13	36.0	4.26	135.0	6.97
		8	5.50	29.9	3.62	136.0	6.90
		9	5.11	26.5	3.25	137.1	6.84
		9.5 (bottom)	4.98	25.4	3.14	137.6	6.81
2	4/15/99	2	1.41	25.4	3.50	161.4	6.13
		3	1.70	24.5	3.34	160.8	6.30
		4	1.95	24.7	3.34	159.8	6.22
		5	2.12	23.3	3.13	159.8	6.23
		6	2.26	20.3	2.72	160.1	6.19
		7	2.44	17.1	2.28	160.8	6.16
		8	2.43	3.9	0.52	166.1	6.16
		9	2.42	1.7	0.21	180.6	6.17
		10	2.41	1.0	0.13	244.9	6.24
2	10/1/98	surface	6.35	60.6	7.21	144.3	7.62
		1	6.25	60.1	7.18	144.8	7.58
		2	6.24	59.7	7.11	144.3	7.57
		3	6.22	59.0	7.06	144.5	7.56
		4	6.22	58.4	6.99	144.7	7.56
		5	6.20	58.0	6.94	144.4	7.56
		6	6.20	58.0	6.95	144.4	7.57
		7	6.18	58.0	6.97	144.4	7.56
		8	6.12	59.0	7.08	144.6	7.58
		9 (bottom)	6.13	58.7	7.00	144.7	7.60

N/T = not tested

Appendix 1 (continued).

Site Number	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (u S/cm)	pH
2	7/28/98	surface	17.52	87.1	8.11	161.6	7.41
		1	17.25	85.1	7.98	162.1	7.44
		2	16.86	83.3	7.92	161.2	7.46
		3	14.17	48.0	4.80	156.9	6.98
		4	11.63	28.7	3.04	142.3	6.78
		5	10.31	22.8	2.46	138.4	6.70
		6	8.26	7.3	0.82	155.2	6.65
		7	7.62	4.4	0.52	159.8	6.64
		8 (bottom)	6.78	3.7	0.44	169.1	6.63
2	3/18/98	1	0.49	N/T	1.26	176.0	7.01
		2	0.79	N/T	1.70	175.0	6.93
		3	0.94	N/T	1.58	176.0	6.85
		4	0.97	N/T	1.08	178.0	6.81
		5	0.99	N/T	0.77	182.0	6.77
		6	1.08	N/T	0.39	184.0	6.75
		7	0.85	N/T	0.08	214.0	6.60
		7.8 (bottom)	0.06	N/T	0.06	281.0	6.53
2	9/25/97	surface	9.34	N/T	6.10	143.0	7.23
		1	9.23	N/T	5.76	145.0	7.10
		3	9.18	N/T	5.67	147.0	7.05
		5	9.01	N/T	4.58	147.0	6.95
		7.5 (bottom)	8.49	N/T	2.65	145.0	6.92

Appendix 1 (continued).

Site Number	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (*u* S/cm)	pH
1	6/2/99	0	9.49	82.9	9.13	134.7	7.29
		1	9.50	81.4	8.99	134.9	7.27
		2	9.52	81.1	8.95	134.5	7.29
		3	9.48	80.7	8.92	134.7	7.30
		4	9.29	77.1	8.54	135.5	7.24
		5	7.47	54.5	6.26	133.4	7.07
		6	6.36	42.3	5.05	134.9	6.99
		7	5.81	36.3	4.39	135.6	6.93
		8	5.14	29.8	3.67	137.3	6.91
		9	4.98	28.2	3.48	137.5	6.90
		10	4.86	26.5	3.24	137.8	6.89
		11	4.79	25.5	3.16	138.4	6.88
		12 (bottom)	4.75	24.9	3.09	138.3	6.86
1	10/1/98	surface	6.27	62.7	7.49	145.1	7.60
		1	6.24	62.6	7.49	145.0	7.57
		2	6.21	62.4	7.47	144.6	7.58
		3	6.20	62.3	7.45	144.5	7.58
		4	6.14	62.9	7.54	144.8	7.60
		5	6.03	64.1	7.70	144.8	7.62
		6	5.87	64.3	7.75	144.3	7.61
		7	5.84	64.3	7.74	144.4	7.61
		8 (bottom)	5.82	64.5	7.79	144.0	7.59
1	7/28/98	surface	17.33	84.2	7.85	161.9	7.56
		1	16.83	81.2	7.67	162.0	7.54
		2	16.66	80.5	7.65	162.2	7.55
		3	14.30	45.7	4.55	157.5	7.08
		4	11.78	25.7	2.72	141.4	6.84
		5	9.93	50.7	5.51	118.6	6.97
		6 (bottom)	9.25	33.3	3.71	127.6	6.90

Appendix 1 (continued).

Site Number	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (*u* S/cm)	pH
1	7/28/98	surface	17.21	83.6	7.84	159.6	7.64
		1	17.14	82.9	7.80	159.8	7.63
		2	16.81	82.3	7.78	160.3	7.63
		3	14.49	46.9	4.64	157.6	7.13
		4	7.92	27.1	3.51	165.0	6.87
		5	6.68	64.7	7.63	115.2	7.03
		6	3.48	9.6	1.14	170.0	6.75
		7 (bottom)	5.23	1.0	0.12	173.0	6.81
1	3/18/98	1	0.50	N/T	1.27	176.0	6.96
		2	0.79	N/T	1.89	178.0	6.89
		3	0.89	N/T	1.71	179.0	6.87
		4	0.96	N/T	2.10	182.0	6.84
		5 (bottom)	0.96	N/T	0.47	186.0	6.75

Appendix 1 (continued).

Site Number	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (u S/cm)	pH
3	6/2/99	0	9.67	88.4	9.67	135.1	7.32
		1	9.60	84.4	9.29	134.8	7.32
		2	9.21	77.9	8.66	134.8	7.27
		3	7.71	57.4	6.50	134.5	7.10
		4	6.93	48.1	5.59	132.5	7.02
		5	5.61	64.3	7.83	115.0	7.11
		6	5.02	69.2	8.55	110.5	7.14
		7 (bottom)	4.92	70.7	8.75	110.5	7.11
3	10/1/98	surface	6.11	71.2	8.53	144.2	7.30
		1	6.05	70.5	8.44	144.2	7.32
		2	5.98	69.4	8.36	144.2	7.34
		3	5.88	69.2	8.35	144.2	7.36
		4 (bottom)	4.93	69.5	8.59	139.4	7.36
3	7/28/98	surface	17.24	86.9	8.15	161.3	7.57
		1	16.71	80.0	7.58	161.8	7.52
		2	16.33	66.9	6.38	161.2	7.33
		3 (bottom)	14.62	58.4	5.75	150.6	7.19
3	3/18/98	1	0.47	N/T	0.31	176.0	6.93
		1.5 (bottom)					
3	9/25/97	surface	9.36	N/T	5.90	156.0	7.94
		1	9.25	N/T	5.62	156.0	7.68
		3	9.10	N/T	5.42	155.0	7.38
		4.5 (bottom	8.96	N/T	4.30	155.0	7.13

Appendix 1 (continued).

Site Number	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (u S/cm)	pH
11	6/2/99	0	8.37	66.7	7.60	134.0	7.15
		1	8.00	61.3	7.01	133.7	7.12
		2	7.44	54.7	6.34	133.9	7.13
		3	6.52	44.2	5.26	134.0	7.06
		4	6.17	40.1	4.80	135.1	7.03
		5	5.86	36.4	4.42	135.9	7.01
		6	6.58	44.5	5.26	135.1	7.03
		7 (bottom)	7.38	53.8	6.44	134.0	7.09
11	10/1/98	surface	5.80	71.9	8.69	144.1	7.57
		1	5.78	72.0	8.70	144.1	7.57
		2	5.75	72.1	8.73	143.9	7.58
		3	5.59	72.3	8.78	144.0	7.59
		4	5.57	72.5	8.82	143.3	7.60
		5	5.53	72.4	8.81	143.8	7.59
		6	5.51	72.3	8.81	143.3	7.59
		7 (bottom)	5.51	72.6	8.84	143.5	7.57
11	7/28/98	surface	17.07	82.4	7.75	160.6	7.60
		1	16.82	79.0	7.47	161.0	7.57
		2	16.15	60.8	5.84	160.0	7.23
		3	14.57	38.1	3.72	155.8	7.00
		4	12.31	15.5	1.66	152.8	6.84
		5	10.53	7.1	0.78	166.7	6.80
		5.5 (bottom	9.78	5.0	0.56	175.8	6.83

Appendix 1 (concluded).

Site Number	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (u S/cm)	pH
7	6/2/99	0	8.84	72.0	8.06	133.5	7.21
		1	8.82	70.3	7.90	133.8	7.20
		2	8.65	68.2	7.67	133.6	7.21
		3	6.21	42.5	5.09	134.9	7.01
		4	6.17	38.8	4.64	135.0	7.01
		4.5 (bottom)	6.16	37.1	4.45	134.9	7.00
7	10/1/98	surface	5.63	67.6	8.22	143.6	7.59
		1	5.52	68.0	8.29	143.9	7.57
		2	5.37	68.4	8.36	143.4	7.58
		3	5.00	68.9	8.51	143.4	7.59
		4	4.92	69.0	8.53	143.0	7.59
		5 (bottom)	4.97	66.6	8.21	143.2	7.56
7	7/28/98	surface	17.22	82.5	7.71	160.5	7.59
		1	16.82	79.7	7.54	161.2	7.57
		2	13.82	58.9	6.70	155.5	7.31
		3 (bottom)	13.22	43.1	4.40	146.3	7.20
7	9/25/97	surface	9.22	N/T	6.34	141.0	7.01
		1	8.97	N/T	5.77	141.0	7.01
		3	8.86	N/T	4.90	142.0	6.94
		4	8.90	N/T	4.76	141.0	6.92
		4.5 (bottom)					

Appendix 2 - Water Quality: Fort Knox Wetlands

Pond	Date	Depth (m)	Temperature (C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (u S/cm)	pH
A	9/3/99	0.5	11.70	75.9	8.06	230.5	7.84
B	9/3/99	0.5	10.11	73.2	8.06	187.5	7.10
C	9/3/99	0.3	12.11	87.1	9.16	236.1	8.28
D	9/3/99	0.5	12.13	78.8	8.31	222.6	7.69
E	9/3/99	0.3	8.78	49.5	5.61	226.1	7.16
F	9/3/99	0.5	11.85	71.2	7.53	190.6	7.68