Technical Report No. 26-01

Fish and Water Quality Monitoring at the Fort Knox Mine, 2025

by

Chad E. Bear

April 2026

Alaska Department of Fish and Game **Habitat Section**

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

TECHNICAL REPORT NO. 26-01

FISH AND WATER QUALITY MONITORING AT THE FORT KNOX MINE, 2025

By

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April 2026

Cover: Arctic grayling fyke net in Fort Knox Reverse Osmosis Discharge Channel Wetlands, Pond AB, May 2025.

Photograph by Chad Bear.

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ACKNOWLEDGEMENTS

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ADF&G Habitat staff Chad Bear and Kieren Vasquez conducted late-winter water quality sampling. Chad Bear, Nik Nichols, Olivia Edwards, Lauren Yancy, Kieren Vasquez, and Maria Wessel participated in Arctic grayling mark-recapture activities, while Chad Bear, Nik Nichols, Maria Wessel, Olivia Edwards, and Lauren Yancy assisted with fall burbot mark-recapture efforts. Al Ott, Olivia Edwards, Chelsea Clawson, Audra Brase (ADF&G Habitat) and Edmond Packee (FGMI) provided reviews of this report.

EXECUTIVE SUMMARY

Water Quality

In April 2025, water quality monitoring was conducted in the Water Supply Reservoir (WSR), Fish Creek, and the Reverse Osmosis (RO) discharge channel. WSR Dissolved oxygen (DO) concentrations remained high in the upper water column, with Fish Creek Bay recording 11.4 mg/L—one of the highest values documented since monitoring began in 1998—and declined sharply below 8 m, reflecting typical seasonal lake stratification. WSR specific conductance values ranged from 141.1 to 239.2 µS/cm and were lower than peak values observed during years with higher RO discharge volumes (2019–2022). In comparison, Fish Creek's natural artesian spring water measured 145.0 µS/cm on April 4, 2025, while the RO Channel was lower at 58.0 µS/cm on the same date. WSR pH ranged from 6.7 to 7.1 and was slightly lower than RO Channel and Fish Creek measurements of 7.2 and 7.3. WSR ORP values were similar across sample sites, ranging from 221 to 285 mV, indicating adequate oxygen availability for organic decomposition. These results confirm that late-winter water chemistry continues to support suitable overwintering habitat for resident fish populations.

Arctic Grayling

Sampling for Arctic grayling (*Thymallus arcticus*) in the WSR and connected wetlands was conducted from April 28–May 9, 2025. A total of 722 grayling >240 mm were captured, including 287 recaptures from 2024. The 2024 WSR population estimate of 3,511 fish >200 mm (95% CI: 3,268–3,835) exceeded the post-mining management goal of 800–1,600 fish. Moderate growth rates were observed, with continued low recruitment in the 200–240 mm size class. Spawning occurred later than average due to cool spring temperatures as no spent females were observed by May 9, one day after water reached the spawning temperature of 4.0°C. No larval *Diplostomulum* of the eye (eye fluke) infections were observed in the 722 Arctic grayling captured during May 2025 WSR sampling, despite the high prevalence documented within the burbot (*Lota lota*) population in fall 2024. In the RO Discharge Channel's isolated Pond AB, 98 Arctic grayling >230 mm were captured, 34 of which were recaptures from 2024. The 2024 Pond AB population estimate of Arctic grayling >200 mm was 635 fish (95% CI: 482–789), with none of the captured fish observed with eye-fluke infections. Maintenance of wetland connectivity through beaver dam management continues to support Arctic grayling movement and access to spawning habitat.

Burbot

During the annual burbot (*Lota lota*) assessment conducted from September 3–15, 2025, a total of 176 burbot were captured in the WSR, including 31 ≥400 mm, with eight recaptures from the fall 2024 sampling. The 2024 WSR population estimate of 109 burbot ≥400 mm (95% CI: 60–158) continued a downward trend since 2022, and the catch per unit effort (0.5 fish/trap/day) remained among the lowest documented since monitoring began. During fall 2025, only one burbot >600 mm was captured, reflecting a decline in the number of large fish relative to the 2020 peak of 21 individuals. Eye fluke prevalence in the WSR burbot increased from 38% in 2024 to 75% in 2025, and a *Myxobolus* sp. infection was detected in gill tissue during the 2024 ADF&G fish pathology lab inspection. WSR length-frequency data shows a reduction in the number of mature adults (>600 mm), and the population's size structure has shifted toward smaller individuals. In the RO Channel's isolated Pond AB, 15 burbot (average length 319 mm) were captured, with no evidence of eye fluke infection observed in either 2024 or 2025, indicating that the parasite has not moved upstream from the WSR and become established in this population. These findings highlight the importance of continued monitoring to track health indicators and ensure long-term population sustainability.

INTRODUCTION

Fairbanks Gold Mining Incorporated (FGMI) began construction of the Fort Knox hard-rock gold mine in March 1995. The mine is located approximately 42 km (26 road miles) northeast of Fairbanks, Alaska, within the headwaters of the Fish Creek drainage, a tributary of the Little Chena River. Development includes an open-pit operation, mill, tailings storage facility (TSF), two heap leach facilities, and a Water Supply Reservoir (WSR), collectively encompassing approximately 8,711 acres (Figure 1). Construction of the WSR dam, which retains Fish Creek water and includes a spillway returning flow to Fish Creek, was completed in July 1996. The first gold pours from mine production occurred in November 1996.

Ore extraction at the Gil Mine, situated about 13 km east of Fort Knox, began in 2021. To facilitate ore transport from Gil to the Fort Knox mill, substantial upgrades to the Gil Haul Road and causeway were completed between 2021 and 2024 (Figure 2). Ore hauling from Gil was suspended in fall 2024, although FGMI has continued exploration drilling in the Gil vicinity.

Prior to Fort Knox mine development, extensive placer and bucket-line dredge mining had altered the upper Fish Creek valley. FGMI has undertaken habitat rehabilitation concurrently with mining activities, and natural revegetation continues to progress. Baseline fish studies began before mine construction, and since 1992, the Alaska Department of Fish and Game (ADF&G) has conducted fish monitoring in the Fish Creek drainage. Water quality monitoring commenced in 1997, followed by winter sampling of the WSR in 1998 and Reverse Osmosis (RO) discharge channel measurements in 2019. Wetlands construction between the tailings dam and WSR began in 1998. Additional habitat improvements, including dike repairs and fish passage enhancements between Ponds D and E, were completed in 2001 and 2002.

In 1992, baseline Arctic grayling (*Thymallus arcticus*) populations in the Fish Creek drainage were assessed to estimate the number of fish available to colonize the WSR (Weber Scannell and Ott 1993). Arctic grayling were distributed throughout the drainage but primarily occupied habitats in flooded mine cuts and settling ponds in Fish and Last Chance Creeks. Resident Arctic grayling exhibited stunted growth, with very few individuals exceeding 220 mm. Baseline sampling in 1994–1995 recorded an average spawner size of 185 mm (Weber Scannell and Ott 1994). Following completion of the freshwater dam in 1996, filling of the WSR inundated the inlets and outlets of former mine cuts, expanding aquatic habitat. The dam's spillway allows fish movement

downstream out of the WSR, but its steep gradient and water velocity prevents upstream passage. From 1996–1998, very few Arctic grayling fry were observed or captured in the WSR or Last Chance Creek (Ott and Morris 2000). In spring 1999, FGMI constructed a channel upstream of the WSR to better connect the Fish Creek wetlands complex, improving access to spawning habitat. Since its construction, Arctic grayling have successfully spawned in the wetlands complex annually.

In 2019, fish habitat within the wetlands complex expanded when RO water discharged from Outfall 002 was routed through Pond AB into a previously dry channel north of Centerline Road (Figure 3). This RO water flooded low-lying areas, creating small ponds and adding 7.9 acres of new wetland habitat. As RO water flows through Pond AB, its relatively warm discharge temperature (~6°C) cools before merging with Fish Creek and entering the WSR. During 2023–2025, reduced RO discharge resulted in lower water levels within the RO channel wetlands. Although the area remains flooded, available fish habitat has decreased compared to years with higher discharge volumes (Appendix H).

Currently, the WSR supports viable, self-sustaining populations of Arctic grayling and burbot (*Lota lota*). Arctic grayling spawning occurs primarily within the wetlands complex between the WSR and the tailings dam, and individuals overwinter in the WSR. Burbot spawning, documented through radio telemetry, likely occurs in Solo Bay where Solo Creek enters the WSR (Ott et al. 2013). Burbot use of the Fish Creek wetlands has been observed during spring Arctic grayling fyke-netting when they are incidentally captured. Both Arctic grayling and burbot recruit into the Stilling Basin via the WSR spillway but cannot return upstream into the WSR (Bear and Burrows 2019). During years of high RO water discharge (2019–2021), Arctic grayling and burbot migrated into and colonized Pond AB, the uppermost waterbody of the RO wetlands complex (Bear 2022). These populations became isolated when beaver dams were built in the RO Channel and the RO discharge rate was reduced in 2023, decreasing connectivity to the WSR.

This report summarizes fish and water quality data collected in 2025 and evaluates these findings in the context of previous research. A chronology of biological and habitat-related events from 2011–2025 is provided in Appendix A.

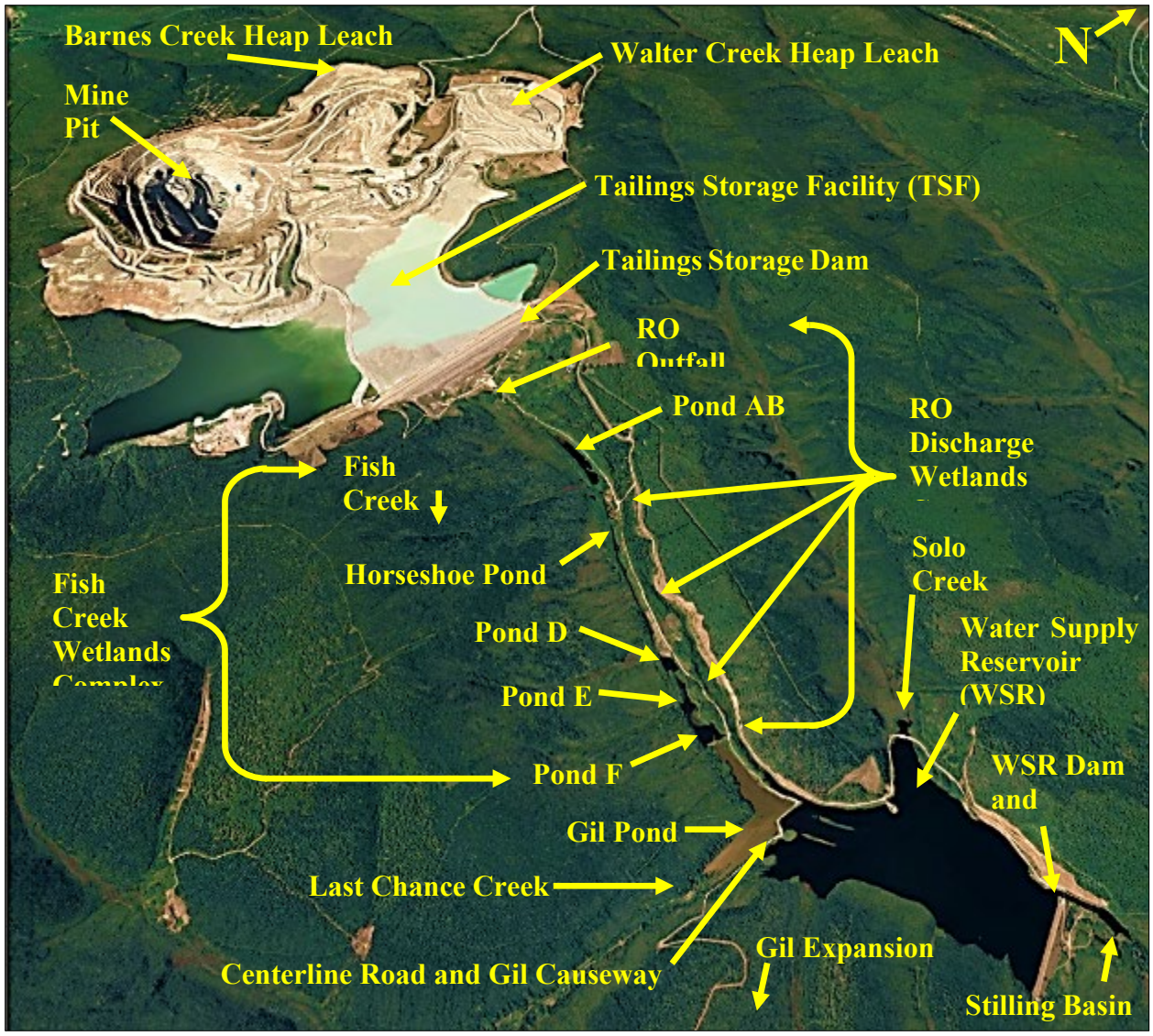

Figure 1.–Fort Knox gold mine, Water Supply Reservoir (WSR) and wetland complexes.

Figure 2.–Gil Causeway Improvements, May 2020 (left) and May 2022 (right).

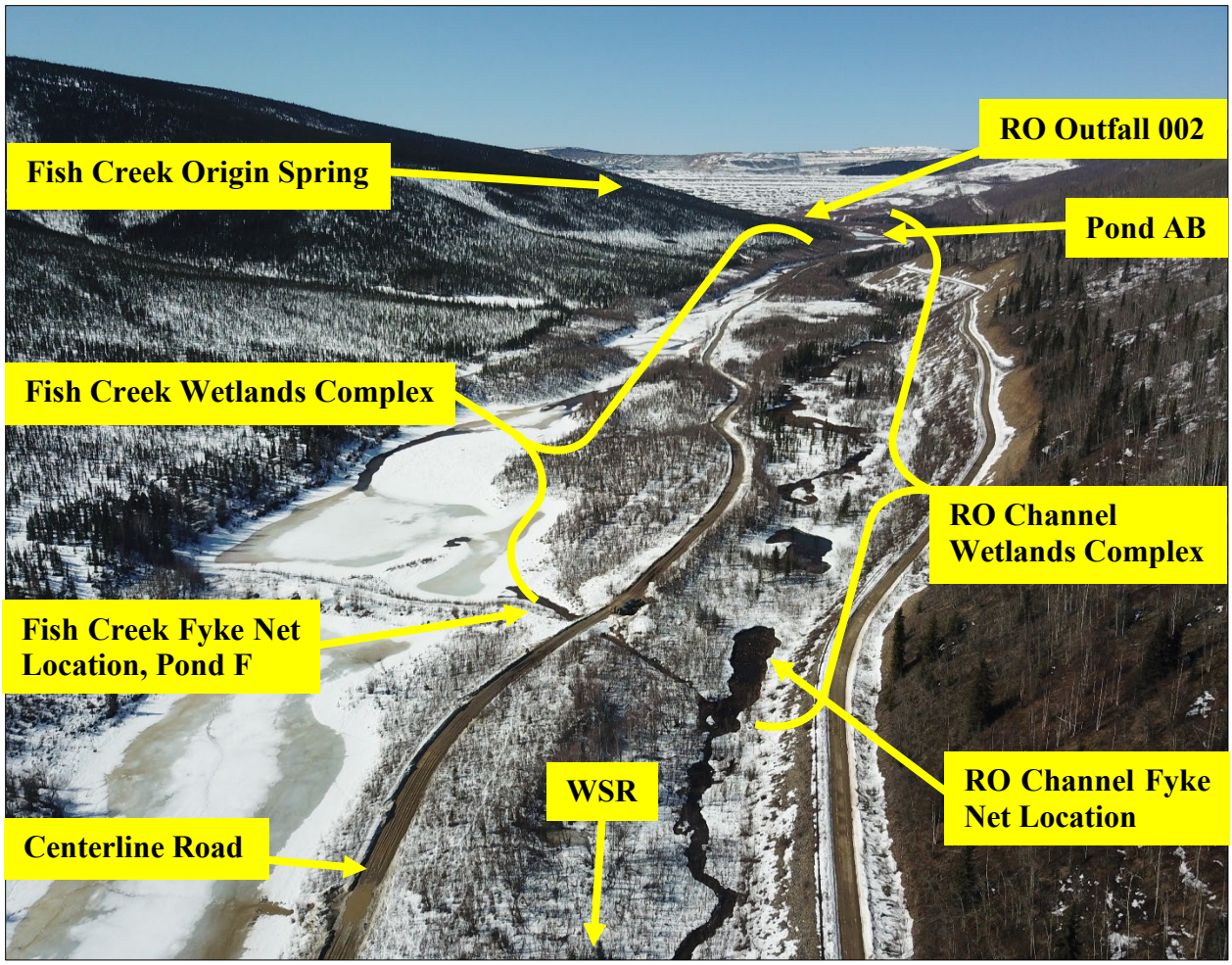

Figure 3.–Fish Creek wetlands (left) and RO Channel wetlands (right), divided by Centerline Road. Photo from 2022 during high RO discharge rate.

OBJECTIVES

The objectives of this report are to evaluate water quality and assess the status of Arctic grayling (*Thymallus arcticus*) and burbot (*Lota lota*) populations within the Fort Knox Water Supply Reservoir (WSR) and adjacent wetland complexes during 2025, and to compare these findings with previous years. The report examines whether water-quality parameters remain within Alaska Department of Environmental Conservation (ADEC) standards and continue to provide suitable habitat for resident fish. It also evaluates Arctic grayling abundance, growth, recruitment, and spawning success relative to post-mining management goals. Burbot population trends, size structure, and health are assessed, including the prevalence of emerging parasites such as eye fluke (*Diplostomulum*) and *Myxobolus* infections. Finally, the report provides management recommendations to support habitat connectivity, fish health, and long-term sustainability of aquatic resources within the Fort Knox mine footprint.

WATER QUALITY MONITORING

The WSR was constructed as the primary water source for mining activities and mill operations at Fort Knox. At full capacity, it holds approximately 3,363 acre-feet (1.1 billion gallons) of water. Since 1998, water levels have remained relatively stable, except during certain winters when substantial volumes were withdrawn for mining processes (Appendix G). Beginning in 2015, operational water demands have been met through dewatering wells in the mine pit and tailings impoundment, eliminating the need to draw water from the WSR. In 2021, the supply pipeline connecting the WSR to mill operations and the Tailings Storage Facility (TSF) was disconnected.

In spring 2015, FGMI began discharging mine operations water treated through RO combined with non-contact water from dewatering wells surrounding the open pit, into the RO Channel wetlands complex via Outfall 001 under Alaska Pollutant Discharge Elimination System (APDES) Permit AK0053643. On January 15, 2019, FGMI commissioned two additional RO facilities (RO2 and RO3) and initiated discharge from Outfall 002 (Figure 4). Discharge from Outfall 001 was rerouted to Outfall 002 and Outfall 001 was subsequently deactivated. RO discharge volumes generally increased from 2015–2020, then declined between 2021–2024 as TSF water balance requirements were achieved. In 2025, 4,294 acre-feet of RO water were discharged into the RO Channel wetlands—a reduction from the 2020 peak of 9,663 acre-feet but an increase from the 2024 total of 1,623 acre-feet (Figure 4; Appendix H).

Figure 4.–Outfall 002 RO water discharge: up to 3,000 gpm during 2019–2021 (2020 left) and reduced to approximately 400 gpm during 2022–2025 (2025 right) into the RO Channel wetlands.

METHODS

Since 1998, six sites within the WSR have been sampled annually (Appendix B). Beginning in 2019, two additional sites in Fish Creek and the RO Channel were added to assess these natural and mine-discharge water sources (Figure 5). In 2025, water quality sampling was conducted on April 4 when the WSR was ice-covered while Fish Creek and the RO Channel were unfrozen.

Vertical profiles of water temperature (°C), dissolved oxygen (DO) concentration (mg/L), DO percent saturation, pH, specific conductivity (µS/cm), ORP, and depth (m) were measured using a handheld YSI ProQuatro *Professional Plus* multiparameter instrument calibrated annually. Measurements were taken at 1 m intervals from just below the ice to the reservoir bottom at the six WSR sites, and at 1 m depth at the Fish Creek and RO Channel sites.

To compare annual WSR conditions, Site 2 is used as the primary indicator. As the deepest station (17 m), it represents the largest water volume and allows evaluation of vertical stratification rather than only surface conditions. Freshwater inputs from Fish Creek, Solo Creek, Last Chance Creek, and the RO Discharge Channel mix within the WSR and flow past Site 2 before exiting through the dam spillway. Sites close to these inflows are less representative of overall reservoir conditions.

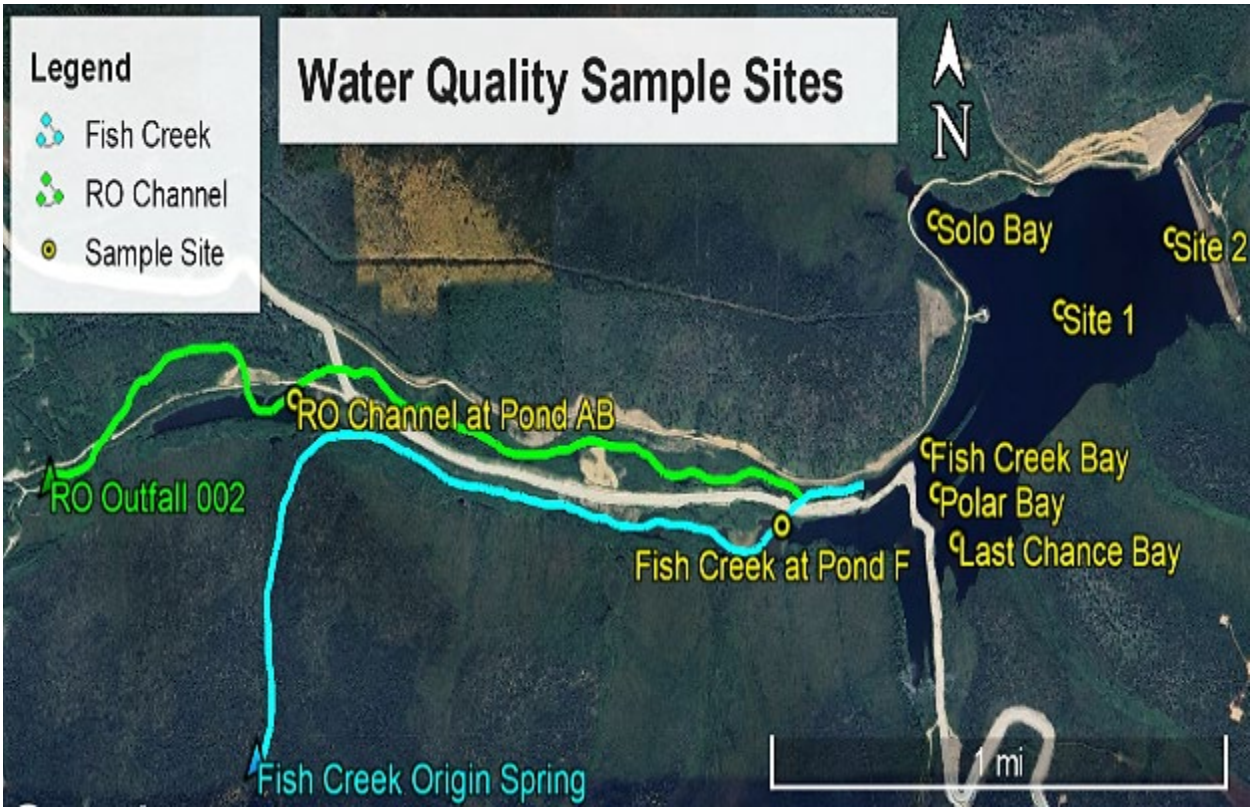

Figure 5.–Fort Knox water quality sample sites, April 4, 2025.

RESULTS AND DISCUSSION

Water Supply Reservoir

In 2025, ice thickness in the WSR was consistent with previous years, measuring slightly less than one meter across all six sampling locations (Figure 1). Beneath the 30 cm snow cover, 5 cm of slushy overflow was observed at most sites. This overflow may have influenced the one-meter depth readings after test-hole drilling but did not affect measurements from the remainder of the water column.

Water Temperature

WSR water temperatures in 2025 ranged from 0.2°C to 3.3°C (Figure 6). The minimum (0.2°C) occurred in Fish Creek Bay just below the ice surface, while the maximum (3.3°C) was recorded at Site 2 at 17 m depth, the deepest part of the reservoir near the bottom. Temperature increased with depth at all six sites. In 2025, the average water column temperature at Site 2 was similar to previous years, with 2023 remaining the warmest year since 1997 (Figure 7).

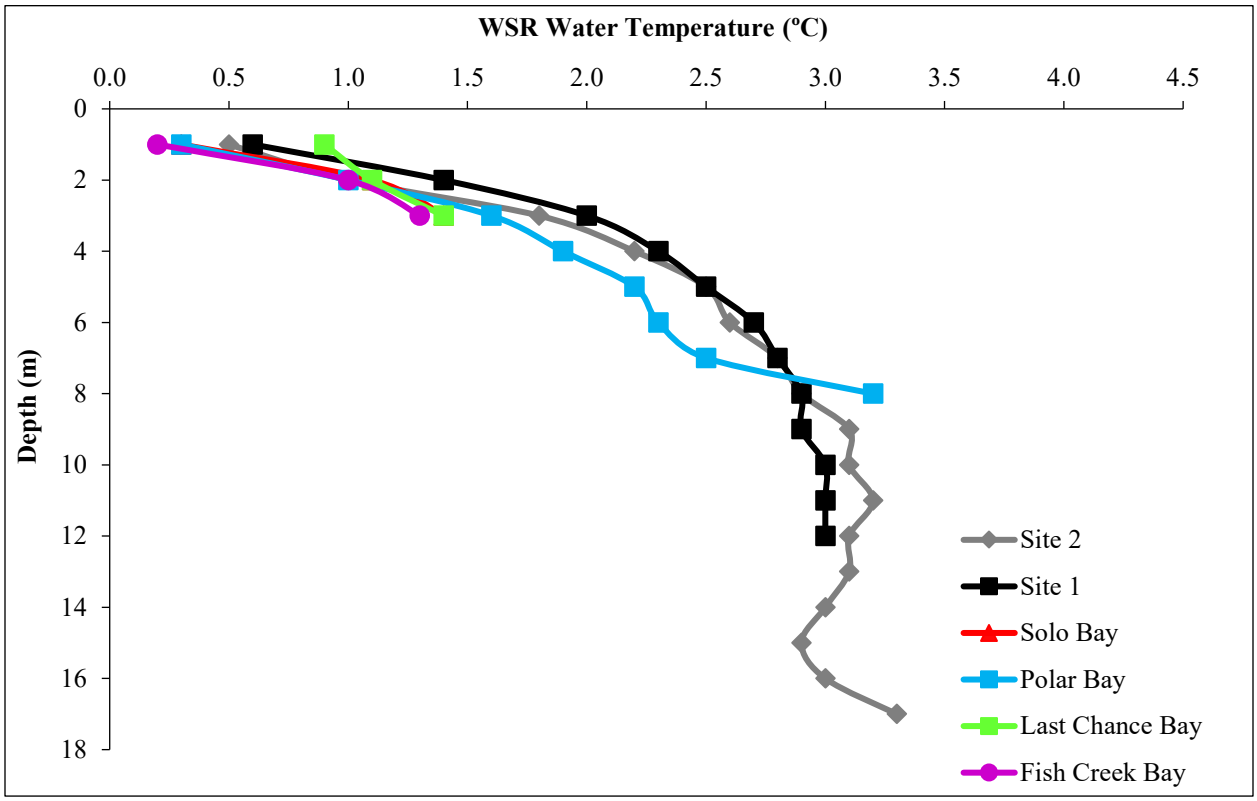

Figure 6.–Water temperature (°C) vertical profiles in the WSR, April 4, 2025.

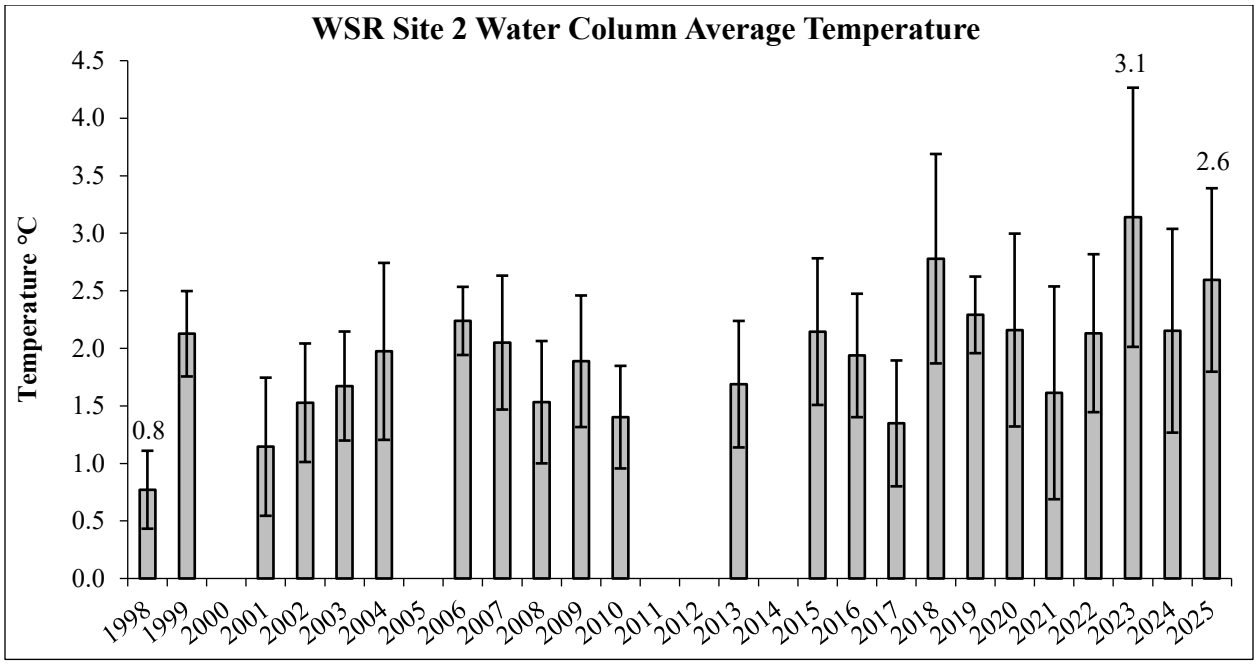

Figure 7.–Annual water column average temperature (°C) at Site 2 in the WSR, 1998–2025.

Dissolved Oxygen (DO)

Adequate DO levels are essential for fish, aquatic invertebrates, and plants. The Alaska Department of Environmental Conservation (ADEC) DO standards for freshwater fish propagation are DO greater than 7 mg/L at the surface, with a minimum of ≥ 5 mg/L in spawning gravel interstices. Water becomes hypoxic when DO falls below 2 mg/L and anoxic as DO approaches 0 mg/L, occurring below approximately 8 m of depth in the WSR. In 2025, DO concentration was highest in Fish Creek Bay at 11.4 mg/L, followed by Polar Bay at 10.1 mg/L, both at 1 meter depth. (Figure 8). These maxima exceed pre-2015 levels, likely due to RO water discharge initiated in March 2015.

Fish Creek Bay had the highest water column average DO (9.43 mg/L) for the tenth consecutive year, followed by Solo Bay at 7.43 mg/L. Across most WSR sites, DO was higher within the upper 8 m of the water column but declined sharply to near 0 mg/L below this depth (Figure 8). Last Chance Bay consistently has lower average DO than other sites, likely due to its location in the southwest corner of the WSR, farthest from the RO discharge water flow route through the WSR (Figure 5).

In 2025, the winter water column average DO at Site 2 (3.25 mg/L) was above the pre-RO average (2.04 mg/L) but below the post-RO average (4.47 mg/L), reflecting reduced RO discharge during winter 2024–2025 (Figure 9).

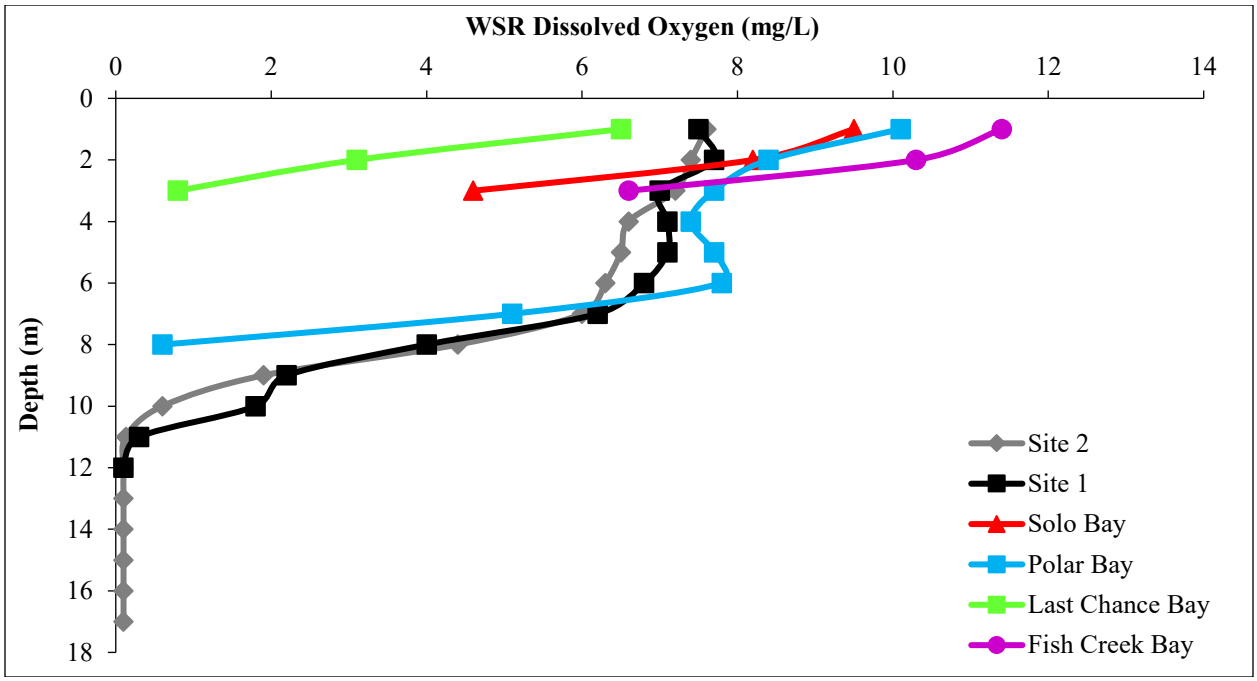

Figure 8.–Dissolved oxygen (mg/L) vertical profiles in the WSR, April 4, 2025.

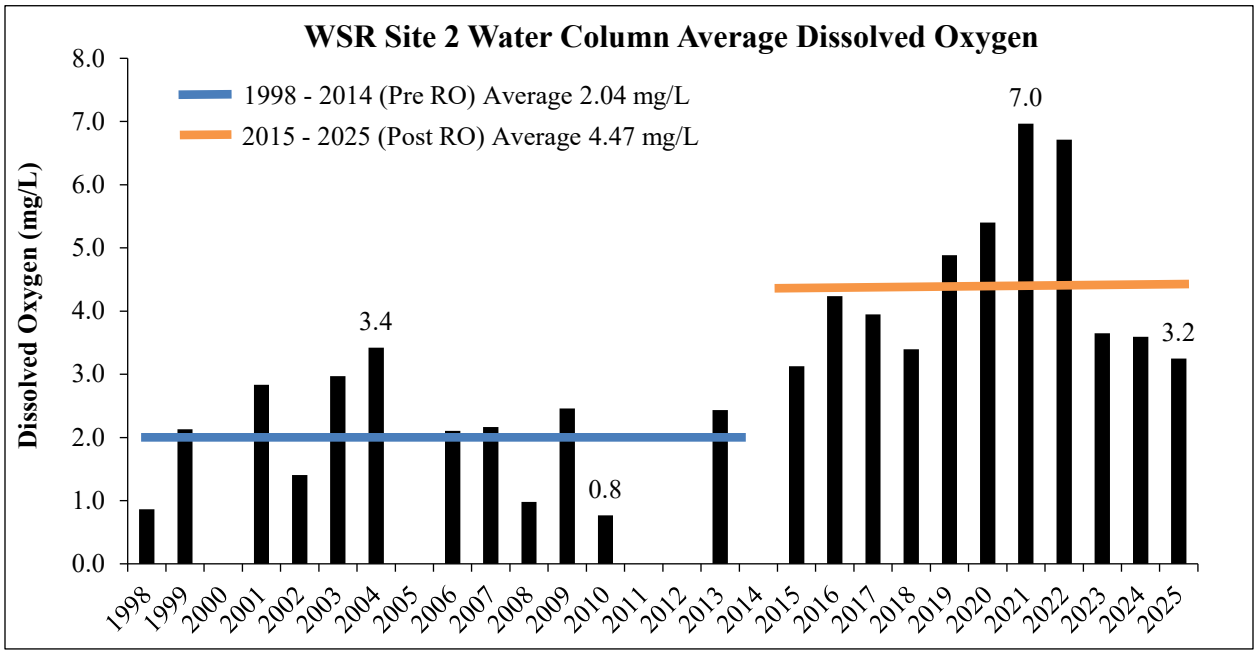

Figure 9.–Water column average dissolved oxygen (mg/L) at Site 2 in the WSR, 1998–2025.

Temperature-specific DO percent saturations in 2025 were stratified across the water column (Figure 10), mirroring DO (mg/L) stratification below 8 m depth (Figure 8). This contrasts with 2022, when higher RO discharge resulted in more mixing and less oxygen stratification (Figure 11). The 2025 vertical DO profiles resemble typical winter lake oxygen stratification under minimal freshwater input (Palshin 2021).

Reduced RO discharge from Outfall 002 during winter 2024–2025 resulted in lower average DO percent saturation at all sites compared to high-discharge years (2019–2022; Figure 9). Last Chance Bay continued to record lower DO but exhibited the same stratification trend compared to other sample sites during both high and low RO discharge years (Figures 10 and 11).

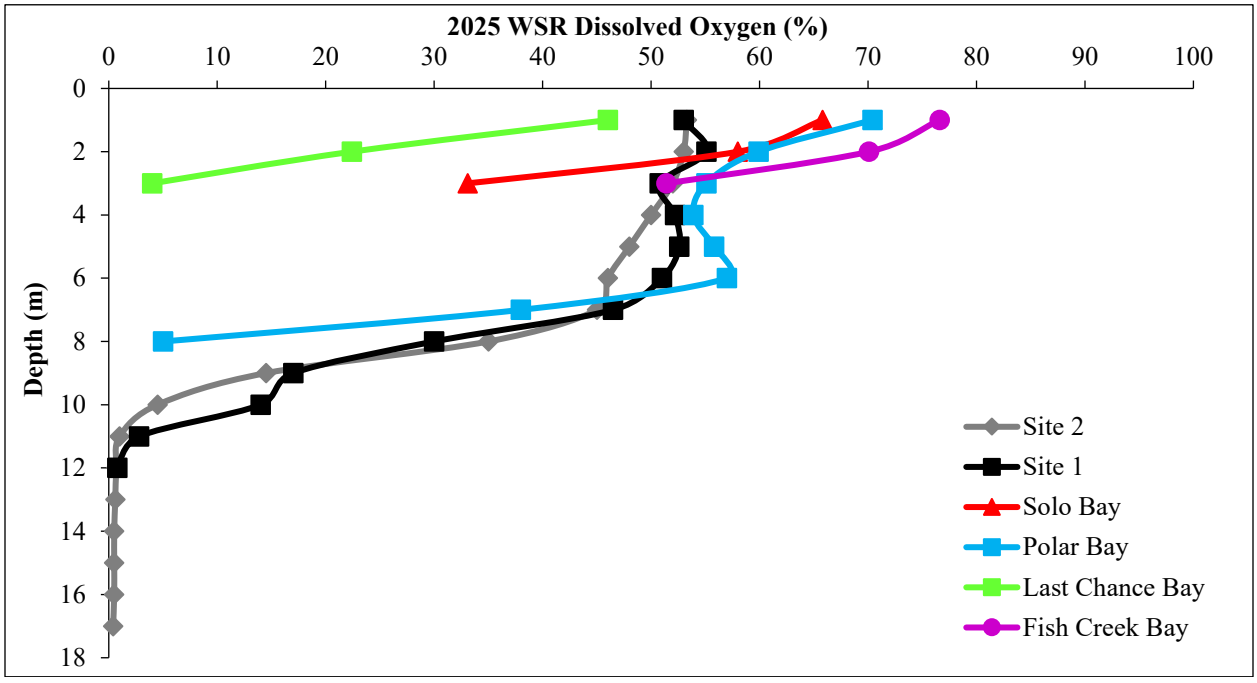

Figure 10.–Temperature-specific dissolved oxygen (% saturation) vertical profiles in the WSR, April 4, 2025.

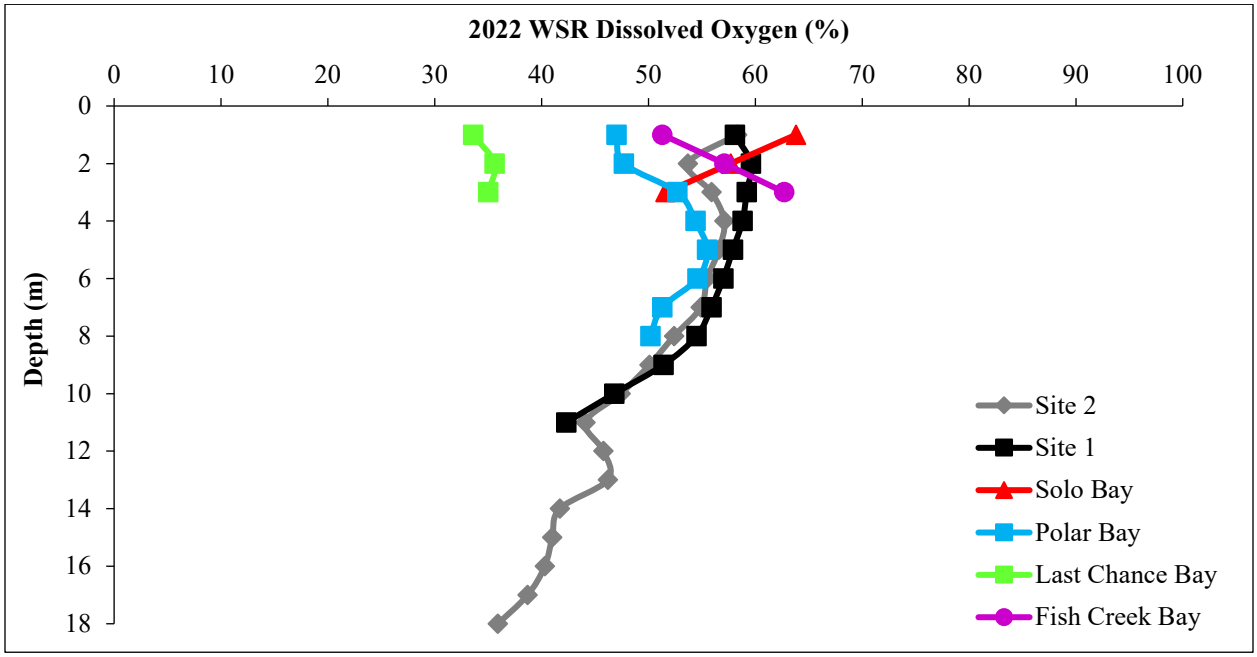

Figure 11.–Temperature-specific dissolved oxygen (% saturation) vertical profiles in the WSR, April 14, 2022.

pH

The pH of water influences aquatic plants and invertebrates, with potential effects on fish reproduction, recruitment, growth rates, and overall health. In 2025, the WSR pH values were similar across all sites and depths. Single point values ranged from 6.7 at Site 1 to 7.1 across all six sites, similar to previous years (Figure 12). All WSR pH measurements in 2025 were within the ADEC standard for aquatic life (6.5 to 8.5).

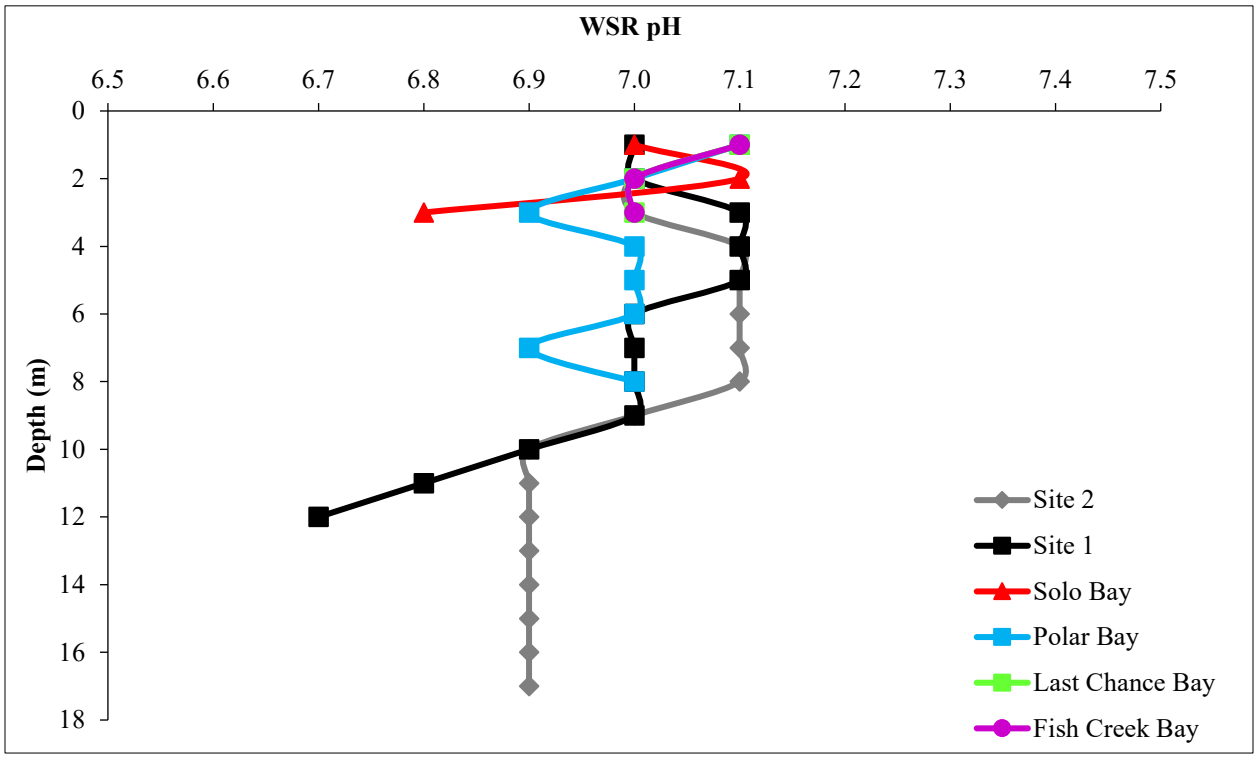

Figure 12.–pH vertical profiles in the WSR, April 4, 2025.

Specific Conductance

Specific conductance measures the ability of water to conduct electrical current, which increases with higher concentration and mobility of charged ions. Higher specific conductance reflects greater concentrations of dissolved solids, including chloride, nitrate, phosphate, sodium, magnesium, calcium, and iron and serves as an important indicator of water quality. In 2025, specific conductance values were consistent across all six WSR sites and generally increased with depth as minerals settled from the surface and accumulated near the bottom (Figure 13).

The 2025 WSR specific conductance single point values ranged from 141.1 to 239.2 µS/cm. At Site 2, the 2025 water column average was 161.4 µS/cm, compared to 396.7 µS/cm in 2021 and 427.2 µS/cm in 2022 (Figure 14).

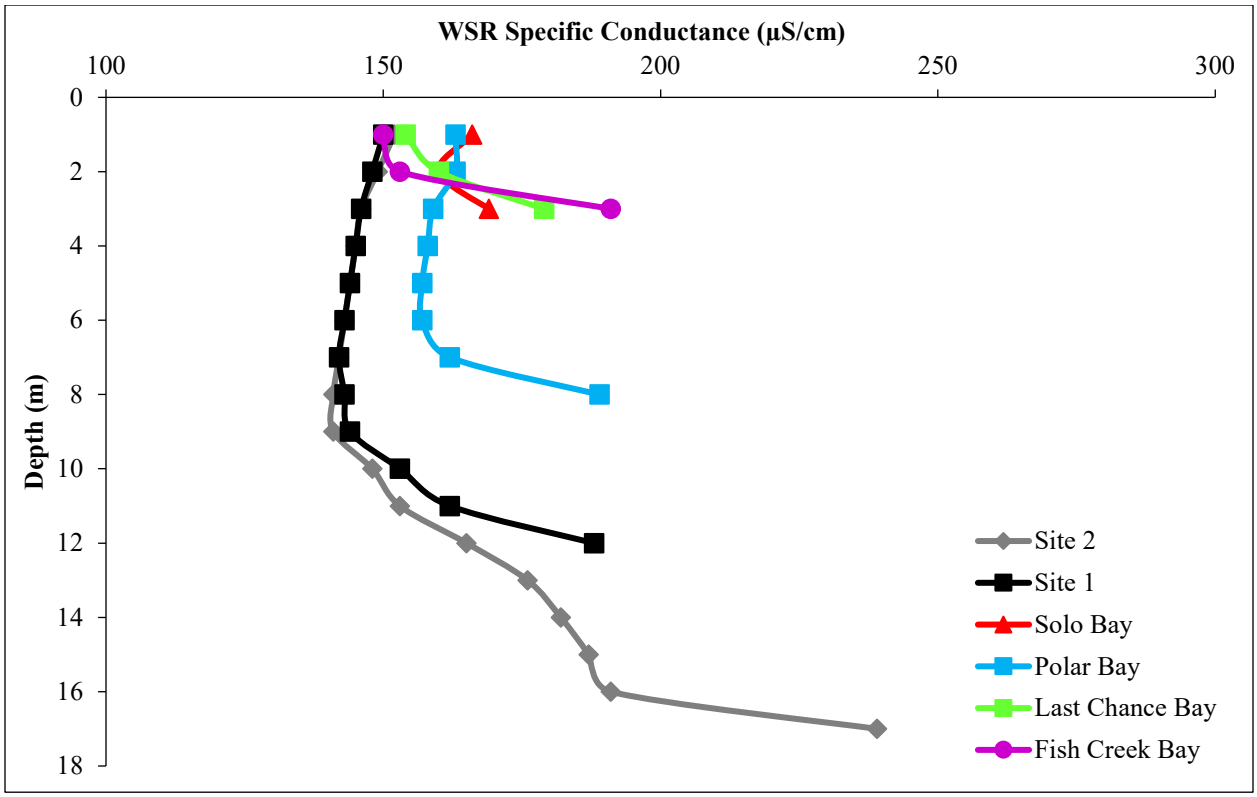

Figure 13.–Specific conductance (µS/cm) vertical profiles in the WSR, April 4, 2025.

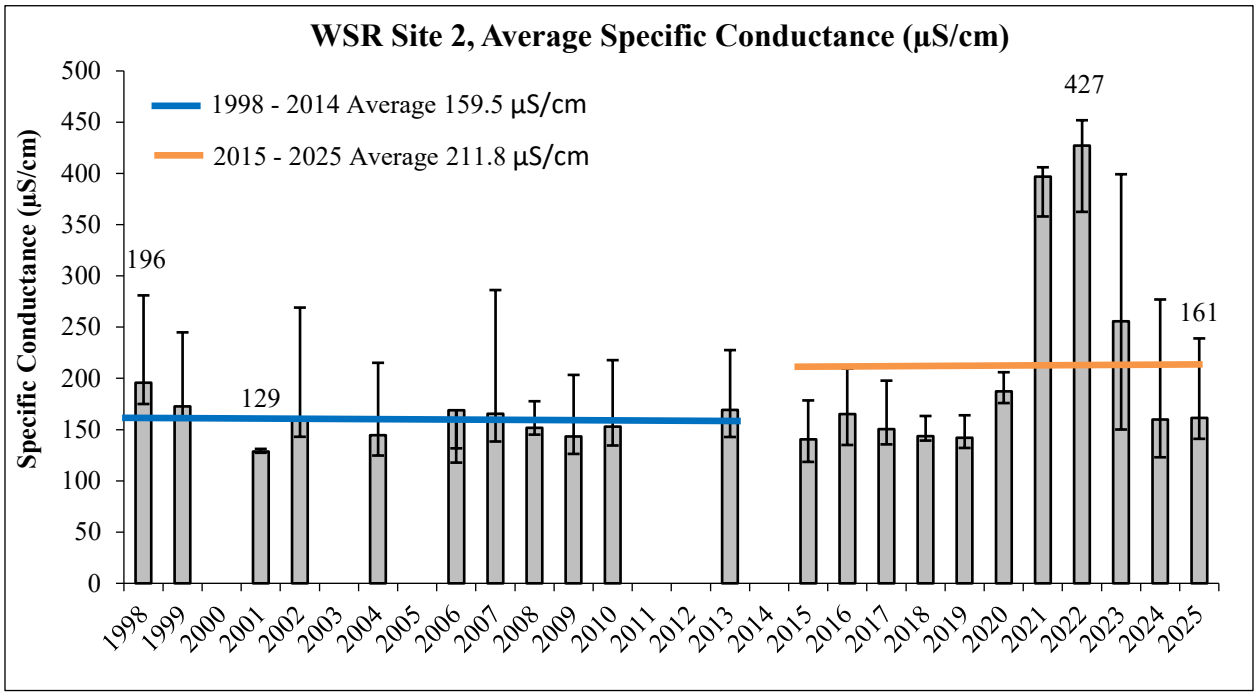

Figure 14.–Water column average specific conductance (µS/cm) at Site 2 in the WSR with pre-RO (1998–2014) and post-RO (2015–2025) averages.

Oxidation-Reduction Potential (ORP)

Oxidation-reduction potential (ORP) indicates the capacity of a lake or river system to break down waste products, such as contaminants or decaying organic material. Higher ORP levels signify sufficient oxygen availability for effective decomposition of these materials by bacteria. In 2025, ORP values were similar across sample sites, ranging from 221 to 285 mV (Figure 15). At Site 1 and Site 2, ORP decreased sharply below 11 meters, reflecting low or absent dissolved oxygen limiting organic decomposition processes.

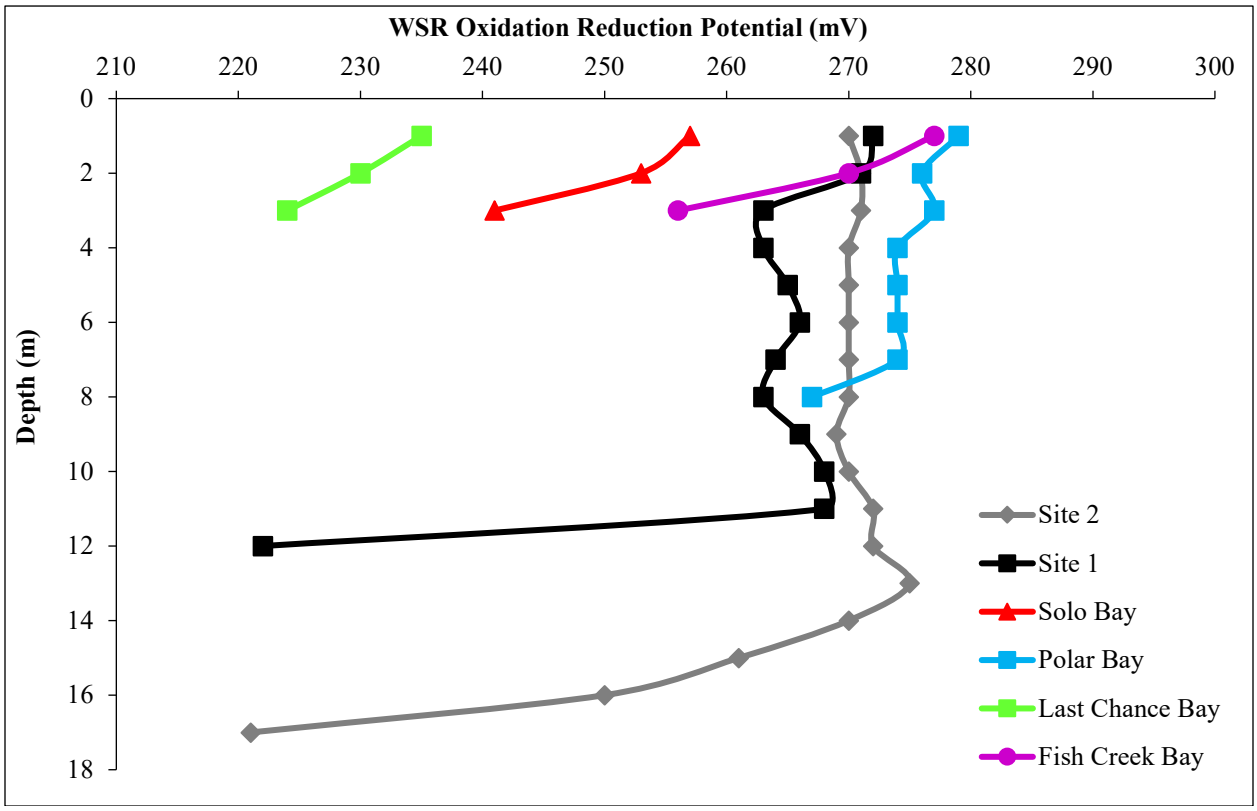

Figure 15.–Oxidation-reduction potential (mV) vertical profiles in the WSR, April 4, 2025.

Fish Creek and RO Channel Wetland Complexes

Water Temperature

From 2019–2025, water quality data were collected at Fish Creek and the RO Channel downstream of Outfall 002 at 1 m depth (Figure 5). On April 4, 2025, RO Channel water temperature at the Pond AB outlet was 2.5°C, while Fish Creek at Pond F was 0.1°C (Figure 16).

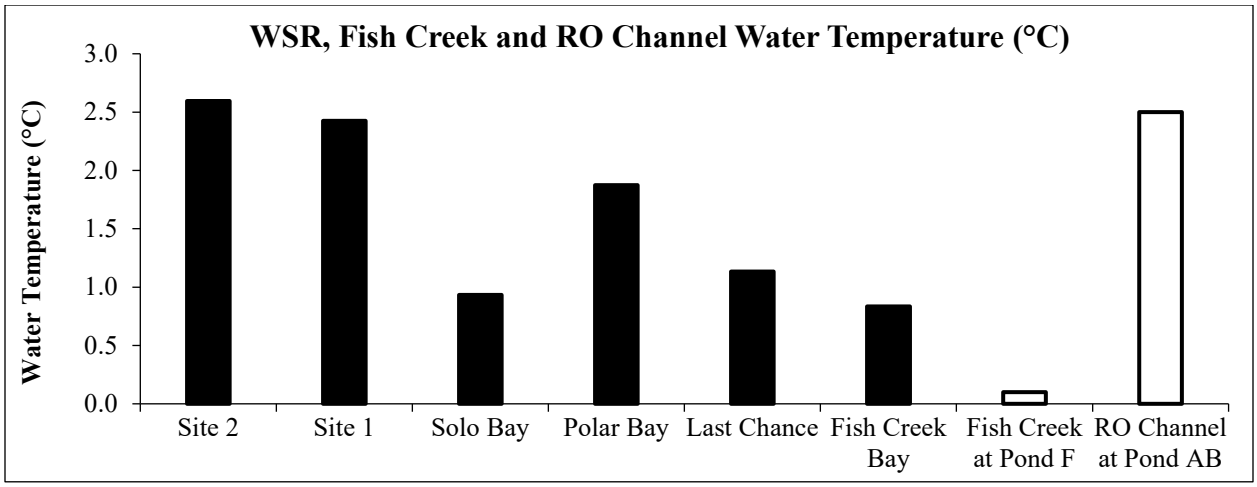

Figure 16.–Water temperature (°C) in Fish Creek and RO Channel (1 m depth; unfilled bars) and Fort Knox WSR (average for water column; filled bars), April 4, 2025.

Dissolved Oxygen (DO)

On April 4, 2025, DO levels in the flowing waters of Fish Creek and the RO Channel (1 m depth) exceeded the average DO levels across the six WSR sample sites, which are typically low in ice-covered lakes during winter (Figure 17). RO water accumulates oxygen during treatment processes, while Fish Creek is oxygenated naturally through hydraulic turbulence as it flows downstream. Fish Creek originates from an artesian spring and maintains a relatively steady flow throughout the year. The RO discharge rate is set by FGMI during the winter months as dictated by mine water balance needs and was around 400 gpm during the winter of 2024-2025. These two reliable sources of well oxygenated water help sustain dissolved oxygen levels in the WSR for overwintering fish.

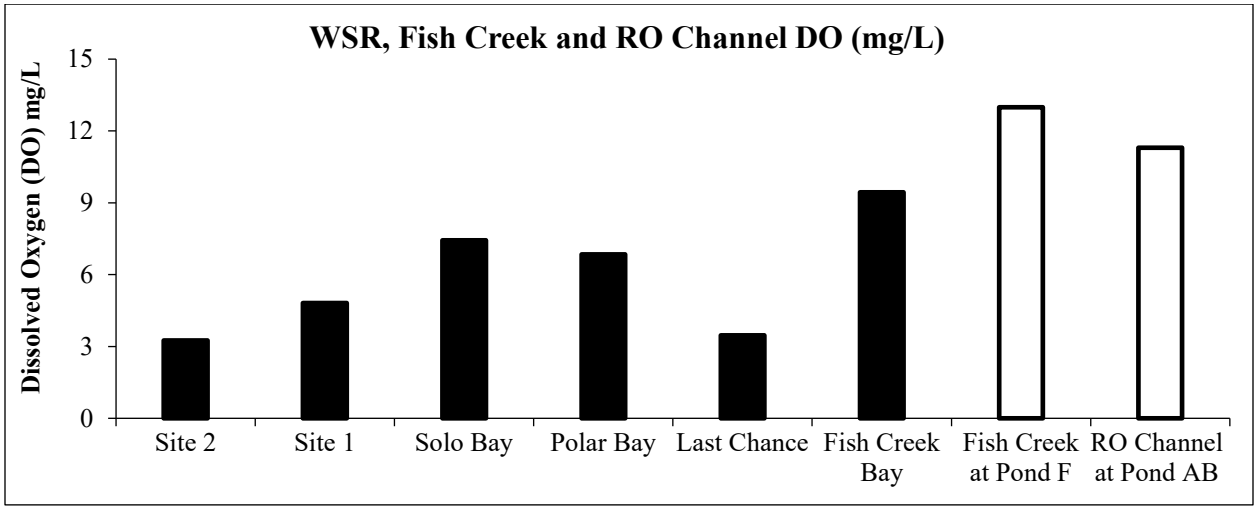

Figure 17.–Dissolved oxygen (mg/L) in Fish Creek and RO Channel (1 m depth; unfilled bars) and the WSR (average for water column; filled bars), April 4, 2025.

Specific Conductance

RO water typically exhibits low specific conductance due to the removal of dissolved minerals during treatment. RO permeate discharged from Outfall 002 is blended with non-contact groundwater from pit dewatering wells and tailings seepage well water to reintroduce minerals removed during the RO process before entering Fish Creek. As a result, final discharge specific conductance is governed by the minerals added during this reintroduction process and was near 50 µS/cm during 2025, though individual measurements may be higher depending on blend ratios and seasonal dewatering needs. In comparison, Fish Creek's natural artesian spring water measured 145.0 µS/cm on April 4, 2025.

In 2025, RO discharge totaled 4,294 acre-feet. In comparison, 2019-2022 were high RO-discharge years, with annual discharge volumes up to 9,663 acre-feet (Appendix H). In 2025, specific conductance at the Pond AB outlet was 58.0 µS/cm on April 4, consistent with values measured in 2023 (40.0 µS/cm) and 2024 (52.1 µS/cm) (Figure 18; Appendix H). During the high-RO discharge years (2019–2022), specific conductance was generally higher, with April 15, 2021, measuring 455 µS/cm, for example. This resulted in elevated specific conductance levels at all WSR sites compared to 2025, with 2021 used as an example in Figure 19. The higher specific conductance values during high discharge years were likely driven by the well-water blending ratios used during remineralization of the RO permeate.

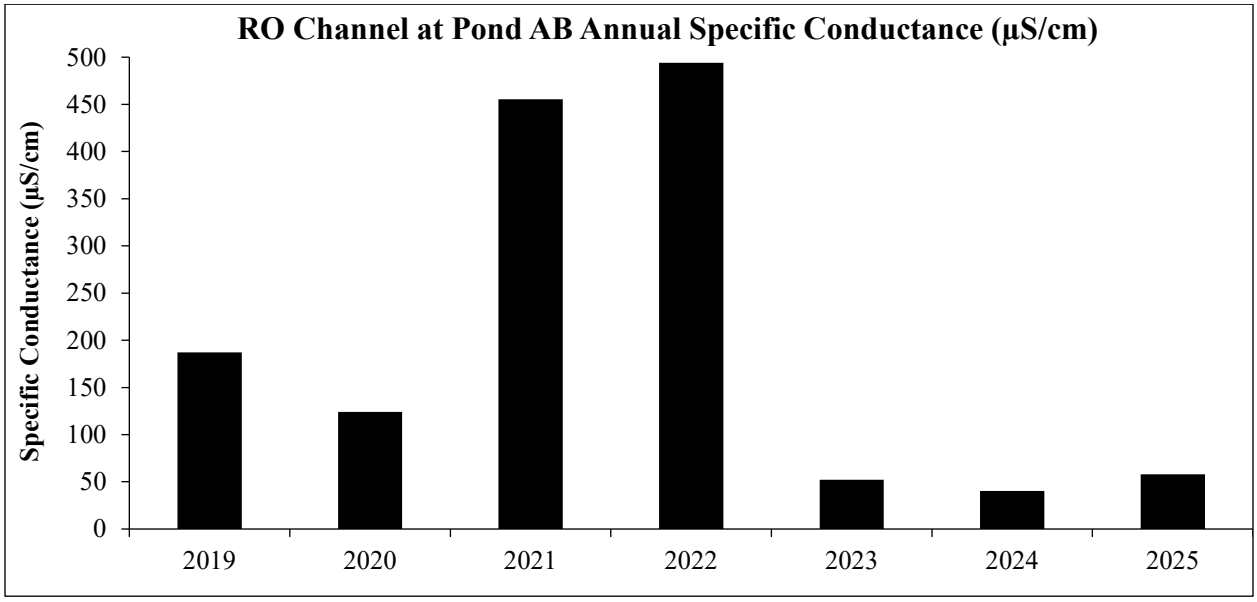

Figure 18.–Specific conductance (µS/cm) in the RO Channel at Pond AB, 2019–2025.

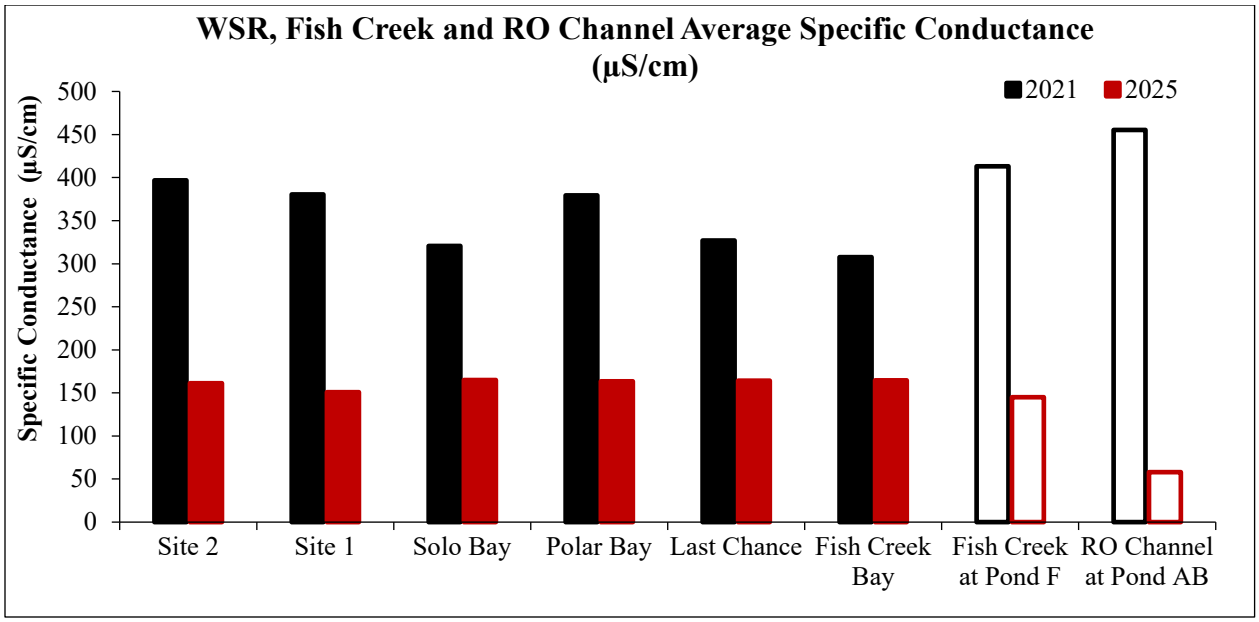

Figure 19.–Specific conductance (µS/cm) in the WSR (average for water column; filled bars), Fish Creek and RO Channel (1 m depth; unfilled bars), April 2021 (black) and 2025 (red).

pH

In 2025, single-point pH measurements collected at the RO Channel at Pond AB (7.23) and Fish Creek at Pond F (7.29) were similar but slightly higher than the WSR water-column averages (Figure 20). Individual measurements across WSR sites ranged from a low of 6.7 at Site 1 to a high of 7.1 at Fish Creek Bay. All recorded pH values from the WSR, Fish Creek, and RO Channel were within the ADEC aquatic life standard of 6.5 to 8.5.

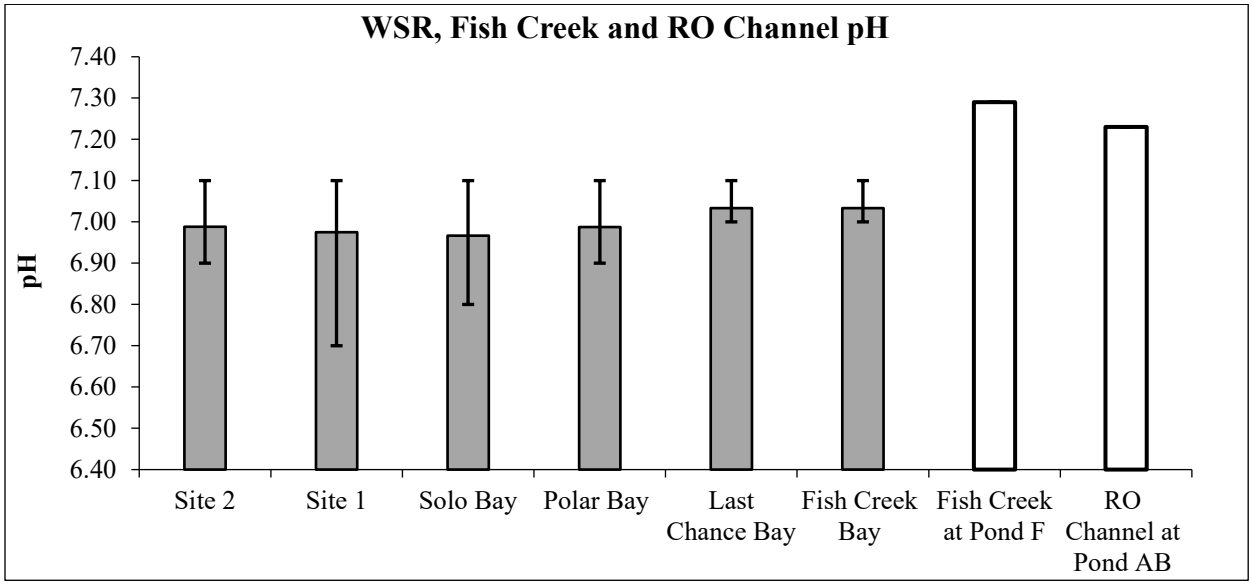

Figure 20.–pH in the WSR (average for water column; filled bars), Fish Creek and the RO Channel (1 m depth; unfilled bars) April 4, 2025.

Water Quality Current Environmental Dynamics

Water quality in the WSR, Fish Creek and the RO discharge channel remained within ADEC standards and continued to support spawning, overwintering and rearing fish habitat. However, RO treatment, while effective at removing contaminants, also eliminates essential minerals such as calcium and magnesium, producing ultra-pure water with very low ionic strength. This can destabilize pH and hardness and cause osmotic stress in fish and invertebrates, as these minerals are vital for osmoregulation and overall physiological health (Boyd, 2015). Without the remineralization done by FGMI post RO treatment, it is possible fish populations residing in Pond AB and the RO channel could experience stress and impaired growth, and aquatic plants and invertebrates could suffer nutrient deficiencies.

To mitigate these risks, ADF&G recommends continuing remineralization of RO water to achieve conductivity closer to natural levels observed in Fish Creek. From 2023-2025 discharged RO water specific conductance averaged 50 µS/cm at Pond AB while Fish Creek's water averaged 112 µS/cm at Pond F during the same time period (Figure 18). Adding additional non-contact ground water or calcium carbonate and magnesium salts can restore ionic balance, stabilize carbonate hardness (KH), and help support biological stability in aquatic systems and reservoirs (Hubick 2025).

ARCTIC GRAYLING ASSESSMENT

Arctic grayling have spawned in the Fish Creek wetland complex since the channel connecting them to the WSR was completed in 1999. However, in some years, substantial aufeis formation and resulting cold-water temperatures in the wetland complex, along with beaver dam construction, have limited available spawning habitat. In recent years, Fish Creek aufeis buildup has been relatively minor, and more effective beaver management has been implemented, including annual removal of dams throughout the wetland complex by FGMI and ADF&G staff.

METHODS

Arctic grayling have been sampled annually in the Fish Creek wetland complex since 1995 (Appendix C). In 2025, sampling methods included fyke nets and visual observations. Fyke nets were deployed in Fish Creek at the Pond F outlet and in the RO Channel just upstream of its confluence with Fish Creek during spring, as Arctic grayling migrate from the WSR to spawn (Figures 21 and 22). The RO Channel net also served to evaluate Arctic grayling use of wetland

habitats created by RO discharge that began in 2015. In Pond AB, a fyke net has been placed near the outlet each spring since 2022, approximately when that population became isolated from the WSR by beaver dams in the RO Channel (Figures 21 and 22; Bear and Ott 2023). Data collected from these sites are used to generate annual abundance estimates and monitor changes in fish population and health over time.

On April 28, one fyke net was set in Fish Creek at the Pond F outlet and another near the Pond AB outlet (Figures 21 and 23). The RO Channel net location initially had substantial aufeis on the valley floor due to reduced RO discharge during winter 2024–2025, which precluded placement of the fyke net until May 6, when the sampling area became ice free (Figures 21 and 22). All fyke nets were checked daily until removal on May 9.

Water temperatures were recorded during the Arctic grayling spawning period for inter-annual comparison. Three *Hobo*® brand temperature loggers were deployed on April 4, 2025, in the RO Channel at the Pond AB outlet, in the RO Channel just upstream of the Fish Creek confluence, and in Fish Creek at the Pond F outlet (Figures 21). Water temperature was recorded hourly to capture daily peak high temperatures. The temperature loggers were removed on May 25.

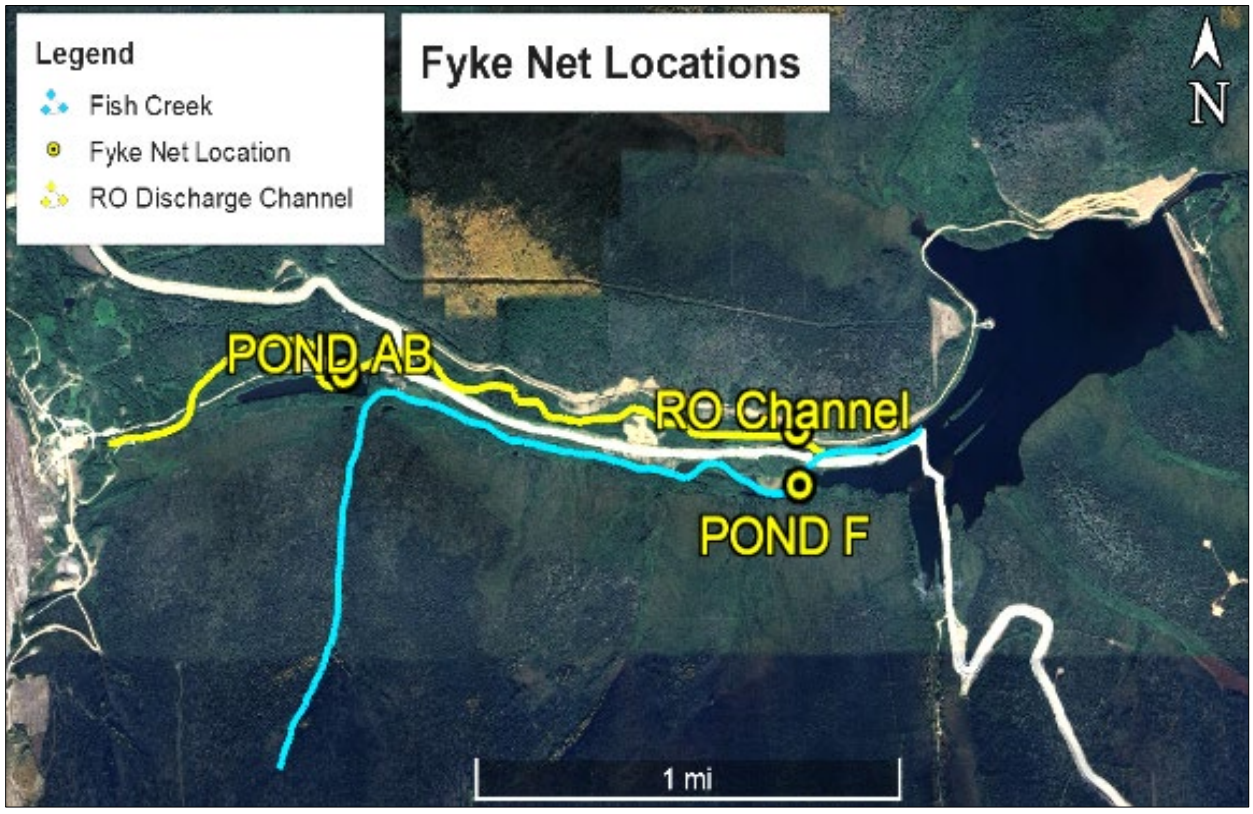

Figure 21.–Fyke net locations in Fish Creek, the RO Channel wetlands complex, and Pond AB 2025.

Figure 22.–Fyke net locations: Fish Creek (left), RO Channel at Pond AB (middle), and Lower RO Channel (right).

Captured Arctic grayling were measured for fork length (FL) to the nearest millimeter, examined for existing tags, assessed for spawning condition, and then released. Untagged Arctic grayling ≥200 mm were tagged with a uniquely numbered Floy® T-bar internal anchor tag for identification. Juvenile Arctic grayling <200 mm were not tagged, but FL was recorded prior to release. Female Arctic grayling were classified as not ripe, ripe, or spent based on spawning condition. Incidental burbot captures were inspected for morphological abnormalities, measured for total length (TL) to the nearest millimeter, then released untagged. Both Arctic grayling and burbot were visually inspected for signs of larval *Diplostomulum* of the eye (eye fluke) by examining both eyes for milky white pupils instead of the typical black pupils, and observations were recorded. See *Burbot Assessment: Current environmental dynamics* for a detailed parasite description.

The 2024 population abundance estimate for Arctic grayling used spring 2024 as the mark event and spring 2025 as the recapture event. Only fish ≥240 mm were included in the abundance estimate. The abundance of Arctic grayling was calculated using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951) and variance calculated following Seber (1982):

Population estimates were calculated as (Chapman 1951):

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

$\widehat{N}_c$= estimated population
n_1= fish marked in first capture event
n_2= fish recaptured during second event
m_2= fish captured during recapture event that were marked in first capture event

Variance was calculated as (Seber 1982):

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

The 95% CI for the population estimate was calculated as:

$$95\%\ \text{CI} = N_c \pm (1.960)\sqrt{\widehat{\text{var}}(\widehat{N}_c)}$$

The Catch Per Unit Effort (CPUE) for each fyke net was calculated as the total number of Arctic grayling captured divided by the hours of fishing effort since the preceding sampling event.

CPUE was calculated as:

$$\text{CPUE} = \left\{\frac{\text{Catch (Number of Fish)}}{\text{Effort (Hours)}}\right\}$$

RESULTS AND DISCUSSION

Water Supply Reservoir

Water Temperature

The 2025 Fish Creek daily peak water temperature was consistent with previous years without RO water intrusion, such as 2019 and 2024, when the Pond AB culverts were blocked and RO discharge water was diverted into Fish Creek (Bear 2020). On April 28, 2025, Fish Creek measured 1.5°C, reflecting conditions influenced solely by natural groundwater and spring meltwater. Cooler spring air temperatures during the 2025 sampling period kept water temperatures lower than in 2024 (Figure 23). The latest spring recorded in the dataset occurred in 2013, when Fish Creek remained below the 4°C spawning threshold until late May, after which it warmed rapidly.

The RO Channel exhibits a distinct winter and spring temperature gradient, with warmer water upstream near Outfall 002 and colder water downstream. RO water enters the system at approximately 6.0°C and begins cooling in Pond AB. Lower in the RO Channel, aufeis formation during winter maintains near-zero flowing water temperatures until late spring. This gradient was evident on April 28, 2025, when the peak daily temperature at the Pond AB outlet was 2.5°C but only -0.3°C just upstream of its confluence with Fish Creek (Figure 21 and 24). This wide temperature range complicates spring sampling timing; thus, Fish Creek temperatures remain the preferred indicator for scheduling fish sampling because they reflect natural conditions unaffected

by discharge variability. By May 21, 2025, RO Channel and Fish Creek water temperatures equalized as spring progressed and warmer weather dictated thermal conditions (Figure 24).

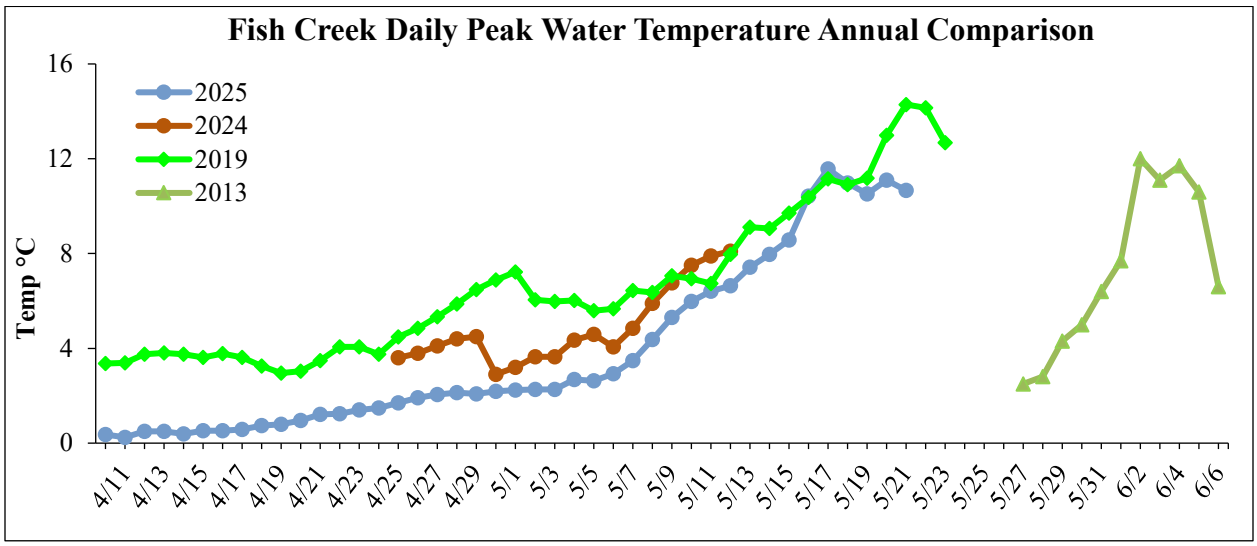

Figure 23.–Daily peak water temperature in Fish Creek at Pond F outlet; select years for reference.

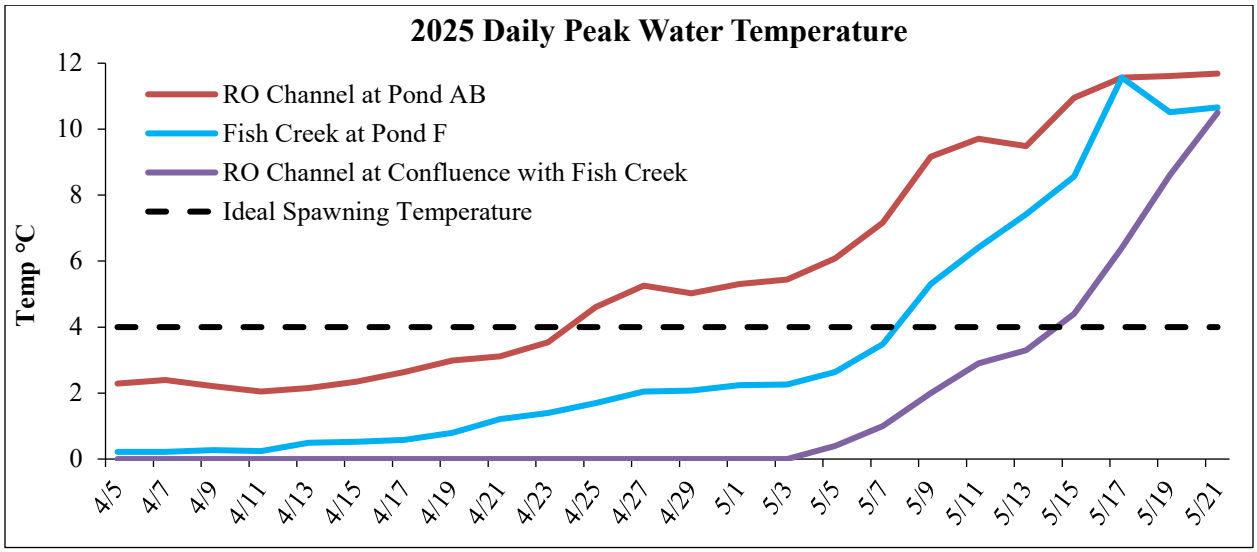

Figure 24.–Daily peak water temperatures in Fish Creek at Pond F outlet, RO Channel at Pond AB outlet and RO Channel upstream of its confluence with Fish Creek, 2025.

Arctic Grayling CPUE

A total of 722 Arctic grayling were captured in the Fish Creek and RO Channel fyke nets during spring sampling. Arctic grayling catch per unit of effort (CPUE) in Fish Creek varied throughout the sampling period, peaking at 5.8 fish/hour on May 9, the final day of sampling, when water temperatures approached the ideal spawning temperature of 4.0°C (Figures 24 and 25). Similarly, CPUE in the RO Channel reached a peak of 5.7 fish/hour on May 9, coinciding with Fish Creek's peak CPUE (Figure 25).

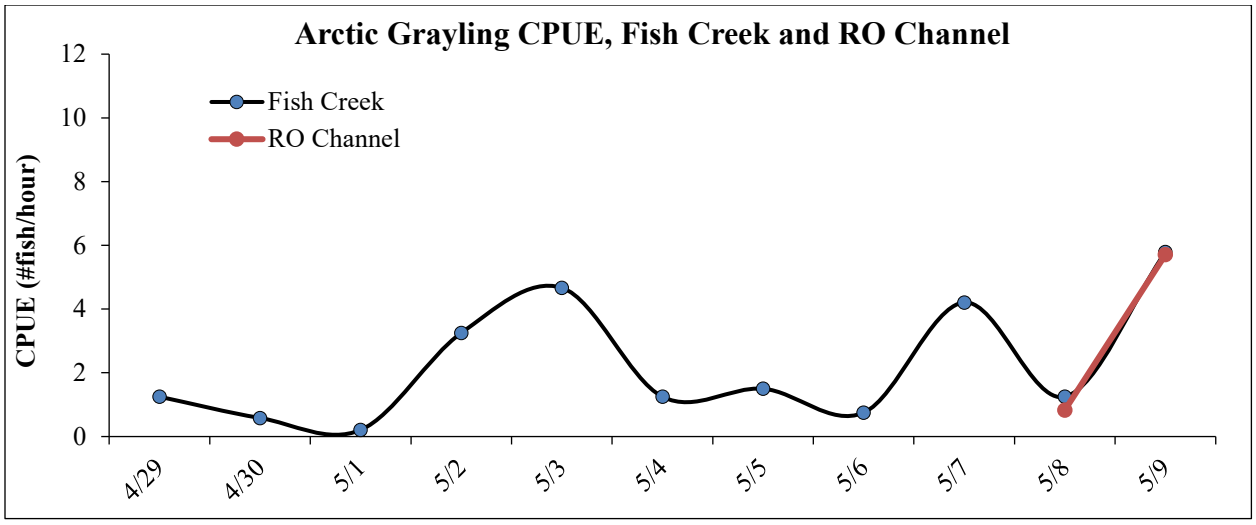

Figure 25.–Arctic grayling catch per unit of effort (CPUE in #fish/hour) in Fish Creek at Pond F and RO Channel fyke nets, 2025.

Female Arctic Grayling Spawning Condition

On April 29, 2025, the first sampling day, all females were classified as not ripe. By May 8, 56% were classified as ripe, while 44% remained not ripe. (Figure 26). No spent females were observed during sampling, likely since Fish Creek water temperatures remained below 4°C for most of the sampling period (Figure 24). The progression from 100% not ripe to over half ripe indicates a temperature-dependent spawning response where the number of fish classified as ripe increase with water temperature. The absence of spent individuals suggests spawning was delayed until after the sampling period, likely due to persistently low water temperatures in 2025. In contrast, spent females have been documented during the sampling period in years where water temperature increased more quickly compared to 2025.

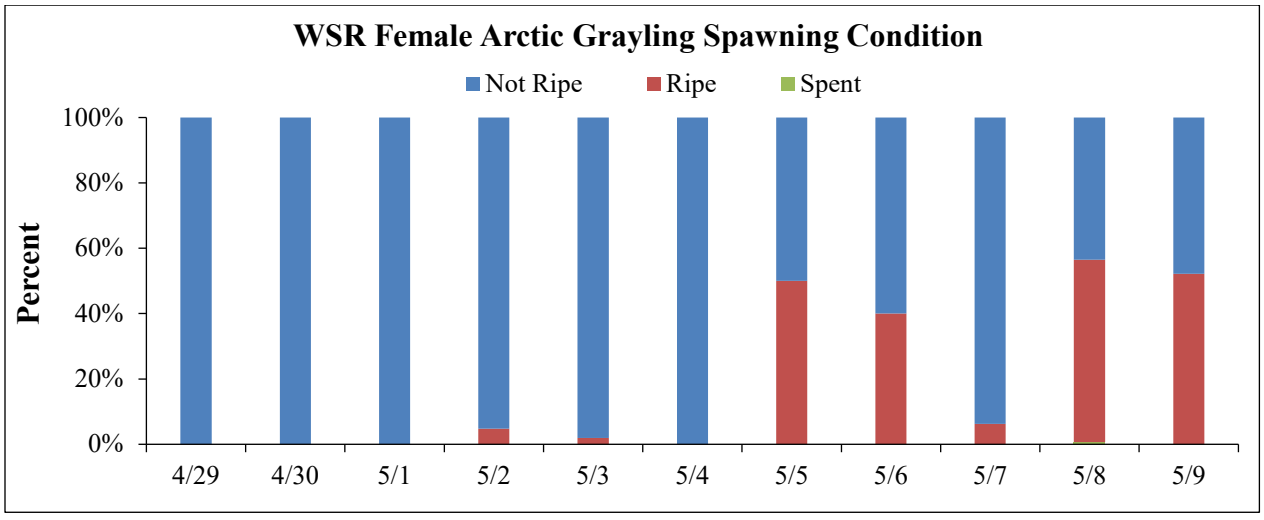

Figure 26.–Spawning condition of female Arctic grayling classified as: not ripe, ripe, or spent, 2025.

Arctic Grayling Population Abundance

In spring 2025, 722 Arctic grayling ≥240 mm were captured in the Fish Creek and RO Channel fyke nets, of which 287 were recaptures. The 2025 capture total excludes 24 fish <240 mm, as they were likely too small to tag in 2024. The 2024 Arctic grayling population estimate was 3,511 fish ≥200 mm (95% CI: 3,268–3,835 fish). Population estimates indicate a decline in abundance from 2017–2021, followed by an increase in 2022–2023, and a subsequent decline in 2024 (Figure 27). The population remains above the post-mining management goal of 800–1,600 fish ≥200 mm.

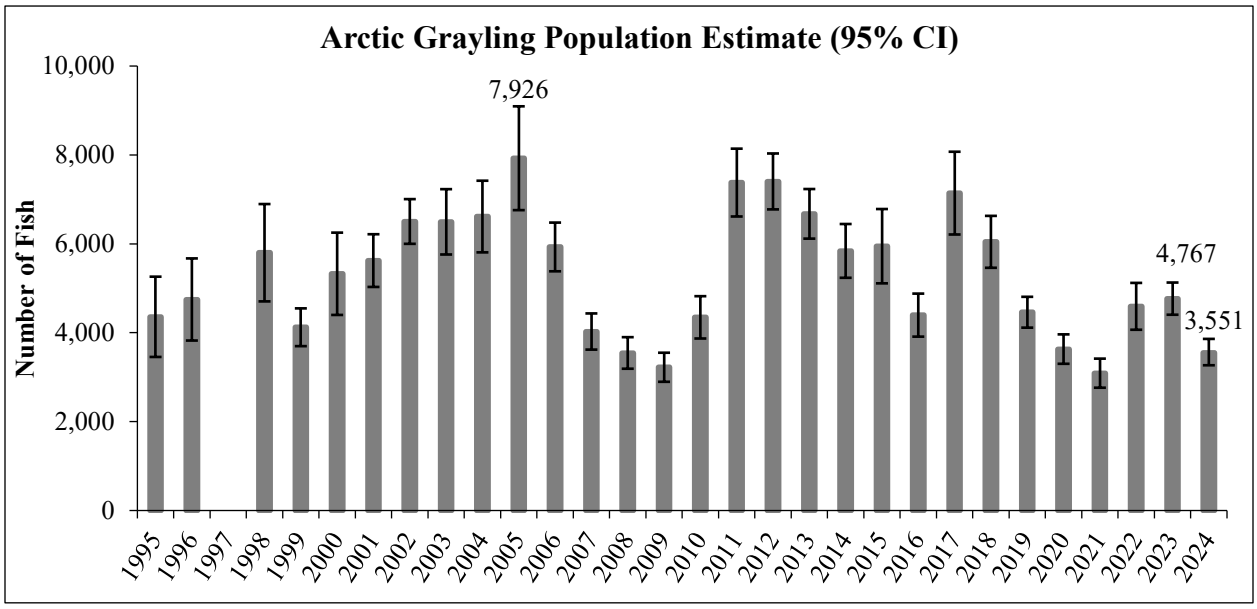

Figure 27.–Annual WSR Arctic grayling population estimates (≥200 mm) with 95% CI, 1995–2024.

Arctic Grayling Recruitment

Recruitment is defined as the total number of untagged Arctic grayling ≥200 mm captured in spring 2025 that were below the tagging threshold (<200 mm) in spring 2024. These age-2 and age-3 individuals typically range from 200–240 mm during spring sampling. Recruitment varies among sampling years, generally following a sinuous pattern. The highest recorded recruitment occurred in 2017 with 406 fish, followed by a decline from 2018–2020 to 41 fish (Figure 28). Recruitment peaked again in 2022 at 370 fish before progressively decreasing from 2023–2025 to 24 fish. In 2025, recruitment was 24 Arctic grayling within the 200–240 mm size range, consistent with other low years in the dataset.

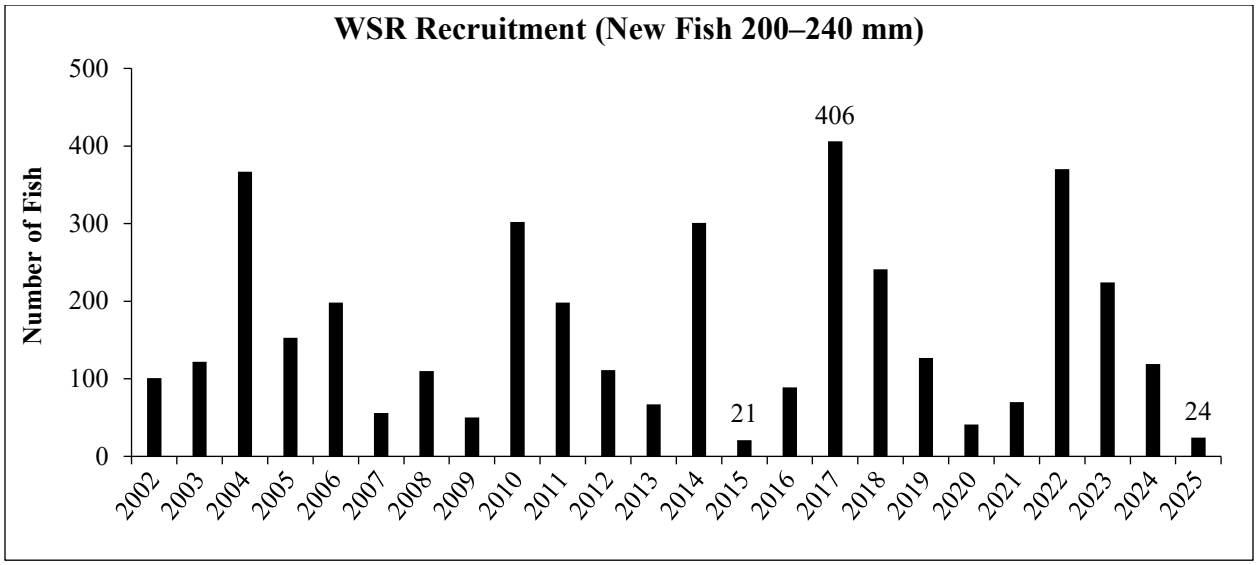

Figure 28.–WSR Arctic grayling recruitment (fish 200–240 mm) 2002–2025.

Arctic Grayling Growth and Length Frequency

Since the construction of the WSR in 1994, the annual average growth of Arctic grayling across size classes has generally increased. Prior to WSR development, growth ranged from 3–17 mm/year among the size classes (Figure 29). In 2025, the average growth for Arctic grayling measuring 210–219 mm at marking was 41 mm (n = 3), while those measuring 260–269 mm exhibited an average growth of 16 mm (n = 59) (Appendix D). This illustrates the decline in annual growth as Arctic grayling age.

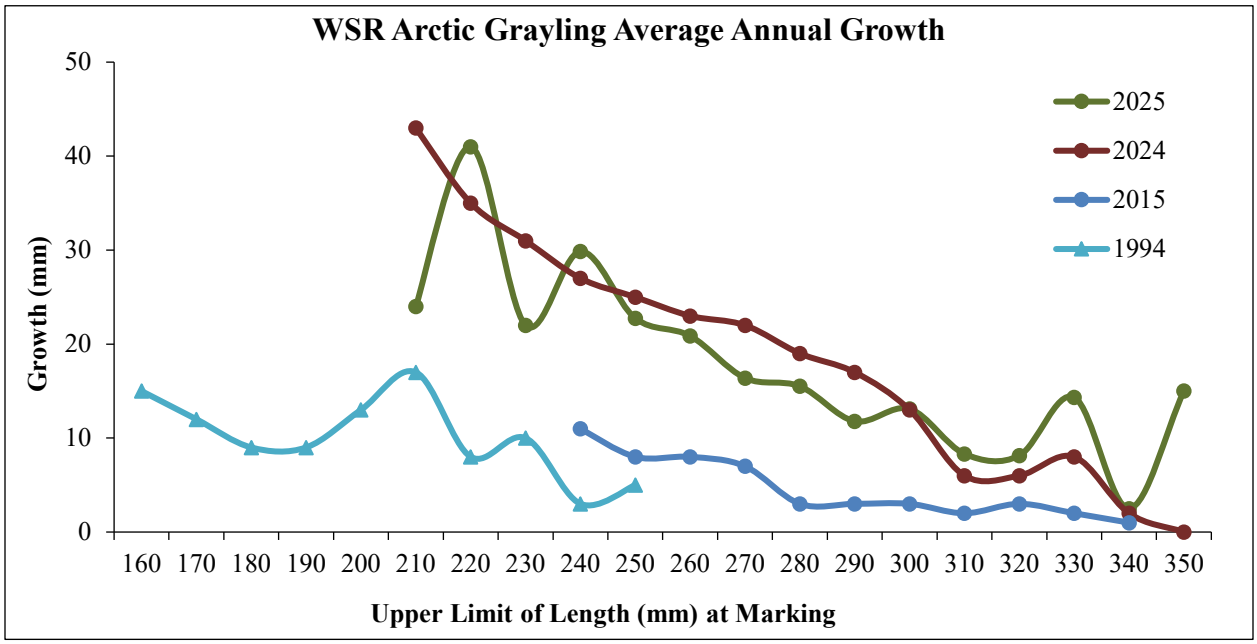

Figure 29.–Average annual growth of Arctic grayling by size group in select years including 1994 baseline (before WSR construction).

The 2025 length frequency distribution of Arctic grayling captured in Fish Creek and the RO Channel fyke nets is presented in Figure 30. Data from 1995, before WSR construction, are included for comparison. The 1995 length frequency distribution reflects the stunted size of individuals in the population compared to 2025. The 1995 average length was 176 mm, while the 2025 average length was 281 mm. The current population shows a primary distribution between 225–355 mm with very few individuals <225 mm captured (Figure 30). Sexually immature Arctic grayling, typically <200 mm within the WSR, may not migrate into the Fish Creek wetlands during spawning timing therefore reducing their likelihood of capture, especially in years with persistent low water temperatures like observed in 2025.

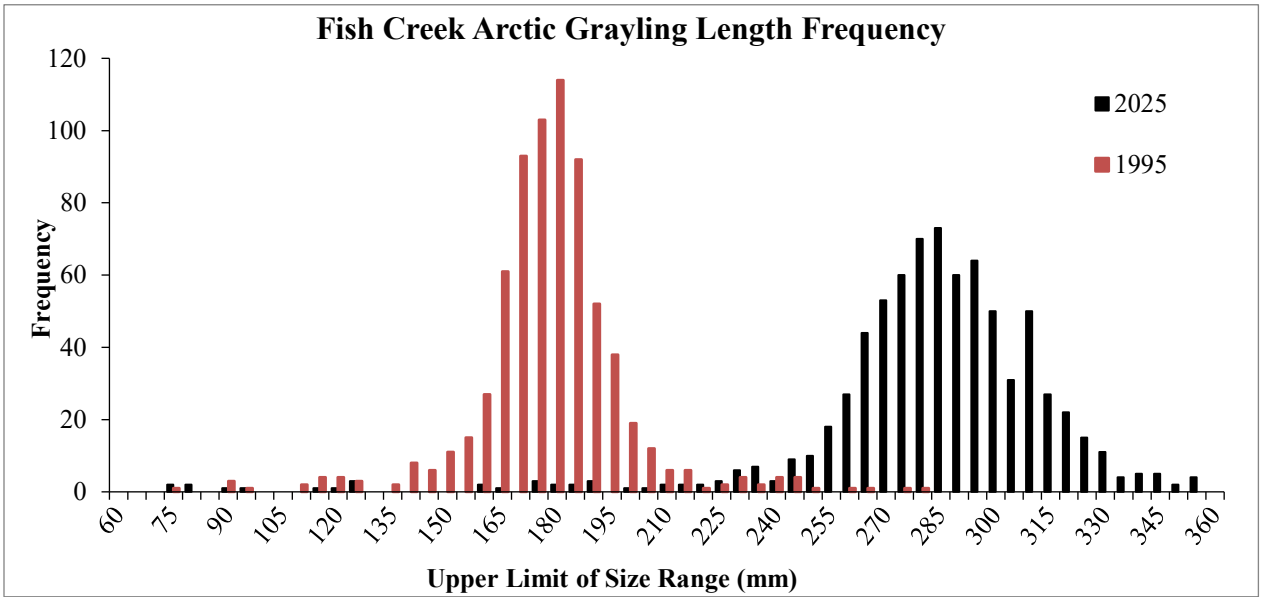

Figure 30.–Length frequency distribution of Arctic grayling captured in Fish Creek, 1995 and 2025.

Pond AB

Pond AB is the uppermost waterbody in the RO wetlands complex, located immediately downstream of the tailings dam and the RO water discharge point (Outfall 002) (Figure 1). Arctic grayling and burbot initially accessed Pond AB during the high RO discharge years (2019–2022). These populations became isolated between 2023 and 2025 due to reduced RO discharge rates combined with beaver dam construction, which restricted fish movement within the RO channel.

A fyke net was deployed in Pond AB from April 28 to May 9, 2025, capturing 501 Arctic grayling, 157 of which were of taggable size (>200 mm). Thirty-four Arctic grayling were recaptures from the 2024 Pond AB sampling, all originally tagged in Pond AB. During the 2023 and 2024 sampling events, two Arctic grayling were recaptured that had been tagged in the lower RO Channel fyke

net, suggesting limited fish passage occurred, most likely during high-water events. In 2025, no Arctic grayling were recaptured from the lower RO Channel or Fish Creek sample sites, indicating Pond AB remains generally isolated from the WSR and Fish Creek wetlands populations.

Population Estimate

In 2025, 98 Arctic grayling >230 mm were captured, including 34 recaptures from 2024. The 2024 population estimate of Arctic grayling ≥200 mm in Pond AB was 635 fish (95% CI: 482–789), which is lower than the 2023 estimate of 1,243 fish (95% CI: 866–1,620) (Figure 31) (Appendix F).

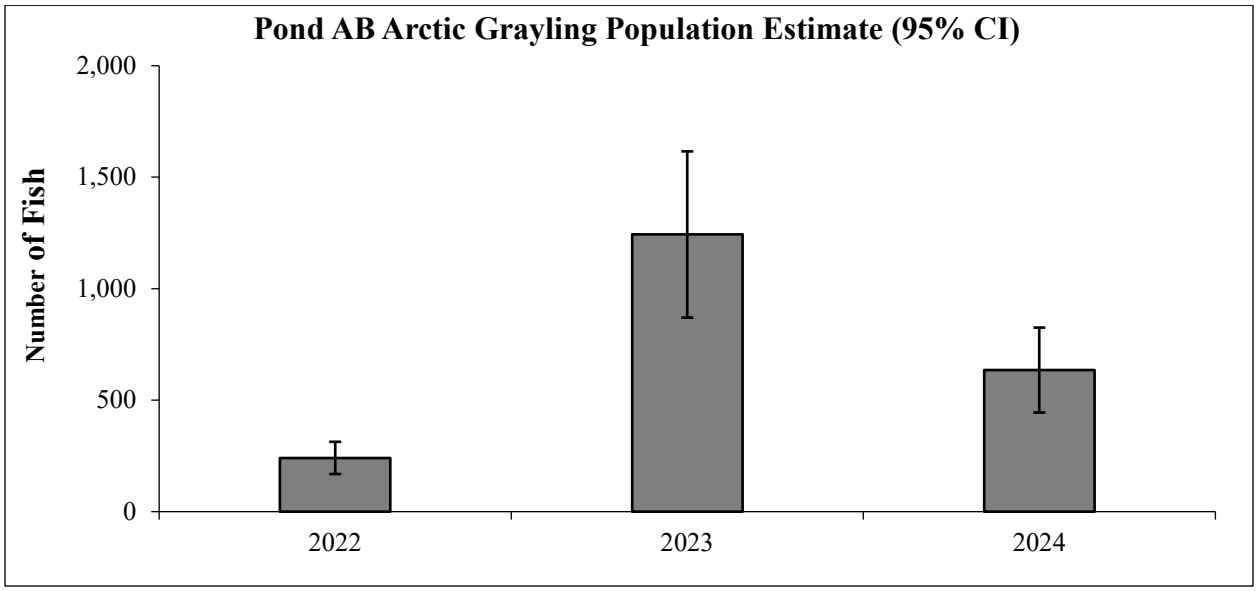

Figure 31.–Annual population estimates of Arctic grayling in Pond AB with 95% CI, 2022–2024.

Length Frequency

Length frequency distributions from 2022–2025 suggests most Arctic grayling in Pond AB belong to a single cohort that entered in 2019. Average length increased from 173 mm (2022) to 237 mm (2023) and further to 261 mm (2024) (Figure 32). In 2024, eight juvenile Arctic grayling (<120 mm) were captured, suggesting successful spawning occurred in Pond AB as the 2019 cohort reached sexual maturity.

In 2025, Arctic grayling ranged in length from 88–290 mm, with an average of 189 mm and 20 juveniles (<120 mm) captured. (Figure 33). The average length declined from 261 mm in 2024 to 189 mm in 2025, with 344 of the 501 fish captured below the taggable threshold of 200 mm. These findings support the assumption of ongoing successful spawning within the isolated Pond AB population.

The 2025 length frequency distribution shows decreased prevalence of large Arctic grayling compared to 2024 and distinct size classes present in Pond AB (Figure 33). Small fish averaged 130 mm, medium size fish averaged 190 mm (most abundant), while larger fish (240–290 mm) declined compared to 2024 (Figure 33).

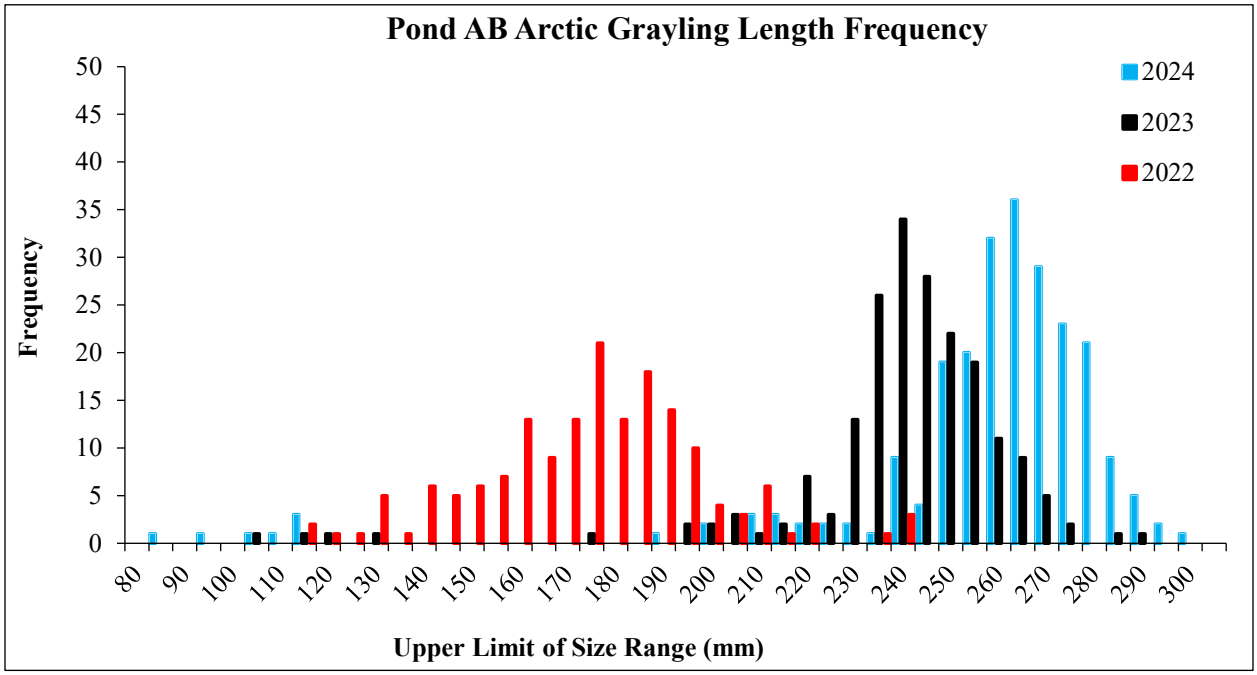

Figure 32.–Length frequency distributions of Arctic grayling captured in Pond AB, 2022–2024.

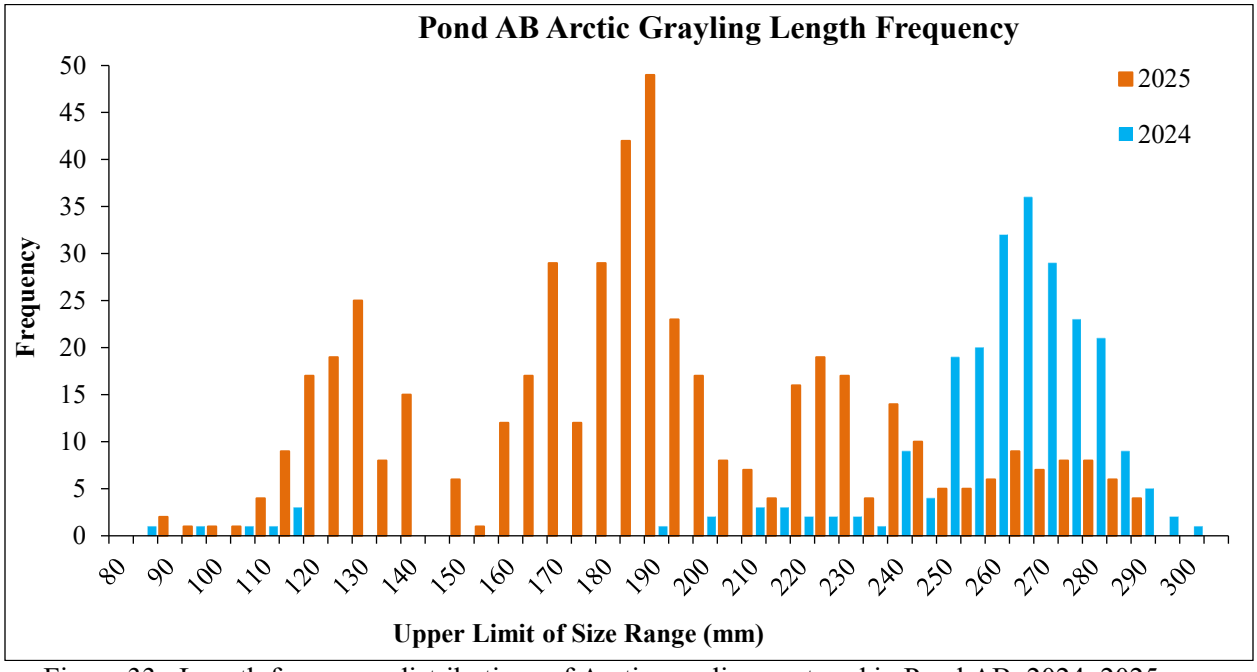

Figure 33.–Length frequency distributions of Arctic grayling captured in Pond AB, 2024–2025.

Growth

Small Arctic grayling in Pond AB (200–210 mm) exhibited the highest annual growth, with rates declining as size increased (Figure 34). Juveniles primarily feed on zooplankton before shifting to immature aquatic insects, while adults rely on drifting insects such as black flies, mayflies, stoneflies, and caddisflies. In 2025, growth for larger grayling (240–290 mm) was near zero, and overall growth across all size classes was significantly lower than that of Fish Creek Arctic grayling (Figure 34). Reduced growth combined with fewer large adults captured suggests limited food resources may have led to downstream movement or mortality.

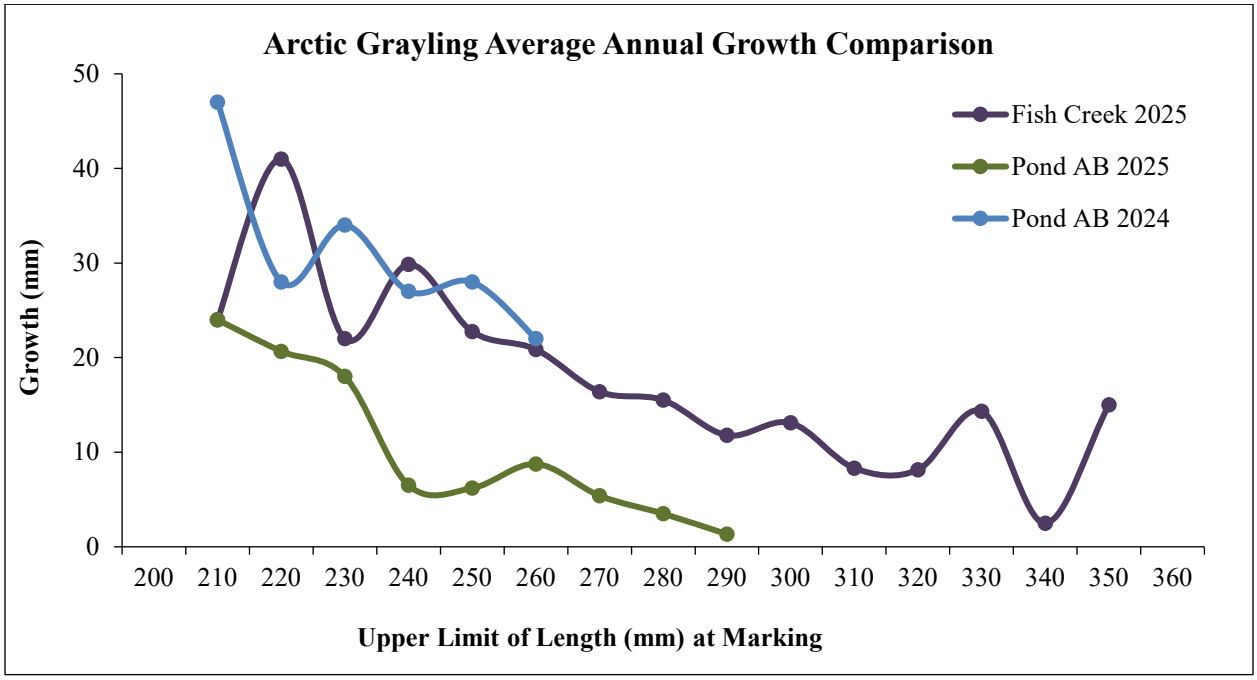

Figure 34.–Average annual growth of Arctic grayling by size group in Pond AB, with Fish Creek growth for comparison.

CPUE

Pond AB CPUE for Arctic grayling ≥200 mm peaked at 1.3 fish/hour on April 29, the first day of sampling (Figure 35). This was lower than Fish Creek's peak CPUE of 5.8 fish/hour on May 5, when new fish migrated from the WSR to spawn as water temperature approached 4°C. Most Fish Creek captures were ≥200 mm, whereas most Pond AB fish were <200 mm, contributing to its lower CPUE for fish ≥200 mm.

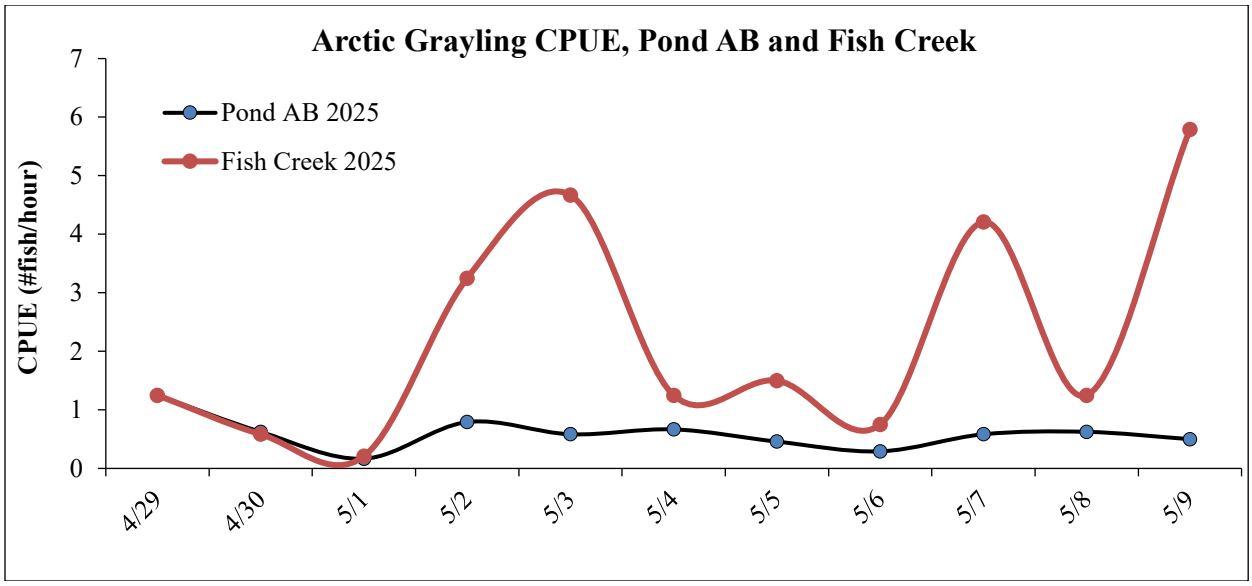

Figure 35.–Catch per unit of effort (CPUE in #fish/hour) for fish >200 mm FL captured in the Pond AB and Fish Creek fyke nets, 2025.

Female Arctic Grayling Spawning Condition

No spent females were observed in Pond AB during the sampling period (Figure 36). However, some spawning may have occurred prior to sampling, as water temperature was 5.6°C on April 29, the first day of sampling. Spawning could occur in the RO Channel upstream of Pond AB or downstream below the outlet culverts, where spent fish could avoid capture. By May 9, 83% of females were classified as ripe and 17% remained not ripe, indicating that spawning continued beyond the sampling period.

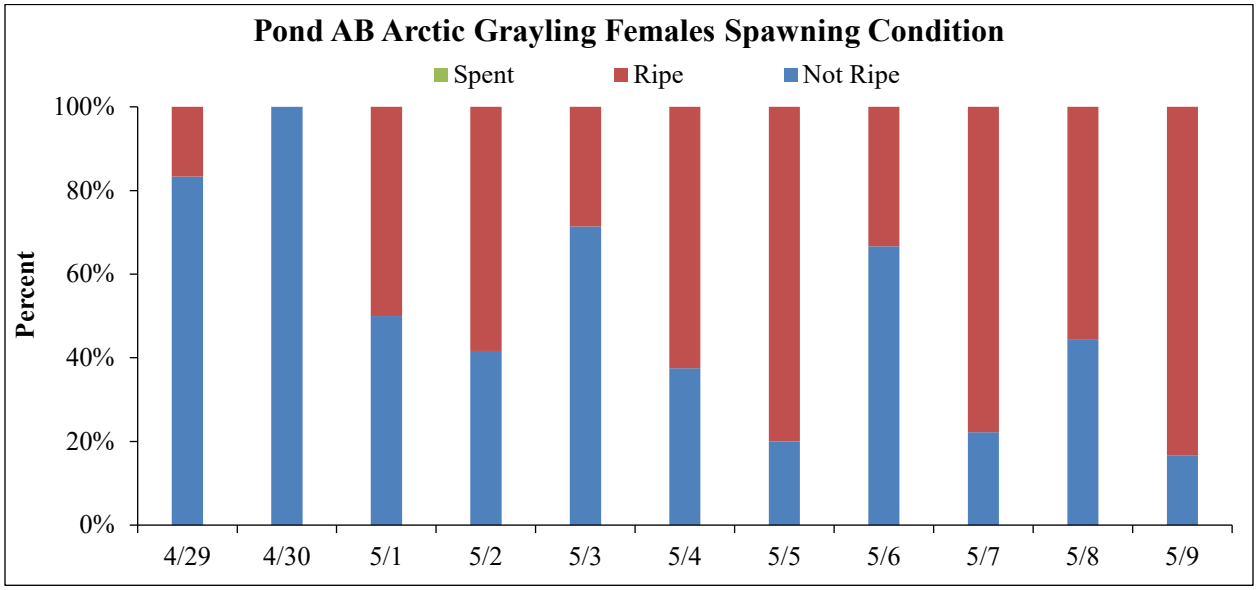

Figure 36.–Spawning condition of female Arctic grayling classified as ripe, not ripe, or spent in Pond AB, 2025.

Arctic Grayling Current Environmental Dynamics

Larval *Diplostomulum* of the Eye (Eye Fluke) Observations

During July and September 2024 sampling in the Stilling Basin and WSR, larval *Diplostomulum* of the eye (eye fluke) was detected in 35% of captured burbot (Bear 2025). In contrast, no eye fluke infections were found among the 775 Arctic grayling sampled in May 2025, indicating the parasite is not currently established in the WSR or Pond AB Arctic grayling despite the high infection rate in WSR burbot. By September 2025, eye fluke prevalence in WSR burbot increased to 75% of captured individuals, while zero of the 15 burbot sampled in Pond AB showed signs of the infection. Given the sharp increase in prevalence observed in fall 2025 WSR burbot, continued monitoring is recommended to determine whether eye fluke becomes established in WSR Arctic grayling and Pond AB fish. See *Burbot–Current Environmental Dynamics* for detailed parasite findings.

Beaver Dam Removal

To improve Arctic grayling passage, ADF&G staff removed a large beaver dam at the Pond D outlet on April 28, restoring access to spawning habitat within the Fish Creek wetlands complex (Figure 37). Annual removal of dams at Ponds D, E, and F is necessary to maintain this access to the lower wetlands complex (Figure 1). The optimal timing for Pond D dam removal is October 1–15, just prior to freeze-up, allowing rearing fish to move to their overwintering habitat in the WSR. Beaver dams obstruct the middle and upper reaches of Fish Creek and the RO Channel, limiting access to spawning areas; similar constraints occur in Last Chance Creek and Solo Creek. Maintaining connectivity to the Fish Creek complex is essential for Arctic grayling spawning success, juvenile rearing, and outmigration to overwinter habitat in the WSR.

Figure 37.–Pond D outlet in the Fish Creek Drainage annual beaver dam removal.

BURBOT ASSESSMENT

Burbot (*Lota lota*) are a freshwater species of the cod family and reside in the WSR and wetlands complex, where they move among the WSR, Fish Creek, and the RO wetland complex. Although no post-mining population goal was established for burbot in the WSR, a small population ≥400 mm has persisted. Juveniles primarily feed on aquatic invertebrates before shifting to a piscivorous diet dominated by Arctic grayling and occasionally other burbot. Because burbot are long-lived (15–20 years) and slow-growing, population recovery from disturbances can take years. Their reliance on cool, well-oxygenated habitats makes them sensitive to changes in water quality and connectivity. The WSR and wetlands complex provides quality habitat but the absence of hydrologic connectivity beyond the upper Fish Creek drainage, due to the WSR Spillway, restricts movement and prevents genetic exchange and recruitment into the population (Figure 1).

METHODS

The 2025 burbot population assessment in the Fort Knox WSR was conducted September 3–15. Sampling occurs in fall when water temperatures are lower to reduce handling stress to fish. Water temperature was taken by a handheld digital thermometer each sample day at approximately the same time and water depth. Water temperatures ranged from 13.8°C on September 3 to 12.0°C by September 15 and the WSR remained ice-free during the sampling period.

Twenty-five hoop traps were set in the WSR and five in Gil Pond (Figure 38). From September 8–15, two hoop traps were set in Pond AB to determine if burbot continued to inhabit the isolated waterbody, as first documented in 2022 (Bear 2023). Gil Pond is connected to the WSR via a fish passage culvert (FH15-III-0219-A3), allowing movement between the two waterbodies. Therefore, fish captured in Gil Pond are included in the WSR population estimate. Hoop traps were deployed at depths ranging 1.5–4.5 m. Deep-water areas were avoided to prevent mortality from low DO. Traps were baited with cut herring and checked every 2–3 days.

All captured burbot were measured to total length (TL) to the nearest millimeter, inspected for tags, and released. Untagged burbot ≥300 mm were marked with a numbered Floy® T-bar internal anchor tag. The 2024 WSR burbot population estimate used fall 2024 sampling as the mark event and fall 2025 sampling as the recapture event. Abundance was estimated using Chapman's modification of the Lincoln-Petersen model (Chapman 1951), with variance calculated following Seber (1982), following the methods described in the previous section, *Arctic Grayling*

Assessment: Methods. Catch per unit effort (CPUE) was calculated by taking the total number of burbot caught since the last trap check and dividing that total by the number of traps fished and number of days since the last trap check, yielding a number of fish caught per trap per day.

Burbot in the WSR and Fish Creek wetlands were incidentally captured (n=3 ≤300 mm) during spring 2025 Arctic grayling fyke netting. Following post-2023 protocols, these fish were counted, measured, and released untagged. Spring captured burbot are not included in annual WSR population estimates, which rely solely on fall mark–recapture. No previously tagged burbot were recaptured in spring 2025, and zero were captured in the Pond AB fyke net from April 28–May 9.

All burbot captured in the WSR and Pond AB were examined for larval *Diplostomulum* of the eye (eye fluke) following its observed prevalence during 2024 sampling in the WSR and Stilling Basin. Both eyes were inspected for milky white pupils, rather than the typical black pupils, and observations were recorded. See *Burbot Assessment: Current Environmental Dynamics* for a detailed parasite description.

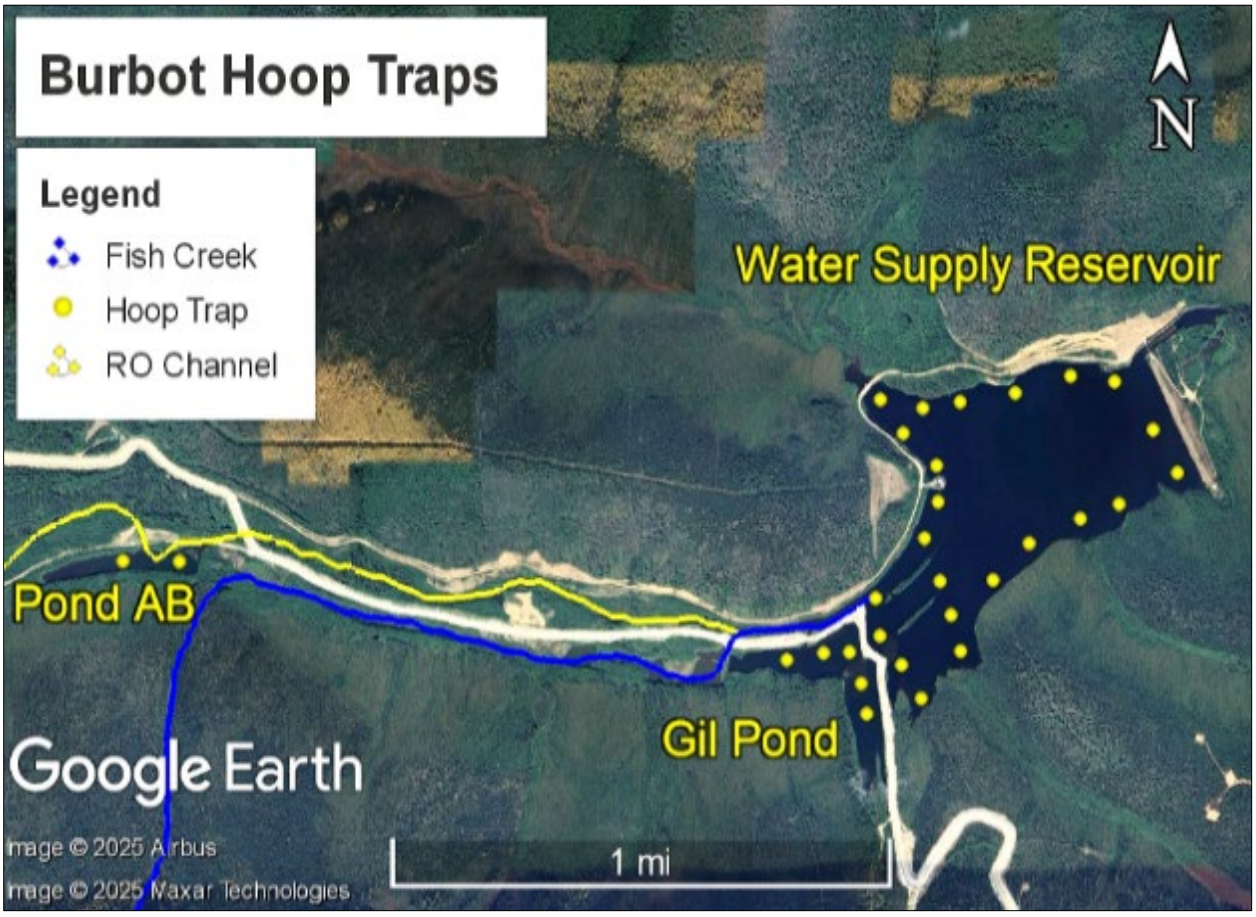

Figure 38.–Burbot hoop trap locations in the WSR, Gil Pond and Pond AB, 2025.

RESULTS AND DISCUSSION

Water Supply Reservoir

Population Estimate

In September 2024, 99 burbot were captured and 55 ≥300 mm tagged, including 30 ≥400 mm. In September 2025, 176 burbot were captured and 60 ≥300 mm were tagged, including 31 ≥400 mm, with eight recaptures from 2024. The 2024 WSR population estimate for burbot ≥400 mm was 109 fish (95% CI: 60–158 fish), substantially lower than the 2023 estimate of 598 fish but within the 2023 wide 95% CI range of 55–1,142 (Figure 39) (Appendix E). The broad CI interval in 2023 was due to a low number of recaptures (n = 3). Prior to 2023, estimates ranged from 80 fish (2013) to 402 fish (2018).

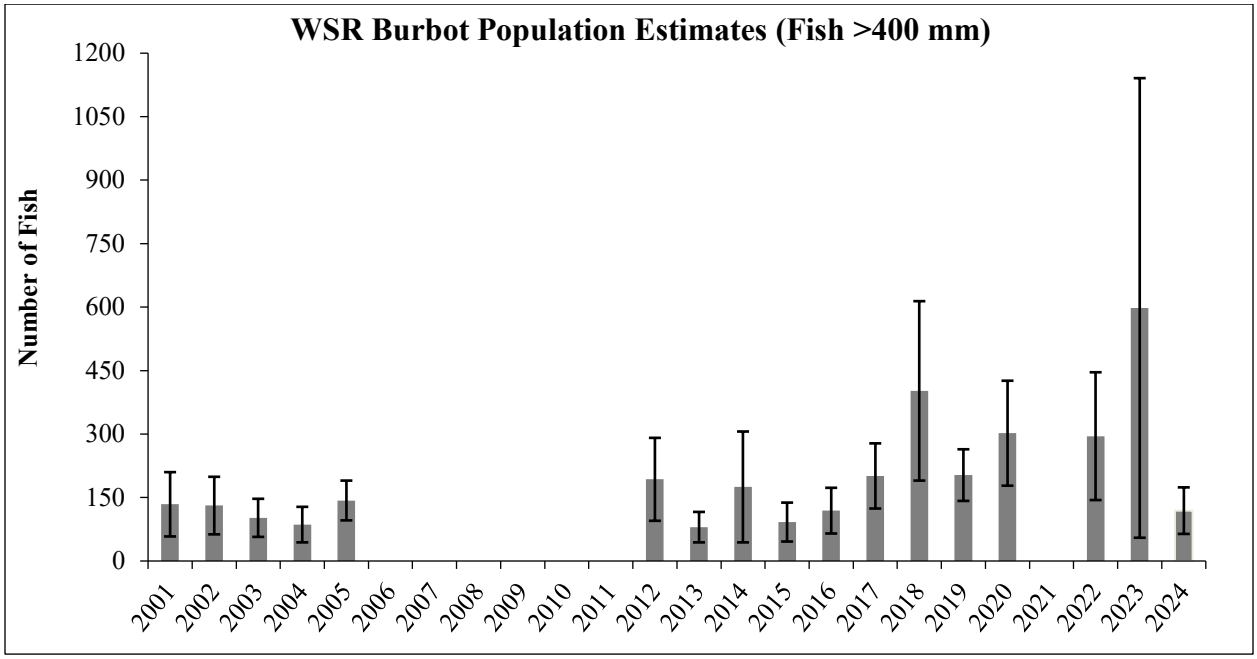

Figure 39.–Annual population estimates of burbot (≥400 mm) with 95% CI in the Fort Knox WSR, 2001–2024.

CPUE

The CPUE for all burbot in fall 2025 sampling was 0.5 fish/trap/day. This is slightly higher than 2024 (0.4) but less than half of 2018 (1.1), and among the lowest since 1996 (Figure 40). The CPUE for burbot ≥400 mm was 0.1 fish/trap/day, equal to 2024 (0.1) but half of 2023 (0.2) (Figures 40).

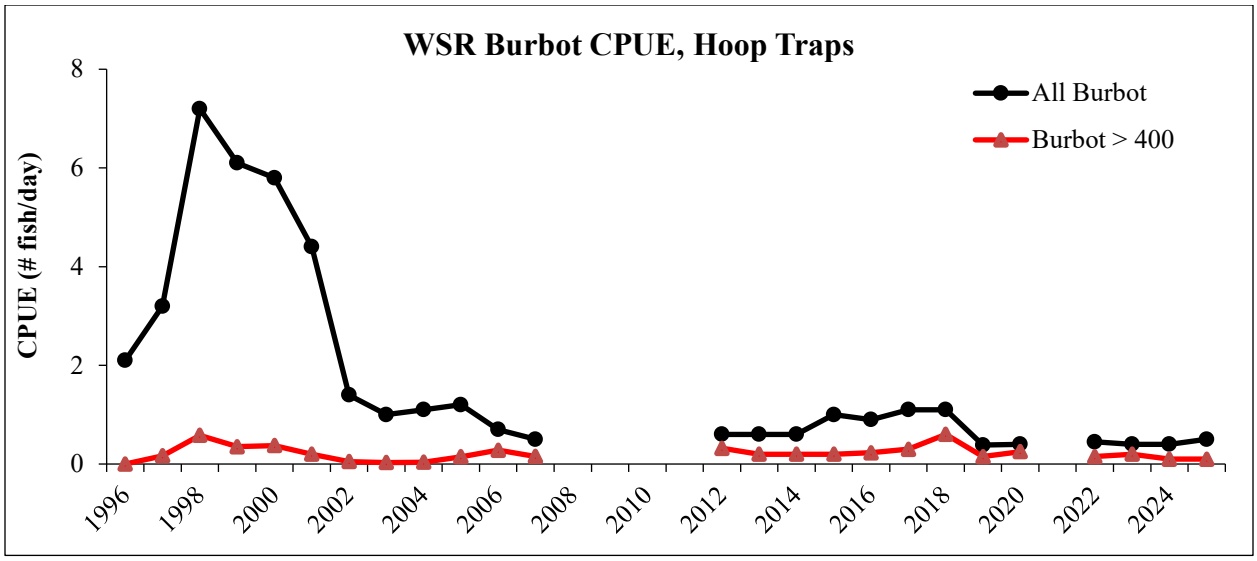

Figure 40.–Burbot catch per unit of effort (CPUE) in the Fort Knox WSR, 1996–2025.

Length Frequency

In fall 2025, burbot lengths ranged from 75 to 745 mm, with 89 juveniles (<200 mm) and only one large individual >600 mm captured. The 2025 length distribution is notably skewed toward smaller fish, with fewer large burbot compared to distributions observed from 2020–2024, using 2023 as an example year (Figure 41). The number of large burbot (>600 mm) peaked in 2020 (21 fish) and declined from 18 in 2023 to one in both 2024 and 2025 (Figure 42). This decline likely reflects mortality among older individuals—potentially associated with blindness caused by the eye-fluke infection—while simultaneously reducing cannibalism and contributing to the increased number of juveniles in the current population (Figure 42).

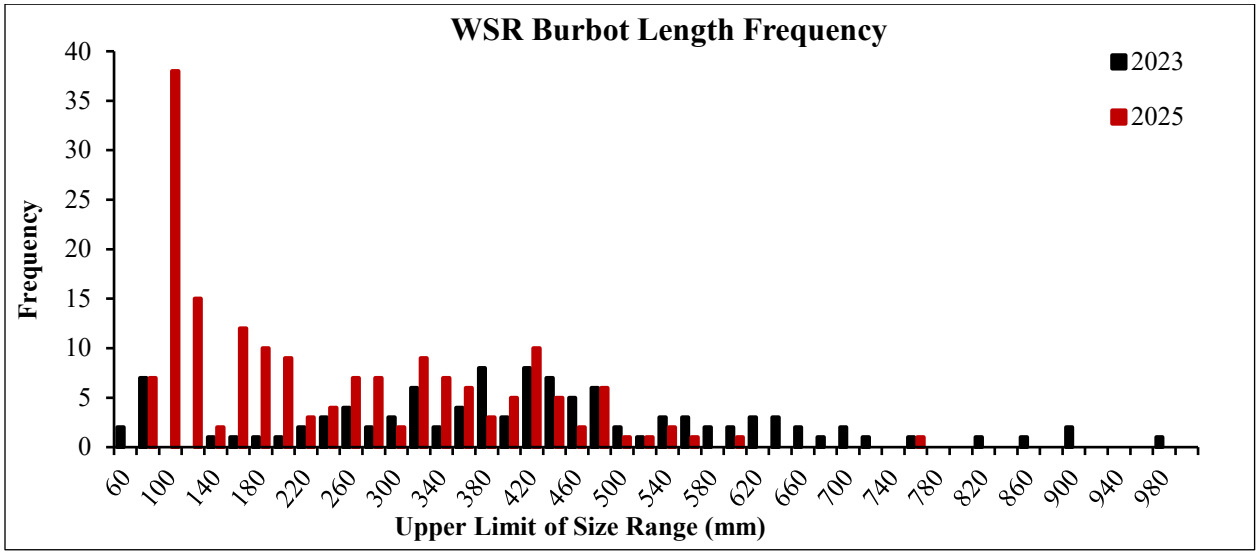

Figure 41.–Length-frequency distribution of burbot captured in the WSR, 2023 and 2025.

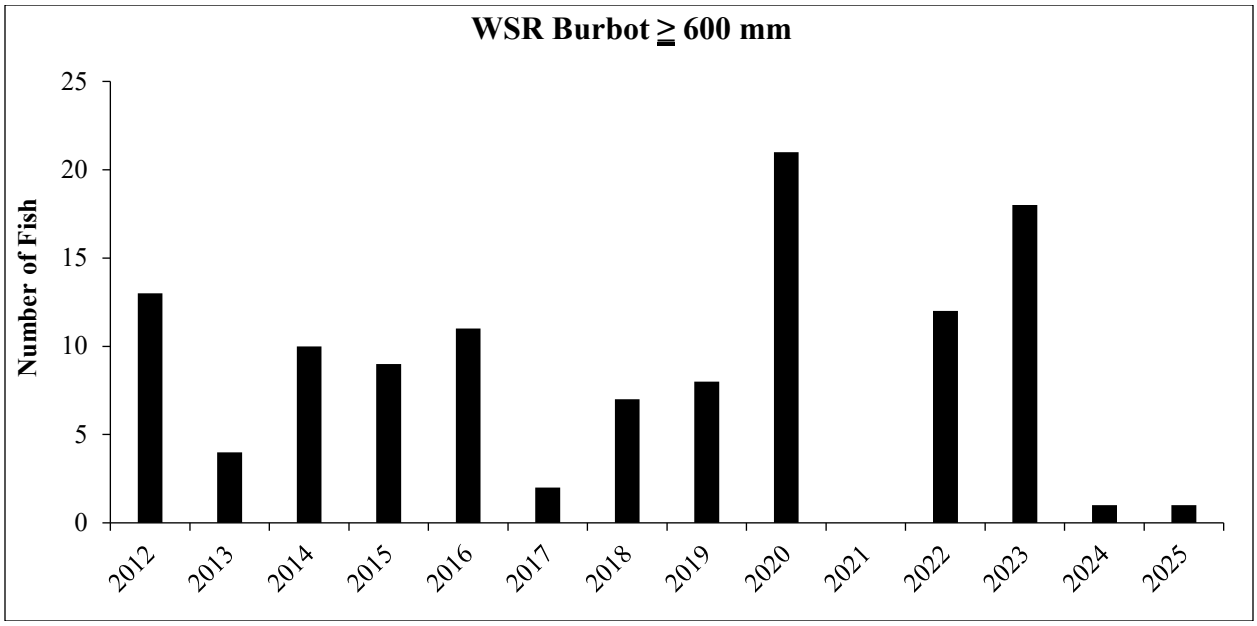

Figure 42.–The number of burbot ≥600 mm captured annually in the WSR, no data available for 2021.

Growth

Average annual burbot growth in the WSR has ranged from 24 mm in 2013 to 70 mm in 2016, with an average annual growth of 46 mm since 2000. In 2024, annual growth measured 63 mm (Figure 43).

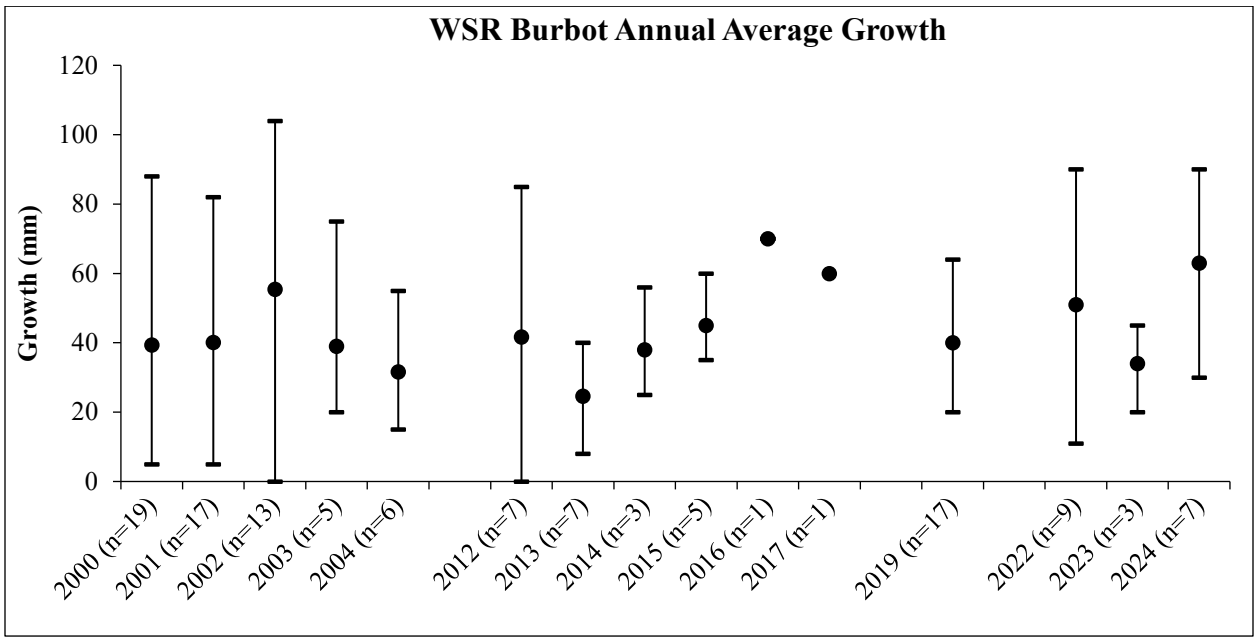

Figure 43.–Average annual burbot growth with minimum and maximum observed growth in the WSR, 2000–2024. Number of recaptured fish per year indicated in parentheses on the x-axis.

Pond AB

Length frequency

Burbot were first documented in Pond AB in 2022 when seven individuals were captured (Bear 2023). Lengths ranged from 170 mm to 301 mm, with an average length of 229 mm. Subsequent sampling in 2023 yielded 25 burbot, and three were captured in 2024. During September 3–15, 2025, 15 burbot were captured, ranging from 240 to 430 mm with an average length of 319 mm, representing an increase in average and maximum length compared to previous years (Figure 44). Eight burbot in 2025 were ≥300 mm and were tagged with unique numbered Floy tags.

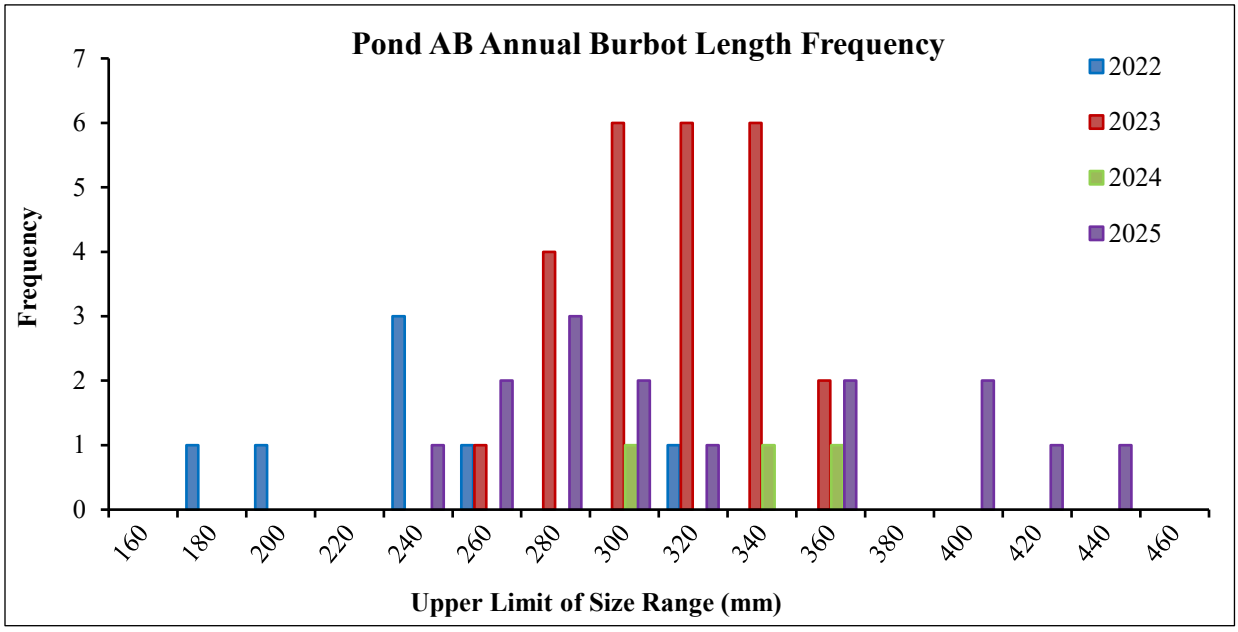

Figure 44.–Length-frequency distribution of burbot captured in the Pond AB, 2022 to 2025.

No juvenile burbot (<200 mm) were captured from 2023 to 2025, suggesting a lack of spawning success within Pond AB and juvenile recruitment from the WSR is absent. Burbot residing in Pond AB are likely an isolated population that migrated in during high RO discharge years (2019–2021). No burbot tagged in 2024 were recaptured during sampling, preventing a 2024 population estimate. The 2023 population estimate for burbot ≥300 mm in Pond AB was 22 individuals (95% CI: 8–35 fish).

The RO Channel connecting Pond AB to the WSR contains multiple beaver dams that impede fish movement. No burbot tagged in the WSR have been recaptured in Pond AB, nor vice versa. Consequently, Pond AB burbot were excluded from the WSR population estimate, and separate assessments will continue until consistent movement is confirmed.

Burbot Current Environmental Dynamics

Larval *Diplostomulum* of the Eye (Eye Fluke) Prevalence

During 2024 WSR sampling, 66 burbot ≥200 mm were captured, with 25 individuals (38%) exhibiting symptoms of eye fluke (Figure 45). In 2025, 87 burbot ≥200 mm were captured, and 65 fish (75%) were infected, indicating a sharp increase. Concurrently, large burbot (>600 mm) captured declined from 18 in 2023 to one in both 2024 and 2025 (Figure 42).

Pond AB was sampled in 2024 and 2025; none of the 18 burbot captured exhibited signs of eye fluke, despite hydrologic connectivity to the WSR via the RO Channel, suggesting the parasite has not moved upgradient from the WSR and become established in Pond AB.

Uninfected burbot typically have black pupils with yellow to golden irises (Figure 46). Milky eyes were previously attributed to trauma or cataracts, but diagnostic testing in 2024 confirmed the presence of eye flukes (ADF&G Pathology Lab Report No. 2025-0016; Ferguson 2025). In September 2025, three whole-body burbot samples were submitted for follow-up diagnostic testing, but results have not been received to date.

Figure 45.–Burbot with eye fluke captured in the WSR, September 2025.

Figure 46.–Burbot with normal pupils captured in Pond AB, September 2025.

The *Diseases of Wild and Cultured Fishes in Alaska Field Guide*, published by the ADF&G Pathology Laboratory, identifies larval *Diplostomulum* of the eye (commonly known as eye fluke) as a digenean larval trematodes of the genus *Diplostomulum*. These parasites infect the eyes of many freshwater fish species in Alaska. A common species D. *spathaceum,* occurs in the eye lens, while others inhabit the vitreous chamber (pupil). Larva can persist in the eye for extended periods of time, often causing cataracts and blindness in the host fish (Meyers et al. 2019).

The life cycle begins when fish are parasitized by free-swimming cercariae released from infected snails. Cercariae penetrate the fish's skin and migrate to the eye, where larvae mature. The host fish is consumed by piscivorous birds (e.g., gulls), allowing the parasite to mature and produce eggs that are expelled in feces. The cycle is completed when eggs develop into miracidia, infect snails, and release cercariae (Meyers et al. 2019).

Glaucous-winged, Glaucous, and Herring gulls are common in interior Alaska. During summer 2024, up to 12 gull pairs nested near the WSR spillway and Stilling Basin (Bear 2024). In 2025, gulls were observed flying within the wetlands complex, but no nesting pairs were observed. These birds are potential hosts for parasites, bacteria, viruses, and fungi that may affect fish populations.

Unidentified *Myxobolus sp*. Infection in Burbot Gills

During 2024 pathology testing (Report No. 25-0016), an incidental finding revealed infection by an unidentified *Myxobolus* species within burbot gill capillaries. Five of seven burbot samples tested positive. Members of this genus exhibit complex life cycles involving oligochaete worms as intermediate hosts; infectious actinospores released by worms penetrate fish tissue (Ferguson 2008).

Currently, only two *Myxobolus* species are known to infect burbot gills: *Myxobolus lotae* (Kola Peninsula, Russia) and *Myxobolus warniakensis* (Northeast Poland) (Muzzall et al. 2011). The unidentified *Myxobolus* sp. detected in Alaska burbot exhibits significantly smaller pseudocysts and myxospores than both species, suggesting a potential novel species (Ferguson 2025). Continued research is essential to confirm this preliminary finding. The pathology report for three whole-body burbot samples submitted in September 2025 is pending.

REPORT CONCLUSION

This report summarizes ADF&G water quality, Arctic grayling, and burbot biomonitoring conducted in 2025 within the Fort Knox Water Supply Reservoir (WSR) and adjacent wetland complexes. Findings indicate stable conditions across the system, with the WSR, Fish Creek, and RO Channel wetlands continuing to provide high-quality overwintering, spawning, and rearing habitat for resident fish populations. Water quality measurements remained within Alaska Department of Environmental Conservation (ADEC) criteria for aquatic life, and fish populations remained in compliance with post-mining permit requirements. Overall, the 2025 results demonstrate stable aquatic habitat conditions under current mine-related and natural environmental influences.

ADF&G biomonitoring results also showed that the WSR Arctic grayling population continued to exceed the established management goal of 800–1,600 fish, reflecting stable habitat conditions and sustained recruitment. In contrast, the WSR burbot population ≥400 mm declined, likely due to increasing parasite prevalence, which appears to be shifting the population's size structure toward smaller size classes and reducing the number of larger, mature individuals. The isolated Pond AB Arctic grayling and burbot populations showed no signs of eye-fluke infection indicating the parasite has not moved upstream from the WSR and become established to date.

The Alaska Department of Fish and Game recommends that FGMI continue supporting Fish Creek rehabilitation projects, active beaver management, and collaborative biomonitoring. Continued investment in these efforts will help ensure early detection of emerging biological or habitat-related challenges and promote the long-term sustainability of aquatic habitats and fish populations within the Fort Knox mine footprint.

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APPENDICES

Appendix A. Summary of Mine Development with Emphasis on Biological Factors, 2011–2025.

2011

- February 9, ADF&G provided input to ADNR on the environmental audit to be conducted in summer 2011. ADF&G identified several possible fish and wildlife enhancement projects originally recommended by Buell and Moody (2005).
- March 4, the ACOE issued a permit (POA-1992-574-M19) authorizing construction of the modified dam raise and expansion of the Tailings Storage Facility (TSF).
- April and May, several Plan of Operations amendments were issued by ADNR for work associated with the TSF, waste rock dumps, powerline, topsoil storage, and dewatering.
- May 2, ADF&G provided input to ADNR on the reclamation and closure plan for Fort Knox. Emphasis was on maintaining the existing developed wetland complex downstream of the TSF.
- Our spring sample event for Arctic grayling and burbot ran May 9–24. ADF&G caught 1,194 Arctic grayling and 117 burbot in a fyke net set in the WSR.
- The estimated spring 2010 Arctic grayling population was 4,346 fish >200 mm long and was an increase from the 2009 estimate of 3,223. Recruitment of new fish in spring 2011 was strong with 198 new fish <230 mm marked.
- A constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring – one chick was seen in August. An active raven nest was observed on the rock cut near the freshwater dam.
- Water began flowing over the spillway on May 27, water had not reached the spillway since winter 2009/2010.
- June 2, ADF&G provided written comments on the Fort Knox and True North environmental audit proposals.
- July 19, FGMI pumped about 10,440 gallons of water from the "801 Pond" downstream – environmental staff were notified, and pumping was immediately stopped – water from the "801 Pond" is supposed to be pumped back into sump below the TSF.
- August 4, ADNR informed us of planned changes at Fort Knox including expansion of the heap leach facility from 160 to 300 million tons, the need for a ADEC permit to discharge non-contact water, and the long-term need for a permit and water treatment plant for closure.
- September 13, ADNR approved the drilling of two monitoring wells in the headwaters of Victoria Creek. The purpose of these monitoring wells is to ensure water in Victoria Creek is not impacted by the increased elevation of tailings in the Pearl Creek drainage.
- September 28, ADF&G met with FGMI to discuss plans to discharge non-contact water from the Fort Knox pit to the WSR.

2012

- ADF&G spring sample event (Arctic grayling and burbot) began on May 7 and ended on May 30. The estimated spring 2011 Arctic grayling population was 7,378 fish ≥200 mm long which was an increase of 3,032 from the 2010 estimate. Recruitment of new fish in spring 2012 was strong with 111 new fish <230 mm marked.
- ADF&G caught 140 burbot (175 to 950 mm long) in spring 2012 in hoop traps and fyke nets.
- Arctic grayling spawned throughout the wetland complex, including the upper portion of Channel C, in spring 2012. Beavers had not rebuilt the dams in the wetland complex.
- A constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring 2012.
- July 13, ADF&G provided input to ADEC on the APDES draft permit for discharge of non-contact water. The discharge point has been changed to the old Fish Creek channel just downstream of Ponds A and B. The ADEC permit was issued on August 15, 2012.
- September 27, ADF&G confirmed that a culvert in the road down the Fish Creek valley had been removed. In our trip report to FGMI, ADF&G recommended some additional civil work to ensure that the discharge water stays on the north side of the valley.

2013

- February 20, FGMI received a Notice of Violation from the ACOE for the unauthorized discharge of fill material into 0.28 acres of wetlands.
- March 1, ADF&G informed FGMI that their 2012 Annual Report was extremely well done and FGMI's report was distributed to all habitat offices in the state.
- March 11, the ACOE issued an After-the-Fact authorization covering the 0.28 acres of wetland fill.
- April 25, water quality data (temperature, dissolved oxygen, etc.) were collected in the WSR under ice cover.
- May 4, the ADNR transmitted comments on the December 2012 reclamation and closure plan.
- The spring sample event (Arctic grayling and burbot) began on May 20 and ended on June 10. The estimated spring 2012 Arctic grayling population was 7,404 fish ≥200
- mm long. Recruitment of new fish in spring 2013 was strong with 114 new fish <230 mm marked.
- ADF&G caught 96 burbot (89 to 697 mm long) in spring 2013 in hoop traps and fyke nets.
- Arctic grayling spawned throughout the wetland complex, including the upper portion of Channel C, in spring 2013. Beavers had rebuilt the dams in the wetland complex, but the dams were notched to allow fish passage.
- A constructed osprey nesting platform adjacent to the main pump house in the WSR was occupied in spring 2013.

- Water was not flowing over the spillway when ADF&G began sampling, but by May 27 water had begun to flow out of the WSR and over the spillway.
- June 25, ADF&G observed Arctic grayling fry (numerous) in the upper portion of Channel C. Very few fry were observed in Pond F and the Pond F outlet.
- October 14, ADF&G submitted comments on the Fort Knox 2013 reclamation plan – eight recommendations were made.
- November 27, ADF&G distributed the Fork Knox technical report for work done in 2013.

2014

- In early April, emails were exchanged to determine when Fish Creek was removed from the list of impaired waterbodies – it was on the 1992 list but was removed from the 1994 list because FGMI had bought out all the existing placer operations and was planning on building the freshwater dam.
- April 2014, the decision was made not to collect winter water quality due to unsafe ice conditions and overflow.
- In spring 2014, ADF&G fished a fyke net in the developed wetlands just upstream of the WSR from April 29 until May 9 and then again from May 12 to 15. Arctic grayling spawned throughout the wetland complex in spring 2014. The only beaver dam present was in the upper end of C Channel.
- Our estimated population of Arctic grayling (>200 mm) for spring 2013 was 6,675 – a slight reduction from the 2011 and 2012 estimates.
- Our estimated population of large burbot ($\geq$400 mm) for spring 2013 was 80 – a substantial reduction from the spring 2012 estimate of 193.
- September 29, FGMI notified state agencies that the new Environmental Manager was Bartly Kleven.
- September 4, ADF&G were notified that the road across Solo Creek had failed – FGMI will determine a proper fix – this is the second time the road has failed at the culvert crossing.
- September 26, the developed wetlands and lower Last Chance Creek were inspected. No beaver dams were observed in Ponds D and F and in lower Last Chance Creek (dams had been removed by FGMI during summer).
- October FGMI and ADF&G discussed a draft design for the Solo Creek culvert replacement, conducted a field inspection, and continued discussions to decide what remedial work will be done.
- October 28, ADF&G distributed the Fork Knox technical report for work done in 2014.
- November 12, FGMI submitted a permit application to replace the Solo Creek culvert. ADF&G had several questions regarding the culvert design specifications and FGMI addressed these questions and a permit was issued on November 20, 2014 to install the new 10-foot diameter pipe.

2015

- March 2, ADF&G conducted a field visit to observe the discharge point for non-contact mine water to the old Fish Creek channel, which is dry, except for breakup and periods of heavy rain.
- FGMI initiated the discharge of non-contact water (about 250 gallons per minute) in mid-March and the discharge has been continuous except for a few shutdowns. The discharge was authorized by a permit issued by the ADEC.
- April 8 and 9, ADF&G collected water quality data in the WSR which was ice covered, high DO concentrations were found in Fish Creek Bay.
- April 17, ADF&G collected water quality data in the old Fish Creek channel downstream from where the non-contact mine water was being discharged and found very high DOs in the water – leading us to conclude that the discharge of non-contact mine water resulted in increased DOs in the WSR.
- Early May, ADF&G field inspected the culvert replacement in Solo Creek and concluded that it had been installed in accordance with the Fish Habitat Permit.
- Spring 2015, ADF&G fished a fyke net in the developed wetlands just upstream of the WSR from May 4 to 8 and then again from May 10 to 13. Arctic grayling spawned throughout the wetland complex in spring 2015.
- Our estimated population of Arctic grayling (≥200 mm) for spring 2014 was 5,841 – a slight reduction from the 2011 and 2012 estimates.
- The estimated population of large burbot (≥400 mm) for spring 2014 was 175 – a substantial increase from the spring 2013, but with a large 95% CI.
- June 19 and July 23, ADF&G collected Arctic grayling fry in the wetland complex, average size on June 19 was 29.7 mm and on July 23 it was 57.3 mm.
- June 19, ADF&G inspected the Last Chance culvert in the Gil Causeway. Material at the east end of the pipe has slumped and the road was blocked with cones and flagging.
- October 28, ADF&G distributed the Fork Knox technical report for work done in 2015.

2016

- March 29 and 31, water quality data were collected at six sites in the WSR, five of which have been sampled nearly annually since 1998. Average winter water column dissolved oxygen at Site 2 (middle of the WSR) was the highest on record and likely the result of the near continuous discharge of non-contact water into the old Fish Creek channel just upstream of the wetland complex.
- In spring 2016, ADF&G fished two fyke nets in the developed wetlands just upstream of the WSR and in Pond F from April 25 to May 4. Based on the fyke net catches, most of Arctic grayling spawned in the wetland complex downstream of Pond F.

- Our estimated population of Arctic grayling (≥200 mm) for spring 2015 was 5,947 – a slight increase from the 2014 estimate.
- Our estimated population of large burbot (≥400 mm) for spring 2015 was 92 – a substantial decrease from spring 2014.
- In early October, hoop traps fished in the WSR captured 26 burbot ranging in size from 200 to 630 mm long.
- October 12, ADF&G met with ADEC and FGMI to discuss plans to design and install a new water treatment plant just downstream of the tailings dam with an estimated discharge of 2,000 to 6,000 gallons per minute.
- October 28, ADF&G were notified by FGMI that beaver dams at Pond D outlet and downstream of Pond F had been removed.
- December 21, ADF&G sent a summary of our meeting on the new water treatment plant to FGMI.

2017

- April 12 and 19, water quality data were collected at six sites in the WSR, five of which have been sampled nearly annually since 1998. Average winter water column dissolved oxygen at Site 2 (middle of the WSR) was above the 15-year running average and the second highest on record, behind 2016.
- In spring 2017, ADF&G fished two fyke nets in the developed wetlands just upstream of the WSR and in Pond F from early May to May 18. Based on the fyke net catches and observations, most Arctic grayling spawned in the wetland complex downstream of Pond F. About 100 Arctic grayling adults were moved from the Pond F fyke net and released into Pond D upstream of a barrier. These fish successfully spawned in Pond D as fry were captured on June 29.
- Our estimated population of Arctic grayling (≥200 mm) for spring 2016 was 4,396, a decrease of about 1,500 fish from 2015.
- May 26, ADEC issued Waste Management Permit 2014DB002 (Modification #1).
- May 26, ADNR issued a permit amendment for the construction of the Barnes Creek heap leach.
- July 19, ADNR issued a Certificate of Approval to construct a dam for the Barnes Creek heap leach (#AK00315).
- October 12, a site visit was conducted to check on the status of beaver dams in the wetland complex that had been removed recently by FGMI.
- October 24, historic information was provided to FGMI on the status of Fish Creek and why it was taken off the impaired waterbody list in 1994.

- December 12, FGMI, ADF&G, ADNR, and ADEC met to discuss alternatives for tailings disposal, closure configuration for the tailing dam at elevation 1557, and a new water treatment plant.
- December 13, FGMI acquired a new parcel of land that contains an estimated 2.1 million ounces of gold.

2018

- March 14, ADNR approved a POA amendment request to replace the power line trail.
- April 3, 5, and 6, water quality data were collected at six sites in the WSR, five of which have been sampled nearly annually since 1998.
- May 3–May 14, two fyke nets were fished in the developed wetlands just upstream of the WSR and in Pond F.
- Our estimated population of Arctic grayling (≥200 mm) for Spring 2017 was 7,141, which is an increase of 2,745 over 2016.
- Our estimated population of large burbot (≥400 mm) was 201 fish, which is an increase of 82 fish over 2016.
- October 9, 2018, the Pond D beaver dam was removed to allow the downstream movement of grayling into the WSR.

2019

- January 15, Fort Knox began the discharge of up to 3000 gpm of Reverse Osmosis (RO) from Outfall 002 into the RO Channel.
- February 20, environmental compliance and management systems audit performed by SRK Consulting found FGMI to be in compliance with all State of Alaska permitting requirements.
- April 3, FGMI requested modification 16 to Plan of Operations (POO) for clearing/grubbing of 15.5 acres of land to stockpile subbase for the Barns Creek Heap Leach facility.
- Between January 15 and April 10, a beaver blocked the Centerline Road culvert between Pond AB and the RO Channel diverting the 3000 gpm of RO water from Outfall 002 into Fish Creek instead of the RO Channel.
- April 10, water quality data were collected as six sites in the WSR, and three new sites in Fish Creek. Average dissolved oxygen (DO) at Site 2, (Middle of the WSR) was higher that all previous year's data. The RO Channel site had higher water temperature (6.0°C) compared to WSR sites.
- April 12 to May 03, ADF&G set one fyke net in Fish Creek near the Pond F outlet to capture Arctic grayling and burbot moving into the developed wetlands.
- Our estimated population of Arctic grayling (≥200 mm) for spring of 2018 was 6,045 fish (95% CI 5,461–6,629 fish).

- June 15, FGMI received a Fish Habitat Permit to lower Centerline Road culvert to improve flow of RO water from Pond AB into the RO Channel.
- June 25–27, ADF&G captured 71 Arctic grayling from 160–315 mm FL and nine burbot from 320–615 mm tail length in the Stilling Basin. Bathymetric measurements were taken in the Stilling Basin and WSR seepage pond.
- August 27–29, WSR water level lowered 1.70 vertical feet for required spillway structural inspection. Water discharged through Stilling Basin into lower Fish Creek.
- September 25–October 9, ADF&G fished twenty-one hoop traps in the WSR and captured 124 burbot for the 2018 population estimate.
- Our estimated population of large burbot (≥400 mm) for spring of 2018 was 402 fish (95% CI 190–613 fish).

2020

- Fort Knox continued discharge of RO water into the RO Channel wetlands. Outfall 001 not operated in 2020. Outfall 002 discharged 9,663 acre-feet of RO water.
- The majority of discharged RO water confined to the RO Channel before combining with Fish Creek and entering the WSR.
- March 2020, FGMI implemented Covid-19 precautions in response to 2020 pandemic when working on FGMI property. ADF&G Habitat Section deployed HOBO temperature loggers on March 31.
- April 10, water quality data were collected at six sites in the WSR and two sites in Fish Creek. Average dissolved oxygen at Site 2 (middle of the WSR) was higher than all previous year's data.
- April 10, water temperature in the RO Channel was 3.01°C from warm RO discharge water compared to 0.23°C in Fish Creek from natural spring thawing.
- From April 24 to May 9 ADF&G sampling with two fyke nets placed in Fish Creek and the RO Channel to capture Arctic grayling and burbot moving into developed wetlands.
- Our estimated population of Arctic grayling (≥200 mm) for Spring of 2019 was 4,461 fish (95% CI 4,114–4,808 fish).
- September 29 to October 9, twenty-six hoop traps were set in the WSR and six in Gil Pond. 123 burbot were captured and used for the 2019 population estimate.
- The 2019 populations estimate of large burbot (≥400 mm) is 203 fish (95% CI 142–264 fish).
- October 2020, Fort Knox began hauling ore to Barns Creek Heap Leach (BCHL) and began leaching processes.
- On November 20, Barns Creek Heap Leach (BCHL) was issued Certificate of Approval to Operate for Stage 1 by ADNR Dam Safety.

2021

- Fort Knox continued discharge of RO water from outfall 002 into the RO channel wetlands. Outfall 001 not operated in 2021. Outfall 002 discharged 8,752 acre-feet of RO water.
- The majority of discharged RO water confined to the RO Channel before combining with Fish Creek and entering the WSR.
- April 13, ADF&G Habitat Section collected water quality data at five gravel pit sites in lower Fish Creek below Fairbanks Creek as part of the Gil Expansion base line survey work.
- April 15, ADF&G Habitat Section deployed HOBO temperature loggers into upper Fish Creek and the RO Channel.
- On April 15, water quality data were collected at six sites in the WSR and two sites in the developed wetlands. Average dissolved oxygen at Site 2 (middle of the WSR) was higher than all previous year's data.
- On April 15, water temperature in the RO Channel was 4.63°C from warm RO discharge water compared to 0.98°C in Fish Creek from natural spring thawing.
- From April 30 to May 12 ADF&G spring sampling with two fyke nets placed in Fish Creek and the RO Channel to capture Arctic grayling and burbot moving into developed wetlands.
- Our estimated population of Arctic grayling (≥200 mm) for Spring of 2020 was 3,632 fish (95% CI 3,301–3,963 fish).
- From April 30 to May 12, 48 burbot were captured in the Fish Creek and the RO Channel fyke nets. Six of these were ≥300 mm and tagged with a unique numbered Floy tag. No burbot were captured that had been previously tagged during past year's wetlands or WSR burbot sampling.
- June 4, Fort Knox initiated a WSR water drawdown to perform a required spillway inspection. Relief valve was closed on Jun 9 and WSR water levels returned to normal.
- July–September, Gil Haul Road improvements cross Fish Creek and Gil Causeway. Three culverts in Fish Creek extended under FH15-III-0218-A1, FH15-III-0219-A1, FH18-III-0039-A1 and FH21-III-0076.
- August 2, Fort Knox initiated a WSR water drawdown to perform spillway repairs. Construction was delayed due to COVID and contractor availability. Repairs were completed on September 29 and the relief valve was closed refilling the WSR.
- Fresh water supply line from WSR to Tailings Storage Facility (TSF) removed during Gil Haul Road improvements.
- September, groundbreaking ceremony for Gil expansion.

2022

- Fort Knox continued discharge of RO water from outfall 002 into the RO Channel wetlands. Outfall 001 not operated in 2021. Outfall 002 discharged 4,682 acre-feet of RO water.

- April 5, ADF&G Habitat Section collected water quality data at five gravel pit sites in lower Fish Creek below Fairbanks Creek as part of the Gil Expansion base line survey work.
- April 14, ADF&G Habitat Section deployed HOBO temperature loggers into upper Fish Creek and the RO Channel.
- The WSR outlet spillway had substantial aufeis built up during the 2021/2022 winter, similar to what was observed in April 2020 and 2021.
- April 14, water quality data were collected at six sites in the WSR and two sites in the developed wetlands. Average dissolved oxygen at Site 2 (middle of the WSR) was the second highest year recorded at 6.71 mg/L.
- April 14, water temperature in the RO Channel was 2.69°C from warm RO discharge water compared to 0.84°C in Fish Creek from natural spring thawing.
- April 21, Fort Knox environmental staff submitted a wildlife mortality report for three dead Arctic grayling recovered from Pond AB. As part of their investigation and response efforts, Fort Knox stopped processing and discharging water from all three RO facilities until water test results were analyzed.
- April 22, ADF&G and FGMI staff performed wetlands survey to document any issues that may be affecting habitats. Arctic grayling were observed swimming in Fish Creek and no additional fish moralities were found.
- April 22, Heavy snowfall during winter 2021/2022 resulted in runoff entering Fish Creek creating turbidity, Fort Knox staff worked on stormwater diversion improvements during summer 2022.
- From May 2 to May 17 ADF&G spring sampling with two fyke nets placed in Fish Creek and the RO Channel to capture Arctic grayling and burbot moving into developed wetlands.
- From May 9 to 17 a fyke net was placed in Pond AB, the uppermost waterbody in the Fish Creek wetlands, and captured 165 Arctic grayling with an average size of 173 mm. These are the first documented grayling in Pond AB.
- Our estimated population of Arctic grayling (≥200 mm) for spring of 2021 was 3,090 fish (95% CI 2,763–3,417 fish).
- From May 2 to May 17, 35 burbot were captured in the Fish Creek and the RO Channel fyke nets. Five of these were ≥300 mm and tagged with a unique numbered Floy tag. One burbot was captured that had been previously tagged during past year's wetlands or WSR burbot sampling.
- August 22, Fort Knox initiated a WSR water drawdown to extend a culvert under FH permit FH15-III-0219-A2. The relief valve was closed on August 24 and WSR water levels returned to normal by September 16.
- August 26, Slippery Creek and Fish Creek near the Gil Project mine pits were sampled for fish presence. Forty-one Arctic grayling and 39 slimy sculpin were captured.

- September 6, during the Fort Knox WSR water drawdown two upland areas along the WSR were excavated and shallow water aquatic habitat was created within the WSR.
- Gil Causeway and Haul Road improvements and widening continue throughout the year including using excavated gravel from the WSR as road fill and berm stabilization.
- September 6–16, ADF&G staff sampled burbot in the WSR with hoop traps. The 2020 WSR burbot population is 302 fish (95% CI 171–432 fish).
- September 14–16, hoop traps were set in Pond AB and seven burbot were captured between 170 mm to 301 mm. These are the first burbot documented in Pond AB.
- October, 2022–April 2023, winter discharge rate of RO water was reduced to 1600 gpm and maintained during the winter.

2023

- Fort Knox continued discharge of RO water from outfall 002 into the RO Channel wetlands. Outfall 001 not operated in 2021. Outfall 002 discharged 1,260 acre-feet of RO water.
- April 14, water quality data were collected at six sites in the WSR and two sites in the developed wetlands. Average dissolved oxygen at Site 2 (middle of the WSR) was lower than recorded in 2021/2022 from the reduced RO discharge winter 2022/2023.
- April 14, the water temperature in the RO Channel near Pond AB was 1.66°C from warm RO discharge water compared to 0.01°C in Fish Creek near Pond F from natural spring thawing.
- The WSR outlet spillway had substantial aufeis built up during the 2022/2023 winter, similar to what was observed in April 2022.
- April 27, ADF&G Habitat deployed two hobo temperature loggers into Fish Creek at Pond F and the lower RO Channel near its confluence with Fish Creek.
- April 27, the lower RO Channel had aufeis filling the valley with water flowing over the glaciated ice. The water temperate near its confluence with Fish Creek was -0.08°C compared to 2.69°C in 2022. The reduced RO discharge rate allowed water to cool and freeze in the RO Channel. In years with high RO Water discharge a thawed channel and flowing water was present.
- From May 8 to 19 ADF&G sampled with a fyke net placed in Fish Creek and from May 15 to 19 a fyke net in the RO Channel (after it thawed) to capture Arctic grayling and burbot moving into developed wetlands.
- The 2022 WSR and Fish Creek wetlands population estimate of Arctic grayling (≥200 mm) was 4,594 fish (95% CI 4,066–5,121 fish).
- From May 8 to 19 a fyke net was placed in Pond AB, the uppermost waterbody in the Fish Creek wetlands. It captured 201 Arctic grayling with an average size of 237 mm.
- The 2022 Pond AB population estimate of Arctic grayling (≥200 mm) was 241 fish (95% CI 60–422 fish). This is the first population estimate generated for the potentially isolated Pond

AB fish. However, one tagged Arctic grayling from the WSR was captured in Pond AB, the first documented to move through the RO channel.

- September 11–20, ADF&G staff sampled burbot in the WSR with hoop traps. The 2022 WSR population estimate for burbot ≥400 mm is 295 fish (95% CI 144–447 fish).
- September 11–20, hoop traps were set in Pond AB and 25 burbot were captured between 280 mm to 355 mm with an average of 306 mm. A population estimate could not be generated with sufficient recaptures from the 2022 sampling event.
- October 1, 2023–April 30, 2024, winter discharge rate of RO water was reduced and maintained during the winter.

2024

- Fort Knox continued discharge of RO water from outfall 002 into the RO Channel Wetlands. Outfall 001 has not operated since 2021. Outfall 002 discharged 1,623 acre-feet of RO water.
- April 9, water quality data were collected at six sites in the WSR and two sites in the developed wetlands. Average dissolved oxygen at Site 2 (middle of the WSR) was slightly lower than recorded in 2022/2023 and significantly lower than peak RO discharge during 2020/2021.
- April 9, the WSR outlet spillway did not have aufeis built up during the 2023 / 2024 winter like past high RO discharge years (2019 – 2022).
- April 24, the RO Channel was mostly dry with very little spring melt water or discharged RO water flowing through the channel. The Pond AB outlet culverts had been blocked by beavers during winter 2023/2024 diverting discharged RO water into Fish Creek.
- April 24, the water temperature in Pond AB was 6.5°C from discharged RO water and cooled to 3.6°C at the Pond F outlet after flowing down Fish Creek.
- April 24, ADF&G Habitat deployed two hobo temperature loggers into Fish Creek at Pond F and the RO Channel downstream of the Pond AB culverts.
- April 29, ADF&G staff cleared the blocked Pond AB culvert returning discharged RO water to the RO Channel.
- April 29, ADF&G staff cleared the blocked Pond D outlet allowing Arctic grayling access further up Fish Creek wetlands increasing available spawning area.
- April 29–May 10, ADF&G sampling with fyke nets placed in Fish Creek and the RO Channel to capture Arctic grayling moving into the developed wetlands for spawning.
- The 2023 WSR and Fish Creek wetlands population estimate of Arctic grayling (≥200 mm) was 4,767 fish (95% CI 4,404–5,129 fish).
- May 3 to 10 a fyke net was placed in Pond AB, the uppermost waterbody in the Fish Creek wetlands. It captured 234 Arctic grayling with an average size of 261 mm.
- The 2023 Pond AB population estimate of Arctic grayling (≥200 mm) was 1243 fish (95% CI 866–1620 fish). Recaptured grayling tag #12273 was the second documented fish to move

from the lower RO channel into Pond AB but the population is still considered separate until significant movement is documented.

- Eight Arctic grayling whole body samples were sent to ACT Laboratories for element analysis comparison to pre-mining baseline data. All 2024 mean element concentrations lower than the 1994 baseline samples mean.
- July 31–August 2, ADF&G sampling conducted in the Stilling Basin. 1 Arctic Grayling captured, and the population may be lower than past years based on reduced ability to capture fish (n=71 in 2019). Eight burbot were captured with hoop traps, and 14 juvenile burbot with minnow traps. One slimy sculpin was also captured.
- 22 total burbot were captured in the stilling basin with 15 having milky appearances to one or both eyes. The ADF&G Fish Pathology Laboratory confirmed the presence of Larval *Diplostomulum* of the eye (eye fluke) and an unidentified *Myxobolus sp.* within the capillaries of the gills. Lab report No. 2025-0016.
- September 24–October 2, ADF&G staff sampled burbot in the WSR with hoop traps. The 2023 WSR population estimate for burbot ≥400 mm is 598 fish (95% CI 55–1,141 fish) but has a wide confidence interval from a low number of recaptured burbot (n=3).
- Ninety-nine total burbot were captured during the September 2024 WSR sampling. Thirty-five of the captured burbot had a milky appearance to one or both of their eye pupils. The ADF&G Fish Pathology Laboratory confirmed Larval *Diplostomulum* of the eye (eye fluke) and an unidentified *Myxobolus sp.* within the capillaries of the gills. Lab report No. 2025-0016.
- September 30–October 2, 2 hoop traps were set in Pond AB. Three burbot were captured between 295 mm to 355 mm. One burbot was recaptured from the 2023 sampling event.
- The 2023 Pond AB population estimate for burbot ≥300 mm is 22 fish (95% CI 8–35 fish).
- December 15, FGMI Wildlife Mortality Report: moose struck and killed on Fort Knox Gold Mine access road. State Troopers, ADF&G and ADEC notified.

2025

- Fort Knox continued discharge of RO water from Outfall 002 into the RO Channel wetlands; Outfall 001 remained inactive. Total discharge in 2025 was 4,294 acre-feet, down from the 2020 peak (9,663 acre-feet).
- April 4, ADF&G collected late-winter water quality data at six WSR sites and two wetlands sites (Fish Creek – Pond F; RO Channel – Pond AB outlet).
- April 4, dissolved oxygen (DO) was high in the upper water column (max 11.4 mg/L in Fish Creek Bay; 10.1 mg/L in Polar Bay) and declined sharply below ~8 m to near 0 mg/L across WSR sites, consistent with historical stratification.
- April 4, specific conductivity measured 145.8 µS/cm at Fish Creek (Pond F) and 58.2 µS/cm at the RO Channel (Pond AB outlet), consistent with low-conductivity RO water patterns observed since 2023.

- April 4, ADF&G deployed HOBO® temperature loggers at the RO Channel (near Pond AB outlet culverts) and Fish Creek (near Pond F); loggers recorded hourly temperatures through May 25.
- April 28, ADF&G placed fyke nets at the Pond F outlet (Fish Creek) and near the Pond AB outlet; significant aufeis was present in the RO Channel valley floor under low RO discharge. A third fyke was added to the RO Channel on May 6 after the preferred site thawed; all fykes were fished through May 9.
- April 28–May 9, ADF&G sampled Arctic grayling: 722 grayling ≥240 mm were captured in the Fish Creek and RO Channel wetlands (287 were recaptures from 2024).
- April 28–May 9, Fish Creek CPUE peaked at 5.8 fish/hour on May 9 as water warmed toward ~4.0°C; RO Channel CPUE peaked at 5.7 fish/hour the same day.
- The 2024 WSR and Fish Creek wetlands estimate for Arctic grayling >200 mm was 3,511 fish (95% CI: 3,268–3,835).
- April 28–May 9, 501 Arctic grayling (88–290 mm; mean 189 mm) were captured in Pond AB; 157 were ≥200 mm, and 34 were recaptures from 2024 (all originally tagged in Pond AB). No 2025 recaptures originated from Fish Creek or the lower RO Channel, indicating continued partial isolation of Pond AB by beaver dams.
- The 2024 estimate for Arctic grayling >200 mm in Pond AB was 635 fish (95% CI: 482–789), lower than the 2023 estimate (1,243 fish; 95% CI: 866–1,620). Length-frequency patterns in 2025 showed strong juvenile presence and fewer large adults, consistent with limited food availability and isolation.
- May 2025, Arctic grayling health screening: no larval Diplostomulum (eye fluke) infections were detected among 775 grayling examined across WSR/Fish Creek/RO Channel sampling.
- September 3–15, ADF&G conducted the annual WSR burbot assessment with 24 hoop traps in the WSR and 6 in Gil Pond; two traps were set in Pond AB from September 8–15. WSR was ice-free; surface water ranged ~13.8°C (Sept 3) to ~12.0°C (Sept 15).
- The 2024 WSR population estimate for burbot ≥400 mm was 109 fish (95% CI: 60–158). 99 burbot were captured in 2024 (55 >300 mm tagged; 30 ≥400 mm). In 2025, 176 burbot were captured (60 >300 mm; 31 ≥400 mm; 8 recaptures).
- September 8–15, Pond AB burbot: 15 burbot were captured (240–430 mm; mean 319 mm); no juveniles (<200 mm) were observed and no 2024 tag recoveries were detected. The most recent Pond AB abundance estimate remains the 2023 value for burbot ≥300 mm (22 fish; 95% CI: 8–35).
- September 2025, Eye fluke prevalence in WSR burbot >200 mm increased from 38% in 2024 (25/66) to 75% in 2025 (65/87). No eye fluke was detected in 15 burbot sampled from Pond AB.

- An unidentified Myxobolus sp. Was observed in burbot gill capillaries (see ADF&G Fish Pathology Laboratory Report No. 2025-0016; 2/13/2025). Three additional burbot were submitted in fall 2025; results pending.
- Throughout 2025, ore hauling from the Gil Mine remained suspended (initiated in fall 2024). FGMI continued exploration test drilling in the Gil vicinity; hydrologic connectivity constraints within the wetlands persisted under reduced RO discharge.
- 2025 management recommendation: continue (and consider increasing) remineralization of RO water to raise conductivity toward natural levels (Fish Creek/WSR), using additional non-contact groundwater or additions of calcium carbonate/magnesium salts to stabilize hardness and support aquatic biota.

Appendix B. Water Quality Data from Fort Knox Water Supply Reservoir (WSR), Fish Creek, and Reverse Osmosis (RO) Channel April 4, 2025.

Site Number (Name)	Depth (m)	Temperature (°C)	% Saturation Dissolved Oxygen	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH	ORP (mV)
1 (Middle WSR)	1	0.6	53.0	7.5	150	7.0	272
	2	1.4	55.1	7.7	148	7.0	271
	3	2.0	50.8	7.0	146	7.1	263
	4	2.3	52.2	7.1	145	7.1	263
	5	2.5	52.6	7.1	144	7.1	265
	6	2.7	51.0	6.8	143	7.0	266
	7	2.8	46.5	6.2	142	7.0	264
	8	2.9	30.0	4.0	143	7.0	263
	9	2.9	17.0	2.2	144	7.0	266
	10	3.0	14.0	1.8	153	6.9	268
	11	3.0	2.8	0.3	162	6.8	268
	12	3.0	0.8	0.1	188	6.7	222
2 (WSR Near Dam)	1	0.5	53.3	7.6	152	7.1	270
	2	1.0	53.0	7.4	149	7.0	271
	3	1.8	52.0	7.2	146	7.0	271
	4	2.2	50.0	6.6	145	7.1	270
	5	2.5	48.0	6.5	144	7.1	270
	6	2.6	46.0	6.3	143	7.1	270
	7	2.8	45.0	6.0	142	7.1	270
	8	2.9	35.0	4.4	141	7.1	270
	9	3.1	14.5	1.9	141	7.0	269
	10	3.1	4.5	0.6	148	6.9	270
	11	3.2	1.0	0.1	153	6.9	272
	12	3.1	0.7	0.1	165	6.9	272
	13	3.1	0.6	0.1	176	6.9	275
	14	3.0	0.5	0.1	182	6.9	270
	15	2.9	0.5	0.1	187	6.9	261
	16	3.0	0.5	0.1	191	6.9	250
	17	3.3	0.4	0.1	239	6.9	221

3 (Solo Bay)	1	0.3	65.8	9.5	166	7.0	257
	2	1.1	58.0	8.2	160	7.1	253
	3	1.4	33.1	4.6	169	6.8	241
7 (Last Chance Bay)	1	0.9	46.0	6.5	154	7.1	235
	2	1.1	22.4	3.1	160	7.0	230
	3	1.4	4.0	0.8	179	7.0	224
11 (Polar Bay)	1	0.3	70.4	10.1	163	7.1	279
	2	1.0	59.9	8.4	163	7.0	276
	3	1.6	55.1	7.7	159	6.9	277
	4	1.9	53.9	7.4	158	7.0	274
	5	2.2	55.8	7.7	157	7.0	274
	6	2.3	57.0	7.8	157	7.0	274
	7	2.5	38.0	5.1	162	6.9	274
	8	3.4	5.0	0.6	189	7.0	267
12 (Fish Creek Bay)	1	0.2	76.6	11.4	150	7.1	277
	2	1.0	70.1	10.3	153	7.0	270
	3	1.3	51.4	6.6	191	7.0	256
Fish Creek (Pond F)	1	0.1	88.8	12.9	145	7.3	305
RO Channel (Pond AB)	1	2.5	83.3	11.3	58	7.2	338

Appendix C. Population estimates of Arctic Grayling >200 mm, Fort Knox Water Supply Reservoir, 1995–2024.

Year[1]	Population Estimate	95% Confidence Interval
1995[2]	4,358	
1996[3]	4,748	3,824–5,672
1996[4]	3.475	2,552–4,398
1998[5]	5,800	4,705–6,895
1999	4,123	3,698–4,548
2000	5,326	4,400–6,253
2001	5,623	5,030–6,217
2002	6,503	6,001–7,005
2003	6,495	5,760–7,231
2004	6,614	5,808–7,420
2005	7,926	6,759–9,094
2006	5,930	5,382–6,478
2007	4,027	3,620–4,433
2008	3,545	3,191–3,900
2009	3,223	2,896–3,550
2010	4,346	3,870–4,823
2011	7,378	6,616–8,141
2012	7,404	6,775–8,033
2013	6,675	6,217–7,333
2014	5,841	5,235–6,446
2015	5,947	5,111–6,783
2016	4,396	3,913–4,880
2017	7,141	6,176–8,018
2018	6,045	5,461–6,629
2019	4,461	4,114–4,808
2020	3,632	3,301–3,963
2021	3,090	2,763–3,417
2022	4,594	4,066–5,121
2023	4,767	4,404–5,129
2024	3,511	3,268–3,835

[1]Population estimates from 1995–1996 include fish ≥150 mm, in all other years fish ≥200 mm.

[2]In 1995, ADF&G used estimates from the ponds and creeks for the Arctic grayling population; a confidence interval was not applicable to the data set.

[3]The 1996 estimate was made with a capture and recapture event in summer 1996 using fyke nets.

[4]In 1996, Arctic grayling were captured with a boat-mounted electro shocker for both the capture and recapture events in fall 1996 by Sport Fish Division.

[5]From 1998 through 2023 the population estimates were made using a mark event in the spring of the year of the estimate, and the recapture event in spring of the following year.

Appendix D. Arctic Grayling Growth Between 2024 and 2025, Fort Knox Water Supply Reservoir.

Upper Limit of Size (mm)	Average (mm)	Maximum (mm)	Minimum (mm)	Sample Size
210	24	24	24	1
220	41	47	36	3
230	22	34	10	2
240	30	49	14	7
250	23	38	4	16
260	21	52	10	30
270	16	32	1	59
280	16	40	-1	51
290	12	25	-3	47
300	13	28	3	30
310	8	26	-2	25
320	8	17	-3	7
330	14	22	7	3
340	3	3	2	2
350	15	24	10	3
360	6	6	6	1

Appendix E. Population Estimate of Burbot (≥400 mm), Fort Knox Water Supply Reservoir, 2001–2024.

Year	Population Estimate	95% Confidence Interval
2001	134	58–210
2002	131	63–199
2003	102	57–147
2004	86	44–128
2005	143	96–191
2006-2011	No Population Estimates Performed	
2012	193	95–290
2013	80	44–117
2014	175	44–305
2015	92	46–138
2016	119	65–173
2017	201	124–278
2018	402	190–613
2019	203	142–364
2020	302	171–432
2021	No Population Estimates Performed	
2022	295	144–447
2023	598	55–1,141
2024	109	60–158

Appendix F. Population Estimates of Arctic Grayling >200 mm, Fort Knox Pond AB, 2022–2024.

Year		Population Estimate	95% Confidence Interval
2022		241	60–422
2023		1,243	866–1,620
2024		635	482–785

Appendix G. Winter (October 1 to April 30) water use from the Fort Knox Water Supply Reservoir, 1997–2015.

Year (Oct 1 to April 30)		Acre-Feet of Water Removed		Percent of Water Removed
1997/1998		660		19.6
1998/1999		605		18.0
1999/2000		577		17.2
2000/2001		1,464		43.5
2001/2002		320		9.5
2002/2003		337		10.0
2003/2004		279		8.3
2004/2005		716		21.3
2005/2006		659		19.6
2006/2007		299		8.9
2007/2008		1,176		35.0
2008/2009		817		24.3
2009/2010		1,167		34.7
2010/2011		187		5.6
2011/2012		59		1.8
2012/2013		1,837		54.6
2013/2014		1,399		41.6
2014/2015		104		3.1
No water was withdrawn from the WSR after 2014/15				

Appendix H. Total RO water discharge from Outfall 001 and 002 into RO Channel Wetlands Complex, (January 1 – December 31), 2015–2025.

Year	Acre-Feet of RO Water[1]
2015	163
2016	461
2017	618
2018	806
2019	6,681
2020	9,663
2021	8,752
2022	4,682
2023	1,260
2024	1,623
2025	4,294

[1]RO Water Discharged from Outfall 001 (2015–2018) and Outfall 002 (2019–2025).