Final Technical Memorandum

To:	Project Owners	Project:	Eklutna Hydroelectric Project
From:	Chuck Sauvageau	cc:	Samantha Owen
Date:	November 14, 2022	Job No.:	22-028
Subject:	Eklutna Lake Water Quality and Trophic Status Summary		

1.0 Introduction and Purpose

As summarized in the Initial Information Package (IIP), there is limited historic water quality data for Eklutna Lake. In addition, the United States Army Corps of Engineers (USACE) reported in 2011 that "…physical limnology studies of Eklutna Lake suggest that the turbidity in Eklutna Lake during much of the year is not conducive to significant primary production. Low numbers and small size of the native land locked sockeye salmon (kokanee) found in the lake supports these biological assumptions." (USACE, 2011). Therefore, one of the goals of the overall Water Quality Study was to gain a better understanding of seasonal water quality parameters in the lake as well as assess the lake's trophic status based on methods described by Carlson (1977).

The results from these water quality assessments will serve as a component to aid in the decision making process for the potential of instream flow release locations into the Eklutna River and well as development of potential fish passage facilities into Eklutna Lake. A detailed summary of study and data collection objectives include the following:

- Collect continuous water temperature data in Eklutna Lake as well as *in situ* profiles of temperature, pH and dissolved oxygen (DO).
- Collect total phosphorus, chlorophyll *a*, and Secchi depth data in Eklutna Lake to determine the trophic status index (TSI) value.

2.0 Eklutna Lake Study Areas

Eklutna Lake sampling occurred at locations where water may be released downstream into the Eklutna River. Water quality study site locations in Eklutna Lake are depicted in Figure 2-2; these locations are:

- Thermistor String 1 – located in Eklutna Lake near the Project intake structure (temperature, DO, pH, total phosphorus, chlorophyll *a* Secchi depth)
- Thermistor String 2 – located in the "pond" near the Project dam in front of the spillway (temperature, DO, pH, total phosphorus, chlorophyll *a*, Secchi depth)

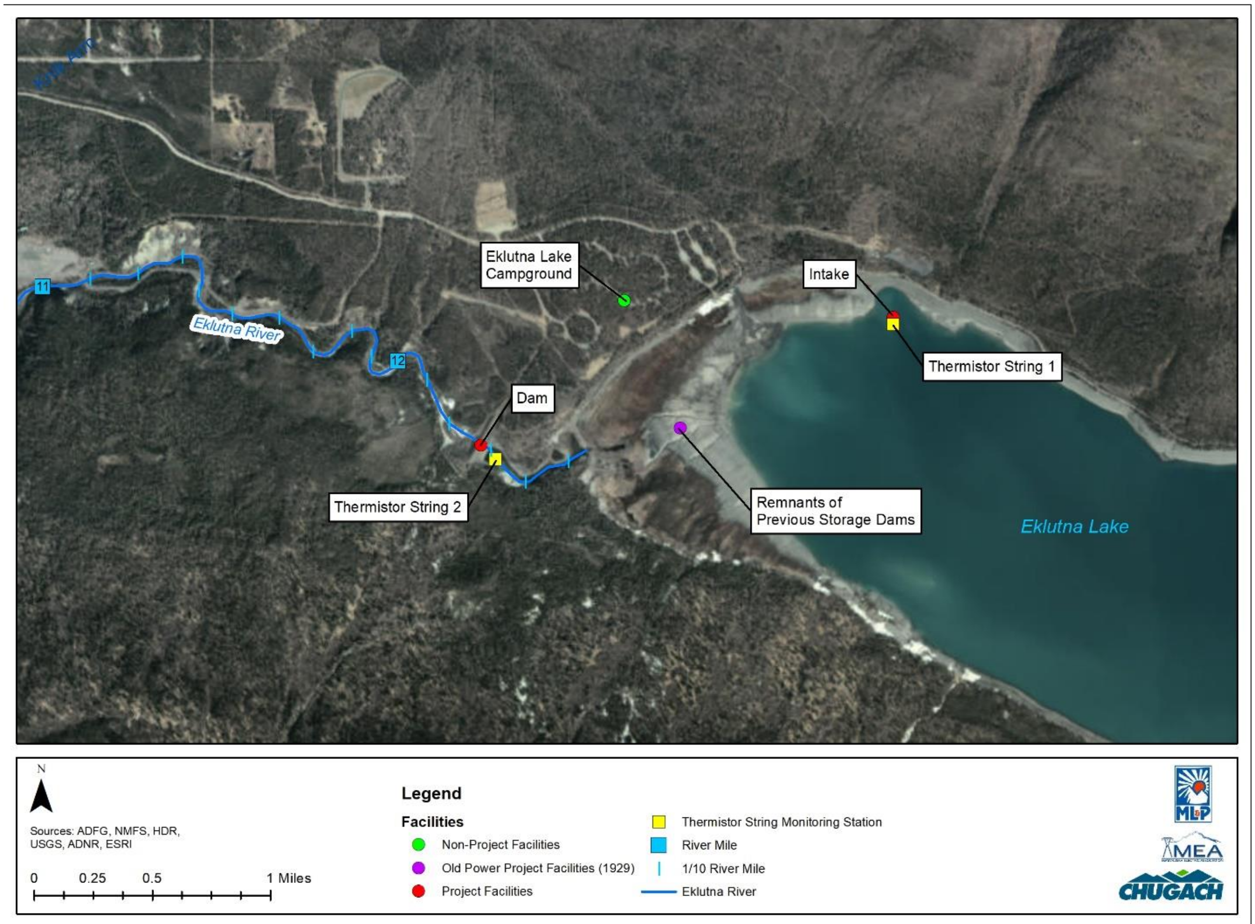

Figure 2-2. Water quality study site locations in Eklutna Lake

3.0 Methods

3.1 Water Temperature

Calibrated thermographs were utilized to continuously record water temperatures in the "pond" (Thermistor String 2) from May of 2021 through October of 2022. The Eklutna Lake thermistor string could not be installed in May due to unsafe lake conditions, and Eklutna Lake data could not be downloaded in September or October of 2022 due to high lake levels; therefore, at the Eklutna Lake intake site (Thermistor Sting 1) continuous temperature data are available from June of 2021 through August of 2022. Field procedures, as well as pre-deployment instrument calibration, followed techniques detailed by Ward (2011). A thermistor string was deployed using a buoy and anchor system at each of the two lake sites (Figure 3-1). Continuous temperature sampling occurred at two distinct depths in the water column. For the thermistor string near the Project intake , temperature sampling occurred at 0.5 meters below the water surface and at approximately El. 793.6 feet (the approximate elevation of the intake). For the thermistor string in the pond near the existing dam in front of the spillway, temperature sampling occurred at 0.5 meters below the water surface and at approximately El. 852 feet (the invert elevation of the drainage outlet gate). In addition to the continuous temperature monitoring efforts, *in situ* measurements of water temperature were taken every 6-8 weeks during the ice free season (May-October) with a calibrated water quality sonde. These *in situ* data were collected to validate logger data during each field maintenance and data download effort as well as providing a temperature profile throughout the entire depth of the water column.

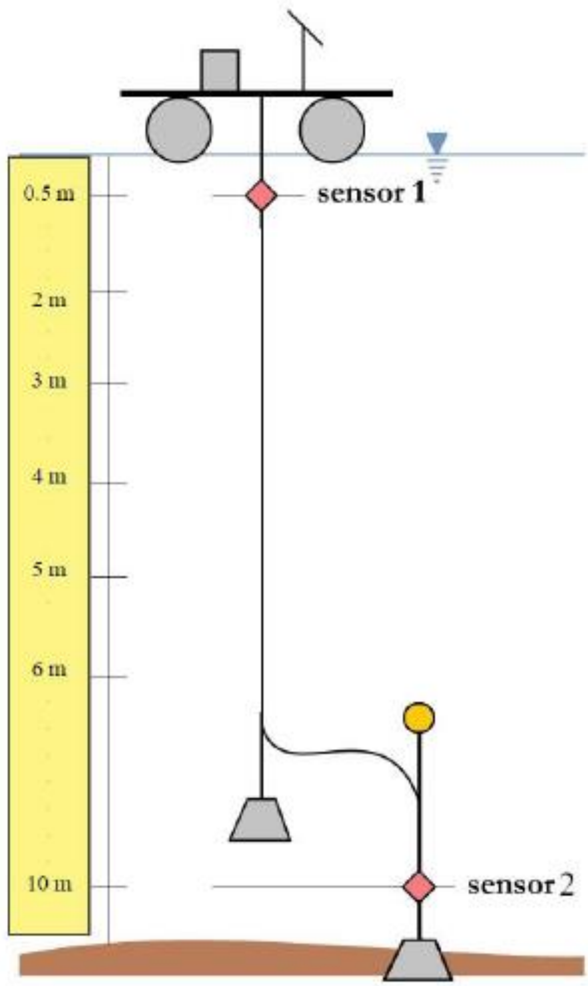

Figure 3-1. Thermistor string schematic for water temperature monitoring in Eklutna Lake.

3.2 Eklutna Lake DO and pH

Monthly DO and pH data were collected as *in situ* profile readings at the two lake stations during the ice-free period from May 20 to September 29 2021, in the pond and from June 23 to September 29, 2021 in Eklutna Lake. DO and pH profile data were collected at 3-foot depth intervals for the entire water column utilizing a water quality sonde calibrated to manufacturer recommendations.

3.3 Eklutna Lake Trophic Status

The mid-summer lake profiling on July 14, 2021, also included the determination of Secchi depth, as well as the collection of total phosphorus and chlorophyll *a* samples. The assessment of these three lake parameters were utilized to provide an index of lake productivity based on Carslon (1977). Water samples for phosphorus and chlorophyll *a* were collected near the surface of the lake utilizing a Van Dorn sampler at the two lake monitoring sites. The Van Dorn sampler was flushed with on-site lake water prior to collection at each site. Collected water samples for total phosphorus were transferred to pre-labeled laboratory-supplied bottles while chlorophyll *a* water samples were filtered through 0.45 µm filters and wrapped in aluminum foil. Both the phosphorus and chlorophyll *a* samples were placed immediately on ice then delivered to analytical laboratories on the same day that the samples were collected. Total phosphorus samples were processed and analyzed by SGS Laboratories in Anchorage, AK. Chlorophyll *a* concentrations were quantified by Professor Erin Larson, PhD at Alaska Pacific University.

4.0 Results

4.1 Eklutna Lake Water Temperatures

Figures 4-1 and 4-2 show the daily maximum water temperatures recorded at Eklutna Lake and the pond, respectively. Overall, both monitoring stations meet the Alaska Department of Environmental Conservation (ADEC) criteria for water use category (C) *Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife,* meaning that water temperatures did not exceed 20°C at any time. However, ADEC also delineates a 15°C maximum temperature criteria for rearing areas (ADEC, 2020). Based on this rearing criteria, the Eklutna Lake and pond sites exceeded the 15°C standard intermittently during 2021 and 2022. At the Eklutna Lake site, only surface water temperatures exceed 15°C from mid-July to mid-August 2021, while in 2022 the 15°C threshold is intermittently exceeded at both depth strata from mid-July to mid-August. At the pond site, water temperatures at depth never exceed 15°C, while surface water temperatures exceeded 15°C at times from early July to mid-August of 2021. In 2022, surface water temperatures exceed the 15°C rearing criteria for four days in early and late July.

Figures 4-3 and 4-4 show water temperature profile data collected every 4-6 weeks at Eklutna Lake and the pond, respectively. These data confirm periods of minor stratification (~1°C) in the summer months as well as the turnover or breakup of temperature gradient in mid to late September. In addition, when Eklutna Lake and the pond were connected during the September 2021 and September 2022 sampling efforts, each basin retained its unique temperature profile.

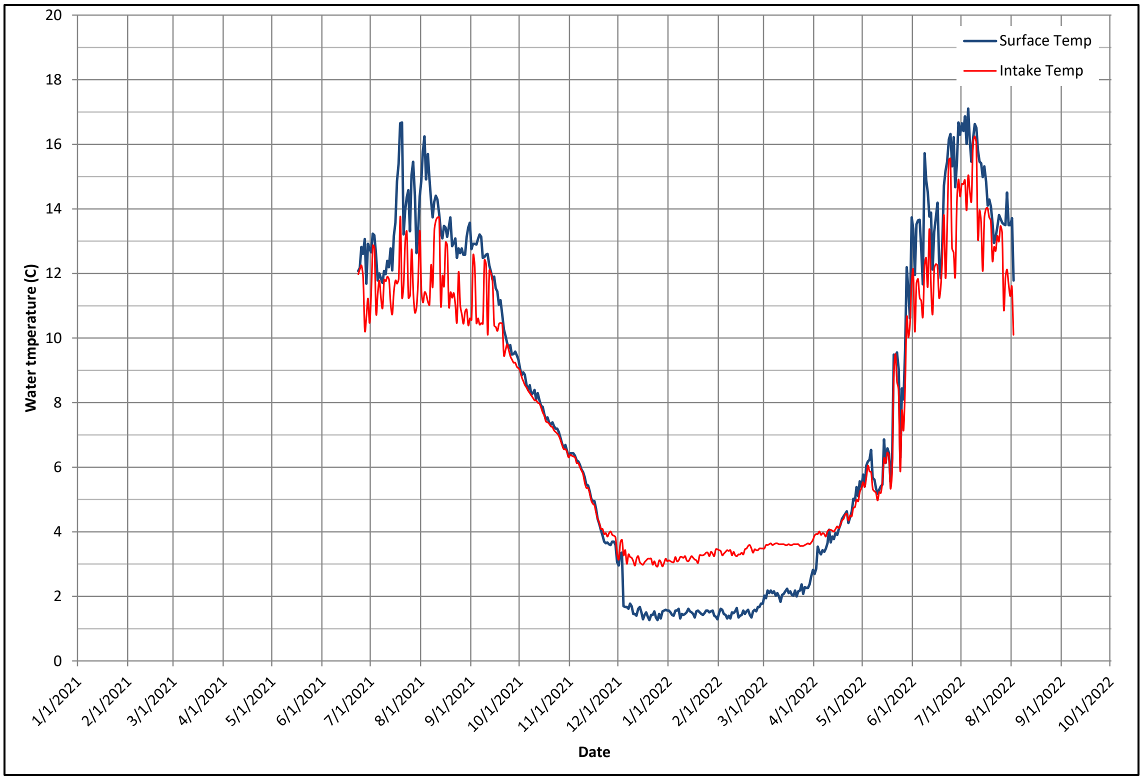

Figure 4-1. Eklutna Lake maximum daily water temperatures 2021-2022.

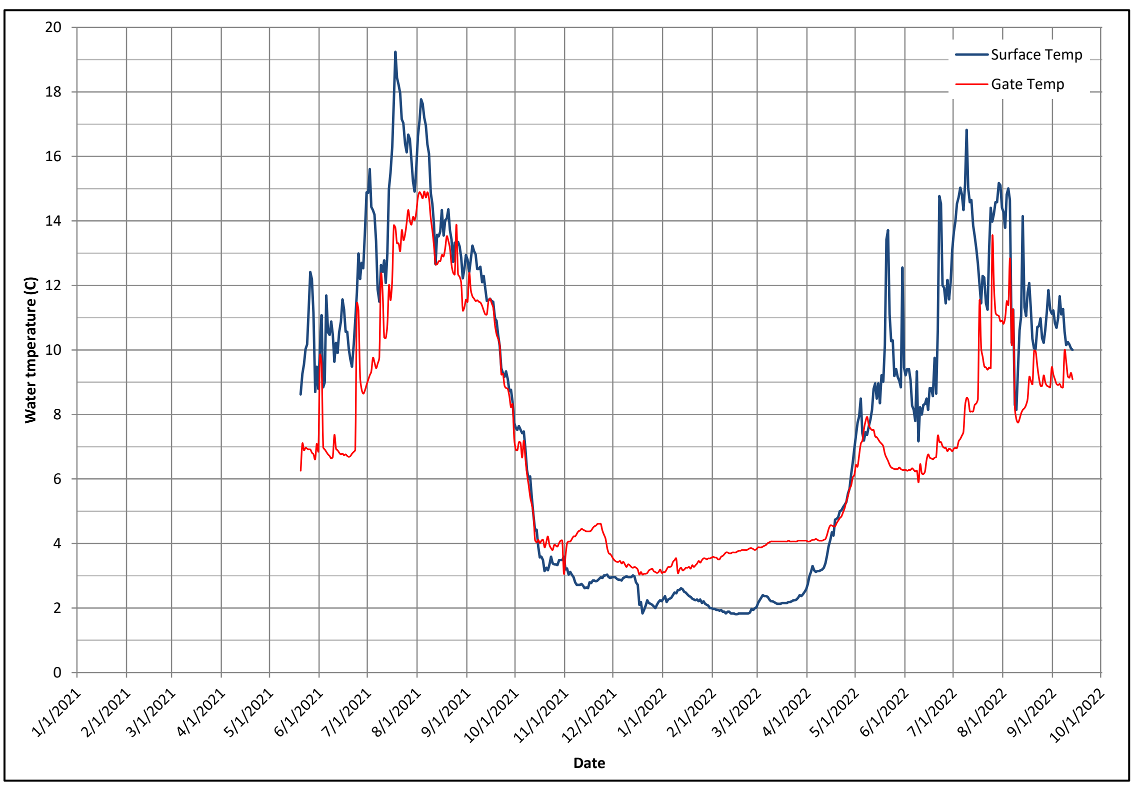

Figure 4-2. Eklutna Pond maximum daily water temperature 2021-2022.

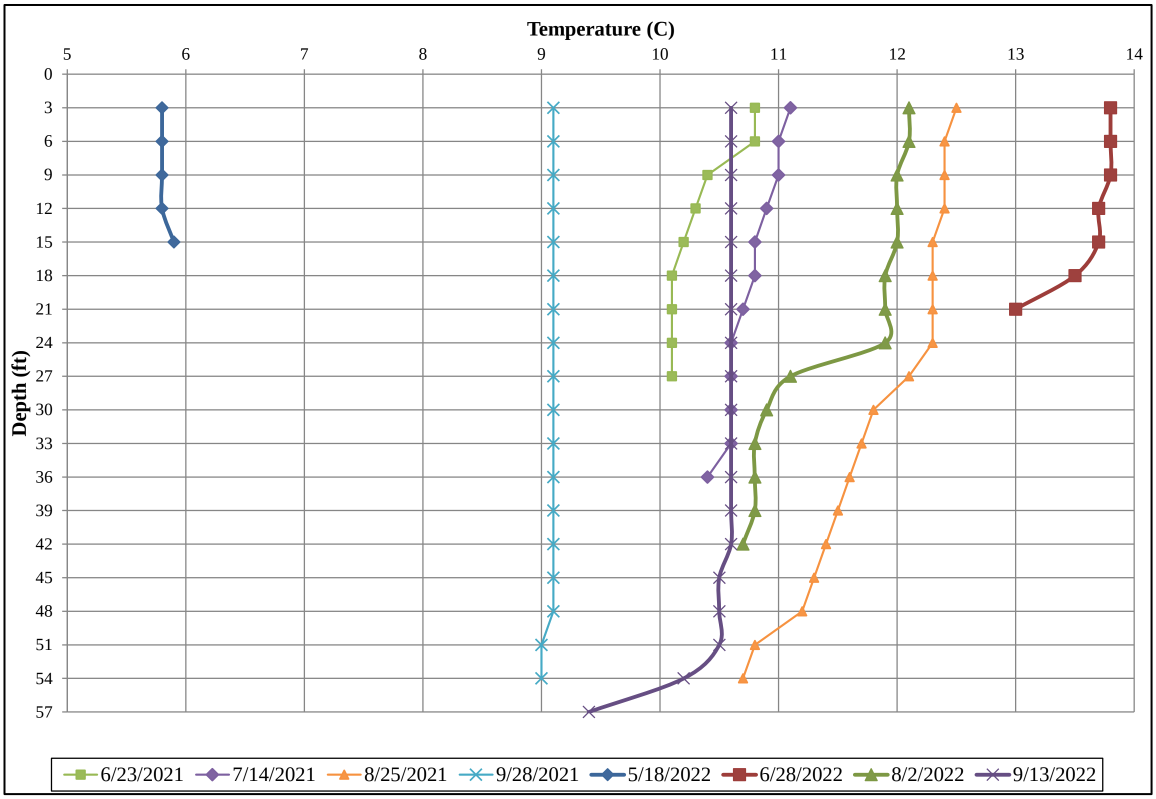

Figure 4-3. Eklutna Lake water temperature depth profiles 2021-2022.

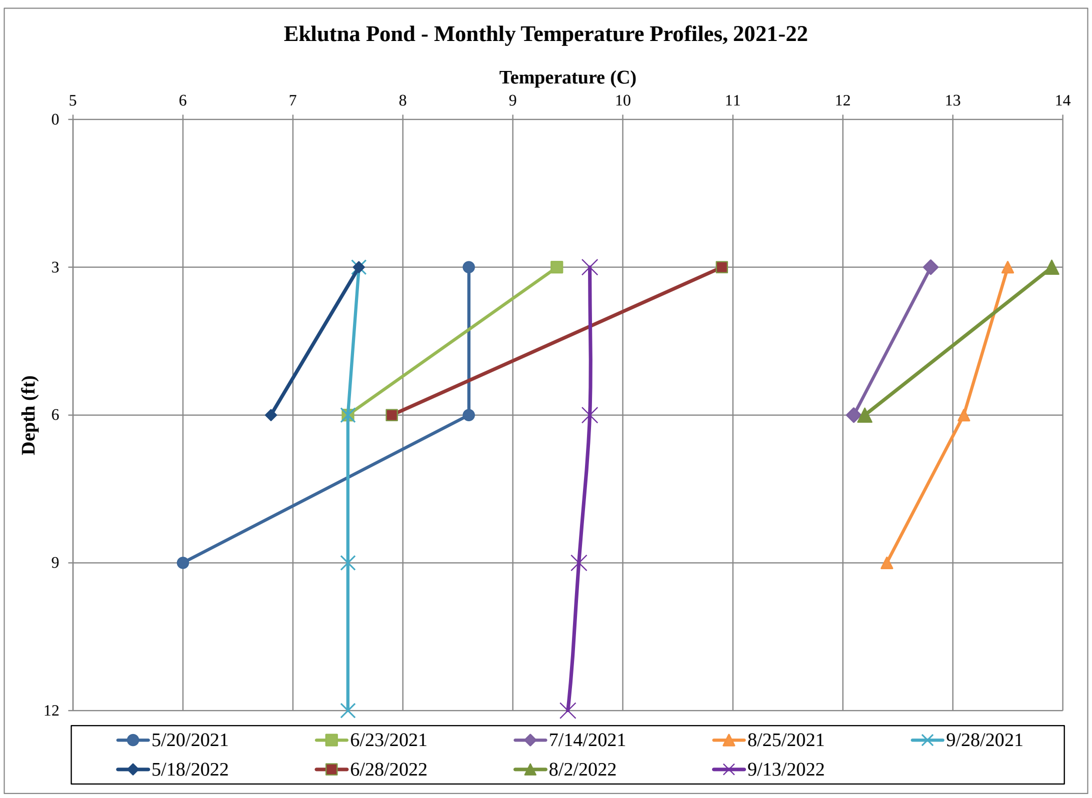

Figure 4-4. Eklutna Pond water temperature depth profiles 2021-2022.

4.2 Eklutna Lake Dissolved Oxygen (DO) and pH

4.2.1 Dissolved Oxygen (DO)

Figures 4-5 and 4-6 show DO profile data collected monthly at Eklutna Lake and the pond, respectively. Eklutna Lake has a relatively uniform DO profile throughout the water column and easily meets ADEC criteria of 7 mg/l (ADEC, 2020). In the pond, DO dropped below the 7 mg/l criteria at a depth of 9 feet and 6 feet in late May and late June of 2021, respectively. Freshwater macrophytes were not observed in the pond, so it is likely that these depleted DO concentrations were a result of leaf litter decomposition near the bottom of the pond. Finally, DO profiles between Eklutna Lake and the pond are nearly identical when both basins were connected in September of 2021.

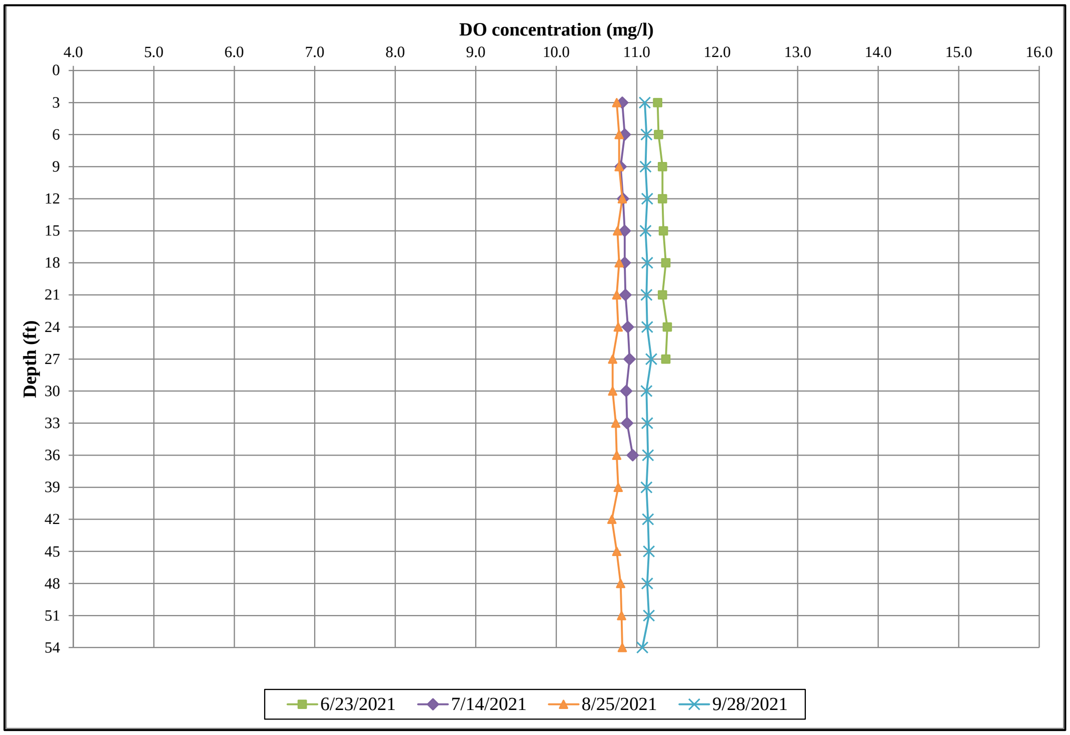

Figure 4-5. Eklutna Lake dissolved oxygen concentration profiles.

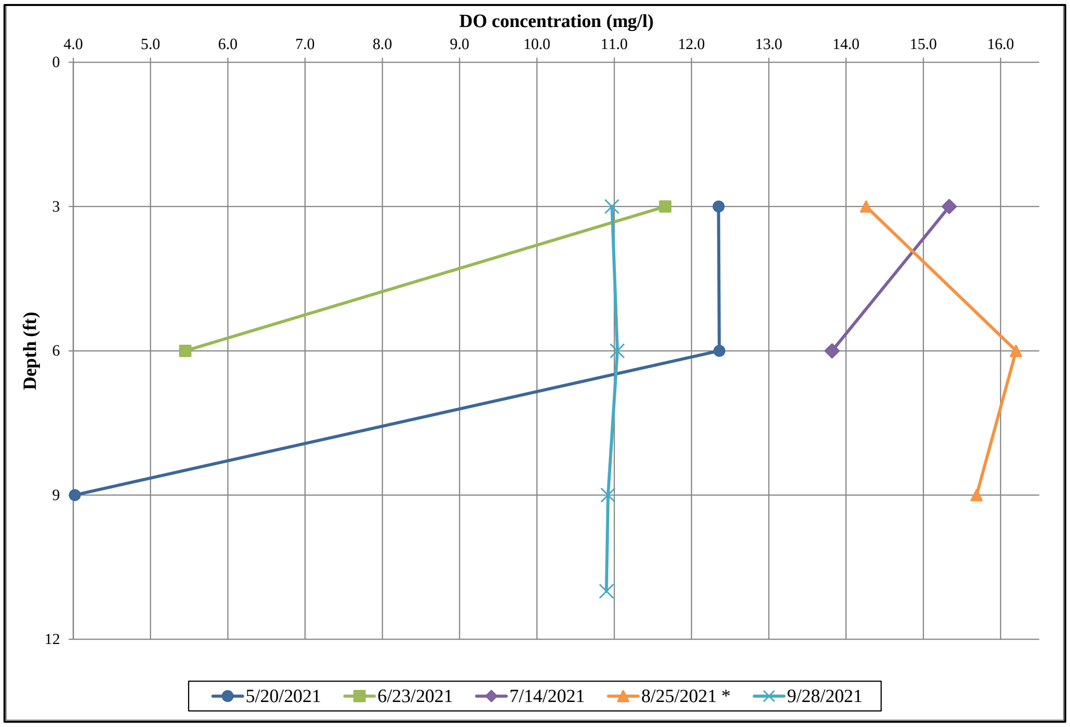

Figure 4-6. Eklutna Pond dissolved oxygen concentration profiles.

4.2.2 pH

Figures 4-7 and 4-8 summarize pH profile data collected monthly at Eklutna Lake and the Eklutna Lake pond, respectively. Values for pH in Eklutna Lake vary seasonally and throughout the water column, but the relatively narrow data range of 7.9-8.3 meet ADEC criteria of 6.5 – 8.5 (ADEC, 2020). Conversely, the pond exceeds the pH 8.5 criteria during the summer profiles collected in mid-July and late August of 2021. Similar to the water temperature results, pH data for Eklutna Lake and the pond remain unique despite being hydrologically connected during the September 2021 sampling effort.

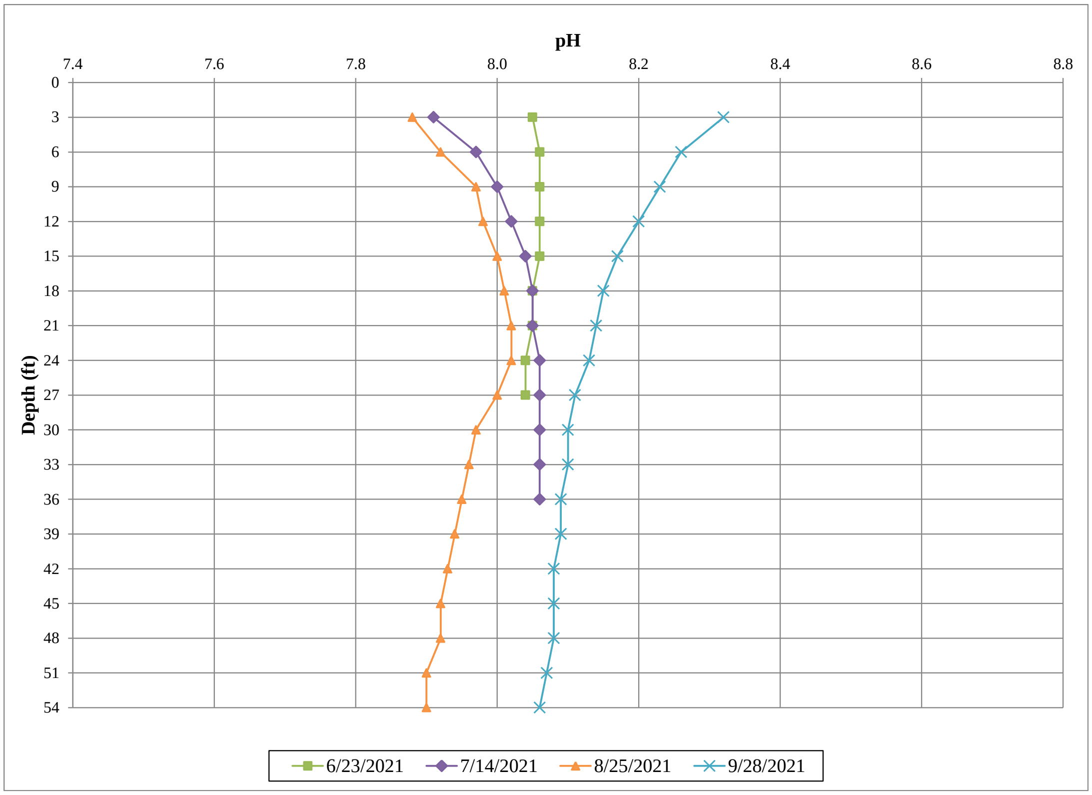

Figure 4-7. Eklutna Lake pH profiles.

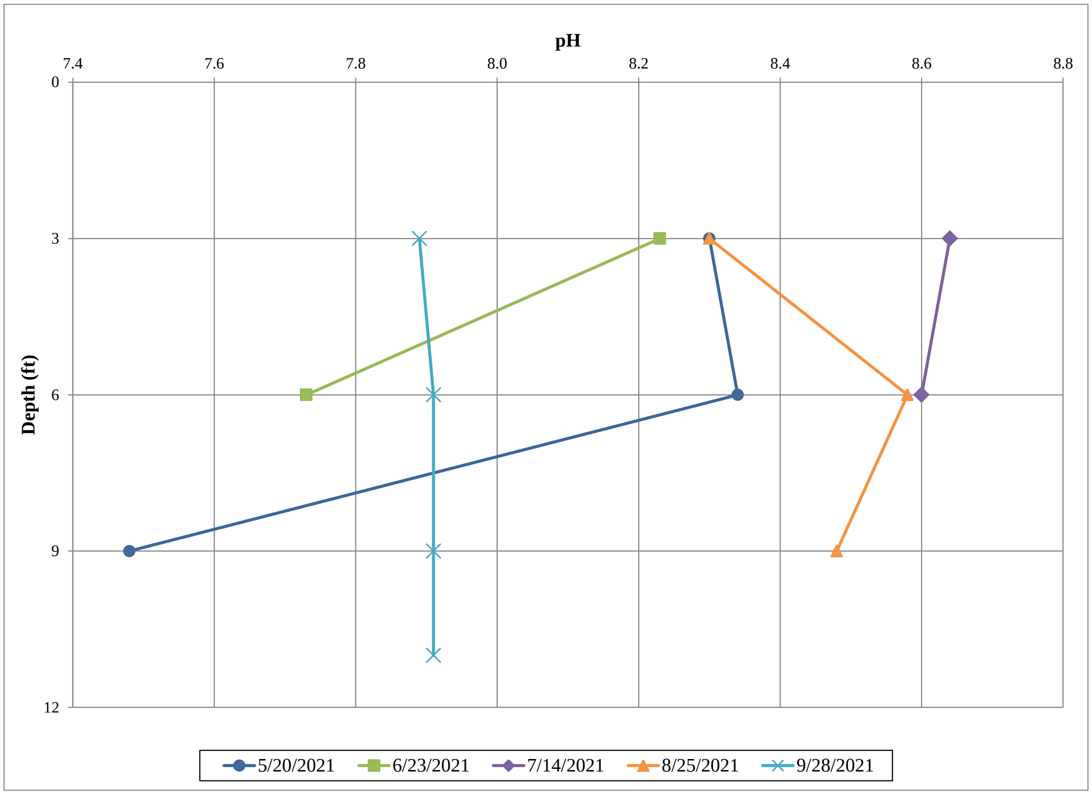

Figure 4-8. Eklutna Pond pH profiles.

4.3 Eklutna Lake Nutrients and Trophic Status

Table 4-1 summarizes the results from samples taken for TSI assessment in Eklutna Lake and the pond in 2021 and 2022. Results from 2021 revealed that Secchi depth and total phosphorus (TP) concentrations were not suitable factors to assess the trophic status of Eklutna Lake or the pond. Glacial runoff from the primary inflow tributaries create a turbid lake that greatly diminishes water clarity and confounds the Secchi depth results in relationship to the other parameters. TP concentrations below the detection limit of 0.04 mg/l (parts per million) does not provide the resolution needed to utilize TP as an index for trophic assessment. TP concentrations in µg/l or parts per trillion would be required to use as an index factor. However, discussions with SGS laboratories confirmed that mg/l or parts per million was the lowest analytical level that could be quantified. Therefore, in 2022, only chlorophyll *a* samples were collected to calculate the trophic index of Eklutna Lake based on the formula summarized Equation 4-1 (Carlson and Simpson, 1996). Based on 2021 results, Eklutna Lake and the pond would have a TSI of 18.5 and 23.2 while the 2022 results show both waterbodies with a TSI Index near 10.0 (10.6 for Eklutna Lake and 9.8 for the pond). Overall, these results would classify Eklutna Lake and the pond as oligotrophic (TSI <30; chlorophyll *a* <0.95 ug/l) or a lake with low primary productivity most likely due to nutrient deficiency. However, the low levels of algal biomass may also be attributed to the glacial turbidity of the lake that limits light penetration.

Table 4-1. Eklutna Lake and Eklutna Pond trophic factors, July 14, 2021, and July 7, 2022.

Sample Source	Chlorophyll *a* (ug/l)	Total Phosphorus (mg/l)	Secchi Depth (m)	TSI Value
Eklutna Lake (2021)	0.29	<0.04	0.85	18.5
Eklutna Pond (2021)	0.47	<0.04	2.04	23.2
Eklutna Lake (2022)	0.13	*not collected*	*not collected*	10.6
Eklutna Pond (2022)	0.12	*not collected*	*not collected*	9.8

Equation 4-1. Trophic State Index calculation utilizing chlorophyll *a* results

$$TSI = 9.81 * \ln(CHL\ a) + 30.6$$

5.0 Conclusions and Discussion

In both Eklutna Lake and the pond, surface water temperatures met the 20°C criteria established by ADEC, but had intermittent periods exceeding ADEC’s 15°C rearing criteria in July and August. The water temperature profile data revealed a very mild thermocline of approximately 1°C in the summer with turnover or an isothermal profile occurring in mid to late September. The Eklutna Lake temperature profile data reflect peak surface water temperatures (~14°C) and a similar timeframe for turnover observed in limnology studies conducted in the 1980’s (APA, 1984; R&M, 1985). However, the temperature profile data from the 1980s were collected at a deeper location (~200 feet) than the intake station (~57 feet). Temperature data from the deeper monitoring station showed a more substantial thermocline from mid-July to mid-August with surface temperatures ranging from 13°C to 14°C and bottom temperatures from 5.2°C to 5.4°C.

Eklutna Lake near the intake met ADEC criteria for DO (>7 mg/l) and pH (6.5-8.5) at all sampling dates in 2021. However, the pond had DO concentrations <7 mg/l at depth near the outlet gate on May 20 and June 23, 2021. Values for pH in the pond also slightly exceeded the upper end of ADEC criteria (8.5) with readings of 8.60 to 8.64 on July 14, 2021 and 8.58 on August 25, 2021 at a depth of 6 feet. In general, water quality conditions within Eklutna Lake are suitable for the ADEC water use category (C) *Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife.* However, there are depth strata and times of the year in which optimal temperature, DO, and pH conditions are not met, most notably in the pond.

As summarized in Section 4.3, the low TSI values from 2021 and 2022 correspond to an oligotrophic classification indicating low primary productivity based on algal biomass. With low primary productivity (phytoplankton), there is likely to be limited secondary production (zooplankton) as well. In addition, nutrient sampling of total phosphorus was below detections limits and reveals that nutrients may be limited within the watershed. Historical nutrient sampling by the USGS from 1972-1973 also indicated low phosphorus concentrations within water conveyed from Eklutna Lake to the Project's tailrace (<0.01 mg/l to 0.01 mg/l) (USGS, 1973). These results, coupled with low levels of nitrogen (0.4-0.18 mg/l) detected in 1972-1973 show that low nutrient concentrations have remained a stable condition within Eklutna Lake over time.

The limited limnological investigations addressed in this study indicate an overall lake productivity that is lower than what would likely be required to maintain complex, abundant planktonic communities and populations (the primary food source for juvenile Sockeye/kokanee populations in nursery lakes). And while these data serve to compliment the results from the fisheries studies conducted in Eklutna Lake and its tributaries in 2021 and 2022, it's important to note that they do not establish a carrying capacity or population potential of anadromous fish for Eklutna Lake. However, these data do confirm USACE conclusions from 2011 that Eklutna Lake is a waterbody with low productivity. Finally, it should be noted that the low TSI values and oligotrophic classification for Eklutna Lake does confirm why the waterbody serves as an excellent drinking water resource.

6.0 References

APA (Alaska Power Authority). 1984. Susitna Hydroelectric Project Eklutna Lake Temperature and Ice Study. 16 pp with 39 Figures. Submitted January 1984.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography. 22:2 361-369.

Carlson, R.E. and J. Simpson 1996. A coordinator's guide to volunteer lake monitoring methods. North American Lake Management Society. 96pp.

Department of Environmental Conservation. State of Alaska. 18 AAC 70. Water Quality Standards. Amended as of March 5, 2020. Register 233, April 2022. 65 pp

R&M (R&M Consultants, Inc.). 1985. Eklutna Lake Suspended Sediment, Turbidity, and Temperature Data 1982-1984. Memorandum submitted 5/1/1985 to Aquatic Study Team Members in support of Project No. 452418. 27 pp.

USACE (United States Army Corps of Engineers). 2011. Eklutna River Aquatic Ecosystem Restoration Technical Report. Submitted November 2011. 72 pp.

USGS (United States Geological Survey). 1973. USGS 612836149084800 EKLUTNA R BL POWER PLANT NR EKLUTNA AK. Accessed April 19, 2020. https://waterdata.usgs.gov/nwis/inventory/?site_no=612836149084800&agency_cd=USGS

Washington State Department of Ecology Environmental Assessment Program, 2011. Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams. Version 2.0. Author: William J. Ward, Reviewers: Dan Sherratt and Dave Hallock. Approved 10/26/2011, Recertified: 3/25/2015.

Technical Memo Comment-Response Table

Comment #	Agency/Interested Party	Draft Eklutna Lake Water Quality and Trophic Status Summary Technical Memo Section (Page) *"Text"*	Comment	Response
Section 4.0 Results				
1	USFWS	Section 4 and Figures 4-3 and 4-4 (Pages 4-5). *"In addition, when Eklutna Lake and the pond were connected during the September 2021 and September 2022 sampling efforts, each basin retained its unique temperature profile."*	Pages 4 to 5: Section 4 and Figures 4-3 and 4-4, describe how water temperatures in the basins of the pond and lake remained unique even when they were connected in September of 2021 and 2022. There were questions during the TWG meeting about how much of the pond and lake are shallow. This is important because shallower areas allow more sunlight which can result in more phytoplankton and zooplankton. The TWG also questioned if a future scenario of more static lake levels may result in greater areas of vegetated shoreline. Please discuss how lake and pond depths may be impacting fish habitat and lake productivity.	The general bathymetry of Eklutna Lake indicates limited shallow areas as it is steep banked along near shore areas with a deep, off-shore basin up to a depth of 208 ft. Based on the depth of the thermistor string deployment and profile data, it is evident that the pond would be considered a shallow area (~6 ft -18 ft deep). However, the pond represents such a small area in comparison to Eklutna Lake that even if the shallow pond were more productive (which the 2021 and 2022 data *have not* validated), it's effect on the overall productivity of Eklutna would be limited. Finally, the impacts of the high turbity from Eklutna Glacier runoff similarly affects the photic zone of the shallow and deep areas of the lake by limiting light penetration.
2	USFWS	Section 4.3 Eklutna Lake Nutrients and Trophic Status (Page 10). *"Glacial runoff from the primary inflow tributaries create a turbid lake that greatly diminishes water clarity and confounds the Secchi depth results in relationship to the other parameters."*	Page 10: Section 4.3, stated, the glacier runoff from the primary tributaries is causing turbidity in the lake that limits sunlight penetration and primary productivity. The rate of glacier-melt and subsequent turbidity levels in the lake will likely change as the glacier recedes (Sass et al. 2017), and levels of suspended glacial sediment and primary productivity in the lake may also change. Furthermore, Alaska has several examples of productive glacier-fed lakes, including Kenai Lake and Skilak Lake, and sockeye salmon (Oncorhynchus nerka) are known to rear in oligotrophic lakes. We request comparisons of similar glacier fed lakes in Alaska. Sass, L., M. Loso, J. Geck, E. Thoms, and D. McGrath. 2017. Geometry, mass balance and thinning at Eklutna Glacier, Alaska: An altitude-mass-balance feedback with implications for water resources. Journal of Glaciology, 63(238), 343-354. 12 pp. doi:10.1017/jog.2016.146	Sass et al. (2017) primarily conclude that the diminishing Eklutna Glacier (i.e. glacial loss) is providing "...7 ± 1% of the average inflow to Eklutna Reservoir…" and that the percent of inflows from glacial loss will likely increase over time. There is no timeframe provided for the end of glacial-melt within the watershed, nor are there any conclusions regarding impacts to turbidity in the receiving waterbody, (Eklutna Reservor). A search for data summarizing liminological parameters that assess productivity in Kenai Lake, Skilak Lake, or other productive glacial fed lakes will be conducted and compared to the Eklutna Reservoir in the Year 2 Study Report.

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General Comments				
3	USFWS	General	During the TWG meeting there were discussions surrounding the Eklutna Lake system going decades without marine derived nutrients and if this could have contributed to the lack of nutrients in the lake. We recommend further analysis of how the lack of marine derived nutrients may be impacting productivity in the lake system.	We agree that Eklutna Lake has lacked marine derived nutirents since the 1929 diversion dam was constructed. Also, the literature is pretty clear on the impacts of marine derived nutrients in sockeye nursery lakes. As described by Stockner and MacIssac (1996) "...declining adult escapements have also resulted in a significant loss of nitrogen (N) and phosphorus (P) nutrients supplied by decomposing adult carcasses and the lakes have become less productive (oligotrophication) for rearing sockeye fry." However, we are not aware of a peer reviewed technique that can model, predict, or quantify how marine dervied nutrients would impact lake productivity. The Stockner and MacIssac (1996) study was based on 20+ years of studying Canada's Lake Enrichment Program, not a predictive model. The addition of liquid fertilizers did increase phytoplankton concentrations (primary production), but this did not always result in zooplankton increases (secondary production) of the primary species consumed by sockeye fry (*Dapnia spp.*). Daphnid zooplanton "...occupy a keystone position in the pelagic food-web and are thought to be one of the principal reasons why interior lakes produce larger smolts than coastal systems [in British Columbia]..." . Finally, it should be noted that "glacially turbid lakes with cold, poorly stratified epilimnia and strong light extinction from high concentrations of suspended glacial silt were rejected for nutrient enrichment." Stockner, J.G. and E.A. MacIsaac. 1996 British Columbia Lake Enrichment Programme: Two Decades of Habitat Enhancement for Sockeye Salmon, Regulated Rivers: Research and Management. Vol 12, 547-561.
4	USFWS	General	It appears productivity in Eklutna Lake has been impaired because of alterations to natural processes. The dam structure is preventing flushing flows from moving sediment through the system, and is preventing marine derived nutrients from getting into the system. The large variances in lake levels are inhibiting shallow habitat vegetated shorelines from producing nutrients. We would like to see more analysis on the impacts that the dam and fluctuating lake levels have had on the Eklutna Lake habitat and nutrients. The lake system could be compared to other functioning systems in Alaska such as Kenai Lake and Skilak Lake.	See answer above related to marine derived nutrients and productivity. Water level fluctuations are not likely to have much effect on pelagic productivity since the same photic zone would be present offshore as it is inshore, and plankton are not place-bound to the near shore environment. Furthermore, without lake level data for Kenai and Skilak Lake, a comparison to these waterbodies would be speculative.

Technical Memo Comment-Response Table

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Comments on Preliminary Engineering for Fish Passage Presentation				
5	USFWS	General	During the potential engineering solutions portion of TWG meeting, we learned that natural river system fish passage measures were determined to be not feasible and were not considered further. However, we are interested in exploring what some natural channel options could look like, and what the costs and benefits of those options would be.	The owners have communicated that dam removal is not a PME measure being explored. However, multiple fish ladder alternatives are being investigated for upstream passage into Eklutna lake. The current gravity flow fish ladder alternative is shown as a weir and orifice style ladder, however other ladder types may be investigated as this alternative is advanced into more detailed design.
6	USFWS	Upstream Fish Passage Scenarios	For upstream fish passage some scenarios could include dam removal, a constructed natural bypass channel, and a hybrid scenario with a bypass channel supported by trap and haul during low lake levels. With these options elevated lake levels may no longer be possible, however pumped energy storage to uphill reservoirs could provide a means for storing water for Eklutna when energy is more abundant (Williams et al. 2020). Williams, K., C. Smith, and B. Higman. 2020. Pumped energy storage for Alaska: A path to lower energy costs for Alaska's future. Alaska Institute for Climate and Energy. 21 pp.	The intent of the engineering alternatives analysis is to mitigate impacts of the existing project, rather than development of a new project. While the implementation of a pumped storage scheme in the railbelt may be attractive at a point in the future to firm excess renewables, it is not something being looked into at this time as part of the Eklutna Project.
7	USFWS	Downstream Fish Passage Scenarioes	Downstream fish passage scenarios could include dam removal both with and without lake fluctuations, resulting in a more run of the river scenario for power generation. We are interested in other options to facilitate outmigration such as a multi-level intake structure with a conduit around the dam (Hansen et al. 2017), and use of induced turbulence or injection of dissolved oxygen to attract outmigrants to safe passage routes (Perry et al. 2005; Biomark 2022). Hansen, A., T. Kock, and G. Hansen. 2017. Synthesis of downstream fish passage information at projects owned by the U. S. Army Corps of Engineers in the Willamette River Basin, Oregon: U.S. Geological Survey Open File Report 2017-1101. 118 pp. https://doi.org/10.3133/ofr20171101. Perry, R., M. Farley, G. Hansen, J. Morse, and D. Rondorf. 2005. Turbulence investigation and reproduction for assisting downstream migrating juvenile salmonids, part ii of ii; effects of induced turbulence on behavior of juvenile salmon. 2001-2005 Final Report, Project No. 200101000. BPA Report DOE/BP-00007427-1. 61 pp.	Multiple downstream passage alternatives are being investigated, including a natural outflow at the dam. Secondary attraction measures (beyond attraction flow) such as induced turbulence or D.O. injection may be analyzed as part of the detailed design.
8	USFWS	Additional Discussions Request	We request focused meetings to discuss dam engineering options. We would like to see more options based on fish passage and biological factors such as seasonal migration, timing, and other fish and aquatic habitat needs.	We will be meeting with stakelholders to review the engineering alternatives in early 2023.

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9	USFWS	Data Request	During the TWG meeting graphs were provided illustrating the 10-year average water surface elevation overlain with water surface elevation per measure proposed. We would like to provide more in-depth analysis based on the biological needs of fish; to do this we request the last few years of actual head/pond fluctuation be provided on a daily scale instead of the 10-year average.	Daily water surface elevation data for Eklutna Lake over the prior 3 years is located at the following link: https://nwis.waterdata.usgs.gov/usa/nwis/uv/?cb_00065=on&cb_72192=on&format=gif_default&site_no=15278000&legacy=1&period=1095&begin_date=2022-12-08&end_date=2022-12-15
10	NVE	General	Trap and haul should not be necessary even at low lake levels with appropriate new "plumbing" engineering at the Eklutna Lake outlet. The lake should be kept high enough to cover the profuse potential sockeye spawning habitat around the lake now in the varial zone.	Fish passage alternatives that do not involve trap and haul and keep the lake level high are being investigated and will be presented as part of the phase 1 engineering analysis.
11	NVE	General	Our analysis recommends a deeper channel through the natural moraine dam, likely with a new hoist gate dam there, which should allow seasonally adequate and continuous flow release, and fish passage like a fish ladder (or "… constructed natural bypass channel" (as per USFWS comments)) without needing trap and haul even at lower lake levels. Dam removal, as per FWS could be nice for the salmon, but probably not so advantageous for power operations. Trap and haul capacity might be retained as an emergency option for abnormally low water years. We are counting on your team to design such options for us.	A deeper channel option as well as a new hoist gate located at the dam are PME measures being investigated, to be presented as part of the phase 1 engineering results.