Eklutna Hydroelectric Project

Draft Summary of Study Results

CHUGACH

MEA
MATANUSKA ELECTRIC ASSOCIATION

MUNICIPALITY OF ANCHORAGE

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Terms, Acronyms, and Abbreviations

1991 Agreement	1991 Fish and Wildlife Agreement
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ADOT&PF	Alaska Department of Transportation and Public Facilities
AEA	Alaska Energy Authority
AF	acre-feet
AL&P	Anchorage Light & Power
APU	Alaska Pacific University
ARRC	Alaska Railroad Corporation
AWWU	Anchorage Water and Wastewater Utility
cfs	cubic feet per second
Chugach	Chugach Electric Association, Inc.
CIAA	Cook Inlet Aquaculture Association
DO	Dissolved Oxygen
EUOC	Anchorage Assembly Enterprise and Utility Oversight Committee
Federal and State Resource Management Agencies	USFWS, NMFS, ADFG, ADEC, and ADNR
FERC	Federal Energy Regulatory Commission
ft	feet
Governor	Governor of Alaska
HEC-RAS	Hydrologic Engineering Center River Analysis System
HSC	Habitat Suitability Criteria
IHN	Infectious Hematopoietic Necrosis
IIP	Initial Information Package
MEA	Matanuska Electric Association, Inc.
MOA	Municipality of Anchorage
MW	megawatt
National Register	National Register of Historic Places
NMFS	National Marine Fisheries Service
NVE	Native Village of Eklutna
OHA	Office of History and Archaeology
OPCC	Opinion of Probable Construction Costs
Parties	MOA, Chugach, MEA, NMFS, USFWS, and the State of Alaska
PHABSIM	Physical Habitat Manipulation
PME	protection, mitigation, and enhancement
Project	Eklutna Hydroelectric Project

Project Owners	MOA, Chugach, and MEA
RM	river mile
SHPO	State Historic Preservation Officer
State	State of Alaska
State Parks	ADNR Division of Parks and Outdoor Recreation
TEK	Traditional Ecological Knowledge
Transaction Date	October 2, 1997
TSS	Total Suspended Solids
TU	Trout Unlimited
TWG	Technical Work Group
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1.0 Introduction

Since it was constructed by the Federal government in the 1950s, the Eklutna Hydroelectric Project (Project) has been operated to maximize the generation of cost-effective, carbon-free, flexible hydroelectric energy for the electric customers in Southcentral Alaska.

In 1997, the Project was sold to and is currently owned by the Municipality of Anchorage (MOA), Chugach Electric Association, Inc. (Chugach), and Matanuska Electric Association, Inc. (MEA), collectively the "Project Owners." As part of the sale of the Project, a binding agreement was entered into by the Project Owners, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and the State of Alaska (collectively the "Parties") that requires the Project Owners to develop and propose to the Governor a program to protect, mitigate damages to, and enhance fish and wildlife impacted by the development of the Project (1991 Agreement). The Parties agreed that the process outlined in the 1991 Agreement obviated the need for the Project Owners to obtain a license from the Federal Energy Regulatory Commission (FERC).

The 1991 Agreement required the Project Owners to fund and conduct studies to examine and quantify, if possible, the impacts to fish and wildlife from the hydroelectric development of the Project. The studies were also designed to examine and develop proposed protection, mitigation, and enhancement (PME) measures to address those impacts. This examination also had to consider the impact of fish and wildlife measures on electric rate payers, municipal water utilities, recreational users, and adjacent land use, as well as available means to mitigate those impacts.

Beginning in 2020, the Project Owners consulted with agencies and interested stakeholders regarding development of a study program. The study program that was developed by the Project Owners, agencies, and other interested stakeholders consisted of two primary years of studies and information gathering (2021 and 2022). This document presents an overview of early study efforts, study planning and implementation, and a summary of the study results. When available, the Project Owners incorporated the results of other studies conducted in the Eklutna watershed by other entities.

1.1.1.1 Early Study Efforts

Study program development began in earnest in 2020. In May 2020 the Project Owners acquired aerial imagery, spherical videography, and LiDAR of the entire Eklutna River as well as the northeastern shoreline of Eklutna Lake along the lakeside trail. The spherical videography is available on the project website and at https://biglook360.com/eklutna/.

In July 2020, the Project Owners conducted a site reconnaissance with ADFG staff to support study planning efforts. The Aquatics TWG met on July 23, 2020, to review the observations made during the site reconnaissance and to kick-off the study planning process. This meeting included initial discussions regarding the planned Instream Flow Study, potential study methods, and associated challenges.

In August 2020, the Project Owners conducted an initial condition assessment of the drainage outlet gate at the base of the spillway and established several monitoring transects and installed scour monitors in the Eklutna River in advance of any potential unplanned spill events to allow for subsequent data collection that could benefit the study program. There were no spill events in 2020; however, the established transects and scour monitors were later utilized during the Geomorphology and Sediment Transport Study to assess erosion and sediment transport through the Eklutna River downstream from Eklutna Lake and to help calibrate the sediment transport model.

1.1.1.2 Year 1 Study Planning and Implementation

Based on this early work, the Project Owners developed a Proposed Study Program Framework and presented it to Aquatics TWG on September 3, 2020. This meeting included discussion regarding how study efforts would occur over a two-year period, the goals and objectives, general study area, proposed methods for each study, the study plan outline, and the study planning schedule.

Draft Study Plans were distributed to the Aquatics TWG on October 26, 2020, for review and comment. The deadline for written comments was November 25, 2020. The Project Owners received comments from NVE, ADFG, USFWS, NMFS, TU, Erin Larson and Jason Geck with APU, and Brett Jokela with the WNRC. Two meetings were held with the Aquatics TWG on November 30, 2020, and December 21, 2020, to review and address the Aquatics TWG's comments on the Draft Study Plans.

The Project Owners revised the Draft Study Plans based on the other comments received, and the Revised Draft Study Plans were distributed to the Aquatics TWG on January 18, 2021, for review and comment. The deadline for written comments on the Revised Draft Study Plans was January 29, 2021.

Since several of the Aquatics TWG's comments on the Draft Study Plans were questions related to the operational capabilities of the Project, the Project Owners decided to start developing the proposed hydro operations model and presented the preliminary modeling results to the Aquatics TWG at a meeting on January 26, 2021, to help inform the Aquatics TWG's comments on the Revised Draft Study Plans. The Project Owners also addressed additional clarifying questions from the Aquatics TWG at the January meeting in advance of the comment deadline.

The Project Owners received comments from ADFG, NMFS, TU, and Erin Larson with APU and revised the study plans again based on comments received. As required by the 1991 Agreement, the Proposed Final Study Plans were distributed to the Parties on February 24, 2021, for review and concurrence on the scope of work.

A meeting amongst the State agencies involved in the Project was held on February 25, 2021 to determine how the State of Alaska, as a party to the 1991 Agreement, would concur on the scope of work in the study plans. The State agencies determined that it would be most appropriate for the Commissioners of each State agency (ADFG, ADEC, ADNR, and ADOT&PF) to sign a letter stating that they concur on the scope of work in the study plans, and then the Project Owners would send those concurrence letters to AEA, the Governor's representative, with the study plans for review and feedback.

The Project Owners received concurrence letters from all of the state and federal agencies, including the NMFS, USFWS, ADFG, ADEC, ADNR, and ADOT&PF. The State agency concurrence letters and the Proposed Final Study Plans were sent to AEA as the Governor's representative for review and feedback; however, the Project Owners did not receive any additional feedback from AEA.

Studies initiated during the 2021 field season included the following:

- **Instream Flow Study** – *informed how much habitat would be created by a range of potential flows for various species (Chinook, coho, sockeye) and life stages (spawning and rearing).*
- **Geomorphology and Sediment Transport Study** – *informed what peak flows might be needed in conjunction with year-round instream flows.*
- **Fish Species Composition and Distribution Study** – *identified what fish species were present in the Eklutna River, what habitat they were utilizing, and when.*
- **Water Quality Study** – *monitored various water quality parameters (temperature, dissolved oxygen, pH, turbidity, nutrients, etc.) in both the Eklutna River and Eklutna Lake.*
- **Macroinvertebrate Study** – *assessed the baseline community of aquatic organisms at three locations in the Eklutna River.*

- **Stream Gaging** – *collected continuous flow data at various points in the Eklutna River and select tributaries to Eklutna Lake.*
- **Lake Aquatic Habitat and Fish Utilization Study** – *examined the presence and health of fish in Eklutna Lake, as well as the availability of potential spawning habitat around the lake shoreline and in its tributaries.*
- **Lakeside Trail Erosion Study** – *identified areas along the Eklutna Lakeside Trail that were experiencing shoreline erosion and the potential causes.*
- **Hydro Operations Model Development** – *allows the assessment of different potential operational scenarios for the hydroelectric project.*
- **Existing Infrastructure Assessment** – evaluated the condition and hydraulic capacity of downstream infrastructure, including the AWWU infrastructure, railroad bridge, and highway bridges.

One of the major components of the year 1 study program was the need to conduct study flow releases for both the Instream Flow Study and the Geomorphology and Sediment Transport Study. With the current infrastructure, the drainage outlet gate at the base of spillway in the dam is the only mechanism for providing controlled flow releases from the lake into the river. However, this gate had not been used regularly, and upon inspection, it was determined that the gate needed to be replaced. The Project Owners were able to design, procure, permit, and install the new drainage outlet gate during the summer of 2021 before the planned study flow releases in the fall of 2021, which ranged from 150 cfs to 25 cfs over 3 weeks.

It should be noted that in 2018, another dam (non-operational since 1955) was removed from the lower stretch of the Eklutna River by Eklutna, Inc. After the removal of this lower dam, a significant portion of the sediment wedge that had accumulated behind the lower dam for decades was left in the river. During year 1 study planning, some TWG members requested a flushing flow as part of this study program to flush the remaining sediment from behind the lower dam site. It was determined that this flushing flow was not necessary for study purposes. However, the Project Owners did commit to evaluating the need for conducting a higher calibration flow as part of the second study year.

In preparation for study flow releases, the Project Owners requested consent and waiver of liability for the planned study flows and potential movement of Eklutna Inc.'s sediment wedge from the principal landowners downstream of the Project: Eklutna, Inc., The Alaska Department of Transportation and Public Facilities (ADOT&PF), Alaska Railroad Corporation (ARRC), and the MOA/AWWU. Among them, only the MOA/AWWU consented and waived such potential liability. ADOT&PF's, ARRC's, and Eklutna, Inc.'s refusals to consent and waive liability for study flows and movement of Eklutna, Inc.'s sediment was noted in the Project Owners' decisions to proceed with study flow releases.

1.1.1.3 Year 2 Study Planning and Implementation

Based on observations during the September/October 2021 site visits and preliminary results from the first year of studies, the Project Owners revised the Study Program Framework for year 2 and presented it to the TWGs on November 8-9, 2021. These meetings included discussion regarding preliminary results from Year 1 (if applicable), what studies were being proposed for Year 2 (Table 1-1), and the goals, general study area, and proposed methods for each study.

Table 1-1. Year 2 Study Program.

Studies Continued from Year 1 (2021)	Studies Initiated in Year 2 (2022)
Instream Flow Study	Engineering Feasibility and Cost Assessment
Geomorphology and Sediment Transport Study	Hydropower Valuation Study
Fish Species Composition and Distribution Study	Wetland and Wildlife Habitat Study
Lake Aquatic Habitat and Fish Utilization Study	Terrestrial Wildlife Study
Water Quality Study	Recreation Study
Stream Gaging	Cultural Resources Study
	LiDAR and Ortho Imagery Acquisition

Following their commitment in 2021, the Project Owners evaluated the need for a higher calibration flow in 2022. However, based on the data collected in year 1, it was determined that reasonably reliable models could be developed using the collected data, and that a higher calibration flow in 2022 was not necessary for study purposes.

The Draft Year 2 Study Plans were distributed to the Parties and TWGs on February 11, 2022, for review and comment. The deadline for written comments on the Draft Year 2 Study Plans was March 11, 2022. The Project Owners received comments from NVE, USFWS, NMFS, ADFG, ADEC, OHA, TU, and The Conservation Fund.

Meetings with the TWGs were held the week of March 21, 2022, to address substantive comments on the Draft Year 2 Study Plans that required further discussion. The Project Owners revised the study plans based on comments received, and the Proposed Final Year 2 Study Plans were distributed to the Parties on April 1, 2022, for review and concurrence.

The Project Owners again received concurrence letters from each of the state agencies. The NMFS and USFWS also provided concurrence letters but only concurred with 10 of the 12 study plans. The federal agencies did not concur with the Geomorphology and Sediment Transport Study Plan or the Instream Flow Study Plan due to their uncertainty about the Project Owners ability to model higher flows without a significantly higher calibration flow.[1] The Project Owners documented this area of non-agreement and distributed the Proposed Final Year 2 Study Plans and state concurrence letters to AEA as the Governor's representative for review and feedback; however, the Project Owners did not receive any additional feedback from AEA.

[1] The Project Owners acknowledge the uncertainty associated with any modeling effort. And after reviewing the modeling results, both federal agencies have confirmed the validity of both models.

2.0 Summary of Study Results

This section provides a summary of each study conducted during the 2-year study program. The full study reports are available on the Project website (www.eklutnahydro.com).

2.1 Instream Flow Study

The goal of the Instream Flow Study was to provide quantitative indices of current and future reach-specific habitat-flow relationships and to use those relationships as a tool to estimate potential fish habitat under various operational flow-release scenarios. Specific objectives included:

1. Mapping current aquatic habitat in the main channel, and where present, side-channels of the Eklutna River affected by Project operations. *Developed by NVE.*
2. Collecting data and information that can be used to characterize, quantify, and model Eklutna River fish habitat.
3. Developing a one-dimensional (1D) HEC-RAS model in coordination with the Geomorphology and Sediment Transport Study (see Section 2.2) for the length of the river that can be used to:
   a. Estimate water surface elevations and average water velocity along modeled transects under alternative operational scenarios; and
   b. Estimate sediment routing and transport capacities under varying flow conditions.
4. Developing Habitat Suitability Criteria (HSC) for target/selected species and life stages of fish for biologically relevant time periods selected in consultation with the Aquatics TWG.
5. In Year 1, developing fish habitat-flow relationships using one-dimensional (1D) Physical Habitat Simulation (PHABSIM) models in Year 1 to produce a time series of data for a variety of biological metrics under existing and potential future conditions resulting from alternative operational scenarios. In Year 2, developing two-dimensional (2D) HEC-RAS and habitat models for four reaches with complex off-channel and side channel juvenile rearing habitats.

6. Evaluating existing conditions and potential future conditions based on alternative operational scenarios using a hydrologic database that includes wet, average, and dry years.

2.1.1 Fish Habitat Modeling

The study area included a 10-mile section of the Eklutna River extending downstream from the existing Eklutna Dam to below the railroad bridge near tidal influence. A meso-habitat map developed by NVE was used to define the fish habitat reaches and select potential study sites for the 1D PHABSIM modeling effort. In June 2021, the Project Owners organized a site visit with the Aquatics TWG to identify and establish transect locations at each study site (Figure 2-1). A total of 30 transects were established throughout the river in relatively stable areas of the river that were not likely to change significantly as a result of the study flow releases.

Figure 2-1. Site Visit with the Aquatics TWG in June 2021.

Field data (water depth, velocity, and substrate) were collected during the 2021 study flow releases as described below.

- Monday, September 13 – Initiated flow releases at **150 cfs** (allowed the channel to stabilize for one week before collecting any field data)
- Monday, September 20 – Initiated field surveys for high-flow release
- Thursday, September 23 – Completed high-flow field surveys

- Friday, September 24 – Down-ramped to **75 cfs**
- Saturday, September 25 – Initiated field surveys for mid-flow release
- Tuesday, September 28 – Completed mid-flow field surveys
- Wednesday, September 29 – Down-ramped to **25 cfs**
- Thursday, September 30 – Initiated field surveys for low-flow release
- Saturday, October 2 – Completed low-flow field surveys
- Wednesday, October 6 – Down-ramped to 0 cfs

Due to feasibility and safety concerns, four sections of the river were unable to be studied as part of the 1D modeling effort. However, the Project Owners were still able to study these sections of the river by using LiDAR data to develop 2D models for those specific sections.

Habitat Suitability Criteria (HSC) curves were developed for three target species (Chinook, coho, and sockeye) and two target life stages (spawning and rearing[2]) in coordination with the Aquatics TWG. The HSC curves were used with both the 1D and 2D models to produce habitat-flow relationship curves for each species and life stage at each 1D transect and 2D reach. Example habitat-flow relationship curves are shown below in Figure 2-2. These curves were derived from 1D PHABSIM modeling and show the relationships of habitat area to flow (left figure) and the same data normalized as a percentage of habitat maximum to flow (right figure).

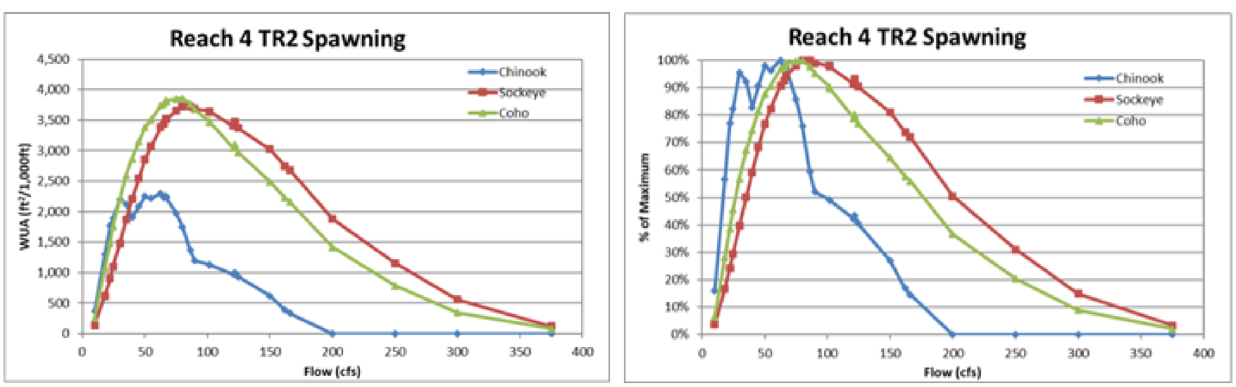


Figure 2-2. Example habitat-flow relationships for Chinook (blue), coho (green), and sockeye (red) spawning habitat at Transect 2 in Reach 4.

[2] No HSC curve was developed for sockeye rearing habitat because sockeye generally rear in lakes, not rivers.

The habitat-flow relationship curves determined the maximum available habitat for each species at each life stage. The periodicity data collected during the Eklutna River Fish Species Composition and Distribution Study (see Section 2.3) was used to prioritize different species and life stages at different times of year. The habitat-flow relationship curves and periodicity data were then used together to develop potential flow release scenarios.

Four example flow levels were developed for demonstration purposes only. The example flow levels correspond to flows that would provide 90%, 70%, 50% and 30% of the maximum available habitat considering all three species and both life stages. Spawning habitat was prioritized for July-October, and rearing habitat was prioritized for November-June. The species that required the highest flow to achieve a given percent of maximum available habitat served as the determinant for that flow level. The example flow levels were then applied to three potential flow release locations, 1) the existing Eklutna Dam at RM 12, 2) the AWWU portal valve at RM 11, and 3) the AWWU pipeline at RM 5.5. The habitat-flow relationships were then used to determine how much habitat (in acres) would be created for each of the example flow levels at each potential flow release location for each species at each life stage (except for sockeye rearing habitat) and compared to existing conditions as shown in Table 2-1.

Table 2-1. Example time series analysis.

Potential Flow Release Locations	Example Flow Levels (% of Max Available Habitat)	Time-Averaged Habitat Expressed as Weighted Usable Area (acres)				
		Chinook		Coho		Sockeye
		Spawning	Rearing	Spawning	Rearing	Spawning
RM 12 (Existing Dam)	90%	1.5	30.6	3.1	41.3	2.5
	70%	1.4	22.6	3.1	30.4	2.7
	50%	1.2	17.6	2.8	22.8	2.4
	30%	1.0	16.2	2.6	20.8	2.2
RM 11 (AWWU Poral Valve)	90%	1.2	28.1	2.4	37.5	2.1
	70%	1.1	20.4	2.5	27.2	2.3
	50%	1.0	16.3	2.4	21.0	2.1
	30%	0.9	15.2	2.2	19.4	1.9
RM 5.5 (AWWU Pipeline)	90%	0.5	22.9	1.4	29.0	1.3
	70%	0.6	16.0	1.6	20.6	1.5
	50%	0.6	13.3	1.6	16.9	1.5
	30%	0.6	12.9	1.5	16.3	1.5
Existing Conditions		0.5	11.9	1.2	14.8	1.0

2.1.2 Channel Connectivity Analysis

The 2D models were used to assess the connectivity of side-channel and off-channel habitats under various flow conditions. An example of the channel connectivity analysis is provided in Figure 2 2 for Reach 3 under four flow conditions (375, 250, 150, and 50 cfs). The figure illustrates how increased flows create increased channel connectivity with side and flood-plain channels.

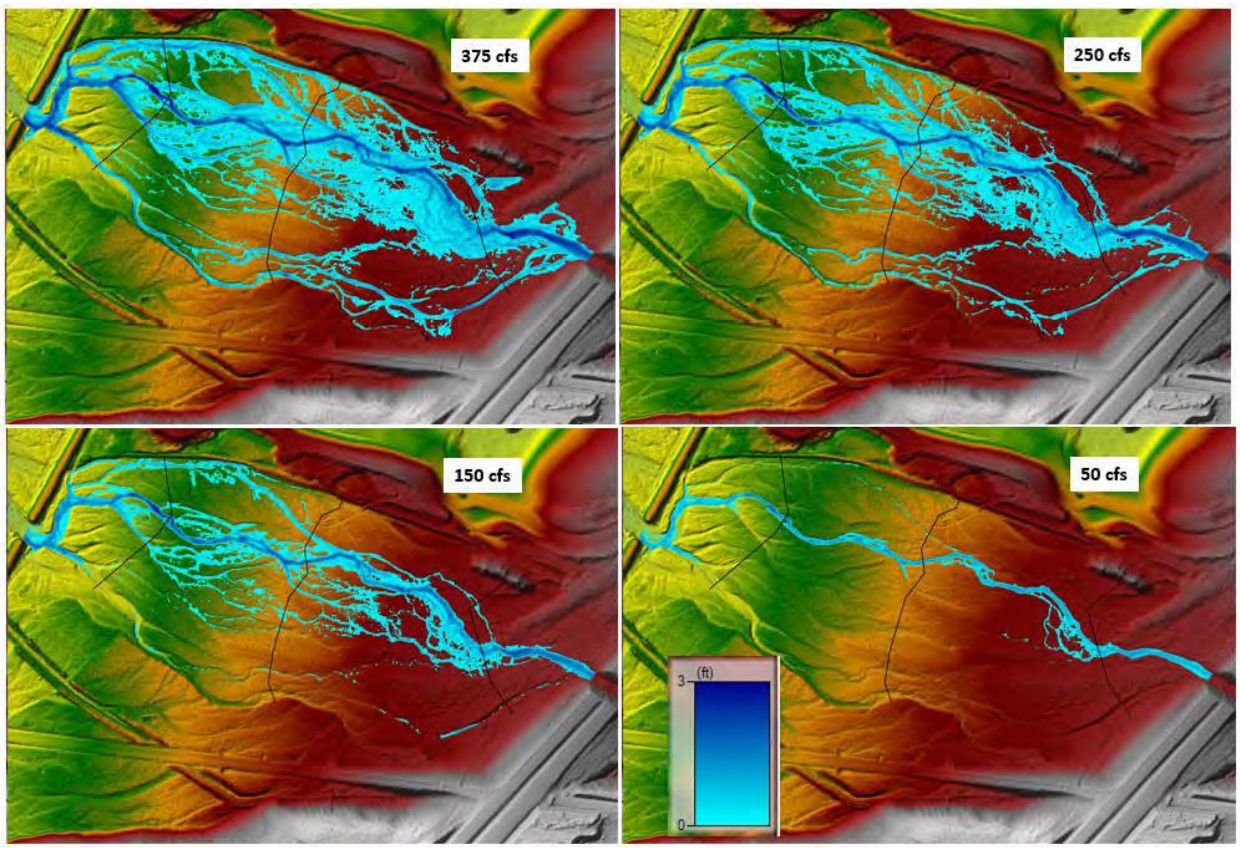


Figure 2-3. Example channel connectivity analysis for the Eklutna River between the railroad bridge and the New Glenn Highway bridges.

2.1.3 Passage Barrier Analysis

During field surveys, five potential passage barriers were identified within the canyon reach of the Eklutna River (Figure 2-4). Physical and hydraulic data were collected at each site in July 2022, and then a 1D hydraulic model was developed for each site. Depth and velocity criteria for Chinook, coho, and sockeye were applied to the hydraulic model outputs to define the minimum flows required for adult fish passage.

Figure 2-4. Potential passage barrier locations.

The analysis indicated that water depth (not velocity) is the major barrier issue at all five sites. The corresponding minimum flows to meet the fish passage requirements were determined at each site. Site B has the highest minimum flow requirement of 50 cfs. However, Site B is located within the sediment wedge (the remaining accumulated sediment behind the lower dam site) and is therefore very dynamic and likely to change. Sites A, D, and E have the next highest minimum flow requirement of 40 cfs.

2.2 Geomorphology and Sediment Transport Study

The goal of the Geomorphology and Sediment Transport Study was to gain an understanding of how sediment supply, transport, and deposition within the Eklutna River downstream of Eklutna Dam are influenced by current Project operations and potential flow regimes. The study methods included five components:

1. A review of existing information on river substrate, sediment transport, and flow conditions;
2. A field data collection program that included 19 monitoring transects along the river from the Eklutna Dam to the railroad bridge to measure substrate characteristics and scour/deposition that occurred as a result of the study flow releases;

3. An estimate of sediment input rates to evaluate future sediment sources downstream from Eklutna Dam;

4. Mapping of channel position changes through time from historic aerial photographs (1949 to 2020) to assess channel migration; and

5. Development of a 1D HEC-RAS sediment transport model in coordination with the Instream Flow Study (see Section 2.1) to calculate sediment transport rates in the Eklutna River under potential future flow regimes and assess the magnitude and effectiveness of different high flow regimes to flush accumulated fine-grained sediment from the river without moving the limited supply of spawning-sized gravel/cobble material out of the channel. The model was calibrated using the field data collected before and after the test flow releases.

2.2.1 Sediment Transport Modeling

Ten geomorphic reaches were delineated in the river based on key characteristics such as flow/tributary input, confinement, and sediment sources to help understand geomorphic processes in different parts of the river. Geomorphic reaches are summarized in Table 2-2.

Table 2-2. Geomorphic reaches.

Geomorphic Reach	River Mile Range	Confinement	Average Gradient	Comments
1	0-1.6	Unconfined	0.6%	Tidal influence within this reach.
2	1.6-2.3	Unconfined	1.2%	Railroad bridge confines flow at downstream end of this reach. Includes flooded forest; past gravel removal in this reach. Existing good spawning area near New Glenn Highway Bridge.
3	2.3-2.85	Confined	1.1%	Downstream from Thunderbird Creek.
4	2.85-3.95	Confined	1.7%	Between Thunderbird Creek and old lower dam site. Has aggraded since removal of old RM 4 dam in 2018.
5	3.95-4.45	Confined	2.0%	Old lower reservoir deposits, also known as the sediment wedge. Fine-grained silt and clay.
6	4.45-5.05	Confined	1.5%	Canyon upstream from the sediment wedge. Gravel accumulations.

Geomorphic Reach	River Mile Range	Confinement	Average Gradient	Comments
7	5.05-5.4	Moderately confined	1.8%	Wider bedrock canyon downstream from lower AWWU access road.
8	5.4-7	Unconfined	1.7%	Wide valley; contains major sediment sources. Fine-grained sediment in streambed prior to 2021 study flow release.
9	7-11.38	Unconfined	1.3%	Wide valley; upstream of major sediment sources (includes smaller sediment sources). Fine-grained sediment in streambed prior to 2021 study flow release.
10	11.38-12.3	Moderately confined by erodible valley walls	0.8%	Upstream of sediment sources; upstream of upper AWWU bridge. Gravel/cobble streambed.

In June 2021, the Project Owners organized a site visit with the Aquatics TWG to identify and establish transect locations. A total of 19 monitoring transects were established throughout the river for the Geomorphology and Sediment Transport Study. Field data was collected before and after the 2021 study flow releases (see Section 2.1.1) in order to measure changes to the river system at the monitoring transects, including changes in substrate characteristics, channel dimension, and sediment transport. Documented changes include:

- Scour of accumulated fine-grained sediment and encroaching alluvial fan deposits to re-establish a stream channel (Figure 2-5);
- Changes in substrate from material too fine for anadromous fish spawning or rearing to substrate sizes suitable for anadromous fish use;
- Transport of up to 30,000 cubic yards of fine-grained material from behind the old lower dam site (RM 4) with up to 30 feet of downcutting;
- Erosion and deposition of up to 4 feet of sediment at other monitoring transects indicating bedload sediment was mobilized; and
- Transport of substrate particles up to 128 mm in diameter.

Figure 2-5. Geomorphic Monitoring Transect B before (top) and after (bottom) study flow release showing erosion of toe of alluvial fan deposits, re-establishment of river channel, and removal of accumulated fine sediment.

A sediment transport model was developed for the Eklutna River from the existing Eklutna Dam to downstream of the railroad bridge. The chosen sediment transport function (Meyer-Peter Muller) has been widely-used to compute sediment transport in gravel-bed rivers for decades and used to extrapolate to higher flow conditions. The model incorporated measured channel dimensions, substrate size, and sediment inputs. The monitoring data from before and after the 2021 study flow release was used to help calibrate the sediment transport model. This was done by first running the model to predict changes at the monitoring transects, and then comparing the modeled changes to the actual changes observed.

- Upstream of the accumulated sediment behind the old lower dam site (also known as the sediment wedge), the modeled and measured channel changes were closely comparable.
- Within the sediment wedge, the model predicted up to 20 feet of channel erosion through the sediments.
- Just downstream of the old lower dam site, the model results were not as closely aligned with measured erosion/deposition depths, but the model did correctly predict erosion and deposition trends. Some of the model difficulty in these downstream areas was likely due to field evidence that suggests at least one wave of eroded reservoir deposits moved downstream as a debris torrent (likely following some of the larger mass wasting events observed on the time lapse cameras) rather than as river-borne sediment transport. The sediment transport model assesses movement by flowing water and does not model debris torrent transport with highly viscous flow. Sediment transport scenarios under potential future flow regimes will not be subject to debris torrents and should provide more reliable results.

The calibrated sediment transport model can be used to assess how potential future flow regimes would impact river substrate over a long-term period and to determine the appropriate peak flows (magnitude, duration, and frequency) that should accompany a selected base flow regime.

2.2.2 Channel Migration

Channel migration downstream from the canyon reach (Geomorphic Reaches 1 and 2) was evaluated using historical aerial photographs from 1949 through 2020 (Figure 2-6).

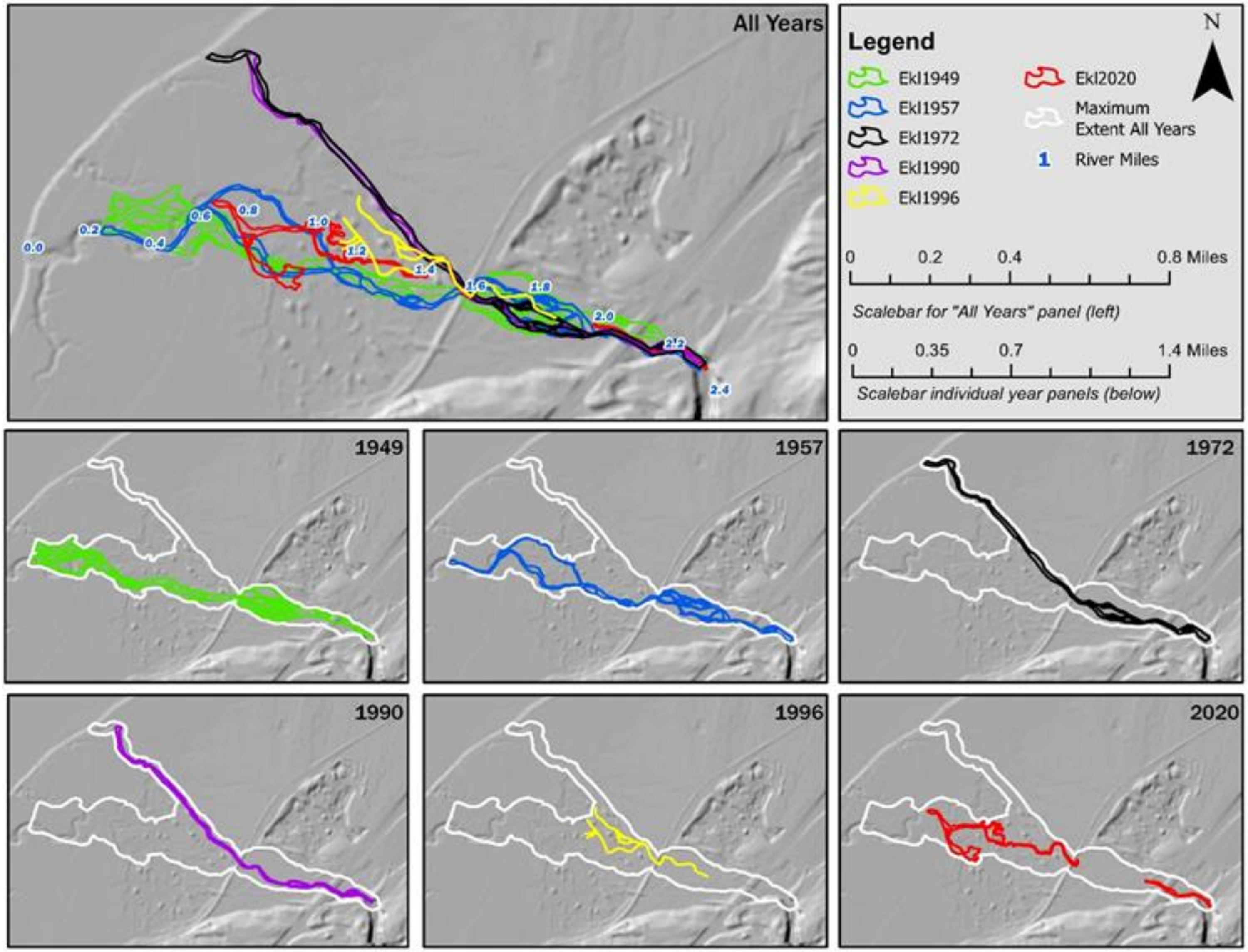


Figure 2-6. Eklutna River Channel Migration Downstream of the Canyon Reach.

In the 1949 photos, prior to construction of the existing hydroelectric project in 1955, the channel carried fine sediment and had a wide, braided character with little vegetation on mid-channel bars downstream from RM 2. These characteristics were also evident in the 1957 photos.

In the 1972 photos, after construction of the existing dam in 1965, the river was less braided between RM 1.6 (the railroad bridge) and RM 2 and was channelized downstream from RM 1.6 into a location north of the former riverbed to allow for gravel mining south of and in the former riverbed between RM 1.2-1.5. Channelization continued through the 1980s.

In the 1990 photos, the river was just starting to break through into the gravel pit (former riverbed) area and flood the former pits, but it appeared the main outlet continued through the channelized area.

In the 1996 photos, the main channel was flowing into the gravel pits and out to Knik Arm through the pits. Since 1996, the river has continued to flow into the old gravel pit ponds and has abandoned the channelized flow area. The gravel bars in the former braided section in Geomorphic Reach 2 (between RM 1.6-2) have become vegetated; the channel in this area was not visible on the aerial photograph after about 1996. Little migration was observed upstream from RM 1.5 after 1996, but some migration still occurs in the tidally-influenced reach downstream from RM 1.5 due to sediment deposition in this low-gradient area.

It is hypothesized that channel migration in the reaches of the Eklutna River that were assessed for this study is triggered by high sediment loading in association with high flows rather than just being a response to high flows.

2.3 Eklutna River Fish Study

The goal of the Eklutna River Fish Study was to characterize the current fish species composition, abundance, distribution, habitat us, and run timing in the Eklutna River. Specific objectives included:

1. Describe the seasonal composition, distribution, and habitat use for juvenile salmonids and resident fishes in the Eklutna River; and
2. Describe the periodicity, abundance, and distribution of adult salmonid spawners in accessible reaches of the Eklutna River and Thunderbird Creek.

2.3.1 Juvenile Salmon and Resident Fish

The area studied included all portions of the wetted mainstem and off-channel habitats (including beaver ponds) that were accessible to fish, beginning at the upper extent of tidewater influence and terminating at the Eklutna Dam. Fish were surveyed using minnow traps, electrofishing, and visual observations, and various habitat and water quality characteristics were measured and quantified. The composition and relative abundance of juvenile salmon and resident fish species was found to vary longitudinally.

- In the lowermost study reach (Reach 1) and the beaver pond complex (just above tidewater), all five species of anadromous Pacific salmon were documented, as well as Dolly Varden, stickleback, Alaska blackfish, and Eulachon. In 2021, juvenile coho and stickleback accounted for over 75% of the total fish sampled in Reach 1. In 2022, juvenile Chinook and coho salmon accounted for 80% of the total fish sampled in the beaver ponds.
- Between the beaver pond complex and the confluence with Thunderbird Creek, three species of anadromous Pacific salmon (Chinook, coho, and chum) were documented, as well as Dolly Varden and sculpins. The relative abundance of Chinook and coho decreased from more than 50% near the beaver pond complex to less than 25% at the Thunderbird Creek confluence while the relative abundance of Dolly Varden increased proportionally.
- Above the confluence with Thunderbird Creek, only resident fishes were documented, including Dolly Varden and sculpin.

Juvenile Chinook and coho displayed extended riverine rearing periods and were documented in the Eklutna River throughout the May-October sampling period. When given an option, juvenile Chinook and coho in the Eklutna River appear to exhibit a preference for low velocity (<1.0 ft/sec), shallow water depth (<3.0 ft) areas. This preference for shallow water habitat was evident during summer sampling when river temperatures ranged from 7.2-11.4°C. During fall sampling when water temperatures were much colder (1.7-4.9°C), the Catch per Unit Effort for juvenile Chinook and coho was highest in pools, along undercut banks, and within structures like beaver dams. The presence of these habitat types during winter months may play an important role in the seasonal distribution of target species.

Representative photographs of juvenile anadromous Pacific salmon and select resident fishes are presented in Figure 2-7.

Figure 2-7. Representative photographs of juvenile salmon and resident fish in the Eklutna River, 2021-2022.

2.3.2 Adult Salmon

The distribution of spawning adult salmon was surveyed visually during pedestrian surveys from the upper extent of tidewater to the downstream extent of the AWWU access road. Observed spawning activities included the presence of adult salmon, active digging or guarding of redds, constructed or partially constructed redds, and presence of post-spawned carcasses. The distribution of completed redds, which is also an indication of the upper extent of Eklutna River use by spawning anadromous salmonids in 2022, is presented in Figure 2-8.

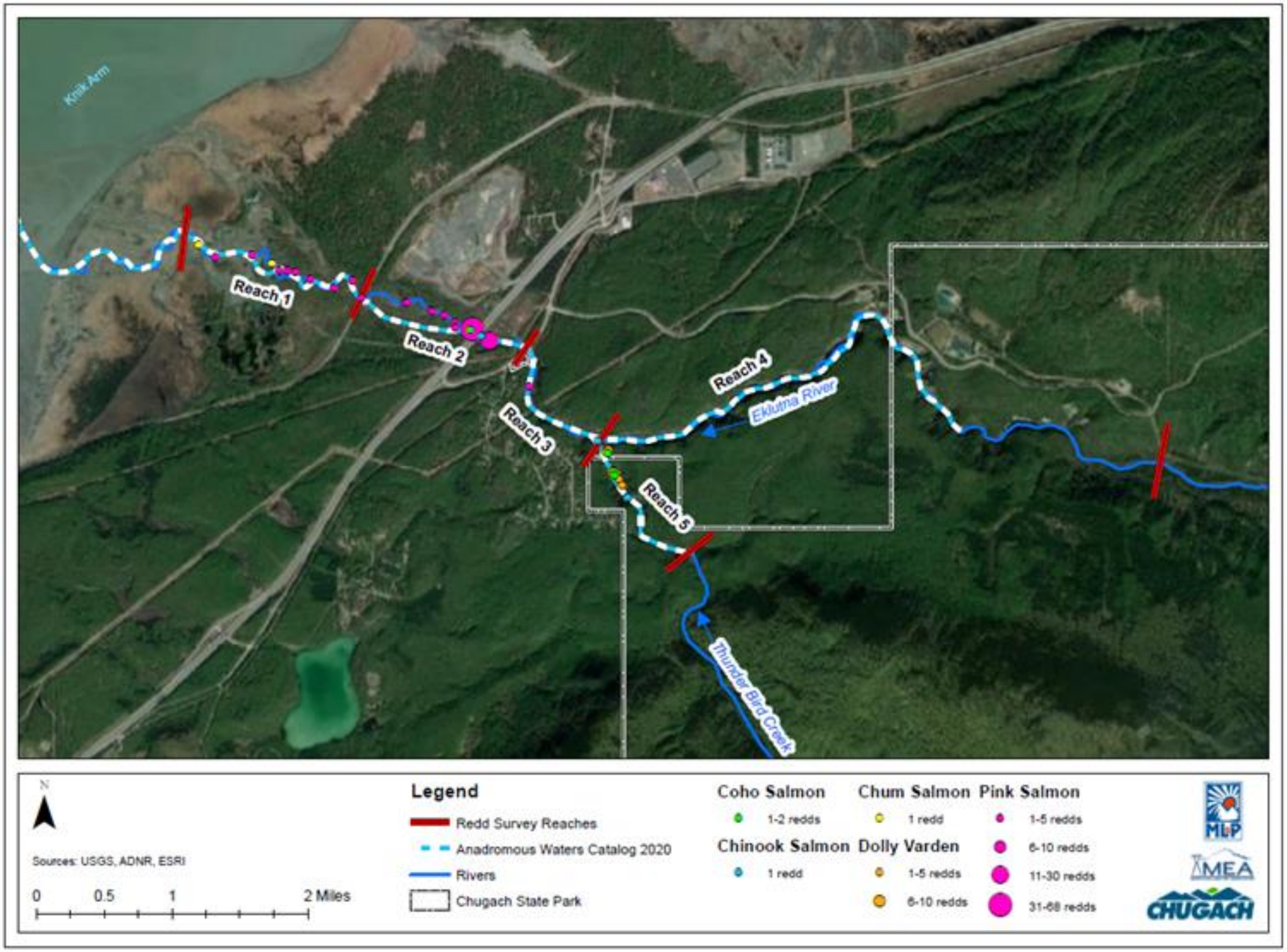
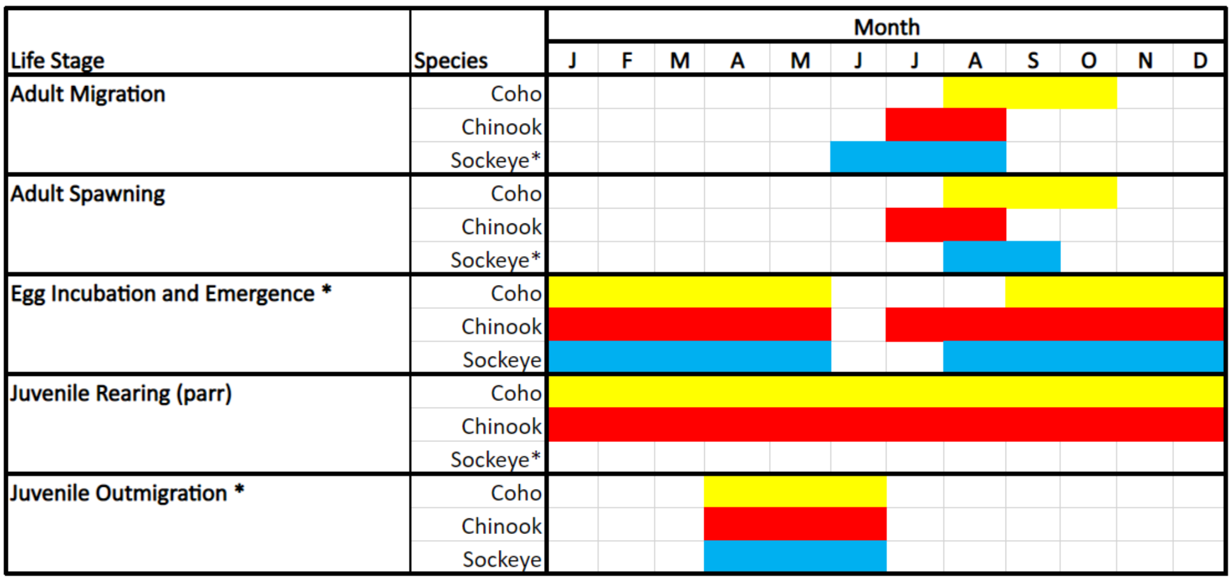


Figure 2-8. Distribution of observed redds by species in Spawning Survey Reaches 1-5 in 2022. Relative size of markers indicates relative abundance of redds at that GPS location.

Spawning activity for all species was limited to the area from tidewater to immediately above the Thunderbird Creek confluence. This limitation is likely due to current low flow conditions that prevent access to potential spawning areas upstream.

The Project Owners' spawning survey data was combined with NVE's spawning survey data to determine the periodicity of target salmon species (Chinook, coho, and sockeye) by life stage in the Eklutna River for 2021 and 2022 (Figure 2-9).



** Not assessed during 2021 River Fish Sampling. Data presented from USACE (2011)*

Figure 2-9. Periodicity of target salmon species (Chinook, coho, and sockeye) by life stage in the Eklutna River for 2021 and 2022.

Pinks were the most observed salmon species with up to 120 individuals documented per survey day. Their activity was concentrated in the lowest reaches of the river. Chinook and coho were both scarce with 0-10 individuals observed per survey day over the monitoring period and fewer than 20 total in 2021 and 2022.

Analysis of carcass heads returned to ADFG in 2021 identified that the origin of the Chinook carcasses was likely the hatchery fish that are stocked in the Eklutna Tailrace by ADFG.

2.4 Eklutna Lake Aquatic Habitat and Fish Utilization Study

The goal of the Eklutna Lake Aquatic Habitat and Fish Utilization Study was to characterize the existing aquatic habitat in Eklutna Lake and its tributaries and to begin to understand the current use of that habitat by resident fish and the potential future use of that habitat by ocean-run salmon. A secondary goal was to determine whether the kokanee in Eklutna Lake are infected with Infectious Hematopoietic Necrosis (IHN), which is a known pathogen in Alaskan kokanee populations and may factor in management decisions about Eklutna Lake. Specific objectives included:

- Assessments of spawning and rearing fish habitat for resident and ocean-run salmonids in the lake, tributaries, and seasonal pond
- Surveys of seasonal habitat use by these fishes for rearing and spawning.
- Collecting samples for IHN analysis and processing by the ADFG Fish Pathology Lab in Anchorage, Alaska.

The Lake Fish Study was conducted on shorelines of Eklutna Lake, the large Eklutna Creek complex that is fed in part by the Eklutna Glacier, and various small, high-gradient tributaries along the northeast and southwest shorelines.

2.4.1 Eklutna Lake Shoreline Habitat and Fish Use

Much of the Eklutna Lake shoreline is steep, bouldery, or characterized by fine silt and grasses. The remaining shorelines that could be accessed during the study (above the waterline) contained ~1.5 acres (68,512 sq ft.) of suitable habitat for lakeshore-spawning ocean-run fishes such as sockeye. These habitats are characterized by small substrate, upwelling groundwater, low embeddedness of fine sediment, and moderate slope. Lake elevation associated with operation of the Eklutna hydro project affects the proportion of this habitat that is inundated at different times during the year.

In lake September and October of 2021 and 2022, kokanee (land-locked sockeye) were observed spawning along the Eklutna shoreline in many of the areas identified as preferred spawning habitat for ocean-run sockeye. Pathological analysis revealed that 75% of the kokanee were infected with IHN.

While spawning habitat selection and spawning timing was typical for kokanee in the region, the observed spawning kokanee were not typical. Kokanee spawners collected from Eklutna Lake were smaller than those reported in many other lake systems, reaching only 4.5-6.5 inches relative to the median size reported for other systems (10-12 inches). The kokanee in Eklutna Lake also differ from other kokanee in their low fecundity (20-30 eggs) and lack of sexual dimorphism and development of spawning color that is typical of the species (Figure 2-10). This is likely an indication of poor nutrient conditions and limited food sources in the environment, which is corroborated by data from the Water Quality Study (see Section 0) and may indicate that Eklutna Lake, in its existing condition, may not provide productive rearing habitat for large populations of ocean-run sockeye.

Figure 2-10. Kokanee carcasses collected on October 1, 2021, on Eklutna Lake shorelines near 61.39104°N, -149.05747°W. Mature eggs were removed from several carcasses (lower left). Eroded anal and caudal fins were indicative of spawning activity.

2.4.2 Eklutna Lake Tributary Habitat and Fish Use

Most tributaries to Eklutna Lake are too steep to provide significant spawning or rearing habitat for ocean-run salmon or other large-bodied fishes (Figure 2-11, LEFT), though some of the lower reaches are used by small-bodied Dolly Varden for rearing.

The only lake tributary with accessible low-gradient habitat suitable for the migration and spawning of ocean-run salmon is the East and West Forks of Eklutna Creek where an estimated 0.765 – 3.61 acres of spawning habitat was documented based on water depth and substrate size (Figure 2-11, RIGHT). A small tributary to the West Fork adds between 0.02 – 0.24 acres of available spawning habitat.

Figure 2-11. (LEFT) Inaccessible entrance to a tributary on the northwest shoreline of Eklutna Lake. (RIGHT) Mainstem of the East Fork of Eklutna Creek.

2.5 Macroinvertebrates

The goal of this study was to characterize the benthic macroinvertebrate (BMI) community within the wetted channel of the Eklutna River. Standard community data metrics were calculated to represent the existing condition.

Four macroinvertebrate study sites were established in the Eklutna River: 1) at the Old Glenn Highway bridge, 2) just above the Thunderbird Creek confluence, 3) at the lower dam site, and 4) at the downstream extent of the AWWU access road. A composite of 8-10 benthic sampling points covering an area of 8-10 ft^2 were collected from representative habitats at each of the four study sites using a kick net sampler (500 µm mesh). Composited samples were sorted to remove a 500-organism subsample from each preserved sample. As part of the taxonomic protocol, all individuals were identified and counted to accurately quantify density. A summary of macroinvertebrate community metrics at all four sampling sites is provided in Table 2-3.

Table 2-3. Benthic macroinvertebrate community metrics for the Eklutna River.

Metric	BMI Site 1	BMI Site 2	BMI Site 3	BMI Site 4
Gross community parameters				
Total taxa richness	28	15	15	30
Total abundance (per square meter)	599	116	461	712
EPT taxa richness	13	7	5	11
% Top 3 taxa	79.8	51.4	94.9	67.1
Warm and cold water adapted biota				

Metric	BMI Site 1	BMI Site 2	BMI Site 3	BMI Site 4
Warm water biota taxa richness	2	0	1	4
% Warm water biota	0.9	0.0	0.2	1.6
Cold water biota taxa richness	8	4	4	8
% Cold water biota	76.9	49.5	95.6	76.3
Non-insects and insect orders				
% Non-insect invertebrates	1.3	9.3	0.7	6.4
% Ephemeroptera (mayflies)	74.2	12.2	8.0	38.9
% Plecoptera (stoneflies)	3.4	20.6	1.9	10.6
% Trichoptera (caddisflies)	2.0	3.7	0.5	12.5
% Diptera (true flies)	19.1	54.2	89.0	31.5
Non-insect groups				
% Oligochaeta (segmented worms)	0.4	9.3	0.2	3.3
% Crustacea	0.5	0.0	0.2	0.3
% Acari (mites)	0.2	0.0	0.2	1.2
Insect families				
% Heptageniidae (mayfly)	4.5	1.9	0.0	1.2
% Baetidae (mayfly)	69.2	10.3	8.0	37.0
% Chloroperlidae (mayfly)	0.4	1.9	0.2	0.0
% Nemouridae (stonefly)	3.1	5.6	1.6	9.7
% Perlodidae (stonefly)	0.0	13.1	0.0	0.9
% Chironomidae (midges)	6.8	1.9	0.0	0.3
% Empididae (dance fly)	0.9	0.0	0.5	1.9
% Simuliidae (black fly)	4.0	34.6	86.4	22.0
Feeding groups				
% Predator	2.7	15.0	1.2	11.6
% Parasite	0.2	0.0	0.2	1.2
% Collector-gatherer	84.0	33.6	10.5	47.8
% Collector-filterer	4.0	34.6	86.4	22.0
% Collector (total)	87.9	68.2	97.0	69.7
% Shredder	3.6	9.3	1.6	9.9
% Scraper	5.4	1.9	0.0	7.4

Most taxa present are common, western North America benthic macroinvertebrates. The dominant coldwater taxa at the four study sites are Baetis bicaudatus complex, Drunella doddsii, Epeorus grandis group, Rhyacophila alberta group, Rhyacophila Vofixa group, Helodon/Prosimulium, and Diamesa. Tolerant or warm water taxa are rare, representing no more than 1.6% of the collected specimens.

The functional feeding groups in the Eklutna River are dominated by collectors, with a range of 68% to 97% of all taxa representing that general feeding strategy. The overall taxa abundance (116-712 organisms/m^2) is low compared to the >1,000 organisms/m^2 typically found in montane streams of the Pacific northwest. Finally, the sampling locations most proximal to the sediment wedge (Sites 2 and 3) correlated to lower metric scores.

2.6 Water Quality

The goal of the Water Quality Study was to gain a better understanding of seasonal water quality parameters within Eklutna Lake and the Eklutna River in comparison to criteria established by Alaska Department of Environmental Conservation (ADEC) for Water Use Category C: Growth and Propagation of Fish, Shellfish Other Aquatic Life, and Wildlife (Table 2-4).

Table 2-4. ADEC Criteria for Water Use Category C.

Parameter	Criteria
Temperature	May not exceed 20°C at any time. The following maximum temperatures may not be exceeded, where applicable: - Migration routes 15°C - Spawning areas 13°C - Rearing areas 15°C - Egg & fry incubation 13°C
Dissolved Oxygen	Greater than 7 mg/L
pH	6.5 to 8.5
Turbidity	May not exceed 25 nephelometric turbidity units (NTU) above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.

Specific objectives included:

1. Collecting continuous water temperature data in Eklutna River and Eklutna Lake;
2. Collecting continuous pH and dissolved oxygen (DO) data in the Eklutna River and in situ profiles of these two water quality parameters in Eklutna Lake;

3. Collecting total suspended solids (TSS) and turbidity samples in Eklutna River at base flows and during 2021 study flow release;

4. Collecting total phosphorus, chlorophyll *a*, and Secchi depth data in Eklutna Lake to determine its trophic status.

Four water quality sites (WQS) were established in the Eklutna River: 1) just above the Thunderbird Creek confluence, 2) at the downstream extent of the AWWU access road, 3) below the AWWU portal valve near RM 10, and 4) above the AWWU portal valve near RM 11.5.

Two monitoring stations were established in Eklutna Lake: 1) in the lake by the existing Project intake, and 2) in the pond by the existing Eklutna Dam.

2.6.1 Water Temperature

Calibrated thermographs were utilized to continuously record water temperatures in both the Eklutna River (at WQS 1 and 2) and Eklutna Lake from May 2021 through October 2022. Monthly in situ profiles were also collected in Eklutna Lake utilizing a calibrated water quality sonde during the ice-free period.

Eklutna River water temperatures at WQS 1 (just above the Thunderbird Creek confluence) were consistently higher than WQS 2 (at the downstream extent of the AWWU access road). under base flows in the non-winter season (April 1 – October 31). However, during the study flow releases from September 15 – October 6, 2021, river temperatures increased > 4°C, becoming nearly isothermal at the two monitoring stations. The winter monitoring period revealed that surface water at WQS 2 doesn't approach freezing (winter low temperature > 2.4°C) while WQS 1 had 39 days of 0°C or freezing conditions from November 1 – March 31, 2021. These data show that groundwater temperatures have the greatest influence at WQS 2 and ambient conditions affect WQS 1.

In both Eklutna Lake (Figure 2-12) and the pond, thermograph data show that stratification occurs in the summer, with surface water temperatures higher than temperatures at depth by as much as 3-4°C. As expected, the winter temperature data reveal that surface temperatures are colder than at depth from early December to mid-April in Eklutna Lake, while the pond generally exhibits this pattern from mid-October to mid-April.

Overall, the two-year monitoring period shows that Eklutna Lake and both sites on the Eklutna River met the 20°C ADEC temperature criteria for water use category C. However, water near the surface of Eklutna Lake does slightly exceed the more restrictive rearing/migration route criteria of < 15°C and the spawning/incubation criteria of < 13°C from late June – August.

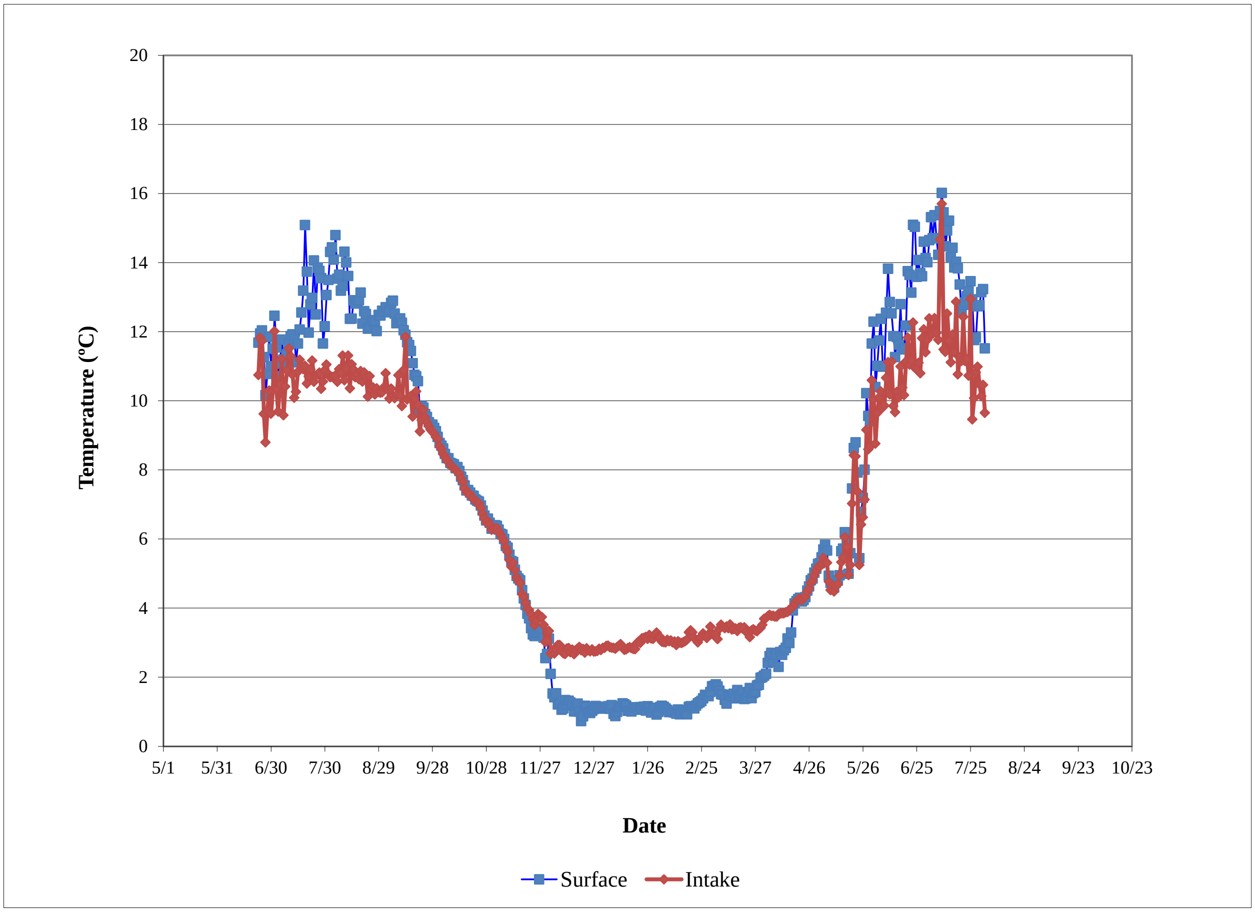


Figure 2-12. Eklutna Lake mean daily water temperature from 2021-2022.

2.6.2 Dissolved Oxygen and pH

Calibrated dissolved oxygen (DO) loggers and pH data loggers were deployed at WQS 1 and WQS 2 in the Eklutna River during the ice-free season from June 22 – September 29, 2021, and collected data every 30 minutes. The summer sampling period was prioritized to represent the time frame when DO concentrations are typically at their lowest, in response to water temperatures being at their warmest.

DO and pH profile data were collected in Eklutna Lake and the pondat 3-foot depth intervals for the entire water column utilizing a water quality sonde calibrated to manufacturer recommendations.

- In Eklutna Lake, data were collected from June 23 – September 29, 2021.
- In the pond, data were collected from May 20 – September 29, 2021.

DO concentrations in the Eklutna River and Eklutna Lake met the 7mg/l or greater criteria established by ADEC. Only the pond dropped below 7mg/l near the bottom from late May through late June in 2021.

Data for pH meet the ADEC criteria of 6.5-8.5 at all study sites with the exception of WQS 1, just above the Thunderbird Creek confluence. At WQS 1, pH consistently hovered around 8.5 and intermittently exceeded the ADEC criteria of 8.5 for fish and other aquatic organisms. However, during the 2021 study flow releases, pH at WQS 1 had a detectable and precipitous decrease of ~0.3 pH units that was maintained through the end of the study flow period.

2.6.3 Total Suspended Solids and Turbidity

Continuous turbidity monitoring was conducted on the final eleven days of the 2021 study flow releases utilizing calibrated water quality sondes deployed at all four WQS starting during the 75 cfs study flow release. Continuous turbidity data collection ended approximately 24 hours after study flow releases ended. Turbidity and TSS samples were also collected as grab samples by lowering a 500 ml Nalgene bottle at mid-depth in the thalweg of the channel during the 75 cfs study flow release (September 27) and 24 hours after flow releases ended while the river was returning to base flow conditions (October 6). Collected samples were immediately stored on ice and transported to SGS Laboratories in Anchorage, AK for analysis.

As expected, the 75cfs to 25cfs study flow releases from September 24, 2021 – October 6, 2021, show that both turbidity and TSS increased moving downstream, with substantial increases at WQS 2, below a distinctly large alluvial fan, and at WQS 1, below the lower dam site and sediment wedge. The two upper valley sites (WQS 3 and WQS 4) remained relatively stable with in situ data showing turbidity levels changing from 1.7-2.1 NTU as study flows receded (Table 2-5). However, at WQS 1 and WQS 2, in situ data showed decreases of 41 NTU below the large alluvial fan (WQS 2) and 108 NTU below the lower dam site and sediment wedge (WQS 2). Therefore, any up ramping of flow releases has the potential to violate ADEC criteria to "…not exceed 25 NTU above natural conditions" for an indeterminate amount of time.

Despite the lack of TSS criteria described by ADEC, the major composition of these "suspended solids" is sediment (i.e., sand and silt) from alluvial fans and the deposits left behind after the diversion dam removal. ADEC does state that sediment loads in the 0.1-0.4 mm size class cannot "…cause adverse effects on aquatic animal or plant life, their reproduction or habitat…" (ADEC 2022). Therefore, any movement or flushing of these sediments downstream from flow releases has the potential to foul or clog the interstitial spaces of gravel beds critical for salmonid reproduction.

Table 2-5. Eklutna River turbidity and TSS during study flow releases.

Sample Source	Turbidity (NTU)		TSS (mg/L)	
	9/27/21	10/6/21	9/27/21	10/6/21
WQS 1 (below lower dam site/sediment wedge)	140	32.0	146	33.3
WQS 2 (below the large alluvial fan)	55.0	14.0	88.1	16.3
WQS 3 (upper valley below minor alluvial fans)	5.10	3.00	7.35	2.23
WQS 4 (upper valley with stable stream banks)	4.40	2.70	3.77	2.18

2.6.4 Eklutna Lake Trophic Status

The mid-summer lake profiling on July 14, 2021, and July 7, 2022, also included the determination of Secchi depth and collection of total phosphorus and chlorophyll *a* samples. The assessment of these three lake parameters were utilized to provide an index of lake productivity or trophic status index (TSI). Water samples for phosphorus and chlorophyll *a* were collected near the surface of the lake and just above the lake bottom utilizing a Van Dorn sampler at the lake and pond monitoring sites. 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 and chlorophyll *a* concentrations were quantified at APU.

All 2021-2022 TSI values based on chlorophyll *a* correspond to an oligotrophic classification (TSI <30), representing a lake with low primary productivity. In addition to the U.S. Army Corps of Engineers (USACE) assumption of elevated turbidity decreasing light penetration (USACE 2011), low nutrient concentrations (i.e. total phosphorus) are also a factor limiting primary productivity within Eklutna Lake. The low algal biomass within Eklutna Lake likely corresponds to low zooplankton densities and appears to be a limiting factor (i.e., food resource) for fish production, especially for resident species such as kokanee. The data described above (i.e., low nutrient and chlorophyll *a* concentrations) confirm why Eklutna Lake serves as an excellent source of drinking water.

2.7 Stream Gaging

The goals of the Stream Gaging Study were to gain a better understanding of the current flow regime in the Eklutna River and to support other aquatic studies being conducted in parallel with this assessment.

- The primary objective of this study was to generate a flow record in the Eklutna River, Thunderbird Creek, Lach Q'atnu Creek (Tributary 1), and the unnamed tributary (Tributary 2) to the pond upstream of the existing Eklutna Dam throughout the duration of the 2021 and 2022 study program.
- A secondary objective was to collect instantaneous flow measurements under stable low-flow conditions, as well as during one of the study flow releases (25 cfs), to assess accretion along the longitudinal profile of the Eklutna River.

Following United States Geological Survey (USGS) guidelines, the stream gages in the Eklutna River (above and below Thunderbird Creek) and in Lach Q'atnu Creek consisted of a staff gage and a continuous stage data logger. The data logger accurately records pressure, which is related to the water surface elevation at the staff gage. Data loggers recorded the following parameters at 15-minute intervals: date and time, temperature (°C), and pressure/water level (feet).

Following gage installation in May 2021, crews maintained and calibrated the stream gaging stations every 4-6 weeks during the study period. During each calibration and maintenance effort, discharge data were collected to develop and maintain a stage-discharge rating relationship at the Eklutna River and Lach Q'atnu Creek stream gages. Discharge measurements continued for the duration of the 2021-2022 study program. During the low-flow winter period, surface waters at the gaging stations were intermittently frozen and did not always provide an accurate continuous stage record. During this November-April timeframe, stage recorders remained in place with visual site inspections conducted on a bi-monthly basis to document site conditions and confirm the expected low-flow discharge condition.

Two years of gaging data below the Thunderbird Creek confluence reflect the 2002-2007 record from the USGS. Daily flow statistics from USGS gage 15280200 show that peak mean daily flows typically occur in mid-June and that winter flows range from 12-25 cfs. Also, the peak mean daily flow of 270 cfs in 2022, is similar to the peak daily flow volume of 255 cfs calculated by the USGS in 2006.

In 2021, mean daily flows above Thunderbird Creek were extremely stable throughout the spring-summer monitoring period, ranging from 6-7 cfs, until the onset of the study flow releases on September 13, 2021. Over the winter of 2021-2022, mean daily discharges stabilized after one short duration runoff event, and remained in the 2-3 cfs range. In 2022, the trend of slowly increasing flow volumes begins in mid-February and peaks at 26 cfs on April 26, 2022. The wetter than normal precipitation totals in the summer and fall of 2022 resulted in a much more dynamic hydrograph with mean daily flow volumes fluctuating substantially in comparison to the stable runoff condition detected in 2021. Finally, the range of Eklutna River discharges upstream of Thunderbird Creek has not changed much over time. Flows not augmented by study flow releases ranged from 2-26 cfs for the 2021-2022 study period, while the 35 instantaneous discharge measurements from 1954-2006 at USGS gaging station 15280100 ranged from 4-24 cfs.

Thunderbird Creek flows were calculated by subtracting flows measured at the stream gage above Thunderbird Creek from the flows recorded at the stream gage below Thunderbird Creek. Figure 2-13 shows the daily mean discharge estimates for Thunderbird Creek in comparison to the two Eklutna River gaging stations. The grey shaded areas represent the 2021 study flow releases and the 2022 O&M flow release.

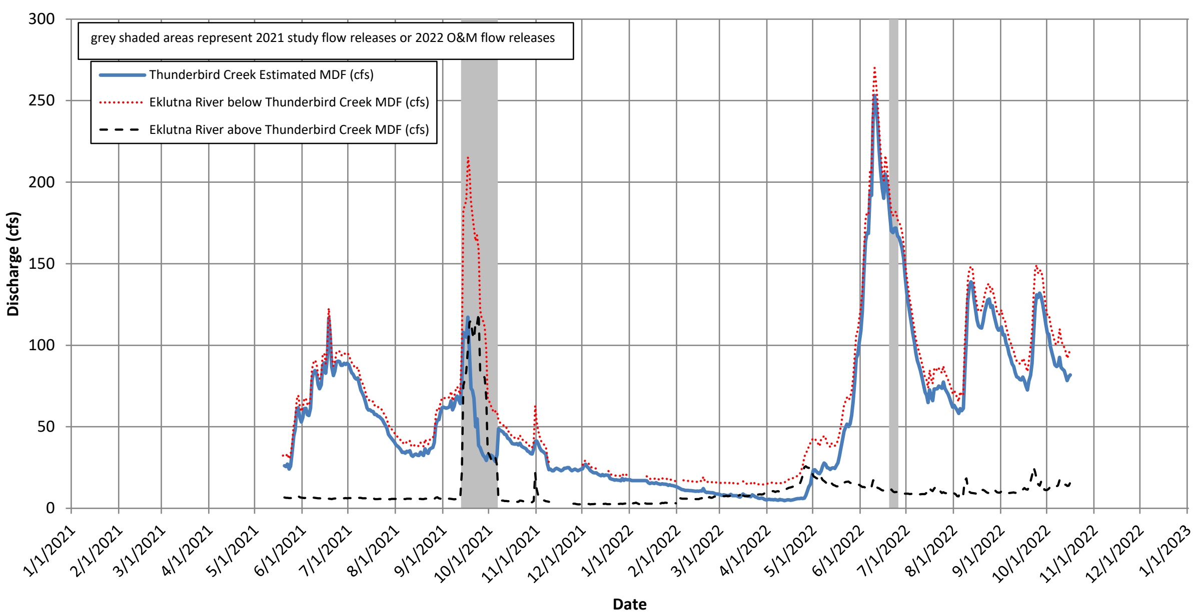


Figure 2-13. Thunderbird Creek estimated daily mean discharge vs Eklutna River stream gaging records, 2021-2022.

Overall, it is evident that Thunderbird Creek is the primary contributor of surface water discharge to the lower Eklutna River. Estimated mean daily flows for Thunderbird Creek are similar to those summarized by NVE in 2003 with peak mean daily flows occurring in the third week of June. Although the magnitude of peak Thunderbird Creek flows in 2022 are substantially greater than data from 2021 and NVE (2003), the time series hydrograph pattern is similar. In 2022, winter flow data (January 1-April 15) from Thunderbird Creek slowly and consistently decreases, ranging from 18 cfs to 5 cfs and again, closely matches flow volumes and patterns from NVE (2003).

Flows in Lach Q'atnu Creek peaked at 12 cfs and 35 cfs in 2021 and 2022 respectively (Figure 2-14). Over the winter of 2021-2022, discharges from mid-November to late April were stable, but extremely low, ranging from nearly 0 cfs to 0.8 cfs with an average mean daily flow of 0.2 cfs. Although peak discharges were nearly 3 times greater in 2022, the Lach Q'atnu Creek watershed appears to be a snowpack driven system. Despite wetter than normal precipitation in the summer and fall of 2022, Lach Q'atnu Creek flows tailed off rapidly through July with daily mean discharges from August 1 to mid-October averaging 2.3 cfs and 3.7 cfs in 2021 and 2022, respectively.

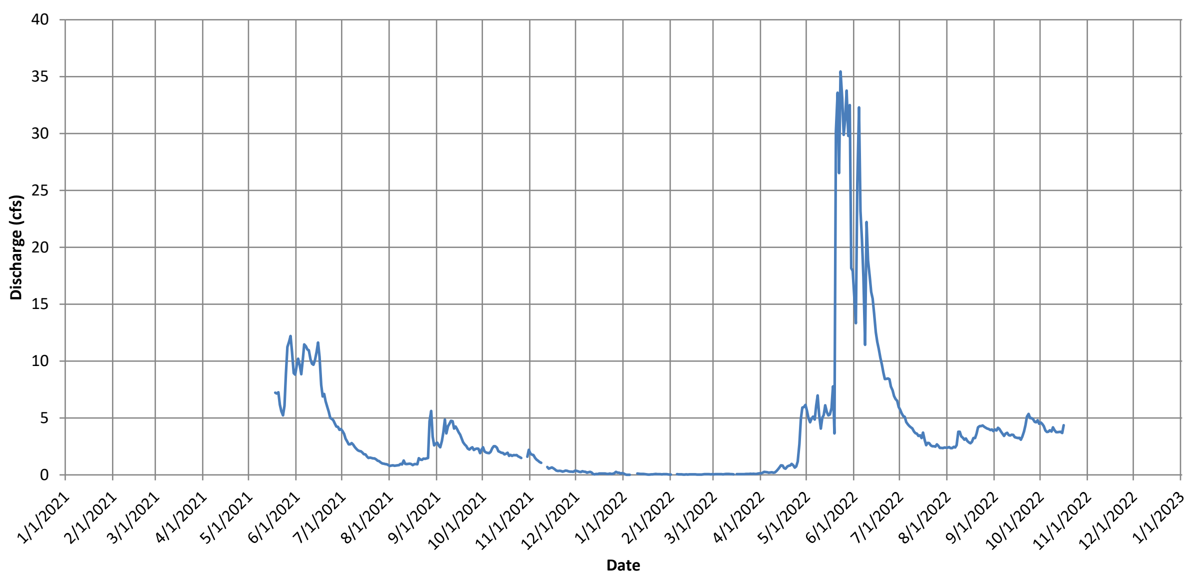


Figure 2-14. Lach Q'atnu Creek daily mean discharge, calendar years 2021-2022.

Monthly spot discharge measurements were taken at the unnamed tributary to the pond (Tributary 2) in 2021 and 2022. The five measurements taking in 2021 indicated relatively low flow volumes (<0.9 cfs). In 2022, the average of the five instantaneous measurements were noticeably higher (<2.7 cfs) in response to deeper snowpack and wetter than normal precipitation totals in the summer and fall of 2022.

Table 2-6. Unnamed pond tributary (Tributary 2) discharge measurements.

Meas. No.	Date	Measured Discharge (cfs)
1	5/19/2021	0.9
2	6/23/2021	0.5
3	7/14/2021	0.5
4	8/25/2021	0.5
5	9/28/2021	0.3
6	5/15/2022	1.1
7	6/28/2022	2.7
8	8/3/2022	0.6
9	9/13/2022	1.4
10	10/16/2022	0.8

For the accretion portion of the study, discharge measurements were collected at five locations in the Eklutna River: 1) below the railroad bridge, 2) at the Old Glenn Highway bridge, 3) just above the Thunderbird Creek confluence, 4) at the downstream extent of the AWWU access road, and 5) below the AWWU portal valve. under a stable base flow or zero-flow release condition on June 22, 2021. Discharge measurements were conducted on June 22, 2021 before the study flow releases and then again on September 30, 2021 during the 25 cfs study flow release (Table 2-7).

Table 2-7. Eklutna River accretion summary.

Location	Measured Discharge (cfs)	
	6/22/2021 (0 cfs release)	9/30//2021 (25 cfs release)
Railroad Bridge (RM 1.3)	88.2	63.0
Old Glenn Highway Bridge (RM 2.3)	93.6	66.2
Above Thunderbird Creek (RM 3.0)	6.1	23.8
Downstream Extent of the AWWU Access Road (RM 5.5)	3.2	22.1
Below the AWWU Portal Valve (RM 10.3)	0.2	19.4

The accretion study shows that measurable stream flows do not occur under existing conditions for approximately two miles downstream of the Eklutna Dam. Both sets of accretion measurements indicate minimal flow accumulations (~4-6 cfs) from RM 10.3

(downstream of the AWWU portal valve) to RM 3.0 (just above the Thunderbird Creek confluence). Downstream of the Thunderbird Creek confluence there is a slight, but consistently measured flow loss averaging about 4 cfs from the Old Glenn Highway bridge downstream to the railroad bridge. The flow loss within this 1-mile section of the Eklutna River represents a decrease of less than 5.8% of the total flow volume.

2.8 Wetlands and Wildlife Habitat

The overall goal of this study was to retroactively assess changes in wetlands and wildlife habitats in the Eklutna River drainage that may have been caused by the development of the Eklutna Hydroelectric Project. The study goal was achieved by comparing present-day mapping of wetlands and wildlife habitats, based primarily on natural color satellite imagery from 2022, to historical mapping derived from black and white aerial photographs taken in 1950. The specific study objectives were to:

1. Prepare a current wetland and wildlife habitat map for the study area using the most recent high-resolution satellite imagery and LiDAR data (May 2022), previous wetland and land cover mapping that includes the Project area, and field ground-reference data collected in August 2022.

2. Include vegetation, macrotopography, and disturbance attributes in all map polygons, including uplands, to facilitate the development of wildlife habitat and wetland functional type maps using an Integrated Terrain Unit methodology.

3. Prepare a wetland functional assessment applied to wetland functional types developed in the classification to support the retrospective image analysis by identifying the highest value wetlands in the study area.

4. Compare the extent and ecological function of current wetlands and wildlife habitats to historic conditions by preparing a historical wetland and wildlife habitat map based on a set of black and white aerial photographs of the area taken in 1950.

A total of 23 National Wetland Inventory (NWI) types were identified in the study area: 12 water, 9 wetland, and 2 upland types. Vegetated wetland types comprise 40% of the study area in which estuarine salt marsh and seasonally flooded riparian shrub were the dominant types. Despite a long history of disturbance in the area, current wetlands in the Eklutna River floodplain are relatively intact and representative of similar riverine wetland systems in Southcentral Alaska.

The attribution of map polygons with wetland and vegetation classes and the other landscape feature variables supported the identification and classification of 23 wildlife habitat types in the study area. Wildlife scientists were consulted to determine that suitable habitats for the bird and mammal species known or expected to occur in the study area were represented in the mapping. The resulting habitat types were then used to directly support the Terrestrial Wildlife Surveys (see Section 2.9). Overall, the Eklutna River drainage study area is comprised of approximately 37% upland habitats, 36% estuarine wetlands, 18% lacustrine waters, and 9% lotic waters in combination with associated riparian freshwater wetlands.

NWI wetland attributes were included in the multivariate wetland function classification process in which a subset of wildlife habitat types (17 wetland functional classes, including waters, unvegetated and exposed littoral zones, and vegetated wetlands) were used in the wetland functional assessment process. In general, wetlands ranged from moderate to high overall function. The highest-ranking wetland functional type was Freshwater Sedge Marsh, which has the vegetation structure and landscape feature characteristics to perform all the evaluated functions at a high level. Freshwater Sedge Marsh is primarily a new wetland type in the study area that has established in the margins surrounding freshwater ponds in the abandoned gravel extraction area in the lower river near the estuary.

In the historical mapping, a total of 14 wetland and wildlife habitat types were identified in the 1950 aerial photography. These types were identified using the same classification system developed for the mapping of current conditions. Comparison of acreages between the current and historical conditions allowed for the detection of habitat change associated with specific human activities that occurred in the study area over time, including impacts resulting from the construction and operation of the Eklutna Hydroelectric Project. The primary impacts of the Eklutna Hydroelectric Project (river dewatering) include the loss of significant areas of seasonally flooded riparian shrub communities occupying the historical Eklutna River floodplain; these areas are gradually converting to upland forest habitats (see Figure 2-15 and Figure 2-16). Additional impacts of the Project include expansion of the littoral zone at the outlet of Eklutna Lake due to increased fluctuations in the lake level throughout the year; this lake littoral zone was far smaller in extent in 1950 than in 2022.

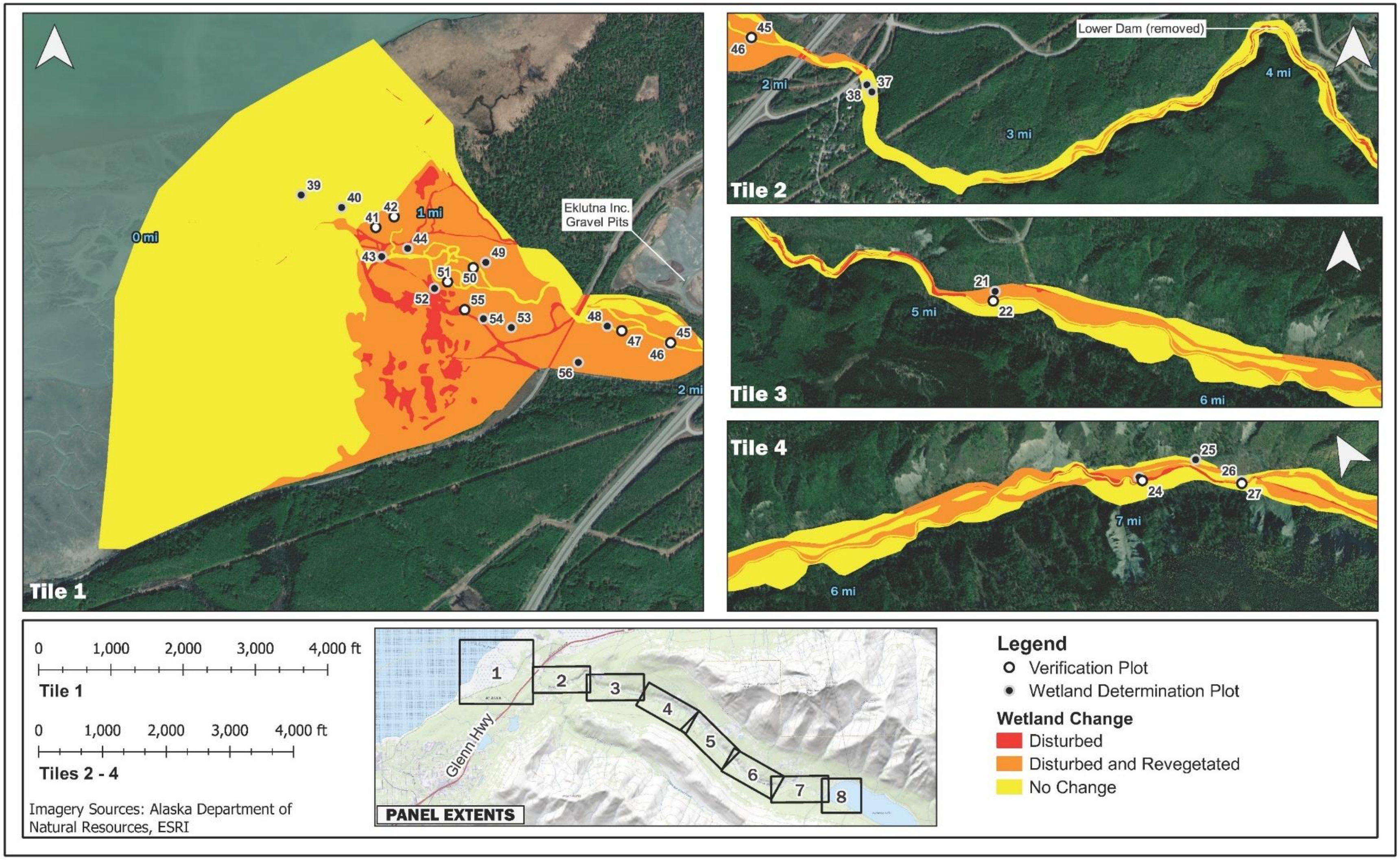


Figure 2-15. Wildlife habitat and wetland functional class changes from historical to current conditions.

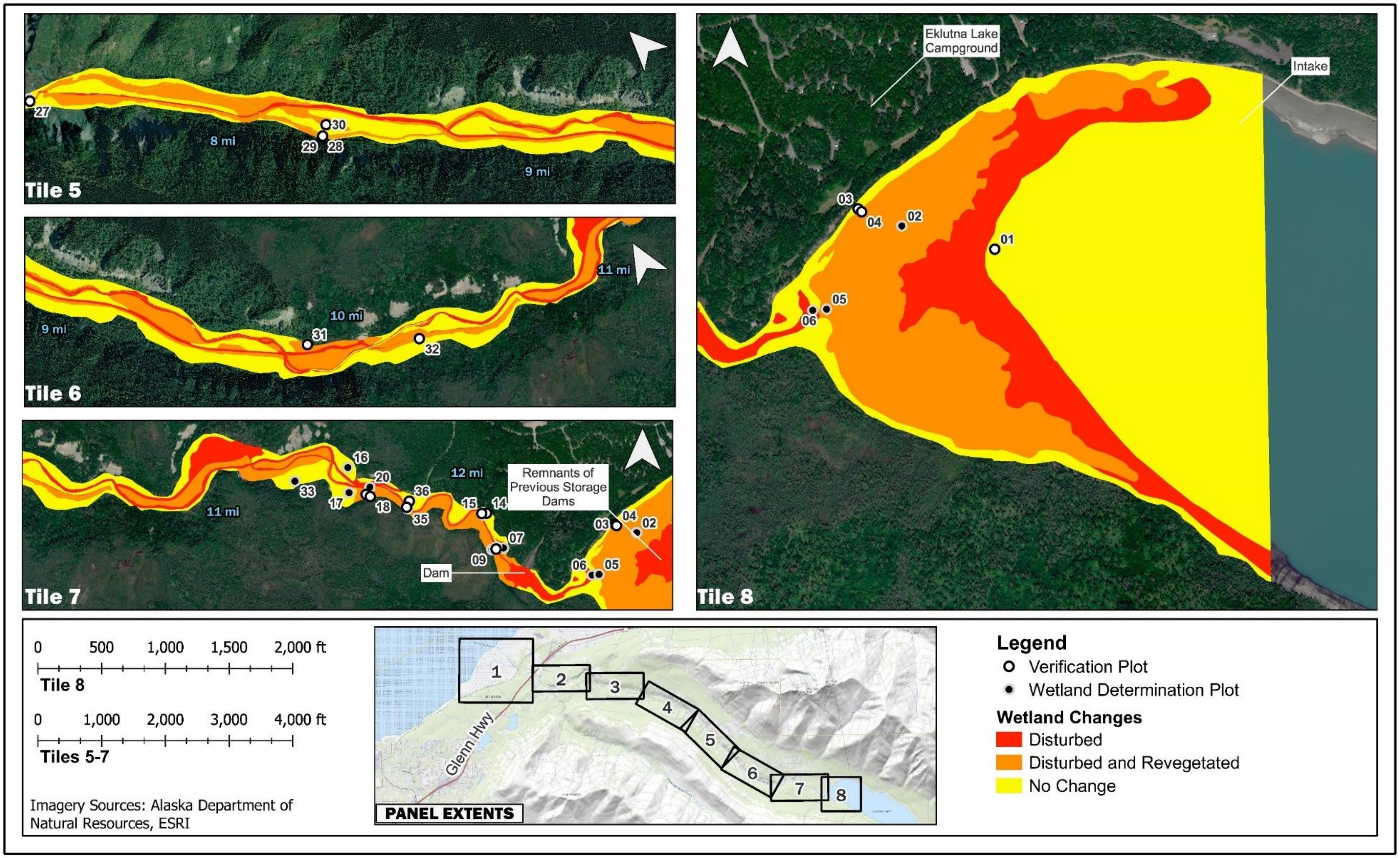


Figure 2-16. Wildlife habitat and wetland functional class changes from historical to current conditions, continued.

2.9 Terrestrial Wildlife Study

The goal of the Terrestrial Wildlife Study was to assess the seasonal presence, abundance, and habitat use for key terrestrial wildlife species in the Eklutna River drainage. Specific objectives included:

1. Raptor Nesting Survey – An aerial raptor survey was conducted in spring 2022 to locate nests of bald eagles and other large raptors.
2. Migratory Waterfowl and Shorebird Surveys – Aerial and ground-based surveys were conducted in spring and fall 2022 to determine the numbers, seasonal occurrence, and habitat use of waterfowl and shorebird species in the study area, focusing on the estuary and adjacent mudflats.
3. Beaver Pond Mapping and Beaver Survey – An aerial and ground-based survey of beaver colonies was conducted, and beaver ponds and dams were mapped to assess current use of the Eklutna River drainage by beavers.
4. Moose Browse Survey – A survey of winter moose browse was conducted to assess the current level of moose browsing pressure relative to habitat carrying capacity to support the local moose population.
5. Camera Traps and Opportunistic Observations – Wildlife camera traps were deployed and additional wildlife observations were recorded opportunistically by other researchers on the Project to provide information on the wildlife species present and their relative abundance in the Eklutna River drainage, focusing on large mammals and furbearers.
6. Wildlife Habitat Evaluation – The value of wildlife habitats in the study area to terrestrial mammals and birds known or expected occur in the study area was assessed using a categorical ranking process. Based on changes in habitats over time (see Section 2.8), assessments of how the Eklutna Hydroelectric Project could have impacted wildlife populations in the past were made.

2.9.1 Raptor Nesting Survey

The raptor nesting survey was conducted on May 9, 2022, following established protocols for the inventory and monitoring of eagle nests using a helicopter survey platform. The survey area included the hillsides and bluffs overlooking the river valley below Eklutna Dam to search for cliff-nesting raptors and a forested area along the coast near NVE where bald eagles were known to nest.

A total of 6 raptor nests were observed in the survey area. Four bald eagle nests were located in large poplar trees along the coast. These nests appeared to represent 2 bald eagle breeding territories. One nest was occupied, and one nest showed inconclusive signs of occupancy. In addition, a common raven or northern goshawk nest was recorded farther upstream in a poplar tree and an active common raven nest was recorded on a gravel-covered cliff-ledge. Overall, the area appears to be lightly used by nesting raptors and the often-eroding cliffs in the survey area are generally of low quality to support larger cliff-nesting raptor species, such as peregrine falcons and golden eagles.

2.9.2 Migratory Waterfowl and Shorebird Surveys

Two migratory waterfowl and shorebird surveys were conducted during the spring and two surveys during the fall of 2022. The survey dates were set to align with the peak numbers of waterfowl and shorebirds migrating through the Cook Inlet area, based on survey data from other Cook Inlet studies.

Waterfowl and shorebird numbers in the study area were moderate and low, respectively, during the field surveys, with waterfowl (ducks, geese, and swans) often accounting for over half the total number of birds present. Eleven species of waterfowl were recorded throughout the study period, with counts ranging from 37–143 individuals per survey. Shorebirds were noticeably absent during the spring surveys, but 13 individuals of 3 species (semipalmated plover, least sandpiper, and spotted sandpiper) were detected on the early fall survey, all on the mudflats at the mouth of the Eklutna River. Outside of the coastal areas, waterfowl and shorebirds were found in very low numbers in all other portions of the Eklutna River drainage including the littoral zone at the mouth of Eklutna Lake.

2.9.3 Beaver Pong Mapping and Beaver Survey

The beaver colony survey was conducted on October 10, 2022, using a helicopter with a single observer seated opposite the pilot. A single ground-based survey was also conducted on September 22, 2022, in an attempt to estimate family sizes of beaver colonies in the area.

Only one active beaver colony with a food cache and one inactive colony were observed below the railroad bridge. Above the canyon reach, a failed beaver dam was found at RM 5.7 and an active colony complex at RM 7.0. The middle river colony complex consisted of one failed dam, six active dams, and a single lodge. The dams in this area spanned all or most of the wetted river channel at the time of the survey (see Figure 2-17 and Figure 2-18). The beaver lodge in the upper river area and a recently removed dam in the same area showed no signs of recent activity.

Figure 2-17. Active Dam-07 (LEFT) and Active Dam-08 (RIGHT) in the middle river colony.

Figure 2-18. Active Dam-09 (LEFT) and Active Dam-10 (RIGHT) in the middle river colony.

During the ground-based survey, no beavers were observed at the middle river colony. The two dams farthest downriver were estimated at approximately six feet tall and looked like potential barriers to adult fish passage, though juveniles may be able to pass through. No signs of rehabilitation of the dam or lodge were evident at the former upper river colony.

2.9.4 Moose Browse Survey

The moose browse survey was conducted during late winter, April 12-15, 2022, so that the data would represent maximum seasonal browse removal. The mean browse removal rates were estimated at the individual plant level by sampling 30 plots within the study area. Brackish and tidal habitats at the coast and the area above the existing Eklutna Dam were excluded as these areas were not expected to receive much moose browse.

During the field survey, researchers sampled 2,281 twigs from 241 plants within 30 plots. Feltleaf willow was the most common forage species sampled, followed by Alaska birch and balsam poplar. Browsing pressure was highest for feltleaf willow (40.8% removal) followed by Barclay's willow (30.0% removal), and diamond-leaf willow (25.0% removal). Broomed architecture was observed on 35.7% of sampled plants. Mean proportional offtake per plant was 22%, which is consistent with a stable or increasing moose population and should exhibit moose twinning rates of ~20–50%.

2.9.5 Camera Traps and Opportunistic Observations

Twelve camera-traps were deployed, set to record either time-lapse (seven cameras) or motion-sensor (five cameras) photographs throughout the Eklutna River drainage. Time-lapse cameras were placed on beaver ponds (n = 2) or coastal wetlands (n = 5), while motion-sensor cameras were placed on trails and river crossing areas that were expected to channel mammal movements. In addition to camera-traps, opportunistic observations and other signs of terrestrial wildlife were recorded by other project personnel working in the area.

The seven motion-sensor cameras recorded 10,263 useable photographs while the five time-lapse cameras recorded 383,363 useable photographs (Figure 2-19). Moose were the most frequently photographed terrestrial mammal species (352 groups), followed by black bears (32 groups), brown bears (14 groups), coyotes (13 groups), unknown canid (3 groups), red fox and snowshoe hare (2 groups each), and wolf and lynx (1 group each).

Figure 2-19. Camera trap photos, moose (LEFT) and black bear (RIGHT).

2.9.6 Wildlife Habitat Evaluation

Twenty-three wildlife habitats were defined and mapped in the study area (see Section 2.8). Wildlife habitat evaluations were then conducted by creating a matrix of wildlife species and the 23 mapped habitats and assigning a categorical habitat-value ranking (high, moderate, low, or negligible value) to each mapped wildlife habitat type for each bird, mammal, and amphibian species known or expected to occur regularly in the study area.

Across all species of birds, mammals, and amphibians known or expected to occur in the study area, each of the 23 mapped habitat types was considered to be of high or moderate value for at least 8 or more of the 145 species assessed. In this habitat evaluation, the most species-rich habitats were Mixed Deciduous-Spruce Forest and Spruce Forest, with those 2 forested habitat types considered to be of high or moderate value for 76 and 64 wildlife species, respectively. This result is driven primarily by the large number of landbird species that are expected to make use of the more complex vegetation structure in these habitat types. Other species-rich habitats were Black Cottonwood Forest, Freshwater Pond, and Freshwater Pond (Beaver Modified). A set of 6 shrub, lacustrine, and marsh habitat types (Seasonally Flooded Low and Tall Alder-Willow Shrub Scrub, Brackish Pond, Upland Low and Tall Alder-Willow Shrub Scrub, Freshwater Lake, Brackish Sedge Marsh, and Freshwater Sedge Marsh) closely followed, and were considered to be of high or moderate value for 47–44 wildlife species. After that, species richness dropped off noticeably, with a set of 8 riverine, forest, mudflat, lacustrine, and shrub habitats considered to be of high or moderate value for 31–20 wildlife species. Types with the lowest levels of species richness were a set of 4 barren, seeps and springs, cliffs and banks, and intermittent stream habitats, which were considered to be of high or moderate value for 17–8 wildlife species.

The mapping of historical (1950) wildlife habitats (see Section 2.8) indicates that prior to the construction of the Eklutna Hydroelectric Project in 1955, riparian shrub habitats were markedly more extensive in the Eklutna River drainage. After 63 years, without the annual or bi-annual high flow events with extensive overbank flooding, these riparian shrub habitats have transitioned to more well-drained spruce and deciduous forest habitats. Wildlife species that rely heavily on riparian shrub habitats are expected to have declined in abundance in the study area, and species that rely heavily on mixed forest habitats are expected to have increased in abundance. In addition, fluctuations in the level of Eklutna Lake throughout the year have exposed a substantial littoral zone at the mouth of the lake, which was far smaller in extent in 1950. The few wildlife species that make use of this lake littoral zone habitat may have increased in abundance since 1955.

2.10 Recreation Study

The goal of the Recreation Study was to itemize and quantify the current level of recreation in the Project area, including quantifying the use types, locations, and frequency of recreational activities. Analysis of compiled existing data provided by ADFG, Chugach State Park, and MOA was supplemented by primary data collected through an online survey, online interactive comment map (Figure 2-20), intercept surveys conducted at high-visitation areas, traffic counts on roadways near parking areas, and a paper survey distributed to members of NVE.

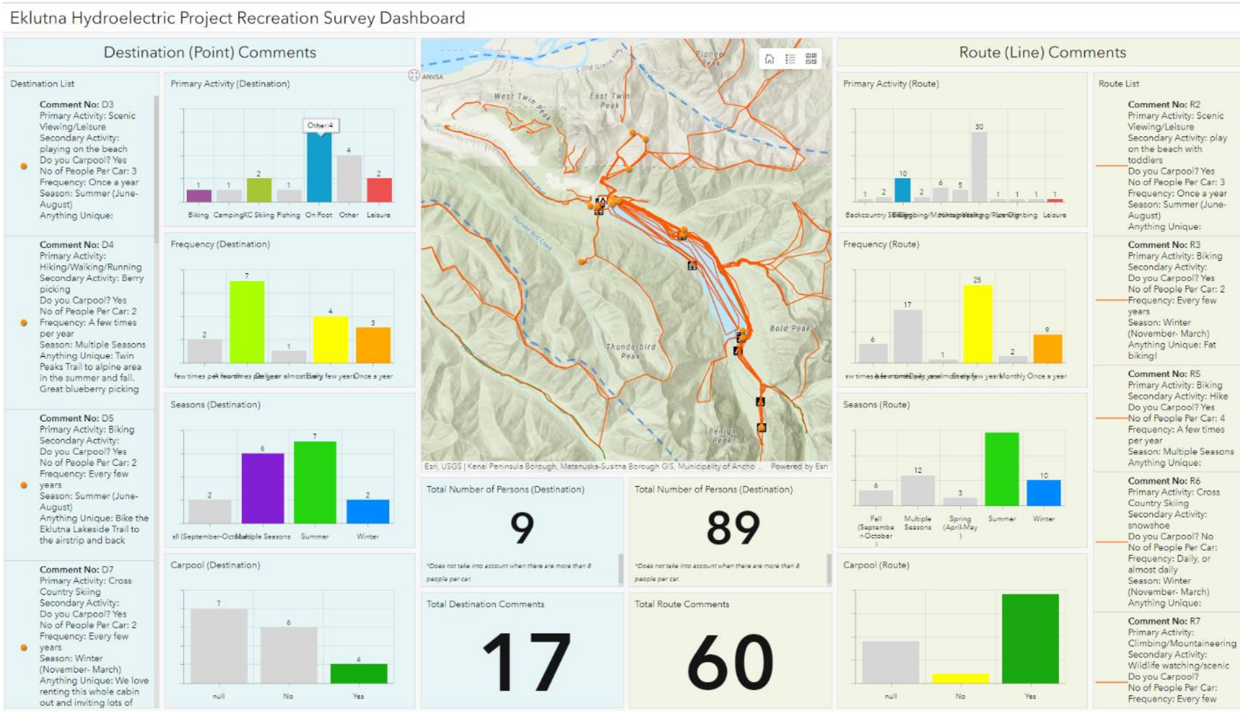


Figure 2-20. Display of Online Interactive Comment Map Dashboard.

2.10.1 Chugach State Park

All lands in the upper watershed of the Eklutna River are located within Chugach State Park. The Eklutna Valley is a heavily used area of Chugach State Park, specifically Thunderbird Falls Trail and the Eklutna Lake Recreation Area, known for its scenic qualities and diverse year-round recreational opportunities. Visitors most frequently enjoy hiking, biking, camping, and scenic viewing, but also participate in horseback riding, climbing, berry picking, hunting, fishing, boating, riding all-terrain vehicles (ATVs), cross-country skiing, dog mushing, and snow machining in the winter.

Eklutna Lakeside Trail was the most frequently reported destination per primary data collection efforts, followed by Twin Peaks Trail, public use cabins, and campgrounds. 2019 MOA trail counts at Eklutna Lakeside Trail reported average annual daily traffic of 200 pedestrians per day, with 407 per day in the summer and 22 in the winter. 2020 MOA trail counts at Thunderbird Falls Trail reported an average annual daily traffic of 370 pedestrians per day, with 888 per day in the summer and 115 in the winter. Public use cabins and campgrounds in the area are popular destinations which see regular use annually. For Fiscal Year (FY) 2022, Chugach State Park collected $273,497 in revenue from recreational use fees (campground and cabin reservations) and parking lot fee stations in the Project Area.

Chugach State Park has fee stations at parking lots and campgrounds in the Eklutna Lake Recreation Area and Thunderbird Falls. Traffic counts collected during the study period were compared to fee station transaction data for the same days as counts were collected and concluded approximately 25% of all vehicles entering these areas pay a fee at an applicable fee station (50% rate of fee station use for the Eklutna Campground). Rates of fee station use were applied to the full year of fee station data provided by Chugach State Park and a conservative, generalized carpool rate of 50% of vehicles entering the Project Area for recreation contain two people was applied to the total vehicle count to determine a minimum number of total recreators. A minimum of 145,881 recreators partook in activities within Chugach State Park fee areas in the Project Area in FY 2022 and drove a personal or rental vehicle to get there.

Guiding, touring, and equipment rental businesses operate in the Eklutna Valley. Most notably, Lifetime Adventures operates a rental facility offering bike and kayak rentals near the Lakeside Trailhead and Day Use Area. Premier Alaska Tour brings approximately 500 visitors to this destination annually during the summer who reliably use Lifetime Adventures services. Other businesses operating in the area provide guided hiking and hunting, outdoor education services, and photography tours.

2.10.2 Eklutna Tailrace

The Eklutna Tailrace is stocked annually with Chinook and coho smolts by ADFG which has facilitated a very popular and sustainable salmon fishery since 2003. Developed facilities including parking, Americans with Disabilities Act (ADA) accessible trails, fishing pads, a bridge providing access to both sides of the tailrace, vault latrines and refuse receptacles. Fishing was the most reported primary activity at the Tailrace, followed by scenic viewing and hiking or walking. Fishing activities are seasonally dependent and therefore summer was reported as the most visited time of the year, but activities were reported year-round. ADFG estimated 13,485 angler days at the Tailrace in 2018. Traffic count data collected and analyzed estimates a total of 23,823 vehicles visited the Tailrace from June 8 through August 23, 2022. Applying the same conservative assumptions for projecting total number of recreators based on carpooling vehicles noted above, a minimum of 31,447 recreators partook in activities at the Tailrace between June 8 and August 23, 2022.

2.10.3 Lower Eklutna River

Activities, whether recreational or subsistence, in the Lower Eklutna River area (considered areas downstream of the Old Glenn Highway bridge), are conducted by members of NVE or Eklutna, Inc. or are otherwise permitted by those entities. One NVE member survey response was received and included both recreational and subsistence activities that they or members of their household participate in within the Lower Eklutna River area.

2.11 Lakeside Trail Erosion Study

The goal of the Lakeside Trail Erosion Study was to determine the effects of Project operations on the Lakeside Trail and identify potential mitigation measures to minimize erosion impacts to this popular recreational trail. The objectives of the study were to document locations where erosion affecting trails or recreation facilities is influenced by lake level fluctuations and determine the causes of erosion at these locations.

The trail includes a former roadbed constructed by the U.S. Army in 1962 that followed the lake shoreline. At very high lake levels, erosion of the trail occurs in locations where the trail is directly adjacent to the lakeshore. Erosion along approximately 3.1 miles of the trail has resulted in narrowing of the original roadbed so that in some places it is too narrow for ATV use; in these areas the main trail has been re-routed up and away from the shoreline and the original shoreline trail is restricted to non-motorized traffic.

A total of 59 eroding areas were delineated along the Eklutna Lakeside Trail, including areas showing past and/or more recent erosion (**Error! Reference source not found.**). The inventory followed the pathway closest to the lake. Shoreline erosion was noted along 0.6 miles of the main trail and 2.4 miles of the non-motorized trail. Nine sites were identified as high priority sites for erosion control, maintenance, or warning signs due to concerns for the safety of trail users.

Five primary types of erosion processes were noted during the field inventory: undercut banks caused by wave erosion, slumping and earthflows caused by saturated soils and/or drainage issues; trampling by recreationalists accessing the lake; raveling of unconsolidated and/or unvegetated cutslopes and banks; and streambank erosion at major stream crossings.

All lakeshore erosion sites had wave action at high lake levels as one of the factors contributing to erosion. Seepage and runoff were the second most common factor, present at 28% of the sites (by length), and blocked culverts were listed at 9% of the sites. Reservoir fluctuation was listed at 28% of the sites. Pedestrian use (19% of the sites) and raveling of steep cutslopes (8%) were the remaining factors affecting erosion.

2.12 Cultural Resources Study

The goal of the Cultural Resources Study was to determine if historic or archaeological resources are present within the study area and evaluate their eligibility for the National Register of Historic Places (National Register). The study area, or Area of Potential Effects

(APE), encompassed all locations of possible Project impacts, with a conservative buffer to fully include all potential historic or archaeological resources that could be directly, indirectly, or cumulatively affected.

Prior to the beginning of field surveys, high resolution LiDAR, satellite imagery, and USGS topographic maps were used to make an initial assessment of the archaeological potential of various portions of the study area. The outlet of Eklutna Lake, the river and lakeshore terraces, tributary creek areas, and peninsulas along the lake were marked as locations with higher potential for past use. In addition, the southeastern end of the lake was judged to have higher potential for cultural resources due to a known historic occupation by a well-known Eklutna elder and military training during the 1960s.

The fieldwork was conducted in June and July of 2022. Cultural sites were mapped and documented with photographs and field descriptions. Investigations around Eklutna Lake encompassed lands within the APE along the northeastern and southwestern shoreline, including adjoining uplands within the Eklutna Lake Campground and at the West Fork of Eklutna Creek at the head of the lake. The survey covered approximately 16 linear miles of the lake margin. For the purposes of survey and reporting, the Eklutna River corridor divided into four segments: 1) the lake outlet to the AWWU portal valve, 2) the AWWU portal valve to the downstream extent of the AWWU access road, 3) the downstream extent of the AWWU access road to the Thunderbird Creek trailhead, and 4) the Thunderbird Creek trailhead to Knik Arm.

Properties within the APE that could be eligible for the National Register are limited to the Eklutna Dam and Spillway and Eklutna River Railroad Bridge. The Eklutna Dam and Spillway are significant as contributing properties to the Eklutna Hydroelectric Project. The Eklutna River Railroad Bridge is significant for its continued association with the operation of the Alaska Railroad between Anchorage and interior Alaska. Other sites that were discovered and documented, but not considered significant enough to possibly be eligible for the National Register, included the remnants of an earlier storage dam at the lake outlet, a cluster of log piers on the beach along the Eklutna Lakeside Trail, and a can scatter on the eastern bank of the Eklutna River, downstream from the Alaska Railroad bridge.

During the study period, a log section from the historic Eklutna Alex cabin was discovered on the shoreline of Eklutna Lake near the Eklutna Lake Campground. There were two hand-hewn, 8" diameter beams measuring 96" and 115" long, toenailed with four iron spikes and an old Alaska State Parks "no campfire" sign (see Figure 2-21). The Project Owners immediately notified NVE, Chugach State Park, and the State Historic Preservation Officer (SHPO). NVE recovered the logs and has plans to display them in the future.

Figure 2-21. (LEFT) Historic Eklutna Alex Cabin in 1987. (RIGHT) Cabin logs discovered on the lake shoreline in 2022.

2.13 Existing Infrastructure Assessment

Prior to proposing modifications to existing Project infrastructure or determining a flow regime into the Eklutna River, an infrastructure assessment study was performed. The investigation assessed how the ability to release any potential future flows may be impacted by hydraulic and/or operational restrictions of Eklutna Lake, or if flows may affect downstream infrastructure below Eklutna Dam. A series of site visits were performed in August 2020 and September 2021 to investigate hydraulic and/or operational restrictions of Eklutna Lake, including the existing storage dam, existing pond, and the outlet works through Eklutna Dam. Additionally, downstream infrastructure was assessed to determine if any deleterious effects may be caused by releasing flows into the Eklutna River, including AWWU's access road and bridges, AWWU's pipeline, the highway bridges, and the railroad bridge. The results of the investigation are summarized in the following subsections.

2.13.1 Eklutna Lake

As currently operated, Eklutna Lake is disconnected from Eklutna Dam for an average of 9 months each year. The lake is drawn down an average of 36-feet each year with the water being utilized for power generation and potable water supply purposes. As such, any gravity-flow release through the dam is currently only possible between September and December (3 months) per year without a substantial change to the reservoir operations.

2.13.2 Historical Storage Dam

The remnants of the historical storage dam create a topographic barrier between Eklutna Dam and Eklutna Lake. The barrier has a crest elevation of El. 860.0 feet (local datum), forming an isolated pond upstream of Eklutna Dam for most of the year. Minor groundwater seepage flows through the foundation of the historical storage dam into Eklutna Lake during the 9 months of the year that the lake is below El. 860.0 feet.

2.13.3 Existing Pond

The pond formed upstream of Eklutna Dam was determined to have a maximum storage capacity of approximately 17 acre-feet at El. 860.0 feet. This pond was investigated to determine if it had sufficient storage to make continuous flow releases into the Eklutna River for any proposed future instream flow requirements. The investigation revealed that if released through the existing gate at the base of the spillway in Eklutna Dam, the pond would be substantially drained within 8 hours and is of insufficient size to make any significant continuous releases downstream of the dam.

2.13.4 Drainage Outlet Gate

The drainage outlet gate at the base of the spillway in Eklutna Dam was inspected and determined to be occluded with rocks, boulders, and debris, and experiencing moderate corrosion. The gate was replaced with a new stainless steel slide gate has a hydraulic capacity of 190 cfs and was used to conduct the 2021 study flow releases. The new gate is also capable of making potential future flow releases into Eklutna River when the lake is connected to the dam. Due to lack of power at the dam site the gate is manually operated, which requires periodic operator adjustments to maintain a set flow rate as the water surface elevation of the lake fluctuates.

2.13.5 AWWU Access Road and Bridges

The AWWU Access Road spans 6.5 miles along the Eklutna River and consists of two small bridges and eight natural bottom ford river crossings. Both bridges are in good condition and have a hydraulic capacity of ~1,000-1,200 cfs. The eight river crossings are armored but will need to be investigated further as part of evaluating potential future flow regimes to determine what modifications would be required to make them safely passable by vehicles if any potential future instream flows are implemented.

2.13.6 AWWU Pipeline

The AWWU pipeline runs underground along the Eklutna River for 6.1 miles from the tunnel diversion to the Eklutna Water Treatment Facility. Along the route of the pipeline, it crosses the Eklutna River in eight locations. Each location evaluated has sufficient depth of cover and armament to protect the pipeline from becoming exposed under potential future flows. The exception is river crossing H (Sta 4306+00), which was completely inundated by a beaver dam pond and was unable to be investigated as part of this study.

The hydraulic capacity of the pipeline was additionally investigated to determine any hydraulic limitations that may exist in the event that the diversion tunnel or portal valve shaft were considered for modification to release flows into the Eklutna River. The investigation revealed that there is sufficient driving head to deliver up to 100 million gallons per day (154.7 cfs) to the Eklutna Water Treatment Facility at the minimum water surface elevation in Eklutna Lake. Any additional flows discharged into the Eklutna River through the diversion tunnel must closely consider this hydraulic limitation of the pipeline to avoid any impacts for water delivery.

2.13.7 Old Glenn Highway Bridge

The Old Glenn Highway bridge has a hydraulic capacity far exceeding the 500-year flood flow, estimated to be 1,800 cfs. However, an intermediate pier exists that has an increased risk of scour when flows exceed the 50-year flood, estimated to be 850 cfs. The hydraulic analysis of the channel beneath the Old Glenn Highway Bridge should be revisited as part of the evaluation of any potential flow regimes to determine if the increased river flows may cause an increased risk of scour of the intermediate bridge pier.

2.13.8 New Glenn Highway Bridges

The New Glenn Highway bridges have a hydraulic capacity well in excess of the 100-year flood event (> 4,700 cfs) and contain no structural elements within the influence of the river. The bridge abutments and scour protection elements were found to be in good condition and no impacts are expected from any potential future instream flow regime.

2.13.9 Railroad Bridge

The Eklutna River Railroad Bridge has an estimated hydraulic capacity far exceeding Eklutna River flood events (> 8,000 cfs). The bridge was determined to be in reasonable condition for its age, with no evidence of scour beneath the abutments or bank erosion occurring. Based on the estimated hydraulic capacity and current condition of the railroad bridge, there are not anticipated to be any modifications required to accommodate potential future instream flows in the river.

2.14 Engineering Feasibility and Cost Assessment

The engineering feasibility and cost assessment study consisted of analyzing a total of 19 measures proposed by the Project Owners and various stakeholder groups. These alternatives are divided into six site improvement categories and represent potential modifications to existing infrastructure or construction of new facilities to protect, mitigate damages to, and enhance fish and wildlife impacted by the development of the Project. A summary of the measures is provided in Table 2-8 and a summary of the Class 5 Opinion of Probable Construction Costs (OPCC) is provided in Table 2-9. The conceptual design drawings associated with each measure are available for review on the Project website.

Table 2-8. PME Measure Descriptions.

	Measures	Work Features
Instream Flow Measures		
A	Dam Release Modifications	Add electric motor operator and controls to existing sluice gate and complete powerhouse upgrades to allow powerhouse to be offline through winter months.
B	Siphon Bypass Pipeline	Add a pipeline that will siphon water out of the Eklutna Lake to Eklutna River and complete powerhouse upgrades to allow powerhouse to be offline through winter months.
C	AWWU Portal Valve Release	Tap into existing 54" bypass pipeline at the AWWU portal valve location to divert flow to Eklutna River.
D	AWWU Pipeline Release	Tap into existing 54" bypass line at specified location along AWWU Pipeline at River Mile 5.5 to divert flow to Eklutna River.
E	Bypass Tunnel Release	Add a tee to the existing 108" APA tunnel and drive a 7,500 foot long 72" diameter tunnel to divert flow to the Eklutna River.
F	Channel Excavation	Excavate a channel from Eklutna Lake past the previous storage dam to make the Eklutna Dam Pond a live storage pool all year.
G	Lach Q'atnu Creek Re-Route	Divert current path of Lach Q'atnu Creek to new channel to allow creek to flow directly to Eklutna River downstream of Eklutna Dam.
Peak Flow Measures		
H	Spillway Modifications - New Tainter Gate	Add new Tainter gate and hoist to the existing Eklutna Dam spillway crest.

I	Spillway Modifications - New Wheel Gate	Add new fixed wheel gate and hoist in place of the existing Eklutna Dam spillway.
Fish Passage Measures		
J	Gravity Flow Fish Ladder	Add gravity fish ladder passage through dam.
K	Variable Exit Fish Ladder	Add variable exit fish ladder passage through dam.
L	Pumped Supply and Slide Fish Ladder	Add new concrete fishway through dam with pumped water supply.
M	Trap and Haul Facility	Add trap and haul fish transfer facilities at new downstream bypass valve.
N	Floating Surface Collector	Add floating surface fish collector in Eklutna Lake.
O	Fish Exclusion Barrier	Add fish exclusion netting at existing intake structure.
P	Replacement Dam	Excavate deep channel, remove existing dam, and replace with larger embankment dam including fish passage.
Infrastructure Improvements		
Q	Lakeside Trail Improvements	Improve the lakeside trail and repair erosional features on the northeast shoreline of Eklutna Lake.
R	AWWU Maintenance Road Crossings	Add 8 new road bridges over Eklutna River on AWWU access road.
Habitat Improvements		
S	Physical Habitat Manipulation	Implement new physical habitat modifications within the Eklutna River to improve fish and wildlife habitat.

Table 2-9. Class 5 OPCC – Cost Summary.

Measures		Total Median Cost	Class 5 Cost Estimate (-50% to +100%)		
A	Dam Release Modifications	$6,680,000	$3,340,000	to	$13,360,000
B	Siphon Bypass Pipeline	$22,371,500	$11,186,000	to	$44,743,000
C	AWWU Portal Valve Release	$5,546,500	$2,773,000	to	$11,093,000
D	AWWU Pipeline Release	$2,248,300	$1,124,000	to	$4,497,000
E	Bypass Tunnel Release	$76,747,200	$38,374,000	to	$153,494,000
F	Channel Excavation	$569,000	$285,000	to	$1,138,000
G	Lach Q'atnu Creek Re-Route	$1,523,000	$762,000	to	$3,046,000
H	Spillway Modifications - New Tainter Gate	$5,574,300	$2,787,000	to	$11,149,000

I	Spillway Modfications - New Wheel Gate	$6,573,500	$3,287,000	to	$13,147,000
J	Gravity Flow Fish Ladder	$16,670,300	$8,335,000	to	$33,341,000
K	Variable Exit Fish Ladder	$17,569,600	$8,785,000	to	$35,139,000
L	Pumped Supply and Slide Fish Ladder	$15,240,200	$7,620,000	to	$30,480,000
M	Trap and Haul Facility	$8,336,200	$4,168,000	to	$16,672,000
N	Floating Surface Collector	$57,557,000	$28,779,000	to	$115,114,000
O	Fish Exclusion Barrier	$3,125,600	$1,563,000	to	$6,251,000
P	Replacement Dam	$113,344,500	$56,672,000	to	$226,689,000
Q	Lakeside Trail Improvements	$1,720,700	$860,000	to	$3,441,000
R	AWWU Maintenance Road Crossings	$2,941,500	$1,471,000	to	$5,883,000
S	Physical Habitat Manipulation	$1,469,200	$735,000	to	$2,938,000

2.15 Hydro Operations Model

The hydro operations model was developed in 2021 to assess impacts to flows, energy generation, and carbon offsets as a result of potential operational changes of the system. This modeling effort used available water surface elevation data from the existing USGS Gage No. 15278000 located in Eklutna Lake near the Project intake, historical flow data for the Eklutna Power Plant, and historical flow data for the Eklutna Water Treatment Plant from AWWU to develop an operations model of the reservoir. Historic spill events were also taken into account. The average water surface elevation of Eklutna Lake is presented in Figure 2-22.

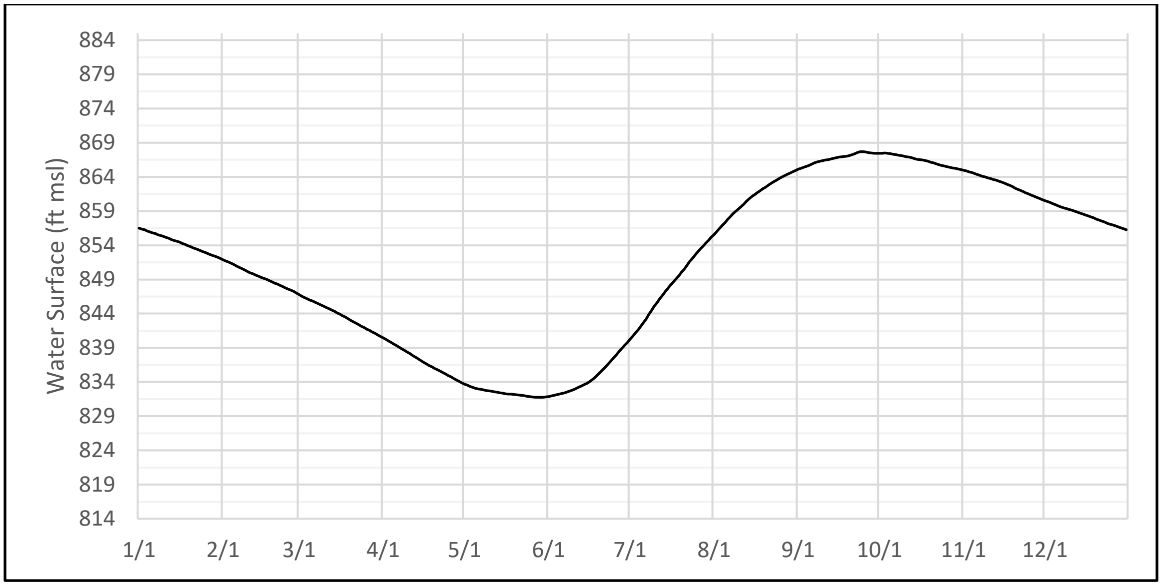


Figure 2-22. Average Water Surface Elevation of Eklutna Lake; 2010 – 2021.

A hydraulic model was developed of the intake and power conduit to determine friction losses as a function of flow rate through the conveyance. Minor losses were included at the trashrack, each pipeline bend, each reduction in conveyance diameter, at the turbine bifurcation, valve, and turbine draft tube. Major friction losses were determined throughout the power tunnel and penstock. The hydraulic grade line represented on the tunnel elevations throughout the power conduit is presented in Figure 2-23.

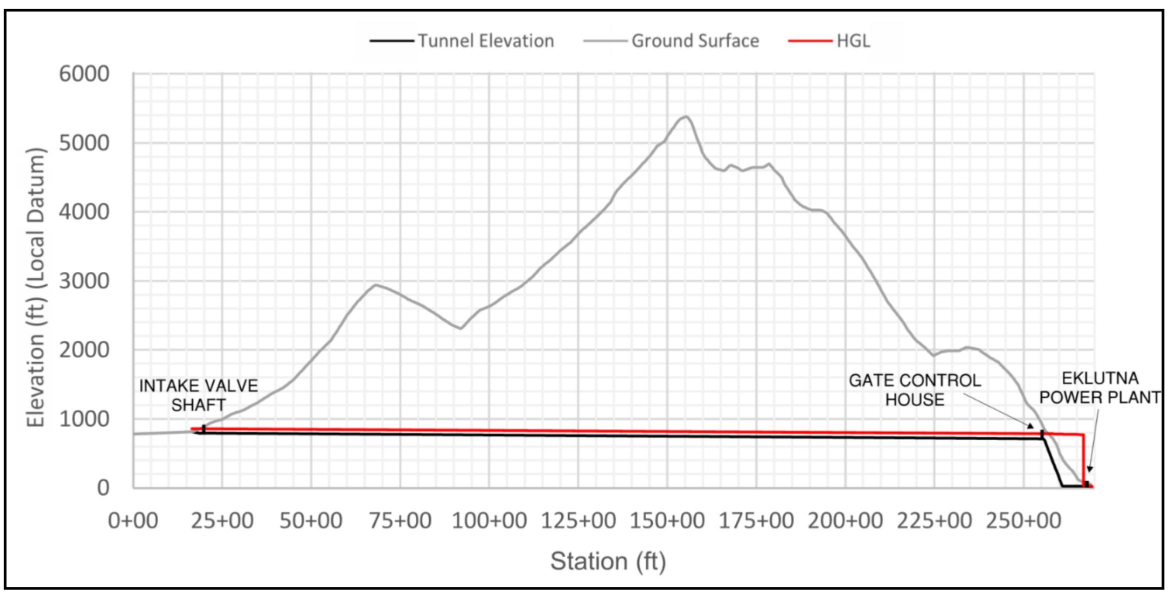


Figure 2-23. Eklutna Power Conduit Hydraulic Grade Line (HGL).

To calculate energy produced through each unit over the operating history analyzed in this study, the turbine efficiency as a function of the net head and flow rate was obtained from published efficiency data obtained through model testing of a homologous unit. Flow data on an hourly timestep from January 2011 to December 2020 were used. Daily generation values were calculated over ten years of operation (2011 – 2021) to validate accuracy with known generation values from the facility. The output of the operations model compared with actual generation values is summarized in Table 2-10.

Table 2-10. Annual Energy Comparison Summary – Actual vs Calculation; 2011 – 2021.

Year	Actual Energy Production (GWh)	Calculated Energy Production (GWh)	% Error
2011	128.1	128.0	-0.1%
2012	145.2	143.8	-1.0%
2013	172.1	169.1	-1.7%
2014	157.3	158.3	0.6%
2015	136.1	138.0	1.4%
2016	169.5	166.5	-1.8%
2017	119.9	118.4	-1.3%
2018	168.8	169.5	0.4%
2019	191.6	192.1	0.3%
2020	179.1	180.9	1.0%
Average	**156.8**	**156.5**	**-0.2%**

The model was able to accurately predict the hydroelectric generation potential as a function of 10-year average Eklutna Lake water surface elevations and hourly power plant flows to within 0.2% of actual values. The model was then utilized to simulate proposed changes to reservoir or power plant operations in order to determine expected changes in energy production and revenue through the power plant as part of the Hydro Valuation Study (see Section 2.16).

2.16 Hydro Valuation Study

The Hydro Valuation Study was conducted as part of the alternatives analysis process to quantify the annual changes in energy revenue associated with proposed operational changes of the reservoir. Variations from baseline energy production as a result of modifying the powerhouse flow regime or reservoir water surface elevations were output from the hydro operations model. To determine the value of energy losses from the Eklutna Hydroelectric

Project, the study investigated the value of the replacement energy within the MEA and Chugach Electric's systems. In the case of both utilities, any energy lost from the facility would be replaced by one of the multiple natural gas generation facilities located in the local system.

The value of energy produced from a natural gas generation facility is directly tied to the price of natural gas. In June 2023 the local provider of natural gas, Enstar Natural Gas Company LLC, presented to the Regulatory Commission of Alaska (RCA) a range of gas prices expected in 2026. The price of gas ranged from a low of $12.20 per thousand cubic feet (MCF) to $13.90/MCF with a median expected value of $13.05/MCF. Using the median expected gas price, the Project Owners performed a production cost model run of energy generation on the Railbelt system utilizing GenTrader®, an energy portfolio modeling software, to determine a forecasted price of energy from natural gas generation sources of $84.65/MWh.

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