Technical Memorandum

To:	Eklutna Project Owners	Project:	Eklutna Fish & Wildlife Program
From:	Sean P. Ellenson, P.E. McMillen, Inc.	cc:	Samantha Owen McMillen, Inc.
Date:	April 24, 2024	Job No:	24-021
Subject:	Technical Risk Assessment of the Removal of Eklutna Dam		

Revision Log

Revision No.	Date	Revision Description
0	03/22/2024	Initial Draft
1	04/05/2024	First Draft for Circulation
2	04/22/2024	Final Draft

1.0 Introduction

The Eklutna Hydroelectric Project (Project) is located in Southcentral Alaska approximately 30 miles northeast of downtown Anchorage near the Native Village of Eklutna (NVE). The Project was originally constructed by the Federal government in the 1950s but was later sold to and is currently owned by Chugach Electric Association (Chugach), Matanuska Electric Association (MEA), and the Municipality of Anchorage (MOA), collectively the “Project Owners”. As part of the sale of the Project, the current Project Owners entered into the 1991 Fish and Wildlife Agreement (1991 Agreement) with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and the State of Alaska (the Parties). The 1991 Agreement requires the Project Owners to develop and propose to the Governor of Alaska (Governor) a program to protect, mitigate damages to, and enhance fish and wildlife impacted by the development of the Project.

1.1 Background

Beginning in 2019, the Project Owners consulted with agencies and interested stakeholders regarding the availability of existing information and development of a study program. This study program took place over the course of two years to investigate the impact of the Project on fish and wildlife. The results of the study program indicated that releasing water back into the Eklutna River would provide benefits to fish and wildlife, particularly in terms of providing new fish habitat. Subsequently, the Project Owners began an alternatives analysis process to determine potential methods to provide water into the Eklutna River as well as other protection, mitigation, and enhancement (PME) measures as part of the future Fish and Wildlife Program.

Ultimately the alternatives analysis process evaluated over 36 comprehensive alternatives proposed by agencies and stakeholders. A cost effectiveness and incremental cost analysis was performed to identify the relative benefits and costs of each measure to help narrow down the list of proposed alternatives. The final list of preferred alternatives proposed by each participant in the alternatives analysis effort encompassed variations on infrastructural improvements (i.e. upstream and downstream fish passage, spillway gates, water release facilities in the river), flow release regimes, and habitat improvement measures to mitigate impacts from the Project. The alternatives analysis and selection of a preferred alternative was presented in the Draft Fish and Wildlife Program (Draft Program) published in October 2023[1].

Following the publication of the Draft Program, the NVE proposed a new alternative that involves the removal of Eklutna Dam. Per their comments on the Draft Program dated December 4, 2023:

> "To meaningfully meet the purpose of the Agreement, NVE proposes an alternative solution – removing the Eklutna Lake dam within ten years when sufficient renewable power generation is available to offset the lost power generation from dam removal."[2]

In response to the letter, the Project Owners committed to studying the alternative of dam removal in further detail. This memorandum aims to document a segment of this analysis.

1.2 Purpose

The purpose of this memorandum is to conduct a high-level analysis of the technical risks and cost implications associated with the removal of Eklutna Dam. This investigation evaluates the effects that an unregulated river hydrograph may have on infrastructure on or adjacent to the Eklutna River downstream of the existing dam, summarizes the costs associated with dam removal and decommissioning of Project infrastructure, investigates potential mitigation measures where necessary to address such risks, and analyzes the use of other comparable

[1] Chugach Electric Association, Matanuska Electric Association, and Municipality of Anchorage. Eklutna Hydroelectric Project Draft Fish and Wildlife Program (Oct 27,2023) https://eklutnahydro.com/wp-content/uploads/2023/10/2023-10-27-Eklutna-Draft-Fish-and-Wildlife-Program_with-Appendices.pdf

[2] Native Village of Eklutna. Letter to Project Owners Submitted via Email Re: Eklutna Hydroelectric Project Draft Fish and Wildlife Program. (December 4, 2023) https://eklutnahydro.com/wp-content/uploads/2023/12/NVE-Eklutna-Draft-Fish-Wildlife-Program-Comment-Letter.pdf

renewable energy sources to determine how to offset the lost generation and ancillary grid services provided by the Eklutna Power Plant. It is pertinent to note that the primary objective of this memorandum is to analyze the technical risks and mitigation measures linked to the dam's removal from an engineering standpoint and explicitly excludes discussions related to the ecological advantages or the potential effects on fish and wildlife habitat.

1.3 Organization

This memorandum is organized into the following sections:

Section 1 – Introduction
Discusses the purpose of the memorandum, the scope of the assessment, and the background of the project.

Section 2 – Eklutna River Hydrology
Summarizes the analysis performed on the Eklutna River watershed to estimate the average annual and predicted peak flow rates of the Eklutna River if the dam were to be removed.

Section 3 – Description of Alternative
Summarizes the scope of the dam removal alternative.

Section 4 – Risk Assessment and Mitigation Strategies
Summarizes the impacts to infrastructure associated with the project and analyzes the mitigation measures necessary following dam removal.

Section 5 – Preliminary Cost Estimates
Summarizes the cost estimates associated with the dam removal and modifications to associated infrastructure.

Section 6 – Risk Assessment Summary
Provides conclusions and an overall summary of the assessment performed.

2.0 Eklutna River Hydrology

Under the proposed scenario where the Eklutna Dam is removed, the Eklutna River would flow year-round in an unregulated state. To assess potential impacts to infrastructure along the river, an improved understanding of the hydrology of the Eklutna watershed is necessary to determine the typical annual hydrograph and peak flood flows expected post-dam removal. As part of the study program, a hydropower operations model was created for the Project that simulated reservoir and power plant operations to calculate historical inflows to the Eklutna watershed from 2011 to 2021. The modeling is based on the stage-storage information of Eklutna Lake, stage gauging information recorded by the United States Geological Survey (USGS), and measured outflows to the Eklutna Power Plant and to the Eklutna Water Treatment Facility (EWTF). The development of this operations model is summarized in the Hydropower Operations Modeling Study Report published in February 2022[3].

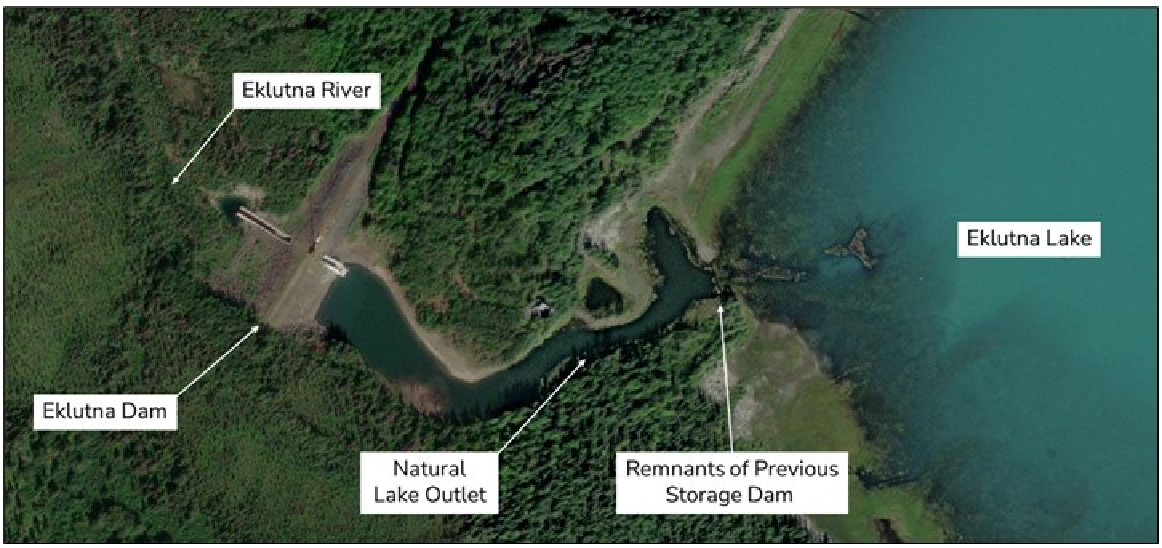

Figure 1.3-1. Location Map - Eklutna Lake Outlet.

To simulate the unregulated streamflow condition in the Eklutna River, the model was modified to consider the removal of Eklutna Dam. As an initial step in this scenario, all water withdrawals from the reservoir were curtailed, including both the power plant withdrawal and the EWTF flow diversion from the intake structure. Rather than the lake being regulated up to a maximum water surface elevation (WSEL) of El. 871.0 (Local Datum[4]) the reservoir would

[3] Chugach Electric Association, Matanuska Electric Association, Municipality of Anchorage. Eklutna Hydroelectric Project Hydropower Operations Modeling Draft Study Report. (February 2022) https://eklutnahydro.com/wp-content/uploads/2022/06/2022-2-11-Eklutna-Study-Report_Hydro-Model_DRAFT.pdf

[4] Multiple vertical survey datums are reported in and around the main features of the Project. Throughout this document, the elevation datum that shall be used is the "local datum" tied to the crest of Eklutna Dam.

flow naturally into the Eklutna River at a minimum WSEL of El. 860.0, corresponding to the elevation of the natural glacial moraine crest located at the remnants of the previous storage dam. The only regulation of streamflow from the reservoir under this proposed scenario would be due to the constriction of the outlet of the lake downstream of this natural crest. A location map identifying key features at the lake outlet is provided in Figure 1.3-1.

With the dam removed and the lake discharging in an unregulated state through its outlet, a stage-discharge relationship of the lake outlet was developed to understand the magnitude and seasonal variation of flow within the Eklutna River. The one-dimensional (1-D) HEC-RAS model developed as part of the study program was modified to determine the WSEL within the natural bend in the lake outlet at varying flow rates without a dam restricting discharge. The development of this model is summarized in the Eklutna River Instream Flow Year 2 Study Report published in June 2023[5]. The stage-discharge relationship of the lake outlet is illustrated graphically in Figure 1.3-2.

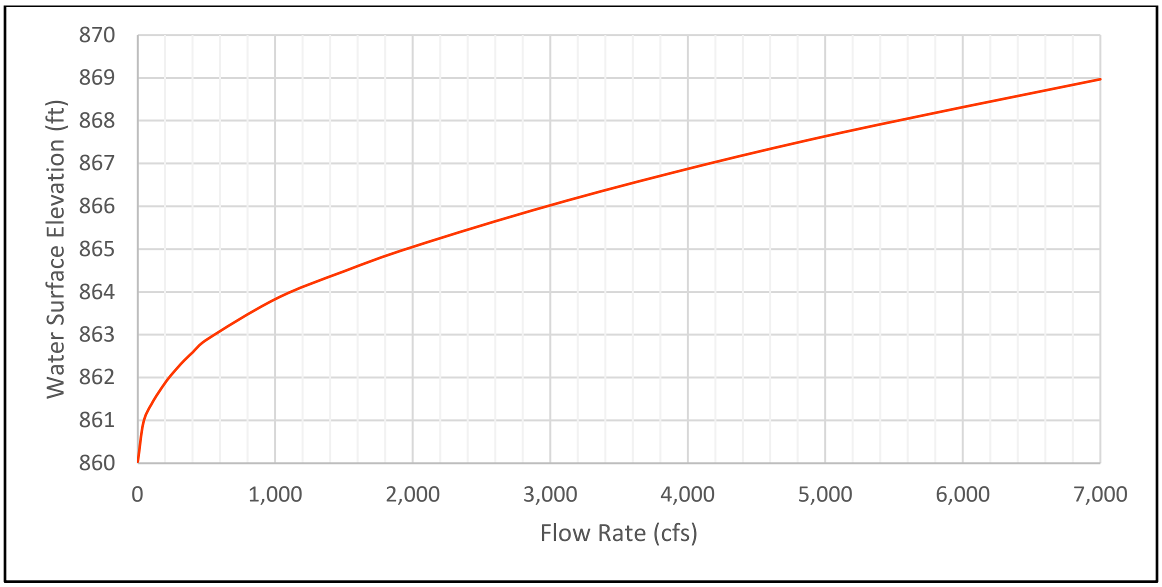

Figure 1.3-2. Stage Discharge Relationship; Eklutna Lake Outlet.

With the inflows to the lake calculated based on historical operating data and the hydraulic constriction at the outlet of the lake better understood, the natural seasonal fluctuation of the lake and the Eklutna River hydrograph were developed. The predicted streamflow of the Eklutna River in a daily timestep from 2011 to 2021 is presented in Figure 1.3-3 and the average seasonal lake fluctuation is presented in Figure 1.3-4.

[5] Chugach Electric Association, Matanuska Electric Association, Municipality of Anchorage. Eklutna Hydroelectric Project Eklutna River Instream Flow Year 2 Study Report. (June 2023) https://eklutnahydro.com/wp-content/uploads/2023/06/Eklutna-Instream-Flow-Y2-Report_FINAL.pdf

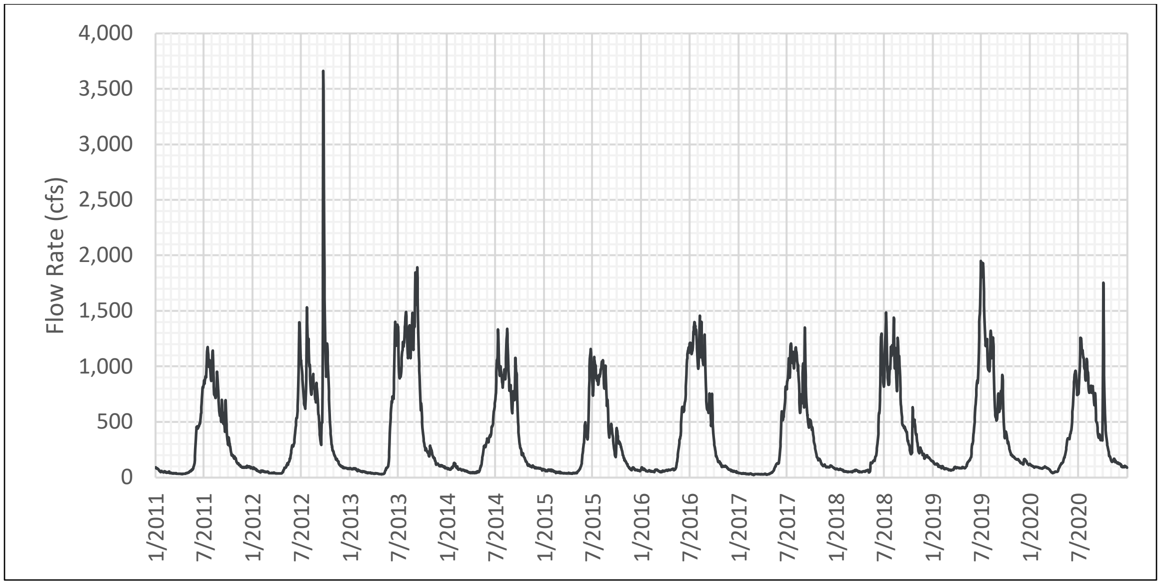

Figure 1.3-3. Eklutna River Unregulated Flow Rate; 2011-2021 Simulation.

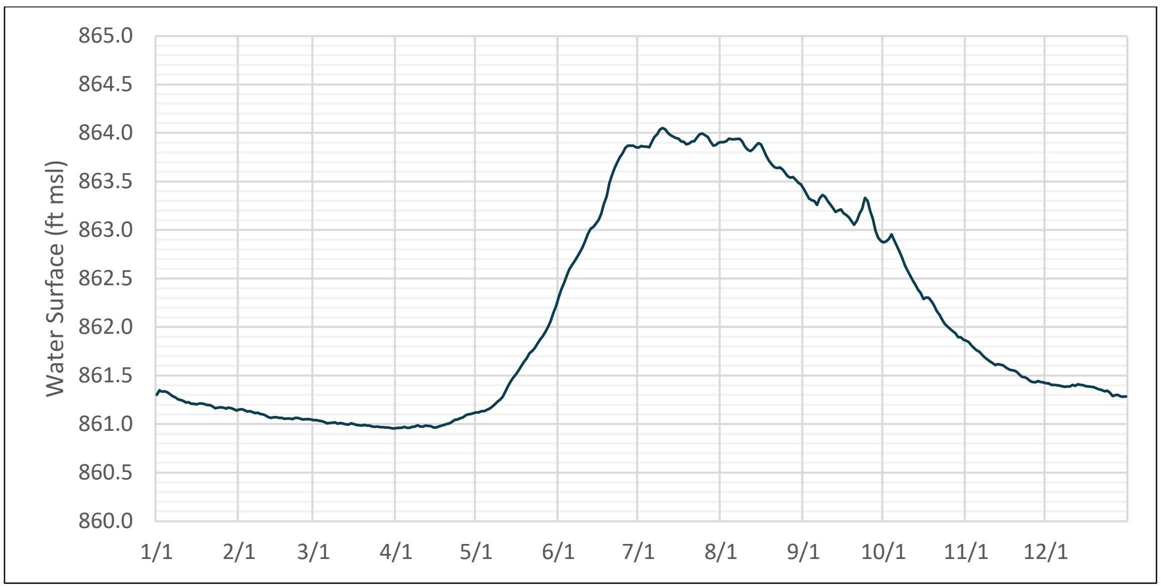

Figure 1.3-4. Eklutna Lake Average WSEL Post-Dam Removal.

Under the dam removal alternative, the Eklutna River would see an average peak flow of approximately 1,200 cubic feet per second (cfs) each year and the lake would fluctuate an average of 3-4 ft each year. The flow rate in the river during the winter months ranges from approximately 30-70 cfs.

To determine the flood magnitude for longer interval events, such as the 25-, 50-, and 100-year return interval storms, regional regression equations were utilized, as published by Curran et al[6]. The regional regression equations are based on a selected annual precipitation depth and watershed drainage area. The analysis was performed at two locations in order to calculate the peak flood events both above and below Thunderbird Creek, the primary tributary to the Eklutna River, the results of which are presented in Table 1.3-1 and Table 1.3-2.

Table 1.3-1. Eklutna River Flood Frequency Peak Flow Rates; Above Thunderbird Confluence.

Return Interval	Annual Exceedance Probability (%)	Peak Flow (cfs)	Lower 90% Prediction Interval (cfs)	Upper 90% Prediction Interval (cfs)
2	50%	2,360	826	6,740
5	20%	3,400	1,220	9,510
10	10%	4,150	1,480	11,600
25	4%	5,110	1,790	14,600
50	2%	5,840	2,000	17,000
100	1%	6,590	2,210	19,600
200	0.5%	7,350	2,390	22,600
500	0.2%	8,370	2,590	27,100

Table 1.3-2. Eklutna River Flood Frequency Peak Flow Rates; Below Thunderbird Confluence.

Return Interval	Annual Exceedance Probability (%)	Peak Flow (cfs)	Lower 90% Prediction Interval (cfs)	Upper 90% Prediction Interval (cfs)
2	50%	2,650	928	7,570
5	20%	3,840	1,370	10,700
10	10%	4,690	1,680	13,100
25	4%	5,790	2,030	16,500
50	2%	6,610	2,270	19,300
100	1%	7,460	2,510	22,200
200	0.5%	8,330	2,710	25,600
500	0.2%	9,480	2,930	30,700

[6] Curran, J.H., Barth, N.A., Veilleux, A.G., and Ourso, R.T.,2016, Estimating Flood Magnitude and Frequency at Gaged and Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada, Based on Data through Water Year 2012: U.S. Geological Survey Scientific Investigations Report 2016-5024, 47 p.

For the purposes of assessing the risks to infrastructure on or adjacent to the Eklutna River downstream of the dam as outlined in Section 4.0, the 1% annual exceedance probability (AEP) was utilized as the design basis flow rate, an industry standard for assessing impacts to bridges and other critical infrastructure. This equates to a flow of 6,590 cfs for infrastructure located above the confluence of Thunderbird Creek, and 7,460 cfs for all infrastructure below the Thunderbird Creek confluence.

In 2018, the USFWS conducted a peak flow analysis for the Eklutna River using the Log Pearson III technique outlined in USGS Bulletin 17B[7]. This analysis utilized eight years of historical gage data from the river before the current dam's construction. By applying various skew coefficients, the study developed a range of potential flood frequency flows. The selected skew coefficient indicated a 1% AEP flood flow of 3,436 cfs.

Although the USGS Bulletin 17B's methodology of fitting flow data to a statistical distribution is valid and typically an accurate estimation of AEPs, it requires at least a 10-year record from a gaged stream, which the Eklutna River lacks. Consequently, the regional regression equations proposed by Curran et al., which calculate peak flows based on watershed drainage area and mean annual precipitation, were considered more suitable for this analysis.

[7] USFWS. 2018. Appendix B - Eklutna River Peak Flow Estimates – USGS Gage 15280000, July 1947 – August 1954. https://www.tu.org/wp-content/uploads/2019/06/Upper-Eklutna-Flow-Assessment-071419-1.pdf

3.0 Description of Alternative

This section defines the necessary infrastructural modifications to Project facilities as part of the proposed dam removal alternative. The following subsections document the assumptions regarding modifications to the Eklutna Dam and to the Eklutna Power Plant, as well as a discussion on the development of alternative energy sources to replace the lost energy from the Project.

3.1 Eklutna Dam

3.1.1 General Description

Figure 3.1-1. Eklutna Dam Looking Upstream.

Eklutna Dam is a zoned earth and rockfill structure with a crest length of 815 ft, a crest elevation of 891.0 ft, and a maximum height above the streambed of 41 ft. The embankment volume is approximately 85,000 cubic yards (CY) of material consisting primarily of clay, silt, sand, and gravel with a rockfill embankment cover. The upstream and downstream rockfill slopes are 3H:1V and 2H:1V, respectively. An 83-ft-wide berm of rockfill was constructed at El. 856.5 ft on the downstream toe of the dam. The structural height (maximum height above the deepest excavation) is 56 ft. The spillway is located near the middle of the dam and consists of a riprap-lined approach channel, concrete inlet structure, ungated ogee-type weir, rectangular concrete conduit through the embankment, concrete-lined chute, concrete stilling basin, and riprap-lined outlet channel. The concrete volume is approximately 3,000 CY.

3.1.2 Work Plan

To facilitate dam removal, construction access improvements would need to be performed at select roads leading to the dam site. The unnamed access road leading to the right abutment of the dam would need to be widened, graded, and re-surfaced to allow for heavy equipment access. Construction access roads utilized during the original construction of the dam would need to be cleared of vegetation, re-graded, and re-surfaced to allow for the loading and transport of excavated materials off-site.

The work would take place with the reservoir drawn down below El. 860.0 and would likely occur over one full construction season. For this to occur with the reservoir drawn down, the work would likely take place in early summer when ground conditions allow for heavy machinery transport and site access. All embankment material, riprap, and concrete would be removed and the Eklutna River channel would be restored to its natural state. The remnants of the previous storage dam upstream of Eklutna Dam are anticipated to be left as-is. For the purposes of the cost estimate and based on discussions with Eklutna, Inc., all material is anticipated to be disposed of in the quarry located between the railroad bridge and New Glenn Highway, approximately 10 miles from the Project site.

3.2 Eklutna Powerplant

3.2.1 General Description

Figure 3.2-1. Eklutna Powerplant as Viewed from Old Glenn Highway.

The Eklutna Power Plant is a reinforced concrete structure located adjacent to the Old Glenn Highway 34 miles northeast of Anchorage. The structure is 149 ft long with a height of approximately 51 ft and houses two vertical shaft hydroelectric turbine-generators. The power plant is divided into three main structures: the powerhouse containing the generating units and accessories, the machine shop located at the northwest corner of the powerhouse, and the transformer structure located at the southwest corner of the powerhouse. The switchyard of the power plant is located on the powerhouse roof.

3.2.2 Work Plan

Under the dam removal scenario, the Eklutna Power Plant would need to curtail operations between November and June in an average year to prevent cutting off flow to the Eklutna River. During the remaining five months when inflows to the lake are sufficient to allow the hydroelectric system to operate, the power plant would need to operate at a reduced capacity in a baseload, run-of-river configuration, subject to instream flow and ramping rate considerations. Preliminary discussions with the Project Owners indicate that the maintenance costs of having the power plant sit idle for seven months each year in addition to the significant reduction in operational flexibility and energy generation in the summer months would lead the Project to be uneconomical to continue to operate. For the purposes of this technical risk assessment, the assumption is that the power plant would be decommissioned, but not removed, under the dam removal scenario.

To decommission the power plant, the fixed wheel gate within the power tunnel surge tank shaft would be closed and the penstock and draft tube would be dewatered and drained. All powerhouse mechanical and electrical equipment and hazardous material would be removed and disposed of. Embedded oil lines and septic systems would be flushed, and all surface mounted and exposed lines would be removed. Downstream of the surge shaft, a concrete plug would be anchored into the bedrock at the penstock transition to seal the power plant from the lake.

The power plant decommissioning work plan assumes that the power plant would remain abandoned in place and gated to prevent vandalism, intrusion, and ensure public safety. The Project Owners and/or insurers may require demolition of the facility to reduce risk to the public under all future conditions, which has not been considered as part of the cost estimation in Section 5.0. Should this alternative be explored further, it's imperative to conduct a comprehensive assessment, which would involve evaluating the feasibility of reutilizing the existing switchyard and thoroughly analyzing the liabilities connected with leaving the power plant site abandoned, in order to identify the most prudent approach.

3.3 Renewable Energy Supply

3.3.1 General Description

The Eklutna Power Plant has a nameplate capacity of 44.4 MW and generates an average of 169 GWh of energy each year for the Alaskan Railbelt electrical grid. Under the dam removal scenario, the facility would cease operation. The loss of this power generation resource would reduce the size of the renewable energy portfolio for both Chugach and MEA. Additionally, the loss of this resource would violate MEA's capacity reserve margin requirement. This reserve is a North American Electric Reliability Council (NERC) guideline that has been adopted by the Intertie Management Committee (IMC) and is intended to allow each utility to meet demand during an unplanned loss of generation in the system.

With the loss of the Eklutna Power Plant as a generating resource, the power would need to be replaced with another equivalent resource. While the possibility exists to add or expand to the existing fossil fuel generation fleet in the Railbelt, this would not be beneficial to or achieve the goals of future state policies being considered such as a renewable portfolio standard (RPS)[8] or existing utility board goals. This fact is recognized by NVE in their proposed alternative, requiring the development of renewable generation projects to offset the lost energy from the Eklutna Power Plant. Some renewable generation projects such as those which utilize wind or solar as the renewable resource are not considered equivalent to a hydroelectric project as they are not firm, dispatchable sources of energy.

The benefit the Eklutna Power Plant provides to the grid as a hydroelectric project coupled with a reservoir with seasonal storage capacity makes it a unique generating resource. With the power plant online, the utilities have a firm spinning reserve that has the ability to load follow and regulate other renewables in the Railbelt. Additionally, the Railbelt has relatively low system inertia, making it susceptible to swings in voltage and frequency as load comes online or generation is lost. The Eklutna Power Plant provides a significant source of grid inertia to stabilize the grid. To replace this resource, another renewable source of generation that can provide spinning reserves to the grid is necessary, such as another hydroelectric project with a reservoir capable of seasonal storage. The site selection and conceptual design of an equivalent hydroelectric project is well beyond the scope of this technical risk assessment; however, high level estimates may be made as part of this analysis to estimate costs for a project of similar capacity.

[8] The Office of Governor Dunleavy. HB 301: Renewable Portfolio Standard FAQ https://gov.alaska.gov/wp-content/uploads/RPS-FAQ.pdf

4.0 Risk Assessment and Mitigation Strategies

This section assesses the technical risks to infrastructure located below the dam following the establishment of unregulated flows into the Eklutna River as well as other impacts to related infrastructure that are dependent on the current reservoir and power plant operations. Following the identification of risks, this section surveys potential mitigation alternatives for those risks if mitigation is necessary.

4.1 AWWU Water Supply Infrastructure

4.1.1 General

In 1988 the Anchorage Water and Wastewater Utility (AWWU) constructed the Eklutna Water Project, which diverts water from the existing tunnel connecting Eklutna Lake with the Eklutna Power Plant. Water flows by gravity through a separate diversion tunnel intersecting the power tunnel downstream of the intake and routes water into a buried pipeline running down the Eklutna River valley to a water treatment plant located on a bench above the river. Following treatment, the water flows by gravity through a 23-mile-long buried pipeline to supply 90% of the municipal water supply to the Anchorage service area.

4.1.2 Risk Assessment

To assess the risks associated with AWWU infrastructure following dam removal, an assessment was performed on the water supply pipeline within the Eklutna river channel, the maintenance and access road along the pipeline, the AWWU maintenance bridges crossing the river, and on the sufficiency of inflows to the reservoir to supply a year-round municipal water supply source for the utility. These were some of the primary concerns documented by AWWU in a February 2024 letter in response to the dam removal alternative[9]. The following subsections document this analysis.

4.1.2.1 Scour Analysis

A 2-dimensional (2-D) HEC-RAS model was developed for the Eklutna River from the Eklutna Dam to the mouth of the river at the Knik Arm of the Cook Inlet. The model was set up to investigate sediment mobilization at locations where the AWWU pipeline would be inundated by hypothetical future river flows. Understanding sediment mobilization will determine if the riverbed has the potential to scour the area of the pipeline. A flow rate of 6,590 cfs was

[9] Corsentino, Mark. "Re: Assessment of Dam Removal". February 1, 2024. Anchorage Water & Wastewater Utility General Managers Office.

utilized as the hydraulic design basis, corresponding to the 1% AEP flood as described in Section 2.0.

The critical diameter (largest diameter of the substrate that can be moved under given flow conditions) was computed for each cell in the 2-D model output using the method described in Appendix B of Engineering Manual 1110-2-1418[10]. This method is based upon the Manning's equation and assumes a Shields number of 0.045, and roughness height (k) equal to 3 times the median grain size (D_{50}). For this analysis, the Shields number was adjusted to 0.03 based on a study of bed-load transport in similar gravel bed streams, as utilized in the Geomorphology and Sediment Transport Study published in 2022[11]. The critical diameter as a function of velocity and water depth was computed in accordance with the following equation:

$$D_{crit} = 0.686\frac{V^3}{\sqrt{d}}$$

Where:

D_{crit} = Critical Diameter (mm)
V = Velocity (ft/s)
d = Depth (ft)

To predict sediment mobilization throughout the streambed, a D_{50} of 18-mm was estimated based on the average gradation from a representative transect (Transect C) as collected in October 2021. A map of the scour potential of the riverbed was developed, color coded based only on sizes greater than or equal to a D_{50} of 18-mm (0.71 inches). A graphical representation of the grain size mobility within the riverbed under the 1% AEP flood is presented in Figure 4.1-1 and Figure 4.1-2.

[10] United States Army Corp of Engineers. Channel Stability Assessment for Flood Control Projects. EM 1110-2-1418.
[11] Chugach Electric Association, Matanuska Electric Association, Municipality of Anchorage. Eklutna Hydroelectric Project Geomorphology and Sediment Transport Year 2 Report. (June 2022). https://eklutnahydro.com/wp-content/uploads/2023/06/Eklutna-Geomorphology-Report_FINAL.pdf

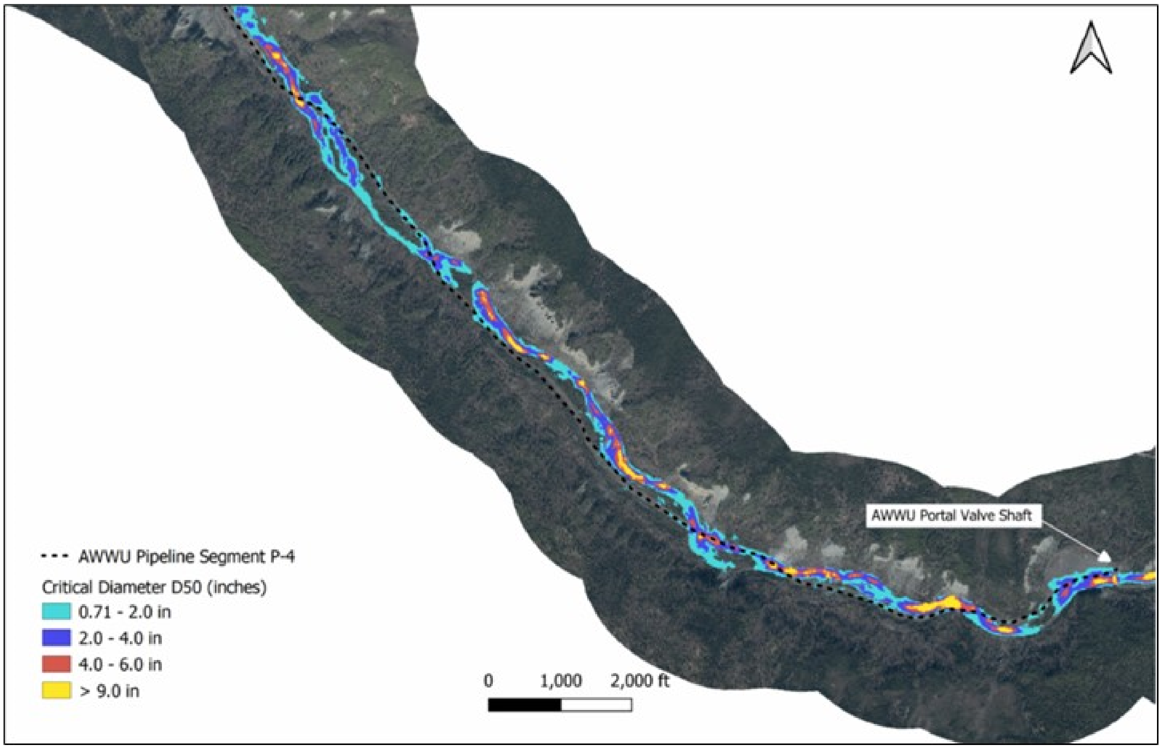

Figure 4.1-1. Grain Size Mobility along Upper Pipeline; 1% AEP Flood.

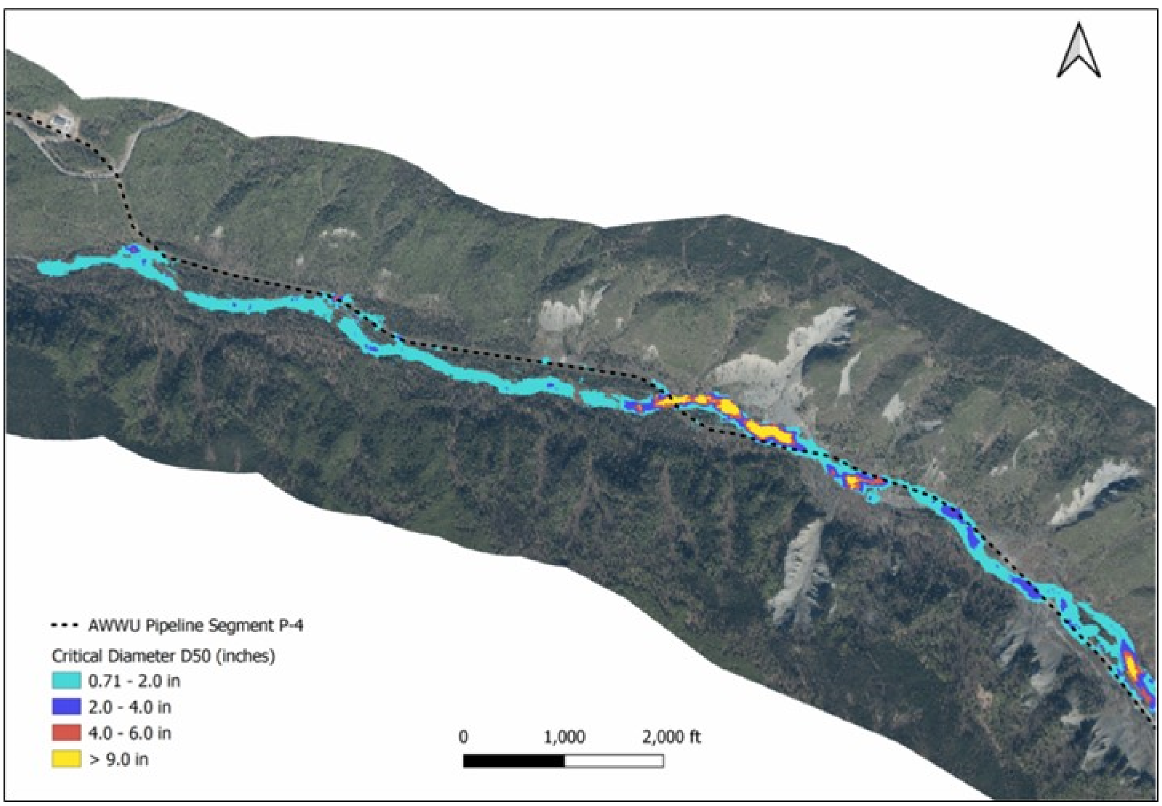

Figure 4.1-2. Sediment Grain Size Mobility along Lower Pipeline; 1% AEP Flood.

Approximately 4.2 miles of the 6.1-mile-long pipeline are inundated by the 1% AEP flood, representing approximately 70% of the total length. Approximately 2.1 miles of the pipeline experiences transport of grains larger than the median grain size of the pipeline zone material. The maximum grain size expected to be mobilized above the pipeline alignment exceeds a diameter of 1-foot, indicating scour of the pipeline cover even in locations which were armored to protect the pipeline. The depths and velocities at each computational cell along the pipeline alignment were utilized to calculate the expected grain size that is mobilized along the length of the alignment, as presented in Figure 4.1-3.

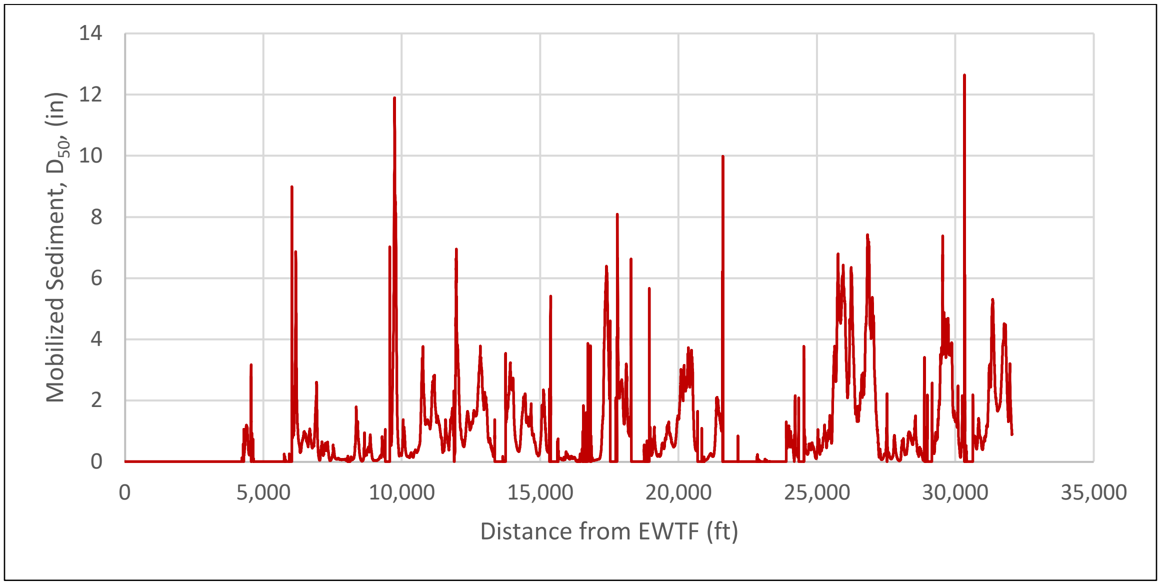

Figure 4.1-3. Mobilized Sediment along Pipeline Alignment – Sediment Size; 1% AEP Flood.

The sediment mobility analysis performed considers a fixed boundary condition within the model and has inherent uncertainties in the sediment transport capability, deposition potential, and does not consider the lateral migration of the channel under these hypothetical future flows. Channel migration cannot be directly modeled using HEC-RAS or other widely accepted models due to the stochastic nature of channel migration (accumulations of large woody debris can play a role in channel migration) and limitations of models to accurately calculate erosion of cohesive materials (e.g., riverbanks with tree and riparian vegetation roots). Within dynamic river systems such as the Eklutna River however, lateral channel migration is likely to occur. Figure 4.1-4 and Figure 4.1-5 show a plan and profile view of two example segments of the Eklutna River that have the potential to migrate laterally and expose the existing pipeline.

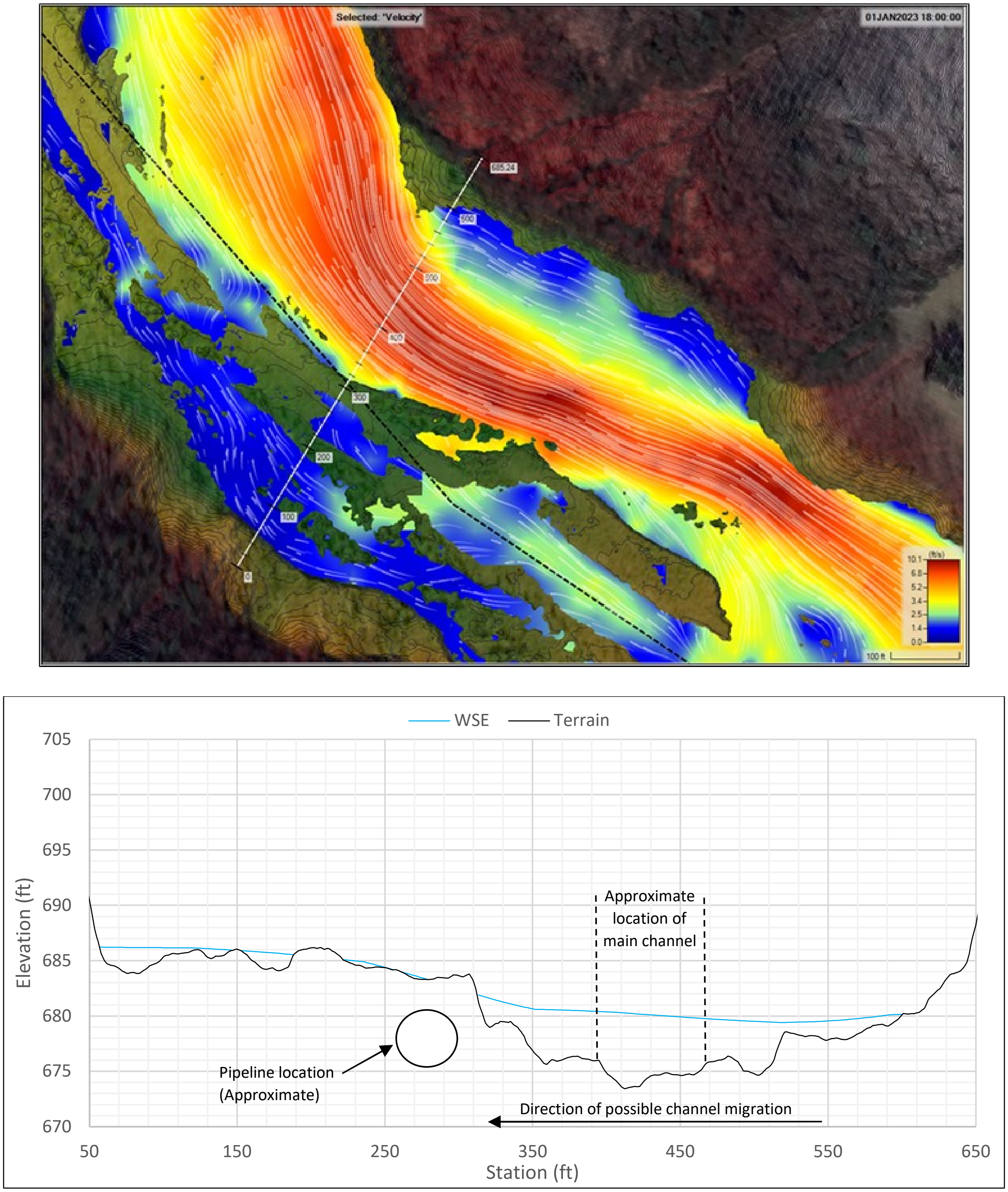

Figure 4.1-4. Plan (top) and Profile View (bottom) of 1% AEP Flood; STA 4252+00.

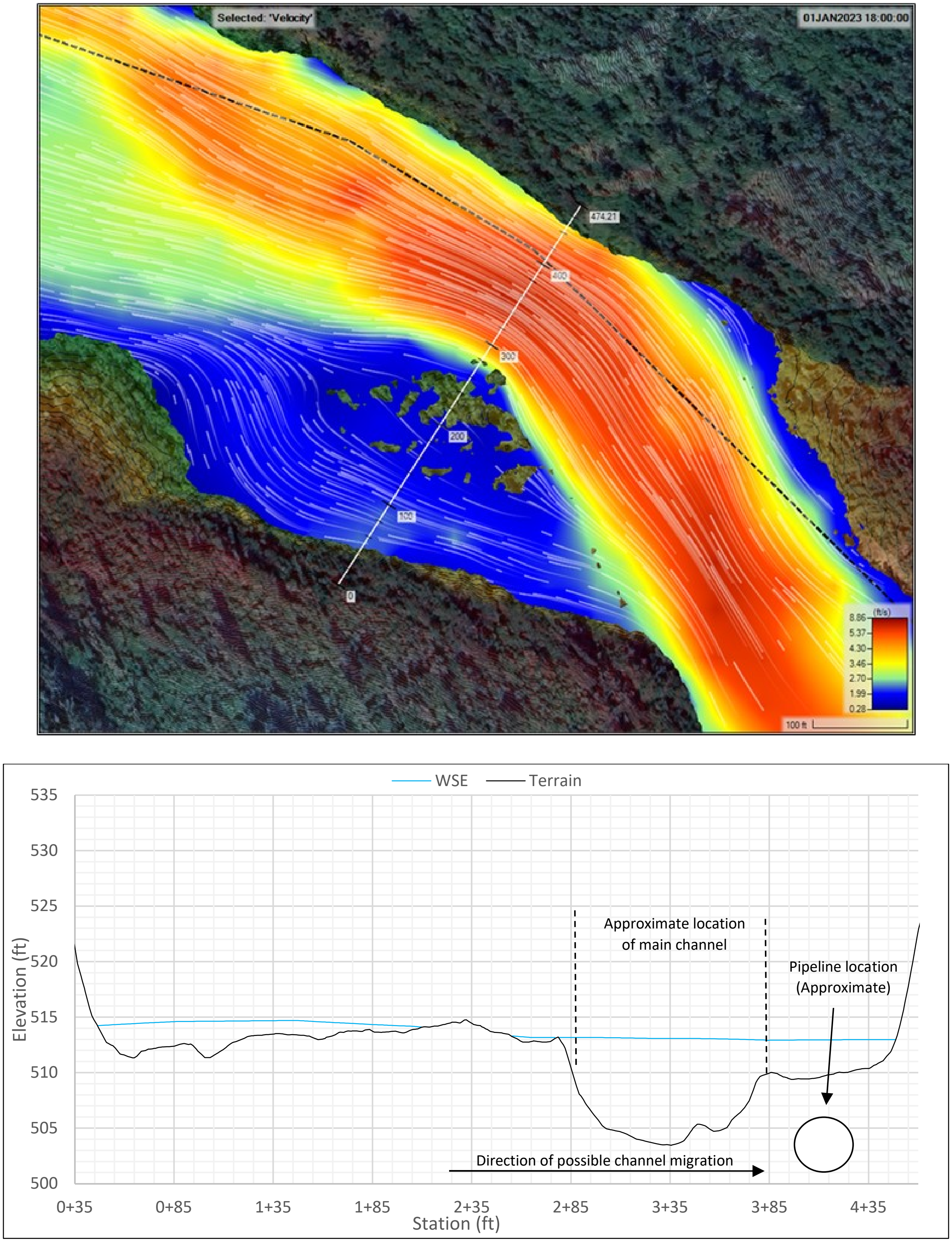

Figure 4.1-5. Plan (top) and Profile View (bottom) of 1% AEP Flood; STA 4136+00.

4.1.2.2 Road Inundation

The AWWU access and maintenance road runs alongside the pipeline adjacent to the Eklutna River for a length of approximately 6.5 miles. The road provides critical access to the pipeline for repairs and maintenance and must be accessible year-round for AWWU. The 1-D HEC-RAS model was run with a flow of 1,200 cfs representing the annual return interval flood within the Eklutna River. Due to the proximity and relatively low elevation of the access road, inundation occurs during the annual flooding conditions, as represented in Figure 4.1-6.

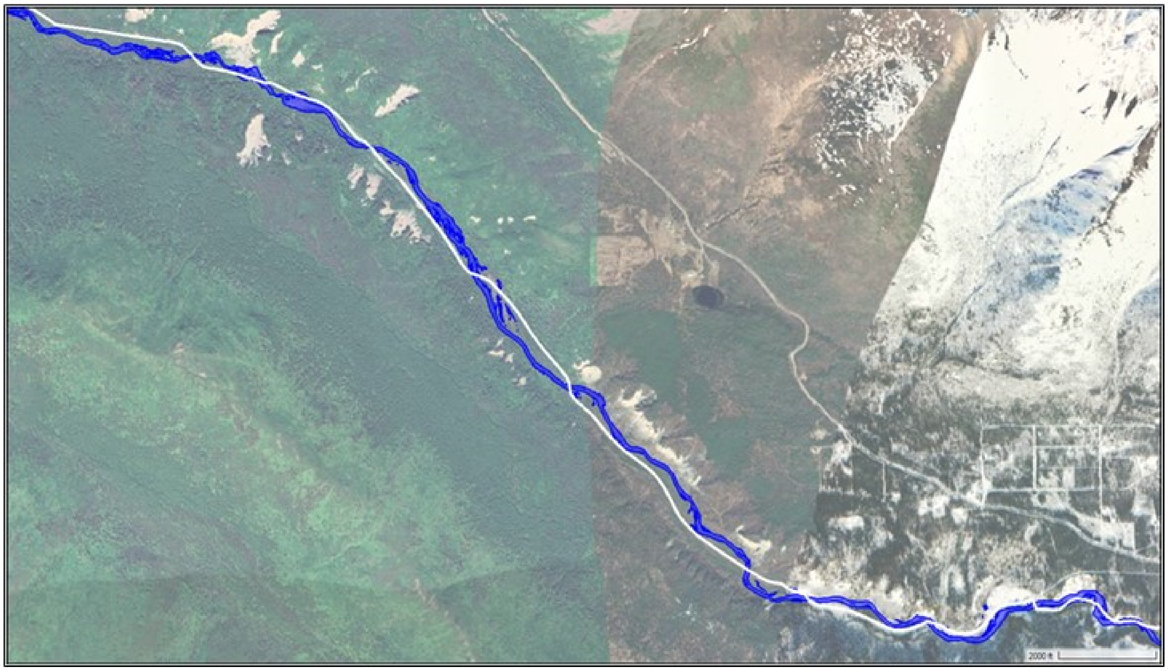

Figure 4.1-6. Access Road (white) and 1-Yr Flood Inundation Boundary (blue).

During the 1-Yr return interval flood, approximately 3,200 ft of the access road is inundated, representing approximately 10% of the road length. The total length of inundation is significantly increased under the larger return interval flooding events. In addition to losing the ability to utilize the access road due to the inundation extents, the road may be damaged by erosion or scour, preventing access by operators, or requiring repairs during the lower flow season. If the access road is to be utilized during future operations of the AWWU water supply infrastructure, mitigation measures would be necessary to allow year-round access to the pipeline.

4.1.2.3 Bridge Inundation

At the farthest upstream extents of the AWWU access and maintenance road exist two bridges spanning the Eklutna River. AWWU Bridge No.1 is the most upstream bridge located at river mile (RM) 11.4, while AWWU Bridge No. 2 is located just downstream of the first bridge at RM 11.1. The bridge superstructures consist of timber decking supported by steel girders. The abutments and wingwalls consist of steel sheet piling keyed into each bank. Each bridge spans a length of 30 ft and has a height above the streambed of 5'-6" to 6'-0". A photograph of Bridge No. 1 is presented in Figure 4.1-7.

Figure 4.1-7. AWWU Bridge No. 1; Looking Upstream.

The design hydraulic capacity of each bridge is unknown. To estimate impacts to the bridge under the future hydrologic conditions of the river, the 1-D HEC-RAS model was utilized to consider the 1-Yr through 10-Yr return interval storm events. At a minimum the required freeboard to the low chord of the bridge shall be one foot to account for debris flow during the design flood. The profile of AWWU Bridge No. 1 as well as the maximum WSELs and freeboard are presented in Figure 4.1-8 and Table 4.1-1.

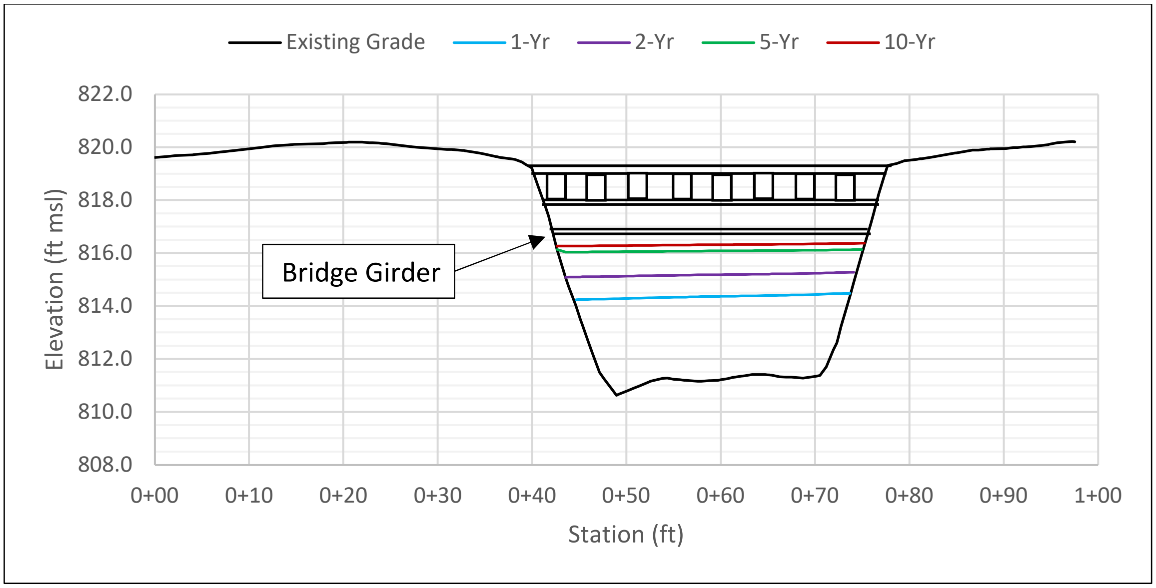

Figure 4.1-8. AWWU Bridge No.1 Profile; 1-Yr to 10-Yr Flood.

Table 4.1-1. AWWU Bridge No. 1; Flood Elevations.

AEP Flood (%)	Recurrence Interval	Flow Rate (cfs)	WSEL (ft msl)	Freeboard (ft)
100%	1-Yr	1,200	814.4	2.3
50%	2-Yr	2,360	815.2	1.5
20%	5-Yr	3,400	816.1	0.6
10%	10-Yr	4,150	816.3	0.4

The analysis indicates that AWWU Bridge No.1 likely has adequate freeboard under the 1-Yr and 2-Yr recurrence interval floods. The 5-Yr recurrence interval flood has less than 1 ft of freeboard which places the bridge at risk of damage due to debris loading or other unaccounted factors such as superelevation, hydraulic jumps, or other flow irregularities. It should be noted that this analysis does not account for potential scour of the banks or abutments and is focused primarily on hydraulic capacity. The same analysis was performed on the downstream AWWU Bridge No. 2. The profile of this bridge as well as the maximum WSELs and freeboard are presented in Figure 4.1-9 and Table 4.1-2.

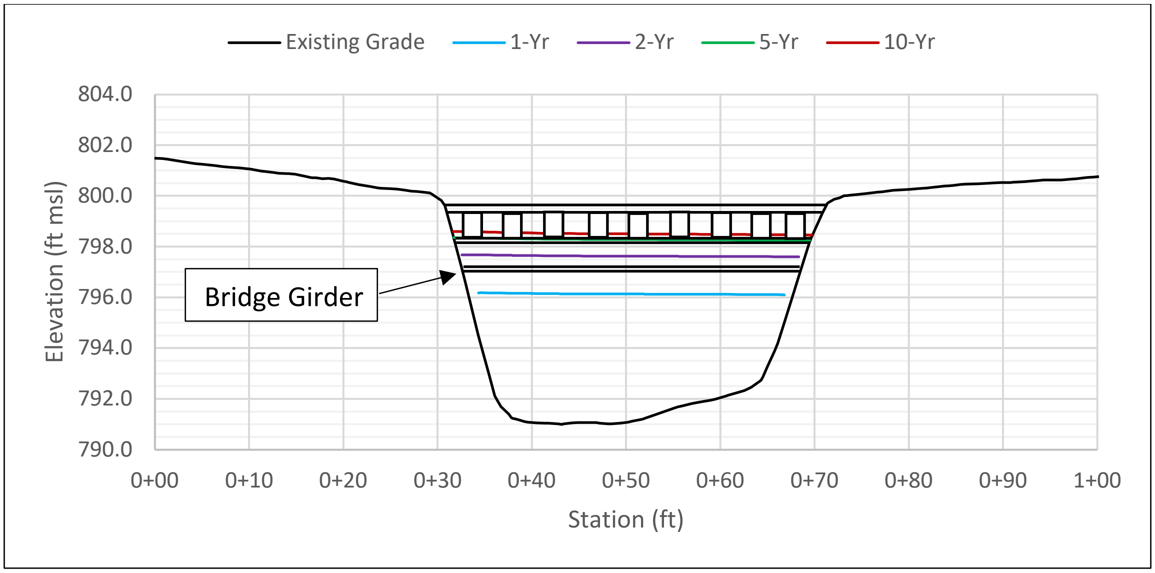

Figure 4.1-9. AWWU Bridge No.2 Profile; 1-Yr to 10-Yr Flood.

Table 4.1-2. AWWU Bridge No. 2; Flood Elevations.

AEP Flood (%)	Recurrence Interval	Flow Rate (cfs)	WSEL (ft msl)	Freeboard (ft)
100%	1-Yr	1,200	796.1	0.9
50%	2-Yr	2,360	797.6	-0.6
20%	5-Yr	3,400	798.3	-1.3
10%	10-Yr	4,150	798.5	-1.5

The analysis indicates that AWWU Bridge No.2 has inadequate freeboard under the 1-Yr recurrence interval flood and would likely be overtopped at flows equal to or exceeding the 2-Yr flood of 2,360 cfs. The bridge is at risk of damage and is inadequate to pass flows under the proposed unregulated Eklutna River hydrograph.

4.1.2.4 Water Curtailment

The EWTF treats all water from Eklutna Lake prior to being discharged through AWWU's water distribution network. The facility at its current capacity is sized to treat a maximum of 32 Million Gallons per Day (MGD), corresponding to an average daily flow of 49.5 cfs; however, AWWU's water permit allows water withdrawals up to a maximum of 41 MGD (63.4 cfs) for public water supply purposes[12]. The flow rate through the facility typically varies from 19-26

[12] State of Alaska Department of Natural Resources Division of Land and Water Management. Permit to Appropriate Water, LAS 2569. (December 16, 1985) https://eklutnahydro.com/wp-content/uploads/2020/03/ADNR-1985-Permit-to-Appropriate-Water-LAS-2569.pdf

MGD (30-40 cfs). The average monthly flow through the EWTF from 2011-2021 is presented in Figure 4.1-10.

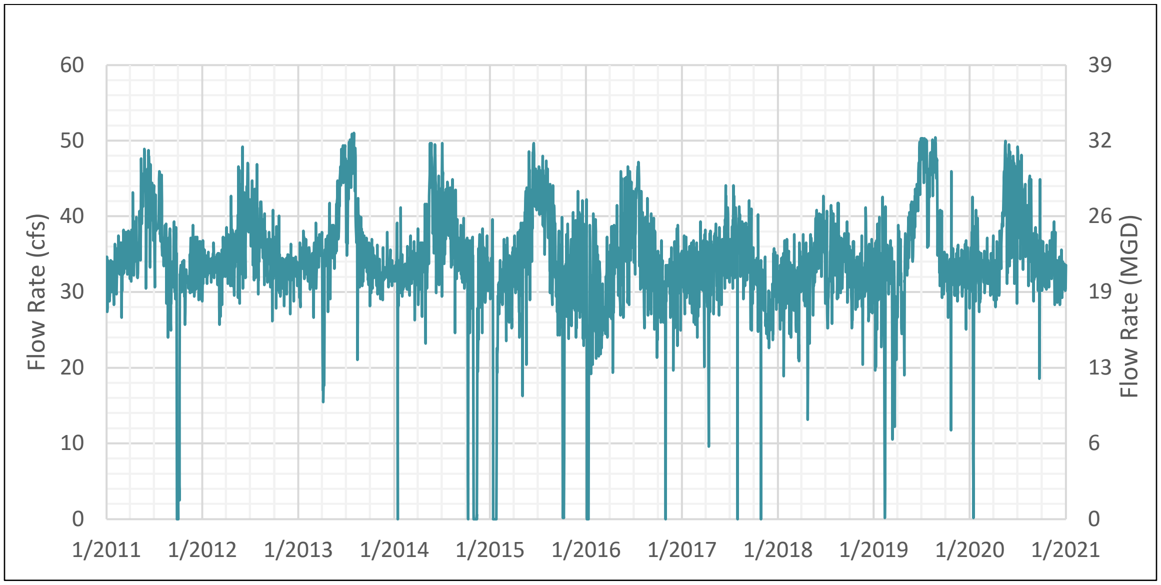

Figure 4.1-10. EWTF Flow Rate; 2011-2021.

The dam removal operations model was updated to calculate reservoir fluctuation and instream flows over the 2011 – 2021 period of record without the powerhouse operational but with AWWU water diversions included. The analysis indicates that over the 10-year period of operation which was analyzed, the withdrawals for water supply would cause the Eklutna River to run dry on three separate occasions. The Eklutna River flow rate following historical water supply withdrawals from Eklutna Lake is presented in Figure 4.1-11.

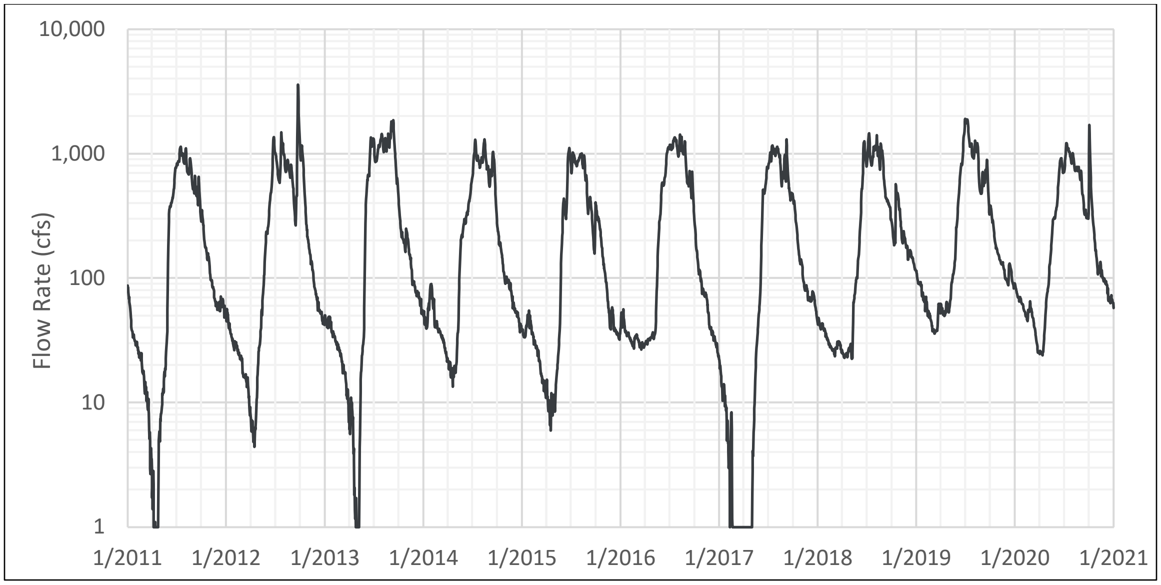

Figure 4.1-11. Eklutna River Flow Rate w/ EWTF Historical Withdrawals; 2011-2021.

The results from the operations model indicate that AWWU water withdrawals from Eklutna Lake would cause the reservoir to be drawn below the crest of the existing lake outlet and the river would run dry during a 17-day span in 2011, an 11-day span in 2013, and a 73-day span in 2017. The results of this analysis suggest that while the water supply project without Eklutna Dam is feasible, it may require curtailing the water supply during certain years to maintain an instream flow or risk dewatering of the river.

A secondary model run was performed to assess instream flows over the 2011 – 2021 period of record with the maximum EWTF water diversion included, corresponding to their water right of 41 MGD. The analysis indicates that over the 10-year period of operation, the withdrawals for water supply would cause the Eklutna River to run dry in the majority of years, with the exception of unusually warm or wet winters. The Eklutna River flow rate following the maximum water supply withdrawal from Eklutna Lake is presented in Figure 4.1-12.

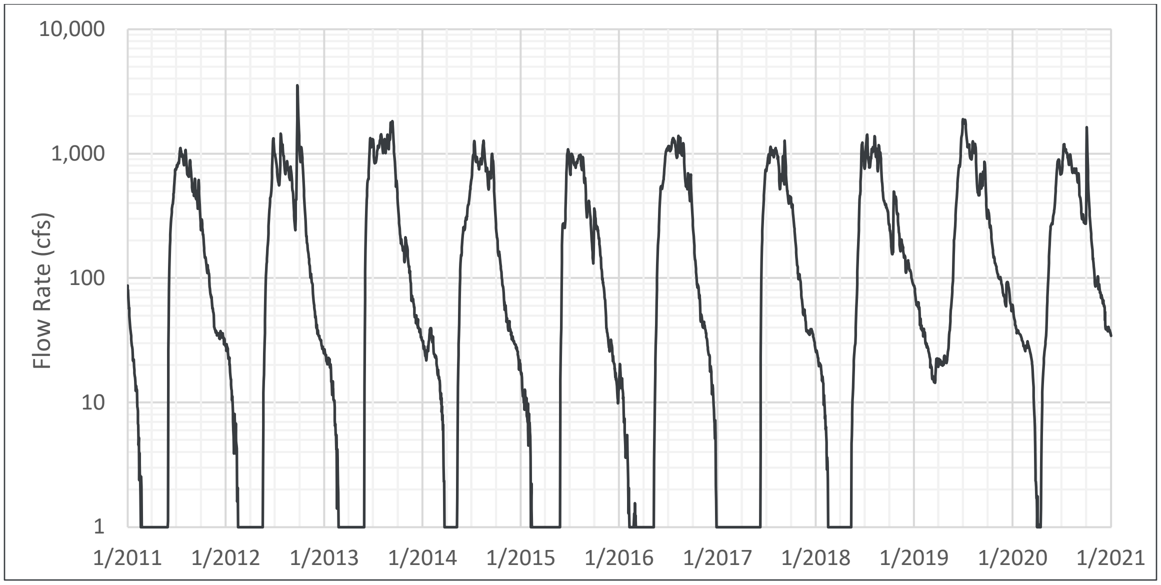

Figure 4.1-12. Eklutna River Flow Rate w/ EWTF Max Withdrawals; 2011-2021.

The operations model indicates that the maximum AWWU withdrawals from Eklutna Lake would cause the reservoir to be drawn below the crest of the existing lake outlet and the river would run dry for two to three months each winter with the exception of the 2019 water year. The results of this analysis suggest that dam removal would prevent the Eklutna Water Project from being able to withdraw their maximum water right (up to 41 MGD) year-round in this hypothetical future operating regime.

4.1.2.5 Risk Assessment

The analysis of the AWWU water supply infrastructure in a dam removal scenario indicates that the buried pipeline Segment P-4 has an increased scour potential under future flow scenarios which may lead to exposure and instability of the pipeline. Depending on the depth and nature of the scour or the extent of channel migration, the exposed pipeline would lose bedding material leading to sagging or potential rupture. Additionally, debris impact may cause failure of the pipeline wall, leading to further damage or potential loss of the water supply. This results in an unacceptable risk to a critical resource and necessitates some form of mitigation to protect the municipal water supply in a post-dam removal scenario, as outlined in Section 4.1.3.

The access and maintenance road along the river channel is inundated under annual peak flows within this scenario, making the pipeline inaccessible under all future flooding events and both bridges exceed their hydraulic capacity and may experience damage and/or failure. This likely would inhibit AWWU from inspecting or repairing the pipeline when water levels are high, which may result in a loss of operation for extended durations. Should the access and maintenance road be utilized for future maintenance of the pipeline, mitigation measures are needed to maintain year-round access.

The operations model performed on the reservoir under the proposed dam removal scenario indicates that there may not be sufficient inflows to the reservoir for AWWU to provide their historical water withdrawals year-round with the dam removed. The analysis further shows that the reservoir is unable to provide the maximum water right granted to AWWU (41 MGD) year-round without the reservoir impoundment in place. This may result in either the river running dry for extended periods of time, or AWWU needing to curtail withdrawals and supply water from other sources during portions of the year.

4.1.3 Mitigation Strategies

Various strategies exist to mitigate the risks associated with dam removal to the current AWWU infrastructure. The strategies considered as part of this evaluation are as follows:

1. Armor the existing pipeline and reconstruct the AWWU maintenance road and bridges to withstand future flooding events;
2. Construct a new pipeline to withdraw water from Eklutna Lake outside of the extents of the Eklutna River;
3. Construct a new water supply project to collect water from an alternative watershed;
4. Increase the system capacity of other existing water supply projects within AWWU's service area.

The following subsections describe in a high level of detail the possible actions under each of these potential mitigation strategies.

4.1.3.1 Armor the Existing Pipeline

The analysis described in Section 4.1.2.1 details that the pipeline is at risk of exposure due to bed scour or channel migration under future flooding events. The analysis assumes that the pipeline bedding, zone material, and backfill consist of a median material size of 18 mm (0.71 in) as estimated from the Year 2 Geomorphology Study report as well as information obtained from the Pipeline as-built drawings and specifications. A potential mitigation strategy to protect the pipeline from future scouring and erosion as a result of channel migration is to excavate the material around the pipeline and provide a protective armor rock layer along the length of the pipeline located within the Eklutna River valley. The pipeline armament would consist of armor rock, or riprap, with a material gradation roughly equivalent to the requirements presented in Table 4.1-3. It should be noted that the initial results of the sediment mobilization study performed indicate mobilization of grain sizes exceeding 12-inches at key areas along the pipeline. These locations may require further armament or protection than the proposed armor rock gradation described below.

Table 4.1-3. Armor Rock Gradation.

Size (in.)	% Passing by Weight
24	100%
12	10% – 50%
6	0% – 20%

For pipeline access, the existing access road would need to be reconstructed to a height above the 1% AEP flood for the Eklutna River. This would require a significant amount of new material to be brought into the access road as well as slope protection on the embankments to prevent erosion under flooding conditions. In locations where the river is more confined, the access road may be unable to be co-located adjacent to the river and may require additional bridges or culverts. Each of the known access road crossings (10 total) would require a bridge to be constructed meeting the hydraulic design criteria of the 1% AEP flood.

While this mitigation strategy may protect the pipeline from scouring under future flooding conditions and allow access to AWWU personnel under most flow conditions, the pipeline likely would be unable to be maintained, repaired, or replaced under a high flow condition due to its current alignment co-located with the river channel. This risk is unable to be mitigated fully under this strategy without re-aligning the pipeline and is not considered the preferred mitigation strategy as part of this assessment.

4.1.3.2 Construct a New Pipeline

To address the risks associated with pipeline access for maintenance and repair under the evaluated future hydrologic conditions, an alternative mitigation strategy is to construct a new pipeline to withdraw water from Eklutna Lake. During the original alternatives analysis of water supply opportunities for AWWU in 1981, the MOA investigated alternative pipeline alignments to extract water from the Eklutna watershed[13]. This study investigated the following routes for the proposed Eklutna Water Project pipeline:

- Alternative 1: Tailrace and River Diversion
    - This alternative would draw water from the power plant tailrace and from the Eklutna River at a point near the Old Glenn Highway bridge. A diversion

[13] Municipality of Anchorage. Eagle River Water Resource Study Executive Summary. (December 1981).

structure would be placed on the Eklutna River to supply a large percentage of summer demand. During periods where the Eklutna River is insufficient to meet demand, water would be pumped from the Eklutna Power Plant tailrace.

- Alternative 2: Tunnel Diversion
  - In this alternative, water would be taken by tapping the existing pressurized power plant tunnel at the adit near the surge tank, located immediately above the power plant.
- Alternative 3: Eklutna Lake and River Diversion
  - This alternative would take water directly from the Eklutna River by releasing flow from Eklutna Lake. A diversion structure would be located on the river near the Old Glenn Highway providing water to the EWTF.

The alternatives investigated as part of the original planning of the Eklutna Water Project may provide some guidance on potential methods for utilizing Eklutna Lake as the primary water supply alternative for AWWU. Of the alternatives originally investigated, any diversion structure or impoundment located on the Eklutna River would not be considered a viable alternative as part of this assessment due to the desire to maintain a continuous hydraulic connection from Eklutna Lake to the mouth of the river on Knik Arm. The alternative to pump water from the Eklutna Power Plant tailrace has its advantages; however, the tailrace would not be supplied flow under the proposed dam removal scenario where flow to the power plant is terminated. While the specific alternatives proposed in the original alternatives analysis may not be feasible under the dam removal scenario, a combination of these alternatives may have merit.

A solution that may be technically feasible is to tap into the existing penstock and construct a new pipeline running from the Eklutna Power Plant to the EWTF. The proposed route results in a new buried pipeline running a length of approximately 9.6 miles from the existing Eklutna Power Plant to the inlet of the EWTF, as presented in Figure 4.1-13. The alignment considered as part of this investigation runs from the power plant along the path of the Old Glenn Highway to the junction with the New Glenn Highway (AK-1). The pipeline follows the highway for approximately 3.5 miles to the junction of the Eklutna Lake Road offramp. The pipeline then follows Eklutna Lake Road a short distance to the EWTF. Note that this alignment does not consider property rights, environmental considerations, or the co-location of any other utilities along the route and is intended to be a conceptual layout for the hypothetical AWWU pipeline re-alignment.

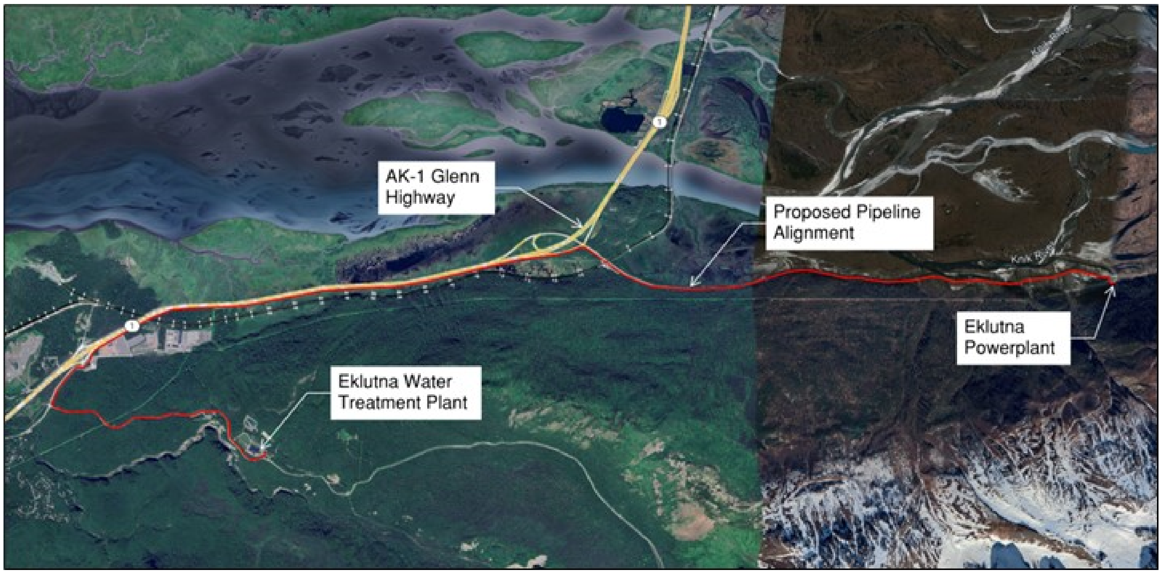

Figure 4.1-13. Conceptual Alignment of Proposed Pipeline Re-Route.

The pipeline would be approximately 54” diameter and rated to withstand the maximum hydraulic pressures expected along the new alignment. The hydraulic gradeline (HGL) of the proposed route was determined by modifying the hydropower operations model developed as part of the study program. The HGL is presented in Figure 4.1-14 and the minimum and maximum steady state pressure on the EWTF under a flow of 41 MGD (63.4 cfs) is presented in Table 4.1-4.

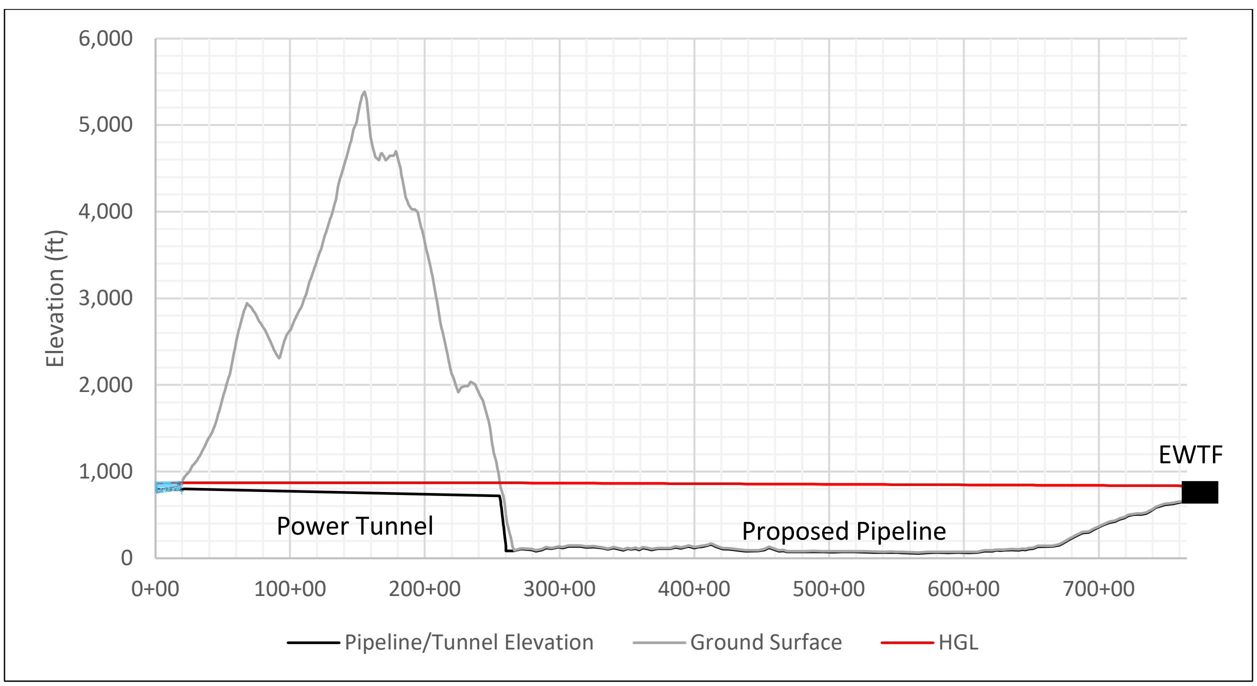

Figure 4.1-14. Hydraulic Gradeline; Proposed Pipeline Alignment at 41 MGD.

Table 4.1-4. Pressure at EWTF; Proposed Pipeline Alignment.

Eklutna Lake WSEL (ft Local Datum)	Flow Rate	EWTF Pressure (PSI)
861.0	0 MGD	92.2
	22 MGD / 34.0 cfs	87.4
	41 MGD / 63.4 cfs	77.1

From a hydraulic perspective, this hypothetical alignment maintains sufficient driving head to convey water from the power plant to the EWTF at the minimum lake level of 861.0 ft. The additional head losses caused by friction due to the increased pipeline length are negligible considering the additional head gained by the lake maintaining a steady elevation of El 861.0 to El 865.0 ft.

The primary risk with this alternative is that curtailment of water withdrawals may be necessary to prevent the river from running dry under the proposed dam removal scenario. Given AWWU's preferential water rights for municipal water supply from this watershed, continuous instream flows, particularly in winter months, may be at risk unless water is sourced from an alternative location. This risk may be avoided if an alternative watershed is selected for future water supply needs.

4.1.3.3 Construct a New Water Supply Project

Evaluating the development of a new watershed for supplying the future water needs for the MOA under a dam removal scenario is a complex process which is beyond the scope and timeline of this risk assessment memorandum. For the purposes of this investigation, we considered the alternative developments proposed as part of the Water Resources Study published in 1981 prior to the development of the Eklutna Water Project. While the study did evaluate alternative pipeline alignments for withdrawing water from the Eklutna watershed as described in the previous subsection, the original intent of the study was to evaluate the potential for utilizing Eagle River as a potential water source. The two alternatives evaluated for utilizing Eagle River as a water source included the development of a well field and groundwater source within the Eagle River valley or the construction of a new reservoir on Eagle River.

As part of the 1981 investigation, eight wells were drilled within the Eagle River watershed in search of an aquifer capable of supplying water to the MOA. This investigation established that the Eagle River Valley consists primarily of silts and clays and does not contain an aquifer capable of meeting water demand for the municipality.

The preferred solution for development of Eagle River as a water supply source was to site a new dam located approximately 1.5 miles east of the New Glenn Highway Bridges over Eagle River. This dam would impound a reservoir capable of meeting a constant diversion of 47 MGD, which would be sufficient for replacing Eklutna Lake as a water supply source. The Eagle River reservoir alternative was eventually not pursued further by the MOA due to serious potential cost, schedule, and operational problems associated with the proposed facility. At this time, pending further analysis of the regional watershed water supply characteristics, the construction of a new water supply project is not weighed heavily as a potential mitigation strategy as part of the current assessment.

4.1.3.4 Increase Capacity of Existing Water Supply Projects

The existing water supply projects serving the MOA are the EWTF, the Ship Creek Water Treatment Facility (SCWTF), and groundwater wells located throughout the municipality. The SCWTF has a treatment capacity of 16 MGD with a water right of 24 MGD but is seasonally limited to 10 MGD of capacity. The groundwater wells vary but are expected to provide a combined total water supply of up to 20.2 MGD[14]; however, 10 MGD of well production is currently inactive while new EPA regulations are being assessed. Investigations have been performed to establish new wells within the MOA to provide added resiliency to the water supply system. These additional well fields would be located east of the SCWTF and are expected to have a capacity of 2 – 4 MGD.

While upgrades to the existing SCWTF and the addition of new well fields may yield additional water for the MOA, the additional gains would not make up for the loss of the EWTF's 32 MGD treatment capacity. Pending further information from the MOA on the ability to increase the output of the SCWTF or the discovery of new aquifers within the region, increasing the capacity of the existing water supply projects does not appear to be a preferred strategy for replacing the Eklutna Water Project as a primary source for water supply.

4.2 Old Glenn Highway Bridge

4.2.1 General

The Old Glenn Highway Bridge was replaced in 2015 and consists of a 254-foot long, two-span concrete bulb-tee girder bridge with three center piers located in the floodplain of the Eklutna River. Due to the topography of the canyon at this location, both bridge abutments are well above the influence of the river, even at extreme flood stages. Photographs of the bridge

[14] Municipality of Anchorage. 2012 Anchorage Water Master Plan. (December 2012).

and pier are provided in Figure 4.2-1 and design details of the bridge pier are provided in Figure 4.2-2.

Figure 4.2-1. Old Glenn Highway Bridge U/S View (Left); Bridge Pier (Right).

The center pier consists of three 4-foot diameter concrete columns with permanent steel casings, located approximately 125 ft from the left abutment. The piers enter the ground surface at El. 87.5 ft and pass through approximately 43 ft of soil before entering bedrock at El 44.0 ft. Each pier is drilled and anchored into approximately 6 ft of bedrock. The design of each pier is presented in Figure 4.2-2.

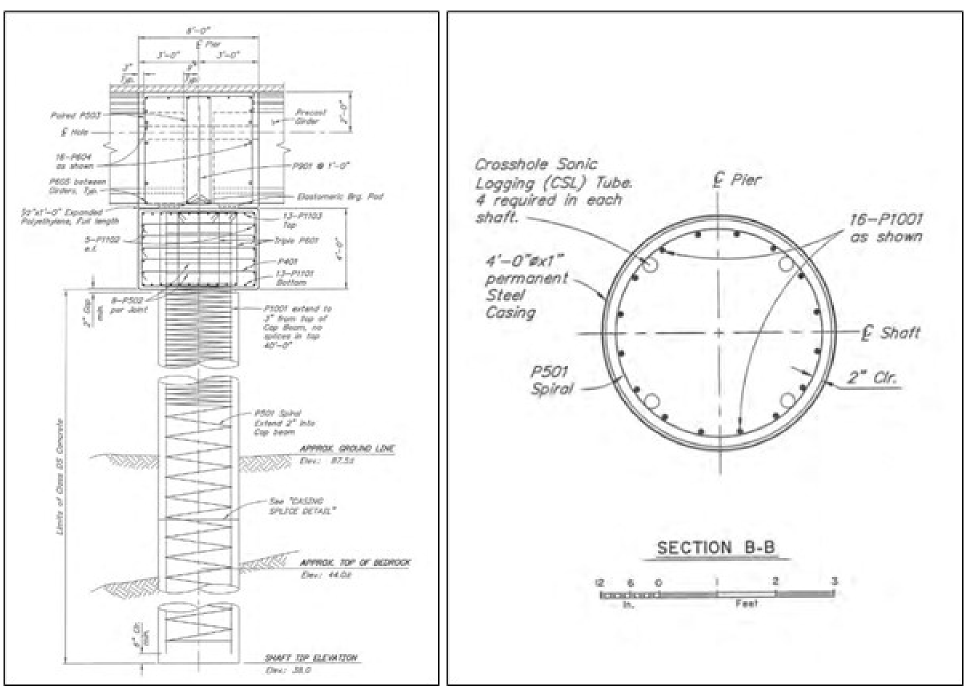

Figure 4.2-2. Old Glenn Highway Bridge Pier Profile (Left); Bridge Pier Section (Right).

4.2.2 Hydraulic Capacity

The existing structure spans a confined stretch of the Eklutna River at a height well above the canyon floor. To determine whether the bridge has sufficient hydraulic capacity under a future dam removal scenario, the 1% AEP flood corresponding to the reach below Thunderbird Creek was analyzed, equating to a total flow of 7,460 cfs as defined in Section 2.0. The low chord of the bridge is located a maximum of 40 ft above the natural river channel and passes the 1% AEP flood with a freeboard of approximately 27 ft. The confined reach of the canyon has a relatively stable cross section both upstream and downstream of the bridge, which reduces the risk of contraction scour on either abutment caused by flooding. However, the center piers located at approximately the midspan of the bridge would experience pier scour during flooding conditions. The flow velocities of the channel beneath the bridge during the 1% AEP flood are presented in Figure 4.2-3 and Figure 4.2-4.

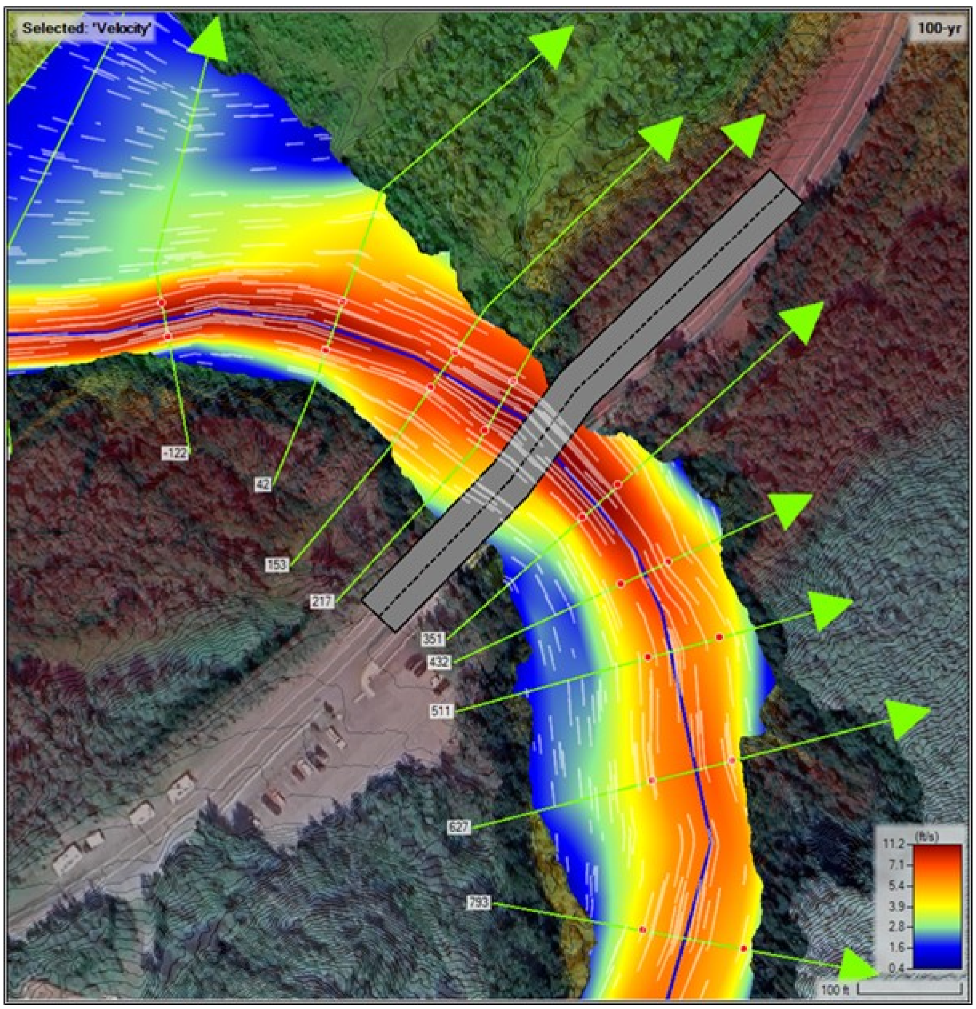

Figure 4.2-3. Maximum Water Velocity Plan View; 1% AEP Flood.

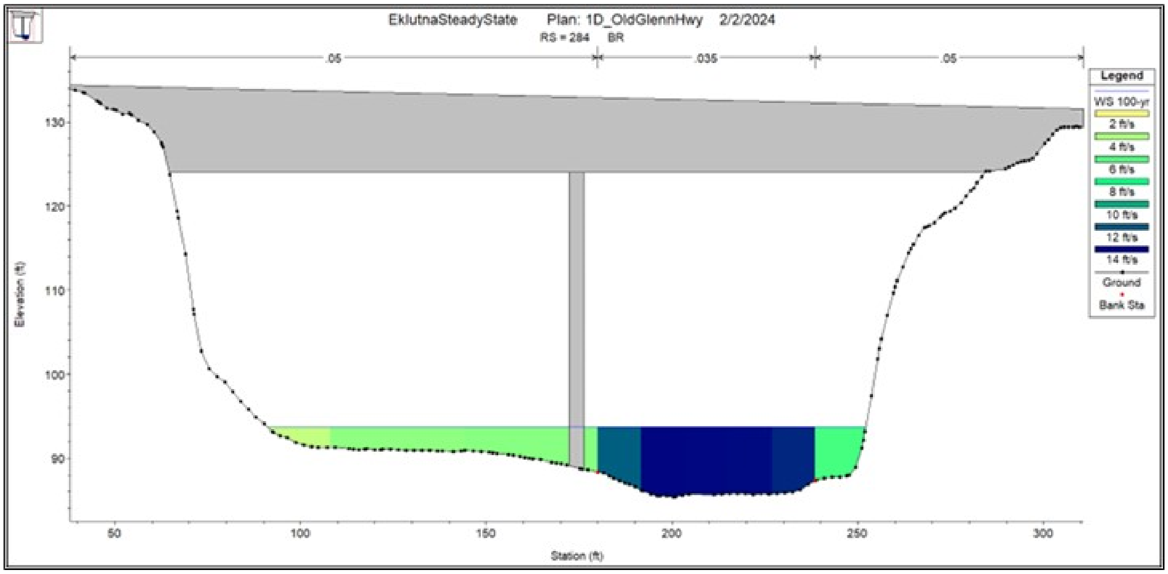

Figure 4.2-4. Water Velocity Upstream Profile; 1% AEP Flood.

4.2.3 Pier Scour

A 1-D HEC-RAS Model was developed to better represent the hydraulics at the Old Glenn Highway Bridge and to gain an understanding of the impacts of the existing bridge pier on flood flows within the Eklutna River channel. The hydraulic characteristics of the 1-D model were calibrated to the characteristics of the 2-D HEC-RAS model previously developed for the Eklutna River channel. The water surface elevations for the 1-D and 2-D modeling approaches are presented in Figure 4.2-5 and indicate general concurrence on the hydraulic profile.

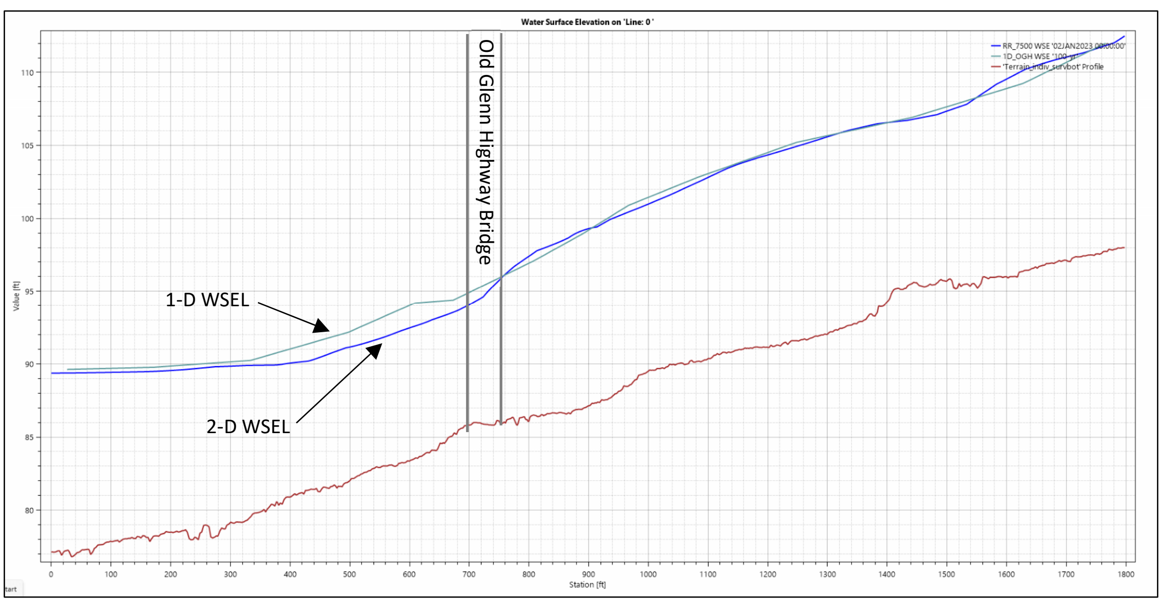

Figure 4.2-5. 1-D and 2-D WSE Profile through Old Glenn Highway Bridge.

The 1% AEP flood flow rate of 7,460 cfs was run through the HEC-RAS model to assess scour at the existing pier. Contraction and pier scour equations for non-cohesive stream bed material were utilized to estimate the depth of scour in accordance with the guidance of HEC-18[15]. The sediment gradation used within the model was based on the information presented in the Year 2 Geomorphology and Sediment Transport Study, which defined a D_{50} of 23-mm from Transect G, located approximately 750 ft downstream of the Old Glenn Highway bridge.

Two sediment transport conditions were calculated to understand the scour risks to the pier located within the Eklutna River floodplain. The live bed scour occurs when the river is actively transporting sediment and both eroding and depositing material simultaneously at a given transect. Clear water scour occurs when there is effectively zero sediment transport upstream of the bridge crossing and the energy of the river is focused on erosion of the bed material. The velocities upstream of the bridge crossing indicate that the sediment transport condition affecting the bridge pier are expected to be the clear water scour condition. Table 4.2-1 summarizes the scour depths calculated from the modeling at the location of the bridge pier.

Table 4.2-1. Scour Depths; Old Glenn Highway Bridge Pier.

Description	Scour Depth (ft)
Clear Water Scour Depth	3.3
Pier Scour Depth	6.1
Total Scour Depth	9.4

4.2.4 Mitigation Strategies

The Old Glenn Highway Bridge has sufficient freeboard to pass the 1% AEP flood without risk of inundation or overtopping of the bridge deck. The existing piers are within the floodplain of the river and appear to be designed against debris impact with 1" steel casing protecting the reinforced concrete columns. The scour analysis presented in the previous section indicates approximately 9-10 ft of total scour at each pier, which does not appear to pose any immediate risks to the structure due to the depth of the drilled pier into soil and bedrock; however, additional confirmation is necessary to conclude that the pier design is sufficient under this proposed new loading condition. At this time, no additional mitigation would be anticipated for the Old Glenn Highway Bridge under the proposed hydrologic conditions of the Eklutna River post-dam removal.

[15] United States Department of Transportation Federal Highway Administration. Evaluating Scour at Bridges, 5th Ed. Hydraulic Engineering Circular No. 18.

4.3 New Glenn Highway Bridges

4.3.1 General

The New Glenn Highway Bridges were constructed in 1975 and consist of a northbound and southbound span of the New Glenn Highway over the Eklutna River. Both spans are prestressed concrete bulb-tee girder bridges and run a length of approximately 100 ft at a maximum height of 18 ft over the streambed. The design highwater elevation for this bridge is El. 82.0 ft. Photographs of the bridge and abutments are provided in Figure 4.3-1.

Figure 4.3-1. New Glenn Highway Bridges D/S View (Left); Right Abutment (Right).

The bridges have a relatively short height when compared to the Old Glenn Highway Bridge with a distance from the low chord of the bridge to the river channel of approximately 16 ft. Beneath the bridges, riprap spans from the river channel to a berm protecting each abutment from erosion, and spans to a height of approximately 14 ft above the riverbed. The elevation view of the bridges looking downstream is provided in Figure 4.3-2.

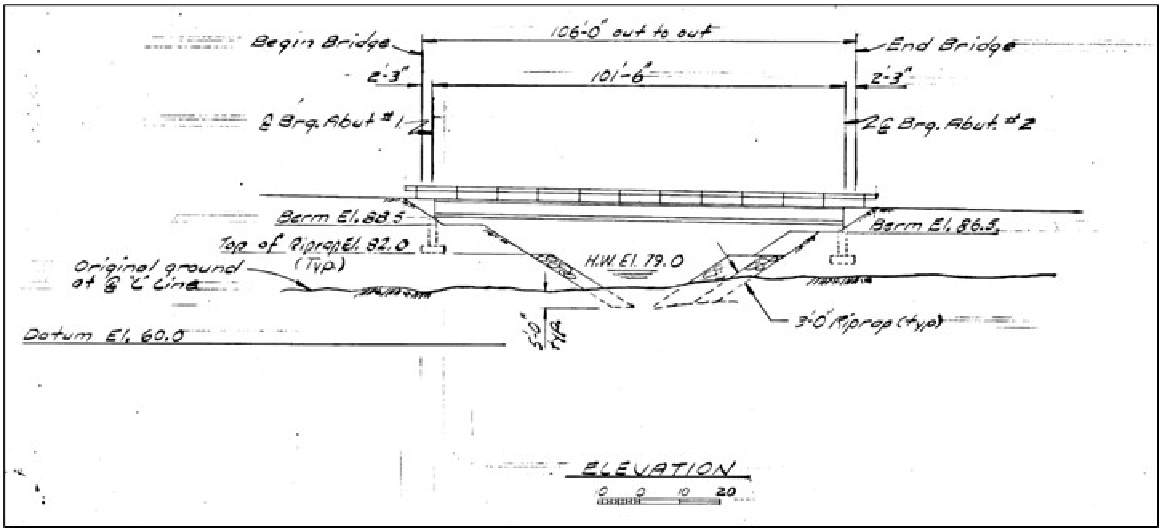

Figure 4.3-2. New Glenn Highway Bridge; Elevation View (MOA 72 Datum).

It shall be noted that a segment of AWWU's 54" diameter water supply pipeline P-3 as well as a 24" diameter segment of pipe which supplies water to the neighborhood around Thunderbird Falls pass beneath the riverbed in the immediate vicinity of the New Glenn Highway bridges. Each pipeline runs at a depth of approximately 10 ft to the crown of the pipe and are armored in reinforced concrete.

4.3.2 Hydraulic Capacity

A 2-D HEC-RAS model was used to represent the existing crossing of the New Glenn Highway Bridges over the Eklutna River. The 1% AEP flood was input into the model to determine impacts to the bridges, corresponding to a flow of 7,460 cfs. Discussions with the State of Alaska Department of Transportation and Public Facilities (DOT&PF) indicate that these bridges would require approximately 2 ft of freeboard plus an additional 1 foot to account for ice and debris, yielding a minimum freeboard requirement at the design flood of 3 ft. The profile of the bridges documenting the maximum water surface elevation of the 1% AEP flood is provided in Figure 4.3-3. The minimum freeboard calculated under this flood scenario is 1.8 ft.

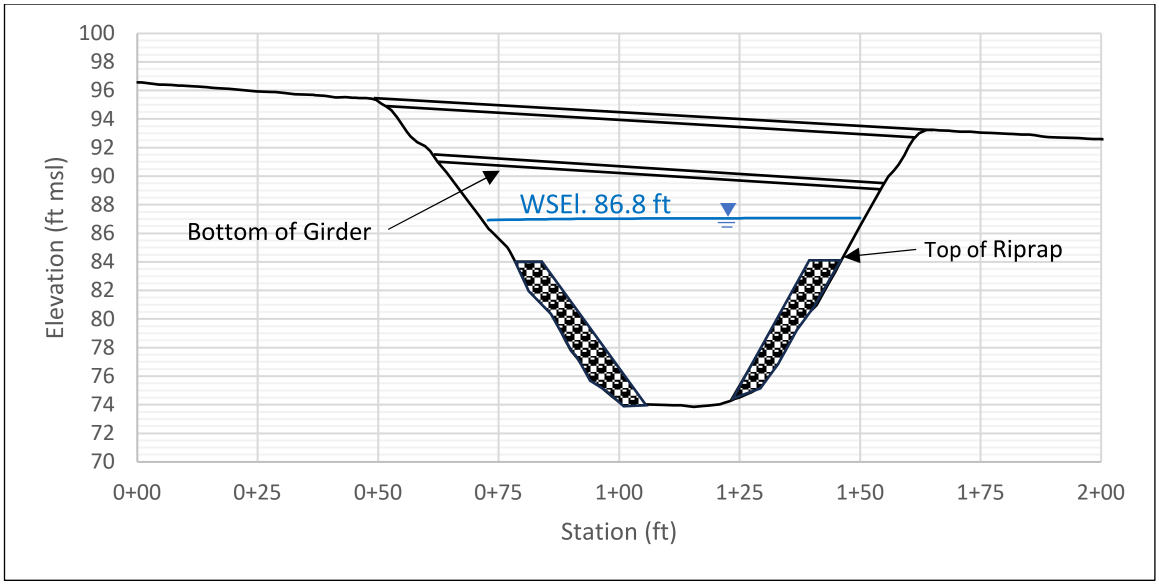

Figure 4.3-3. New Glenn Highway Bridge Profile; 1% AEP Flood (MOA72 Datum).

The reach between the New Glenn Highway and Old Glenn Highway bridges is relatively unconfined, which allows for a backwater effect to form at the location of the New Glenn Highway Bridges. This creates a significant contraction in the flow at the location of the bridges, exacerbating the potential for contraction and abutment scour. Additionally, the design of the current bridges utilizes shallow spread footings located high on either abutment, which is susceptible to damage or failure caused by scour under high flow events.

4.3.3 Mitigation Strategies

Based on the preliminary hydraulic analysis performed, the current New Glenn Highway bridges are not sufficient to pass the flood flows incurred under the proposed dam removal scenario. The bridges would need to be replaced with a bridge of larger span to increase freeboard and lessen the hydraulic contraction currently in place.

An alternative 2-D HEC-RAS model was produced that increased the span of the New Glenn Highway Bridges from 100 ft to 250 ft. This alternative reduced velocities through the bridge span substantially as well as reduced the freeboard under the 1% AEP flow. Although contraction of the channel at the location of the bridges still occurs, the increased span length reduces the upstream backwater effect and provides approximately five additional feet of freeboard. Figure 4.3-4 presents the water velocities through the bridge span and Figure 4.3-5 presents a longitudinal profile of the water surface elevations through the bridge span pre- and post-bridge replacement.

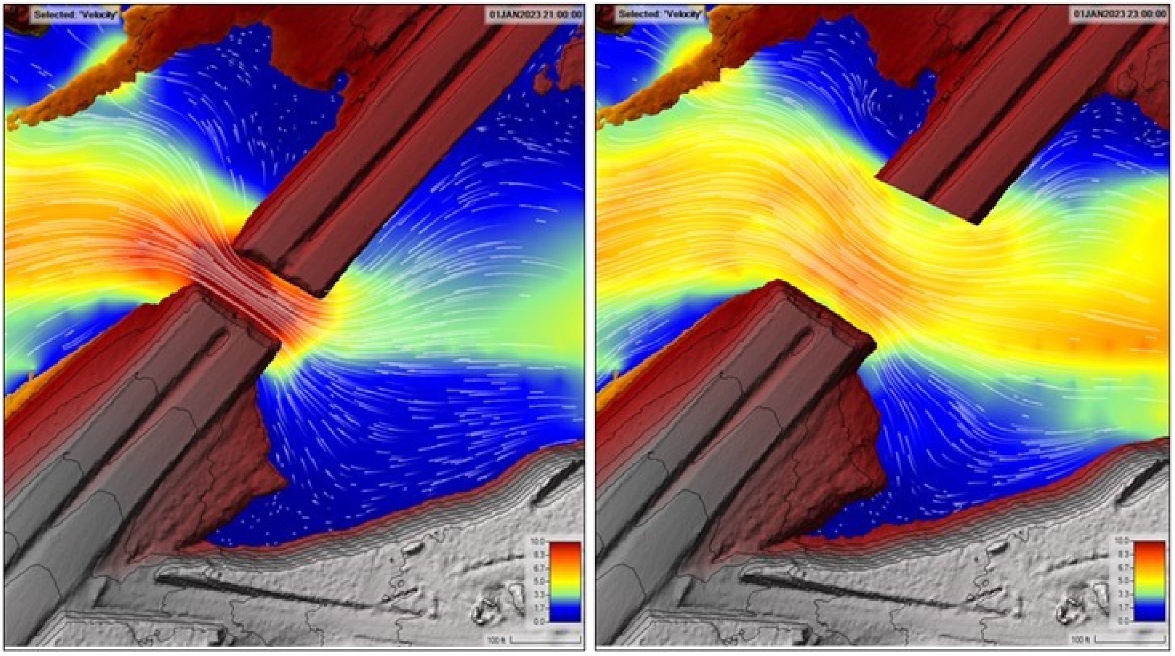

Figure 4.3-4. Plan view of velocities at the New Glenn Highway Bridges pre- and post-Bridge Replacement.

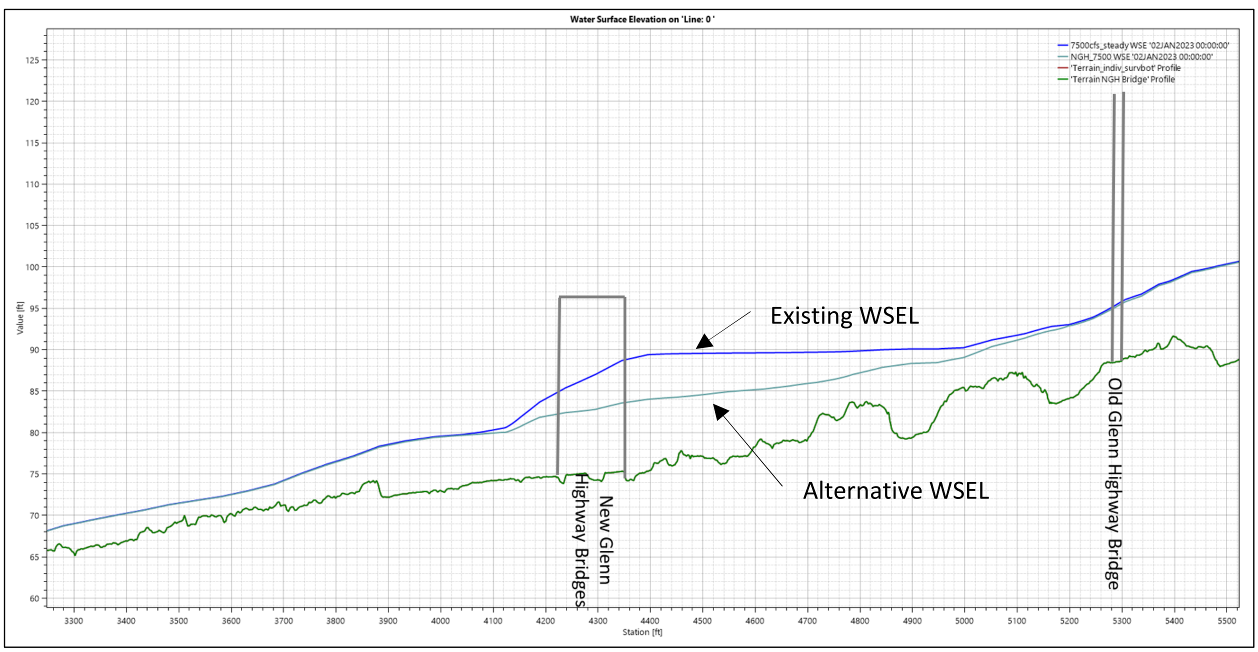

Figure 4.3-5. Existing and alternative WSEL profiles at the New Glenn Highway Bridges.

4.4 Railroad Bridge

4.4.1 General

Figure 4.4-1. Eklutna River Railroad Bridge U/S View (Left); Left Abutment Wall (Right).

The Eklutna River railroad bridge was constructed in 1927, prior to the construction of the original hydropower project on the Eklutna River in 1929. The structure consists of a riveted steel open deck girder bridge, spanning approximately 70 ft at a height of 14 ft above the riverbed. The bridge abutments consist of concrete walls of unknown depth and thickness. Photographs of the railroad bridge are provided in Figure 4.4-1.

4.4.2 Hydraulic Capacity

A 2-D HEC-RAS model was used to represent the existing crossing of the Eklutna River railroad bridge. The 1% AEP flood was input into the model to determine impacts to the bridge, corresponding to a flow of 7,460 cfs. The existing span creates a significant backwater effect upstream of the bridge under flooding conditions. The potential for contraction and abutment scouring at the bridge is high due to the constriction of flow and resultant increase of water velocity through the bridge span. The left abutment is specifically at risk for increased scour depths due to high water velocities encompassing the abutment, increasing the risk of undermining the structure. Velocities through the span reach up to 10.2 ft/s under this flood condition. This correlates to a shear stress of 9.81 lb/ft^2, capable of moving boulders as large as 26-inches.

Discussions with the Alaska Railroad indicate that there is a significant concern regarding the impact this flooding would have on the morphology of the river and regarding the potential for scour of the abutments and erosion of the embankments of the railroad at this location. The bridge must be protected from the high velocities under the span, and the embankments must be protected from erosion that could lead to slope failure.

4.4.3 Mitigation Strategies

Based on the preliminary hydraulic analysis performed, the current span of the railroad bridge is not sufficient to pass the flood flows incurred under the proposed dam removal scenario. The bridges would need to be replaced with a bridge of larger span to reduce the backwater effect upstream of the structure, minimize velocities through the bridge span, and lessen the risks of scour at the bridge abutments and erosion of the railroad embankments.

An alternative 2-D HEC-RAS model was produced that increased the span of the Eklutna River railroad bridge from 70 ft to 325 ft. The alternative geometry expands the bridge span approximately 100 ft to the south and an additional 155 ft to the north. Slight modifications to the approach geometry were made to include a 45-degree wingwall on the left abutment to help reduce overall velocities along that surface and better distribute the flow through the span. A map of the velocities pre- and post-bridge replacement is presented in Figure 4.4-2.

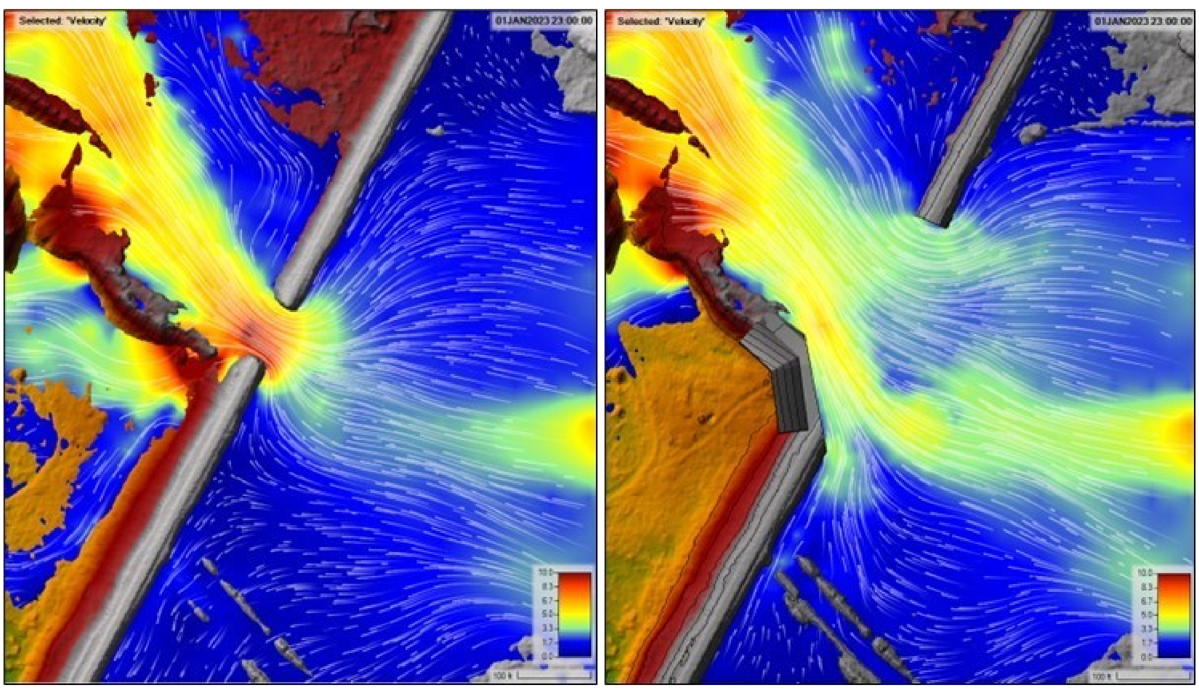

Figure 4.4-2. Plan View of Velocities (ft/s) at the Eklutna River Railroad Bridge Pre- and Post- Bridge Replacement.

This conceptual alternative produced a maximum velocity of 5.8 ft/s through the bridge span. This velocity corresponds to a maximum shear stress of 3.8 lb/ft^2 which reduces the maximum particle size capable of transport from approximately 26 inches to 9 inches. The increased span length reduces the upstream backwater effect by approximately 2 ft of head and increases the freeboard by approximately 1 foot. The increased span would significantly decrease the potential for abutment scour; however, additional erosion protection measures would likely need to be implemented along the railroad embankments.

4.5 Eklutna Tailrace Fishery

4.5.1 General

Figure 4.5-1. Eklutna Tailrace Fishery.

The Eklutna Tailrace Fishery is operated by the Alaska Department of Fish and Game (ADFG), who began stocking the tailrace with coho salmon smolts in 1998. In 2002, they included Chinook salmon smolts as part of the Northern Cook Inlet Chinook salmon enhancement program. These stocking efforts have facilitated a very popular and sustainable salmon fishery since 2003. Salmon originating from the drainages of the Knik and Matanuska Rivers are also harvested at the confluence of the tailrace and the Knik River. Sport fishing for Chinook salmon at the tailrace continues to be a popular recreational fishery for residents. The fishery is handicap accessible and a youth only fishery takes place each year in June.

The primary purpose of the program is to maintain or increase Chinook salmon sport fishing opportunities in the Mat-Su valley. In addition to these opportunities this fishery also reduces the fishing pressure on local wild stocks. The stocking program provides alternative opportunities for anglers that might otherwise direct their efforts toward native fish that are vulnerable to over-fishing. As sport fishing pressure continues to increase in the Matanuska-Susitna Valley, hatchery fish are becoming a more important management tool to satisfy recreational demands. Chinook salmon have had significantly poor marine survival, resulting in little to no harvest opportunities on wild stocks. This fishery plays an important role in allowing harvest for the duration of the Chinook salmon return. The goal of this fishery is to generate 10,000 angler-days annually of Chinook salmon sport fishing effort and another 6,000 angler-days directed at coho fishing.

Based on estimates provided by ADFG, an average of approximately 2,400 salmon are harvested from the fishery each year[16]. Including other species such as Dolly Varden and Arctic Char, an average of approximately 4,900 total fish are harvested from the fishery each year. A photograph of the fishery is presented in Figure 4.5-1.

4.5.2 Risk Assessment

The Eklutna Tailrace fishery receives the entirety of its water supply from the Eklutna Power Plant, which would cease operations under the dam removal scenario. With the flow supply removed, the tailrace would be unable to be stocked with salmon and utilized as a sport fishery. Quantifying the impacts that the loss of the fishery would have on the region is difficult to determine, as little to no economic data exists specific to the site. According to a 2018 publication by the McDowell Group, non-residents spent an estimated $25 million in the sport harvest of hatchery salmon and accounted for $16 million in annual labor income created directly or indirectly by Alaska's hatcheries statewide in 2016[17]. This number is limited to impacts resulting from non-resident sport harvest of hatchery salmon and should be considered conservative. Resident sport/personal use/subsistence harvest of hatchery salmon have additional economic impacts as well as significant social and cultural impacts in Alaska. Additionally, it should be noted that the Eklutna Tailrace is the only open system stocked with coho and Chinook salmon smolts, and in 2024 this is the only fishery for anglers to harvest Chinook salmon, as all other areas are restricted.

4.5.3 Mitigation Strategies

Discussions with ADFG indicate that the loss of the Eklutna Tailrace fishery would be difficult to replace elsewhere within the region. The statewide hatchery program is designed to minimize interactions with wild salmon stock and may only be replicated should a suitable site be found that is not currently a salmon-bearing anadromous stream. For the purposes of this assessment, there are no mitigation strategies that may be developed, and no estimated cost impacts associated with the loss of the Eklutna Tailrace fishery.

[16] Chugach Electric Association, Matanuska Electric Association, Municipality of Anchorage. Eklutna Hydroelectric Project Recreation Study Report. (March 2023) https://eklutnahydro.com/wp-content/uploads/2023/04/Draft-Eklutna-Recreation-Report.pdf

[17] McDowell Group. Economic Impact of Alaska's Salmon Hatcheries. (October 2018) https://www.adfg.alaska.gov/static/fishing/PDFs/hatcheries/2018_alaskahatchery_executive_summary.pdf

5.0 Preliminary Cost Estimates

Preliminary cost estimates have been developed for the proposed infrastructural modifications and mitigation strategies detailed within this memorandum. The cost estimates presented herein are consistent with a Class 5 estimate as defined by the Association for the Advancement of Cost Engineering standard Practice 69R-12[18]. The estimates were prepared by utilizing historical cost data from similarly technical projects which McMillen has designed or constructed, or from parametric comparisons of similar projects for which McMillen has obtained detailed cost breakdowns. Due to the level of uncertainty at the conceptual level of design, a contingency of 25% has been added to the costs. The accuracy range for the cost estimate at this phase of investigation is estimated to be -50% to +100%.

To account for the construction timeline proposed as part of the alternative dam removal scenario, each estimate was escalated to Q1 2034 U.S. Dollars. To escalate the proposed costs, the Civil Works Construction Cost Index System (CWCCIS) was utilized with a cost index applicable for the construction type[19]. The following subsections present the estimated costs for each of the proposed modifications or mitigation strategies employed as part of the dam removal alternative.

5.1 Eklutna Dam

The removal of Eklutna Dam involves the development of site access, demolition and excavation of the dam embankment and spillway, transport of material to the quarry, and restoration of the site as detailed in the work plan in Section 3.1.2.

A conceptual level cost estimate was developed as part of this technical risk assessment to determine the anticipated total cost for removal of the dam structure. This cost estimate is summarized in Table 5.1-1.

[18] Association for the Advancement of Cost Engineering. Recommended Practice 69R-12. Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Hydropower Industries.
[19] United States Army Corp of Engineers. EM 1110-2-1304 Civil Works Construction Cost Index System. Tables 1-4. (September 2023)

Table 5.1-1. Cost Estimate; Eklutna Dam Removal.

Description	Qty	Unit Cost	Value	Notes
Division 01 Indirects				
Mobilization and Establishment of Site Infrastructure	10%	$5,495,000	$549,000	10% Direct Costs
Contractor General Requirements	15%	$5,495,000	$824,000	15% Direct Costs
Site Construction and Access Roads				
Road Improvements - Abandoned Access Road	1,000 LF	$80	$80,000	Tree Clearing/Regrading
Temporary Construction Roads	500 LF	$80	$40,000	Tree Clearing/Regrading
Erosion and Sediment Control; Turbidity Control	LS	$60,000	$60,000	
Dam Removal				
Dam Removal; Excavation	85,000 CY	$30	$2,550,000	In-Situ Volume
Dam Removal; Concrete	3,000 CY	$500	$1,501,000	In-Situ Volume
Material Transport, Haul 30 miles, Bulk Volume	101,000 CY	$7.50	$759,000	Eklutna Inc. Gravel Pit
Site Disposal, Compaction	101,000 CY	$4.00	$405,000	Eklutna Inc. Gravel Pit
Site Restoration	LS	$100,000	$100,000	
Project Subtotal				
Direct Costs	LS		$6,868,000	
Overhead				
GC Overhead and Profit	15%		$1,030,000	
Construction Bonds	1.25%		$99,000	
Direct Cost Contingency				
Overall Project Contingency	25%		$1,999,000	Typical
Total Construction Cost $2024				
Median Construction Cost	LS		$9,996,000	
Total Construction Cost $2034				
Cost Index (Q1 2024)		1156.95		Dam Index Q1 2024
Cost Index (Q1 2034)		1497.03		Dam Index Q1 2034
Median Construction Cost	LS		$12,934,000	
Engineering/Licensing Costs	5%	$12,934,000	$647,000	
Total Cost			**$13,581,000**	
Lower Cost Range			$6,790,500	-50%
Upper Cost Range			$27,162,000	+100%

5.2 Eklutna Powerplant

The proposed removal of Eklutna Dam would result in the decommissioning of the Eklutna Power Plant. While the exact details of decommissioning are not fully understood at this time, some assumptions were made regarding the abatement of hazardous materials and isolation of the plant from the reservoir as detailed in Section 3.2.2.

A conceptual level cost estimate was developed as part of this technical risk assessment to determine the anticipated total cost for the decommissioning of the power plant. This cost does not include demolition of the power plant or restoration of the site. This cost estimate is summarized in Table 5.2-1.

Table 5.2-1. Cost Estimate; Eklutna Power Plant Decommissioning.

Description	Qty	Unit Cost	Value	Notes
Division 01 Indirects				
Mobilization and Establishment of Site Infrastructure	10%	$1,800,000	$180,000	10% Direct Costs
Contractor General Requirements	15%	$600,000	$270,000	15% Direct Costs
Powerhouse Decomissioning				
Abate/Remove Hazmat and Lead Paint	LS	$1,200,000	$1,200,000	
Backfill Tailrace Conduit	LS	$500,000	$500,000	
Install Concrete Plug in Tunnel	LS	$0.00	$0	See Note 1
Site Fencing and Security	LS	$100,000	$100,000	
Project Subtotal				
Direct Costs	LS		$2,250,000	
Overhead				
GC Overhead and Profit	15%		$338,000	
Construction Bonds	1.25%		$32,000	
Direct Cost Contingency				
Overall Project Contingency	25%		$655,000	Typical
Total Construction Cost $2024				
Median Construction Cost	LS		$3,275,000	
Total Construction Cost $2034				
Cost Index (Q1 2024)		1156.36		Composite Index Q1 2024
Cost Index (Q1 2034)		1494.69		Composite Index Q1 2034
Median Construction Cost	LS		$4,233,000	
Engineering/Licensing Costs	5%	$4,233,000	$212,000	
Total Cost			**$4,445,000**	
Lower Cost Range			$2,222,500	-50%
Upper Cost Range			$8,890,000	+100%

[1] Based on the recommended mitigation strategy for the AWWU pipeline presented in Section 4.1, costs associated with installation of a concrete plug are not included as part of this estimate.

5.3 Renewable Energy Supply

To replace the energy and capacity lost with the removal of the Eklutna Power Plant, an equivalent renewable energy supply must be constructed by the year 2034. While a 10-year horizon for the site selection, investigation, licensing, and design of a new hydroelectric project may be feasible, it is heavily dependent on the complexity of the project and environmental concerns related to its development. For the purposes of this assessment, it is assumed an equivalent project with a 44.4 MW generation capacity is developed in accordance with the mitigation strategy outlined in Section 3.3.

To estimate costs associated with the construction of a new hydroelectric project, cost estimating tools developed by Oak Ridge National Laboratory were utilized which were developed based on a collection of contemporary cost data within the industry[20]. An equation was developed to determine the initial construction costs associated with the hydroelectric development on a new site, as presented in the following equation:

$$ICC = 8{,}717{,}830 * P^{0.975} * H^{-0.120}$$

Where:

ICC = Initial Construction Cost ($2012)
P = Project Capacity (MW)
H = Head (ft)

For a 44.4 MW project with a rated head of 800 ft, the calculated initial cost for construction, including indirect costs, is $157,847,000 (2012 $USD A summary of the cost escalation and anticipated costs of the project construction are presented in Table 5.3-1.

Table 5.3-1. Cost Estimate; Development of New Hydroelectric Project.

Description	Value	Notes
Estimated Construction Costs	$157,847,000	Q1 2012 $USD
Cost Index (2012)	722.83	Powerplant Index Q1 2012
Cost Index (2034)	1375.93	Powerplant Index Q1 2034
Expected Construction Costs	$300,467,000	2034 $USD
Engineering/Licensing Costs	$15,023,000	5% Total Contract Amount
Total Cost	**$315,490,000**	Excludes Transmission Lines
Lower Limit	$157,745,000	-50%
Upper Limit	$630,980,000	+100%

It shall be noted that the cost estimate detailed above does not include costs associated with the construction of new transmission lines to the site. Development of transmission to a site could make up a considerable portion of the Project cost, dependent on the location identified.

[20] Oak Ridge National Laboratory. Hydropower Baseline Cost Modeling. (January 2015). Pub53978.pdf (ornl.gov)

For comparison purposes, a cost estimate was developed to determine the present worth of the replacement energy should the energy obtained from the Eklutna Power Plant be replaced by energy from the existing fossil fuel generation fleet. This analysis assumes a future price of $13.05 per Thousand Cubic Feet (MCF) of natural gas, as provided by the utilities as a projection to the year 2026. The production cost of running the fossil fuel generation fleet at this rate results in an energy price of $84.65/MWh with an escalation of 1% per annum, as detailed in the Cost Effectiveness Modeling technical memorandum as part of the Draft Fish and Wildlife Program[21]. Additionally, a price of $48M must be included to procure and install a new generating unit at the Eklutna Generation Station (EGS) to allow MEA to meet their capacity reserve requirements as required by the IMC. A summary of the replacement costs of energy should the project be replaced by fossil fuel sources is provided in Table 5.3-2 for comparison purposes.

Table 5.3-2. Cost Estimate; Replacement of Energy from Fossil Fuel Sources.

Description	Value	Notes
Average Annual Energy	168,588 MWh	Average Annual Output; EPP
Energy Rate	$84.65/MWh	Based on $13.05/MCF
Annual Replacement Cost	$14,271,000	
Expected Lifetime of Asset	50 Yrs	
Present Worth of Replacement Energy	$305,606,000	Includes 1% Escalation in Energy
Cost for Additional EGS Unit	$48,000,000	Per MEA Estimate
Present Worth of Energy and Capital Cost	**$353,606,000**	

The comparison indicates that the lifetime costs for replacement of energy with the existing fossil fuel fleet may exceed that of the development of a new renewable hydropower resource on the Railbelt. For the purposes of this assessment, the estimated costs for development of a new hydroelectric project will be considered as part of the overall impacts of the alternative.

5.4 AWWU Water Supply Infrastructure

The proposed mitigation strategy as part of this technical risk assessment for the impacts to the AWWU Water Supply Infrastructure is to construct a new pipeline from the EWTF to the Eklutna Power Plant as discussed in Section 4.1.3.2. While no engineering design has been performed at this stage for the hypothetical pipeline construction, we may estimate the order

[21] Chugach Electric Association, Matanuska Electric Association, and Municipality of Anchorage. Appendix D – Supporting Data for Cost Effectiveness Model Technical Memorandum. https://eklutnahydro.com/wp-content/uploads/2023/10/2023-10-27-Eklutna-Draft-Fish-and-Wildlife-Program_with-Appendices.pdf

of magnitude costs parametrically by utilizing the construction costs for the existing Eklutna Water Project pipeline segment P-4 constructed in 1987[22]. A summary of the cost escalation and anticipated costs of the pipeline construction are presented in Table 5.4-1.

Table 5.4-1. Cost Estimate; AWWU Water Supply Infrastructure Mitigation Strategy.

Description	Value	Notes
Original Contract Amount	$7,257,106	October 1987 $USD
Cost Index (1987)	366.08	Composite Index Q4 1987
Cost Index (2034)	1494.69	Composite Index Q1 2034
Expected Contract Amount	$29,630,474	January 2028 $USD
Original Distance (mi.)	6.1	Pipeline Segment P-4
Cost per Mile	$4,857,455	$/Mi
Anticipated Distance (mi.)	9.6	Hypothetical Alignment
Anticipated Pipeline Cost	$46,632,000	
Engineering/Licensing Costs	$2,332,000	5% Total Contract Amount
Total Cost	**$48,964,000**	
Lower Limit	$24,482,000	-50%
Upper Limit	$97,928,000	+100%

5.5 New Glenn Highway Bridge

The proposed mitigation strategy as part of the technical risk assessment for the impacts to the New Glenn Highway Bridges involves the replacement of both bridges with wider and longer span structures. The new bridges would have a span of 250 ft based on the results of the hydraulic analysis and a width of 43 ft per recommendations from the DOT. At this span, a central drilled pile would be required at about midpoint of the bridge. Both abutments are anticipated to be founded on deep foundations. The existing bridges are to be demolished and constructed one at a time and the total work effort is anticipated to occur over two construction seasons. The cost estimate assumes that a traffic control plan would be in place with both spans of the New Glenn Highway traffic utilizing one or the other bridge during construction activities. Due to the high levels of traffic on this highway, this may not be a reasonable assumption and a temporary bridge may need to be constructed which is not included within these costs. Typical parametric costs for highway bridges in $/ft^2 were provided by the DOT. Demolition and traffic control costs were obtained from reference DOT bid data from recent

[22] Municipality of Anchorage Water & Wastewater Utility. Final Payment Estimate, Contract Performance. Eklutna Water Project Pipeline Segment P-4. (December 1987).

highway and bridge projects. A summary of the anticipated costs of the New Glenn Highway Bridges are presented in Table 5.5-1.

Table 5.5-1. Cost Estimate; New Glenn Highway Bridge Mitigation Strategy.

Description	Unit	Unit Cost	Value	Notes
Division 01 Indirects				
Mobilization and Establishment of Site Infrastructure	10%	$20,850,000	$2,085,000	10% Direct Costs
Contractor General Requirements	15%	$20,850,000	$3,127,500	15% Direct Costs
New Glenn Highway Bridges				
Northbound Bridge Demolition	LS	$500,000	$500,000	
Northbound Traffic Control	LS	$250,000	$250,000	
Northbound Bridge Construction	SF	$900.00	$9,675,000	43 ft width 250 ft span
Southbound Bridge Demolition	LS	$500,000	$500,000	
Southbound Traffic Control	LS	$250,000	$250,000	
Southbound Bridge Construction	SF	$900.00	$9,675,000	43 ft width 250 ft span
Project Subtotal				
Direct Costs	LS		$26,062,500	
Overhead				
GC Overhead and Profit	15%		$3,909,000	
Construction Bonds	1.25%		$375,000	
Direct Cost Contingency				
Overall Project Contingency	25%		$7,587,000	Typical
Total Construction Cost $2024				
Median Construction Cost	LS		$37,933,500	
Total Construction Cost $2034				
Cost Index (Q1 2024)		1156.36		Composite Index Q1 2024
Cost Index (Q1 2034)		1494.69		Composite Index Q1 2034
Median Construction Cost	LS		$49,032,000	
Engineering/Licensing Costs	5%	$49,032,000	$2,452,000	
Total Cost			**$51,484,000**	
Lower Cost Range			$25,742,000	-50%
Upper Cost Range			$102,968,000	+100%

5.6 Railroad Bridge

The proposed mitigation strategy as part of the technical risk assessment for the impacts to the Eklutna River railroad bridge involves the replacement of the bridge with a longer span. The new bridge would have a span of 325 ft and additional erosion protection measures would be implemented along the railroad embankments to prevent future erosion under flood conditions. Typical parametric costs for railroad bridges in $/ft were provided by the Alaska

Railroad. A summary of the anticipated costs of the new railroad bridge is presented in Table 5.6-1.

Table 5.6-1. Cost Estimate; Railroad Bridge Mitigation Strategy.

Description	Qty	Unit Cost	Value	Notes
Division 01 Indirects				
Mobilization and Establishment of Site Infrastructure	10%	$34,360,000	$3,436,000	10% Direct Costs
Contractor General Requirements	15%	$34,360,000	$5,154,000	15% Direct Costs
Railroad Bridge				
Bridge Demolition	LS	$500,000	$500,000	
New Bridge Construction	LF	$100,000	$32,500,000	325 ft span
Erosion Protection/Riprap	SF	$5.00	$360,000	3,600 ft length, 20 ft height
Channel Stabilization/Migration Prevention	LS	$1,000,000	$1,000,000	
Project Subtotal				
Direct Costs	LS		$42,950,000	
Overhead				
GC Overhead and Profit	15%		$6,443,000	
Construction Bonds	1.25%		$617,000	
Direct Cost Contingency				
Overall Project Contingency	25%		$12,503,000	Typical
Total Construction Cost $2024				
Median Construction Cost	LS		$62,513,000	
Total Construction Cost $2034				
Cost Index (Q1 2024)		1156.36		Composite Index Q1 2024
Cost Index (Q1 2034)		1494.69		Composite Index Q1 2034
Median Construction Cost	LS		$80,803,000	
Engineering/Licensing Costs	5%	$80,803,000	$4,040,000	
Total Cost			**$84,843,000**	
Lower Cost Range			$42,421,500	-50%
Upper Cost Range			$169,686,000	+100%

6.0 Risk Assessment Summary

This memorandum details the technical risks and associated costs necessary for the alternative related to the removal of the Eklutna Dam, as well as a comprehensive evaluation of various mitigation strategies to offset the consequent impacts on associated infrastructure. It is important to note that this assessment does not make assumptions regarding the allocation of these costs or identify the responsible parties. Instead, its primary purpose is to provide a high-level overview of the essential infrastructural modifications necessary to restore the Eklutna River to an unregulated state. The following subsections summarize the impacts to infrastructure, mitigation strategies, and costs associated with the dam removal alternative.

6.1 Eklutna Dam

Under this alternative the Eklutna Dam would be removed. The site would be restored to the natural topography of the streambed and site vegetation restored. The Eklutna River would return to its natural state with the exception of flows withdrawn for water supply purposes for AWWU. The work would likely take place over the course of one construction season and is expected to cost approximately $13.6M (USD $2034).

6.2 Eklutna Power Plant

Following the removal of Eklutna Dam, the power plant would be taken offline and the facility decommissioned. The current assumption is that the facility would be left in place after removal of all hazardous materials occur. The site would be fenced and security measures in place to prevent risk to the public. The work would take place over the course of one construction season and is expected to cost approximately $4.4M (USD $2034).

6.3 Renewable Energy Supply

The removal of Eklutna Dam and decommissioning of the power plant would result in the loss of a firm, dispatchable renewable energy source for the Railbelt. A reduction in 44.4 MW of capacity and an average of 169 GWh per year in energy would need to be replaced with an equivalent firm, dispatchable renewable source. While the design and site selection of an equivalent source is not anticipated to occur as part of this investigation, a project of similar capacity is anticipated to cost approximately $315.5M (USD $2034).

6.4 AWWU Water Supply Infrastructure

With the Eklutna Dam removed and the river flowing in an unregulated state, the existing AWWU infrastructure including the pipeline, road, and maintenance bridges are at particular risk of damage during flood conditions. Given the critical nature of this infrastructure to supply water to the MOA, the pipeline is assumed to be re-routed out of the Eklutna riverbed and would follow the alignment of the highway from the EWTF to a connection point at the Eklutna Power Plant penstock. This work would take place over the course of two construction seasons and is expected to cost approximately $49.0M (USD $2034).

A secondary impact to the water supply that may be unavoidable is related to the ability for the natural lake to supply municipal water releases without a dam. Based on historical water supply withdrawals, the lake would be withdrawn below its natural crest thus dewatering the Eklutna River or requiring water supply curtailment in dry years. This impact would become much greater should AWWU increase withdrawals from the lake beyond their historical levels.

6.5 Old Glenn Highway Bridge

The Old Glenn Highway Bridge has sufficient hydraulic capacity to pass flood flows post-dam removal. Some additional scouring would result at the bridge pier located within the floodplain of the river; however, this is not anticipated to put the bridge at risk pending further investigation. No mitigation measures are proposed at the Old Glenn Highway Bridge as part of this assessment.

6.6 New Glenn Highway Bridges

The New Glenn Highway Bridges do not have sufficient hydraulic capacity to pass flood flows under the unregulated flow of the Eklutna River and are at risk of damage. The bridges would need to be replaced with a longer span segment to reduce the hydraulic contraction at this location of the river and increase freeboard during flooding conditions. This work would take place over the course of two construction seasons and is expected to cost approximately $51.5M (USD $2034).

6.7 Railroad Bridge

The railroad bridge does not have sufficient hydraulic capacity to pass flood flows under the natural flow of the Eklutna River and is at risk of damage due to scour of the abutments. The bridge would need to be replaced with a longer span segment to reduce the hydraulic contraction at this location of the river, increase freeboard during flooding conditions, and reduce the average velocities through the span during flooding. This work would take place over the course of one construction season and is expected to cost approximately $84.8M (USD $2034).

6.8 Cost Estimate Summary

To accommodate the construction timeline for the proposed alternative dam removal scenario, each cost estimate was adjusted to reflect Q1 2034 U.S. Dollars. For clarity purposes, the cost estimate summary provides the equivalent costs in Q1 2024 U.S. Dollars to allow for direct comparison to other alternatives presented by stakeholders. A breakdown of the estimated costs for the proposed infrastructural adjustments and mitigation strategies, expressed in both 2024 and 2034 U.S. Dollars, is detailed in Table 6.8-1.

Table 6.8-1. Cost Estimate Summary

Description	Cost ($2024)	Cost ($2034)	Notes
Eklutna Dam Removal	$10,496,000	$13,581,000	
Eklutna Power Plant Decommissioning	$3,439,000	$4,445,000	
New Hydroelectric Project	$243,820,000	$315,490,000	
Re-route AWWU Pipeline	$37,880,000	$48,964,000	
New Glenn Highway Bridge Replacement	$39,830,000	$51,484,000	
Railroad Bridge Replacement	$65,639,000	$84,843,000	
Total Cost	**$401,104,000**	**$518,807,000**	
Lower Limit	$200,552,000	$259,403,500	-50%
Upper Limit	$802,208,000	$1,037,614,000	+100%