APPRAISAL STUDY
EIGHTMILE LAKE STORAGE RESTORATION

Prepared for

Chelan County Natural Resources Department
316 Washington Street, Suite 401
Wenatchee, Washington 98801

Icicle and Peshastin Irrigation Districts
P.O. Box 371
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March 2015

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This appraisal study was prepared under
the supervision of a registered Professional Engineer.

March 19, 2015

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LIST OF ACRONYMS AND ABBREVIATIONS

Anchor QEA	Anchor QEA, LLC
Aspect	Aspect Consulting, LLC
CCNRD	Chelan County Natural Resources Department
cfs	cubic feet per second
CMP	corrugated metal pipe
DC	direct current
DEM	digital elevation model
DSO	Ecology's Dam Safety Office
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
ESA	Endangered Species Act
Forsgren	Forsgren Associates, Inc.
GIS	geographic information system
gpm	gallon per minute
Gravity	Gravity Consulting
HDPE	high-density polyethylene
IID	Icicle Irrigation District
IPID	Icicle and Peshastin Irrigation Districts
IWG	Icicle Working Group
LNFH	Leavenworth National Fish Hatchery
MOA	Memorandum of Agreement
NEPA	National Environmental Policy Act
NRCS	U.S. Natural Resource Conservation Service
NRHP	National Register of Historic Places
OCR	Office of Columbia River
OHWM	ordinary high water mark
PHS	Priority Habitat and Species

PID	Peshastin Irrigation District
RM	River Mile
SNOTEL	Snow Telemetry
TU	Trout Unlimited
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Survey
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area

1 INTRODUCTION

This report presents an Appraisal Study of proposed improvements that would restore storage capacity in Eightmile Lake. Eightmile Lake is one of four Alpine Lakes that is managed by Icicle and Peshastin Irrigation Districts (IPID). A small dam, gate, and discharge pipeline at the lake outlet allow for controlled releases to supplement flows in Icicle Creek to increase water supply during low flow periods for irrigation. The proposed project would repair or replace the dam, low-level outlet, and controls to restore the usable storage capacity of the lake and allow for automation and optimization of releases from the lake.

This project is one of several potential projects currently being evaluated under the direction of the Icicle Work Group (IWG). The IWG was formed to take a comprehensive look at water resource management in the Icicle Creek Sub-basin. The IWG consists of federal, state, and local agencies; irrigation districts; the City of Leavenworth; the Leavenworth National Fish Hatchery (LNFH); non-profit organizations; environmental groups; and other stakeholders. The IWG is working together to identify and evaluate projects that will improve management of water in the Icicle Creek Sub-basin and improve instream flow conditions in lower Icicle Creek. The Chelan County Natural Resources Department (CCNRD) retained Anchor QEA, LLC and Aspect Consulting, LLC (Anchor QEA/Aspect) to complete the Appraisal Study. The study was funded under a grant (Grant No. G1400161) from the Washington State Department of Ecology (Ecology).

Projects endorsed by the IWG are collectively intended to meet the following nine Guiding Principles:

1. Streamflow that:
   - Provides passage
   - Provides healthy habitat
   - Serves channel formation function
   - Meets aesthetic and water quality objectives
   - Is resilient to climate change
2. Sustainable hatchery that:
   - Provides healthy fish in adequate numbers

- Is resource efficient
- Significantly reduces phosphorus loading
- Has appropriately screened diversion(s)
- Does not impede fish passage

3. Tribal Treaty and federally protected fishing/harvest rights are met at all times.
4. Provide additional water to meet municipal and domestic demand.
5. Improve agricultural reliability that:
   - Is operational
   - Is flexible
   - Decreases risk of drought impacts
   - Is economically sustainable
6. Improve ecosystem health including protection and enhancement of aquatic and terrestrial habitat.
7. Comply with state and federal law.
8. Protect Non-Treaty Harvest.
9. Comply with the Wilderness Act of 1964, the Alpine Lakes Wilderness Act of 1976, and the Alpine Lakes Wilderness Management Plan.

The intent of the Eightmile Lake Restoration Project is to meet multiple prongs of the Guiding Principles. This project has the potential to:

- Augment streamflow in Icicle Creek (Guiding Principle No. 1)
- Provide additional water to meet municipal demands (Guiding Principle No. 4)
- Improve agricultural reliability by increasing water supply available in the late summer to meet IPID's diversion needs (Guiding Principle No. 5)
- Benefit fish passage and habitat (Guiding Principle No. 6) and Treaty and Non-Treaty Harvest (Guiding Principles No. 3 and No. 8)

Relative to Guiding Principle 2, maintaining a sustainable hatchery, it should be noted the project could also potentially be used to release additional water during the winter low flow period, which would benefit LNFH water supply needs. Low flow conditions in the Icicle Creek Sub-basin typically occur in late-summer and again during the winter when the hard freeze occurs. The Hatchery Canal is dewatered from mid-summer through early spring to

meet instream flow needs in Icicle Creek. Releases from Eightmile Lake have not typically occurred during the winter low-flow period, but the improvements discussed in this report could potentially allow for management of releases to benefit LNFH.

1.1 Background

Eightmile Lake is located in the Alpine Lakes Wilderness area of Okanogan-Wenatchee National Forest approximately 10 miles west of the City of Leavenworth. It is one of four lakes in the Alpine Lakes Wilderness area managed by IPID. A small dam with a low-level outlet and control gate was installed at the outlet of each of the lakes in the early part of the 20th century to allow IPID to capture and store runoff during the winter and spring for release during the late summer low flow period. The supplemental flows allow IPID to maintain irrigation diversions and meet instream flow obligations.

The dam, outlet, and control gate at Eightmile Lake are aging and are in need of repair. The masonry portion of the dam is deteriorating. The embankment portion of the dam has eroded. Consequently, the dam is not currently capable of impounding water to the overflow level for which it was designed and at which it historically operated. The gate that controls flow to the low level outlet is also very difficult to operate and needs to be refurbished or replaced. IPID is proposing to repair or replace the dam, outlet, and control facilities to restore water storage in the lake and improve control of releases.

1.2 Appraisal Study Description

This Appraisal Study identifies and evaluates options for restoring water storage in Eightmile Lake by restoring the dam and reconfiguring the low-level outlet. These improvements would enable IPID to draw the lake down further or raise the level higher than is currently possible with the condition and configuration of the existing dam and outlet. The following summarizes the scope and purpose of the Appraisal Study.

1.2.1 Scope of Work

The scope of work identified for this appraisal study included the following work:

- **Assessment of Existing Storage Conditions** – The Anchor QEA/Aspect team assessed existing conditions of the storage at Eightmile Lake by completing the following:
  - Collection and review of background information, including water rights documentation and available operational information
  - A site visit to review and document existing conditions
  - An evaluation of existing lake operations based on available background information and observations made during the site visit
  - A summary of structural and operational limitations
- **Identify and Evaluate Options for Increasing Storage** – The Anchor QEA/Aspect team identified and evaluated four potential options for increasing storage, including:
  - Increasing the useable storage to approximately 2,000 acre-feet by restoring the dam and increasing the available drawdown
  - Increasing the useable storage to approximately 2,500 acre-feet by restoring the dam and increasing the available drawdown
  - Increasing the useable storage to approximately 2,500 acre-feet by restoring the dam, including raising the crest 1 foot, and increasing the available drawdown
  - Increasing the useable storage to approximately 3,500 acre-feet by rebuilding the dam, and raising the crest and increasing the available drawdown
- **Identify and Evaluate Options for Improving Operations** – The Anchor QEA/Aspect team identified and evaluated options for improving operations. This work included:
  - Identifying and describing the potential uses of water stored in Eightmile Lake
  - Reviewing the timing of releases
  - Determining whether releases could be optimized with instream flows and out-of-stream water needs
- **Summarize Potential Water Use and Benefits** – As part of this task, the Anchor QEA/Aspect team quantified and summarized the following for the improvement options that were identified:
  - Storage yield
  - Instream flow benefits
  - Out-of-stream use benefits
  - Reliability of additional water supply

- **Preliminary Environmental Review and Permitting Fatal Flaw Analysis** – The Anchor QEA/Aspect team also completed a preliminary review of environmental resources and permitting requirements to identify potential "fatal flaws" with the improvement options that were identified.
- **Prepare Appraisal Study Report** – The Anchor QEA/Aspect team prepared this report to summarize the findings of the Appraisal Study.

These tasks were completed in conjunction with work performed by Gravity Consulting (Gravity) and Forsgren Associates, Inc. (Forsgren) under the direction of IWG member Trout Unlimited (TU). The work completed by Gravity and Forsgren included:

- A bathymetric survey of Eightmile Lake and topographic survey of the dam and shoreline area adjacent to Eightmile Lake.
- An evaluation of storage volumes and water levels in Eightmile Lake.

This results of this effort are summarized in the *Draft Icicle Irrigation District Instream Flow Improvement Options Analysis Study* (Forsgren 2014).

1.2.2 Project Goals

The goals of the appraisal study are to:

- Review and provide a more complete understanding of existing storage conditions and operational challenges.
- Evaluate the improvement options in enough detail to provide IPID and other stakeholders with the information needed to compare the proposed project with other projects being considered by the IWG and determine whether additional resources can be allocated for more detailed study and implementation of the project.

The overall goal of the Eightmile Lake Restoration project is to restore storage capacity at Eightmile Lake and improve control of releases from the lake to improve the water supply available in Icicle Creek to meet instream flow and out-of-stream water supply needs.

1.2.3 Report Organization

This report is organized into the following sections:

- **Existing Storage Conditions** provides a summary of existing storage conditions at Eightmile Lake based on recent work done by Gravity and Forsgren, input from IPID, and conditions documented during a site visit to the lake.
- **Potential Storage Restoration Options** summarizes four alternatives that were identified for increasing storage levels in Eightmile Lake.
- **Potential Operational Improvement Options** summarizes additional improvements that can be made to improve the operation of Eightmile Lake and optimize releases to better meet instream flow and out-of-stream water supply needs.
- **Summary of Potential Water Use and Benefits** summarizes the potential use of additional water stored in Eightmile Lake and benefits of that would be available through release of that storage to the Icicle Creek Sub-basin.
- **Preliminary Environmental and Permitting Evaluation** provides a preliminary evaluation of environmental impacts and potential permitting requirements associated with the improvement options identified in this study.
- **Cost Analysis** includes a summary of preliminary opinions of probably project costs associated with each improvement option.
- **Summary and Recommendations** provides an overall summary of the Appraisal Study and recommendations for future study and implementation.

Tables and figures are included throughout the report. Appendices, including photographs, calculations, and other information, are included at the back of the report.

2 EXISTING STORAGE CONDITIONS

Eightmile Lake is located in the Icicle Creek Sub-basin in the Cascade Mountains approximately 10 miles west of the City of Leavenworth, Washington (See Figure 2-1). The lake is situated within Sections 32 and 33, T24N, R16E, and currently has a full water surface area of approximately 76.6 acres. Eightmile Lake captures water from a 3,804-acre drainage basin and discharges surface water to Eightmile Creek, which is a tributary to Icicle Creek.

Eightmile Lake can be accessed on foot via the Eightmile Lake trail (United States Forest Service (USFS) Trail No. 1552). The trailhead is accessible from Leavenworth by vehicle following Icicle Road, USFS Road 7600, and USFS Road 7601. The trail generally follows Eightmile Creek from USGS Road 7601 to Eightmile Lake. The distance from the trailhead to the lake is approximately 4 miles. Because of its relative accessibility, the lake is a popular destination for hikers and campers. Because of its proximity to Icicle Creek and relative ease of access, IPID operates the gate to release water from Eightmile Lake more frequently than at the more remote lakes.

2.1 Description of Existing Facilities

A water resource engineer from the Anchor QEA/Aspect team visited Eightmile Lake with IPID Manager Tony Jantzer on November 1, 2013, to observe the condition of existing facilities at the lake and review operations with the manager. Photographs were taken to document existing site conditions (see Appendix A). The following provides a brief description of the facilities at Eightmile Lake:

2.1.1 Dam

The existing dam consists of a masonry rock and concrete wall structure with an earthen embankment section. The portion of the earthen embankment closest to the rock and concrete structure has eroded to an elevation that is several feet below the original dam crest and overflow elevation. Portions of the masonry rock and concrete wall structure have deteriorated and fallen down, but most of the structure is still intact.

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ANCHOR QEA

Miles
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Figure 2-1
Location Map
Appraisal Study
Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

An opening in the masonry rock and concrete wall forms the primary spillway outlet for the lake. It appears that stop logs or flashboards were once installed at this spillway opening to control the overflow elevation of the lake. No stop logs or flashboards are currently installed in the opening and water spills over large woody debris and rock that have collected at the spillway opening. Water spills through the opening into a spillway well. The spillway well is filled with rock and debris. The IPID manager indicated that when the gate is closed on the low level outlet and water spills into the well over the spillway crest, the water flows out the discharge pipeline and into Eightmile Creek below the dam. If the spillway well fills, excess water then spills over the downstream wall of the well and into the spillway channel. The IPID Manager indicated that under current operation, the lake typically overflows to the spillway channel during the spring and early summer. Photographs 1 through 6 (Appendix A) show the dam and spillway structures.

2.1.2 Low Level Outlet and Gate

A gate and low level outlet pipeline control releases from Eightmile Lake to Eightmile Creek. The gate is submerged in the lake just upstream of the dam, but can be opened to release water from the lake through the low level outlet pipeline to Eightmile Creek. It appears that a concrete control tower was once in place to protect the gate stem and support a manual operator above the water surface of the lake, similar to the equipment currently in place at Colchuck Lake. The tower appears to have completely deteriorated and the manual gate operator has been removed and is in the shed at the IPID office. The gate now has to be operated by inserting a come-along into a square metal loop welded to the stem just above the gate (below the water surface). This makes gate operation very challenging. The IPID Manager indicated that rock has also settled above and against the bottom of the gate, making it impossible to completely close the gate. Photographs 7 and 8 (Appendix A) show the existing gate location.

The existing low level outlet pipeline is nearly 300 feet long and is assumed to be 36-inch diameter corrugated metal pipe (CMP). Most of the pipe is buried under large rock. The location of the pipe outlet to Eightmile Creek is shown in Photographs 9 and 10 (Appendix A). The pipe outlet is submerged. A large rock has been naturally deposited in the channel immediately downstream of the outlet. The IPID Manager indicated that when the gate is

open and the reservoir is releasing water, conditions at the pipe outlet are turbulent and the rock is submerged. The bottom of the pipe is filled with debris. During the site visit, the IPID Manager measured the outlet from the top of pipe to the top of the debris at the invert at approximately 32 inches.

2.1.3 Overflow Spillway Channel

An overflow channel extends from the dam approximately to the low-level pipeline outlet. The channel is filled with large rock. Some of the rock appears to have been deposited in the channel naturally since it was first constructed. Two weathered concrete cutoff wall structures are exposed near the upstream end of the channel. The channel is shown in Photographs 11 and 12.

2.1.4 Lake and Usable Storage Capacity

The survey and lake volume evaluation completed by Gravity and Forsgren (Forsgren 2014) estimated the volume of the lake at key water surface elevations. These are summarized in Table 2-1. The current high water surface elevation was estimated at approximately 4,667 feet. This high water surface elevation reflects the current configuration of the dam and controls, including the absence of stop logs or flashboards in the spillway opening. The total estimated volume of the lake at that elevation is estimated to be approximately 2,706 acre-feet. The current useable storage in the lake is the volume of water storage between the minimum drawdown level, which was estimated by Gravity and Forsgren to be approximately 4,644 feet, and the current high water surface elevation, 4,667 feet. The current usable storage volume was estimated to be approximately 1,375 acre-feet.

Table 2-1
Current Lake Volume Summary

Description	Water Surface Elevation (Feet)	Water Surface Area (Acres)	Total Volume (Acre-feet)	Usable Storage Volume (Acre-feet)
1) Current Low Level Outlet (Max Drawdown)	4,644	44.1	1,331	↑
2) Top of Weir at Spillway Opening	4,664	73.5	2,486	1,375
3) Current High Water Surface	4,667	76.6	2,706	↓
4) Current Dam Crest/Historic Overflow	4,671	80.8	2,998	

2.2 Operational Challenges and Deficiencies

Several operational challenges and deficiencies exist due to the current configuration and condition of the facilities at Eightmile Lake. These include:

- Gate Operation – As was noted in the Section 2.1.2, the structure that once supported and protected the gate stem and manual gate operator is no longer intact. The manual operator has been removed because it was no longer operable. Gate operation now requires that IPID personnel insert a come-along into a metal loop welded to the gate stem below the water surface to turn the gate stem and open the gate. In addition, rock and debris have settled against and at the bottom of the gate, making it nearly impossible to close. Gate maintenance and removal of rock and debris require working in cold water.
- Dam Condition and Level Control – The dam is no longer in condition to allow for control of the water level at the spillway opening. The embankment portion of the dam has eroded adjacent to the masonry portion of the dam to an elevation that is lower than the dam crest and historic overflow elevation. In addition, guides for flash boards or stop logs in the spillway opening are no longer operable and debris and rock have plugged the spillway opening.
- Lake Drawdown – IPID's water rights allow for lake storage to be drawn down below the invert of the existing low level outlet. However, drawing the lake down below the invert of the existing low level outlet pipe requires pumping.
- Low Level Outlet Pipe Condition – The condition of the low level outlet pipe is generally unknown. Inspection at the outlet of the pipe indicates that the pipe is at

least partially plugged with rock and debris. This likely limits the rate at which the lake can release water when the gate is fully opened.

2.3 Hydrology and Lake Recharge

Hydrology and lake recharge was estimated for Eightmile Lake as part of the draft *Alpine Lakes Optimization and Automation Appraisal Study* (Aspect/Anchor QEA 2015). The Appraisal Study used lake drainage basin areas, average monthly precipitation rates, data from nearby Snow Telemetry (SNOTEL) stations operated by the U.S. Natural Resource Conservation Service (NRCS), and data from nearby evaporation stations. The following describes the methodology used to estimate the water supply available from the drainage basin tributary to Eightmile Lake.

- The drainage basin for Eightmile Lake was delineated using geographic information system (GIS) software and digital elevation model (DEM) data from the U.S. Geologic Survey (USGS).
- Daily precipitation and snow-water equivalent data were downloaded from seven SNOTEL stations near Eightmile Lake. The monthly runoff, in inches, was estimated at each SNOTEL station based on daily precipitation and snow-water equivalent data.
- The average monthly precipitation in the Eightmile Lake drainage basin was estimated in GIS from the 1981 to 2010 average precipitation dataset from the Oregon State University PRISM Climate Group.
- The locations, elevations, and precipitation data from Water Years 1985 to 2013 of the SNOTEL sites was compared with the location, elevation, and estimated precipitation for the Eightmile Lake drainage basin. Based on the comparison, the Stevens Pass SNOTEL site was identified as the most appropriate for determining runoff for Eightmile Lake.
- A precipitation ratio was developed for Eightmile Lake that represents the ratio of the average annual precipitation in the lake's drainage basin, as estimated from the PRISM precipitation data. PRISM data was checked against the average annual precipitation at the Stevens Pass SNOTEL site to confirm that the average annual precipitation for both datasets was comparable.

- Monthly runoff, in inches, was estimated for the Eightmile Lake drainage basin by multiplying the estimated runoff at the Stevens Pass SNOTEL site by the precipitation ratio developed for the lake for Water Years 1985 to 2013.
- The total monthly runoff volume, in acre-feet, was estimated for Eightmile Lake by multiplying the estimated runoff, in inches, by the area of the lake's drainage basin for Water Years 1985 to 2013.
- Evaporation was estimated for Eightmile Lake by using estimated evaporation from nearby stations. The two stations closest to Eightmile Lake are Wenatchee and Bumping Lake. It was determined that the Bumping Lake evaporation station would be the most appropriate for determining evaporation for Eightmile Lake because the elevations are similar. Monthly evaporation rates were determined by multiplying the monthly pan evaporation rate for Bumping Lake by 75% to convert pan evaporation to lake evaporation. The lake evaporation was then multiplied by the lake area to get an estimated monthly evaporation volume for Eightmile Lake for Water years 1985 to 2013.
- Available water supply was estimated for Eightmile Lake by subtracting the monthly evaporation volume from the monthly runoff volume.

Statistics of available annual water supply, or net annual inflow, were developed for Eightmile Lake, including 10%, 50%, and 90% annual exceedance probabilities. These values are summarized in Table 2-2.

Table 2-2
Eightmile Lake Drainage Area and Estimated Inflow

Characteristic	Estimated Value
Drainage Area	3,804 acres
10% Exceedance Annual Inflow	18,713 acre-feet
50% Exceedance Annual Inflow	14,141 acre-feet
90% Exceedance Annual Inflow	10,896 acre-feet

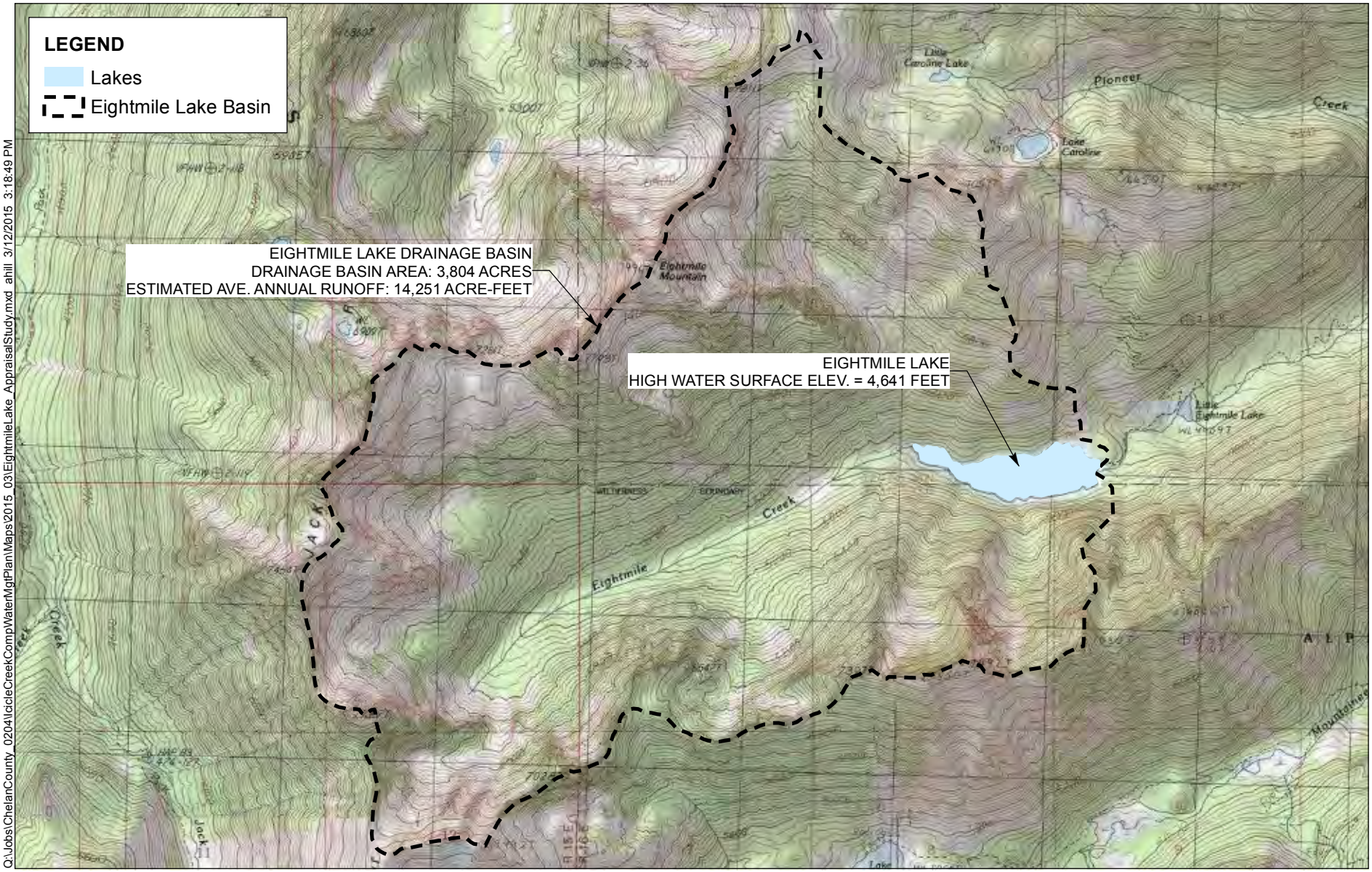

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Figure 2-2
Eightmile Lake Drainage Basin
Appraisal Study
Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

2.4 Water Use and Water Rights

In 1926 Icicle Irrigation District (IID) filed an application with the state Office of Supervisor of Hydraulics (an Ecology predecessor agency) requesting to divert water from Eightmile Lake for seasonal irrigation. A petition was also filed with the Department of Public Lands (a Department of Natural Resources predecessor) to procure the shore and overflow rights to the lake[1]. The Office of Supervisor of Hydraulics issued a permit (Permit 828) in January 1927 to develop the lake source. Following payment of fees to cover damages to state lands from overflow of the lake, the Department of Public Lands then issued an Order dated October 26, 1927, which reads in part: "the right to overflow and perpetually inundate said lands [Eightmile Lake] may be duly exercised in accordance with the terms of this order[2], the lands included being more particularly described as follows: The bed and shores of … Eight Mile Lake."

In 1927, water rights to Icicle Creek and its tributaries were adjudicated in Chelan County Superior Court. The 1929 Final Court Decree affirmed IID's water right permit for Eightmile Lake in the amount of 25 cubic feet per second (cfs), 2,500 acre-feet. The decree noted that the water right represented by the permit was "inchoate but may be perfected by compliance with provisions under which the permits were issued; that these rights for storage of water under said permits do not affect the water rights of any other claimant herein reported."

The storage right was subsequently certificated (Certificate 1228) by the Office of Supervisor of Hydraulics for 25 cfs for the purpose of irrigation of 7,000 acres; no annual quantity was specified on the certificate. The 2,500 acre-feet of annual storage volume specified in the Court Decree establishes the maximum authorized storage volume.

In the *Draft Icicle Irrigation District Instream Flow Improvement Options Analysis Study*, Forsgren and Gravity estimated that the current high water mark corresponds to a usable storage volume of approximately 1,375 acre-feet, whereas the top of dam overflow elevation represents a usable volume of 1,666 acre-feet. The total lake volume is 2,700 to 3,000 acre-

[1] Additional applications and petitions were concurrently filed for use of water from Klonaqua Lake and Colchuck Lake.

[2] No specific terms were spelled out in the Order. The Order references Section 102, Chapter 255 of the Session Laws of 1927. This Chapter and Section authorized the Commissioner of Public Lands to grant the right to "back and hold water" and overflow and inundate state shore lands for the purpose of constructing and operating works for the impoundment of water for irrigation and other uses.

feet at these corresponding water surface levels, which is in excess of the 2,500 acre-feet permitted to be stored and beneficially used under IID's water right. In dry years, it is possible for IID to augment its usable storage volume by drawing down the lake further than the normal outlet elevation through additional mechanical or gravity means. The water right record is unclear whether IID's water rights are single-fill storage rights, or whether they can rely on additional natural flows to augment storage, which would further enhance the beneficial use history of the water right. If additional water right authority were needed to augment storage to meet Guiding Principles under an Icicle Integrated Plan, it is possible that additional spring filling water rights could be granted by Ecology, since water is routinely available in excess of adopted instream flows during this time period.

In 1990 IPID and the USFS agreed to a land exchange where the USFS received title to IPID's interest in lands adjacent to Eightmile Lake. Lands at Eightmile Lake conveyed to USFS are described as Section 5, Lots 1 and 2 of Township 23 N, Range 16 EWM and Section 33, Lot 1 of Township 24 N, Range 16 EWM. These descriptions correspond to an approximately 40 acre square parcel at the lake outlet and dam structure and an approximately 80 acre rectangular parcel along the south shore of the lake (see Figure 2-3). Under the land exchange agreement recorded with the Chelan County recorder's office IPID retained several rights to the land, including:

> "a nonexclusive, perpetual easement across, through, along, and upon the property described herein for the purposes of maintenance, repair, operation, modification, upgrading and replacement of all facilities presently located in or upon the property described herein, together with a nonexclusive right of ingress to and egress from all such facilities for all such purposes, in accordance with Rules and Regulations of the Secretary of Agriculture, 36 CFR 251.17 and 251.18, attached hereto and made a part hereof, in such manner as not unreasonably to interfere with its use by the United States, its authorized users or assigns, or cause substantial injury thereto.
>
> The Grantor [IPID] may exercise the rights hereunder by any means reasonable for the purposes described, including but not limited to the use of motorized transportation and equipment, or aircraft. These rights include the right to regulate water level of all facilities located upon the property described herein. In performing maintenance, repair, operation, modification, upgrading and replacement of facilities

> located in or upon the property described herein, the Grantor will not without prior written consent of the Forest Service, which consent shall not unreasonably be withheld, materially increase the size or scope of the facilities."

The recorded deed further recognized that IPID reserved their rights under water right Certificate 1228 and the Order granted by the Commissioner of Public Lands.

Eight Mile Lake Easements

Eight Mile Lake Storage Appraisal Study
Prepared for: Chelan County Department of Natural Resources
Chelan County, Washington

Aspect CONSULTING	NOV-2014	BY: JM / EAC	FIGURE NO. 2-3
	PROJECT NO. 120045	REV BY: ---	

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

GIS Path: T:\projects_8\ChelanCounty_DNR\8MileLake_120045\Deliverech\EightMileLakeEasements.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 11/18/2014 || User: ecrumbaker || Print Date: 11/18/2014

3 POTENTIAL RESTORATION OPTIONS

The Anchor QEA/Aspect team developed four potential storage restoration improvement options based on the lake storage volume evaluation from Forsgren and Gravity and input from IPID. The four options would increase the usable storage in the lake by one or a combination of the following improvements:

- Installing a siphon to draw the lake down further.
- Rebuilding the dam to restore the maximum water surface elevation to the historic overflow level (4,671 feet).
- Rebuilding the dam with a higher overflow to increase the maximum water surface elevation beyond the historic overflow level.

3.1 Option 1 – Increase Useable Storage to 2,000 Acre-feet

Option 1 would consist of the following improvements:

- Rebuilding the dam to restore the maximum water surface elevation to the historic overflow elevation (4,671.0 feet).
- Installing a low level siphon to lower the minimum drawdown water surface elevation to 4,636.7 feet.

These improvements would increase the usable storage to 2,000 acre-feet. Lake contours from Gravity Consulting were used to develop a stage-storage analysis for Eightmile Lake. The stage-storage relationship was used to determine the maximum elevation at which the low level siphon could be placed to increase the usable storage volume to 2,000 acre feet. In order to increase the usable storage to 2,000 acre-feet with a maximum water surface elevation of 4,671.0 feet, a siphon would need to be installed to draw the water surface elevation down to 4,636.7 feet, which is 7.3 feet lower than the current maximum drawdown, as reported by Forsgren and Gravity.

The following features would be included in Option 1 (See Figures 3-1A, 3-1B, and 3-1C):

- Intake Screen - An intake screen would be installed at the upstream end of the siphon. The screen would be designed to prevent debris from entering the siphon.

- **Siphon** – A siphon would be created by sliplining the existing 36-inch diameter low-level outlet pipe with a 30-inch diameter high-density polyethylene (HDPE) pipe. The pipe invert at the inlet would be set in the lake at an elevation of 4,636.7 feet. The pipe would need to extend down the existing outlet channel beyond the existing low-level outlet pipe to an elevation at least 6 to 7 feet below the pipe inlet. The siphon pipe would be approximately 540 feet in length.
- **Vent** – A vent with a combination air release valve would be installed on the siphon near the dam to release entrapped air. The vent would also be designed to prevent the siphon from breaking during operation. Controls would be provided to allow air to enter the siphon through the vent to facilitate draining the siphon at the end of the season.
- **Control Valves** - 30-inch control valves would be provided on the siphon near the dam and at the downstream end to enable draining of the siphon and to allow the siphon to recharge when the lake refills in the winter and spring.
- **Dam –** The existing masonry dam would be completely removed and a new concrete dam with rock masonry facing would be installed. The new dam would have a spillway crest elevation of 4,671.0 feet and top elevation of 4,673.0 feet. The dam would be approximately 180 feet long and would include a walkway at the top of the dam.
- **Spillway –** A notch in the concrete dam would allow the lake to overflow. The spillway would discharge water to a rock pad and down the existing rock-lined spillway channel.

Figures 3-1A illustrates the improvement concept in plan view. Figure 3-1B provides a conceptual section of the dam, siphon, and spillway. Figure 3-1C illustrates the new minimum and maximum water surface areas that would result from implementation of Option 1. The maximum inundation area, approximately 81.7 acres, would be equal to the historic maximum inundation area. The water surface area at the new maximum drawdown elevation would be approximately 38.3 acres, which is approximately 6.3 acres less than the water surface is at the current maximum drawdown elevation.

3.2 Option 2 – Increase Useable Storage to 2,500 Acre-feet

Option 2 would consist of the following improvements:

- Rebuilding the dam to restore the maximum water surface elevation to the historic overflow elevation (4,671.0 feet).
- Installing a low level siphon to lower the minimum drawdown water surface elevation to 4,621.6 feet.

These improvements would increase the usable storage to 2,500 acre-feet. The stage-storage relationship developed from lake contours provided by Gravity Consulting was used to determine the maximum elevation at which the low level siphon could be placed to increase the usable storage volume to 2,500 acre feet. In order to increase the usable storage to 2,500 acre-feet with a maximum water surface elevation of 4,671.0 feet, a siphon would need to be installed to draw the water surface elevation down to 4,621.6 feet, which is 22.4 feet lower than the current maximum drawdown, as reported by Forsgren and Gravity.

The following features would be included in Option 2 (See Figures 3-2A, 3-2B, and 3-2C):

- **Intake Screen** - An intake screen would be installed at the upstream end of the siphon. The screen would be designed to prevent debris from entering the siphon.
- **Siphon** – A siphon would be created by sliplining the existing 36-inch diameter low-level outlet pipe with a 30-inch diameter HDPE pipe. The pipe invert at the inlet would be set in the lake at an elevation of 4,621.6 feet. The pipe would need to extend down the existing outlet channel beyond the existing low-level outlet pipe to an elevation at least 6 to 7 feet below the pipe inlet. The siphon pipe would be approximately 760 feet in length.
- **Vent** – A vent with a combination air release valve would be installed on the siphon near the dam to release entrapped air. The vent would also be designed to prevent the siphon from breaking during operation. Controls would be provided to allow air to enter the siphon through the vent to facilitate draining the siphon at the end of the season.
- **Control Valves** - 30-inch control valves would be provided on the siphon near the dam and at the downstream end to enable draining of the siphon and to allow the siphon to recharge when the lake refills in the winter and spring.

- **Dam –** The existing masonry dam would be completely removed and a new concrete dam with rock masonry facing would be installed. The new dam would have a spillway crest elevation of 4,671.0 feet and top elevation of 4,673.0 feet. The dam would be approximately 180 feet long and would include a walkway at the top of the dam.
- **Spillway –** A notch in the concrete dam would allow the lake to overflow. The spillway would discharge water to a rock pad and down the existing rock-lined spillway channel.

Figures 3-2A illustrates the improvement concept in plan view. Figure 3-2B provides a conceptual section of the dam, siphon, and spillway. Figure 3-2C illustrates the new minimum and maximum water surface areas that would result from implementation of Option 2. The maximum inundation area, approximately 81.7 acres, would be equal to the historic maximum inundation area. The water surface area at the new maximum drawdown elevation would be approximately 27.1 acres, which is approximately 17.5 acres less than the water surface are at the current maximum drawdown elevation.

3.3 Option 3 – Increase Useable Storage to 2,500 Acre-feet

Like Option 2, Option 3 would also increase the usable storage volume in the lake to 2,500 acre-feet. Option 3 would include the following improvements:

- Rebuilding the dam with an overflow elevation of 4,672.0 feet, or 1 foot higher than the historic overflow elevation (4,671.0 feet)
- Installing a low level siphon to lower the minimum drawdown water surface elevation to 4624.6 feet.

The stage-storage relationship developed from lake contours provided by Gravity Consulting was used to determine the maximum elevation at which the low level siphon could be placed to increase the usable storage volume to 2,500 acre feet. In order to increase the usable storage to 2,500 acre-feet with a maximum water surface elevation of 4,672.0 feet, a siphon would need to be installed to draw the water surface elevation down to 4,624.6 feet, which is 19.4 feet lower than the current maximum drawdown, as reported by Forsgren and Gravity.

The following features would be included in Option 3 (See Figures 3-3A, 3-3B, and 3-3C):

- **Intake Screen -** An intake screen would be installed at the upstream end of the siphon. The screen would be designed to prevent debris from entering the siphon.
- **Siphon** – A siphon would be created by sliplining the existing 36-inch diameter low-level outlet pipe with a 30-inch diameter HDPE pipe. The pipe invert at the inlet would be set in the lake at an elevation of 4,624.6 feet. The pipe would need to extend down the existing outlet channel beyond the existing low-level outlet pipe to an elevation at least 6 to 7 feet below the pipe inlet. The siphon pipe would be approximately 680 feet in length.
- **Vent** – A vent with a combination air release valve would be installed on the siphon near the dam to release entrapped air. The vent would also be designed to prevent the siphon from breaking during operation. Controls would be provided to allow air to enter the siphon through the vent to facilitate draining the siphon at the end of the season.
- **Control Valves -** 30-inch control valves would be provided on the siphon near the dam and at the downstream end to enable draining of the siphon and to allow the siphon to recharge when the lake refills in the winter and spring.
- **Dam –** The existing masonry dam would be completely removed and a new concrete dam with rock masonry facing would be installed. The new dam would have a spillway crest elevation of 4,672.0 feet and top elevation of 4,674.0 feet. The dam would be approximately 190 feet long and would include a walkway at the top of the dam.
- **Spillway –** A notch in the concrete dam would allow the lake to overflow. The spillway would discharge water to a rock pad and down the existing rock-lined spillway channel.

Figures 3-3A illustrates the improvement concept in plan view. Figure 3-3B provides a conceptual section of the dam, siphon, and spillway. Figure 3-3C illustrates the new minimum and maximum water surface areas that would result from implementation of Option 3. The maximum inundation area, approximately 82.8 acres, would be less than 2 acres larger than the historic maximum inundation area. Most of the newly inundated area would be along the existing, relatively steep shoreline. The water surface area at the new maximum drawdown elevation would be approximately 29.2 acres, which is approximately 15.4 acres less than the water surface are at the current maximum drawdown elevation.

3.4 Option 4 – Increase Useable Storage to 3,500 Acre-feet

Option 4 would increase the usable storage volume in the lake to 3,500 acre-feet by completing the following improvements:

- Rebuilding the dam with an overflow elevation of 4,682.0 feet, or 11 feet higher than the historic overflow elevation (4,671.0 feet).
- Installing a low level siphon to lower the minimum drawdown water surface elevation to 4,619.0 feet.

These improvements were determined by estimating lowest reasonable drawdown level through the proposed siphon. A siphon has a maximum workable height, or maximum difference between the water level at the inlet and the high point on the siphon, equal to the atmospheric pressure plus pressure losses through the flowing siphon. For Eightmile Lake, the atmospheric pressure is approximately 12.46 pounds per square inch (psi), which is equal to 28.7 feet of pressure head. If pressure losses through the flowing siphon are estimated to be approximately 10%, the maximum workable height is approximately 25 feet. In order to increase useable storage to 3,500 acre-feet using a maximum drawdown that is 25 feet below the existing maximum drawdown level (elevation 4619.0 feet), the dam overflow elevation would have to be increased to elevation 4682.0 feet, which is 11 feet higher than the historical overflow elevation.

The following features would be included in Option 4 (See Figures 3-4A, 3-4B, and 3-4C):

- **Intake Screen -** An intake screen would be installed at the upstream end of the siphon. The screen would be designed to exclude fish and prevent debris from entering the siphon.
- **Siphon** – A siphon would be created by sliplining the existing 36-inch diameter low-level outlet pipe with a 30-inch diameter HDPE pipe. The pipe invert at the inlet would be set in the lake at an elevation of 4,619.0 feet. The pipe would need to extend down the existing outlet channel beyond the existing low-level outlet pipe to an elevation at least 6 to 7 feet below the pipe inlet. The siphon pipe would be approximately 800 feet in length.
- **Vent** – A vent with a combination air release valve would be installed on the siphon near the dam to release entrapped air. The vent would also be designed to prevent the siphon

from breaking during operation. Controls would be provided to allow air to enter the siphon through the vent to facilitate draining the siphon at the end of the season.

- **Control Valves –** 30-inch control valves would be provided on the siphon near the dam and at the downstream end to enable draining of the siphon and to allow the siphon to recharge when the lake refills in the winter and spring.
- **Dam –** The existing masonry dam would be completely removed and a new concrete dam with rock masonry facing would be installed. The new dam would have a spillway crest elevation of 4,682.0 feet and top elevation of 4,684.0 feet. The dam would be approximately 360 feet long and would include a walkway at the top of the dam.
- **Spillway –** A notch in the concrete dam would allow the lake to overflow. The spillway would discharge water to a rock pad and down the existing rock-lined spillway channel.

Figures 3-4A illustrates the improvement concept in plan view. Figure 3-4B provides a conceptual section of the dam, siphon, and spillway. Figure 3-4C illustrates the new minimum and maximum water surface areas that would result from implementation of Option 4. The maximum inundation area, approximately 91.1 acres, would be more than 9 acres larger than the historic maximum inundation area. Most of the newly inundated area would be along the existing, relatively steep shoreline. The water surface area at the new maximum drawdown elevation would be approximately 25.7 acres, which is approximately 18.9 acres less than the water surface are at the current maximum drawdown elevation.

The stage storage curve developed for Eightmile Lake is illustrated in Figure 3-5. The minimum and maximum water surface elevations and volumes associated with each Option are also shown in Figure 3-5.

EIGHTMILE LAKE

4,620
4,630
4,640
4,662
4,632
4,640
4,670
4,664
4,670
4,660
4,680
4,684
4,682
4,684
4,680
4,670
4,660
4,650

INTAKE SCREEN
IE 4,637

30" ø HDPE SIPHON
540 LF

EX OUTLET
GATE

30" ø CONTROL GATE

VENT WITH COMBINATION AIR RELEASE VALVE

SPILLWAY (CREST ELEVATION 4,671)

EX ROCK EMBANKMENT

EX CUTOFF
WALL (TYP)

CONCRETE DAM WITH ROCK FACING
180' LONG; TOP ELEV. = 4,673

EX SPILLWAY WELL

EX SPILLWAY CHANNEL

EX MASONRY DAM

WALKWAY

EX 36" ø CMP LOW-LEVEL
OUTLET PIPE

EXTEND SIPHON TO DAYLIGHT IN CHANNEL AT ELEV. 4,630

3-1A
3-1B

0 40
Scale in Feet

SOURCE: Aerial image provided by ERSI; Topography provided by Forsgren Associates
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: NAVD 88

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Mar 12, 2015 3:39pm ahill

Figure 3-1A
Improvement Plan, Option 1 - Increase Useable Storage to 2,000 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

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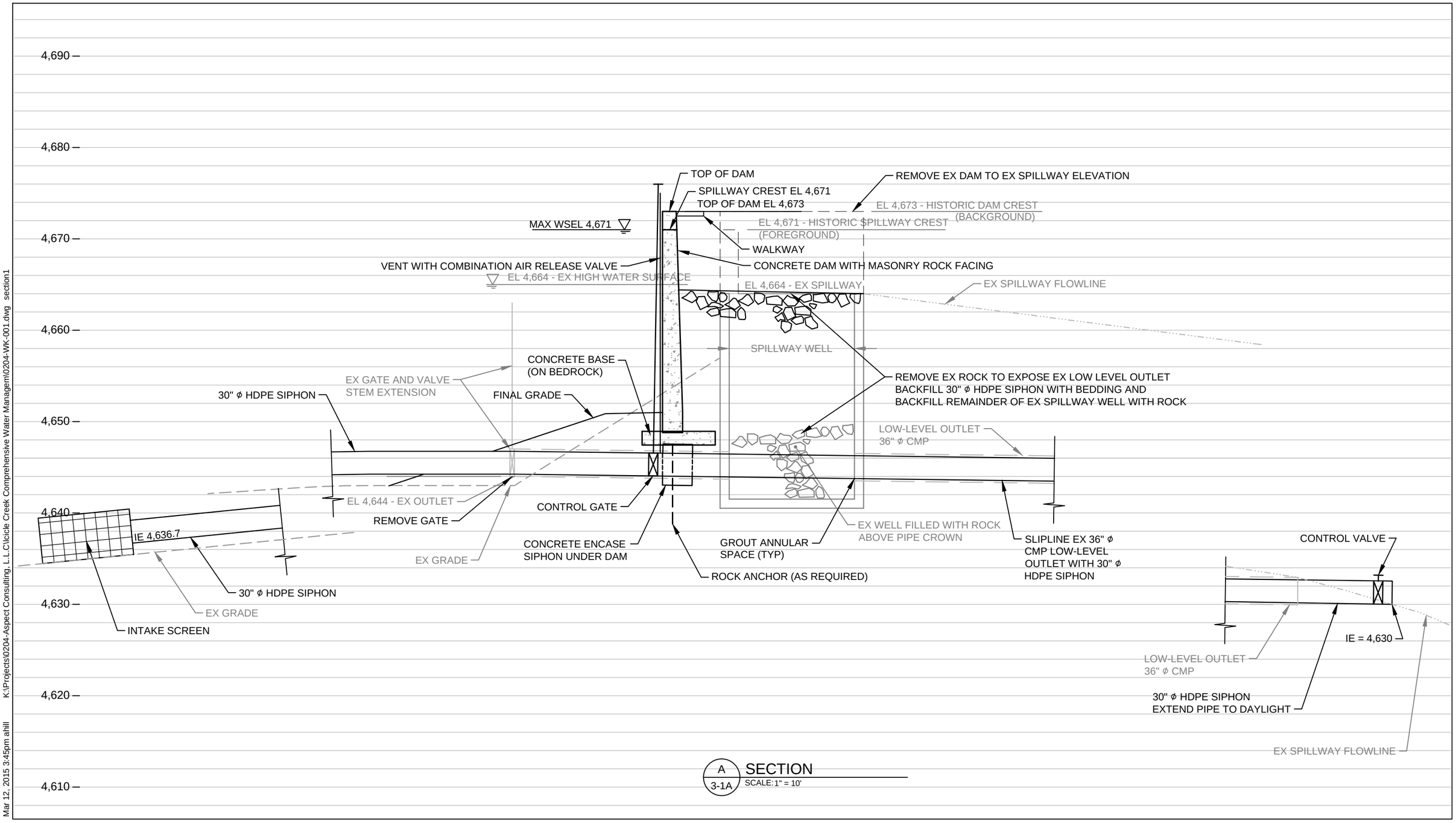

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Figure 3-1B
Improvement Section, Option 1 - Increase Useable Storage to 2,000 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

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Source: Aerial image provided by Esri.
Horizontal Datum: Washington State Plane North, NAD83, U.S. Feet.

Feet
0 150 300 450 600

Figure 3-1C
Minimum and Maximum Inundation Areas, Option 1 - Increase Usable Storage to 2,000 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

SOURCE: Aerial image provided by ERSI; Topography provided by Forsgren Associates
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: NAVD 88

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Figure 3-2A
Improvement Plan, Option 2 - Increase Useable Storage to 2,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

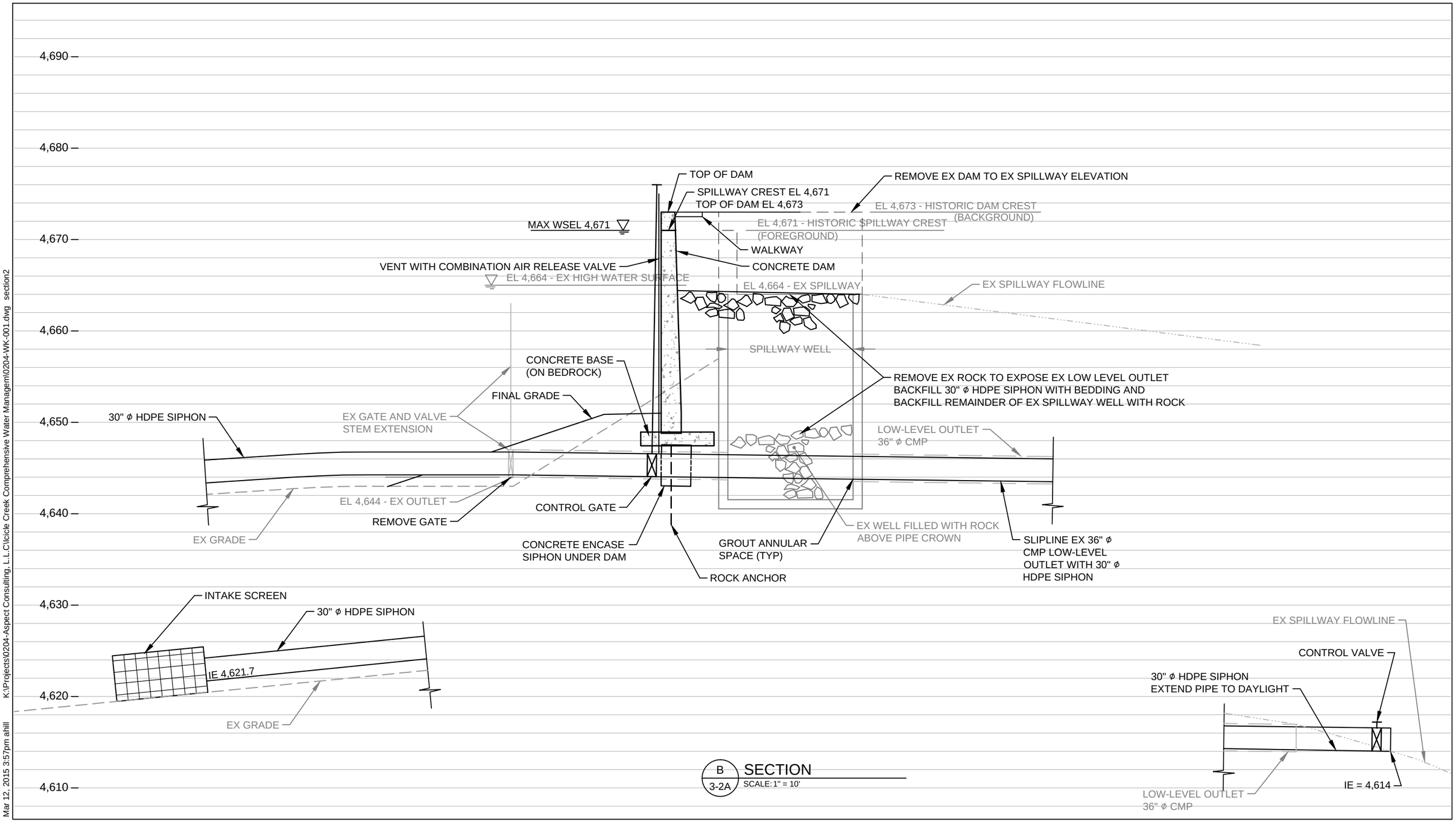

Figure 3-2B
Improvement Section, Option 2 - Increase Useable Storage to 2,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

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Source: Aerial image provided by Esri.
Horizontal Datum: Washington State Plane North, NAD83, U.S. Feet.

Feet
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Figure 3-2C
Minimum and Maximum Inundation Areas, Option 2 - Increase Usable Storage to 2,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

EIGHTMILE LAKE

4,620

4,630

4,640

4,662

4,632

4,640

4,672

4,670

4,664

4,670

4,674

4,660

4,680

4,684

4,682

4,684

4,680

4,670

4,660

4,650

INTAKE SCREEN
IE 4,624

30" ϕ HDPE SIPHON
680 LF

EX OUTLET
GATE

30" ϕ CONTROL GATE

VENT WITH COMBINATION AIR RELEASE VALVE

SPILLWAY (CREST ELEVATION 4,672)

EX ROCK EMBANKMENT

EX CUTOFF
WALL (TYP)

CONCRETE DAM WITH ROCK FACING
190' LONG; TOP ELEV = 4,674

EX SPILLWAY WELL

EX SPILLWAY CHANNEL

EX MASONRY DAM

WALKWAY

EX 36" ϕ CMP LOW-LEVEL
OUTLET PIPE

EXTEND SIPHON TO DAYLIGHT IN CHANNEL AT ELEV. 4,618

C
3-3B

0 40
Scale in Feet

SOURCE: Aerial image provided by ERSI; Topography provided by Forsgren Associates
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: NAVD 88

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Figure 3-3A
Improvement Plan, Option 3 - Increase Useable Storage to 2,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

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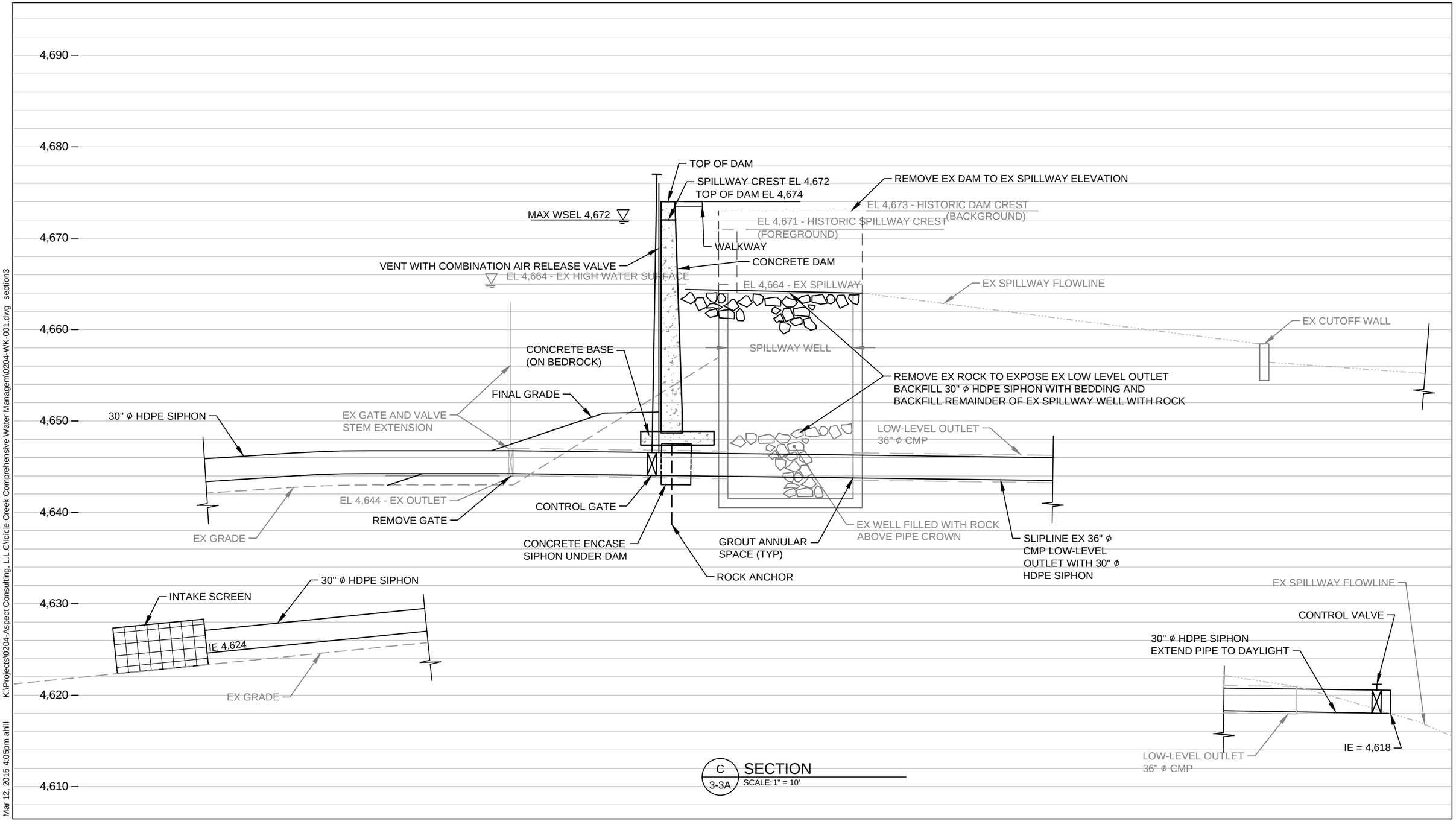

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Figure 3-3B
Improvement Section, Option 3 - Increase Useable Storage to 2,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

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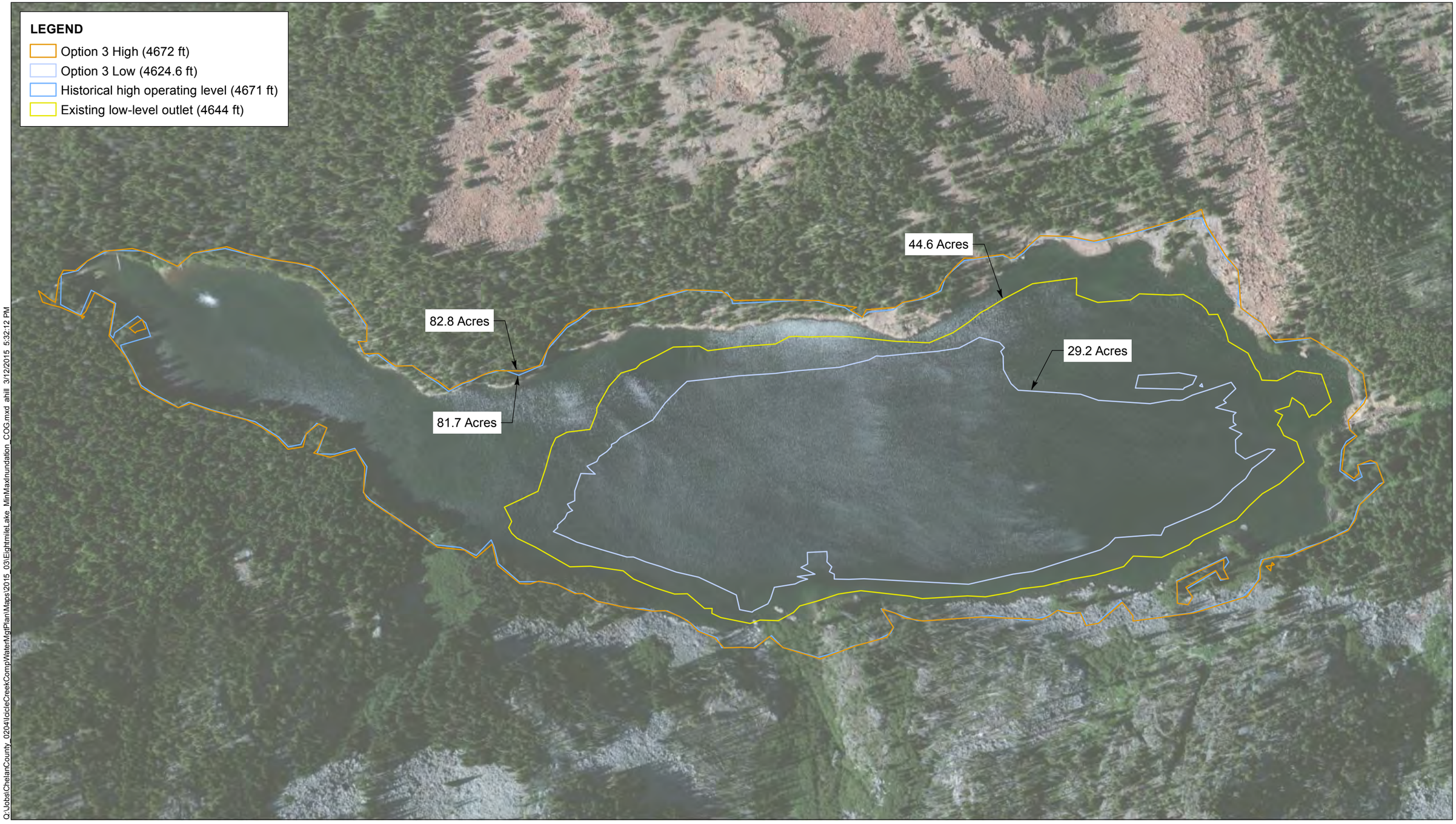

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Source: Aerial image provided by Esri.
Horizontal Datum: Washington State Plane North, NAD83, U.S. Feet.

Feet
0 150 300 450 600

Figure 3-3C
Minimum and Maximum Inundation Areas, Option 3 - Increase Usable Storage to 2,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

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Figure 3-4A
Improvement Plan, Option 4 - Increase Useable Storage to 3,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

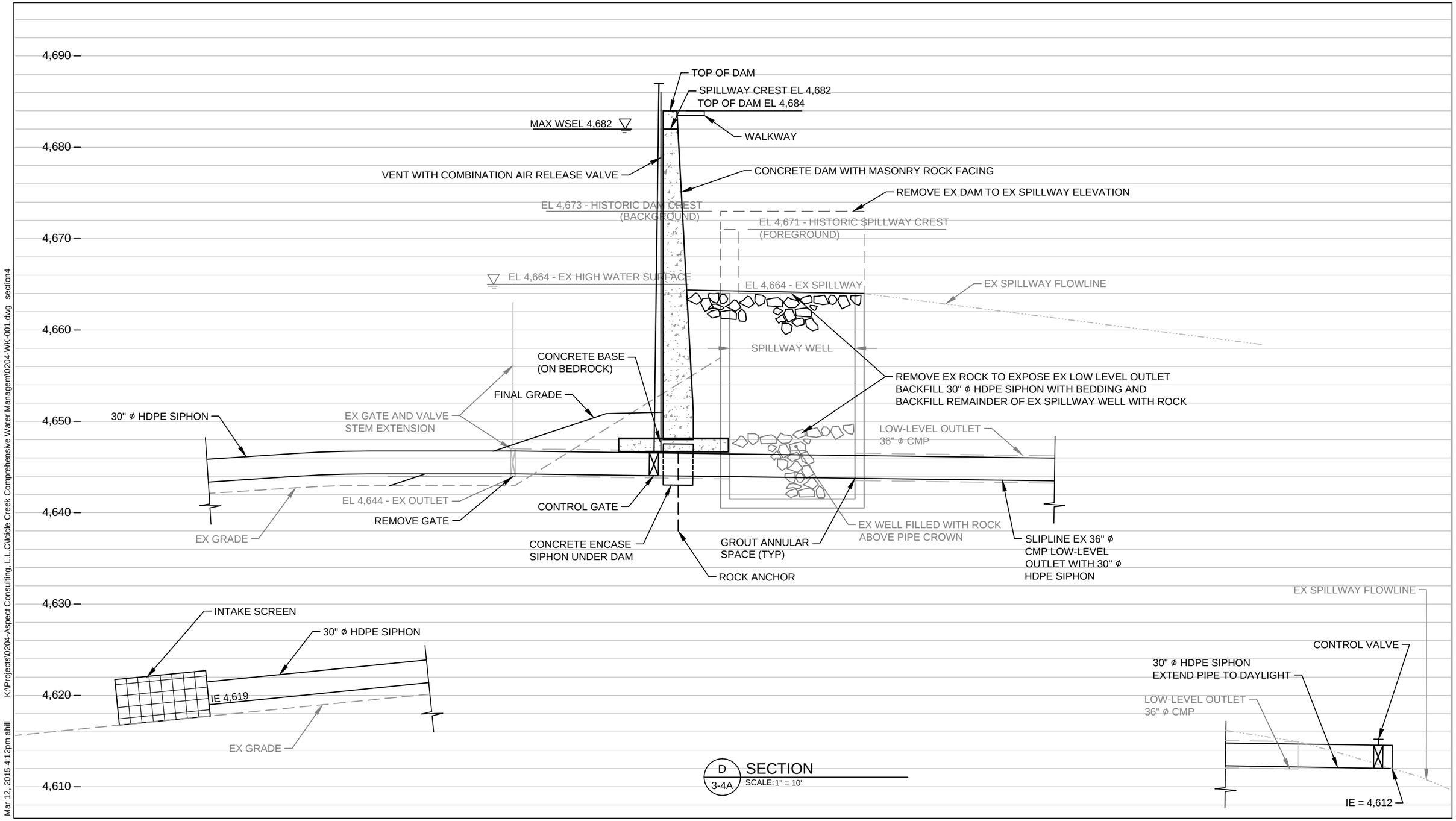

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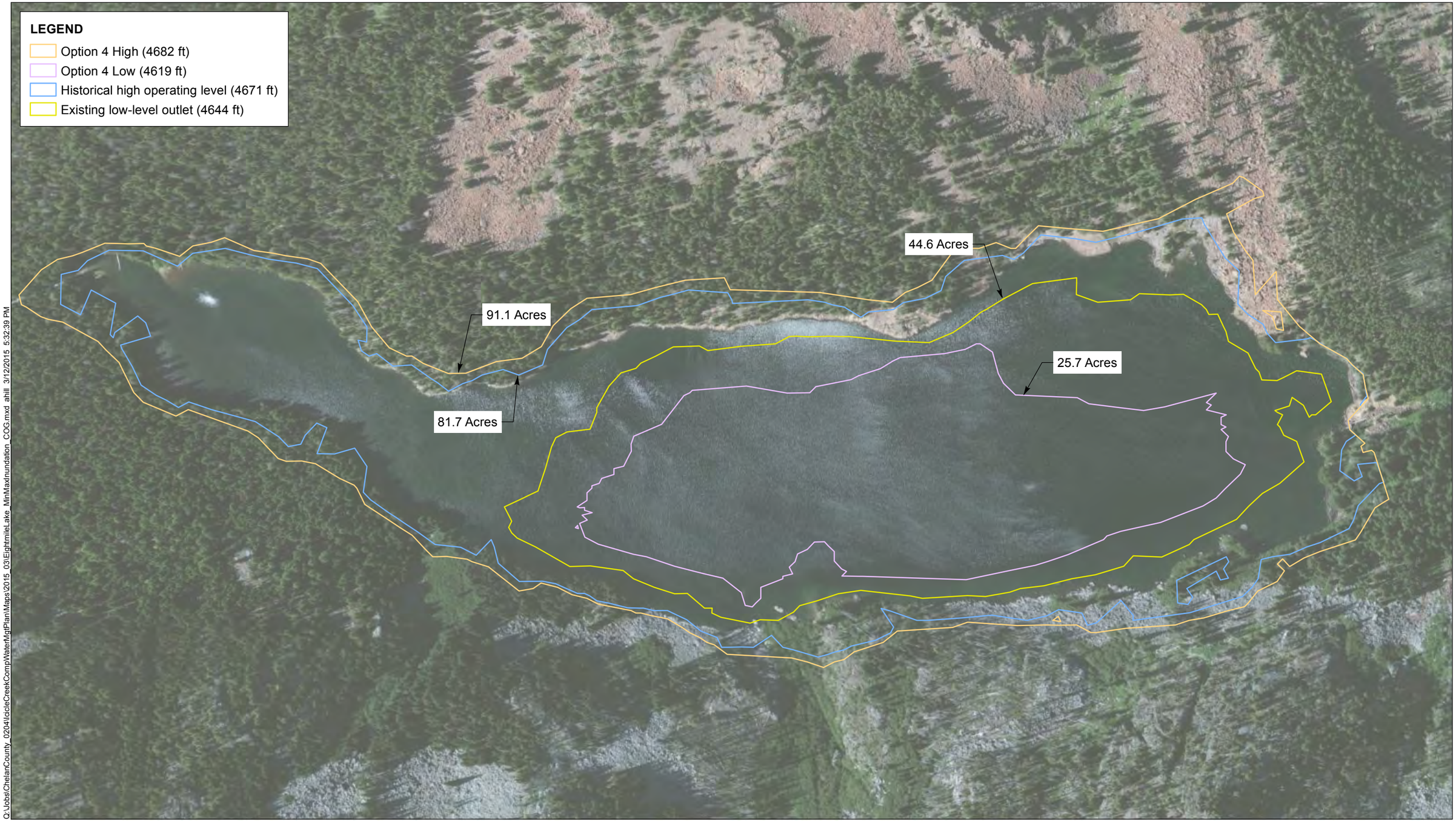
Figure 3-4B
Improvement Section, Option 4 - Increase Useable Storage to 3,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts



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Source: Aerial image provided by Esri.
Horizontal Datum: Washington State Plane North, NAD83, U.S. Feet.

Feet
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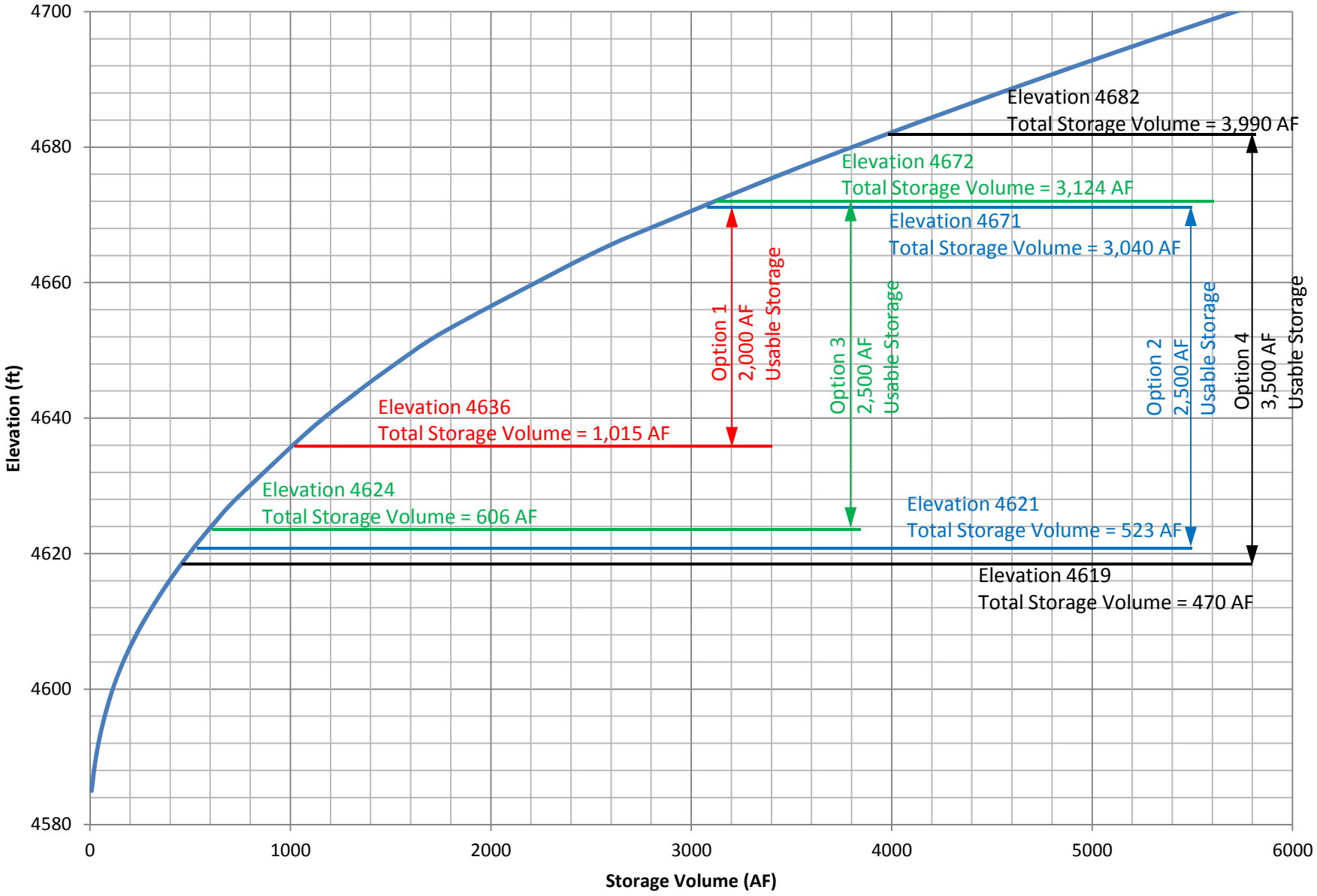
Figure 3-4C
Minimum and Maximum Inundation Areas, Option 4 - Increase Usable Storage to 3,500 Acre-feet
Appraisal Study Eightmile Lake Storage Restoration
Chelan County Natural Resources Department/Icicle and Peshastin Irrigation Districts

Figure 3-5: Eightmile Lake Stage-Storage Curve



4 POTENTIAL OPERATIONAL IMPROVEMENT OPTIONS

Modernization, automation, and remote control of releases from the Alpine Lakes are detailed in the draft *Alpine Lakes Optimization and Automation Appraisal Study* (Aspect and Anchor QEA 2014), which was prepared concurrently with this report. That study outlines requirements for potential operational improvements at each of the IPID-managed lakes that would allow for remote control of releases and optimized use of existing storage. Additional detail is provided in that report regarding automation improvements. The information developed for that report is summarized for Eightmile Lake in this section.

4.1 Gate Improvements and Automation

The existing outlet works at Eightmile Lake include a rising stem positive seating slide gate. As noted previously, the existing gate is very difficult to operate because the actuator has been removed and rock and debris have piled up against and below the existing gate. Installation of a siphon with new control valves is proposed as part of each improvement option. The main components that would be required to automate operation of the valves and provide for remote control of lake releases include:

- A motorized actuator
- A programmable controller
- Telemetry
- A power supply
- An enclosure to protect the equipment

4.1.1 Motorized Actuator

In order to automate releases from the lake, the new control valves would need to be provided with motorized actuators compatible with direct current power supply. Options include custom actuator construction or commercially available models. Commercially available options include motor, limit sensors/controls, gear reduction, and enclosure and are available in many torque ranges from as little as 20 feet-pound to over 700 feet-pound. Most of the commercially available motorized actuators are available with optional hand wheels for manual override operation of valves if needed.

4.1.2 Programmable Controller

The interface between the remote communication and the motorized actuator is the programmable controller which translates signals received from the radio signal/modem to control signals for actuator operation. The controller would preferably be non-volatile memory, meaning that data and programming would not be lost in the event of power failure. Many commercially available controllers would be suitable in this application. One that has been successfully implemented by Reclamation for similar installations is the Campbell Scientific CR10X.

4.1.3 Communications

Assuming radio is the preferred wireless communication means; the necessary equipment would consist of a radio modem, a radio transceiver, and a directional radio antenna. This equipment would allow for communication of a signal from a nearby repeater station using a VHF signal to the programmable datalogger/controller.

4.1.4 Power Supply

Due to the remote location of the lake, the power supply for the gate operators and controls would need to be direct current (DC)/battery-operated. It is assumed that batteries would be rechargeable with a permanently installed solar panel array. Similar installations have been successfully installed at Nada and Snow Lakes. Based on analysis completed for the *Alpine Lakes Optimization and Automation Appraisal Study*, solar supply for a rechargeable DN/battery-operated system is not anticipated to be a limiting factor in providing for remote operation of control gates.

4.2 Optimization of Releases with Automation

Remote communication at Eightmile Lake was also evaluated in detail as part of the *Alpine Lakes Optimization and Automation Appraisal Study*. The ability to remotely communicate would allow for remote operation of control gates, fine tuning of releases, and monitoring of conditions at the lake without time consuming trips to inspect the lake in person. The two primary technologies that were considered and field tested were cellular and radio wave communication, as follows:

- Cellular Communication: Cellular communication, where available, affords the most direct transmission of data over a cellular carrier's IP network directly to an on-site, or cloud-based server. Cell modems are an increasingly common option where coverage is available.
- Radio Communication: Radio wave communication allows the use of intermediate repeater stations to accommodate greater ranges in areas where no other method of communication is available.

The analysis indicated that a new a repeater station would be required to provide radio communication to all of the IPID-managed lakes, including Eightmile Lake, in the Alpine Lakes Wilderness. Line-of-site and radio-path analyses completed for the *Alpine Lakes Optimization and Automation Appraisal Study* indicated that, of all the Alpine Lakes, Eightmile Lake had the most potential for successful communication with existing communications infrastructure. In addition, the IPID Manager has indicated that he has had cellular phone reception at Eightmile Lake.

5 SUMMARY OF POTENTIAL WATER USE AND BENEFITS

5.1 Icicle Work Group Guiding Principles

The Office of Columbia River (OCR) granted Chelan County funding for this appraisal study to evaluate the potential for restoration and possible expansion of Eightmile Lake to meet Guiding Principles adopted by the IWG. The purpose of the IWG is to develop a comprehensive Icicle Creek Water Resource Management Strategy through a collaborative process that will achieve diverse benefits defined by all of the Guiding Principles described in Section 1. The IWG is using best available science to identify and support water management solutions that lead to implementation of high-priority water resource projects within the Icicle Creek drainage.

Table 5-1 summarizes the Guiding Principles from Section 1 and where this project helps meet them.

Table 5-1
Applicability of Icicle Work Group Guiding Principles

Guiding Principle	Eightmile Restoration
1. Streamflow Improvement	Significant enhancement of flows
2. Sustainable Hatchery	Could potentially benefit hatchery operations if lake was managed to allow for winter low-flow period releases
3. Tribal Treaty Rights	Significant enhancement of flows
4. Municipal/Domestic Supply	900+ acre-feet of new supply for municipal use
5. Agricultural Reliability	Restores storage volume, while automation and optimization improves reliability of supply
6. Ecosystem Health/Habitat	Instream flow enhancement benefits habitat
7. Compliance with State/Federal Laws	Required for project permitting and construction
8. Non-Treaty Harvest Protection	Significant enhancement of flows
9. Wilderness Act Compliance	Required for project permitting and construction

5.2 Storage Yield

Each of the options presented above would increase the storage yield for Eightmile Lake. In its current configuration, the Eightmile Lake usable storage is 1,375 acre-feet. If the total usable storage is released over a 60-day release period, the average flow released is

approximately 11.6 cfs. Table 5-2 provides a summary of the additional storage volume and release rates that would be made available by the improvements included in each Option. Option 1 would increase the volume available for release by 45% (625 acre-feet). Options 2 and 3 would increase the volume available for release by 82% (1,125 acre-feet), and Option 4 would increase this volume by 155% (2,125 acre-feet).

Table 5-2
Estimated Usable Volume and Releases

Restoration Option	Usable Volume (acre-feet)	Increase in Usable Volume (acre-feet)	Additional Release Over 60-day Period (cfs)
Existing Condition	1,375	0	0
Option 1	2,000	625	5.3
Option 2	2,500	1,125	9.5
Option 3	2,500	1,125	9.5
Option 4	3,500	2,125	17.9

5.3 Instream Flow Benefits

Release of additional storage from Eightmile Lake could simultaneously help meet the Guiding Principles related to agricultural reliability, instream flows, ecosystem health and habitat, and protection of tribal treaty and non-treaty fisheries harvest that would benefit from flow and habitat improvements. As shown in Table 5-2, if the increased storage is released over a 60-day period corresponding with late summer/early fall low flows in Eightmile Creek and Icicle Creek, approximately 5 to 18 cfs in flow benefits could be achieved for the storage options that have been evaluated, relative to the current usable storage of 1,375 acre-feet.

Late summer/early fall flow augmentation releases would benefit about five miles of Eightmile Creek and about 9 miles of Icicle Creek. If the City of Leavenworth accesses their 900 acre-feet of water using their existing wells in hydraulic continuity with the Wenatchee River, the entire reach of Icicle Creek, including the historic creek channel adjacent to the Leavenworth National Fish Hatchery, would experience the full benefit of increased flows.

5.4 Out-of-Stream Use Benefits

The intent of the Eightmile Lake storage restoration project is to meet multiple prongs of the Guiding Principles as part of an integrated package. This is part of a broader package of projects under development designed in part to meet IPID's needs through the Guiding Principles. If IPID agrees with the Integrated Projects being developed, we understand IPID is willing to retain 1,600 acre-feet of storage supply under its adjudicated water rights for Eightmile Lake and transfer 900 acre-feet of supply to the City of Leavenworth[3]. Implementation of this project would allow the current litigation over water rights between the City of Leavenworth and Department of Ecology to be dismissed. The City and Ecology are in dispute over interpretation of the City's water rights, with the disputed quantities totaling 800 acre-feet per year. This project would supply water in excess of that quantity to the City for municipal water supply.

5.5 Reliability

From Section 2.3, the estimated 90% exceedance annual inflow is approximately 10,900 acre-feet. This value is more than three times the proposed usable storage volumes for all options, so it is anticipated that inflows from the lake's drainage basin will be able to reliably recharge the additional storage and releases made available from the proposed improvements.

To check reliability for potential future inflows from climate change impacts, an analysis of climate change was completed as part of the draft *Alpine Lakes Optimization and Automation Appraisal Study*. It was found that for the climate change scenarios that were evaluated (moderate future conditions, less adverse future conditions, and more adverse future conditions), the 90% exceedance annual inflow would still be at least 2.5 times the proposed usable storage volumes for all options. Based on this analysis, inflows should be able to reliably supply the additional storage and releases made available from improvements even with potential climate change effects.

[3] The contractual terms of this transfer between IPID and the City are still under negotiation and likely would not be finalized until following feasibility study and environmental review.

6 PRELIMINARY ENVIRONMENTAL AND PERMITTING EVALUATION

Using existing information and professional knowledge of the study area, a preliminary review of environmental resources and permitting requirements was conducted to identify potential impact(s) or requirement(s) that could be considered "fatal flaws" associated with the Eightmile Lake water storage options. The analysis included consideration of regulatory requirements associated with repairing or replacing the dam and reconfiguring the low-level outlet to restore the useable storage capacity of the lake and allow for automation and optimization of releases from the lake. Four options were reviewed and analyzed with specific emphasis on identifying any regulatory issues that would preclude one or more of the options being carried forward for additional analysis.

6.1 Natural Resources

Natural resources are naturally occurring environmental features that may have material and/or aesthetic and recreational value. They are primarily regulated by local governments and state and federal agencies. Specific natural resources assessed in this evaluation include salmonids, wildlife species, fish and wildlife habitat conservation areas, riparian areas, and wetlands that might exist within, in proximity of, or downstream of the proposed options.

Discussion of natural resources is focused on Eightmile Lake and its downstream watershed, including Eightmile Creek, and Icicle Creek, downstream of its confluence with Eightmile Creek.

6.1.1 Aquatic Habitat and Species

6.1.1.1 Aquatic Habitat

Eightmile Lake is a part of the Icicle Creek watershed within the Wenatchee Sub-basin (Water Resource Inventory Area [WRIA] 45). Eightmile Lake discharges surface water to Eightmile Creek, which is a tributary to Icicle Creek. Eightmile Creek also flows through Little Eightmile Lake downstream of the larger lake, and then merges with Mountaineer Creek, prior to its confluence with Icicle Creek.

Fish passage is blocked in several areas downstream of Eightmile Lake. Fish passage is unlikely in the upper reaches of Eightmile Creek as a result of steep elevation along the creek up to Little Eightmile and Eightmile lakes. Fish passage is also at least partially blocked on Icicle Creek downstream of its confluence with Eightmile Creek at River Mile (RM) 5.6, where there is a natural boulder field that creates a substantial velocity and gradient barrier (partial barrier at some flows) on Icicle Creek. In 2013, Trout Unlimited finalized the *Icicle Creek Boulder Field Fish Passage Assessment* (Dominguez 2013), assessing the potential for fish distribution in the 23 miles above the natural boulder field on Icicle Creek. The National Oceanic and Atmospheric Administration's (NOAA) Pacific Coastal Salmon Recovery Fund program has identified the Icicle Creek Boulder Field Passage Design Project for funding, which proposes to complete preliminary designs for fish passage at the boulder field and assess spawning and rearing habitat above the barrier (NOAA 2014). The status of the design project is noted as "ongoing" on the NOAA's website (NOAA 2014).

Fish passage is also restricted further downstream on Icicle Creek at RM 2.7 at the U.S. Fish and Wildlife Service (USFWS) LNFH. Additionally, there are several irrigation diversions along Icicle Creek in this reach (Andonaegui 2001). The upper portion of the Icicle Creek watershed above RM 5.6 contains high quality aquatic and terrestrial habitat, and is designated as a key watershed by the Northwest Forest Plan (WRIA 45 Planning Unit 2006).

The *USFWS Wetlands Mapper for NWI Map Information* does not identify any wetland features adjacent to or within the vicinity of Eightmile Lake (USFWS 2014). The Chelan County GIS Mapper does not identify any Federal Emergency Management Agency designated 100-year or 500-year floodzones adjacent to or within the vicinity of Eightmile Lake (Chelan County 2014).

6.1.1.2 Endangered Species Act-Listed and Priority Habitat Species

Within the Icicle Creek watershed, Endangered Species Act (ESA)-listed Upper Columbia River spring-run Chinook salmon (*Oncorhynchus tshawytscha*), Upper Columbia River steelhead trout (*O. mykiss*), and bull trout (*Salvelinus confluentus*) use the area for upstream and downstream movement, migration, and juvenile rearing. These species were also chosen by the WRIA 45 Planning Unit as species of interest (Anchor QEA 2007).

The Icicle Creek watershed is also within the Wenatchee Core Area of the Upper Columbia Bull Trout Recovery Unit. The Icicle Creek bull trout were added as a local migratory population in a revised version of the draft bull trout recovery plan, and the potential use of Icicle Creek by migratory bull trout and their status and interaction with the resident component were identified as research needs (USFWS 2004 and USFWS 2009). Migratory and resident bull trout spawn in the colder headwater tributaries (including Eightmile Creek [Andonaegui 2001]) and migrate within other Wenatchee subwatersheds and the Columbia River (WRIA 45 Planning Unit 2006).

Priority Habitat and Species (PHS) managed by Washington Department of Fish and Wildlife (WDFW) located within Eightmile Lake include breeding and migration areas for rainbow trout (*O. mykiss*) (WDFW 2014).

As discussed in Section 6.1.1.1 there is a significant change in elevation from the lower reaches of Eightmile Creek up to Little Eightmile Lake and Eightmile Lake, making fish migration up to the lakes unlikely. Although bull trout have been noted in the lower reaches of Eightmile Creek, it is unlikely bull trout can successfully migrate up to the lakes. Additionally, while WDFW's PHS mapping shows Eightmile Lake as a breeding and migratory area for rainbow trout, these are likely introduced stocked fish species. See Section 6.1.1.3 for more discussion on introduced species.

6.1.1.3 Other Aquatic Species

Salmonids known to inhabit Icicle Creek above the natural boulder field at RM 5.6 are Eastern brook trout, hybrid bull trout x brook trout (*S. confluentus x fontinalis)*, westslope cutthroat trout (*Oncorhynchus clarki lewisi)*, rainbow trout, and redband rainbow trout (*O. mykiss gairdneri)*.

Other salmonids found only downstream of RM 5.6 in Icicle Creek include spring and summer hatchery Chinook salmon (*O. tshawytscha),* hatchery coho salmon (*O. kisutch)*, stray hatchery sockeye salmon (*O. nerka)*, and mountain whitefish (*Prosopium williamsoni).* Non-salmonid species downstream of the boulder field within Icicle Creek include northern pikeminnow (*Ptychocheilus oregonensis)*, longnose dace (*Rhinicthys cataractae)*, speckled

dace (*Rhinicthys osculus),* redside shiner (*Richardsonius balteatus),* various sculpin species (*Cottus* spp.), and various sucker species (*Catostomus* spp.*)* (USFWS 2009).

In addition to the PHS managed rainbow trout, Eightmile Lake contains introduced Eastern brook trout (*Salvelinus fontinalis*) and lake trout (*Salvelinus namaycush*) (NWPPC 2004).

6.1.2 Terrestrial Habitat and Species

6.1.2.1 Terrestrial Habitat

The Icicle Creek watershed supports significant amounts of both maritime and arid continental vegetation. Shrubs and herbs dominate the vegetated alpine areas; wetter areas support more herbaceous vegetation while red mountain heather and moss-heathers are found in well-drained areas. Mountain hemlock (*Tsuga mertensiana*), silver fir (*Abies amabilis*), and western hemlock (*Tsuga heterophylla*) dominate the maritime influenced forest communities, which also support numerous understory plants such as cascade huckleberry (*Vaccinium deliciosum*), rusty menziesia (Rhododendron menziesii), devil's club (*Oplopanax horridus*), rosy twisted stalk (*Streptopus lanceolatus*) and coolwort foamflower (*Tiarella trifoliata*). Open forests of mountain hemlock, whitebark pine (*Pinus albicaulis*) and subalpine larch *(Larix lyallii)* can be found at the extreme upper elevation limit for trees (NWPCC 2004). From the U.S. Forest Service (USFS) wilderness boundary to the head waters, aquatic habitat closely resembles historic conditions. Around Eightmile Lake, the vegetation includes a mix of conifer and deciduous trees and also shrubs consistent with the rest of the Icicle Creek watershed. There are also significant open areas where rock slides and perhaps also historic fires have reduced or eliminated vegetation.

Floodplain connectivity and riparian habitat below the wilderness boundary have been altered through the construction of roads, campground development, timber harvests, and private development (NWPCC 2004). Timber harvest and fire have changed the vegetation and increased the exposed soils. Some drainages in Eightmile Creek have been scoured to bedrock. Sediment that does reach Eightmile Creek is transported to the alluvial fan at the confluence with Icicle Creek. The USFS Road 7601 is a major contributor of sediment to Eightmile Creek (Andonaegui 2001).

6.1.2.2 Terrestrial Species

Terrestrial PHS managed by WDFW located within close proximity (approximately 1,000 feet) of Eightmile Lake was Golden eagle (*Aquila chrysaetos*). A northern spotted owl (*Strix occidentalis*) PHS management buffer area was identified approximately 3.5 miles north of Eightmile Lake. Wolverine (*Gulo gulo*) occurrences are also documented in the area (WDFW 2014).

6.2 Potential Impacts and Regulatory Requirements

Eightmile Lake is one of four lakes in the Alpine Lakes Wilderness Area with irrigation supply facilities managed by IPID. The Alpine Lakes Wilderness Area is almost entirely owned by the USFS. As described in Section 2.4, the IPID transferred ownership of two parcels totaling 120 acres on the eastern and southern boundaries of the lake to the USFS, including the lake outlet and dam structure. As part of this transfer, IPID retained an easement on the property for maintenance, repair, upgrades and replacement of their facilities, along with associated access that would be needed.

6.2.1 Construction-related Effects

Construction-related effects for all four options are similar and are therefore not broken down by option. Work would occur in the late summer and early fall towards the end of the irrigation season. All equipment and materials needed for construction would be transported to the construction site via helicopter. This would likely include a pump system and generator; small excavator; cement mixer, cement, reinforcing steel, and any aggregate not available on site; plastic pipe; and other needed equipment and materials.

All four options include lowering the lake level by gravity or pumping down the lake to a level below the bottom of the existing gate to allow work except for the installation of the new pipe and gate to be conducted in the dry. If needed, water from Eightmile Lake would be temporarily pumped into Eightmile Creek using the pump system. This drawdown water will flow from Eightmile Creek into Icicle Creek and then drain into the Wenatchee and Columbia rivers. The current low lake elevation is 4,644 feet and the high water elevation is 4,667 feet. Each option will require that the lake level be drawn down approximately 5 to 10 feet below the existing low lake elevation for construction of the improvements,

concentrating the area where existing fish species will be located into a smaller area until the lake level recovers after the construction period.

Once the lake level has been lowered, then debris around the existing gate and dam would be removed, and the existing outlet pipe would be cleaned of debris at both the lake and stream ends and a plastic pipe liner would be slip fit into the existing outlet pipe and extended out into the lake with a intake screen at the end of the plastic pipe. The upstream end of the siphon would be floated out into position and slowly submerged in the lank by introducing water in the upstream end of the siphon. The new dam would be constructed using both material available on site and concrete and aggregate also brought in by helicopter.

Fish passage at the dam is not being proposed due to the natural fish passage barrier resulting from the steep drop in elevation going from Eightmile Lake to the lower creek valley, which currently prevents existing upstream passage. A screen at the end of the new gate could potentially be installed to prevent stocked trout species from migrating downstream.

Short-term impacts anticipated from the construction activities associated with removing and reconstructing the dam, and installing the low level siphon pipe and gate include excavation of the existing dam, and gated outlet structure, and clearing and grading around the existing dam and adjacent uplands for the reconstructed dam. There is limited vegetation in this area and work will largely be conducted on existing disturbed areas. Construction materials will also be staged in disturbed and non-vegetated areas on the dam and to the north of the dam. Excavation and fill below the ordinary high water mark (OHWM) will be conducted in the dry with temporary stormwater detention facilities put in place to protect surface water quality and to maintain a dry construction environment. A stormwater retention barrier of sandbags or other suitable material would be put in place around the construction areas to keep the work areas dry and to prevent loose soil, gravel and other rock from potentially being washed into either the lake or downstream. Wood and rock debris would be removed from the existing dam structure during construction and staged to the north of the existing dam.

6.2.2 Operational Effects

Operational effects vary based upon the four different options, and include varying amounts of habitat inundation around the lake. Habitat surrounding the lake affected by raising the dam's outlet elevation includes steep slopes, shrubs and conifers, large rockslide areas on the southern shoreline, with significant deadfall zones on the southeast portion of the shoreline. The northern shoreline is less severely sloped, with a similar vegetation mix but more heavily forested with conifers. Along the northeast corner there are significant amounts of bare rock exposed, with limited or no vegetation.

Figures 3-1C, 3-2C, 3-3C, and 3-4C illustrate the different surface elevations and associated inundation the Options evaluated by this study. Under options 1 and 2, the dam and overflow facilities would be reconstructed to maintain the historical water level with a maximum surface elevation of 4,671 above mean sea level. Under Option 3 and 4, additional long-term impacts would include the inundation of additional shorelands due to the increased elevation of the dam/overflow. Maximum surface elevation for Option 3 is 4,672 feet and Option 4 is 4,682 feet.

Option 3 would increase the dam/overflow height by 1 foot, which would result in an additional inundation of 1.1 acres of shoreland comprised of approximately 65% shrubs and conifers and 35% exposed rock. Option 4 includes an 11-foot increase of the dam/overflow elevation, which would result in an additional inundation of 9.4 acres of shoreland comprised of approximately 75% shrubs and conifers and 25% exposed rock areas.

Under all four options, operational effects include operation of the outlet gate and associated maintenance activities. Short- and long-term effects resulting from operation of the outlet gate and maintenance activities would be offset by downstream flow improvements on Eightmile and Icicle creeks for the targeted salmonid species, including Wenatchee River spring-run Chinook salmon, Upper Columbia River steelhead trout, and bull trout.

6.3 Mitigation Opportunities

Best management practices will be implemented during design and construction to avoid and minimize impacts to the natural environment to the greatest extent practicable. If required,

work that occurs within the lake and below OHWM will be conducted during the in-water work window consistent with permit requirements. As discussed under Section 6.2.1, steep elevation acts as natural barriers likely prevent existing upstream passage by native or introduced fish. Fish screens on the end of the temporary pump system used to drawdown the lake level during construction at the end of the new permanent gate could potentially be installed to prevent stocked trout species in the lake from migrating downstream.

Unavoidable impacts to riparian and upland vegetation are expected for Options 3 and 4, as described above. Impacts would need to be mitigated on-site where possible, but offsite mitigation options should also be considered, along with the anticipated downstream flow benefits for ESA-listed salmonid species.

As discussed in Section 6.1, ESA-listed bull trout have been documented in lower Eightmile Creek and the within the Icicle Creek watershed. Dam improvements will result in downstream flow improvements and associated increased habitat area for spawning and rearing during low flow periods on Eightmile and Icicle creeks, benefiting bull trout and other ESA-listed salmonid species, including the River spring-run Chinook salmon and Upper Columbia River steelhead trout. Flow releases from the lake would need to be managed to optimize targeted instream habitat improvements and associated lifestages for bull trout, steelhead and other species. Approximating how to achieve more normative flows and meeting other habitat needs should be considered. These aquatic habitat improvements should be quantified to the extent possible and factored into the project mitigation strategy, as applicable.

6.4 Preliminary Permitting Requirements

For the purpose of the fatal flaw analysis, a tailored permitting process was evaluated for the project. This process includes applying for and obtaining all relevant applicable federal, state, and local permits. Additionally, because the lake is part of the Alpine Lakes Wilderness Area and the dam and water outlet facilities are addressed in an agreement between USFS and IPID, additional USFS approvals are required consistent with the agreement and federal requirements. Table 6-1 lists the anticipated permits to be obtained for the project, along with the USFS approvals per the agreement.

Because the project takes place on USFS land, review under the National Environmental Policy Act (NEPA) and Section 106 of the National Historic Preservation Act would be required (see additional discussion below), in addition to other USFS specific permits summarized in Table 6-1. There is an added layer of approval complexity associated with this project because it is on Wilderness Area land. The USFS has not yet conducted a thorough evaluation of the approval requirements for the project options, as they are awaiting the more detailed information from this report to use in reviewing and confirming the specific approvals and associated environmental review that will be required for each option. One approval could include seeking U.S. Presidential authorization for the project (Snider 2014). Additionally, ESA consultation and Essential Fish Habitat (EFH) review would be required due to the presence ESA-listed Wenatchee River spring-run Chinook salmon, Upper Columbia River steelhead trout and bull trout downstream of the project area. Please see Table 6-1 for a complete summary of preliminary permits that may be required for the project.

For Section 106 compliance, the Washington State Department of Archaeology and Historic Preservation database was searched to identify any recorded sites or cultural resource surveys. No recorded sites or surveys were found. The project will likely require a field survey to evaluate the National Register of Historic Places (NRHP)-eligibility of the dam and outlet facilities, as well as investigate any areas of planned ground disturbance for potential archaeological resources. To conduct the survey, a USFS research permit must be acquired prior to fieldwork. If archaeological resources are located and must be further investigated, an Archaeological Resources Protection Act permit will be required.

If the field survey and consultation indicate that NRHP-eligible historic properties are present, and will be adversely affected by the project, the USFS must develop a Memorandum of Agreement (MOA) describing mitigation measures. If other federal agencies are involved, they will need to participate in the MOA process.

Ecology's Dam Safety Office (DSO) has regulatory jurisdiction over all reservoirs that impound 10 acre-feet or more of water. Replacement of the dam at Eightmile Lake will require a dam construction permit from DSO. Successful application for a dam safety permit will require completion of a downstream hazards analysis, hydrologic and hydraulic

modeling to determine downstream inundation impacts in the case of a dam failure, and completion of required reports and applications demonstrating that the replacement dam is designed to DSO guidelines and requirements.

This fatal flaws analysis concludes that, other than the yet-to-be confirmed determination of all necessary USFS reviews and approvals, all options appear to be feasible from an environmental and permit approvals perspective. Appropriate avoidance, minimization, and mitigation measures will vary to offset potential impacts. Cultural resources, Wilderness/USFS requirements and approvals, and the inundation area effects from Options 3 and 4 appear to have the greatest amount of regulatory complexity and risk. Option 3 has additional impact by inundating just over one additional acre during high water conditions. Option 4 would have the most effects, both on-site (rock and vegetation inundation of up to an additional 9.4 acres) and downstream (more potential for flow enhancement), that will require additional analyses and results to support the needed USFS and other federal, state, and local approvals; and to determine downstream flow benefits.

Table 6-1

Standard Federal, State, and Local Permits List

Permit	Agency	Apply with the JARPA (Y/N)	Permits Needed	Notes
Section 404 Permit[1]	Corps	Y	✓	Discharging dredged or fill material into waters of the U.S.
ESA Section 7 Concurrence	NMFS and USFWS	N	✓	ESA consultation may require a Biological Assessment given presence of spotted owl habitat in the project vicinity and listed salmonids and designated critical habitat within the watershed downstream of the project. Beneficial effects for bull trout and other ESA listed species downstream of the lake are expected to be identified as part of the consultation process.
EFH Concurrence	NMFS	N	✓	
NEPA Review	USFS and Corps	N (USFS) Y (Corps)	✓	NEPA review will be required since the project is proposed on USFS property and will require a Corps permit. Assume that this will be an environmental assessment review but this will need to be verified with the federal lead agencies.
USFS Special Use Permit	USFS	N	✓	Authorizes uses on National Forest Service land that provide a benefit to the general public and protect public and natural resources values. Would be required for inundation of additional lands outside of IPID easement.
USFS Research Permit	USFS	N	✓	Required to conduct field survey under Section 106
NHPA Section 106 concurrence, Archaeological Resources Protection Act Permit (if applicable)	Corps, USFS and DAHP	N	✓	With the federal nexus of USFS permit and the project occurring on federal land), DAHP and tribes must be consulted. No recorded sites or cultural surveys were identified.
Hydraulic Project Approval	WDFW	Y	✓	For work below the OHWM in waters of the state
Section 401 Water Quality Certification	Ecology	Y	✓	For projects that require excavation in or discharge dredge or fill material into water or isolated wetlands.
NPDES Construction Stormwater General Permit	Ecology	N	✓	Required if clearing, grading and/or excavation results in the disturbance of 1 or more acres and discharges stormwater to surface waters of the State.

Permit	Agency	Apply with the JARPA (Y/N)	Permits Needed	Notes
Dam Safety Approval	Ecology	N	✓	Required for dams and supplemental structures impounding or controlling more than 10 acre-feet of water or with a head in excess of 6 feet.
Shoreline Substantial Development Permit	Chelan County	N[2]	✓	Per the County Shoreline Management Plan, possible exemption for modification of existing agriculture facilities.
SEPA Determination	Chelan County	N	✓	A SEPA checklist or EIS will be required.
Critical Areas Ordinance Compliance	Chelan County	N	✓	Per the County Shoreline Management Plan, possible exemption for construction of irrigation structures.
Fill and Grade Permit	Chelan County	N	✓	

Notes:
1. Eightmile Lake is not a navigable waterway per USACE guidance and therefore does not require a Section 10 permit.
2. To be verified with the County on whether agricultural facilities exemption applies.

Corps = U.S. Army Corps of Engineers
DAHP = Washington State Department of Archaeology and Historic Preservation
Ecology = Washington State Department of Ecology
EFH = Essential Fish Habitat
EIS = Environmental Impact Statement
ESA = Endangered Species Act
IPID = Icicle and Peshastin Irrigation Districts
JARPA = Joint Aquatic Resource Permit Application
NHPA = National Historic Preservation Act
NMFS = National Marine Fisheries Service
NPDES = National Pollutant Discharge Elimination System
OHWM = ordinary high water mark
SEPA = State Environmental Policy Act
USFS = U.S. Forest Service
USFWS = U.S. Fish and Wildlife Service
WDFW = Washington Department of Fish & Wildlife

7 COST ANALYSIS

7.1 Implementation Costs

Table 7-1 summarizes the opinion of probable project implementation costs for the project. A more detailed breakdown of the opinion of probable costs is included in Appendix B. The opinion of probable costs includes the following assumptions and allowances:

- A 7.5% allowance for miscellaneous mobilization/demobilization.
- An estimated allowance for helicopter mobilization, as described below.
- A 30% contingency was included.
- A 20% allowance was included for engineering, permitting, and construction administration.
- The total project cost includes 8.2% sales tax.

The overall project costs include an allowance for haul of materials and equipment to the site via helicopter. Columbia Helicopters was contacted for preliminary budget information on the cost of hauling equipment and materials to the site via helicopter. They provided the following:

- A helicopter with a hauling capacity of 6,500 to 7,000 pounds at 5,000-foot altitude and a temperature of 70 °F would cost approximately $7,000 per hour to rent plus approximately $15,000 to mobilize to the Wenatchee area.
- A helicopter with a hauling capacity of 20,000 to 30,000 pounds at 5,000-foot altitude and a temperature of 70 °F would cost approximately $14,000 per hour to rent plus $20,000 to mobilize to the Wenatchee area.
- Costs may vary depending on the location and availability of helicopters at the time of the project.

The costs assume that the helicopter with the larger hauling capacity would be used to allow for hauling of small equipment (a small excavator and a small track loader) to the site to facilitate the work, and that concrete materials would be mixed on-site for the dam replacement project at Eightmile Lake. The alternative would be to haul ready-to-pour concrete via helicopter to the site, which would likely be accomplished with a smaller helicopter and more helicopter trips.

Table 7-2 provides a summary of costs in terms of cost per additional acre-feet of storage and cost per additional cfs of release made available by each option. The cost of implementing the improvements that would allow for increased storage capacity, increased releases, and automated control of releases would vary from $1,397 per acre-foot ($166,294 per cfs over a 60-day release period) for Option 2 to $2,398 per acre-foot ($285,429 per cfs over a 60-day release period) for Option 1. Options 2 and 3 would provide the most benefit per dollar spent, while Option 1 would provide the leas. These costs compare favorably to other conservation and water savings projects that have been implemented in the Wenatchee River Watershed. The costs for each option include a 30% contingency, which will be narrowed down with further planning and engineering.

7.2 Long-term Operating Costs

The cost to operate and maintain the new facilities will include:

- Regular maintenance and repair of gates, monitoring equipment, and communications equipment.
- Repair and servicing of power supply (rechargeable DC solar/battery power system)
- Inspection and repair of the new siphon and related equipment.
- On-site start-up and shut down each season.
- Access to prime the siphon in the event that the siphon pressure and flow break.

For the most part, operation and maintenance of the proposed facilities would require more effort than the current facilities require. A conservative allowance of 0.5% of the total project cost should be considered as a guideline for annual operations and maintenance costs (in 2014 dollars). Based on this guideline, operations and maintenance costs would vary from approximately $7,500 per year for Option 1 to $18,500 per year for Option 4. This level of operations and maintenance would cover four to five 1-day visits to the lake per year by IPID personnel, with an allowance for cleaning, inspection, and repair of equipment at Eightmile Lake. The long-term operating costs would likely increase with inflation.

Table 7-1

Summary of Opinion of Probable Project Costs

Item	Option 1	Option 2	Option 3	Option 4
Install Monitoring Equipment	$10,000	$10,000	$10,000	$10,000
Remove Existing Control Gate	$2,500	$2,500	$2,500	$2,500
Automate Valves to Optimize Releases	$57,500	$57,500	$57,500	$57,500
Clear Wood and Debris from Dam	$5,000	$5,000	$5,000	$5,000
Install Siphon and Valve	$143,850	$193,600	$175,000	$202,900
Repair/Rebuild Dam	$508,300	$508,300	$557,100	$1,412,700
Subtotal	**$727,000**	**$777,000**	**$807,000**	**$1,691,000**
Mobilization/Demobilization (7.5%)	$54,525	$58,275	$60,525	$126,825
Helicopter Mobilization/Demobilization/Rental	$316,800	$316,800	$344,000	$887,800
Construction Subtotal	**$1,098,000**	**$1,152,000**	**$1,212,000**	**$2,706,000**
Contingency (30%)	$329,400	$345,600	$363,600	$811,800
Engineering and Administration (20%)	$65,880	$69,120	$72,720	$162,360
Tax (8.2%)	$5,402	$5,668	$5,963	$13,314
Total Project Cost	**$1,499,000**	**$1,572,000**	**$1,654,000**	**$3,693,000**

Notes:

1 Costs are in 2014 dollars. Actual costs may vary based on material and labor costs at time of construction.

2 Subtotals are rounded to the nearest $100. The Construction Subtotals and Total Project Costs are rounded to the nearest $1,000.

Table 7-2

Cost-Benefit Summary

Item	Option 1	Option 2	Option 3	Option 4
Additional Usable Storage Capacity	625	1,125	1,125	2,125
Total Project Cost/Acre-foot of Additional Storage	**$2,398**	**$1,397**	**$1,470**	**$1,738**
Additional Release Available (60-day Release Period)	5.3	9.5	9.5	17.9
Total Project Cost/cfs of Additional Release (60-day Release)	**$285,429**	**$166,294**	**$174,969**	**$206,822**
Additional Release Available (92-day Release Period)	3.4	6.2	6.2	11.6
Total Project Cost/cfs of Additional Release (92-day Release)	**$437,658**	**$254,984**	**$268,285**	**$317,128**

8 SUMMARY AND RECOMMENDATIONS

8.1 Summary of Potential Improvement Options

Four potential improvement options have been identified for consideration by IPID and the IWG. They include:

Option 1 – Option 1 would increase the usable storage in Eightmile Lake to 2,000 acre-feet by rebuilding the dam to restore the maximum water surface elevation to the historic overflow elevation (4,671.0 feet) and installing a low level siphon to lower the minimum drawdown water surface elevation to 4,636.7 feet. The estimated implementation cost of Option 2 is $1,499,000, which is equal to $2,398 per acre-foot of additional storage created.

Option 2 – Option 2 would increase the usable storage in Eightmile Lake to 2,500 acre-feet by rebuilding the dam to restore the maximum water surface elevation to the historic overflow elevation (4,671.0 feet) and installing a low level siphon to lower the minimum drawdown water surface elevation to 4,621.6 feet. The estimated implementation cost of Option 2 is $1,572,000, which is equal to $1,397 per acre-foot of additional storage created.

Option 3 – Option 3 would increase the usable storage in Eightmile Lake to 2,000 acre-feet by rebuilding the dam with an overflow elevation of 4,672.0 feet, or 1 foot higher than the historic overflow elevation (4,671.0 feet), and installing a low level siphon to lower the minimum drawdown water surface elevation to 4624.6 feet. The estimated implementation cost of Option 2 is $1,654,000, which is equal to $1,470 per acre-foot of additional storage created.

Option 4 - Option 4 would increase the usable storage in Eightmile Lake to 3,500 acre-feet by rebuilding the dam with an overflow elevation of 4,682.0 feet, or 11 feet higher than the historic overflow elevation (4,671.0 feet) and installing a low level siphon to lower the minimum drawdown water surface elevation to 4,619.0 feet. The estimated implementation cost of Option 2 is $3,693,000, which is equal to $1,738 per acre-foot of additional storage created.

8.2 Data Gaps and Additional Study

Additional information should be collected to provide additional basis for further study and implementation. Additional information that may be needed includes:

- **Additional Hydrologic Review:** Additional review of hydrology may be needed to refine the analysis of flow and storage benefits and to provide inundation analyses needed to meet Ecology DSO permit requirements. Modification of the dam at the site will require additional study to determine changes to the current hazard classification listed for the dam by Ecology DSO. An increased hazard classification could potentially increase operational requirements and risk exposure.
- **Geologic Review:** Additional review of geologic conditions at Eightmile Lake would be needed to complete the design of dam improvements.

8.3 Recommended Next Steps

The managed lakes in the Alpine Lakes Wilderness, including Eightmile Lake, offer an efficient, cost-effective way to improve management of water in the Icicle Creek Sub-basin. Implementation of the improvements outlined in the Options identified in this study would enable IPID to release up to 2,125 additional acre-feet to Icicle Creek during the critical late summer low flow period. It is recommended that IPID continue to work with the IWG to evaluate the options identified in this study and work toward implementing a project that includes the following:

- Install monitoring equipment to allow for monitoring of lake levels and release rates at Eightmile Lake.
- Install telemetry equipment needed to provide for remote control of valves and gates.
- Replace the existing dam.
- Replace the existing low-level outlet with siphon and automated control valves.
- Complete related improvements.

The next steps toward implementation would be to select a preferred option and perform a more detailed feasibility level study. This would include a more detailed fatal flaw analysis of environmental impacts and permitting, a geologic analysis, preliminary coordination with Ecology's Dam Safety Office, a more detailed hydrologic and hydraulic analyses, and development of feasibility-level design drawings.

9 REFERENCES

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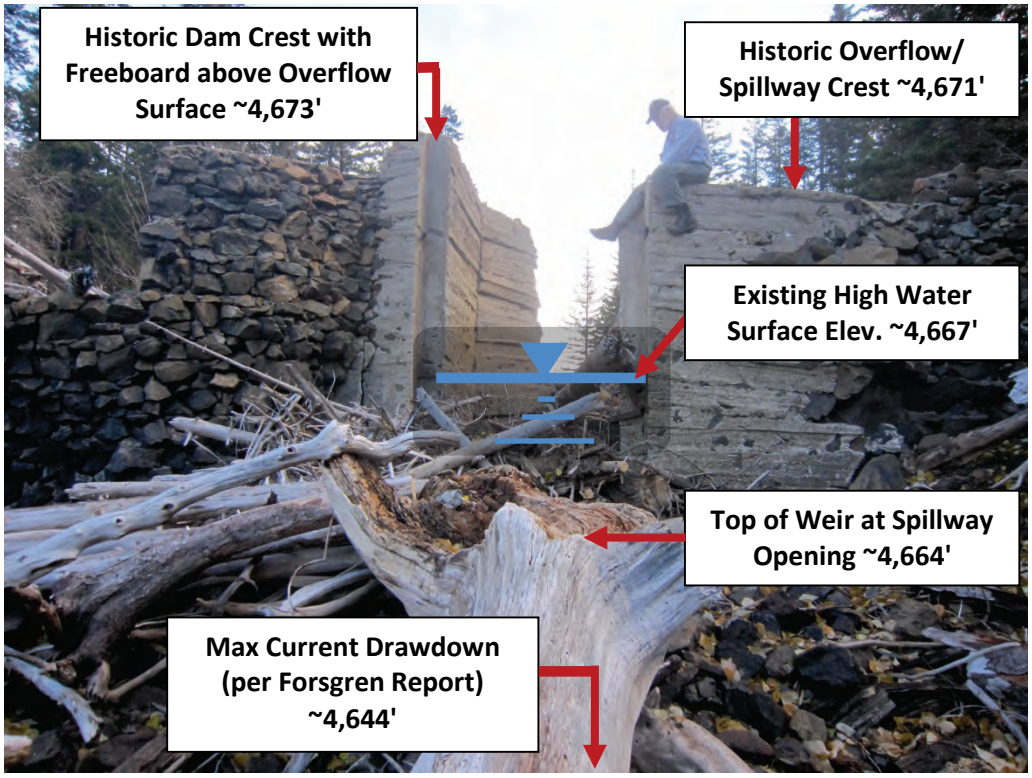
APPENDIX A
PHOTOGRAPHS

Photograph 1 – Masonry Rock and Concrete Dam from Earthen Embankment

Photograph 2 – Remnants of Earthen Embankment



Photograph 3 – Masonry Rock and Concrete Dam (from Lake, Notation from Forsgren 2014)

Photograph 4 – Spillway Opening

Photograph 5 – Primary Spillway Well

Photograph 6 – South Leg of Masonry Rock and Concrete Dam

Photograph 7 – Top of Outlet Gate

Photograph 8 – Outlet Gate Location

Photograph 9 – Discharge Pipe Outlet to Eightmile Creek

Photograph 10 – Discharge Pipe Outlet to Eightmile Creek

Photograph 11 – Overflow Spillway Channel

Photograph 12 – Overflow Spillway Channel with Exposed Cutoff Wall

Photograph 13 – Eightmile Lake from Dam

Photograph 14 – Eightmile Lake from Dam

APPENDIX B
OPINIONS OF PROBABLE COSTS

Opinion of Probable Costs D. Cisakowski
Eightmile Lake Storage Restoration 18-Mar-15

ITEM	UNIT	UNIT COST	OPTION 1 QTY	OPTION 1 COST	OPTION 2 QTY	OPTION 2 COST	OPTION 3 QTY	OPTION 3 COST	OPTION 4 QTY	OPTION 4 COST
Install Monitoring Equipment										
Install Staff Gage / Lake Level Monitoring (Transducer Type)	EA	$3,500	1	$3,500	1	$3,500	1	$3,500	1	$3,500
Install Staff Gage / Discharge Monitoring and Develop Rating	EA	$6,500	1	$6,500	1	$6,500	1	$6,500	1	$6,500
Subtotal - Install Monitoring Equipment				**$10,000**		**$10,000**		**$10,000**		**$10,000**
Remove Existing Control Gate										
Remove Existing Gate	LS	$2,500	1	$2,500	1	$2,500	1	$2,500	1	$2,500
Subtotal - Remove Existing Control Gate				**$2,500**		**$2,500**		**$2,500**		**$2,500**
Automate Gates/Valves to Optimize Releases										
Motorized Valve or Gate Actuator	EA	$20,000	1	$20,000	1	$20,000	1	$20,000	1	$20,000
Power Supply (Solar Panels and Battery Pack)	EA	$5,000	1	$5,000	1	$5,000	1	$5,000	1	$5,000
Controls, Communications/Telemetry and Enclosure	EA	$7,500	1	$7,500	1	$7,500	1	$7,500	1	$7,500
Repeater Station	EA	$25,000	1	$25,000	1	$25,000	1	$25,000	1	$25,000
Subtotal - Automate Gates/Valves to Optimize Releases				**$57,500**		**$57,500**		**$57,500**		**$57,500**
Clear Wood and Debris from Dam										
Clear Wood and Debris from Dam	LS	$5,000	1	$5,000	1	$5,000	1	$5,000	1	$5,000
Subtotal - Clear Wood and Debris from Dam				**$5,000**		**$5,000**		**$5,000**		**$5,000**
Install Siphon and Valves										
Slipline Existing Outlet with 30-inch HDPE Siphon	LF	$210	260	$54,600	260	$54,600	260	$54,600	260	$54,600
Submerged 30-inch HDPE Siphon	LF	$250	205	$51,250	350	$87,500	290	$72,500	380	$95,000
Buried 30-inch HDPE Siphon along Spillway Channel	LF	$180	75	$13,500	150	$27,000	130	$23,400	160	$28,800
Intake Screen	LS	$12,000	1	$12,000	1	$12,000	1	$12,000	1	$12,000
Install Vent and Combination Valve on Siphon	EA	$2,500	1	$2,500	1	$2,500	1	$2,500	1	$2,500
Install 30-inch Control Gate or Valve on Low-level Outlet	EA	$5,000	2	$10,000	2	$10,000	2	$10,000	2	$10,000
Subtotal - Install Siphon and Valve				**$143,850**		**$193,600**		**$175,000**		**$202,900**
Repair/Rebuild Dam										
Clearing and Tree Removal	AC	$3,500	0.3	$924	0.3	$924	1.0	$3,414	7.6	$26,497
Stripping and Stockpiling of Organic Material	CY	$6	213	$1,278	213	$1,278	222	$1,333	380	$2,278
Diversion and Care of Water	LS	$15,000	1	$15,000	1	$15,000	1	$15,000	1	$15,000
Temporary Erosion and Sediment Control	LS	$15,000	1	$15,000	1	$15,000	1	$15,000	1	$15,000
Demolition/Removal of Existing Dams	LS	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000
Loose Rock Removal for Dam Construction	CY	$45	32	$1,440	32	$1,440	34	$1,520	80	$3,600
Hard Rock Removal for Dam Construction	CY	$110	128	$14,080	128	$14,080	135	$14,862	320	$35,200
Waste of Excavated Material On Site	CY	$12	373	$4,476	373	$4,476	391	$4,693	780	$9,356
Installation of Drilled Rock Anchors	LF	$120	150	$18,000	150	$18,000	150	$18,000	210	$25,200
Place Reinforced Concrete for Dam	CY	$1,000	259	$258,648	259	$258,648	282	$282,026	748	$748,078
Place Rock/Masonry Facing on Dam	SF	$50	3,120	$156,000	3,120	$156,000	3,540	$177,000	9,910	$495,500
Install Walkway/Platform On Dam Crest	SF	$25	540	$13,500	540	$13,500	570	$14,250	1,080	$27,000
Subtotal - Repair/Rebuild Dam				**$508,300**		**$508,300**		**$557,100**		**$1,412,700**

Opinion of Probable Costs D. Cisakowski
Eightmile Lake Storage Restoration 18-Mar-15

ITEM	UNIT	UNIT COST	OPTION 1 QTY	OPTION 1 COST	OPTION 2 QTY	OPTION 2 COST	OPTION 3 QTY	OPTION 3 COST	OPTION 4 QTY	OPTION 4 COST
Subtotal - All Work				**$727,000**		**$777,000**		**$807,000**		**$1,691,000**
Mobilization Costs (Assumes Use of Helicopter)				**$371,000**		**$375,000**		**$405,000**		**$1,015,000**
Miscellaneous Mobilization/Demobilization	7.5%			$54,525		$58,275		$60,525		$126,825
Helicopter Mobilization/Demoblization/Rental				$316,800		$316,800		$344,000		$887,800
Construction Subtotal				**$1,098,000**		**$1,152,000**		**$1,212,000**		**$2,706,000**
Contingency	30.0%			$329,400		$345,600		$363,600		$811,800
Engineering, Permitting and Administration	20.0%			$65,880		$69,120		$72,720		$162,360
Sales Tax	8.2%			$5,402		$5,668		$5,963		$13,314
Total Project Cost				**$1,499,000**		**$1,572,000**		**$1,654,000**		**$3,693,000**
Existing Usable Storage Capacity				1,375		1,375		1,375		1,375
Usefule Storage Capacity After Project Implementation				2,000		2,500		2,500		3,500
Additional Release Available Due to Project (Acre-feet)				625		1,125		1,125		2,125
Total Project Cost ($/Acre-foot of Additional Usable Storage)				**$2,398**		**$1,397**		**$1,470**		**$1,738**
Additional Release Available Due to Project (cfs, 60-day release period)				5.3		9.5		9.5		17.9
Total Project Cost ($/cfs of Release, 60-day Release)				**$285,429**		**$166,294**		**$174,969**		**$206,822**
Additional Release Available Due to Project (cfs, 92-day release period)				3.4		6.2		6.2		11.6
Total Project Cost ($/cfs of Release, 92-day Release)				**$437,658**		**$254,984**		**$268,285**		**$317,128**

Notes:

1) This opinion of cost was developed in November 2014. Actual costs may vary depending on labor and materials costs at the time of construction.

2) Subtotals are rounded to the nearest $100. Construction subtotals and totals are rounded to the nearest $1,000.