January 2022
Snoqualmie Valley Watershed Improvement District

Comprehensive Storage Study

Prepared for Snoqualmie Valley Watershed Improvement District

1/31/2022

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Prepared for
Snoqualmie Valley Watershed
Improvement District
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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ABBREVIATIONS

BDA	beaver dam analog
cfs	cubic foot per second
DAHP	Washington Department of Archaeology and Historic Preservation
DNR	Washington State Department of Natural Resources
DNS	Determination of Non-Significance
DO	dissolved oxygen
DSO	Dam Safety Office
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FTE	full-time equivalency
JARPA	Joint Aquatic Resources Permit Application
LiDAR	Light Detection and Ranging
NEHRP	National Earthquake Hazards Reduction Program
NPDES	National Pollutant Discharge Elimination System
NWP	Nationwide Permit
O&M	operations and maintenance
OHWM	ordinary high-water mark
SEPA	State Environmental Policy Act
Services	National Marine Fisheries Service and U.S. Fish and Wildlife Service
SHPO	State Historic Preservation Officer
SVWID	Snoqualmie Valley Watershed Improvement District
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USFS	U.S. Forest Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WREC	Watershed Restoration and Enhancement Committee
WSEL	water surface elevation
WRIA	Water Resource Inventory Area
WWHM	Western Washington Hydrologic Model

Executive Summary

Water resource managers in the Snoqualmie River Watershed have long discussed the potential for creating new water storage within the watershed to improve management of winter flood flows and late-summer low flows. This study represents an ongoing effort led by the Snoqualmie Valley Watershed Improvement District (SVWID) to study the potential for storage within the Snoqualmie River Watershed. The study includes a screening of 20 potential water storage sites in the Snoqualmie Valley and more detailed evaluation of 7 of the most highly ranked sites. The study is intended to be an important first step toward helping water resources managers understand the benefits and challenges associated with implementing water storage in the watershed.

Background

In 2018, with funding from the Washington State Department of Ecology (Ecology), SVWID initiated a study of the potential for creating small-scale water storage within the Snoqualmie Valley. SVWID enlisted Anchor QEA to complete an assessment of small-scale surface water storage facilities that would be limited in size, with targeted storage capacities generally smaller than 10 acre-feet (the Small-Scale Storage Study). The study focused on the lower Snoqualmie River and its tributaries that flow through the SVWID service area from just upstream of Fall City to just downstream of Duvall. That study was completed early in 2020.

Early in the development of the Small-Scale Storage Study, the need became apparent for a more robust, Comprehensive Storage Study that would assess the potential for a wide range of surface water storage options, including small to large storage opportunities throughout the watershed. Funding for a Comprehensive Storage Study was awarded through the Ecology Streamflow Restoration Grant Program. The scope of work for the Comprehensive Storage Study included the following:

- **Preliminary design of a natural storage enhancement project.** A natural storage enhancement site was identified on Stossel Creek and evaluated as part of this study.
- **Identification and screening analysis of 15 to 25 storage sites.** Initially, a Work Plan was prepared to outline the methodology and criteria used to complete the screening analysis. Then, GIS data were used to identify 26 potential storage sites. That list was reduced to 20 sites that were evaluated through the screening analysis.
- **Detailed evaluation of 5 to 10 storage sites.** Of the storage projects identified as potentially favorable and ranked highly as part of the screening analysis, seven sites were advanced for more detailed evaluation.
- **Preparation of this report.** This report summarizes the work completed and key findings of the Comprehensive Storage Study for the Snoqualmie River Watershed.

Approach

This study focuses on water storage opportunities in the Snoqualmie River Watershed, which is part of Water Resource Inventory Area (WRIA) 7. WRIA 7 encompasses the Snoqualmie River Watershed, the Skykomish River Watershed, and the Lower Snohomish River Watershed. The Snoqualmie River merges with the Skykomish River to form the Snohomish River near Monroe, Washington. The Snoqualmie River drains approximately 700 square miles within a watershed that extends from the Snoqualmie River Valley to the crest of the Cascade Mountains. The WRIA 7 Watershed Enhancement and Restoration Committee (WREC) is considering a variety of potential ways to offset projected domestic consumptive water use, including both surface water and groundwater storage. The focus of this study is primarily on surface water storage.

As an initial step toward completing the Comprehensive Storage Study, a detailed Work Plan (Anchor QEA 2020b) was prepared outlining the proposed approach to completing GIS and site-specific analyses to identify and evaluate potential storage sites at a screening level. As indicated by the Work Plan, the following tasks were completed as part of this screening analysis:

1. The criteria outlined in the Work Plan were used to screen the storage sites as summarized in this report (Section 2.3).
2. The data collected and identified in the Work Plan were mapped in GIS, and a model was built to characterize, score, and rank raster grid cells within the watershed based on criteria that could be readily evaluated in GIS using a weighted overlay analysis, as outlined in the Work Plan. The scoring of each criterion was weighted and combined, as outlined in the Work Plan, to create an overall GIS-based favorability score for each raster grid cell in the model.
3. The outcome of the weighted overlay analysis, along with a thorough review of the data mapped in GIS, was then used as a basis for identifying potential storage sites. A preliminary list of 26 storage sites was identified, and that list was reduced to 20 storage sites for screening.
4. Each storage site was then evaluated outside of the GIS model to characterize, score, and rank each specific site based on criteria that could not be easily evaluated with spatial data in GIS. The scoring of each criterion was weighted and combined, as outlined in the Work Plan, to create an overall favorability score for each site based on the site-specific analysis.
5. A shapefile for each storage site was then loaded into the GIS, and the raster-based scoring was averaged for each storage site to score the GIS-based criteria for the storage site.
6. The scoring for the site-specific analysis that was developed outside GIS was also loaded into GIS with the shape file of each storage site.
7. An overall favorability score was developed, as outlined in the Work Plan, by combining the scores from the GIS-based analysis and the site-specific analysis.

Criteria outlined in the Work Plan were grouped into the categories shown in Table ES-1. Some of the criteria were selected for analysis using spatial data in GIS. Other criteria were evaluated using site-specific analyses outside of GIS. For each criterion, a rating or score was given based on data from the GIS overlay analysis or results of the site-specific analysis. Scores were given on a scale from low to high (1 to 5). The higher the score, the more favorably a site was expected to perform for a given criterion, as shown in Table ES-2. The scoring colors shown in Table ES-2 were kept consistent throughout this report to easily visualize the favorability of each site based on different criteria. The scores within each category were weighted based on the criterion's importance within a particular category, as shown in Table ES-1. The weighted scores were then combined to generate an overall favorability scoring for each category.

Table ES-1
Screening Criteria, Analyses, and Categories

Criteria	GIS Analysis	Site-Specific Analysis
Physical Criteria that Measure Benefit to Offset/Out-of-Stream Uses (35% weighting)		
Proximity to Water Source	✓	
Location Within Watershed	✓	
Ability to Offset Domestic Well Use	✓	
Project Footprint		✓
Available Storage Capacity		✓
Ability to Store High Flows		✓
Physical Criteria that Measure Benefit to Instream Flows and Habitat Conditions (40% weighting)		
Fish Habitat	✓	
Fish Presence	✓	
Current Vegetation/Land Use	✓	
Instream Flow Benefits		✓
Water Quality – Temperature, Dissolved Oxygen		✓
Water Quality – Toxics		✓
Reliability/Resilience		✓
Other Cost-Benefit and Feasibility Criteria (25% weighting)		
Property Ownership	✓	
Site Accessibility	✓	
Storage Type	✓	
Constructability		✓
Critical Areas and Resource Impacts		✓
Cost and Funding Potential		✓
Operation and Maintenance		✓

Table ES-2
Screening Criteria Scoring

Rating	Scoring Symbol/Number
Low (Least Beneficial)	1
Medium Low	2
Medium	3
Medium High	4
High (Most Beneficial)	5

GIS Weighted Overlay Analysis

The datasets identified in the Work Plan were collected and mapped in GIS. Geoprocessing models were built in GIS to characterize and score 6-foot-by-6-foot-sized raster grids across the watershed for each criterion. The initial steps of the GIS analysis produced two basin-wide coverages that were used to characterize sites by soil permeability and topography. The geoprocessing model was then used to score raster grid cells for each criterion based on GIS data relevant to each criterion. A detailed description of the how each criterion was scored is included in Section 3 of this report. Scores for criteria within each category were then weighted and combined to generate a favorability score for each category. The score from each category was weighted and combined to generate an overall favorability score for each raster grid cell based on the GIS weighted overlay analysis.

Identification of Potential Storage Sites and Site-Specific Analysis

Results of the GIS weighted overlay analysis and aerial photography were reviewed to identify a preliminary list of 26 potential storage sites. That list was narrowed down to 20 potential sites for the screening analysis. The storage sites that were identified and evaluated through the screening analysis are located throughout the Snoqualmie River Watershed and do not duplicate any sites analyzed in the prior Small-Scale Storage Study. The sites are shown on a map of the watershed in Figure 3-9. Based on input from SVWID and the WRIA 7 WREC, potential storage sites were not considered in subbasins that are closed year-round to further water right appropriations,

A summary of each site considered as part of the screening analysis is included in Section 3 of this report. These sites were evaluated on a site-by-site basis using the site-specific criteria identified in the Work Plan and outlined in Table ES-1. The analyses included an evaluation of each site, a preliminary configuration of each storage reservoir, and an initial estimate of the capacity and cost.

Scores were assigned to each criterion based on the site-specific analysis summarized in Section 4 of this report. Scores for criteria within each category outlined in Table ES-1 were tabulated and weighted to generate a favorability score. The overall favorability score for each category was then weighted and combined to develop an overall favorability scoring and ranking based on the site-specific analysis described in Section 4 of this report.

Ranking and Selection of Storage Sites for Further Analysis

Raster-based scoring from the GIS analysis was averaged over the area of each potential storage site to generate a site-specific, GIS-based favorability score for each site. The overall favorability scoring from the site-specific analysis for each site was then combined with the GIS scoring to generate an overall favorability score for each site. The sites were then ranked based on the overall favorability score. Table ES-3 summarizes each site, the overall scoring for each site, and the ranks of the storage sites. GIS maps depicting the site screening and favorability scoring were uploaded into an ArcGIS online webmap application, and a Story Map was developed for stakeholder interaction.

The results of the screening analysis were reviewed with SVWID and interested members of the WRIA 7 WREC through multiple presentations and a workshop meeting. Based on the final scoring and ranking of the sites included in the screening analysis, and additional discussions with SVWID and other stakeholders, seven storage projects were selected from the top 10 ranked sites from the screening analysis for further, more detailed analysis. The sites selected are summarized Table ES-4.

Detailed Evaluation of Selected Storage Projects

Section 5 of this report outlines the detailed evaluation of the storage projects listed in Table ES-4. The following is a summary of the key findings from the detailed analysis of these sites:

- **DNR Sites:** Two of the sites, CCK2 and MFK1, are owned and managed by the Washington State Department of Natural Resources (DNR) and forest trust lands for the State of Washington. Anchor QEA and SVWID met with DNR to present and discuss the potential storage projects. Based on those conversations, DNR has indicated that they cannot support further evaluation of these storage projects because they do not believe that storage is compatible with the intended use of the properties, would result in lost timber revenue, and would not allow DNR to meet its trust obligations. Other concerns cited by DNR include liability, impacts to natural resources, and restrictions on the use of the properties established when the properties were acquired.
- **Snoqualmie Timber, LLC Sites:** The remaining sites listed in Table ES-4 are on property owned by Snoqualmie Timber, LLC, whose properties in the Snoqualmie River Watershed are managed by Campbell Global, LLC. Anchor QEA met with Campbell Global, LLC, to present and discuss the potential storage projects. Based on those conversations, Campbell Global, LLC, indicated that they are not supportive of storage projects that would replace existing, productive tree farms (Sites NFT4 and NFK2). They manage these sites for timber harvest and cited loss of timber harvest revenue, liability, and impact to resources as key concerns. They did express a willingness to look at modifications to existing lakes that are on Snoqualmie

Timber, LLC, property and would be modified to store additional water (Sites TOK2, TOK3, and TOK4). A site visit was completed to each of these sites.

- **Hydrology:** Hydrologic analysis was completed to delineate the watersheds that are tributary to each reservoir or point on a tributary where water would be diverted to a reservoir. The analysis also estimated runoff rates and volumes from each tributary area that could be captured by the proposed reservoir.
- **Water Balance:** A water balance spreadsheet model was developed to evaluate the potential water balance in each lake or reservoir based on modeled inflows from the hydrologic analysis, stage-storage curves for each reservoir, evaporation losses, and releases from each reservoir. The water balance analysis revealed the following:
  - **Site CCK2:** The reservoir at Site CCK2 would only capture enough flow from the tributary area to completely fill the targeted reservoir capacity (173 acre-feet) during wet to extremely wet years. It would not refill during dry years. The volume captured in the reservoir at Site CCK2 would sustain an average release of approximately 2 cubic feet per second (cfs) for nearly 15 days during the late-summer low-flow period.
  - **Site NFT4:** The reservoir at Site NFT4 would not capture enough flow from the tributary area to completely fill the targeted reservoir capacity (1,296 acre-feet), even during wet to extremely wet years. During the wettest year modeled, most of the reservoir capacity (99.4%) would be used. The volume captured in the reservoir at Site NFT4 would sustain an average release of approximately 12 cfs for more than 26 days during the late-summer low-flow period.
  - **Site TOK2:** The proposed modifications at Site TOK2 (Bridges Lake), which would result in raising the lake level 2 feet and managing the top 2 feet of the lake as storage, would allow for consistent filling of the additional capacity in the lake (89 acre-feet) during wetter than average years. However, it would be a challenge to maintain storage levels through the late summer because precipitation and inflow would be reduced during the summer while water would continue to be discharged as base flow to the downstream tributary or be lost via evaporation. The volume captured and held in the top 2 feet of the lake would sustain an average release of approximately 0.6 cfs for nearly 8 days during the late-summer low-flow period.
  - **Site TOK3:** The proposed modifications at Site TOK3 (Klaus Lake), which would result in raising the lake level 2 feet and managing the top 2 feet of the lake as storage, would allow for consistent filling of the additional capacity in the lake (121 acre-feet) during wetter than average years. Similar to Bridges Lake, it would be a challenge to maintain storage levels through the late summer because precipitation and inflow would be reduced during the summer while water would continue to be discharged as base flow to the downstream tributary or be lost via evaporation. The volume captured and held

in the top 2 feet of the lake would sustain an average release of approximately 0.8 cfs for nearly 10 days during the late-summer low-flow period.

- **Site TOK4:** The proposed modifications at Site TOK4 (Black Lake), which would result in raising the lake level 2 feet and managing the top 2 feet of the lake as storage, would allow for consistent filling of the additional capacity in the lake (76 acre-feet) during wetter than average years. Similar to Bridges Lake, it would be a challenge to maintain storage levels through the late summer because precipitation and inflow would be reduced during the summer while water would continue to be discharged as base flow to the downstream tributary or be lost via evaporation. The volume captured and held in the top 2 feet of the lake would sustain an average release of approximately 0.6 cfs for nearly 8 days during the late-summer low-flow period.
- **Site NFK2:** The reservoir at Site NFK2 would not capture enough flow from the tributary area to completely fill the targeted reservoir capacity (482 acre-feet), even during wet to extremely wet years. During the wettest year modeled, only 60.8% of the reservoir volume would be used. The volume captured in the reservoir at Site NFT4 would sustain an average release of approximately 4 cfs for more than 19 days during the late-summer low-flow period.
- **Site MFK1:** The reservoir at Site MFK1 would not capture enough flow from the tributary area to completely fill the targeted reservoir capacity (3,311 acre-feet), even during wet to extremely wet years. During the wettest year modeled, only 59.4% of the reservoir volume would be used. The volume captured in the reservoir at Site NFT4 would sustain an average release of approximately 14 cfs for more than 29.5 days during the late-summer low-flow period.

Table ES-3
Overall Storage Site Favorability Scoring and Ranking

Project ID	Overall Rank	Description	Estimated Storage Volume (Acre-Feet)	Maximum Water Surface Area (Acres)	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	**1**	Snoqualmie Timber - NF Tolt (C)	1,296	133.6	**4.00**	4.04	3.97
MFK1	**2**	DNR - MF Snoq	3,311	173.8	**3.94**	3.68	4.20
TOK3	**3**	Klaus Lake	121	70.2	**3.86**	3.95	3.76
NFK2	**4**	Snoqualmie Timber - NF Snoq (B)	482	26.9	**3.80**	3.69	3.92
NFK1	**5**	Snoqualmie Timber - NF Snoq (A)	449	47.3	**3.65**	3.96	3.34
TOK2	**6**	Bridges Lake	89	47.8	**3.64**	3.95	3.33
NFT1	**7**	DNR - NF Tolt (B)	113	11.6	**3.59**	4.05	3.14
NFT3	**8**	DNR - NF Tolt (D)	132	11.5	**3.56**	4.05	3.07
CCK2	**9**	Cherry Lake	173	22.2	**3.54**	3.52	3.56
TOK4	**10**	Black Lake	76	40.7	**3.53**	3.81	3.24
TOK1	**11**	Snoqualmie Timber - Tokul	38	8.1	**3.42**	3.91	2.93
CCK1	**12**	Lake Margaret	106	53.1	**3.40**	2.84	3.96
NFT2	**13**	Snoqualmie Timber - NF Tolt (A)	62	7.3	**3.38**	3.95	2.82
NFK3	**14**	Snoqualmie Timber - NF Snoq (D)	29	6.0	**3.37**	3.80	2.94
LOT1	**15**	Snoqualmie Timber - Tolt (A)	84	23.7	**3.33**	3.41	3.26
SNO3	**16**	Twin Peaks Timber - Snoq	197	17.9	**3.25**	3.33	3.18
SNO1	**17**	Loutsis Lake	38	18.8	**3.24**	3.57	2.91
LOT2	**18**	Snoqualmie Timber - Tolt (B)	130	19.4	**2.97**	3.29	2.64
SNO2	**19**	Nelson Pond	42	14.7	**2.79**	3.45	2.13
CCK3	**20**	Upper Margaret Creek	22	7.9	**2.63**	2.91	2.36

Table ES-4
Sites Selected for Further Analysis

Project ID	Overall Rank	Description	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	**1**	Snoqualmie Timber - NF Tolt (C)	**4.00**	4.04	3.97
MFK1	**2**	DNR - MF Snoq	**3.94**	3.68	4.20
TOK3	**3**	Klaus Lake	**3.86**	3.95	3.76
NFK2	**4**	Snoqualmie Timber - NF Snoq (B)	**3.80**	3.69	3.92
TOK2	**6**	Bridges Lake	**3.64**	3.95	3.33
CCK2	**9**	Cherry Lake	**3.54**	3.52	3.56
TOK4	**10**	Black Lake	**3.53**	3.81	3.24

- **On-Channel and Off-Channel Reservoir Sites:** Based on this analysis, if Sites CCK2, NFT4, NFK2, and MFK1 were to move forward for additional evaluation and development, a reduction in the targeted reservoir size would need to be considered for each reservoir to optimize the size and cost of the reservoir with the inflow available from the reservoir's tributary area.
- **Existing Lake Sites:** Sites TOK2, TOK3, and TOK4 would all refill with reasonable reliability. However, it would be a challenge to keep the reservoirs full throughout the summer until the flow was needed downstream, during the late-summer low-flow period, due to water discharged as baseflow to the downstream tributary and losses via evaporation or seepage.
- **Access:** All of the sites would require improved access. However, Sites CCK2, TOK2, TOK3, and TOK4 would all require extension of existing access roads to the location where improvements would be constructed and maintained.
- **Critical Areas:** Sites CCK2, TOK2, and TOK3 have mapped landslide hazard or erosion areas in relatively close proximity to the reservoir. Additional analysis would be needed to confirm any design constraints associated with these critical areas.
- **Wetlands:** Sites CCK2, TOK2, TOK3, and TOK4 would impact existing mapped wetland areas.
- **Water Quality:** All of the sites have potential to impact water temperatures in downstream tributaries, streams, and rivers. Additional analysis will be needed to quantity the increase in temperature and identify the best measures for mitigating the warming that would occur during the summer in each of the water storage reservoirs.

Ranking and Scoring of Sites Selected for Detailed Evaluation

Another round of scoring and ranking of the sites was completed based on the additional analysis of the seven sites selected using the same methodology that was used for the screening analysis. The scoring and ranking of these seven sites relative to one another are summarized in Table ES-5.

Table ES-5
Revised Storage Site Favorability Scoring and Ranking – Detailed Evaluation

Project ID	Overall Rank from Screening Analysis	Rank from Detailed Analysis	Description	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	1	1	Snoqualmie Timber - NF Tolt (C)	3.69	4.04	3.34
TOK3	3	2	Klaus Lake	3.61	3.95	3.27
MFK1	2	3	DNR - MF Snoq	3.48	3.68	3.28
TOK2	6	4	Bridges Lake	3.45	3.95	2.96
NFK2	4	5	Snoqualmie Timber - NF Snoq (B)	3.40	3.69	3.11
TOK4	10	6	Black Lake	3.38	3.81	2.96
CCK2	9	7	Cherry Lake	3.32	3.52	3.12

Preliminary Design of a Natural Storage Site

As part of the scope of work funded through Ecology's Streamflow Restoration Grant, the design team developed preliminary designs for a "natural storage" project. The concept of "natural storage" as envisioned when it was introduced in the *Small-Scale Storage Study Summary Report* (Anchor QEA 2020a) would be to place natural materials, such as a beaver dam analog (BDA) or large wood and boulders, near a pond outlet to raise the water surface in an existing pond or wetland by 1 to 2 feet. This would enhance groundwater recharge, attenuate the release of water, and increase the storage in these natural features. The intended result would be to improve flows throughout the tributary and mainstem during low-flow periods. Increasing natural storage also has potential to enhance fish and wildlife habitat, including habitat for federally listed fish species.

A natural storage enhancement site was selected on DNR land near the headwaters of Stossel Creek at the outlet of a complex of ponds. The site consists of two distinct, but hydraulically connected, ponds/wetland areas surrounded by brush and trees. The lower pond outlets to Stossel Creek through a relatively narrow channel. The natural storage project is outlined in Appendix B.

A watershed of approximately 410 acres drains through the site. Raising the pond level at the site by 2 feet would provide approximately 15 acre-feet of additional storage volume. Peak flow runoff at the pond outlet would be reduced because peak flows would be attenuated by the enhanced storage pond. Infiltration would increase after capture from high runoff events. Water infiltrated to the shallow aquifer at the site would likely contribute to baseflow downgradient along the Stossel Creek channel. The distance and timing to zones of increased baseflow would be contingent on the presence and thickness of an unsaturated zone beneath the site, which are not yet well understood.

Next Steps

Planning, design, and implementation of a large storage project may take several years. The following steps are recommended to continue the discussion and evaluation of potential storage opportunities in the Snoqualmie River Watershed:

- Consult with someone who has expertise in forestry economics and real estate transactions to more clearly understand the economics of acquiring land for storage.
- Continue discussions with Campbell Global, LLC, regarding the potential for implementing storage at Bridges, Klaus, and Black lakes.
- Continue discussion with the WRIA 7 WREC and other interested stakeholders to build support for storage projects.
- Consider project-level feasibility studies for projects that have support and appear to offer promise for future development.
- Continue to work with landowners to implement small-scale storage.

1 Introduction

This report provides a summary of a comprehensive study to identify and evaluate potential surface water storage opportunities in the Snoqualmie River Watershed. The report identifies and evaluates potential storage projects of varying sizes and configurations throughout the watershed. A total of 26 potential storage projects were identified. A screening analysis was completed to evaluate 20 of those projects. A more detailed analysis was then conducted for seven of the projects that were identified through the screening analysis as the most promising. In addition, preliminary design was completed for a "natural storage" project identified through a prior study of small-scale storage projects.

This report summarizes the work completed to date and provides a basis for more detailed work needed to investigate the feasibility of specific storage projects within the Snoqualmie River Watershed. This work was completed under the direction of the Snoqualmie Valley Watershed Improvement District (SVWID) with key input from SVWID's project partners on the Water Resource Inventory Area (WRIA) 7 Watershed Restoration and Enhancement Committee (WREC). The work has been funded with grants awarded to SVWID by the Washington State Department of Ecology (Ecology) under Ecology's Streamflow Restoration Grant Program.

1.1 Background

Water resource managers in WRIA 7 have long discussed the potential for creating new storage within the watershed to improve management of winter flood flows and late-summer low flows. Prior to 2019, no thorough study of the feasibility of storage proposals in WRIA 7 had been completed. In 2018, SVWID received a Watershed Implementation and Flow Achievement Grant Award from Ecology to investigate the potential for creating small-scale water storage within the Snoqualmie Valley. SVWID enlisted Anchor QEA to complete an assessment of small-scale surface water storage facilities that were limited in size, with targeted storage capacities generally smaller than 10 acre-feet, with a focus on the lower Snoqualmie River and its tributaries that flow through the SVWID service area from just upstream of Fall City to just downstream of Duvall.

After initiating that study, it became apparent that there would be value in a more comprehensive study that would assess the potential for a wide range of surface water storage options, including small to large storage opportunities throughout the watershed. In 2019, SVWID secured funding under Ecology's Streamflow Restoration Grant Program to complete a comprehensive study of potential storage opportunities in the Snoqualmie River Watershed. Anchor QEA and our subconsultants, Aspect Consulting and AMP Insights, were retained by SVWID to complete this Comprehensive Storage Study.

1.1.1 Study Location

Ecology manages water in the State of Washington by watershed and has divided the state into WRIAs for coordination of water resource planning and management. Each WRIA consists of a major watershed or combinations of adjacent watersheds. This study focuses on water storage opportunities in the Snoqualmie River Watershed, which is part of WRIA 7. WRIA 7 encompasses the Snoqualmie River Watershed, the Skykomish River Watershed, and the Lower Snohomish River Watershed. The Snoqualmie River merges with the Skykomish River to form the Snohomish River near Monroe, Washington. The Snoqualmie River drains approximately 700 square miles within a watershed that extends from the Snoqualmie River Valley to the crest of the Cascade Mountains.

SVWID was formed by farmers and rural landowners in the Snoqualmie River Valley to assist landowners in finding solutions to water supply problems. SVWID serves approximately 14,000 acres of rural and agricultural lands in the lower Snoqualmie River Watershed, including properties primarily within the floodplain of the Snoqualmie River and its tributaries, from just below Snoqualmie Falls to the King County line near Duvall.

1.1.2 Study Context and Need

The Snoqualmie River is a critical resource that provides water for multiple needs, including water supply for domestic water use, irrigation water for agriculture, and streamflows that support fish and wildlife. The Snoqualmie River and its tributaries are home to several fish species that are listed as threatened or endangered under the Endangered Species Act (ESA). ESA-listed species include Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*), bull trout (*Salvelinus confluentus*), and Puget Sound steelhead (*O. mykiss*). The river and its tributaries also provide habitat for a variety of other fish and wildlife species. Preserving and augmenting streamflows is critical to supporting both instream and out-of-stream water needs.

Like other rivers in western Washington, the Snoqualmie River is influenced by seasonal rains; mountain snowmelt; and a relatively dry, warm summer. Heavy autumn and winter rains cause frequent flooding in the Snoqualmie River Valley. Peak flow rates occur during these warm, heavy rain events. Higher than average flow conditions persist through the late summer and spring, as snowmelt influences the hydrograph throughout the watershed. The late summer brings warmer, drier weather and low-flow conditions that prevail at the time when water is needed most for both instream and out-of-stream uses. With changing climate and shifting weather patterns, the availability of Snoqualmie River flows to meet instream and out-of-stream needs is not as certain.

Water storage has become an increasingly valuable tool for water resource managers to meet instream and out-of-stream needs in the face of changing climate and shifting weather patterns. Water stored during high-flow periods in the autumn, winter, and spring can be released during the late summer, when water is needed to provide additional and more reliable water supply and to augment streamflows to support fish and wildlife.

1.1.3 Consistency with WRIA 7 Watershed Planning

The WRIA 7 WREC consists of a variety of stakeholders, including SVWID, local and state government agencies, the Snoqualmie Indian Tribe and the Tulalip Tribes, and nonprofit organizations that help manage water in WRIA 7. The WREC recently completed updates to WRIA 7 watershed planning documents, as authorized by the Streamflow Restoration Act (Revised Code of Washington 90.94). The WREC updated the 20-year consumptive water use demand forecasts for permit-exempt wells and identified projects that will offset the projected consumptive use. The WREC considered a wide variety of ways to achieve that offset. Surface water storage, which is the focus of this study, would provide multiple benefits throughout the watershed. Surface water storage was included in updates to the watershed planning documents as a potential solution to providing additional water to offset domestic permit-exempt well use and improve streamflows in the watershed.

1.2 Prior and Supporting Studies

As noted previously, prior to 2019, no detailed study of the feasibility of storage in WRIA 7 had been completed. Recent studies and efforts that have led to the completion of this Comprehensive Storage Study are summarized below:

1.2.1 Small-Scale Storage Study

In 2018, SVWID secured a Watershed Implementation and Flow Achievement Grant Award from Ecology to investigate the potential for creating small-scale water storage within the Snoqualmie Valley. The work completed under that grant was summarized in the *Small-Scale Storage Study Summary Report* (Anchor QEA 2020a) and included an assessment of the potential for incorporating small-scale storage within the Snoqualmie River Watershed. The Small-Scale Storage Study focused on projects generally less than 10 acre-feet, and the study area was limited to tributaries that feed the Snoqualmie River and areas near the mainstem Snoqualmie River within the SVWID service area. The need for a more robust, Comprehensive Storage Study was identified early during the Small-Scale Storage Study.

As part of the Small-Scale Storage Study, screening criteria and methodology were developed to rank and compare small-scale storage sites (Anchor QEA 2018). The criteria and methodology were applied to screen and rank 16 potential small-scale storage sites (Anchor QEA 2019a). Of these 16 sites, 3 sites were selected for a more detailed evaluation: Foster Pond, the Goose and Gander Farm, and the Green Crow Parcel. Conceptual design development for the Foster Pond was advanced through a separate grant from the Washington State Department of Agriculture (Anchor QEA 2019b), while conceptual designs for the Goose and Gander Farm and Green Crow Parcel sites were further developed as part of the Small-Scale Storage Study. The work completed to date on these small-scale storage sites is preliminary. Additional work to develop at least one small-scale storage site will move forward when additional funding is secured.

The Comprehensive Storage Study is not intended to replace or supersede the Small-Scale Storage Study. Rather, it builds on the work initiated through the Small-Scale Storage Study by identifying additional surface water storage opportunities throughout the watershed that vary in size and geography from those identified in the Small-Scale Storage Study.

1.2.2 Natural Storage

The Small-Scale Storage Study also identified opportunities for enhancing natural ponds or wetlands in the headwaters of tributaries to the lower Snoqualmie River, referred to in that document as "natural storage" projects. Natural storage projects would consist of placing natural materials, such as large wood or beaver dam analogs, near the outlet of a natural pond or wetland to attenuate the release of water and increase the storage in these natural features.

Other projects identified in the Small-Scale Storage Study would require excavation and construction of an impoundment to store water. Those projects were identified as "constructed storage" projects. The funding provided by Ecology's Streamflow Restoration Grant Program for this Comprehensive Storage Study included funding to advance at least one of the natural storage projects identified in the Small-Scale Storage Study to the preliminary design level. The selection and development of the natural storage project is summarized in Section 7.

1.2.3 Other Related Studies

Other preliminary studies were completed as part of the scope of work and to support the Comprehensive Storage Study. These included the following studies, which are incorporated into this report, either directly into the report text or as appendices.

Snoqualmie River Watershed Comprehensive Storage Study, Work Plan (Anchor QEA 2020b)

Anchor QEA and our subconsultants completed a detailed Work Plan early in 2020 that outlined the proposed approach for completing the screening analysis summarized in this report. The Work Plan (Appendix A) identified the criteria and methodology to be used in completing the screening and ranking of storage sites for the Comprehensive Storage Study. The Work Plan is summarized in more detail in Section 2. The Work Plan was reviewed and refined with input from SVWID, Ecology, the Snoqualmie Indian Tribe and the Tulalip Tribes, and other members of the WRIA 7 WREC. It was then used as a guide for evaluating potential storage sites using a robust GIS-based analysis approach, combined with site-specific analyses outside the GIS model to identify and characterize potential reservoir sites.

For the most part, the methodology, criteria, and other detailed guidance for scoring and ranking potential storage sites were followed as outlined in the Work Plan. Some minor variations were incorporated as the analysis was completed to ensure that scoring and ranking outcomes were accurate and reflected the priorities expressed by SVWID, Ecology, the Snoqualmie Indian Tribe and the Tulalip Tribes, and other members of the WRIA 7 WREC.

Draft Snoqualmie River Watershed Comprehensive Storage Study, Screening Analysis Summary (Anchor QEA 2020c)

Anchor QEA and our subconsultants completed the screening analysis of potential storage sites in July 2020. The screening analysis included a high-level evaluation of 20 potential storage projects. GIS data were collected and evaluated to perform a weighted-overlay analysis for criteria easily associated with spatial data. Site-specific analyses were then completed for other criteria. The screening analysis was used to complete a preliminary scoring and ranking of potential storage sites based on the selected criteria. The screening analysis summary is incorporated directly into this report. The screening analysis criteria and methodology are outlined in Section 2, and the results of the screening analysis are summarized in Section 3.

Preliminary Design Analyses, Snoqualmie River Watershed – Natural Storage Enhancement Project (Anchor QEA 2021)

This memorandum was prepared to summarize the preliminary design of the natural storage enhancement project on Stossel Creek that was developed as part of the scope of work of the Comprehensive Storage Study. The memorandum outlines observations made during a site visit to potential natural storage project sites, selection of a site on Stossel Creek for the project, and hydrologic and hydraulic analysis completed to support the preliminary design of the natural storage enhancement project. A draft memorandum was submitted to SVWID and Ecology for review in March 2021. The memorandum has since been updated and is included as Appendix B to this report. A detailed overview of the natural storage enhancement project is provided in Section 7.

1.3 Scope and Purpose

The scope of the Comprehensive Storage Study includes the following:

- **Task 1:** This task called for phased implementation and preliminary design of a natural storage enhancement project identified as part of the Small-Scale Storage Study in the headwaters of a tributary to the Snoqualmie River. A natural storage enhancement site was identified in the Stossel Creek headwaters and evaluated in completion of this task.
- **Task 2:** This task included preliminary identification and analysis of 15 to 25 storage sites, including preparation of the Work Plan and completion of the screening analysis summarized

in this report. Initially, 26 potential sites were identified. That list was reduced to 20 sites that were evaluated through the screening analysis in completion of this task.

- **Task 3:** This task called for a more detailed evaluation of 5 to 10 storage sites identified as potentially favorable and highly ranked as part of the screening analysis. Ultimately, seven sites were advanced from the screening analysis for more detailed evaluation.
- **Task 4:** This task included preparation of this report, which summarizes the findings of the Comprehensive Storage Study.

The objectives of the Comprehensive Storage Study are to 1) advance a specific natural storage project to the preliminary design stage; and 2) conduct a comprehensive study of a wide range of potential surface water storage projects throughout the Snoqualmie River Watershed that would benefit instream flows. The ultimate goal of the Comprehensive Storage Study is to identify and evaluate storage projects that could be developed through further feasibility-level evaluations and design work, funded, and constructed to store water that would be released to benefit instream flows during the critical low-flow period and offset projected consumptive water use.

1.4 Overview of Report

This report is organized into the following sections:

- **Section 1–Introduction:** This section provides a project background, summarizes prior work completed, and outlines the scope and purpose of the study.
- **Section 2–Storage Study Approach:** This section summarizes the study area and limitations, outlines the criteria and methodology used for screening potential storage projects, and describes the approach to evaluating selected storage projects and the natural storage enhancement project in more detail.
- **Section 3–Screening of Potential Storage Sites:** This section includes a summary of the GIS-based and site-specific analyses completed as part of Task 2 to screen potential storage sites.
- **Section 4–Ranking and Selection of Storage Sites for Further Analysis:** This section includes a detailed description of the results of the screening analysis, ranking of potential storage sites, and selection of storage projects for more detailed analysis.
- **Section 5–Detailed Evaluation of Highly Ranked Sites:** This section provides a site-by-site summary of the additional analyses performed for the 7 sites that were advanced from the screening analysis for more detailed evaluation.
- **Section 6–Permitting and Regulatory Requirements:** This section summarizes potential impacts, likely permits required, and a recommended approach to securing permits for the 7 sites that were advanced from the screening analysis for more detailed evaluation.
- **Section 7–Overview of Natural Storage on Stossel Creek:** This section provides an overview of the natural storage enhancement project in the Stossel Creek headwaters that was developed to a preliminary design level as part of this study.

- **Section 8–Recommended Next Steps:** This section summarizes recommended next steps for investigating the feasibility of storage in the Snoqualmie River Watershed.
- **Section 9–References:** This section provides detailed information about the information sources cited in the report.

Tables and figures are inserted throughout the report. Supporting documents, calculations, and other information are included as appendices.

2 Storage Study Approach

As an initial step in completing the Comprehensive Storage Study, a Work Plan was prepared to outline the proposed criteria and methodology to be used in completing the analysis of potential storage projects. The original Work Plan that was developed early in 2020 is included in Appendix A. This section summarizes the approach to completing the screening analysis of potential storage sites, scoring and ranking those sites, identifying highly ranked projects to move forward through a more detailed evaluation, and performing the more detailed evaluation for those selected projects.

2.1 Study Area and Limitations

The Comprehensive Storage Study includes the entire Snoqualmie River Watershed, from its confluence with the Skykomish River to the top of the watershed at the Cascade Crest. The study area is shown Figure 2-1.

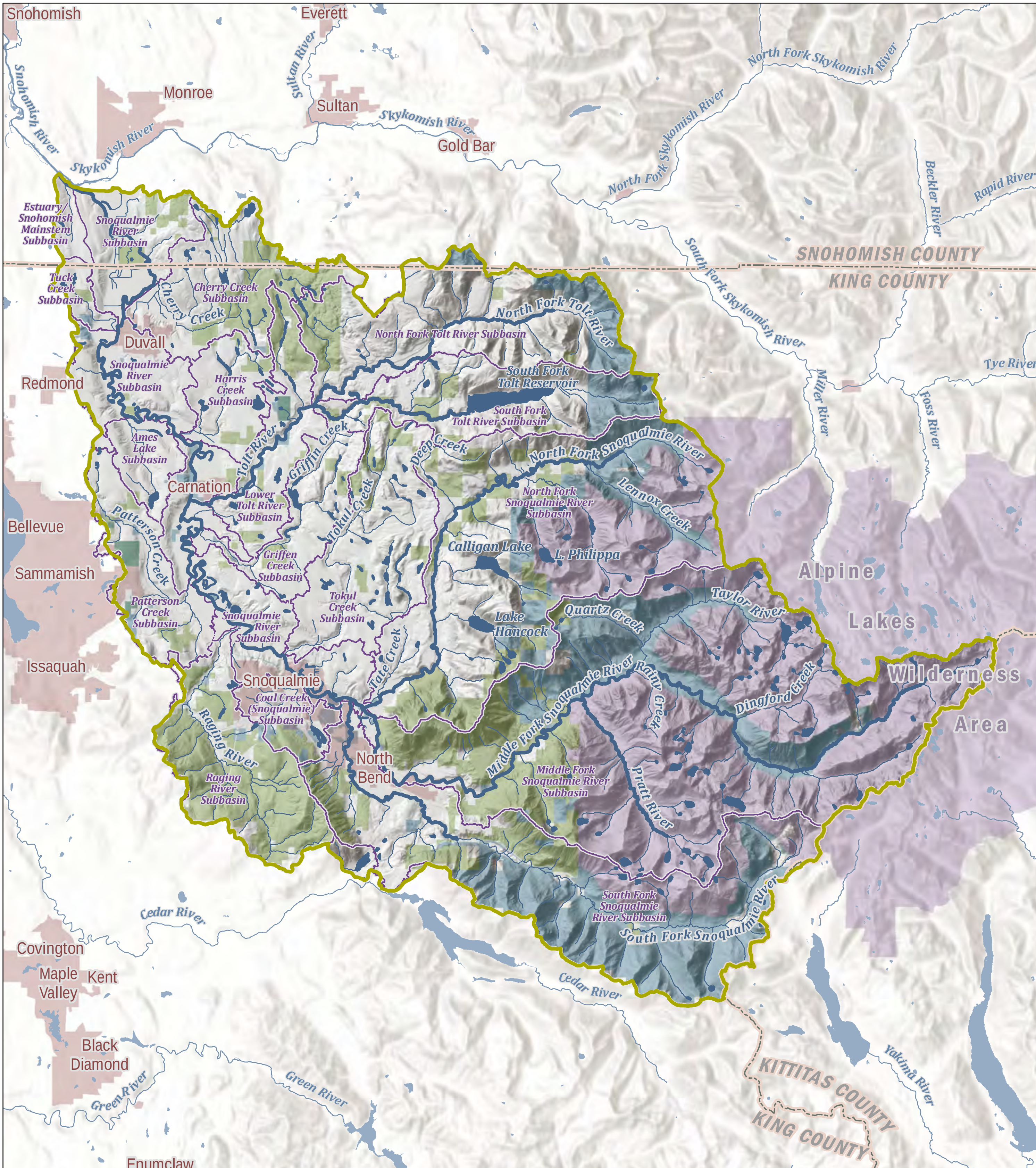
2.1.1 Focus on Surface Water Storage

Like the Small-Scale Storage Study, the focus of this Comprehensive Storage Study is primarily on creating surface water storage. The WRIA 7 WREC is considering a wide variety of potential ways to offset projected domestic consumptive water use. Surface water storage is one of the actions being considered. Subsurface water storage is also being considered. While this study does not specifically identify opportunities for subsurface water storage, this study has characterized areas where soil conditions and topography may be well suited for infiltration, and areas where soil conditions and topography may be better suited for storage without infiltration.

2.1.2 Instream Flow Limitations

Unlike the Small-Scale Storage Study, the Comprehensive Storage Study did not limit the size or geographic location when identifying potential storage sites within the Snoqualmie River Watershed. The analysis presented in this report was applied to the entire watershed, and the storage sites included represent a wide range of storage capacities. However, one of the potential limitations on development of storage projects within the Snoqualmie River Watershed will be whether there is an instream flow limitation within a particular tributary subbasin. Water rights will be required to capture or divert and store water. Instream flow limitations on waterbodies within the watershed could make water storage in certain subbasins infeasible.

An instream flow rule was adopted for rivers and streams within the larger Snohomish River Watershed that includes the study area. That instream flow rule is codified in the Washington Administrative Code (WAC) 173-507. Minimum instream flows are established for the South Fork Snoqualmie River, the North Fork Snoqualmie River, and the mainstem Snoqualmie River at key locations. Minimum streamflow limitations also exist for several tributaries to the Snoqualmie River.



GIS Path: G:\projects\SVWID\ComprehensiveStorageStudy_200026\Delivered\FinalReport\2_1 Location Map.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/20/2021 || User: nkochie || Print Date: 12/20/2021

City Limit
DNR-Managed Land
Other State Land
County Boundary
Snoqualmie Watershed
Subbasin Boundary

0 5 10
Miles

N

Location Map

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	**2-1**

Basemap Layer Credits || Sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

Some tributaries to the Snoqualmie River are closed year-round to further water right appropriations under the instream flow rule (WAC 173-507-030), including the following:

- Griffin Creek
- Harris Creek
- Patterson Creek
- Raging River

The study area also includes streams and tributaries with instream flow limitations under the rule, including the following:

- Langlois Creek
- Soldberg Creek (Ames Creek)
- Unnamed Tributary to Cherry Creek
- Tate Creek

In addition, the Middle Fork of the Snoqualmie River has been designated as a wild and scenic river under the National Wild and Scenic Rivers System, which was created by Congress in 1968 to preserve rivers with unique or outstanding natural, cultural, and recreational values in a free-flowing condition. This would not necessarily limit creation of storage within the Middle Fork Snoqualmie River subbasin but may limit potential for creating an in-channel impoundment for storage.

Instream flow limitations were not included as a criterion in the GIS weighted overlay analysis or site-specific analysis outlined in this report. The Work Plan anticipated that there might be opportunities for storage designed to specifically enhance instream flows (without providing any out-of-stream benefit or future domestic water use offset) within basins that have limitations or are closed to further water right appropriations due to lack of available streamflow. The Work Plan indicated that the analysis would identify promising storage opportunities throughout the watershed without considering whether there is an instream flow limitation. However, based on further discussions within the WRIA 7 WREC and guidance from SVWID, storage sites were generally not identified in subbasins that are closed year-round to further water right appropriations.

2.2 Work Plan

The Work Plan (Appendix A) included the following:

- A summary of proposed storage analysis criteria
- A summary of the proposed storage analysis characterization, scoring, and ranking
- A summary of existing information collected and identification of data gaps
- A summary of the proposed storage analysis methodology
- A summary of next steps toward completing the analysis

As described in the Work Plan, the general flow of the work completed as part of the screening analysis was as follows:

1. The criteria outlined in the Work Plan were used to screen the storage sites as summarized in this report. Those criteria are summarized in more detail in Section 2.3.
2. The data collected and identified in the Work Plan were mapped in GIS, and a model was built to characterize, score, and rank raster grid cells within the watershed based on criteria that could be readily evaluated in GIS using a weighted overlay analysis, as outlined in the Work Plan. The scoring of each criterion was weighted and combined, as outlined in the Work Plan, to create an overall GIS-based favorability score for each raster grid cell in the model.
3. The outcome of the weighted overlay analysis, along with a thorough review of the data mapped in GIS, was then used as a basis for identifying potential storage sites. A preliminary list of 26 storage sites was identified, and that list was reduced to 20 storage sites for screening.
4. Each storage site was then evaluated outside of the GIS model to characterize, score, and rank each specific site based on criteria that could not be easily evaluated in GIS. The scoring of each criterion was weighted and combined, as outlined in the Work Plan, to create an overall favorability score for each site based on the site-specific analysis.
5. A shapefile for each storage site was then loaded into the GIS, and the raster-based scoring was averaged for each storage site to score the GIS-based criteria for the storage site.
6. The scoring for the site-specific analysis that was developed outside GIS was also loaded into GIS with the shape of each specific storage site.
7. An overall favorability score was developed, as outlined in the Work Plan, by combining the scores from the GIS-based analysis and the site-specific analysis.

2.3 Screening Analysis Criteria

The criteria used for the screening analysis are listed in Table 2-1. A detailed explanation of why each criterion was included and how each was evaluated is provided in the Work Plan. The Work Plan identified criteria that could easily be evaluated in GIS based on readily available attribute data, and the data layers were overlaid to evaluate areas within the watershed for storage favorability. Other criteria were identified that would need to be evaluated outside GIS on a site-specific basis using engineering analysis tools and other data. Table 2-1 lists the criteria and the type of analysis used to evaluate them. The criteria were grouped into the following categories:

- Physical criteria that measure benefit to out-of-stream uses, including offset for future domestic water use
- Physical criteria that measure benefit to instream flows and habitat conditions
- Other cost-benefit and feasibility criteria

Table 2-1
Screening Criteria, Analyses, and Categories

Criteria	GIS Analysis	Site-Specific Analysis
Physical Criteria that Measure Benefit to Offset/Out-of-Stream Uses (35% weighting)		
Proximity to Water Source	✓	
Location Within Watershed	✓	
Ability to Offset Domestic Well Use	✓	
Project Footprint		✓
Available Storage Capacity		✓
Ability to Store High Flows		✓
Physical Criteria that Measure Benefit to Instream Flows and Habitat Conditions (40% weighting)		
Fish Habitat	✓	
Fish Presence	✓	
Current Vegetation/Land Use	✓	
Instream Flow Benefits		✓
Water Quality – Temperature, Dissolved Oxygen		✓
Water Quality – Toxics		✓
Reliability/Resilience		✓
Other Cost-Benefit and Feasibility Criteria (25% weighting)		
Property Ownership	✓	
Site Accessibility	✓	
Storage Type	✓	
Constructability		✓
Critical Areas and Resource Impacts		✓
Cost and Funding Potential		✓
Operation and Maintenance		✓

2.4 Scoring and Ranking of Storage Sites

For each criterion, a rating or score was provided based on data from the GIS overlay or characteristics identified as part of the site-specific analysis. Scores were given on a scale from low to high, with a corresponding numerical score (1 to 5). The higher the score, the more favorably a site was expected to perform for a given criterion, as shown in Table 2-2.

The scores within each category were weighted based on the criterion's importance within a particular category. The weighted scores were then combined to generate an overall scoring for each category. A separate score was generated for each category as part of the GIS overlay analysis and as part of the site-specific analysis. The score from each category was weighted to produce an overall score for a storage site from both the GIS analysis and the site-specific analysis, as follows:

- Physical criteria that measure benefit to offset/out-of-stream uses (35%)
- Physical criteria that measure benefit to instream flows and habitat conditions (40%)
- Other cost-benefit and feasibility criteria (25%)

Table 2-2
Screening Criteria Scoring

Rating	Scoring Symbol/Number
Low (Least Beneficial)	1
Medium Low	2
Medium	3
Medium High	4
High (Most Beneficial)	5

2.5 Refinements to Work Plan and Scoring

The following provides a summary of the minor adjustments and refinements that were incorporated as the screening analysis was completed to ensure that scoring and ranking outcomes accommodated the data available, were accurate, and reflected the priorities expressed by SVWID, Ecology, the Snoqualmie Indian Tribe and the Tulalip Tribes, and other members of the WRIA 7 WREC.

2.5.1 GIS Weighted Overlay Analysis and Scoring

Site Characterization: North Puget Sound Light Detection and Ranging (LiDAR) digital elevation model data (USGS 2006) were used to characterize areas based on permeability and the slope of the terrain to assess their potential to accommodate a Storage Reservoir with Seepage Loss or a Storage Reservoir with Negligible Seepage Loss, as described in the Work Plan. GIS models were developed for reservoirs with each of these classifications. More recent LiDAR covering smaller portions of the watershed exist, but a LiDAR dataset that fully covers the watershed does not currently exist. In the Storage Reservoir with Seepage Loss model, the slope classification categories used for site characterization were adjusted slightly from those originally presented in the Work Plan.

Offset/Out-of-Stream Benefit: Due to the nature of the subbasin-based geometry used to represent the criterion Location Within the Watershed, large areas were mapped with single values. After reviewing initial runs of the Benefit to Offset/Out-of-Stream Uses model, it was apparent that the layer was overemphasizing values across large areas in the watershed. The weighting for this criterion was reduced from 0.45 to 0.35 and weighting of the Ability to Offset Domestic Well Use criterion was increased from 0.20 to 0.30. Additionally, the selection of subbasins grouped together in GIS as a basis for the Location Within the Watershed criterion was revised to better model upstream and downstream conditions. Finally, the ranges of total consumptive water use growth values mapped in GIS as a basis for scoring the Ability to Offset Domestic Well Use criterion were adjusted to better cover the range of values occurring within the basin.

Instream Benefit: To better reflect the desire to minimize the potential impact of storage on fish species listed as threatened or endangered under the ESA, changes were made to the way the data on fish presence were combined, weighted, and scored. The improvements to the evaluation of the Fish Presence criterion included adjustments to the scoring so that streams where ESA-listed fish species are known to be rearing or spawning would receive the lowest score (1); followed by those where ESA-listed fish species are known to be present; then reaches where species of concern could be spawning, rearing, or present; with streams where no ESA-listed species or species of concern are known to be present receiving the highest score (5). To increase the priority of this criterion, the weighting of the score for the Fish Presence criterion was increased from 0.35 to 0.40, and the Fish Habitat criterion weighting was adjusted from 0.40 to 0.35.

Current Vegetation/Land Use: Some changes were also made to the Current Vegetation/Land Use criterion evaluation. In addition to the datasets described in the Work Plan, zoning from Snohomish County (Snohomish County 2020), city and Urban Growth Area boundaries (WSDOT 2019), wilderness areas (USDA 2020), Washington State Parks, and public areas (DNR 2020e) were included in various spatial combinations in order to better represent land use and vegetation. The categories were adjusted as shown in Table 2-3.

Table 2-3
Revised Vegetation/Land Use Category Descriptions and Scoring

Score	Screening Analysis Category	Work Plan Category
5	Forested	Forest
4	--	Open
3	Rural and Agriculture Related	Rural
2	Wilderness Area, Washington State Parks, Other	Other
1	City/Urban Growth Area	City/Urban Growth Area

Notes:
Sources: DNR 2020e; King County 2020a; Snohomish County 2020; WSDOT 2019; and USDA 2020
--: Scoring category not used.

Cost-Benefit and Feasibility: The GIS data used for evaluating the Site Accessibility criterion (King County 2020d) were updated to better capture the presence of forest roads (DNR 2020d). Additionally, a combination of land use and ownership was used to represent the cost-benefit and feasibility of potential project locations (Table 2-4). Public lands used for open, rural, or agricultural uses were scored highest, followed by public lands used for forest and timber. Private forested lands scored 3, and privately owned rural and agricultural lands came in above public parks and wilderness areas, which were scored the lowest.

Table 2-4
Property Ownership Category Descriptions and Scoring

Score	Revised Land Use	Revised Ownership	Work Plan Definition
5	Rural-Agriculture	Public (without parks)	Forested public lands
4	Forest	Public (without parks)	Open/rural public lands
3	Forest	Private	Forested private land
2	Rural-Agriculture	Private	Open/rural private land
1	Other Uses	Public (without parks), public parks and wilderness areas, private (DNR 2020c; King County 2020a; DNR 2020e)	Other

Sources: King County 2020a; King County 2020b; DNR 2020c; DNR 2020e; and Snohomish County 2020

2.5.2 Site-Specific Analysis Revisions

No significant changes or adjustments were made in the methodology, criteria, or weighting of criteria outlined in the Work Plan for the site-specific analysis performed outside of GIS. However, the methodology and values used to score each criterion were not well defined in the Work Plan, so additional thought was given to the scoring of those criteria evaluated through the site-specific analysis. The site-specific analyses included a rough evaluation in AutoCAD Civil 3D of potential storage sites, areas, capacity, and impoundment configurations. The data gathered from this analysis were used as a basis for developing opinions of probable cost for each storage concept.

The site-specific analysis of each storage site is preliminary and is intended to provide only a general definition of the storage concept. Little was known about any one particular site when the screening analysis was completed. Development of more detailed design information and data on the existing conditions and constraints at each site is beyond the scope of the screening analysis. As part of this Comprehensive Storage Study, additional background information, an assessment of the willingness of the owner to investigate the possibility of storage at the site, an investigation of the physical characteristics of each site, a determination of water supply needed for filling the potential reservoirs, and the reliability of that water supply were studied in more detail for the 7 storage sites that were advanced from the screening analysis.

2.6 Completion of Screening Analysis

The screening analysis that was completed as part of this study is summarized in more detail in Section 3. A draft of the screening analysis was completed in July 2020. SVWID then engaged the WRIA 7 WREC by presenting the results in July 2020. That was followed by a workshop session for interested participants in August 2020 and participation in subsequent meetings with interested participants from the WRIA 7 WREC in September 2020 and February 2021. Feedback provided during and following those meetings was integrated into the final screening analysis that is summarized in Section 3 and the screening analysis results summarized in Section 4.

2.7 Selection of Highly Ranked Storage Sites

Based on the final scoring and ranking of the sites included in the screening analysis, and additional discussions with SVWID and other stakeholders, 7 of the top 10 ranked potential storage projects were selected for advancement through a more detailed analysis. Additional detail regarding selection of these sites is provided in Section 4.

2.8 Detailed Analysis of Highly Ranked Storage Sites

Once 7 potential storage projects were selected for advancement, the sites were evaluated in more detail by completing the following tasks and analyses:

- **Landowner Outreach Coordination:** The landowner for each of the potential storage sites was contacted by SVWID and a WebEx meeting was scheduled to discuss the potential project, identify landowner concerns, and gage the willingness of the landowner to further explore the potential for water storage at the site.
- **Site Visits:** Where possible, site visits were scheduled and completed with landowner representatives to observe the existing conditions at each potential storage site. Physical conditions and site constraints were discussed, observed, and documented with photographs during these site visits.
- **Engineering Analyses:** More detailed engineering analyses were completed for each of the seven storage sites, as follows:
  - Refined hydrologic and hydraulic analyses were completed to more clearly define water storage capacity, the stage-storage-water surface area relationship, contributing watershed area, runoff from the contributing watershed area, potential inflows and releases from each reservoir, refill probability, and the infrastructure needed to fill and release water from each reservoir.
  - Further review and documentation of site constraints were completed, including steep slopes, landslide hazards, and accessibility.
  - A high-level operational analysis was completed to better understand how the reservoirs would fill and the timing and magnitude of releases from each.

  - Water quality issues were explored in more detail to define the likely impacts on water quality in receiving waters and define additional work needed to address these impacts during feasibility-level study and design.
  - Constructability concerns were identified and described in more detail.
  - A refined opinion of probable implementation costs was prepared for each of the seven potential storage projects.
  - A refined opinion of probable long-term operating costs was prepared for each of the seven potential storage projects.
  - A refined matrix and ranking of the seven storage sites, relative to one another, was completed and included in this study.
- **Permitting and Regulatory Requirements Evaluation:** For each of the potential storage sites, the likely permits that would be required to implement the storage project were identified and summarized. A table was prepared to summarize the permits required, list the agencies responsible for issuing permits, identify permit triggers, and describe anticipated timelines associated with securing the permits identified.

2.9 Evaluation of Highly Ranked Storage Sites

The evaluation of the seven sites that were advanced through more detailed analyses culminated in development of a refined matrix that scored and ranked the seven sites based on the criteria and according to the methodology outlined earlier. The detailed evaluation of the seven highly ranked sites and the results of this evaluation are summarized in more detail in Section 5.

2.10 Reporting of Results

The final step in completing the scope of the Comprehensive Storage Study includes preparation of this report to document the findings of the study, presentation of the results to the SVWID Board of Directors, presentation of the results to the WRIA 7 WREC, and completion and transfer of GIS data to SVWID from the web-based map that was created to communicate results. This Comprehensive Storage Study was finalized after review by SVWID and interested members of the WRIA 7 WREC.

2.11 Natural Storage Preliminary Design Development

As noted previously, the scope of work for this Comprehensive Storage Study also included development of a natural storage enhancement project in Upper Stossel Creek to the preliminary design level. That work is summarized in Section 7 of this report and outlined in more detail in a memorandum included as Appendix B.

3 Screening of Potential Storage Sites

After completing the Work Plan, GIS data were used to identify potential storage sites, the initial list of 26 potential storage sites was narrowed down to 20 potential storage sites, and the screening analysis was completed for those 20 sites. This section summarizes that analysis.

3.1 GIS Weighted Overlay Analysis

GIS weighted overlay tools assist with decision-making by producing a consistent metric that measures a location's potential for favorable results, in this case related to water storage and as represented by in-stream, offset/out-of-stream, and cost-feasibility benefits. To produce the tool, six geoprocessing models were built, each containing a variety of related criteria. For each criterion, a set of spatial data was interpolated as a continuous 6-foot by 6-foot grid across the watershed. In each model, the team developed a value for every cell by employing a variety of spatial analysis methods, including giving numeric scores to data that were textual or coded (such as exempt well forecasting); reclassifying raster datasets (such as surface slope); grouping, merging, and combining data (such as parcel ownership and pared-down land use categories); and buffering and merging data (such as proximity to water source). Raster math, used to add, subtract, multiply, and conduct mathematical functions on spatial data, was used to weight and sum the data values.

Site screening and favorability layers optimized for web performance were uploaded into six ArcGIS online webmap applications and combined into an ESRI Story Map for stakeholders to interact with. Favorability scoring was also used to score identified potential sites.

The team reviewed publicly available GIS data for its ability to represent important factors in a successful water storage siting project. The following sections summarize how the data were used to produce the GIS analysis and results.

3.1.1 Site Characterization

The initial steps of the analysis produced two basin-wide coverages that can be used to characterize sites by soil permeability and topography. Potential storage sites can be evaluated for whether they would favor either 1) storage reservoirs constructed over soils and topography that have a higher potential for seepage and that may provide recharge and benefits to shallow groundwater systems; or 2) storage reservoirs constructed in soils and topography that have a lower potential for seepage and would result in negligible losses to groundwater.

A system that induces groundwater recharge generally requires low-gradient slopes and permeable soils that improve the rate of infiltration. Storage reservoirs that do not leak generally require areas of nonpermeable surficial geology, like bedrock or glacial till, and steep or narrow-valley topography that provides natural features where water can be impounded. The coverages shown can be used to identify areas with concentrations of high scores, or "hot spots," as well as a first pass for feasibility for both scenarios.

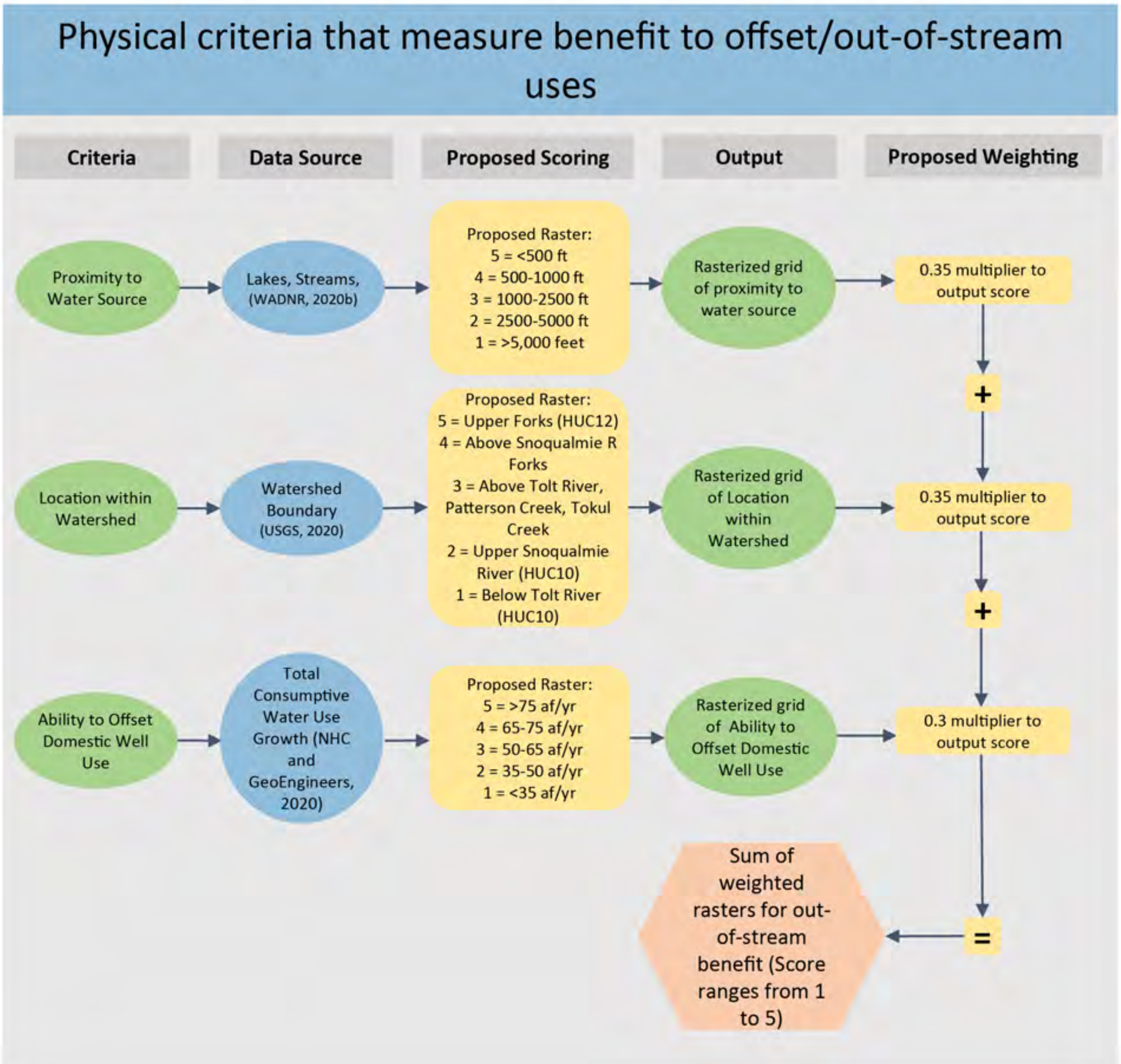
3.1.2 GIS Analysis of Benefit to Offset/Out-of-Stream Uses

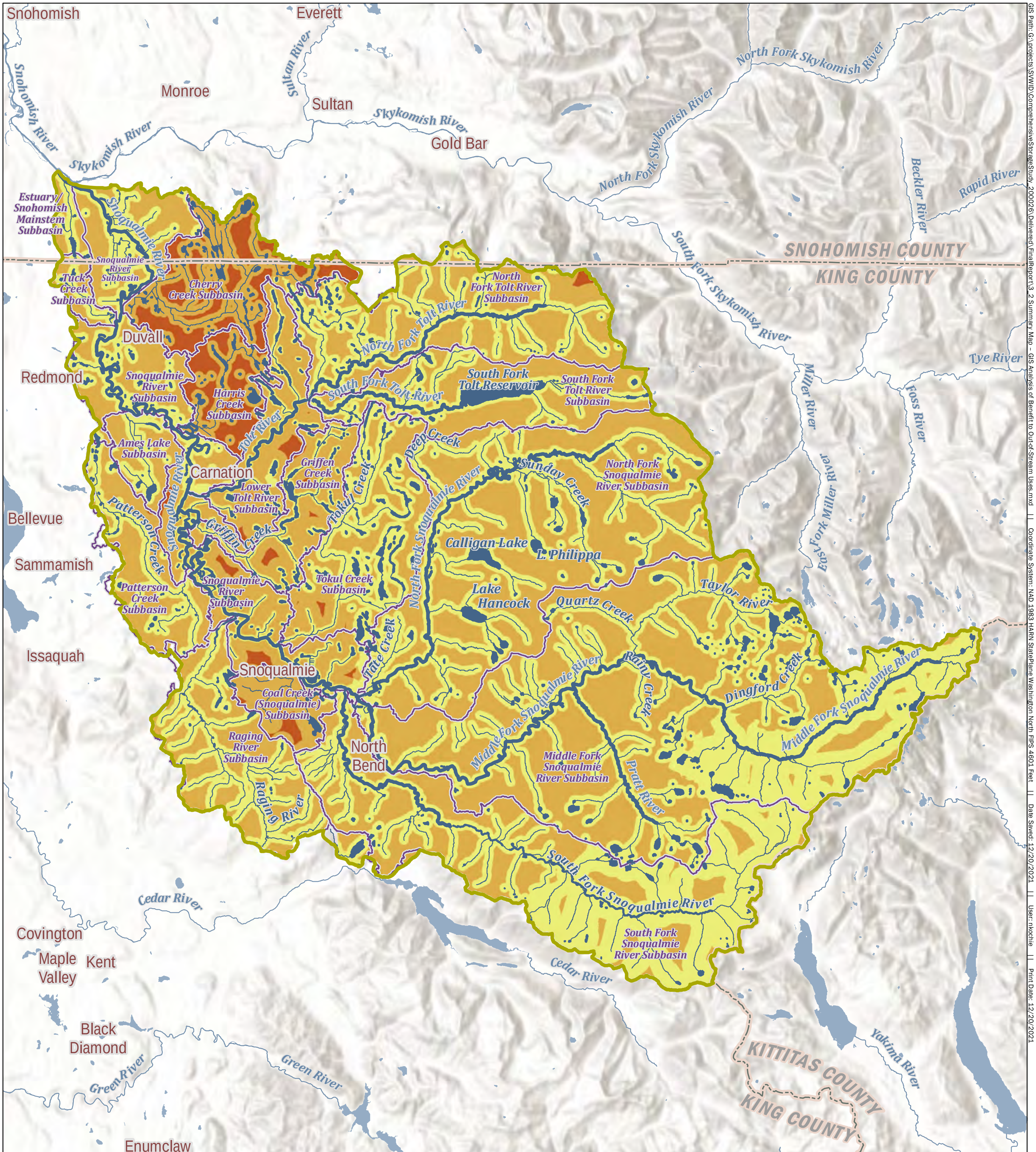
The potential for a storage site to offset domestic water use or otherwise enhance out-of-stream uses was evaluated in the GIS weighted overlay analysis by looking at a site's proximity to water that could be used to fill a reservoir, the location of the site within the watershed, and the potential for water stored at the site to mitigate future demand for domestic well use that will result from population growth. The following describes the criteria, data, scoring, and weighting used in the GIS analysis of the category Benefit to Offset/Out-of-Stream Uses:

- **Proximity to water source:** The extents of proximity to water source were created by buffering waterbodies and waterways and scoring them to promote both ease of planning and potential benefit downstream if a facility is located close to a water source, based on a hydrography dataset (DNR 2020b).
- **Location within watershed:** To represent the potential benefit to downstream water uses when water is stored topographically higher in a basin, a subbasin-based dataset (USGS 2020) was used. For this criterion, upstream basins were scored higher and downstream basins lower.
- **Ability to offset domestic well use:** As part of the analysis being completed for the update of the WRIA 7 Watershed Plan, population growth and the corresponding increase in consumptive water use have been forecasted (NHC and GeoEngineers 2020).The GIS analysis scored areas within each subbasin such that higher scores were given in subbasins where predicted future domestic water needs are greatest.

The process for evaluating, scoring, and weighting these criteria in GIS is illustrated in Figure 3-1. These criteria were each scored and then weighted and combined to provide an overall score for each raster in the GIS model representing the outcome of the GIS analysis of the category Benefit to Offset/Out-of-Stream Uses. The overall scoring of each raster in the GIS model is presented in the map of the watershed in Figure 3-2. Similar to the other figures presented in this section, the colors range from the lowest scoring (red and orange) to the highest scoring (green).

Figure 3-1
GIS Analysis of Benefit to Offset/Out-of-Stream Uses





Out-of-Stream Uses

Scored Values

- <1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5

County Boundary

Subbasin Boundary

Snoqualmie Watershed

N

0 5 10

Miles

GIS Analysis of Benefit to Offset/Out-of-Stream Uses

Screening Analysis Memo

Snoqualmie Valley Watershed Improvement District

WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO. 3-2
	PROJECT NO. 200026	REVISED BY: NLK	

Basemap Layer Credits || Sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

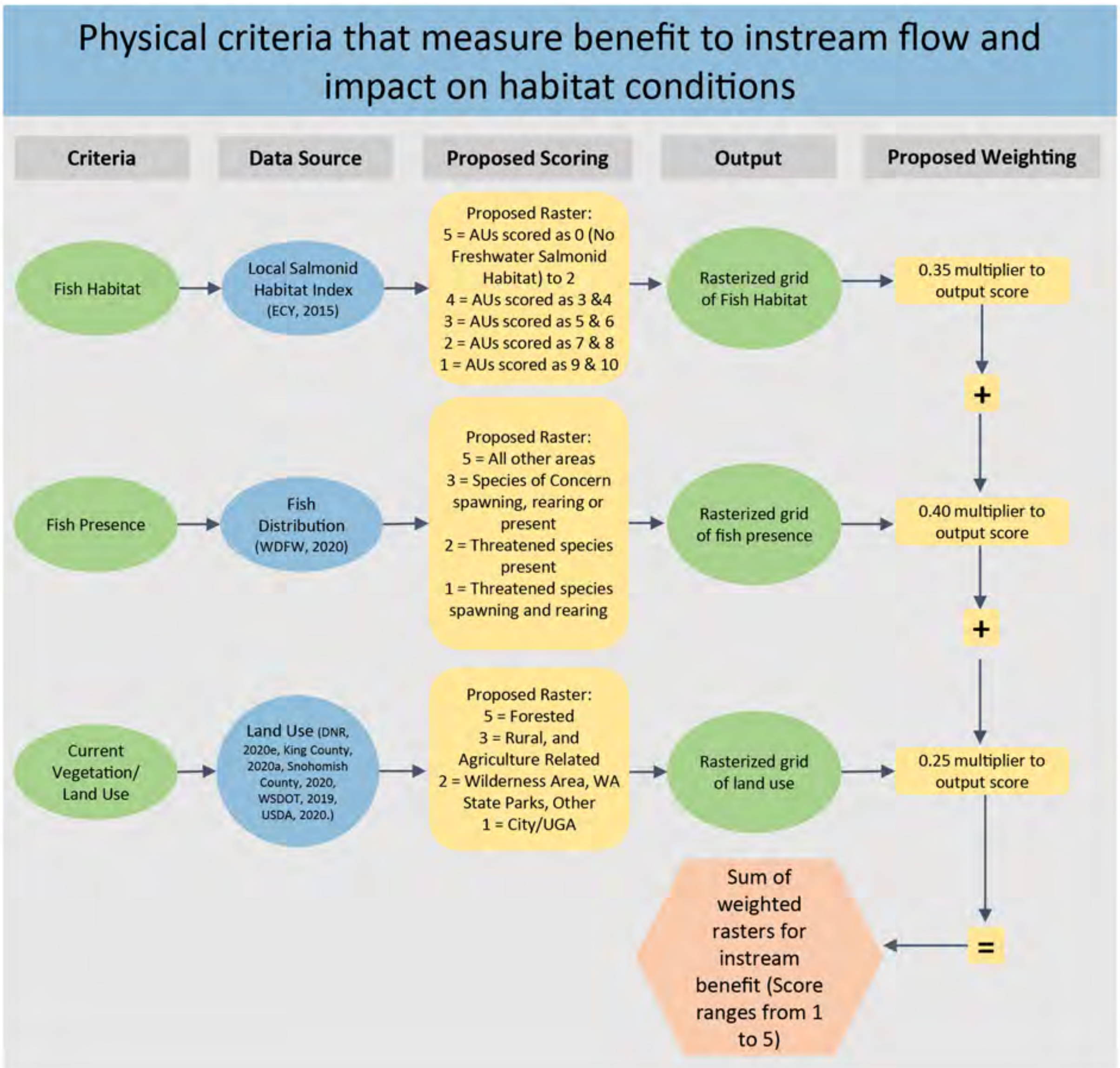
3.1.3 GIS Analysis of Benefits to Instream Flows and Habitat

Protection of critical fish habitat and the ability to improve instream flows directed the input data choices, scoring, and weighting used in the category Benefit to Instream Flows and Habitat. To better protect all fish species, and to prioritize species listed as endangered or threatened, the GIS analysis scored information related to stream reaches where spawning and rearing of Puget Sound Chinook salmon, bull trout, and steelhead are known to occur. A dataset that estimates the potential quality of habitat in different areas was also incorporated into the analysis to evaluate Fish Habitat. The following describes the criteria, data, scoring, and weighting used in the GIS analysis of the category Benefit to Instream Flows and Habitat:

- **Fish habitat:** Ecology has developed scorings of habitat for salmonids within WRIA 7 (Ecology 2015). For this study, the highest score was given to Assessment Units with the lowest habitat value. This approach would be protective of existing salmonid habitat by rating those areas with salmon habitat as less favorable for water storage.
- **Fish presence:** The presence of fish within the Snoqualmie River or its tributaries is mapped by the statewide Washington Integrated Fish Distribution Data Portal (WDFW 2020). The dataset also describes where different fish species are known to spawn, rear, or visit. The model was adjusted to incorporate scoring of reaches based on whether threatened, endangered, or fish species of concern were known to spawn, rear, or visit. Those areas where threatened, endangered, or fish species of concern are found were rated less favorably than areas where these species are not found. The scored dataset was then buffered by 100 feet.
- **Current vegetation and land use:** Current vegetation and land use are used as an indicator of potential benefit to instream use, with forested timber lands and agricultural areas rated higher than protected parks, wilderness areas, and urban areas (Table 2-3).

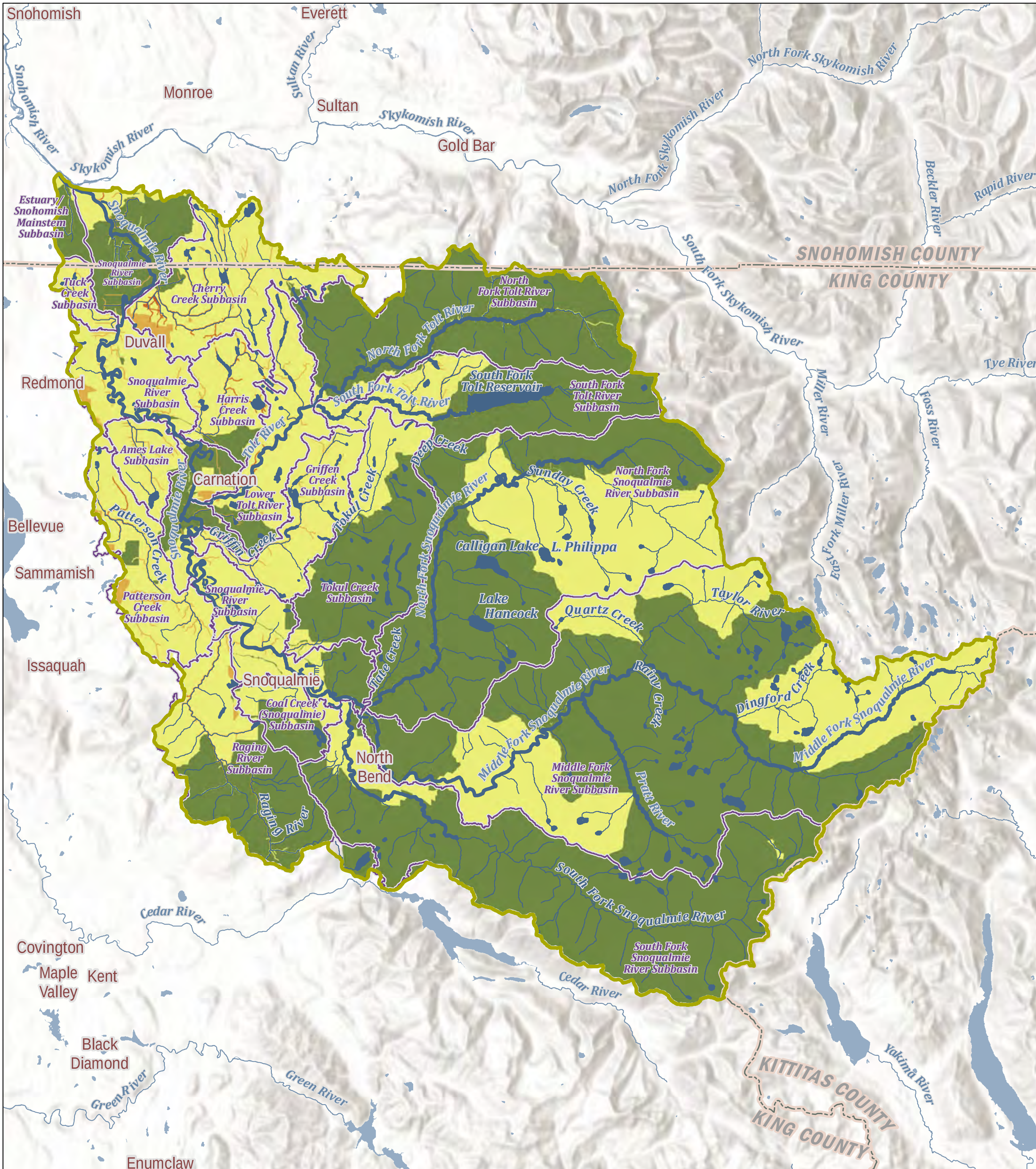
The process for evaluating, scoring, and weighting these criteria in GIS is illustrated in Figure 3-3. These criteria were each scored and then weighted and combined to provide an overall score for each raster in the GIS model representing the GIS analysis of the category Benefit to Instream Flows and Habitat. The overall scoring of each raster in the GIS model is presented in the map of the watershed in Figure 3-4. Similar to the other figures presented in this section, the colors range from the lowest scoring (red and orange) to the highest scoring (green).

Figure 3-3
GIS Analysis of Benefit to Instream Flows and Habitat



Notes:

1. As noted previously, the weighting and scoring for the category of criteria that measure the potential benefit to instream flow and habitat benefit were adjusted during the analysis to better reflect the priority of minimizing the impact of storage on fish species listed as threatened or endangered under the ESA. Streams where threatened, endangered, or fish species of concern were known to spawn, rear, or visit were scored lower (rated less favorably) than areas where these species are not found, and the fish presence criterion was given a stronger weighting in this category.



Instream Flow and Habitat

Scored Values

- <1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5

- County Boundary
- Subbasin Boundary
- Snoqualmie Watershed

N

0 5 10
Miles

GIS Analysis of Benefit to Instream Flow and Impact on Habitat

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-4

Basemap Layer Credits || Sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

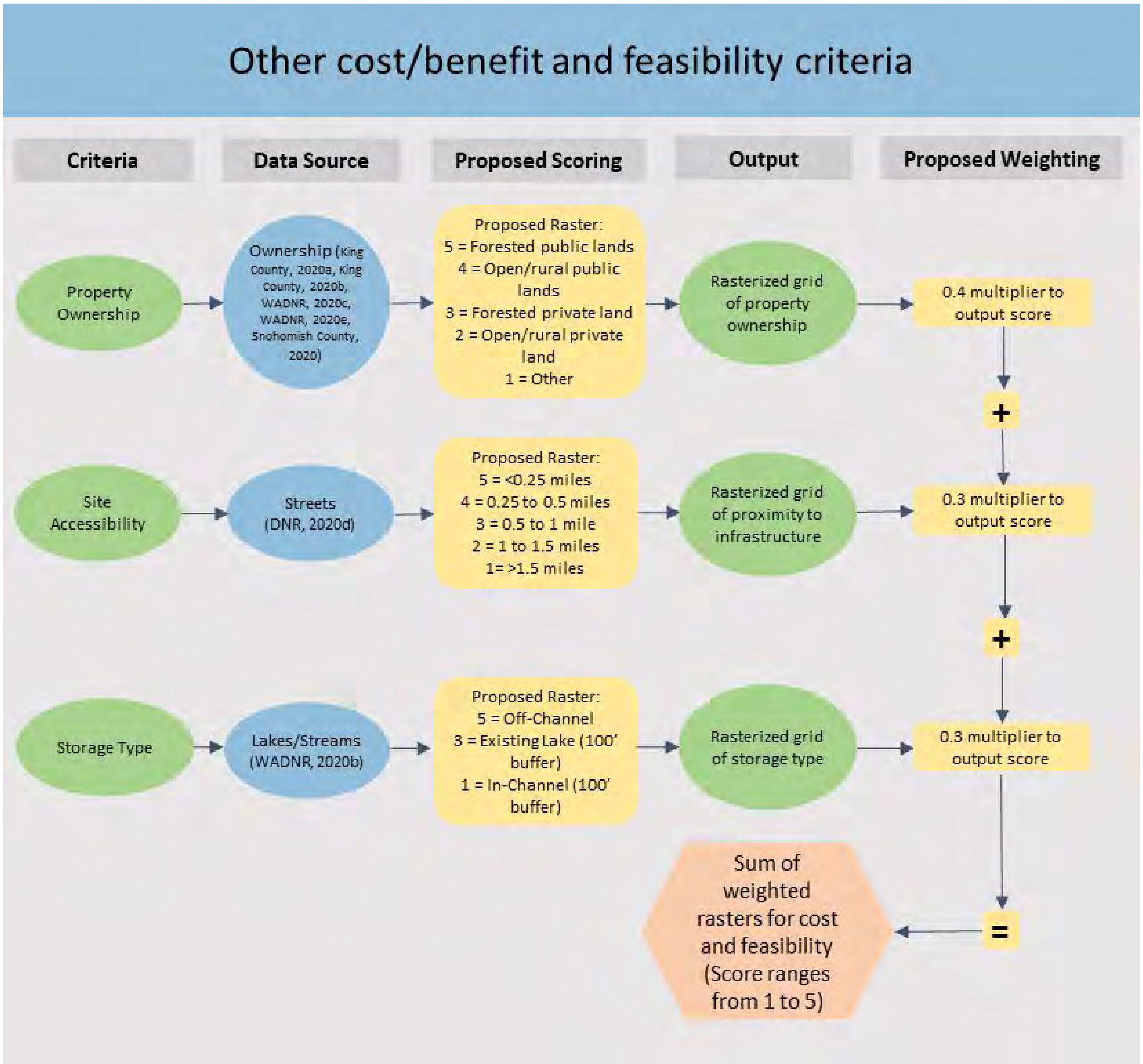
3.1.4 GIS Analysis of Cost-Benefit and Feasibility Criteria

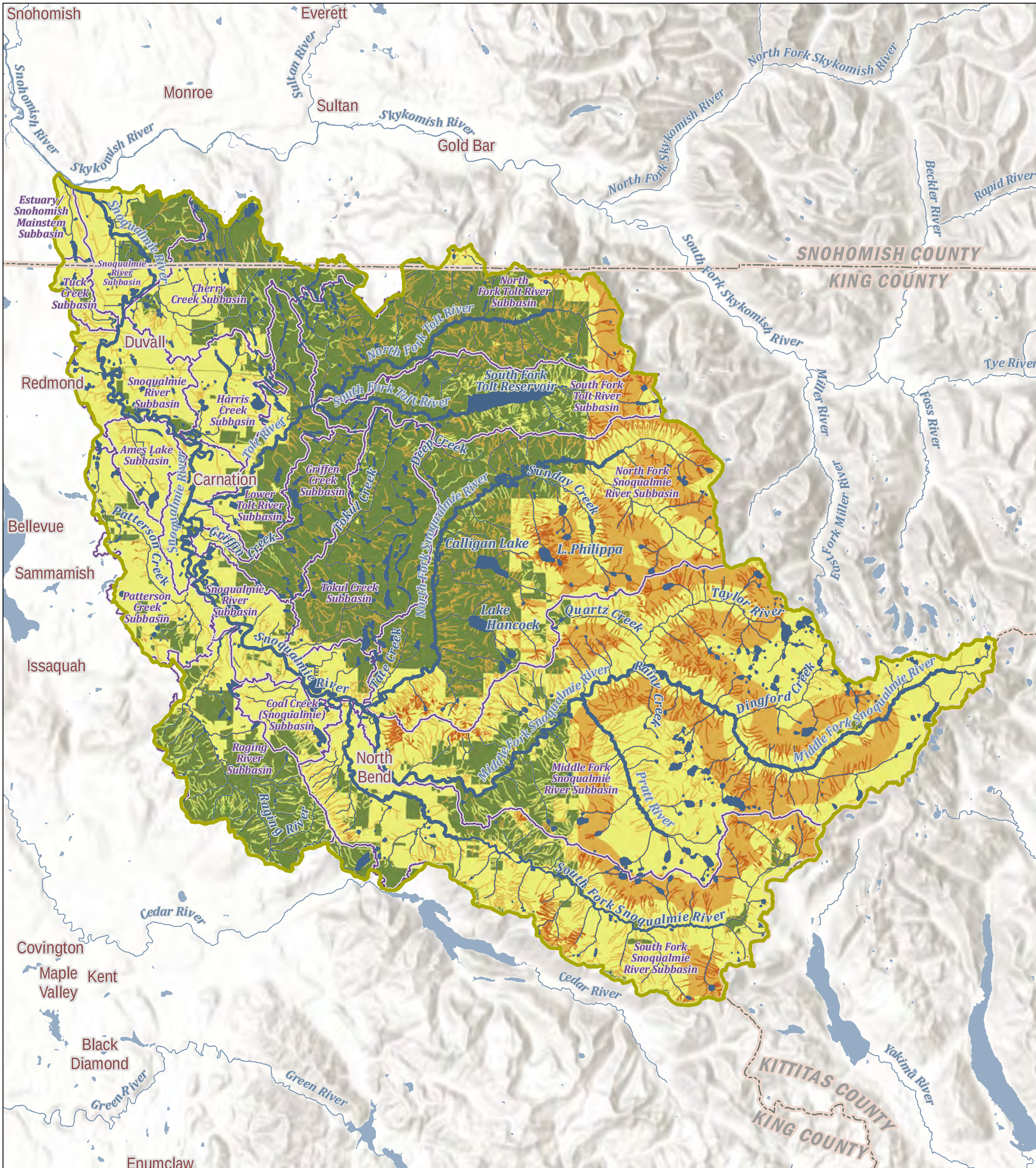
The feasibility of permitting and constructing a storage site is critical to its success. The team evaluated permitting complexity and constructability in GIS with a compilation of datasets that were scored, weighted, and added to create a final weighted raster score. The following describes the criteria, data, scoring, and weighting used in the GIS analysis of the category Cost-Benefit and Feasibility Criteria:

- **Property ownership**: The feasibility of finding land and permitting a water storage project varies greatly depending on the way the land is used and who owns it. A combination of land use and ownership was used to reflect the varied feasibility within these categories (Table 2-4). Public lands used for open, rural, or agricultural uses scored highest because the potential feasibility of obtaining land and permitting a water storage project is higher when those conditions are met. Public lands used for forest and timber follow in rank. There are more challenges encountered with privately held forested lands. Following that are privately owned rural and agricultural lands where people live, and agricultural uses are actively occurring. Last are public parks, wilderness areas, and other lands that are either protected or unlikely candidates for a project.
- **Site accessibility**: Distance from existing roads, including U.S. Forest Service roads, was scored to reflect the ease of access to potential site locations for construction and for operating and maintaining a water storage reservoir. Areas closer to existing roads were scored higher in the GIS analysis of this criterion than those farther from existing roads.
- **Storage type**: The types of storage that can be built could include on-channel projects that impound water flowing in a tributary, stream, or river, and off-channel projects that are constructed off of the tributary, stream, or river and then filled by diverting water from a nearby tributary, stream, or river. Raster grid cells were assessed by the proximity to a mapped tributary, stream, or river. The WRIA 7 WREC has expressed a preference for off-channel storage, because of the potential impact on-channel storage projects can have on fish and other wildlife. As a result, on-channel locations were scored lower and off-channel locations were scored higher for this criterion.

The process for evaluating, scoring, and weighting these criteria in GIS is illustrated in Figure 3-5. These criteria were each scored and then weighted and combined to provide an overall score for each raster representing the GIS analysis for the category Cost-Benefit and Feasibility Criteria. The overall scoring of each raster in the GIS model is illustrated in the map of the watershed provided in Figure 3-6. Similar to the other figures presented in this section, the colors range from the lowest scoring (red and orange) to the highest scoring (green).

Figure 3-5
GIS Analysis of Cost-Benefit and Feasibility Criteria





Cost Benefit and Feasibility

Scored Values

- <1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5

- County Boundary
- Subbasin Boundary
- Snoqualmie Watershed

0 5 10
Miles

GIS Analysis of Cost Benefit and Feasibility Criteria

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-6

GIS Path: G:\projects\SVWID\ComprehensiveStorageStudy_200026\Delivered\FinalReport\3_6 Summary Map – GIS Analysis of Cost Benefit and Feasibility Criteria.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/20/2021 || User: nkochie || Print Date: 12/20/2021

Basemap Layer Credits || Sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

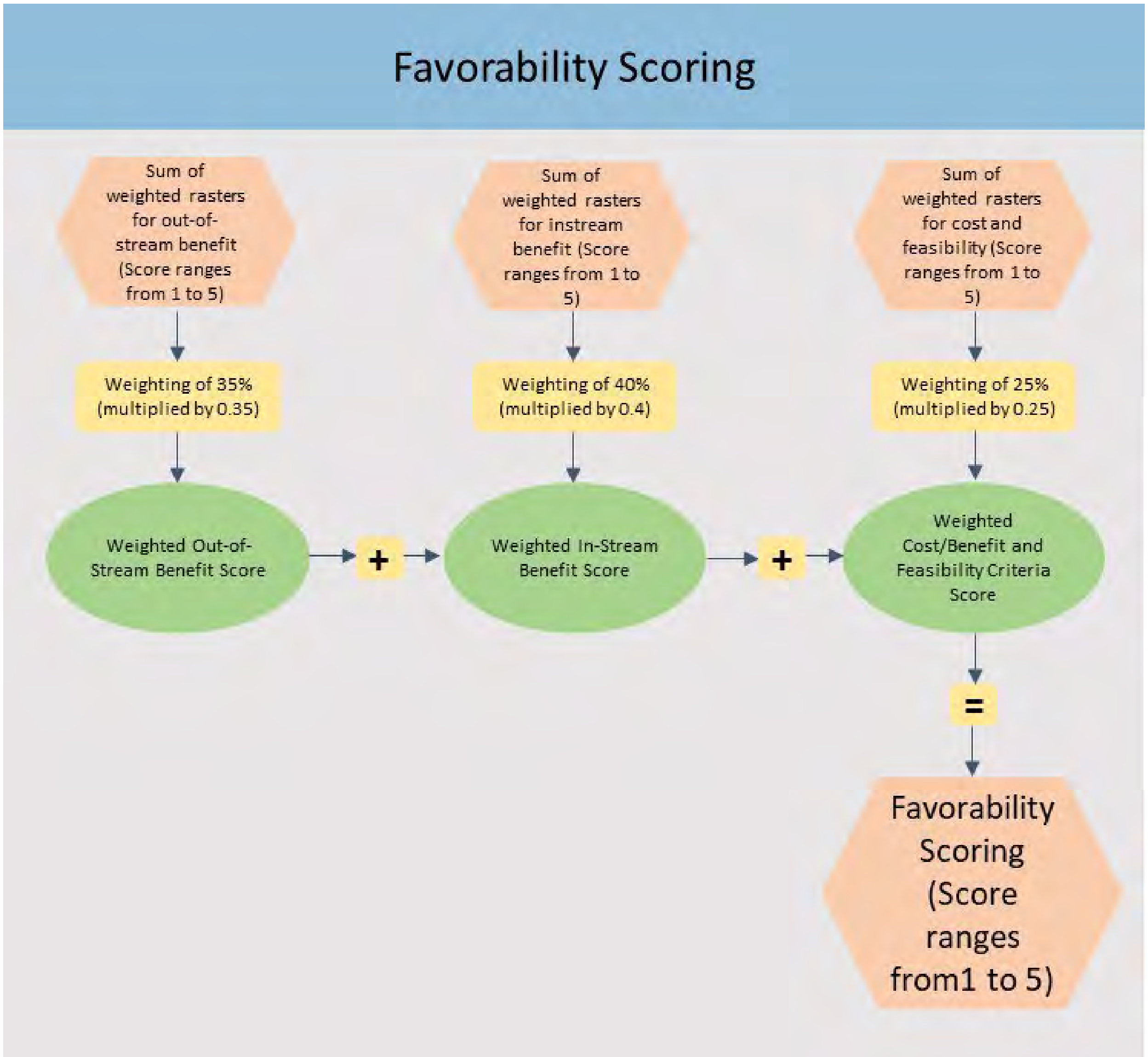
3.1.5 Summary of GIS Favorability Scoring

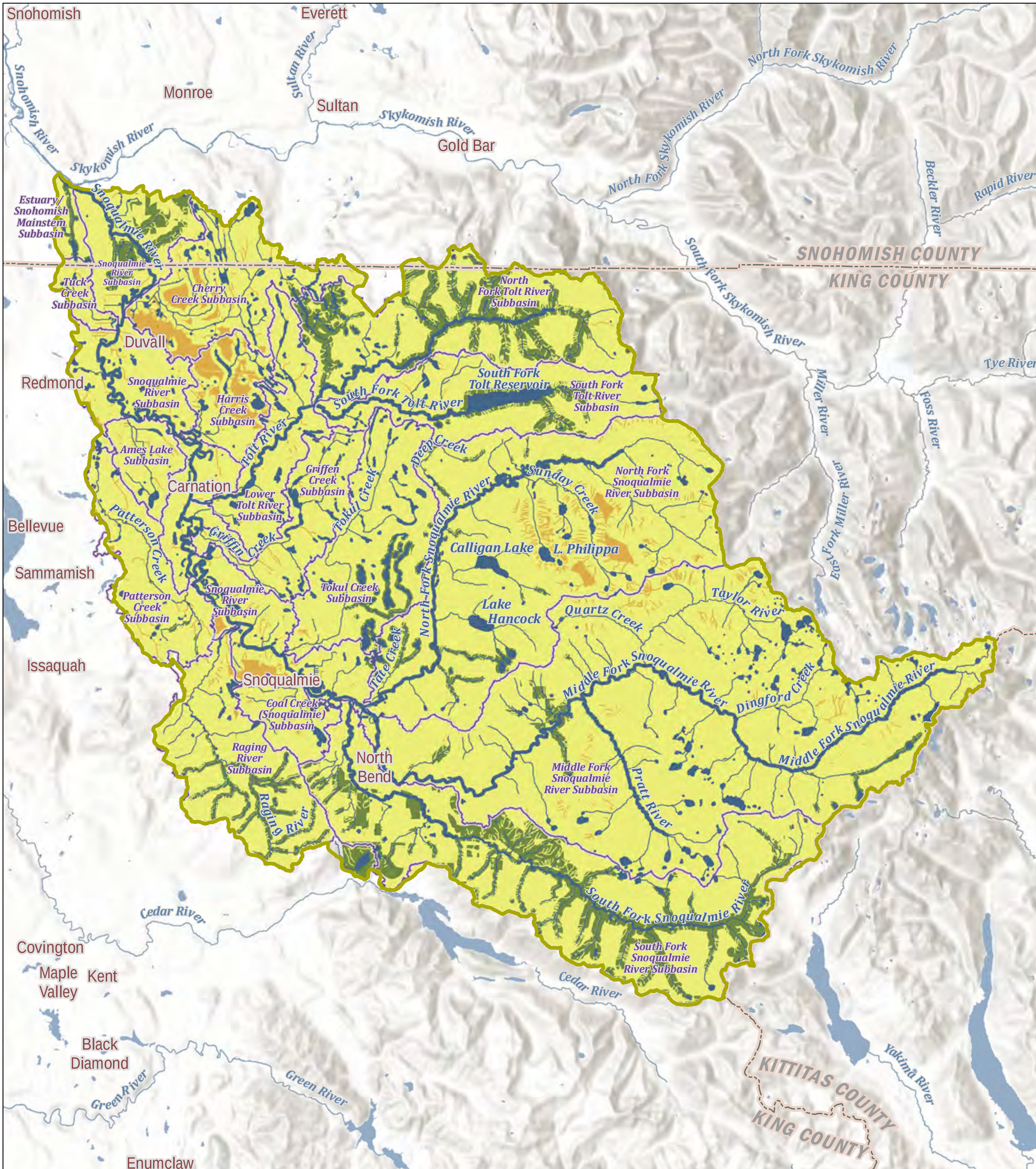
The Work Plan, which described how the data would be combined, scored, weighted, and ranked, was circulated to key stakeholders and finalized. As described in previous sections, geoprocessing models were built and run on a variety of publicly available datasets. The models produced output data for each of the three categories: Benefit to Instream Flows and Habitat, Benefit to Offset/Out-of-Stream Uses, and Cost-Benefit and Feasibility. These three output datasets were then combined and weighted to create a final favorability data layer at a resolution of 6-foot cell size, as shown in Figure 3-7.

The GIS datasets were then post-processed for web optimization. The resulting data, at an 18-foot grid cell, can be viewed on the webmap applications found in an online Story Map that will be temporarily hosted on Aspect Consulting's website. A screening report functionality can be run (expect delays in processing) straight from the browser on the Site Favorability tab for a quick "at a glance" idea of the average score over any user-defined area. The other tabs highlight each of the benefit categories and allow users to "Click Here" to experience interactive webmap applications by toggling datasets on and off.

The process for evaluating, scoring, and weighting these criteria in GIS is illustrated in Figure 3-7. The overall favorability scoring for the raster-based GIS weighted overlay analysis is shown on the map of the watershed in Figure 3-8. Similar to the other figures presented in this section, the colors range from the lowest scoring (red and orange) to the highest scoring (green). These results and the GIS data used to create them were used as a basis for identifying specific storage sites, as outlined in Section 3.2.1. The raster-based scoring over each storage site identified in Section 3.2.1 was analyzed to estimate a mean score for the criteria evaluated in this section for a given site, as described in Section 4, and then those scores were combined with the criteria scores from the site-specific analysis to determine an overall score for each site. The overall scoring is summarized in further detail in Section 4.

Figure 3-7
Summary of GIS Favorability Scoring





GIS Path: G:\projects\SVWID\ComprehensiveStorageStudy_200026\Delivered\FinalReport\3_8_Summary Map – GIS Weighted Overlay Analysis Favorability Scoring.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/20/2021 || User: rkoche || Print Date: 12/20/2021

Favorability Scoring

Scored Values

- <1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5

County Boundary

Subbasin Boundary

Snoqualmie Watershed

N

0 5 10

Miles

GIS Weighted Overlay Analysis Favorability Scoring

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	**3-8**

Basemap Layer Credits || Sources: Esri, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

3.2 Site-Specific Analysis

Following the compilation of the GIS database and development of the GIS weighted overlay analysis, Anchor QEA completed a thorough review of the GIS data and aerial photography to identify potential locations for storage reservoirs. A preliminary list of 26 potential storage sites was generated. That list was then narrowed down to a list of 20 potential sites that were evaluated on a site-by-site basis using the site-specific criteria outlined in Section 2. The challenges, benefits, and specific values associated with the site-specific criteria were identified through a series of analyses. The results are summarized in the screening matrix included in Appendix C. This section summarizes each of the sites that were evaluated through the site-specific screening analysis.

3.2.1 Identification of Potential Storage Sites

After compiling maps and reviewing the GIS data, Anchor QEA completed a search of all basins within the watershed that are not closed to future water right appropriations to identify potential storage sites. This brainstorming exercise identified 26 potential storage sites. The sites were mapped initially using Google Earth mapping software to facilitate visualization and discussion with the project team. The preliminary list and a few bullets describing each site were tabulated. This preliminary list is included as Table 3-1.

The preliminary list of 26 potential storage sites was reduced to a list of 20 total sites to be evaluated through the screening analysis and ranking outlined in this report. The list was reduced by eliminating sites that had apparent topographic constraints, access issues, anticipated property owner constraints, less potential for reliable refill, less storage volume, presence of salmonids, or other apparent constraints that would likely make water storage at these sites less favorable or potentially infeasible. The sites identified for inclusion in the screening analysis and ranking are listed in Table 3-2. These sites are shown on an overall map of the watershed in Figure 3-9.

Table 3-1
Preliminary List of Potential Storage Sites

Prel. Site ID	Description	Property Owner	Type of Storage	Initial Notes
1	Loutsis Lake	Private Owner, Owner Name Supplied to SVWID	Existing Lake, Raise Water Surface 1 to 2 Feet	• Small lake near Duvall. Proposal would be to raise lake level slightly. • In residential area. Would need to better understand controls at lake outlet, shoreline infrastructure, docks, etc.
2	Nelson Pond	Private Owner, Owner Name Supplied to SVWID	Existing Pond, Expand with Constructed Impoundment	• Small pond in depression south of Duvall. • Could capture additional volume with small embankment near outlet.
3	Twin Peaks Timber (1)	Twin Peaks Timber, LLC	Existing Pond, Expand with Constructed Impoundment	• Cleared timber property upslope of Rutherford Slough. • Could create an impoundment and divert water to storage from adjacent tributary.
4	Lake Margaret	Waterbody within Plat, Multiple Waterfront Parcels	Existing Lake, Raise Water Surface 1 to 2 Feet	• Small lake near northeast of Duvall. Proposal would be to raise lake level slightly. • In residential area. Would need to better understand controls at lake outlet, shoreline infrastructure, docks, etc.
5	Cherry Lake	DNR	Existing Lake, Expand with Constructed Impoundment	• Small lake near headwaters of Cherry Creek. • A larger reservoir could be created with an impoundment near outlet of narrow valley.
6	Upper Margaret Creek	Private Owner, Owner Name Supplied to SVWID	Existing Pond, Expand with Constructed Impoundment	• Small pond/wetland area near headwaters of Margaret Creek. • A larger reservoir could be created with an impoundment near outlet of narrow valley.
7	Snoqualmie Timber - Tolt (1)	Snoqualmie Timber, LLC	Existing Pond, Expand with Constructed Impoundment	• Small pond/wetland area east of Langlois Lake. • A larger reservoir could be created with an impoundment near outlet of narrow valley.
8	Snoqualmie Timber - Tolt (2)	Snoqualmie Timber, LLC	Off-channel, Constructed Impoundment	• Large, cleared timber property upslope of Tolt River. • Could create an impoundment to capture water from upslope tributary areas.

Prel. Site ID	Description	Property Owner	Type of Storage	Initial Notes
9	DNR - NF Tolt (1)	DNR	Off-channel, Constructed Impoundment, Near Tributary	• Narrow, wet, low area near subbasin boundary. • May be better location for investigation of a natural storage project.
10	DNR - NF Tolt (2)	DNR	Off-channel, Constructed Impoundment	• Clear area with wetlands near upstream end of a North Fork Tolt River tributary. • Could create an impoundment and divert water to storage from the adjacent tributary.
11	DNR - NF Tolt (3)	DNR	Off-channel, Constructed Impoundment, Near Tributary	• Forested area between hills, downslope of a tributary to the North Fork Tolt River. • Could create an impoundment and divert water to storage from the adjacent tributary.
12	Snoqualmie Timber - NF Tolt (1)	Snoqualmie Timber, LLC	Off-channel, Constructed Impoundment, Near Tributary	• Narrow valley between hills in uplands of North Fork Tolt watershed on timberland that appears to have been harvested in last 20 years. • Could create an impoundment between hills and capture runoff from upslope tributary areas.
13	Upper North Fork Creek	DNR	Impoundment on Upstream End of Small Tributary	• Narrow, wet, low area near subbasin boundary. • May be better location for investigation of a natural storage project.
14	Snoqualmie Timber - NF Tolt (2)	Snoqualmie Timber, LLC	Existing Pond, Expand with Constructed Impoundment	• Partially forested timberland with existing pond near base of hill. • Could expand by creating an impoundment and capture water from upslope tributary areas.
15	Snoqualmie Timber - NF Tolt (3)	Snoqualmie Timber, LLC	Off-channel, Constructed Impoundment, Timber Area	• Very large, relatively flat track of timber that appears to have been harvested in last 20 years. • Could create a very large impoundment and divert flow to storage from nearby tributaries that flow to the North Fork Tolt River.
16	Twin Peaks Timber - Tokul (1)	Twin Peaks Timber, LLC	Existing Pond, Expand with Constructed Impoundment	• Narrow, wet, low area adjacent to cleared timberland. • May be better location for investigation of a natural storage project.

Prel. Site ID	Description	Property Owner	Type of Storage	Initial Notes
17	Twin Peaks Timber - Tokul (2)	Twin Peaks Timber, LLC	Off-channel, Constructed Impoundment	• Cleared, gently sloping timber parcel. • Could create an impoundment and divert water to storage from the adjacent tributary.
18	Snoqualmie Timber - Tokul	Snoqualmie Timber, LLC	Off-channel, Constructed Impoundment	• Forested area between hills, very close to Tokul Creek. • Could create an impoundment and divert water from Tokul Creek to storage.
19	Bridges Lake	Snoqualmie Timber, LLC	Existing Lake, Raise Water Surface 1 to 2 Feet	• Medium-sized lake in chain of lakes in Tokul Creek subbasin. Proposal would be to raise lake level slightly. • Would need to better understand how water flows out of lake, whether there are any controls, etc.
20	Klaus Lake	Campbell Global, LLC	Existing Lake, Raise Water Surface 1 to 2 Feet	• Medium-sized lake in chain of lakes in Tokul Creek subbasin. Proposal would be to raise lake level slightly. • Would need to better understand how water flows out of lake, whether there are any controls, etc.
21	Black Lake	Snoqualmie Timber, LLC	Existing Lake, Raise Water Surface 1 to 2 Feet	• Medium-sized lake in chain of lakes in Tokul Creek subbasin. Proposal would be to raise lake level slightly. • Would need to better understand how water flows out of lake, whether there are any controls, etc.
22	Snoqualmie Timber - NF (1)	Snoqualmie Timber, LLC	Off-channel, Constructed Impoundment, Near Tributary	• Large, relatively flat forested area adjacent to a tributary that flows into the North Fork Snoqualmie River. • Could create a fairly large impoundment and divert water to storage from the adjacent tributary.
23	Snoqualmie Timber - NF (2)	Snoqualmie Timber, LLC	Off-channel, Constructed Impoundment, Timberland	• Cleared, gently sloping timber parcel on bluff above the North Fork Snoqualmie River. • Could create an impoundment and capture water from upslope tributary areas.
24	Snoqualmie Timber - NF 3)	Snoqualmie Timber, LLC	Existing Pond, Expand with Constructed Impoundment	• Low area just south of the North Fork Snoqualmie River with an existing pond and crossed by a U.S. Forest Service road. • Could create an impoundment at the head of a tributary that exits the area to the west through a narrow ravine.

Prel. Site ID	Description	Property Owner	Type of Storage	Initial Notes
25	Snoqualmie Timber - NF (4)	Snoqualmie Timber, LLC	Impoundment on Upstream End of Small Tributary	• High, relatively narrow valley on timberland northeast of Mount Si. • Could create an impoundment across the valley and capture runoff from a fairly large upstream tributary area.
26	DNR - MF (1)	DNR	Off-channel, Constructed Impoundment, Near Tributary	• Very large, relatively flat track of DNR timber property. • Could create a very large impoundment and divert flow to storage from nearby tributaries that convey water down the south slope of Mount Si and the adjacent ridge to the east.

Table 3-2
List of Storage Sites Evaluated Through Screening Analysis

Prel. Site ID	Site ID for Screening Analysis	Subbasin	Property Owner(s)	Estimated Full Water Surface Area (Acres)	Estimated Water Storage Volume (Acre-Feet)	Description/Type
1	SNO1	Lower Snoqualmie	Private Owner, Owner Name Supplied to SVWID	18.8	38	Existing Lake, Raise Water Surface 1 to 2 Feet
2	SNO2	Lower Snoqualmie	Private Owner, Owner Name Supplied to SVWID	14.7	42	Existing Pond, Expand with Constructed Impoundment
3	SNO3	Lower Snoqualmie	Twin Peaks Timber, LLC	17.9	197	Existing Pond, Expand with Constructed Impoundment
4	CCK1	Cherry Creek	Waterbody Within Plat, Multiple Waterfront Parcels	53.1	106	Existing Lake, Raise Water Surface 1 to 2 Feet
5	CCK2	Cherry Creek	DNR	22.2	173	Existing Lakes, Expand with Constructed Impoundment
6	CCK3	Cherry Creek	Private Owner, Owner Name Supplied to SVWID	7.9	22	Existing Pond, Expand with Constructed Impoundment
7	LOT1	Lower Tolt	Snoqualmie Timber, LLC	23.7	84	Existing Pond, Expand with Constructed Impoundment
8	LOT2	Lower Tolt	Snoqualmie Timber, LLC	19.4	130	Off-channel, Constructed Impoundment
10	NFT1	North Fork Tolt	DNR	11.6	113	Off-channel, Constructed Impoundment
12	NFT2	North Fork Tolt	Snoqualmie Timber, LLC	7.3	62	Off-channel, Constructed Impoundment, Near Tributary
13	NFT3	North Fork Tolt	DNR	11.5	132	Impoundment on Upstream End of Small Tributary
15	NFT4	North Fork Tolt	Snoqualmie Timber, LLC	133.6	1,296	Off-channel, Constructed Impoundment, Timber Area
18	TOK1	Tokul Creek	Snoqualmie Timber, LLC	8.1	38	Off-channel, Constructed Impoundment

Prel. Site ID	Site ID for Screening Analysis	Subbasin	Property Owner(s)	Estimated Full Water Surface Area (Acres)	Estimated Water Storage Volume (Acre-Feet)	Description/Type
19	TOK2	Tokul Creek	Snoqualmie Timber, LLC	40.0	80	Existing Lake, Raise Water Surface 1 to 2 Feet
20	TOK3	Tokul Creek	Campbell Global, LLC	50.6	101	Existing Lake, Raise Water Surface 1 to 2 Feet
21	TOK4	Tokul Creek	Snoqualmie Timber, LLC	38.4	77	Existing Lake, Raise Water Surface 1 to 2 Feet
22	NFK1	North Fork Snoqualmie	Snoqualmie Timber, LLC	47.3	449	Off-channel, Constructed Impoundment, Near Tributary
23	NFK2	North Fork Snoqualmie	Snoqualmie Timber, LLC	47.3	482	Off-channel, Constructed Impoundment, Timberland
25	NFK3	North Fork Snoqualmie	Snoqualmie Timber, LLC	6.0	29	Impoundment on Upstream End of Small Tributary
26	MFK1	Middle Fork Snoqualmie	DNR	173.8	3,311	Off-channel, Constructed Impoundment, Near Tributary

Potential Storage Site

DNR-Managed Land

Other State Land

County Boundary

Snoqualmie Watershed

Subbasin Boundary

0 5 10

Miles

N

Overview of Potential Storage Sites

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-9

GIS Path: G:\projects\SVWID\ComprehensiveStorageStudy_200026\Delivered\FinalReport\3_9 Overview of Potential Storage Sites.mxd || Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet || Date Saved: 12/20/2021 || User: nkochie || Print Date: 12/20/2021

3.2.2 Summary of Site-Specific Analyses

The following summarizes the evaluation of each potential storage site that was included in the screening analysis. Each site was given an identification number based on the subbasin where the site is located. Each site was then characterized by the values, challenges, and benefits associated with the analysis of site-specific criteria outside of GIS. The scoring and weighting of the sites, based on the information summarized in each of the following subsections, are included in screening matrix tables for the analysis (Appendix C).

3.2.2.1 Site SNO1: Loutsis Lake

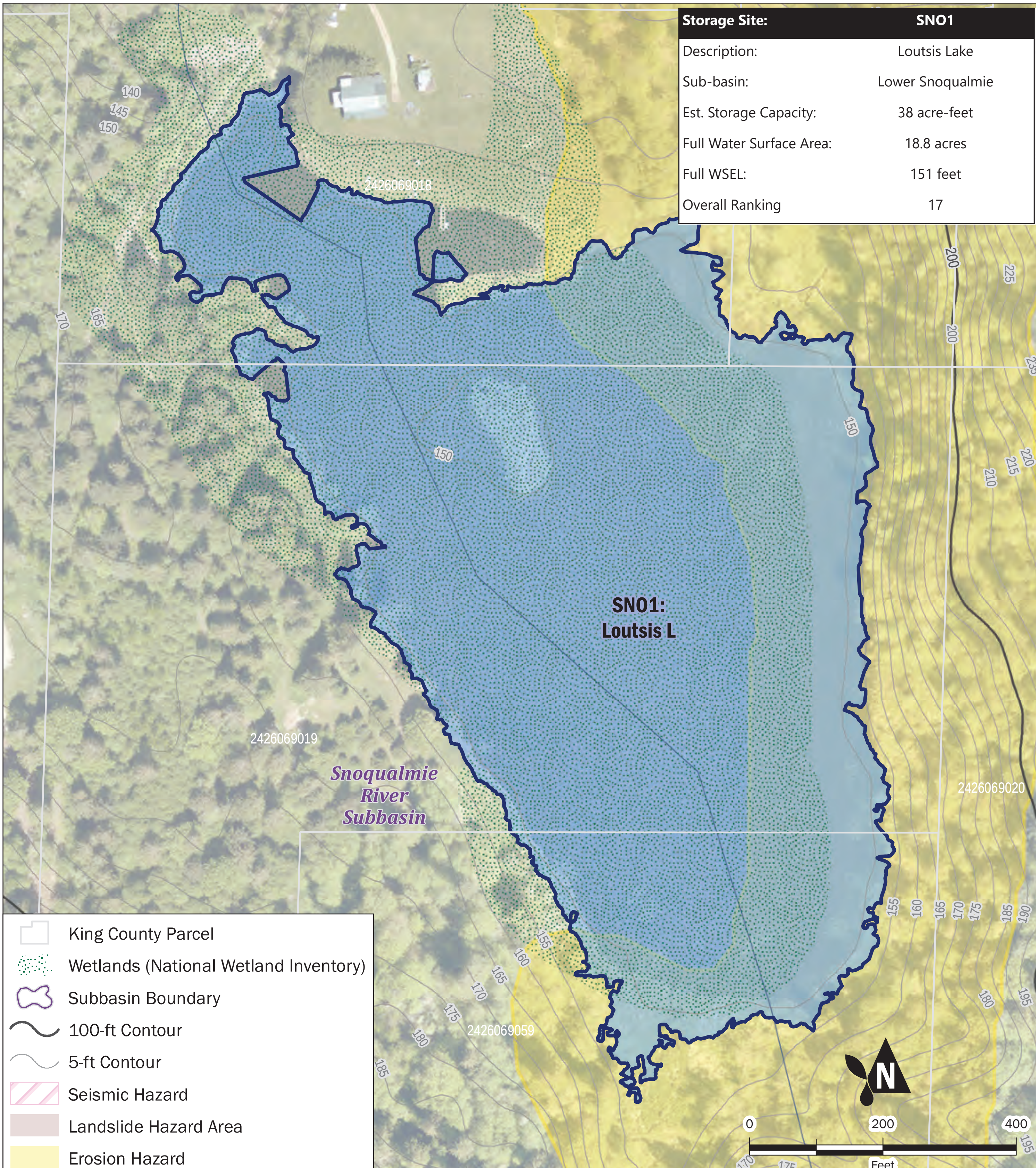
Site SNO 1 (Loutsis Lake) is a small lake located on residential parcels south of the town of Duvall within the Lower Snoqualmie subbasin. The property is privately owned as a rural residential property. The lake is approximately 18.8 acres in size. Storage capacity could potentially be developed at this existing lake by adjusting the controls at the outlet of the lake to allow for water to be stored and captured from the tributary area upslope of the lake, then released during the critical low-flow period in the late summer. Raising the water surface 2 feet would create approximately 38 acre-feet of additional storage. The concept is illustrated in Figure 3-10. Table 3-3 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

The lake owner has not yet been consulted, and the operation of the lake, the controls at the lake outlet, and the uses of the lake are not currently understood. If this project were to move forward, additional work would need to be done, including coordination with the property owner to gage willingness and provide information on the existing lake.

Table 3-3
Summary of Key Information for Site SNO1: Loutsis Lake

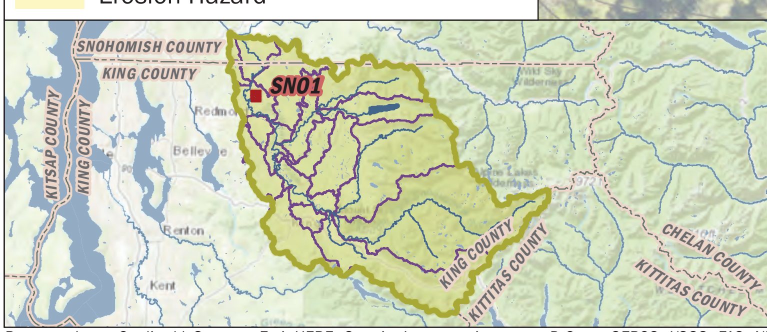
Key Physical Characteristic	Value
Site ID	SNO1
Overall Ranking (See Section 4)	17
Description	Existing Lake, Raise Water Surface 1 to 2 Feet
Parcel	King Co. 2426069018 King Co. 2426069019 King Co. 2426069059
Parcel Owner(s)	Private Owner, Owner Name Supplied to SVWID
Full Water Surface Elevation	151
Estimated Full Water Surface Area	18.8
Estimated Full Water Surface Volume	38
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Moderate Seepage Loss/Infiltration Potential

Key Criteria	Notes
Project Footprint	• The project would raise the level of an existing lake. • Raising the level would impact the shoreline, which appears to include landowner access infrastructure.
Available Storage Capacity	• The project concept would make approximately 38 acre-feet of additional storage capacity available for offset by raising the lake 2 feet.
Ability to Store High Flows	• The proposed lake has a relatively small tributary area (less than 1 square mile), with little ability to store high flows.
Instream Flow Benefits	• Water would be released to a small tributary that flows to the mainstem Snoqualmie River near Duvall. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 0.68-cfs flow benefit to the tributary and to the Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake is existing and the increase in level would likely have little impact on temperature and dissolved oxygen in downstream waters. • The Snoqualmie River is listed as Category 4A for temperature where the tributary flows into the river.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• Although the watershed tributary to the lake is relatively small, the ratio of the watershed to the size of the lake is better than for many of the sites that were evaluated.
Constructability	• The site would be relatively easy to access and construction would only include modifications or upgrades to existing infrastructure, rather than a new impounding structure.
Critical Areas and Resource Impacts	• GIS data indicate that the lake has mapped wetlands adjacent to it. • King County has mapped potential erosion hazards near the lake (King County 2020g).
Cost and Funding Potential	• Estimated cost: $650,000 to $980,000 • Estimated cost per acre-foot: $17,400 to $26,100 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• The lake is existing, has established access, and is in Ecology's Dam Safety Office inventory of regulated dams. • Likely relatively low operations and maintenance effort required at this site.



Storage Site:	SNO1
Description:	Loutsis Lake
Sub-basin:	Lower Snoqualmie
Est. Storage Capacity:	38 acre-feet
Full Water Surface Area:	18.8 acres
Full WSEL:	151 feet
Overall Ranking	17

King County Parcel
Wetlands (National Wetland Inventory)
Subbasin Boundary
100-ft Contour
5-ft Contour
Seismic Hazard
Landslide Hazard Area
Erosion Hazard



Concept Map, Storage Site: SNO1

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING

DEC-2021	BY: EAC	FIGURE NO.
PROJECT NO. 200026	REVISED BY: NLK	3-10

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3.2.2.2 Site SNO2: Nelson Pond

Site SNO2 (Nelson Pond) is a small pond located on residential parcels in a depression south of the town of Duvall within the Lower Snoqualmie subbasin. Properties are privately owned rural residential properties. The pond is approximately 15 acres in size. Storage capacity could potentially be developed by constructing a small embankment near the outlet on the west side of the pond to allow for water to be stored and captured from the tributary area upslope of the pond, then released during the critical low-flow period in the late summer. The embankment would create approximately 42 acre-feet of additional storage. The concept is illustrated in Figure 3-11. Table 3-4 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

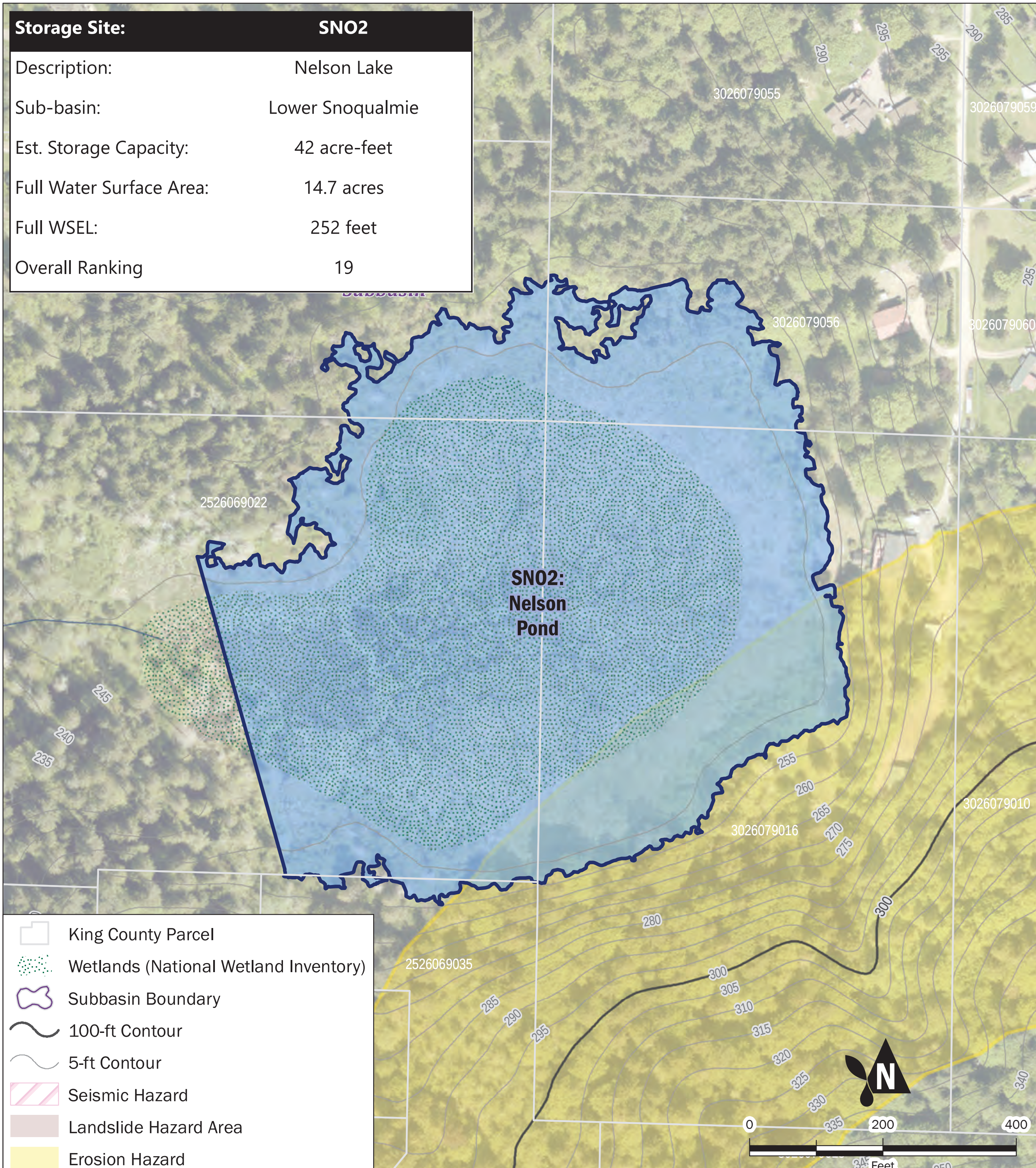
The property owners have not yet been consulted, and the current operation, controls, and uses of the pond are not currently understood. If this project were to move forward, additional work would need to be done, including coordination with the property owners to gage willingness and provide information on the existing pond.

Table 3-4
Summary of Key Information for Site SNO2: Nelson Pond

Key Physical Characteristic	Value
Site ID	SNO2
Overall Ranking (See Section 4)	19
Description	Existing Pond, Expand with Constructed Impoundment
Parcel	King Co. 2526069022 King Co. 302679016
Parcel Owner(s)	Private Owner, Owner Name Supplied to SVWID
Full Water Surface Elevation	252
Estimated Full Water Surface Area	14.7
Estimated Full Water Surface Volume	42
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would expand an existing pond.
Available Storage Capacity	• The project concept would make approximately 42 acre-feet of storage available.
Ability to Store High Flows	• The proposed lake has a small tributary area (less than 1 square mile) and would have little ability to store high flows.

Key Criteria	Notes
Instream Flow Benefits	• Water would be released to a small tributary that flows to the mainstem Snoqualmie River near Duvall. • If the storage volume was released over a 4-week low flow period, it would provide a 0.76-cfs flow benefit to the tributary and to the Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The pond is existing and the increase in level would likely have little impact on temperature and dissolved oxygen in downstream waters. • The Snoqualmie River is listed as Category 4A for temperature where the tributary flows into the river.
Water Quality – Toxics	• The Snoqualmie River is listed as Category 4A for bacteria where the tributary flows into the river.
Reliability/Resilience	• The watershed tributary to the pond is small, and the ratio of the watershed to the size of the pond is worse than many of the sites that were evaluated.
Constructability	• The site would need to be accessed through a private dirt road.
Critical Areas and Resource Impacts	• GIS data indicate that the pond and adjacent area are mapped as wetlands. • King County has mapped potential erosion hazards near the pond.
Cost and Funding Potential	• Estimated cost: $2,750,000 to $4,160,000 • Estimated cost per acre-foot: $65,600 to $98,400 • The cost per acre-foot of storage is high relative to other sites evaluated.
Operation and Maintenance	• The site would need to be operated in accordance with Ecology Dam Safety guidelines.

Storage Site:	SNO2
Description:	Nelson Lake
Sub-basin:	Lower Snoqualmie
Est. Storage Capacity:	42 acre-feet
Full Water Surface Area:	14.7 acres
Full WSEL:	252 feet
Overall Ranking	19



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Concept Map, Storage Site: SNO2

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect Consulting	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-11

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3.2.2.3 Site SNO3: Twin Peaks Timber - Snoqualmie

Site SNO3 (Twin Peaks Timber – Snoqualmie site) is an existing pond located in cleared timber property upslope of Rutherford Slough. The property is owned by Twin Peaks Timber, LLC. Storage capacity could potentially be developed by constructing an impoundment across the northwest portion of the pond and diverting water from the adjacent tributary to storage, which could then be released during the critical low-flow period in the late summer. This impoundment could store 197 acre-feet of water. The concept is illustrated in Figure 3-12. Table 3-5 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

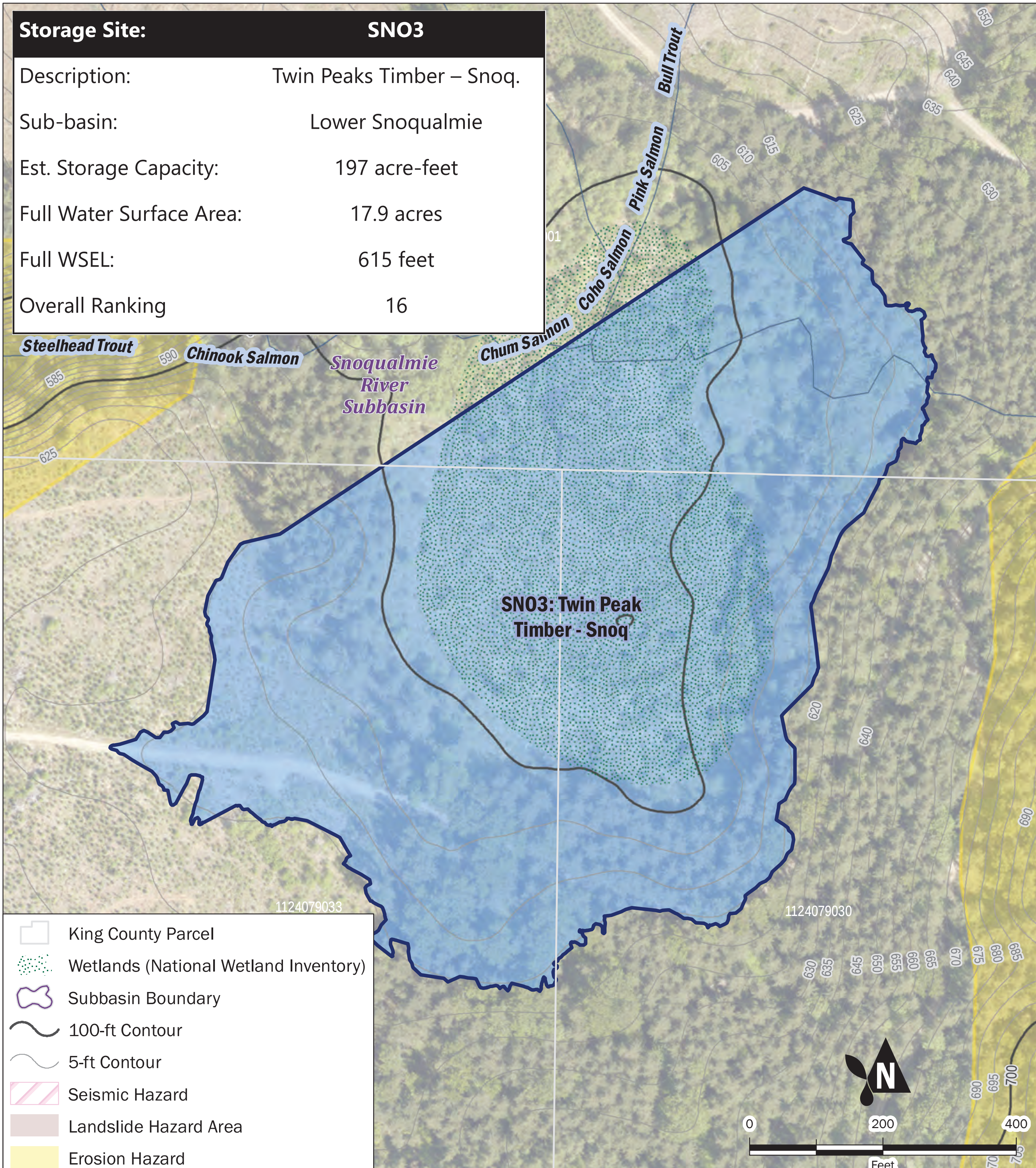
Twin Peaks Timber, LLC, has not yet been consulted. If this project were to move forward, additional work would need to be done, including coordination with Twin Peaks Timber to gage willingness.

Table 3-5
Summary of Key Information for Site SNO3: Twin Peaks Timber - Snoqualmie

Key Physical Characteristic	Value
Site ID	SNO3
Overall Ranking (See Section 4)	16
Description	Existing Pond, Expand with Constructed Impoundment
Parcel	King Co. 0224079001 King Co. 1124079033 King Co. 1124079030
Parcel Owner(s)	Twin Peaks Timber, LLC
Full Water Surface Elevation	615
Estimated Full Water Surface Area	17.9
Estimated Full Water Surface Volume	197
Source of Inflow	Tributary diversion
Categorization by Seepage Loss Potential	Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would impound an existing pond. • Portions of the project area are uncleared forest.
Available Storage Capacity	• The project concept would make approximately 197 acre-feet of storage available.
Ability to Store High Flows	• The proposed project has a small tributary area (less than 1 square mile) and would have little ability to store high flows.

Key Criteria	Notes
Instream Flow Benefits	• Water would be released to a small tributary that flows to the mainstem Snoqualmie River near Rutherford Slough. • This project has a direct connection to a fish-bearing stream. • If the storage volume was released over a 4-week low flow period, it would provide a 3.55-cfs flow benefit to the tributary and to the Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• Releases could impact temperature and dissolved oxygen conditions in the tributary. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer. • The Snoqualmie River is listed as Category 4A for temperature where the tributary flows into the river.
Water Quality – Toxics	• No potential sources of contamination were noted in the project area.
Reliability/Resilience	• The ratio of the tributary watershed to the size of the project is small.
Constructability	• The project site is near established trails but has limited road access. • A long embankment would be required for this project, making constructability more difficult than other projects analyzed.
Critical Areas and Resource Impacts	• GIS data indicate the existing pond is mapped as a wetland area. • Water would be diverted from an adjacent stream mapped as habitat for various salmon, steelhead, and bull trout.
Cost and Funding Potential	• Estimated cost: $5,100,000 to $7,660,000 • Estimated cost per acre-foot: $25,900 to $38,800 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• Nearby forestland may require additional operation/maintenance. • The site would need to be operated in accordance with Ecology Dam Safety guidelines.

Storage Site:	SNO3
Description:	Twin Peaks Timber – Snoq.
Sub-basin:	Lower Snoqualmie
Est. Storage Capacity:	197 acre-feet
Full Water Surface Area:	17.9 acres
Full WSEL:	615 feet
Overall Ranking	16



Legend:
- King County Parcel
- Wetlands (National Wetland Inventory)
- Subbasin Boundary
- 100-ft Contour
- 5-ft Contour
- Seismic Hazard
- Landslide Hazard Area
- Erosion Hazard

Concept Map, Storage Site: SNO3

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-12

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3.2.2.4 Site CCK1: Lake Margaret

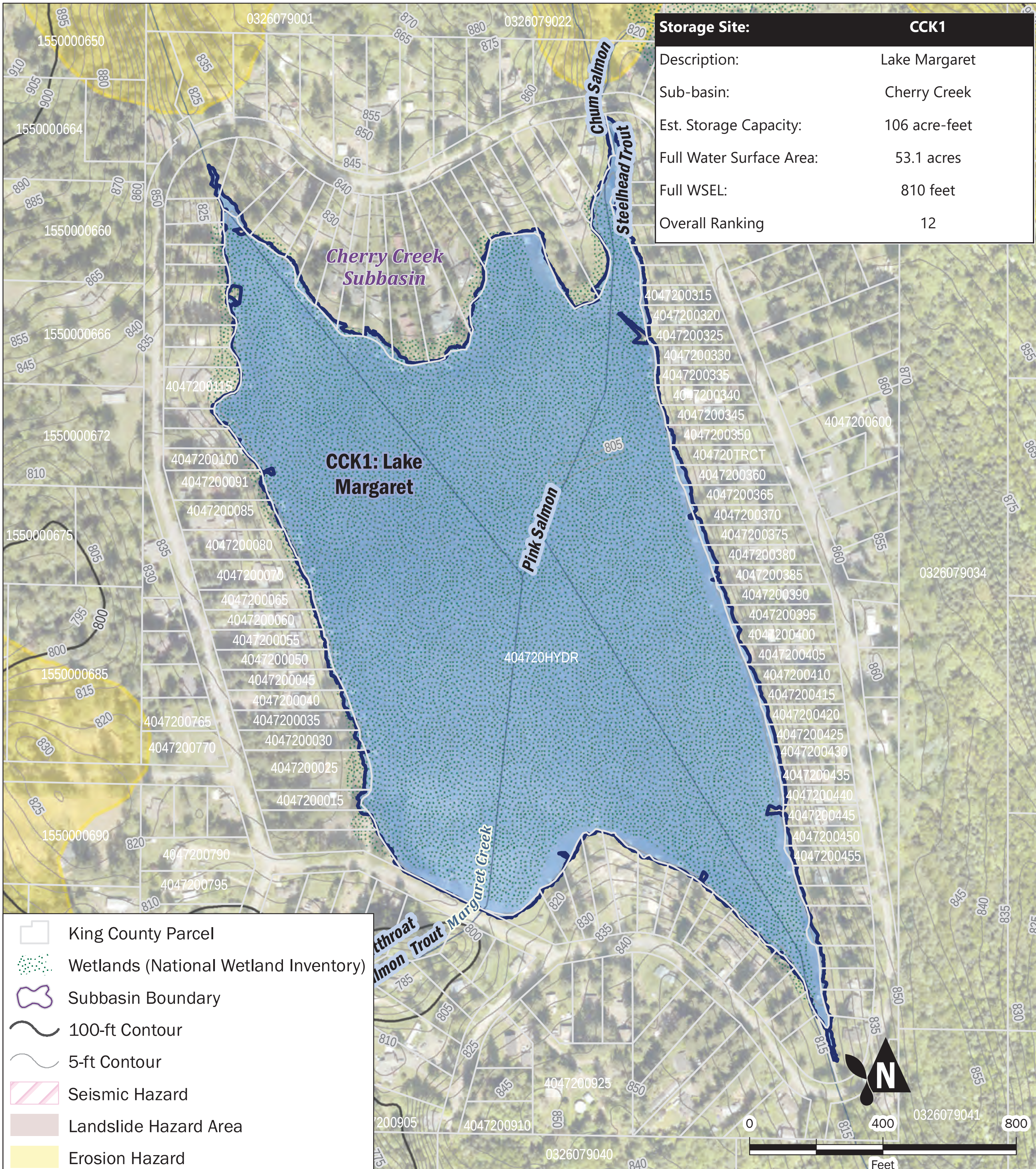
Site CCK1 (Lake Margaret) is a small lake northeast of Duvall in the Cherry Creek subbasin. It is located within a plat that has multiple residential waterfront parcels. The lake is approximately 53.1 acres in size. Storage capacity could potentially be developed at this existing lake by adjusting the controls at the outlet of the lake to allow for water to be stored and captured from the tributary area upslope of the lake, then released during the critical low-flow period in the late summer. Raising the water surface 2 feet would create approximately 106 acre-feet of additional storage. This storage concept is shown in Figure 3-13. Table 3-6 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

The operation of the lake, the controls at the lake outlet, shoreline infrastructure, and dock information are not currently understood. If this project were to move forward, additional work would need to be done, including coordination with the surrounding property owners to gage willingness and provide information about the existing lake.

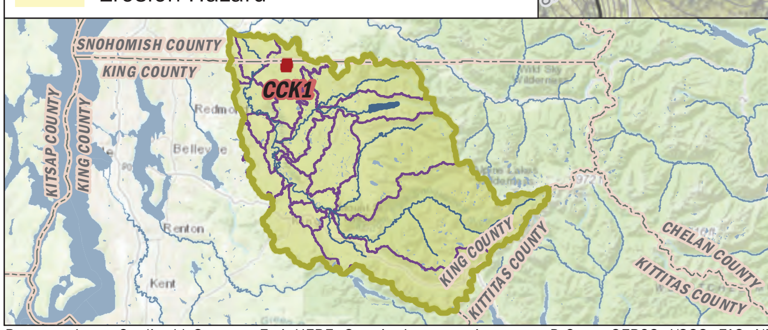
Table 3-6
Summary of Key Information for Site CCK1: Lake Margaret

Key Physical Characteristic	Value
Site ID	CCK1
Overall Ranking (See Section 4)	12
Description	Existing Lake, Raise Water Surface 1 to 2 Feet
Parcel	Waterbody within Plat; Multiple Waterfront Parcels
Parcel Owner(s)	In Plat Hydrology Parcel, Multiple Private Lakefront Owners
Full Water Surface Elevation	810
Estimated Full Water Surface Area	53.1
Estimated Full Water Surface Volume	106
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would raise the level of an existing lake. • Raising the level would impact the shoreline, which includes waterfront docks and infrastructure.
Available Storage Capacity	• The project concept would make approximately 106 acre-feet of storage available for offset by raising the lake 2 feet, which does not include the existing volume of water stored in the lake.
Ability to Store High Flows	• The proposed lake has a moderate tributary area (2.76 square miles) relative to the other storage projects.

Key Criteria	Notes
Instream Flow Benefits	• Water would be released to Margaret Creek which flows to Cherry Creek then to the mainstem Snoqualmie River. • The lake has a direct connection to a fish-bearing stream. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 1.91-cfs flow benefit to Margaret Creek, Cherry Creek, which is flow deficient in the late summer, and the Snoqualmie River downstream of Cherry Creek.
Water Quality – Temperature, Dissolved Oxygen	• The lake is existing and the increase in level would likely have little impact on temperature and dissolved oxygen in downstream waters. • Cherry Creek is listed as Category 4A for temperature where Margaret Creek flows into Cherry Creek.
Water Quality – Toxics	• Cherry Creek is listed as Category 4A for bacteria where Margaret Creek flows into Cherry Creek.
Reliability/Resilience	• The ratio of the watershed to the size of the lake is better than for many of the sites that were evaluated.
Constructability	• The site would be relatively easy to access and construction would only include modifications or upgrades to existing infrastructure, rather than a new impounding structure.
Critical Areas and Resource Impacts	• GIS data indicate that the lake is mapped as a wetland.
Cost and Funding Potential	• Estimated cost: $1,430,000 to $2,140,000 • Estimated cost per acre-foot: $13,500 to $20,200 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• The lake is existing, has established access, and is in Ecology's Dam Safety Office inventory of regulated dams. • Likely relatively low operations and maintenance effort required at this site.



Storage Site:	CCK1
Description:	Lake Margaret
Sub-basin:	Cherry Creek
Est. Storage Capacity:	106 acre-feet
Full Water Surface Area:	53.1 acres
Full WSEL:	810 feet
Overall Ranking	12



Concept Map, Storage Site: CCK1

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect Consulting	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-13

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3.2.2.5 Site CCK2: Cherry Lake

Site CCK2 (Cherry Lake) is a small lake located on Washington State Department of Natural Resources (DNR) land, along with some other small ponds, near the headwaters of Cherry Creek. The proposed storage reservoir would extend approximately 22 acres through narrow valleys at the upstream end of the Cherry Creek subbasin. Storage capacity could potentially be developed by constructing an embankment near the outlet of the narrow valley. The estimated storage capacity of this project is 173 acre-feet. This storage concept is shown in Figure 3-14. Table 3-7 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

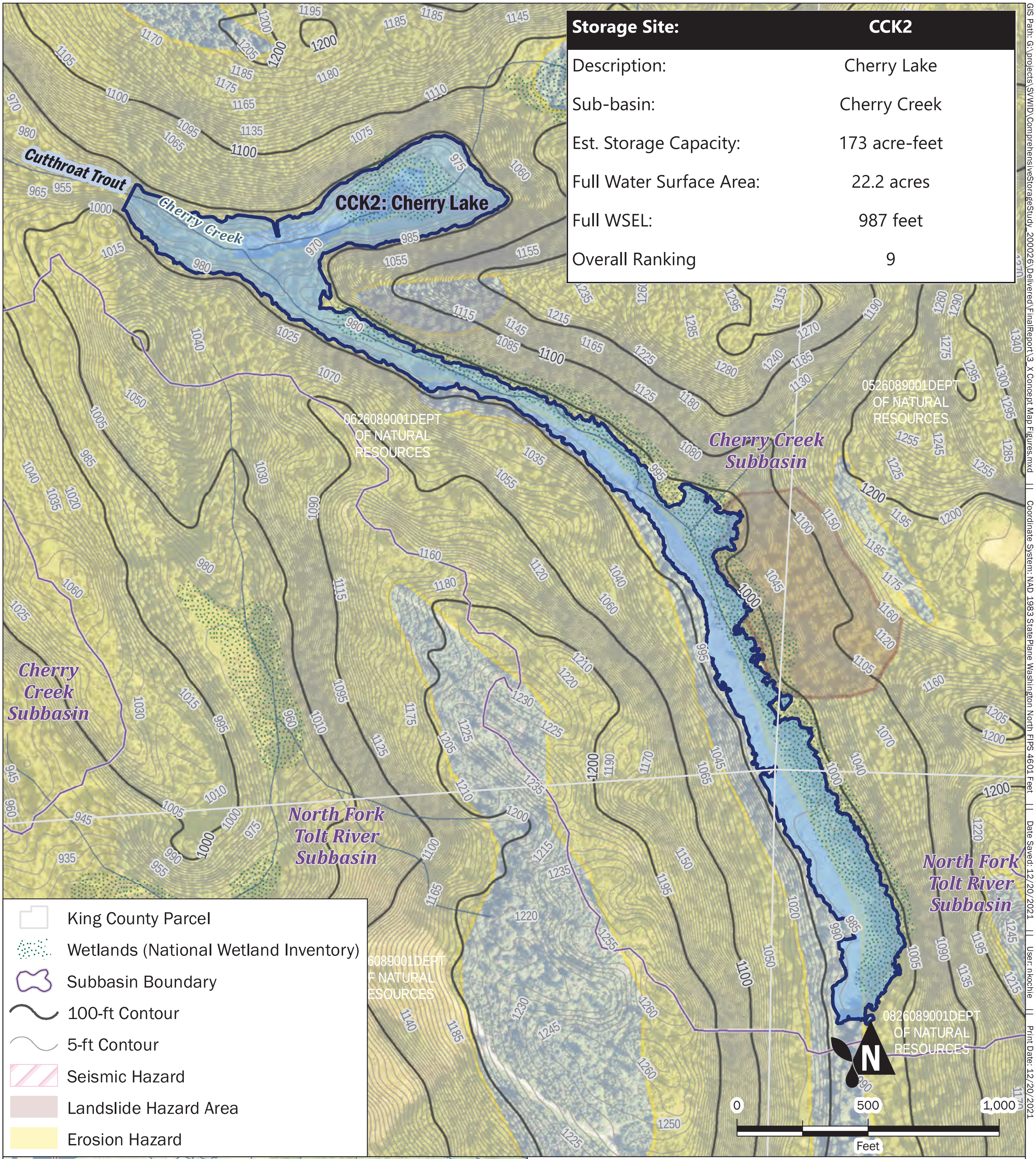
DNR had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with DNR.

Table 3-7
Summary of Key Information for Site CCK2: Cherry Lake

Key Physical Characteristic	**Value**
Site ID	CCK2
Overall Ranking (See Section 4)	9
Description	Existing Lakes, Expand with Constructed Impoundment
Parcel	King Co. 0626089001 King Co. 0526089001 King Co. 0826089001
Parcel Owner(s)	DNR
Full Water Surface Elevation	987
Estimated Full Water Surface Area	22.2
Estimated Full Water Surface Volume	173
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would impound existing lakes. • Portions of the impounded area are uncleared forest.
Available Storage Capacity	• The project concept would make approximately 173 acre-feet of storage available.
Ability to Store High Flows	• The proposed project has a relatively moderate tributary area (2.09 square miles).
Instream Flow Benefits	• Water would be released to Cherry Creek. • Cherry Creek is a fish-bearing stream. • If the storage volume was released over a 4-week low flow period, it would provide a 3.11-cfs flow benefit to Cherry Creek, which is flow deficient in the late summer, and to the Snoqualmie River downstream of Cherry Creek.

Key Criteria	Notes
Water Quality – Temperature, Dissolved Oxygen	• The proposed reservoir is relatively narrow, so the impoundment may have little impact on temperature and dissolved oxygen in downstream waters. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer.
Water Quality – Toxics	• Cherry Creek is listed as Category 5 for pH at the outlet location.
Reliability/Resilience	• The ratio of the watershed to the size of the lake is average compared to other sites that were evaluated.
Constructability	• The site has limited access so it may be difficult accessing the site for construction. • The proposed embankment is relatively small compared to other projects evaluated.
Critical Areas and Resource Impacts	• GIS data indicate that the lake has mapped wetlands adjacent to it and within proposed reservoir footprint. • King County has mapped potential erosion hazards at the project. • King County has mapped a potential landslide hazard area near the potential project area (King County 2020f).
Cost and Funding Potential	• Estimated cost: $1,870,000 to $2,800,000 • Estimated cost per acre-foot: $10,800 to $16,200 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• Limited access may increase the difficulty of operation/maintenance. • Nearby forestland may require additional operation/maintenance. • The site would need to be operated in accordance with Ecology Dam Safety guidelines.

Storage Site:	CCK2
Description:	Cherry Lake
Sub-basin:	Cherry Creek
Est. Storage Capacity:	173 acre-feet
Full Water Surface Area:	22.2 acres
Full WSEL:	987 feet
Overall Ranking	9



- King County Parcel
- Wetlands (National Wetland Inventory)
- Subbasin Boundary
- 100-ft Contour
- 5-ft Contour
- Seismic Hazard
- Landslide Hazard Area
- Erosion Hazard

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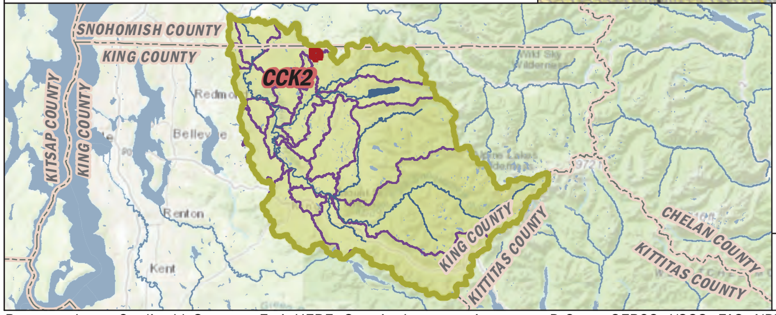

Concept Map, Storage Site: CCK2

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect Consulting	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-14

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3.2.2.6 Site CCK3: Upper Margaret Creek

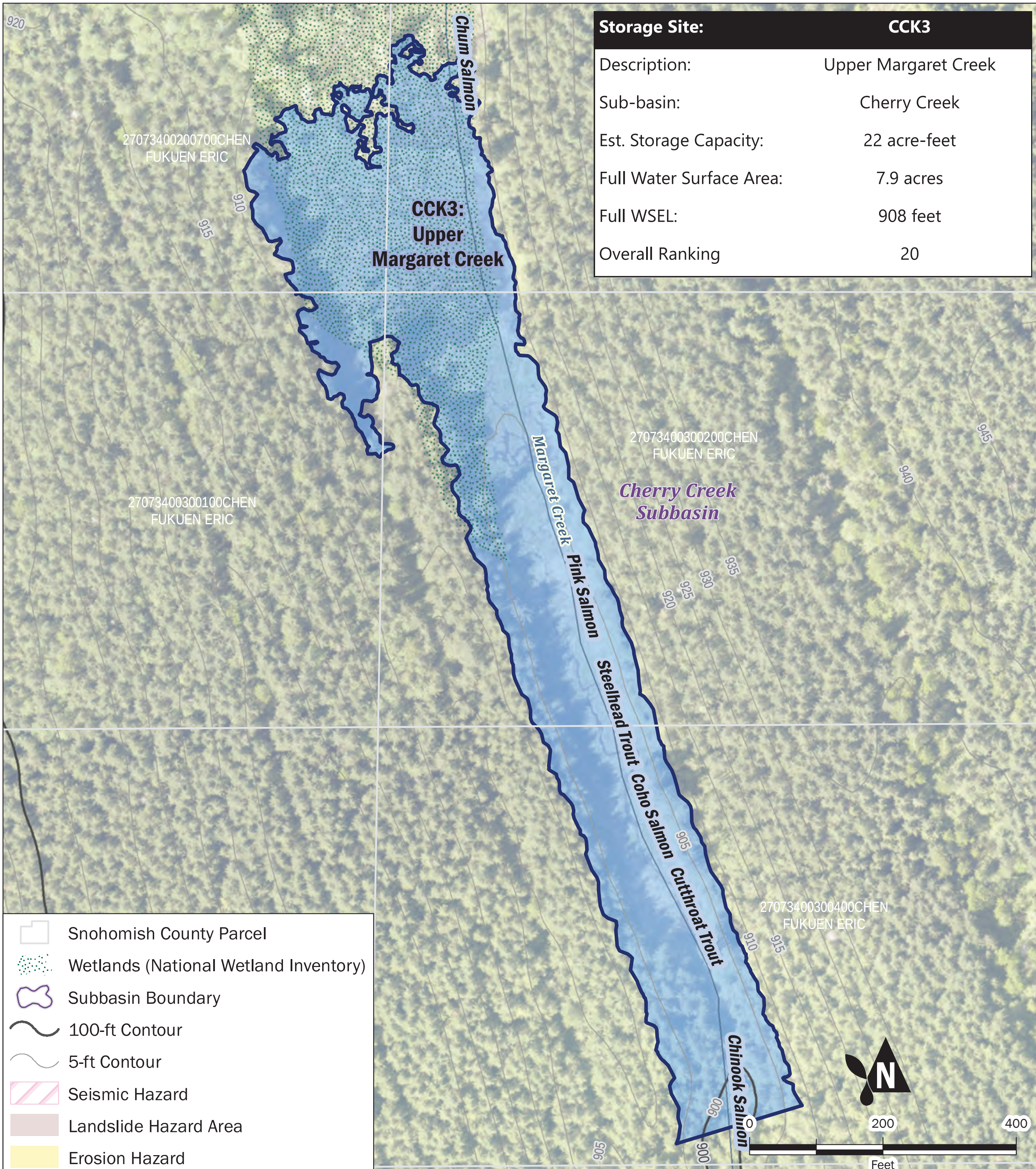
Site CCK3 (Upper Margaret Creek) includes an existing pond in a narrow valley in Snohomish County in the headwaters of the Cherry Creek subbasin. The project is located on undeveloped, forested property owned by a private landowner. The project area is approximately 7.9 acres. Storage capacity could be created with an impoundment near the outlet of a narrow valley to allow for water to be stored and captured from the tributary area upslope of the pond, then released during the critical low-flow period in the late summer. The impoundment would create approximately 22 acre-feet of storage. This storage concept is shown in Figure 3-15. Table 3-8 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

The property owner has not yet been consulted. If this project were to move forward, additional work would need to be done, including coordination with the property owner to gage willingness.

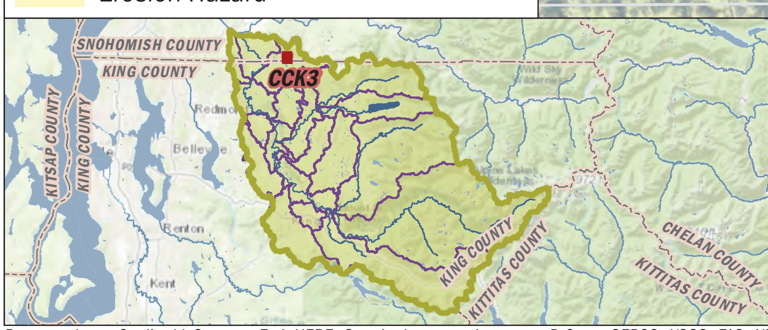
Table 3-8
Summary of Key Information for Site CCK3: Upper Margaret Creek

Key Physical Characteristic	Value
Site ID	CCK3
Overall Ranking (See Section 4)	20
Description	Existing Pond, Expand with Constructed Impoundment
Parcel	Snohomish Co. 27073400200700 Snohomish Co. 27073400200800 Snohomish Co. 27073400300100 Snohomish Co. 27073400300200 Snohomish Co. 27073400300300 Snohomish Co. 27073400300400
Parcel Owner(s)	Private Owner, Owner Name Supplied to SVWID
Full Water Surface Elevation	908
Estimated Full Water Surface Area	7.9
Estimated Full Water Surface Volume	22
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• This project would impound an existing pond. • Most of this project area is uncleared forestland.
Available Storage Capacity	• This project concept would make approximately 22 acre-feet of storage available.
Ability to Store High Flows	• The proposed project has a small tributary area (less than 1 square mile) and would have little ability to store high flows.

Key Criteria	Notes
Instream Flow Benefits	• Water would be released to Margaret Creek which flows through Margaret Lake to Cherry Creek, then to the mainstem Snoqualmie River. • The lake has a direct connection to a fish-bearing stream. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 0.40-cfs flow benefit to Margaret Creek, Cherry Creek, which is flow deficient in the late summer, and the Snoqualmie River downstream of Cherry Creek.
Water Quality – Temperature, Dissolved Oxygen	• The proposed project is relatively narrow, so the impoundment may have little impact on temperature and dissolved oxygen in downstream waters. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer. • Cherry Creek is listed as Category 4A for temperature where Margaret Creek flows into Cherry Creek.
Water Quality – Toxics	• Cherry Creek is listed as Category 4A for bacteria where Margaret Creek flows into Cherry Creek.
Reliability/Resilience	• Although the watershed tributary to the lake is relatively small, the ratio of the watershed to the size of the lake is average compared to other sites evaluated.
Constructability	• The site has limited access so it may be difficult accessing the site for construction. • The proposed embankment is relatively small compared to other projects evaluated.
Critical Areas and Resource Impacts	• GIS data indicate that there are mapped wetlands within and adjacent to the proposed reservoir.
Cost and Funding Potential	• Estimated cost: $1,220,000 to $1,830,000 • Estimated cost per acre-foot: $55,200 to $82,800 • The cost per acre-foot of storage is high relative to most of the other sites that were evaluated.
Operation and Maintenance	• Limited access may increase the difficulty of operation/maintenance. • Nearby forestland may require additional operation/maintenance. • The site would need to be operated in accordance with Ecology Dam Safety guidelines.



Storage Site:	CCK3
Description:	Upper Margaret Creek
Sub-basin:	Cherry Creek
Est. Storage Capacity:	22 acre-feet
Full Water Surface Area:	7.9 acres
Full WSEL:	908 feet
Overall Ranking	20



Concept Map, Storage Site: CCK3

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

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	PROJECT NO. 200026	REVISED BY: NLK	3-15

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3.2.2.7 Site LOT1: Snoqualmie Timber – Tolt (A)

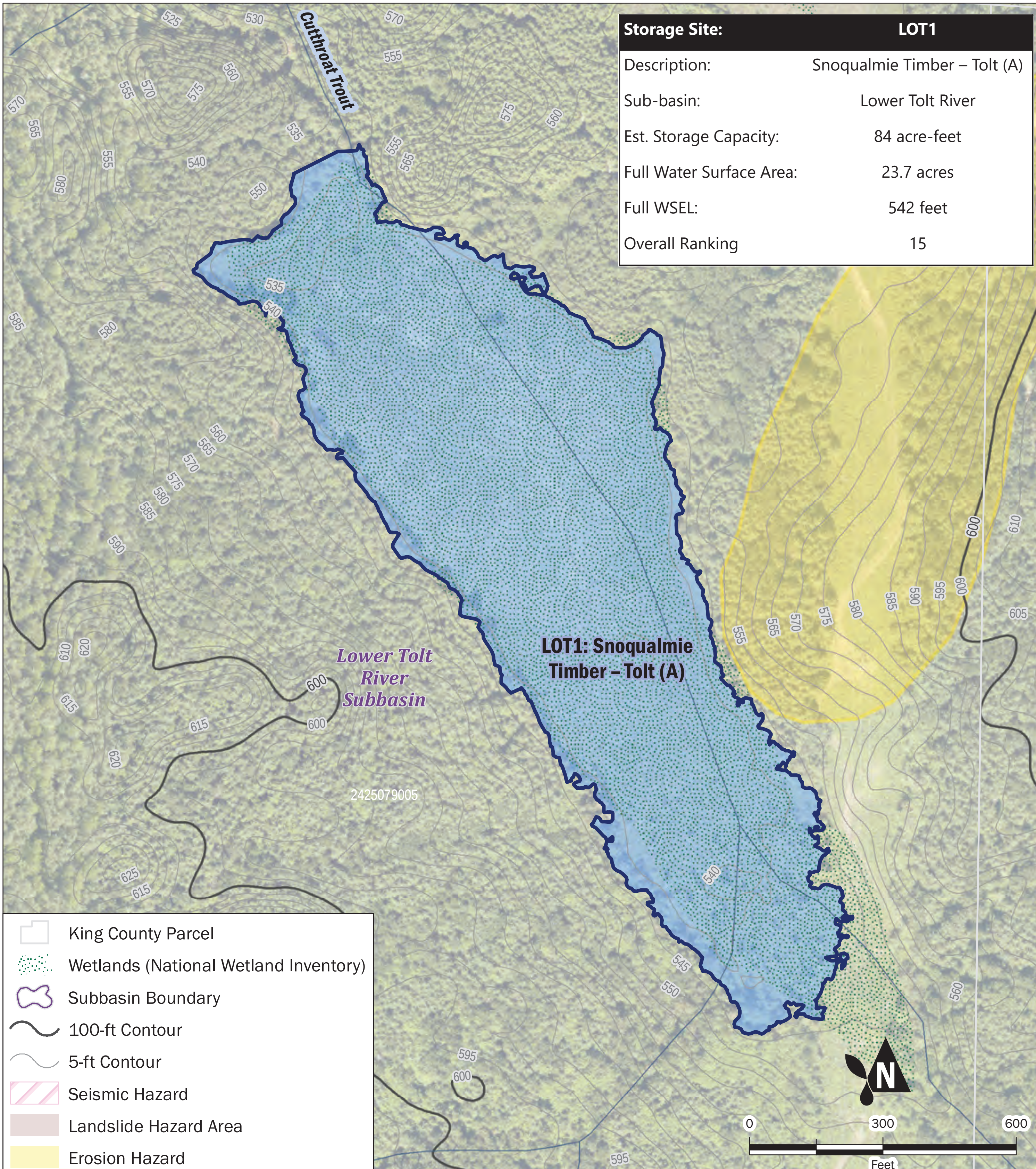
Site LOT1 (Snoqualmie Timber – Tolt (A) site) is located on a small pond/wetland area east of Langlois Lake in the Lower Tolt subbasin. The property is owned by Snoqualmie Timber, LLC. The area is approximately 23.7 acres in size. Storage capacity could potentially be developed by constructing an impoundment near the outlet of the narrow valley, allowing water to be stored and captured from the tributary area upslope of the area, then released during the critical low-flow period in the late summer. The impoundment would create approximately 84 acre-feet of storage. This storage concept is shown in Figure 3-16. Table 3-9 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

Snoqualmie Timber, LLC, had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordination with Snoqualmie Timber.

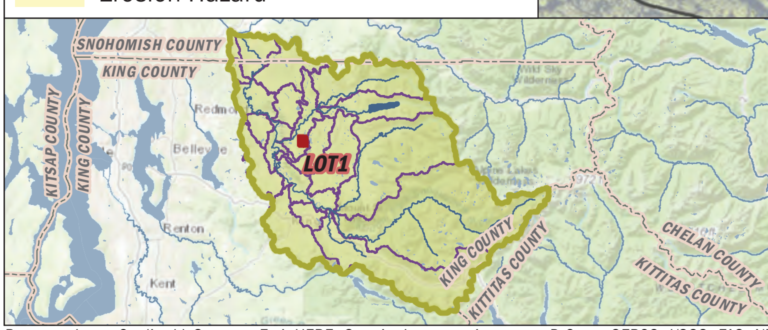
Table 3-9
Summary of Key Information for Site LOT1: Snoqualmie Timber – Tolt (A)

Key Physical Characteristic	**Value**
Site ID	LOT1
Overall Ranking (See Section 4)	15
Description	Existing Pond, Expand with Constructed Impoundment
Parcel	King Co. 2425079005
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	542
Estimated Full Water Surface Area	23.7
Estimated Full Water Surface Volume	84
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• This project would expand an existing pond. • Some of this project area is uncleared forestland.
Available Storage Capacity	• This project concept would make approximately 84 acre-feet of storage available.
Ability to Store High Flows	• The proposed lake has a relatively small tributary area (1 square mile) and would have little ability to store high flows.

Key Criteria	Notes
Instream Flow Benefits	• Water would be released to a small tributary that flows to the Tolt River. • The impoundment has a direct connection to a fish-bearing stream. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 1.51-cfs flow benefit to the Tolt River.
Water Quality – Temperature, Dissolved Oxygen	• The relatively shallow depth of the proposed impoundment may impact temperature and dissolved oxygen. • The Tolt River is listed as Category 4A for temperature near its confluence with the Snoqualmie River.
Water Quality – Toxics	• No potential sources of contamination were noted in the project area.
Reliability/Resilience	• Although the watershed tributary to the impoundment is relatively small, the ratio of the watershed to the size of the pond is average compared to sites that were evaluated.
Constructability	• The site has limited access for construction. • The proposed embankment is relatively small compared to other projects evaluated.
Critical Areas and Resource Impacts	• GIS data indicate that most of the reservoir footprint is a mapped wetland.
Cost and Funding Potential	• Estimated cost: $1,780,000 to $2,670,000 • Estimated cost per acre-foot: $21,300 to $32,000 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• Limited access may increase the difficulty of operation/maintenance. • Nearby forestland may require additional operation/maintenance. • The site would need to be operated in accordance with Ecology Dam Safety guidelines.



Storage Site:	LOT1
Description:	Snoqualmie Timber – Tolt (A)
Sub-basin:	Lower Tolt River
Est. Storage Capacity:	84 acre-feet
Full Water Surface Area:	23.7 acres
Full WSEL:	542 feet
Overall Ranking	15



Concept Map, Storage Site: LOT1

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect Consulting	DEC-2021	BY: EAC	FIGURE NO.
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3.2.2.8 Site LOT2: Snoqualmie Timber- Tolt (B)

Site LOT2 (Snoqualmie Timber – Tolt (B) site) is located on a large, cleared timber property upslope of the Tolt River. The property is owned by Snoqualmie Timber, LLC. The area is approximately 19.4 acres in size. Storage capacity could potentially be developed by constructing an impoundment and diverting water from the adjacent tributary, then releasing the water during the critical low-flow period in the late summer. The impoundment would create approximately 130 acre-feet of storage. This storage concept is shown in Figure 3-17. Table 3-10 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

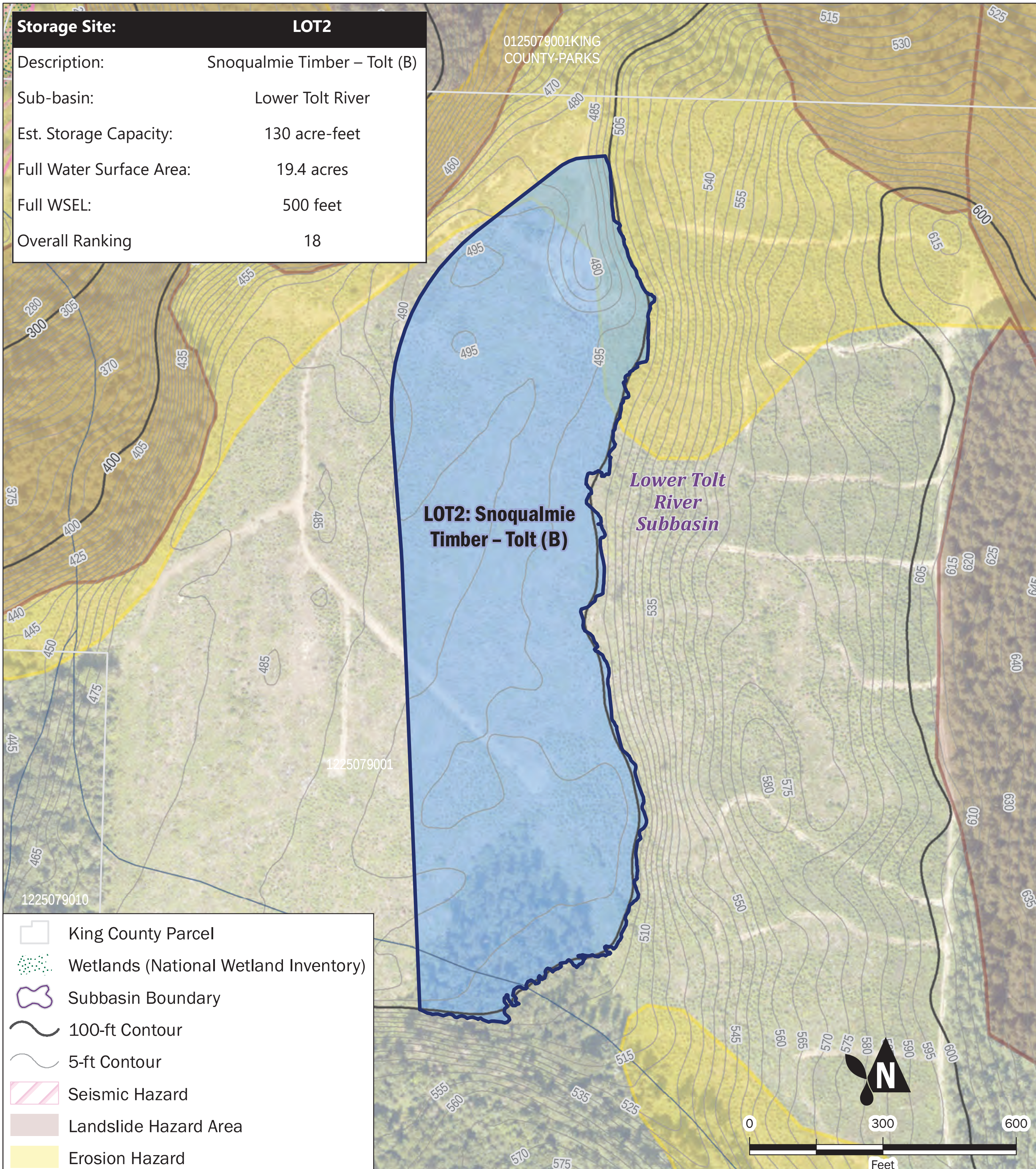
Snoqualmie Timber, LLC, had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordination with Snoqualmie Timber.

Table 3-10
Summary of Key Information for Site LOT2: Snoqualmie Timber – Tolt (B)

Key Physical Characteristic	Value
Site ID	LOT2
Overall Ranking (See Section 4)	18
Description	Off-channel, Constructed Impoundment
Parcel	King Co. 1225079001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	500
Estimated Full Water Surface Area	19.4
Estimated Full Water Surface Volume	130
Source of Inflow	Tributary Diversion
Categorization by Seepage Loss Potential	Moderate to High Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• A small portion of the project area consists of uncleared forest.
Available Storage Capacity	• The project concept would make approximately 130 acre-feet of storage available.
Ability to Store High Flows	• The proposed lake has a relatively small tributary area (less than 1 square mile) and would have little ability to store high flows.
Instream Flow Benefits	• Water would be released to a small tributary that flows to the Tolt River. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 2.34-cfs flow benefit to the tributary and to the Tolt River downstream of the storage site.

Key Criteria	**Notes**
Water Quality – Temperature, Dissolved Oxygen	• Releases could impact temperature and dissolved oxygen conditions in the tributary. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer. • The Tolt River is listed as Category 4A for temperature near its confluence with the Snoqualmie River.
Water Quality – Toxics	• No potential sources of contamination were noted in the project area.
Reliability/Resilience	• The ratio of the tributary watershed to the size of the project is small.
Constructability	• The site has limited road access so it may be difficult accessing the site for construction. • The proposed embankment is relatively large compared to other projects evaluated.
Critical Areas and Resource Impacts	• King County has mapped small areas of potential erosion hazards adjacent to the project.
Cost and Funding Potential	• Estimated cost: $10,400,000 to $15,600,000 • Estimated cost per acre-foot: $80,300 to $120,400 • The cost per acre-foot of storage is high relative to most of the other sites that were evaluated.
Operation and Maintenance	• Limited access may increase the difficulty of operation/maintenance. • The site would need to be operated in accordance with Ecology Dam Safety guidelines.

Storage Site:	LOT2
Description:	Snoqualmie Timber – Tolt (B)
Sub-basin:	Lower Tolt River
Est. Storage Capacity:	130 acre-feet
Full Water Surface Area:	19.4 acres
Full WSEL:	500 feet
Overall Ranking	18



King County Parcel
Wetlands (National Wetland Inventory)
Subbasin Boundary
100-ft Contour
5-ft Contour
Seismic Hazard
Landslide Hazard Area
Erosion Hazard

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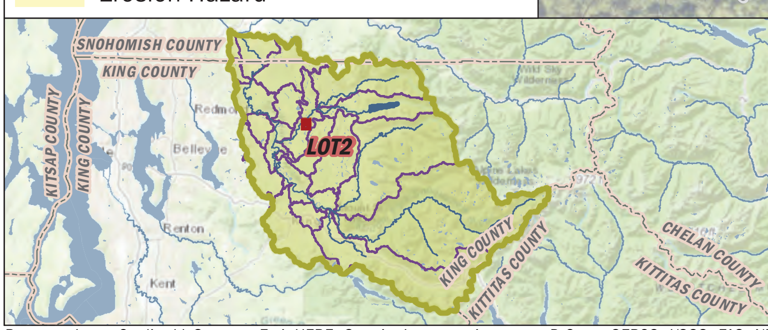

Concept Map, Storage Site: LOT2

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

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3.2.2.9 Site NFT1: DNR – North Fork Tolt (A)

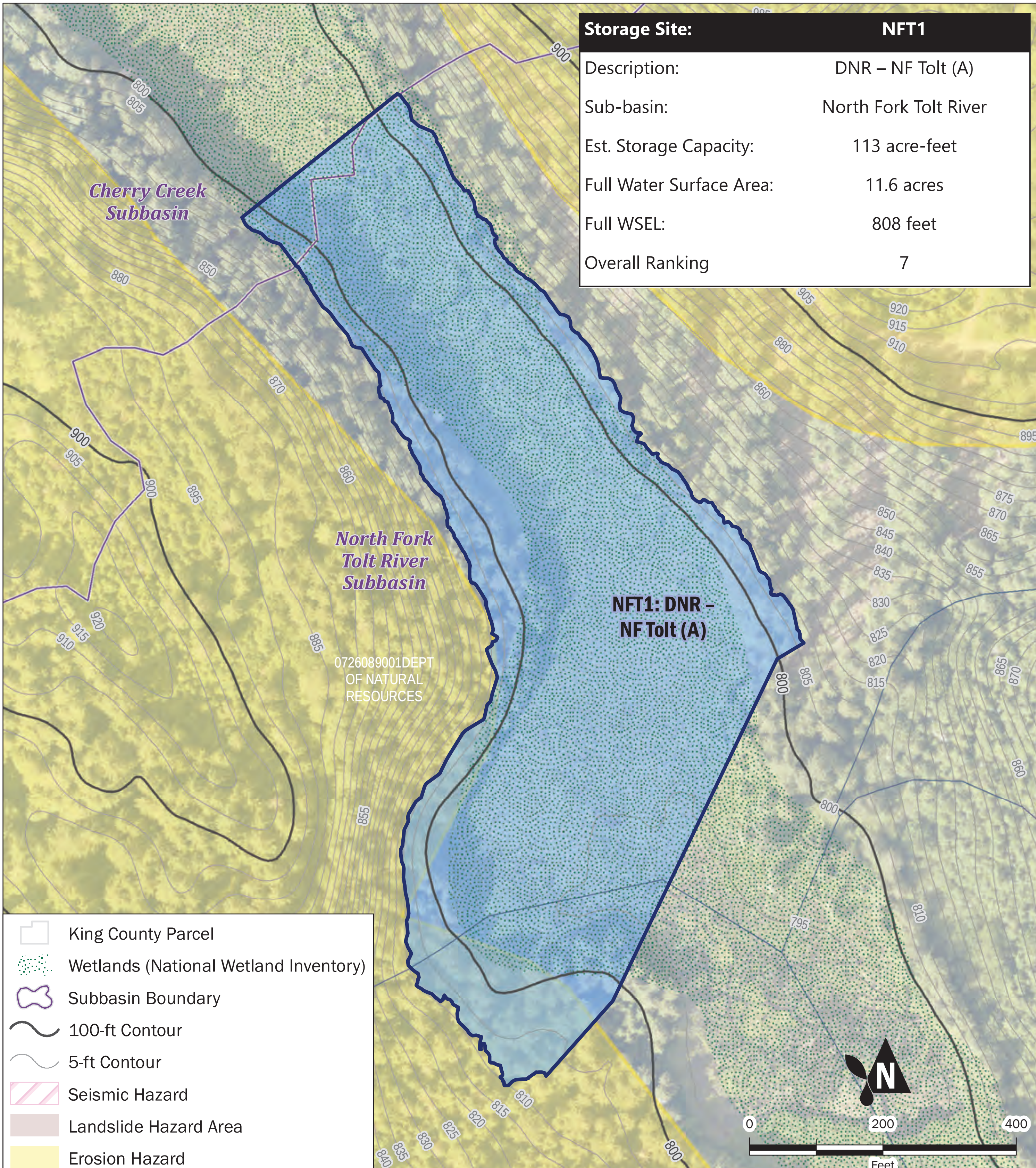
Site NFT1 (DNR – North Fork Tolt (A) site) is a cleared area with wetlands near the upstream end of a tributary in the Nork Fork Tolt subbasin. The property is on DNR land. The project area is approximately 11.6 acres. Storage capacity could be developed by creating an impoundment and diverting water from the adjacent tributary to store, then releasing the stored water during the critical low-flow period in the late summer. The impoundment is estimated to create 113 acre-feet of storage. This storage concept is shown in Figure 3-18. Table 3-11 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

DNR had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with DNR.

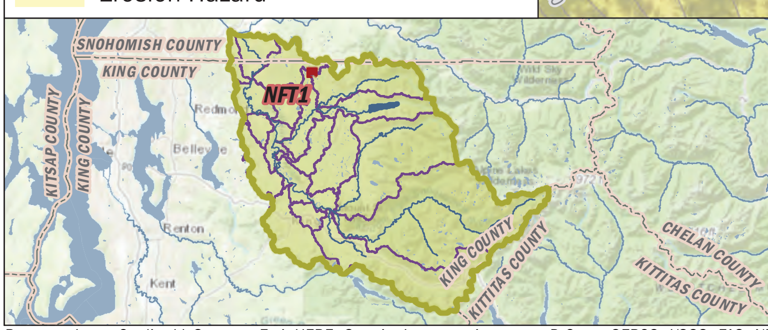
Table 3-11
Summary of Key Information for Site NFT1: DNR – North Fork Tolt (A)

Key Physical Characteristic	Value
Site ID	NFT1
Overall Ranking (See Section 4)	7
Description	Off-channel, Constructed Impoundment
Parcel	King Co. 0726089001
Parcel Owner(s)	DNR
Full Water Surface Elevation	808
Estimated Full Water Surface Area	11.6
Estimated Full Water Surface Volume	113
Source of Inflow	Diverted Tributary
Categorization by Seepage Loss Potential	Low Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• This project would impound an existing wetland. • Small portions of the project area consist of uncleared timber.
Available Storage Capacity	• This project would make approximately 113 acre-feet of storage.
Ability to Store High Flows	• The proposed lake has a relatively small tributary area (less than 1 square mile) and would have little ability to store high flows.
Instream Flow Benefits	• Water would be released to North Fork Creek and the North Fork Tolt River. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 2.03-cfs flow benefit to North Fork Creek and the North Fork Tolt River.

Key Criteria	Notes
Water Quality – Temperature, Dissolved Oxygen	• Releases could impact temperature and dissolved oxygen conditions in the tributary. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer.
Water Quality – Toxics	• No potential sources of contamination were noted within the project area.
Reliability/Resilience	• The watershed tributary to the lake is relatively small and the ratio of the watershed to the size of the lake is worse than for many of the sites that were evaluated.
Constructability	• The site has limited road access so it may be difficult accessing the site for construction. • The proposed embankment is moderate compared to other projects evaluated.
Critical Areas and Resource Impacts	• GIS data indicate that the project area has mapped wetlands within and adjacent to the reservoir footprint. • King County has mapped potential erosion hazards near the project area.
Cost and Funding Potential	• Estimated cost: $4,540,000 to $6,810,000 • Estimated cost per acre-foot: $40,300 to $60,500 • The cost per acre-foot of storage is moderate relative to the other sites that were evaluated.
Operation and Maintenance	• Limited access may increase the difficulty of operation/maintenance. • Nearby forestland may require additional operation/maintenance. • The site would need to be operated in accordance with Ecology Dam Safety guidelines.



Storage Site:	NFT1
Description:	DNR – NF Tolt (A)
Sub-basin:	North Fork Tolt River
Est. Storage Capacity:	113 acre-feet
Full Water Surface Area:	11.6 acres
Full WSEL:	808 feet
Overall Ranking	7



Concept Map, Storage Site: NFT1

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-18

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3.2.2.10 Site NFT2: Snoqualmie Timber – North Fork Tolt (A)

Site NFT2 (Snoqualmie Timber – North Fork Tolt (A) site) is a narrow valley located between hills in the uplands of the North Fork Tolt subbasin. The property is owned by Snoqualmie Timber, LLC. It is located on timberland that appears to have been harvested within the last 20 years. The project area is approximately 7.3 acres. Storage capacity could potentially be developed at this site by creating an impoundment between the hills and capturing runoff from the upslope tributary areas, then releasing the water during the critical low-flow period in the late summer. The estimated storage volume created would be 62 acre-feet. This storage concept is shown in Figure 3-19. Table 3-12 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

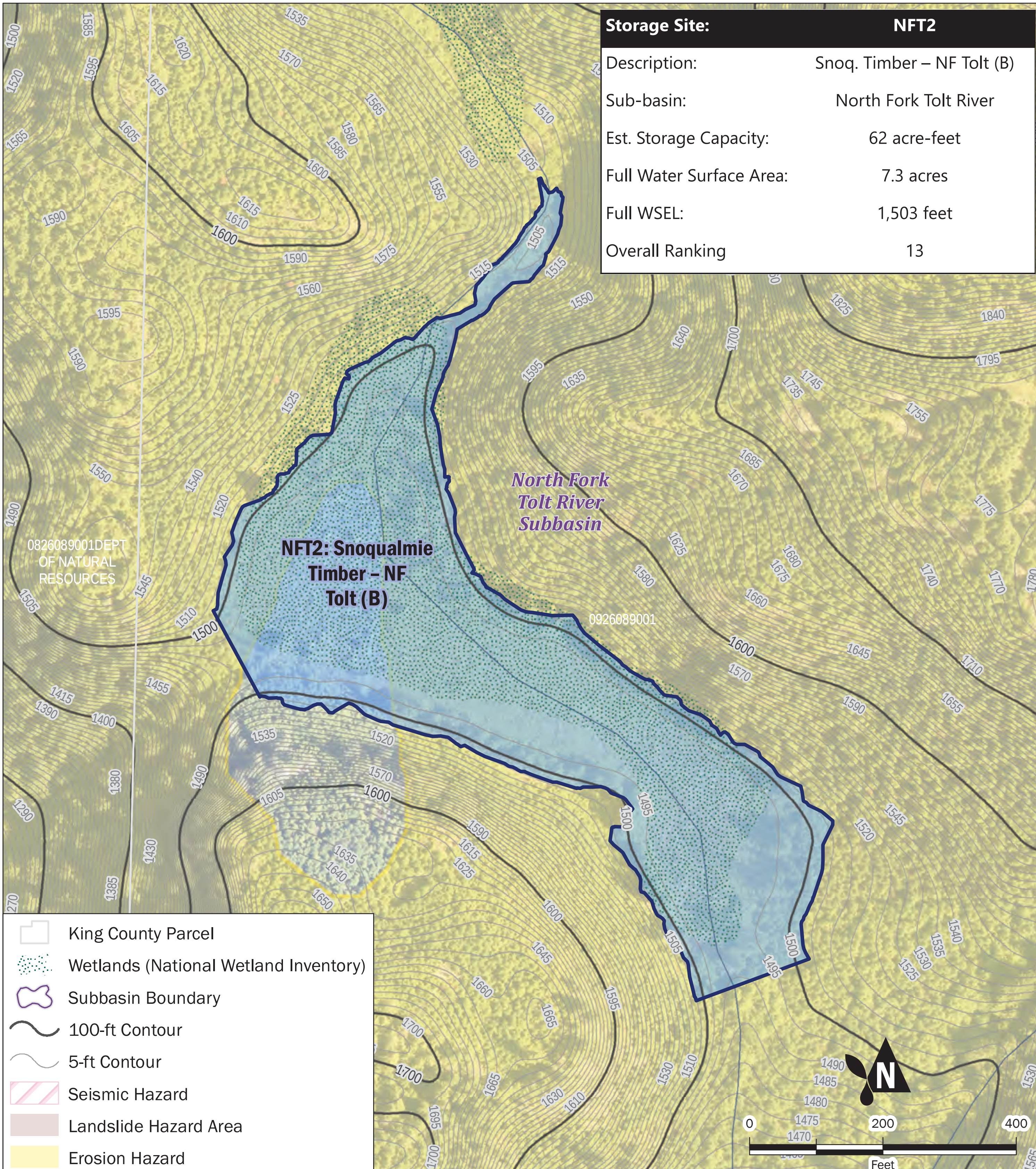
Snoqualmie Timber, LLC, had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordination with Snoqualmie Timber.

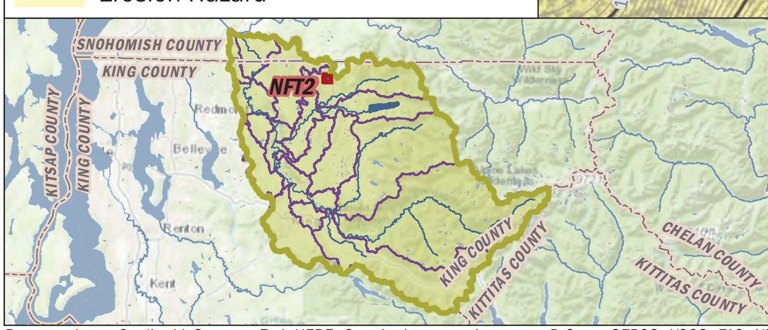
Table 3-12
Summary of Key Information for Site NFT2: Snoqualmie Timber – North Fork Tolt (A)

Key Physical Characteristic	Value
Site ID	NFT2
Overall Ranking (See Section 4)	13
Description	Off-channel, Constructed Impoundment, Near Tributary
Parcel	King Co. 0926089001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	1,503
Estimated Full Water Surface Area	7.3
Estimated Full Water Surface Volume	62
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• This project would inundate an existing wetland. • Portions of the project area consist of uncleared timber.
Available Storage Capacity	• The project would make approximately 62 acres of storage available.
Ability to Store High Flows	• The proposed lake has a small tributary area (less than 1 square mile) and would have little ability to store high flows.

Key Criteria	Notes
Instream Flow Benefits	• Water would be released to North Fork Creek and the North Fork Tolt River. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 1.12-cfs flow benefit to North Fork Creek and the North Fork Tolt River.
Water Quality – Temperature, Dissolved Oxygen	• Releases could impact temperature and dissolved oxygen conditions in the tributary. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer.
Water Quality – Toxics	• No potential sources of contamination were noted within the project area.
Reliability/Resilience	• The watershed tributary to the lake is relatively small and the ratio of the watershed to the size of the lake is worse than for many of the sites that were evaluated.
Constructability	• The site has limited road access so it may be difficult accessing the site for construction. • The proposed embankment is moderate compared to other projects evaluated.
Critical Areas and Resource Impacts	• GIS data indicate that the project area has mapped wetlands within the reservoir footprint. • King County has mapped potential erosion hazards in the project area.
Cost and Funding Potential	• Estimated cost: $1,800,000 to $2,690,000 • Estimated cost per acre-foot: $28,900 to $43,300 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• Limited access may increase the difficulty of operation/maintenance. • Nearby forestland may require additional operation/maintenance. • The site would need to be operated in accordance with Ecology Dam Safety guidelines.

Storage Site:	NFT2
Description:	Snoq. Timber – NF Tolt (B)
Sub-basin:	North Fork Tolt River
Est. Storage Capacity:	62 acre-feet
Full Water Surface Area:	7.3 acres
Full WSEL:	1,503 feet
Overall Ranking	13





Concept Map, Storage Site: NFT2

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect Consulting	DEC-2021	BY: EAC	FIGURE NO.
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3.2.2.11 Site NFT3: DNR – North Fork Tolt (D)

Site NFT3 (DNR – North Fork Tolt (D) site) is located in a narrow, forested valley in the North Fork Tolt subbasin on land owned by DNR. The site is near the upstream end of a small tributary and near the boundary of the subbasin. Water storage would be created by constructing an earthen impoundment across the narrow valley to capture and hold runoff from the tributary and other areas upslope. Water would then be released through a controlled low-level outlet pipeline to the downstream tributary, which flows south to the North Fork Tolt River. The proposed storage concept is shown in Figure 3-20.

The concept, as shown, would create approximately 132 acre-feet of storage capacity. The water surface of the reservoir would extend over approximately 11.5 acres when full, inundating a narrow valley including wetland areas and forested slopes. Table 3-13 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

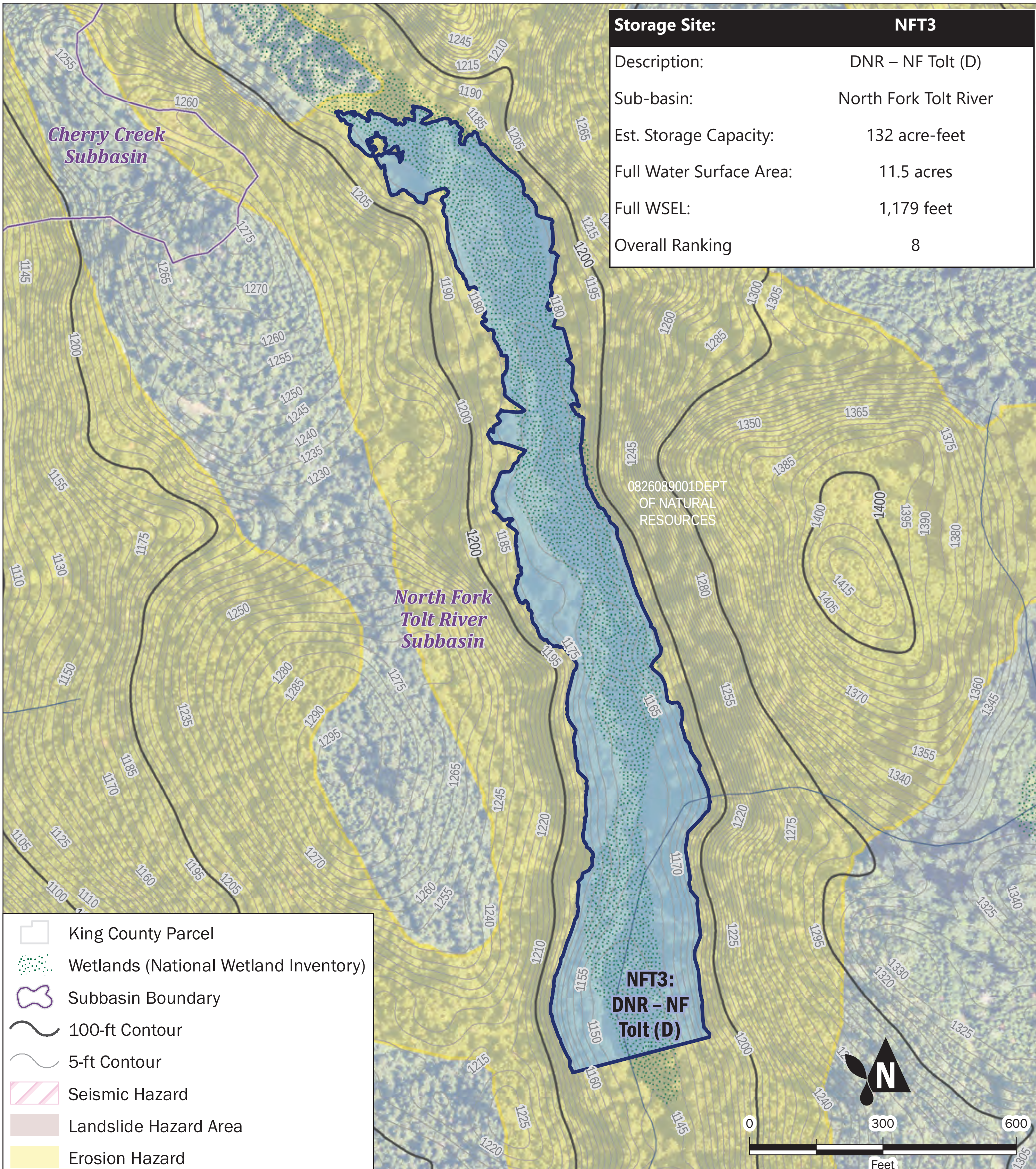
DNR had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with DNR.

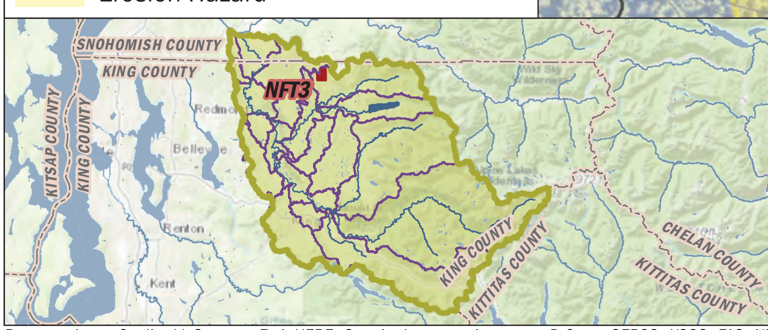
Table 3-13
Summary of Key Information for Site NFT3: DNR – North Fork Tolt (D)

Key Physical Characteristic	Value
Site ID	NFT3
Overall Ranking (See Section 4)	8
Description	Impoundment on Upstream End of Small Tributary
Parcel	King Co. 0826089001
Parcel Owner(s)	DNR
Full Water Surface Elevation	1,179
Estimated Full Water Surface Area	11.5
Estimated Full Water Surface Volume	132
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would convert more than 11 acres of private timberland and wetland areas into a storage reservoir. • Portions of the area would need to be logged and cleared prior to construction.
Available Storage Capacity	• The project concept would make approximately 132 acre-feet of storage available by impounding a small tributary to the North Fork Tolt River.

Key Criteria	**Notes**
Ability to Store High Flows	• The proposed reservoir would be relatively high in the subbasin and would not have a large upstream watershed. • The relatively small watershed (less than 1 square mile) would limit the ability to store high flows.
Instream Flow Benefits	• Water would be released to via a low-level outlet to the downstream tributary, which flows to the North Fork Tolt River. • If the additional storage volume was released over a 4-week low-flow period, it could provide a 2.38-cfs flow benefit to the tributary and to the North Fork and mainstem Snoqualmie Rivers downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake is at a moderately high elevation and would capture cold runoff from the tributary. • The reservoir would be in a narrow, well-shaded valley. • Likely to have low to no impact on temperature and dissolved oxygen.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• The ratio of the watershed to the volume of the lake would be relatively low compared to most of the other concepts. • Additional analysis would be required to verify ability for flows from the upstream tributary to fill the reservoir.
Constructability	• Forest access roads would need to be extended to provide access to the site for construction. • The site is remote and would require access via a number of narrow forest access roads. • Transport and placement of materials at this location would be challenging.
Critical Areas and Resource Impacts	• GIS data indicate that there are existing wetlands within the reservoir footprint. • GIS data indicate that potential erosion hazards exist near the site. • Trees and riparian areas in the forested sections of the proposed reservoir would need to be cleared.
Cost and Funding Potential	• Estimated cost: $2,610,000 to $3,920,000 • Estimated cost per acre-foot: $19,800 to $29,600 • The cost per acre-foot of storage is low relative to the other sites that were evaluated.
Operation and Maintenance	• The site would need to be operated in accordance with Ecology Dam Safety guidelines. • The reservoir would likely require regular maintenance and operation of diversion and outlet control facilities.

Storage Site:	NFT3
Description:	DNR – NF Tolt (D)
Sub-basin:	North Fork Tolt River
Est. Storage Capacity:	132 acre-feet
Full Water Surface Area:	11.5 acres
Full WSEL:	1,179 feet
Overall Ranking	8





Concept Map, Storage Site: NFT3

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

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3.2.2.12 Site NFT4: Snoqualmie Timber – NF Tolt (C)

Site NFT4 (Snoqualmie Timber – NF Tolt (C) site), the farthest upstream site in the North Fork Tolt subbasin that was identified for screening, is a large, gently sloping tract of timberland owned by Snoqualmie Timber, LLC. From the current aerial photographs of the area, the property appears to have been logged sometime within the last 20 to 30 years. The property is located north of the North Fork Tolt River near the northeast corner of the Snoqualmie River Watershed. The property has several forest access roads and small tributaries that flow south along the east and west edges of the tract of timber. The proposed concept would be to log a large tract of the property and perform considerable earthwork to construct a very large impoundment to store water. Water supply to fill the impoundment would flow in from the tributary area upslope of the impoundment, and a diversion would be established on the largest adjacent tributary that runs along the west side of the site to supply water to the reservoir. The water could then be released through a pipeline or other constructed conveyance down the adjacent tributary to the North Fork Tolt River. The proposed storage concept is shown in Figure 3-21.

The concept, as shown, would create approximately 1,296 acre-feet of storage capacity. This represents the second largest of the lakes that were evaluated as part of this screening analysis. The water surface of the reservoir would extend over approximately 134 acres when full. The water storage would provide a variety of benefits. In addition to providing a significant source of instream flows from a location higher up in the watershed to offset projected domestic consumptive water use, the storage could be designed to provide water supply for other out-of-stream uses, recreation opportunities, and enhanced habitat. Table 3-14 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

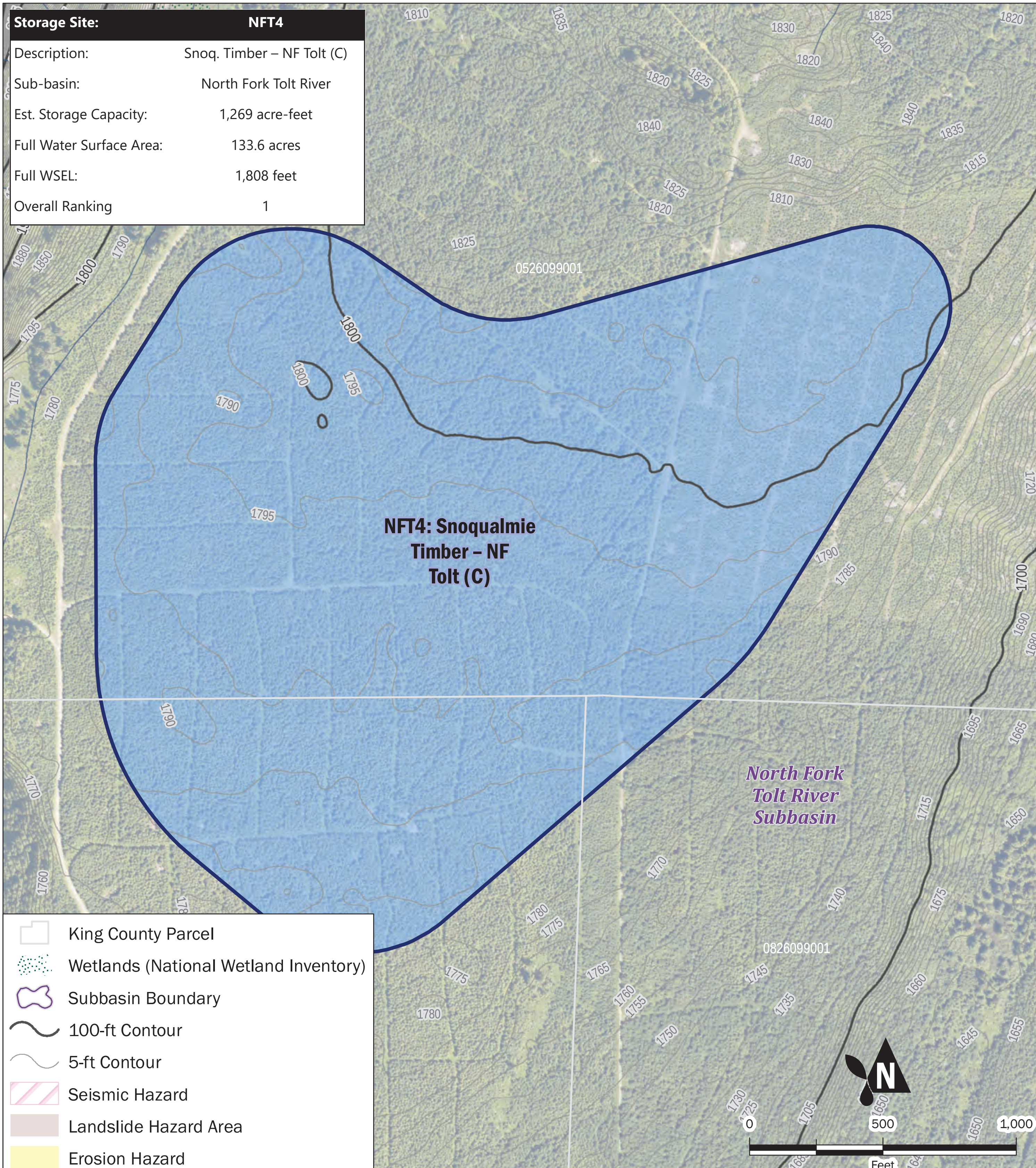
Snoqualmie Timber, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Snoqualmie Timber.

Table 3-14
Summary of Key Information for Site NFT4: Snoqualmie Timber – NF Tolt (C)

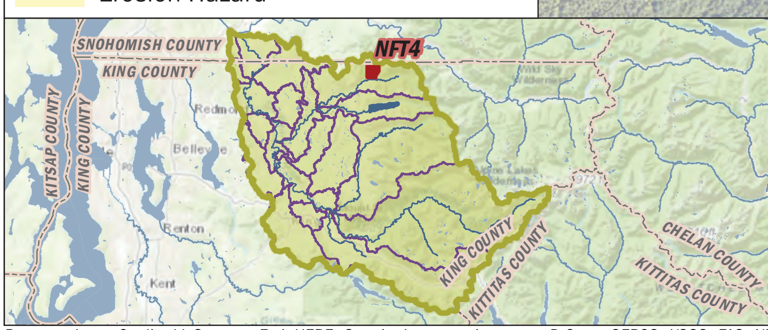
Key Physical Characteristic	Value
Site ID	NFT4
Overall Ranking (See Section 4)	1
Description	Off-channel, Constructed Impoundment, Timber Area
Parcel	King Co. 0526099001 King Co. 0826099005 King Co. 0826099001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	1,808
Estimated Full Water Surface Area	133.6
Estimated Full Water Surface Volume	1,296
Source of Inflow	Diversions on Adjacent Tributaries
Categorization by Seepage Loss Potential	Moderate to High Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project converts more than 100 acres of private timberland into a surface water reservoir. • The area would need to be logged and cleared prior to construction.
Available Storage Capacity	• The project concept would make approximately 1,296 acre-feet of storage available by creating a large impoundment.
Ability to Store High Flows	• The proposed lake is the second largest storage reservoir identified by this screening study but is high up in the watershed with a relatively small upslope watershed area. • The project would have limited ability to capture high flows.
Instream Flow Benefits	• Water would be released via an outlet pipeline and nearby tributary to the North Fork Tolt River. • If the additional storage volume was released over a 4-week low-flow period, it could provide a nearly 23-cfs flow benefit to the tributary, the North Fork Tolt River, the Tolt River, and the Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake would be relatively high in elevation and would capture cold runoff from the adjacent tributary. • The large surface area could result in some impact to water temperature. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• Although the proposed reservoir is very large, the tributary area upstream of the reservoir is modest in size. • Additional analysis would be needed to verify that enough water could be captured to reliably fill the reservoir.

Key Criteria	Notes
Constructability	• The site can be accessed via forest roads and logging roads, but construction would require a significant logging and clearing effort. • Construction would require a massive amount of earthwork and would likely take multiple years to complete.
Critical Areas and Resource Impacts	• No critical areas were noted within the project site. • The site is heavily forested and would need to be logged and cleared to provide space for the reservoir.
Cost and Funding Potential	• Estimated cost: $28,570,000 to $42,850,000 million • Estimated cost per acre-foot: $22,000 to $33,100 • The cost per acre-foot of storage is low to moderate relative to the other sites that were evaluated.
Operation and Maintenance	• The reservoir would need to be operated in accordance with Ecology Dam Safety guidelines. • The reservoir would likely require regular maintenance for a large facility and operation of diversion and outlet control facilities.

Storage Site:	NFT4
Description:	Snoq. Timber – NF Tolt (C)
Sub-basin:	North Fork Tolt River
Est. Storage Capacity:	1,269 acre-feet
Full Water Surface Area:	133.6 acres
Full WSEL:	1,808 feet
Overall Ranking	1



- King County Parcel
- Wetlands (National Wetland Inventory)
- Subbasin Boundary
- 100-ft Contour
- 5-ft Contour
- Seismic Hazard
- Landslide Hazard Area
- Erosion Hazard



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Concept Map, Storage Site: NFT4

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-21

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3.2.2.13 Site TOK1: Snoqualmie Timber - Tokul

Site TOK1 (Snoqualmie Timber – Tokul) is located in a narrow, low-lying area between two hills just north of Tokul Creek on timberland owned by Snoqualmie Timber, LLC. Water storage would be created by impounding the low-lying area on both the south and the north. An embankment dam would be constructed across the narrow low-lying area just north of Tokul Creek and on the north side of the low-lying area near the top of the Tokul Creek subbasin. Water supply would primarily be diverted from Tokul Creek just east of the proposed storage site. The water would then be released through a controlled low-level outlet pipeline back to Tokul Creek, which flows to the Snoqualmie River just downstream of Snoqualmie Falls. The proposed storage concept is shown in Figure 3-22.

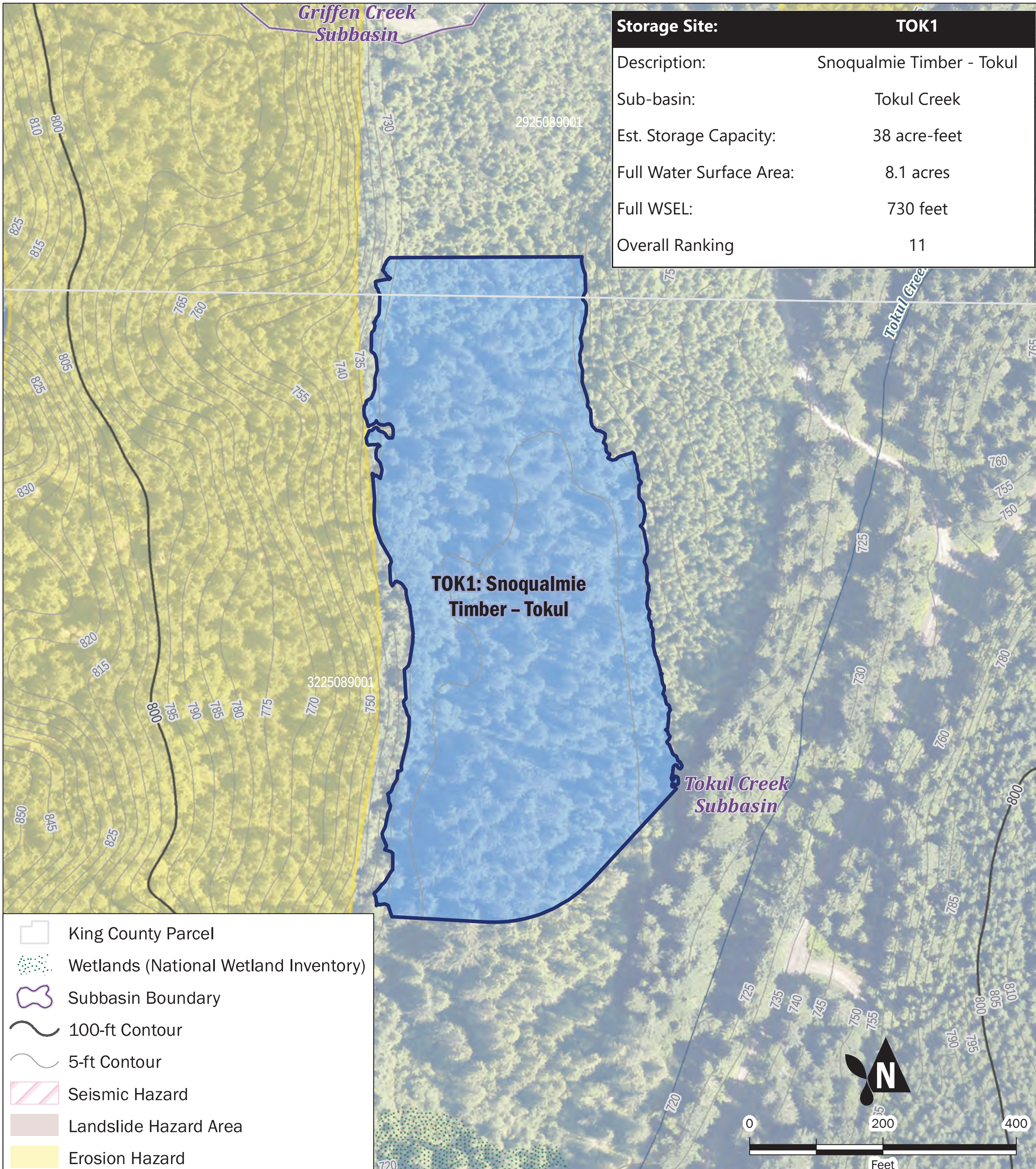
The concept, as shown, would create approximately 38 acre-feet of storage capacity. The water surface of the reservoir would extend over approximately 8 acres when full. It may be possible to store more water at this location and create more storage capacity with higher embankments. More refinement would be needed if this concept moves forward to maximize the size to enhance potential benefits of the water storage. The primary benefit would be flows to offset projected domestic consumptive water use. Table 3-15 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

Snoqualmie Timber, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Snoqualmie Timber.

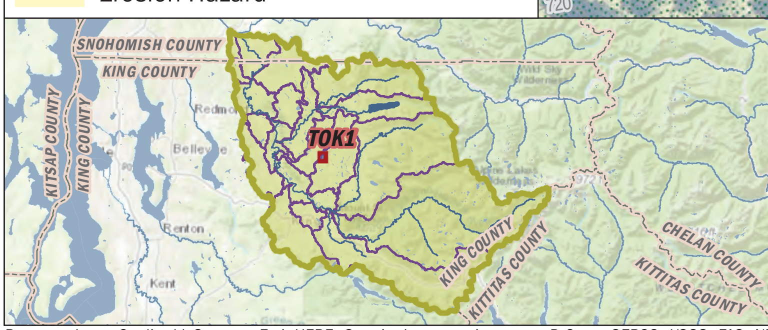
Table 3-15
Summary of Key Information for Site TOK1: Snoqualmie Timber - Tokul

Key Physical Characteristic	Value
Site ID	TOK1
Overall Ranking (See Section 4)	11
Description	Off-channel, Constructed Impoundment
Parcel	King Co. 3225089001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	730
Estimated Full Water Surface Area	8.1
Estimated Full Water Surface Volume	38
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Moderate to High Seepage Loss/Infiltration Potential

Key Criteria	Notes
Project Footprint	• The off-channel storage project would occupy just over 8 acres of heavily forested private timberland. • The project area would need to be logged and cleared prior to construction of storage.
Available Storage Capacity	• The project concept would make approximately 38 acre-feet of storage available by impounding a low-lying off-channel area adjacent to Tokul Creek.
Ability to Store High Flows	• The proposed reservoir would be able to capture high flows from Tokul Creek. • The small storage volume would limit the ability to store high flows.
Instream Flow Benefits	• Water would be released via a low-level outlet to Tokul Creek, which flows to the mainstem Snoqualmie River. • If the additional storage volume was released over a 4-week low-flow period, it could provide a 0.68-cfs flow benefit to Tokul Creek and the mainstem Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake would capture relatively cool runoff from Tokul Creek. • Water temperature could potentially increase in the lake prior to release back to Tokul Creek. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer. • The Snoqualmie River is listed as Category 4A for temperature and dissolved oxygen where the tributary flows into the river.
Water Quality – Toxics	• Tokul Creek is listed as Category 4A for bacteria near the Snoqualmie River.
Reliability/Resilience	• The ratio of the watershed upstream along Tokul Creek to the volume of the lake would be high, and there would likely be more than enough water to refill the lake each season.
Constructability	• The site would require extension of forest access roads to provide access for construction. • Construction would require extensive clearing and installation of two moderately sized embankment dams.
Critical Areas and Resource Impacts	• No critical areas were noted within the site. • The site would need to be logged and cleared prior to construction of the impounding structures.
Cost and Funding Potential	• Estimated cost: $4,420,000 to $6,620,000 • Estimated cost per acre-foot: $116,100 to $174,200 • The cost per acre-foot of storage is high relative to the other sites that were evaluated.
Operation and Maintenance	• The site would need to be operated in accordance with Ecology Dam Safety guidelines. • The reservoir would likely require regular maintenance and operation of diversion and outlet control facilities.



Storage Site:	TOK1
Description:	Snoqualmie Timber - Tokul
Sub-basin:	Tokul Creek
Est. Storage Capacity:	38 acre-feet
Full Water Surface Area:	8.1 acres
Full WSEL:	730 feet
Overall Ranking	11



Concept Map, Storage Site: TOK1

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING

DEC-2021	BY: EAC	FIGURE NO.
PROJECT NO. 200026	REVISED BY: NLK	3-22

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3.2.2.14 Site TOK2: Bridges Lake

Site TOK2 (Bridges Lake) is the highest in a chain of lakes that also includes Boyle Lake and Klaus Lake. The relatively small existing lake is located on private timberland in the upper portion of the Tokul Creek subbasin. The property surrounding the lake is timberland owned by Snoqualmie Timber, LLC. The lake is just over 40 acres in size. Storage capacity could potentially be developed at this existing lake by adding a control structure at the outlet of the lake to allow for water to be stored and captured from the tributary area upslope of the lake, then released during the critical low-flow period in the late summer. Raising the water surface 2 feet would create approximately 89 acre-feet of additional storage. The full storage area would be approximately 47.8 acres. This storage concept is shown in Figure 3-23. Table 3-16 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

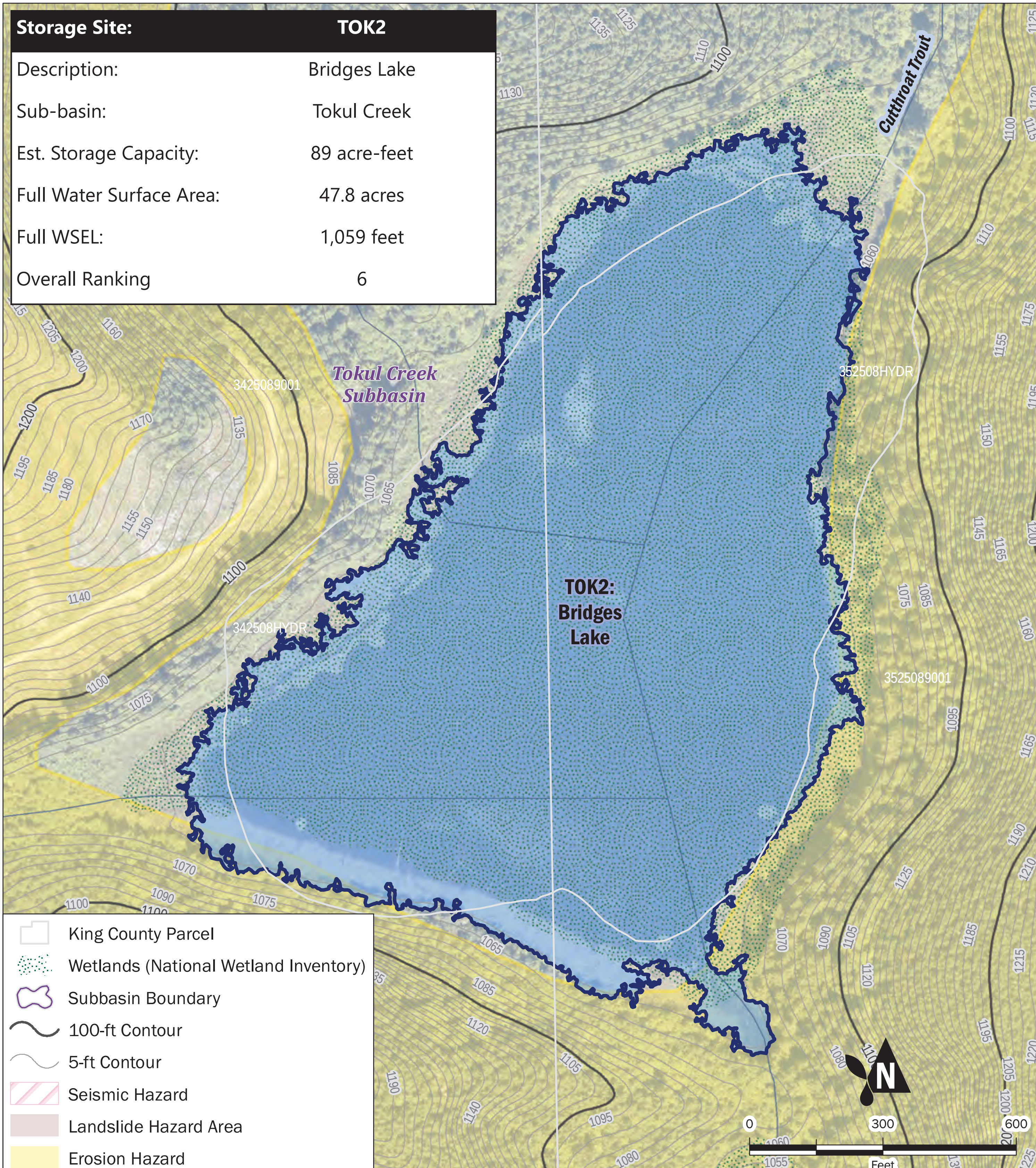
Snoqualmie Timber, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Snoqualmie Timber.

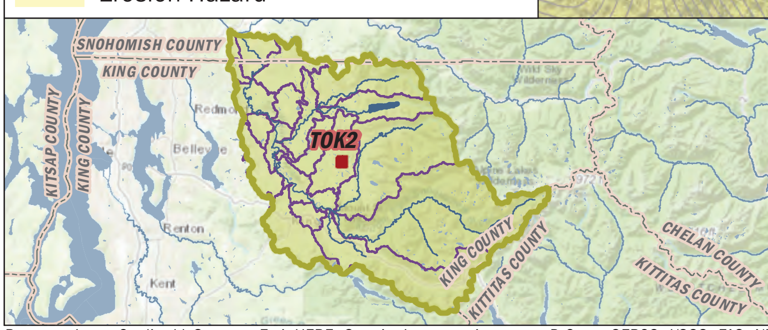
Table 3-16
Summary of Key Information for Site TOK2: Bridges Lake

Key Physical Characteristic	Value
Site ID	TOK2
Overall Ranking (See Section 4)	6
Description	Existing Lake, Raise Water Surface 1 to 2 Feet
Parcel	King Co. 352508HYDR King Co. 342508HYDR King Co. 3425089001 King Co. 3525089001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	1,059
Estimated Full Water Surface Area	47.8
Estimated Full Water Surface Volume	89
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would raise the level of an existing lake. • Raising the level would impact the shoreline, which appears to include mostly forest and wetland areas.

Key Criteria	Notes
Available Storage Capacity	• The project concept would make approximately 89 acre-feet of storage available for offset by raising the lake 2 feet, which does not include the existing volume of water stored in the lake.
Ability to Store High Flows	• The proposed lake has a relatively small tributary area and would have some capacity to store flows from that area. • The volume stored would be small relative to peak runoff volumes from the overall Snoqualmie River Watershed.
Instream Flow Benefits	• Water would be released downstream to a small tributary that flows through a chain of lakes, including Boyle Lake and Klaus Lake, then on to Tokul Creek. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 1.59-cfs flow benefit to the tributary and to Tokul Creek and the Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake is existing and the increase in level would likely have little impact on temperature and dissolved oxygen in downstream waters. • The Snoqualmie River is listed as Category 4A for temperature and dissolved oxygen where the tributary flows into the river.
Water Quality – Toxics	• Tokul Creek is listed as Category 4A for bacteria near the Snoqualmie River.
Reliability/Resilience	• The watershed tributary to the lake is moderately large and the ratio of the watershed area to the size of the lake is moderate when compared to the other sites that were evaluated.
Constructability	• The site would require extension of forest access roads to provide access for construction. • Construction would likely include a new outlet control structure, but it would likely be relatively small compared to the large earthen embankments proposed at other sites.
Critical Areas and Resource Impacts	• GIS data indicate that the lake and areas adjacent to it are mapped as wetlands.
Cost and Funding Potential	• Estimated cost: $1,390,000 to $2,082,000 • Estimated cost per acre-foot: $15,700 to $23,500 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• The lake is existing. • The lake would require permanent access extended from established forest access routes. • Controlling the outlet may trigger the need for oversight by Ecology's Dam Safety Office and compliance with its operation and maintenance guidelines. • Likely relatively low operations and maintenance effort required at this site based on small anticipated size of improvements.

Storage Site:	TOK2
Description:	Bridges Lake
Sub-basin:	Tokul Creek
Est. Storage Capacity:	89 acre-feet
Full Water Surface Area:	47.8 acres
Full WSEL:	1,059 feet
Overall Ranking	6





Concept Map, Storage Site: TOK2

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect CONSULTING	DEC-2021	BY: EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: NLK	3-23

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3.2.2.15 Site TOK3: Klaus Lake

Site TOK3 (Klaus Lake) is the lowest in a chain of lakes that also includes Boyle Lake and Bridges Lake. The relatively small existing lake is located on private timberland in the upper portion of the Tokul Creek subbasin. The property surrounding the lake is timberland owned by Campbell Global, LLC (Campbell Global). The lake is just over 50 acres in size. Storage capacity could potentially be developed at this existing lake by adding a control structure at the outlet of the lake to allow for water to be stored and captured from the tributary area upslope of the lake, then released during the critical low-flow period in the late summer. Raising the water surface 2 feet would create approximately 121 acre-feet of additional storage. The full water surface area of the lake would be approximately 70.2 acres. This storage concept is shown in Figure 3-24. Table 3-17 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

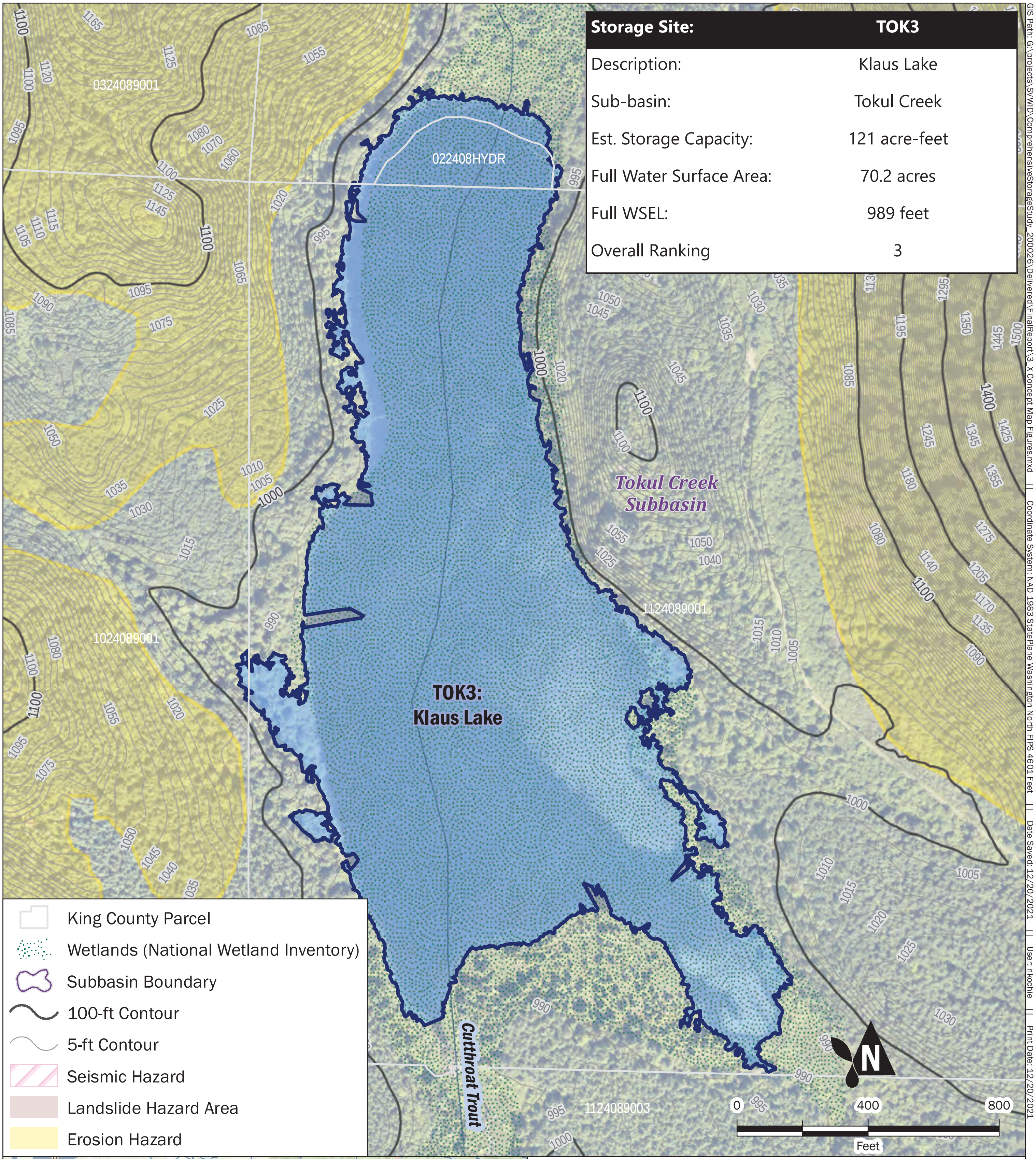
Campbell Global, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Campbell Global.

Table 3-17
Summary of Key Information for Site TOK3: Klaus Lake

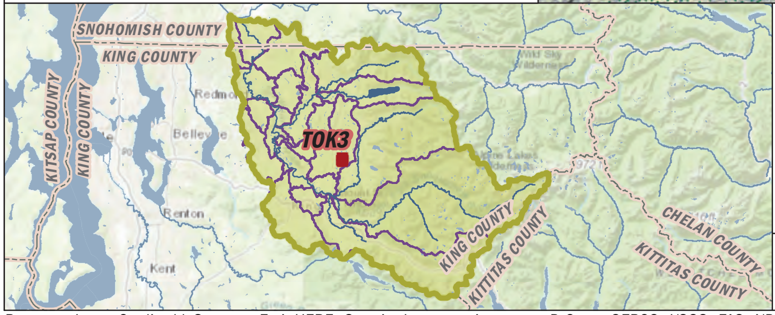
Key Physical Characteristic	Value
Site ID	TOK3
Overall Ranking (See Section 4)	3
Description	Existing Lake, Raise Water Surface 1 to 2 Feet
Parcel	King Co. 022408HYDR King Co. 1124089001 King Co. 0224089001
Parcel Owner(s)	Campbell Global, LLC
Full Water Surface Elevation	989
Estimated Full Water Surface Area	70.2
Estimated Full Water Surface Volume	121
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would raise the level of an existing lake. • Raising the level would impact the shoreline, which appears to include mostly forest and wetland areas.
Available Storage Capacity	• The project concept would make approximately 121 acre-feet of storage available for offset by raising the lake 2 feet, which does not include the existing volume of water stored in the lake.

Key Criteria	Notes
Ability to Store High Flows	• The proposed lake has a moderately sized tributary area and would have some capacity to store flows from that area. • The volume stored would be small relative to peak runoff volumes from the overall Snoqualmie River Watershed.
Instream Flow Benefits	• Water would be released downstream to a small tributary that flows to Tokul Creek. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 2.19-cfs flow benefit to the tributary and to Tokul Creek and the Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake is existing and the increase in level would likely have little impact on temperature and dissolved oxygen in downstream waters. • The Snoqualmie River is listed as Category 4A for temperature and dissolved oxygen where the tributary flows into the river.
Water Quality – Toxics	• Tokul Creek is listed as Category 4A for bacteria near the Snoqualmie River.
Reliability/Resilience	• The watershed tributary to the lake is moderately large and the ratio of the watershed area to the size of the lake is relatively high when compared to the other sites that were evaluated.
Constructability	• The site would require extension of forest access roads to provide access for construction. • Construction would likely include a new outlet control structure, but it would likely be relatively small compared to the large earthen embankments proposed at other sites.
Critical Areas and Resource Impacts	• GIS data indicate that the lake and areas adjacent to it are mapped as wetlands.
Cost and Funding Potential	• Estimated cost: $1,910,000 to $2,870,000 • Estimated cost per acre-foot: $15,800 to $22,600 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• The lake is existing. • The lake would require permanent access extended from established forest access routes. • Controlling the outlet may trigger the need for oversight by Ecology's Dam Safety Office and compliance with its operation and maintenance guidelines. • Likely relatively low operations and maintenance effort required at this site based on small anticipated size of improvements.

Storage Site:	TOK3
Description:	Klaus Lake
Sub-basin:	Tokul Creek
Est. Storage Capacity:	121 acre-feet
Full Water Surface Area:	70.2 acres
Full WSEL:	989 feet
Overall Ranking	3



King County Parcel
Wetlands (National Wetland Inventory)
Subbasin Boundary
100-ft Contour
5-ft Contour
Seismic Hazard
Landslide Hazard Area
Erosion Hazard



Concept Map, Storage Site: TOK3

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

Aspect Consulting	DEC-2021	BY: EAC	FIGURE NO.
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3.2.2.16 Site TOK4: Black Lake

Site TOK4 (Black Lake) is a small lake located on private timberland in the upper portion of the Tokul Creek subbasin. The property surrounding the lake is timberland owned by Snoqualmie Timber, LLC. The lake is approximately 38.4 acres in size. Storage capacity could potentially be developed at this existing lake by adding a control structure at the outlet of the lake to allow for water to be stored and captured from the tributary area upslope of the lake, then released during the critical low-flow period in the late summer. Raising the water surface 2 feet would create approximately 77 acre-feet of additional storage. The full water surface area would be approximately 40.7 acres. This storage concept is shown in Figure 3-25. Table 3-18 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

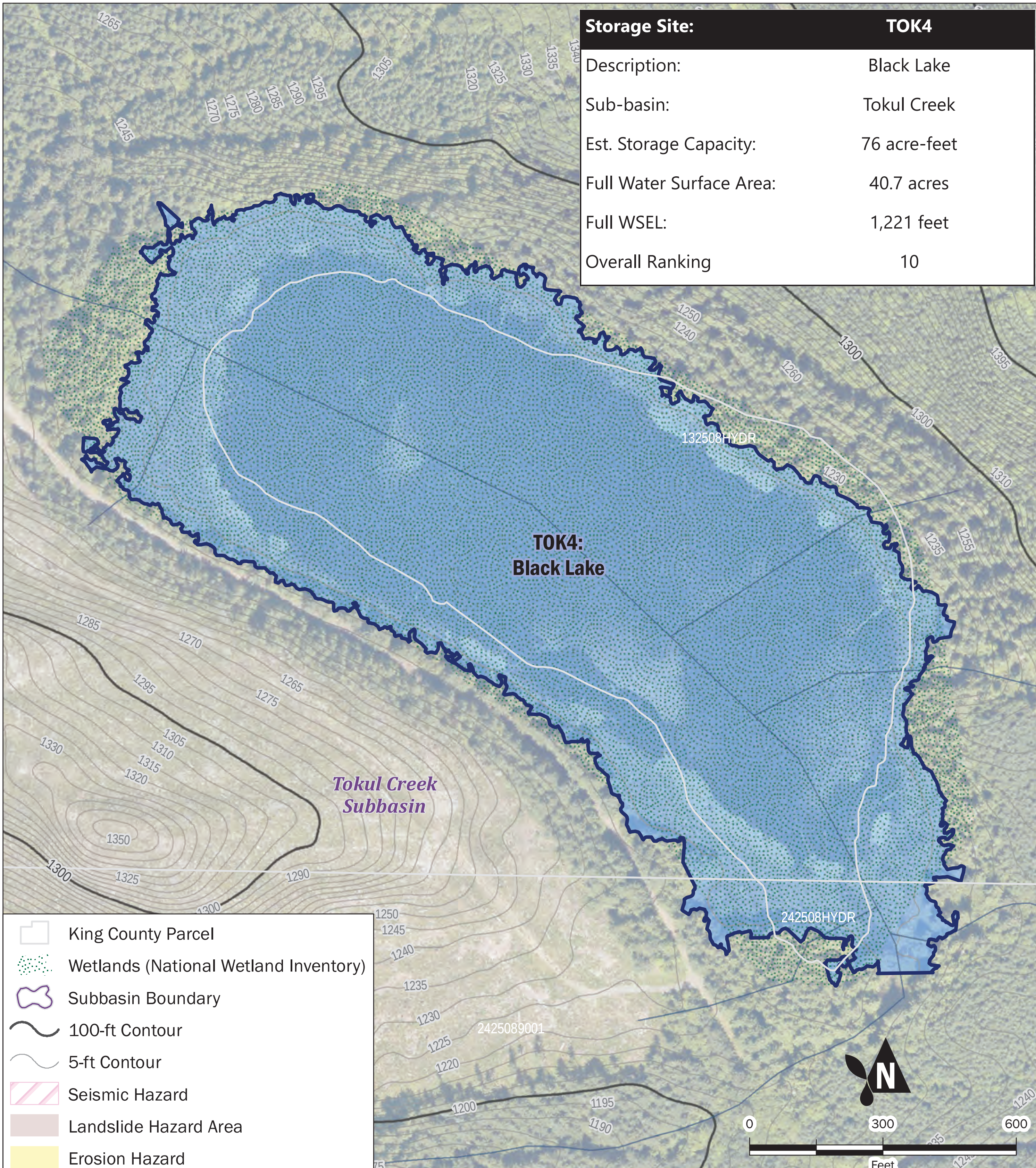
Snoqualmie Timber, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Snoqualmie Timber.

Table 3-18
Summary of Key Information for Site TOK4: Black Lake

Key Physical Characteristic	Value
Site ID	TOK4
Overall Ranking (See Section 4)	10
Description	Existing Lake, Raise Water Surface 1 to 2 Feet
Parcel	King Co. 132508HYDR King Co. 1325089001 King Co. 2425089001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	1,221
Estimated Full Water Surface Area	40.7
Estimated Full Water Surface Volume	76
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project would raise the level of an existing lake. • Raising the level would impact the shoreline, which appears to include mostly forest and wetland areas.
Available Storage Capacity	• The project concept would make approximately 76 acre-feet of storage available for offset by raising the lake 2 feet, which does not include the existing volume of water stored in the lake.

Key Criteria	Notes
Ability to Store High Flows	• The proposed lake has a relatively small tributary area (less than 1 square mile) and would have little ability to store high flows.
Instream Flow Benefits	• Water would be released to a small tributary that flows to Tokul Creek. • If the additional storage volume was released over a 4-week low-flow period, it would provide a 1.37-cfs flow benefit to the tributary and to Tokul Creek and the Snoqualmie River downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake is existing and the increase in level would likely have little impact on temperature and dissolved oxygen in downstream waters. • The Snoqualmie River is listed as Category 4A for temperature and dissolved oxygen where the tributary flows into the river.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• The watershed tributary to the lake is relatively small and the ratio of the watershed area to the size of the lake is moderate when compared to the other sites that were evaluated.
Constructability	• The site would be relatively easy to access via paved roads and forest access roads. • Construction would likely include a new outlet control structure, but it would likely be relatively small compared to the large earthen embankments proposed at other sites.
Critical Areas and Resource Impacts	• GIS data indicate that the lake and areas adjacent to it are mapped as wetlands.
Cost and Funding Potential	• Estimated cost: $1,210,000 to $1,810,000 • Estimated cost per acre-foot: $15,800 to $23,700 • The cost per acre-foot of storage is low relative to most of the other sites that were evaluated.
Operation and Maintenance	• The lake is existing and close to established forest access routes. • Controlling the outlet may trigger the need for oversight by Ecology's Dam Safety Office and compliance with its operation and maintenance guidelines. • Likely relatively low operations and maintenance effort required at this site based on small anticipated size of improvements.

Storage Site:	TOK4
Description:	Black Lake
Sub-basin:	Tokul Creek
Est. Storage Capacity:	76 acre-feet
Full Water Surface Area:	40.7 acres
Full WSEL:	1,221 feet
Overall Ranking	10



King County Parcel
Wetlands (National Wetland Inventory)
Subbasin Boundary
100-ft Contour
5-ft Contour
Seismic Hazard
Landslide Hazard Area
Erosion Hazard

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Concept Map, Storage Site: TOK4

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Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

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3.2.2.17 Site NFK1: Snoqualmie Timber – North Fork Snoqualmie (A)

Site NFK1 (Snoqualmie Timber – North Fork Snoqualmie (A) site) is the lowest site identified in the North Fork Snoqualmie subbasin. It is a large, gently sloping, heavily forested tract of timberland owned by Snoqualmie Timber, LLC near a small tributary (Deep Creek) that flows south to the North Fork Snoqualmie River. The property is a large, relatively flat area adjacent to the creek that is flanked on either side by steeper slopes. The valley narrows to the north and south. The proposed concept would include logging and clearing a large tract of the property and performing considerable earthwork to construct an impoundment to store water. The resulting reservoir would be relatively large and shallow. Water supply to fill the impoundment would be diverted from Deep Creek by constructing a new diversion at the appropriate elevation north of the site. The water could then be released through a pipeline back to Deep Creek and then on to the North Fork Snoqualmie River. The proposed storage concept is shown in Figure 3-26.

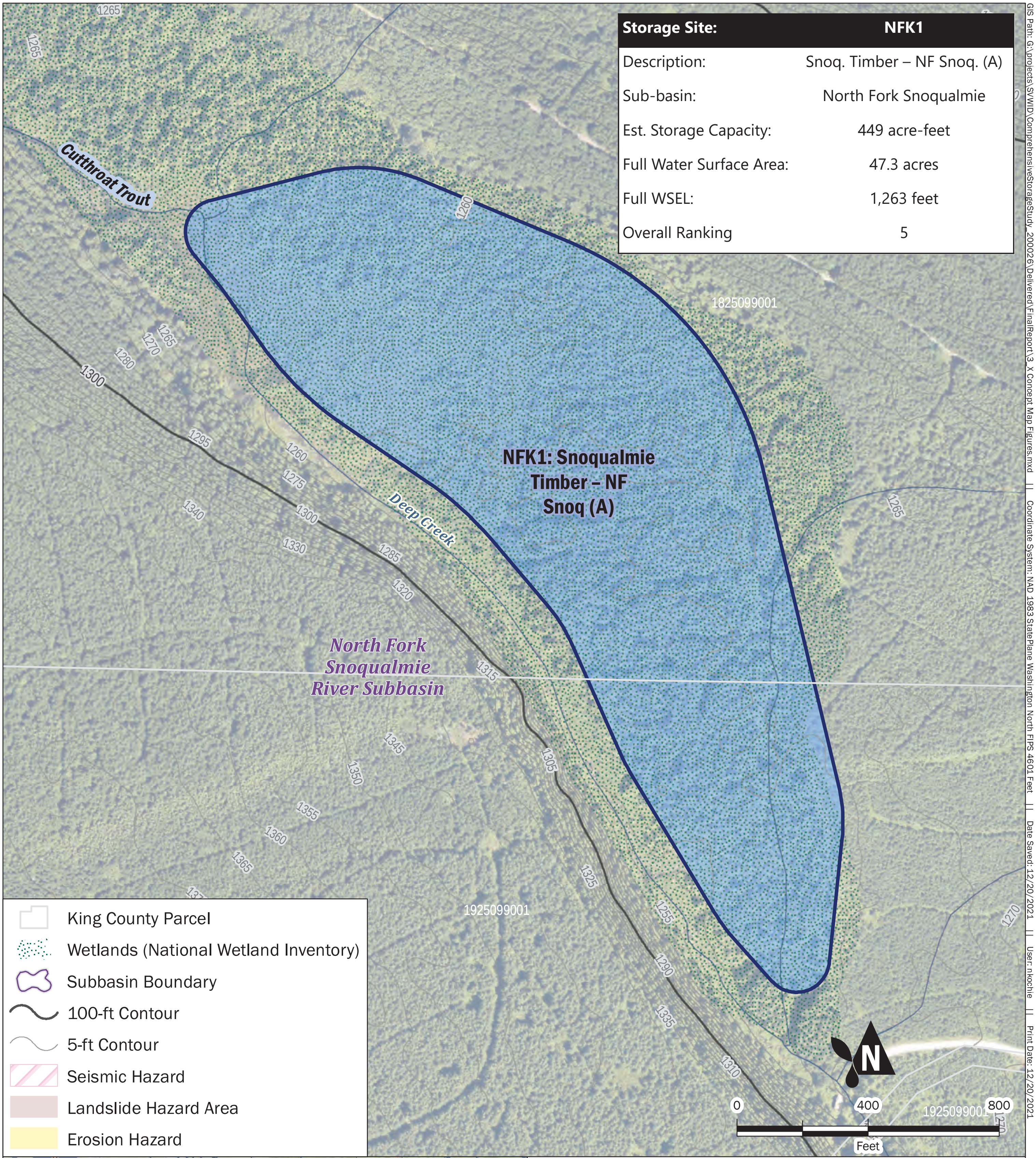
The concept, as shown, would create approximately 449 acre-feet of storage capacity. This represents one of the larger lakes that were evaluated as part of this screening analysis. The water surface of the reservoir would extend over approximately 47 acres when full. The water storage would provide a variety of benefits. In addition to providing a significant source of instream flows to offset projected domestic consumptive water use, the storage could be designed to provide water supply for other out-of-stream uses, recreation opportunities, and enhanced habitat. Table 3-19 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

Snoqualmie Timber, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Snoqualmie Timber.

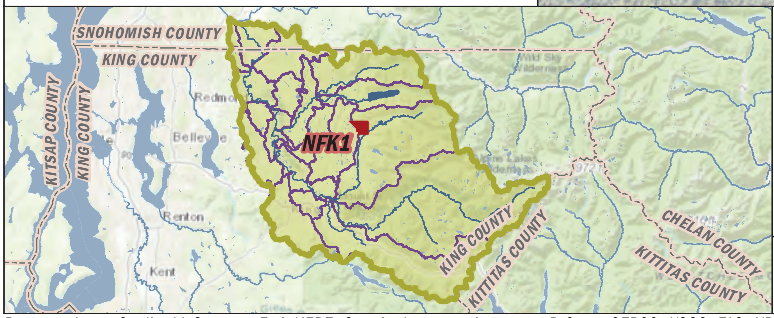
Table 3-19
Summary of Key Information for Site NFK1: Snoqualmie Timber – North Fork Snoqualmie (A)

Key Physical Characteristic	Value
Site ID	NFK1
Overall Ranking (See Section 4)	5
Description	Off-channel, Constructed Impoundment, Near Tributary
Parcel	King Co. 1825099001 King Co. 1925099001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	1,263
Estimated Full Water Surface Area	47.3
Estimated Full Water Surface Volume	449
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Moderate to High Seepage Loss/Infiltration Potential

Key Criteria	Notes
Project Footprint	• The project would convert more than 47 acres of private timberland into a surface water reservoir. • The area would need to be logged and cleared prior to construction.
Available Storage Capacity	• The project concept would make approximately 449 acre-feet of storage available by creating a large impoundment.
Ability to Store High Flows	• The proposed lake would be able to capture water from a relatively large watershed by diverting flow from Deep Creek, a moderately sized tributary to the North Fork Snoqualmie River. • The volume of water that could be captured would be relatively small relative to peak flow runoff volumes.
Instream Flow Benefits	• Water would be released via an outlet pipeline to Deep Creek, which flows south to the North Fork Snoqualmie River.
Water Quality – Temperature, Dissolved Oxygen	• The lake would capture relatively cold runoff from Deep Creek, which could warm slightly in the relatively large, shallow reservoir. • The North Fork Snoqualmie River is listed as Category 4A for temperature and dissolved oxygen where the tributary flows into the river.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• Although the proposed reservoir is large with a limited upslope tributary area, a moderately sized tributary (Deep Creek) flows to the North Fork Snoqualmie River along the west side of the site. • Water would likely be diverted from Deep Creek.
Constructability	• There is no direct access to the site, but there are forest access and logging roads nearby. • Construction would require extensive earthwork and would likely take multiple years to complete.
Critical Areas and Resource Impacts	• Wetland areas were mapped within the project site and the site forms a floodplain for Deep Creek. • The site is heavily forested and would need to be logged and cleared to provide space for the reservoir.
Cost and Funding Potential	• Estimated cost: $20,670,000 to $31,050,000 (assumes a liner will be needed; if no liner is needed, cost would decrease) • Estimated cost per acre-foot: $46,100 to $69,200 • The cost per acre-foot of storage is moderately high relative to the other sites that were evaluated.
Operation and Maintenance	• The reservoir would need to be operated in accordance with Ecology Dam Safety guidelines. • The reservoir would likely require regular maintenance for a relatively large facility and operation of diversion and outlet control facilities.



Storage Site:	NFK1
Description:	Snoq. Timber – NF Snoq. (A)
Sub-basin:	North Fork Snoqualmie
Est. Storage Capacity:	449 acre-feet
Full Water Surface Area:	47.3 acres
Full WSEL:	1,263 feet
Overall Ranking	5



Concept Map, Storage Site: NFK1

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Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

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3.2.2.18 Site NFK2: Snoqualmie Timber – North Fork Snoqualmie (B)

Site NKF2 (Snoqualmie Timber – North Fork Snoqualmie (B) site) is located on mostly cleared timberland high on a bluff just north of the North Fork Snoqualmie River owned by Snoqualmie Timber, LLC. The site appears to have been harvested recently. A few trees remain along a small tributary that runs through the parcel. Logging roads provide access through the site. Water storage would be created by constructing a large earthen impoundment and capturing runoff from the tributary area upslope of the impoundment, which includes forested slopes. Water would then be released through a controlled low-level outlet pipeline to the downstream tributary, which flows to the North Fork Snoqualmie River. The proposed storage concept is shown in Figure 3-27.

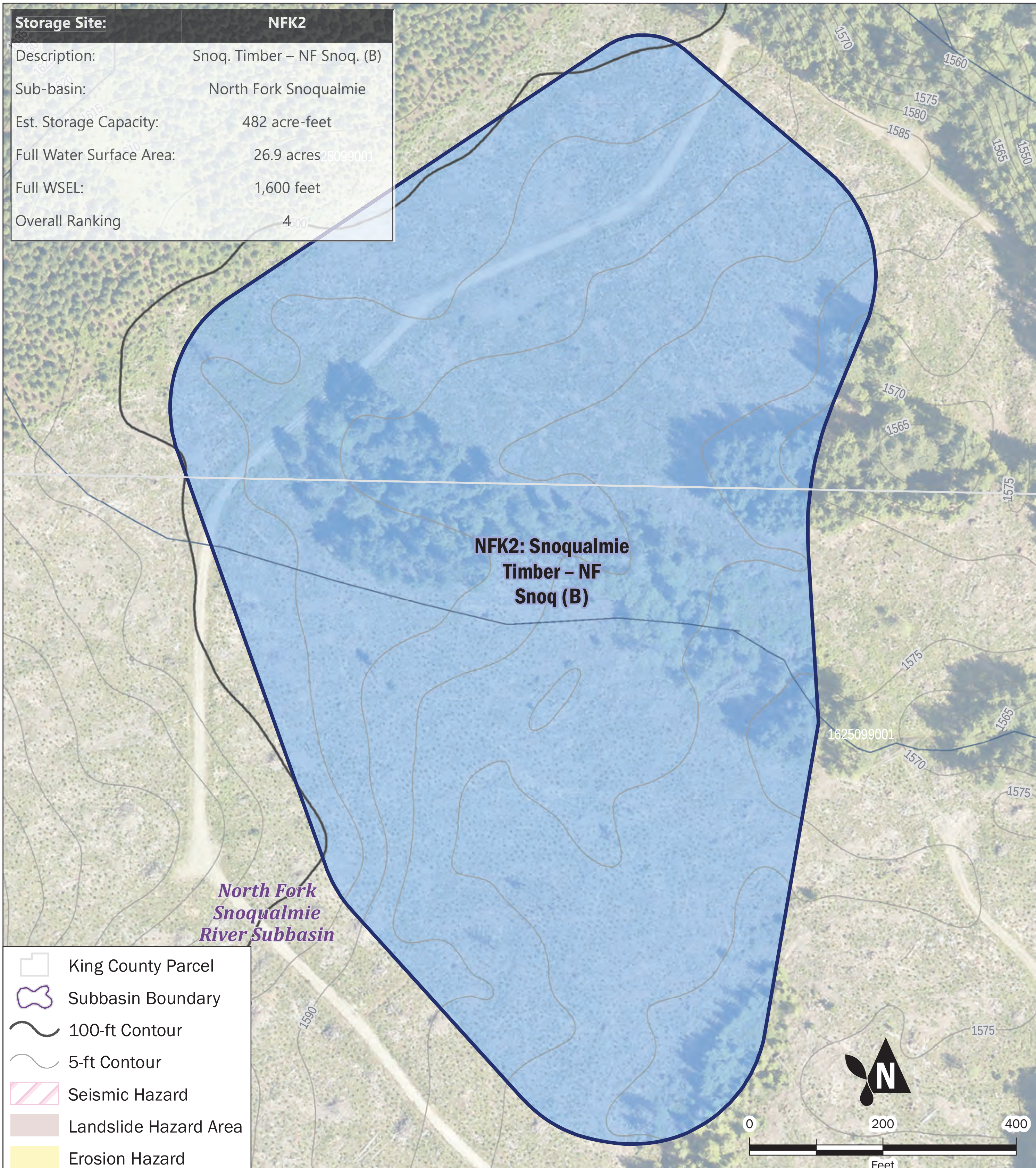
The concept, as shown, would create approximately 482 acre-feet of storage capacity. The water surface of the reservoir would extend over approximately 47 acres when full. The reservoir at this site could be scaled to be larger or smaller, depending on the need and potential benefits. The primary benefit would be flows to offset projected domestic consumptive water use. Table 3-20 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

Snoqualmie Timber, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Snoqualmie Timber.

Table 3-20
Summary of Key Information for Site NFK2: Snoqualmie Timber – North Fork Snoqualmie (B)

Key Physical Characteristic	Value
Site ID	NFK2
Overall Ranking (See Section 4)	4
Description	Off-channel, Constructed Impoundment, Timberland
Parcel	King Co. 1625099001 King Co. 0925099001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	1,600
Estimated Full Water Surface Area	26.9
Estimated Full Water Surface Volume	482
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project occupies more than 26 acres of mostly cleared timberland that slopes from the north and west to the east. • Forest access roads would likely need to be rerouted to accommodate the storage.

Key Criteria	Notes
Available Storage Capacity	• The project concept would make approximately 482 acre-feet of storage available by constructing a large impoundment on cleared timberland. • The impoundment would capture flows from upslope areas, including a small tributary to the North Fork Snoqualmie River.
Ability to Store High Flows	• The proposed reservoir would be high in the mountains with a relatively large watershed tributary to it. • To provide additional benefit, the project could be designed to capture flows from additional areas.
Instream Flow Benefits	• Water would be released via a low-level outlet to the downstream tributary, which flows to the North Fork Snoqualmie River. • If the additional storage volume was released over a 4-week low-flow period, it could provide an 8.68-cfs flow benefit to the tributary and to the North Fork and mainstem Snoqualmie Rivers downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake would be relatively deep and would capture cold water from higher elevations. • The North Fork Snoqualmie River is listed as Category 4A for temperature and dissolved oxygen where the tributary flows into the river.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• Although the storage capacity is relatively large, the watershed upslope of the reservoir is also relatively large and the ratio of the watershed area to the volume of the lake would still be relatively high compared to most of the other concepts.
Constructability	• The site is remote and would require access via a number of steep forest access roads. • Construction could require improving and rerouting some access roads.
Critical Areas and Resource Impacts	• No critical areas were noted within the site. • Some limited clearing of trees and vegetation would be required prior to construction.
Cost and Funding Potential	• Estimated cost: $13,240,000 to $19,860,000 • Estimated cost per acre-foot: $27,500 to $41,200 • The cost per acre-foot of storage is moderately low relative to the other sites that were evaluated.
Operation and Maintenance	• The site would need to be operated in accordance with Ecology Dam Safety guidelines. • The reservoir would likely require regular maintenance and operation of diversion and outlet control facilities.



Concept Map, Storage Site: NFK2

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

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3.2.2.19 Site NFK3: Snoqualmie Timber – North Fork Snoqualmie (D)

Site NFK3 (Snoqualmie Timber – North Fork Snoqualmie (D) site) is located in a high, narrow valley northeast of Mount Si on timberland owned by Snoqualmie Timber, LLC. Water storage would be created by impounding a small tributary that flows through the site. An embankment dam would be constructed across a narrow portion of the valley to impound water. The water would then be released through a controlled low-level outlet pipeline to the downstream tributary, which flows to the North Fork Snoqualmie River. The proposed storage concept is shown in Figure 3-28.

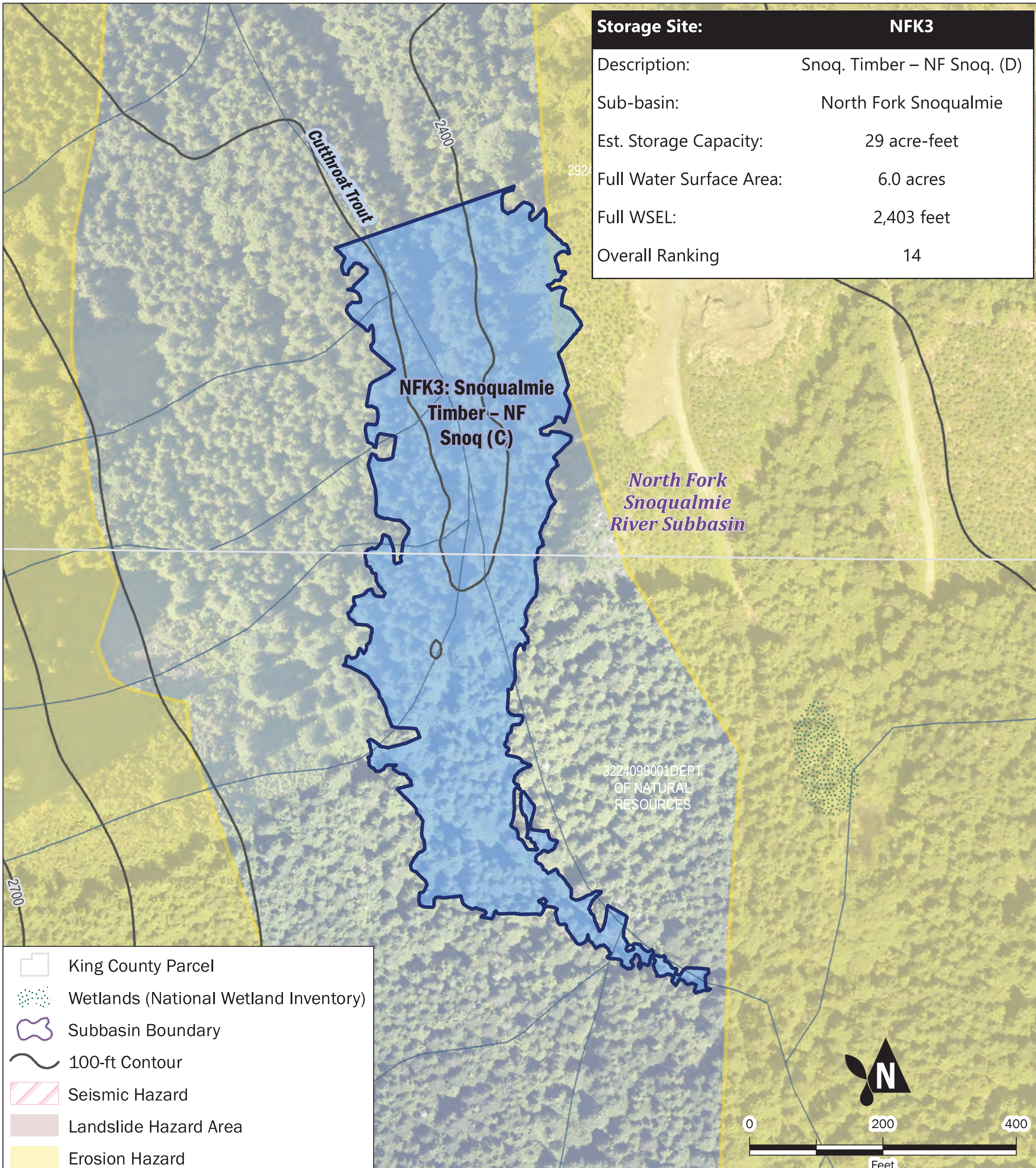
The concept, as shown, would create approximately 29 acre-feet of storage capacity. The water surface of the reservoir would extend over approximately 6 acres when full. It is likely possible to store more water at this location and create more storage capacity with a higher dam. More refinement would be needed if this concept moves forward to maximize the size to enhance potential benefits of the water storage. The primary benefit would be flows to offset projected domestic consumptive water use. Table 3-21 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

Snoqualmie Timber, LLC had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with Snoqualmie Timber.

Table 3-21
Summary of Key Information for Site NFK3: Snoqualmie Timber – North Fork Snoqualmie (D)

Key Physical Characteristic	Value
Site ID	NFK3
Overall Ranking (See Section 4)	14
Description	Impoundment on Upstream End of Small Tributary
Parcel	King Co. 3224099001 King Co. 2924099001
Parcel Owner(s)	Snoqualmie Timber, LLC
Full Water Surface Elevation	2,403
Estimated Full Water Surface Area	6.0
Estimated Full Water Surface Volume	29
Source of Inflow	Upstream Tributary Area
Categorization by Seepage Loss Potential	Low to Moderate Seepage Loss/Infiltration Potential
Key Criteria	**Notes**
Project Footprint	• The project occupies just over 6 acres of forested ravine and cleared timberland. • Forest access roads would likely need to be rerouted to accommodate the storage.

Key Criteria	**Notes**
Available Storage Capacity	• The project concept would make approximately 29 acre-feet of storage available by impounding a small tributary to the North Fork Snoqualmie River.
Ability to Store High Flows	• The proposed reservoir would be high in the mountains with a small to moderate tributary area. • The small storage volume and relatively small watershed would limit the ability to store high flows.
Instream Flow Benefits	• Water would be released via a low-level outlet to the downstream tributary, which flows to the North Fork Snoqualmie River. • If the additional storage volume was released over a 4-week low-flow period, it could provide a 0.52-cfs flow benefit to the tributary and to the North Fork and mainstem Snoqualmie Rivers downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake is at high elevation and would capture cold runoff from the tributary. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer. • The North Fork Snoqualmie River is listed as Category 4A for temperature and dissolved oxygen where the tributary flows into the river.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• Although both the storage capacity and watershed size are relatively small, the ratio of the watershed to the volume of the lake would still be relatively high compared to most of the other concepts.
Constructability	• The site would be accessible via forest roads and logging roads, but construction could require improving and rerouting some access roads. • The site is remote and would require access via a number of steep forest access roads.
Critical Areas and Resource Impacts	• Minor potential erosion hazards exist near the site. • Trees and riparian areas in the forested sections of the proposed reservoir would need to be cleared.
Cost and Funding Potential	• Estimated cost: $1,710,000 to $2,560,000 • Estimated cost per acre-foot: $59,000 to $88,500 • The cost per acre-foot of storage is moderately high relative to the other sites that were evaluated.
Operation and Maintenance	• The site would need to be operated in accordance with Ecology Dam Safety guidelines. • The reservoir would likely require regular maintenance and operation of diversion and outlet control facilities.



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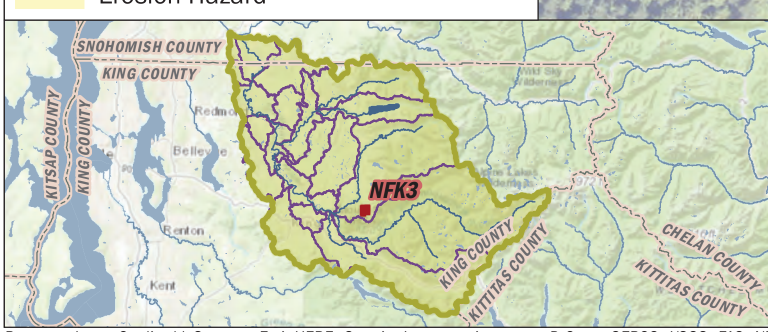

Concept Map, Storage Site: NFK3

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
WRIA 7, Washington

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3.2.2.20 Site MFK1: DNR – Middle Fork Snoqualmie

Site MFK1 (DNR – Middle Fork Snoqualmie), the only site located in the Middle Fork Snoqualmie subbasin identified for screening, is a large, gently sloping, heavily forested tract of timberland owned by the DNR near the base of a steep ridge east of Mount Si. The property has forest access roads, and at least two tributaries flow from the slopes of the ridge to the valley along the north edge of the property. The proposed concept would be to log a large tract of the property and perform considerable earthwork to construct a large impoundment to store water. Water supply to fill the impoundment would flow in from the tributary area upslope of the impoundment. A portion of the two largest tributaries that enter the valley from the side of the mountain along the north edge of the property could be diverted to the storage reservoir. The water could then be released through a pipeline down the adjacent tributary to the Middle Fork Snoqualmie River. The proposed storage concept is shown in Figure 3-29.

The concept, as shown, would create approximately 3,300 acre-feet of storage capacity. This represents the largest of the lakes that were evaluated as part of this screening analysis. The water surface of the reservoir would extend over approximately 174 acres when full. The water storage would provide a variety of benefits. In addition to providing a significant source of instream flows to offset projected domestic consumptive water use, the storage could be designed to provide water supply for other out-of-stream uses, recreation opportunities, and enhanced habitat. Table 3-22 summarizes the key characteristics of this concept for storage, with key notes summarizing the challenges and benefits of each of the key criteria evaluated as part of the site-specific analysis outside of GIS.

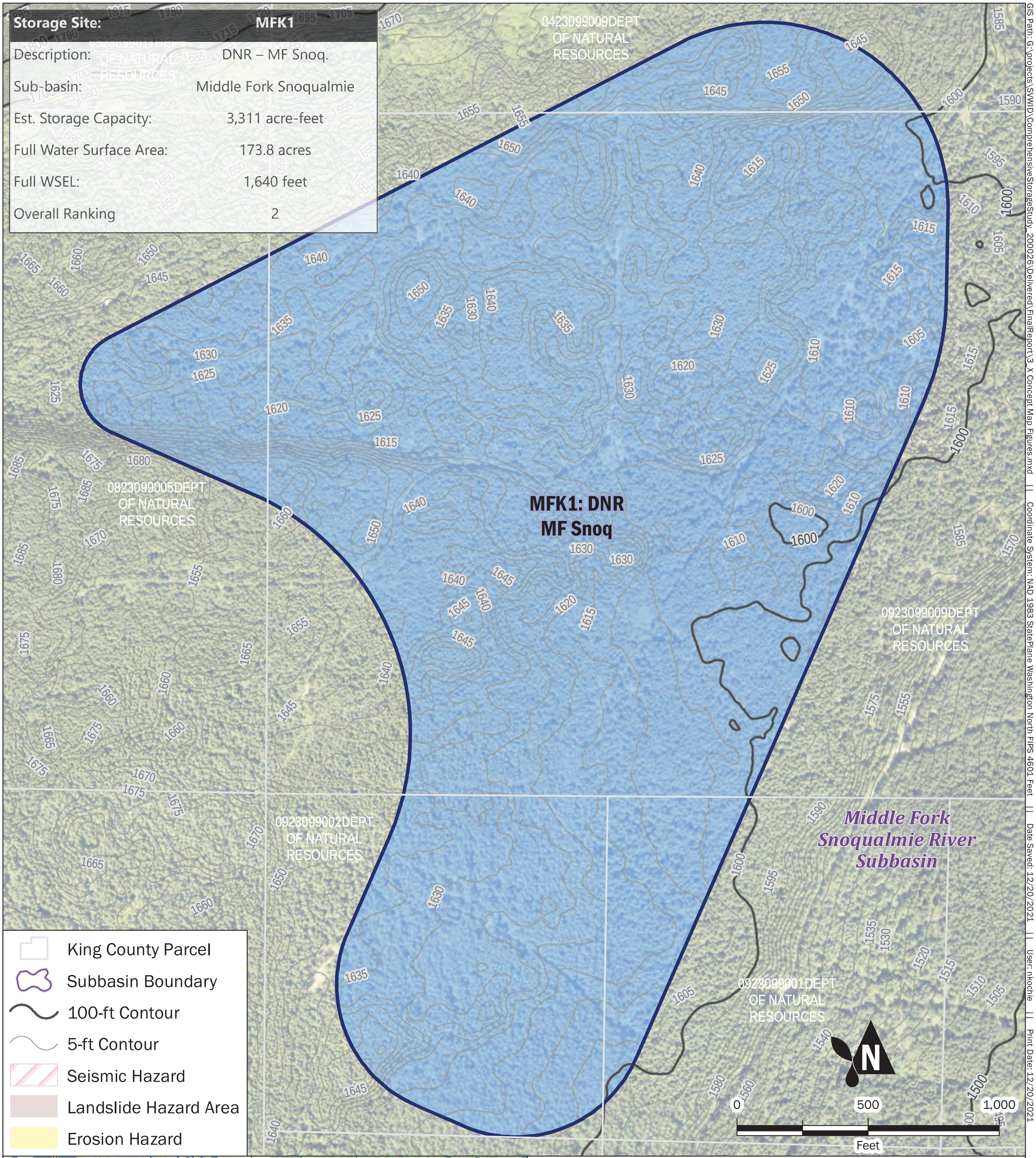
DNR had not yet been consulted at the time the screening analysis was completed. If this project were to move forward, additional work would need to be done, including coordinating with DNR.

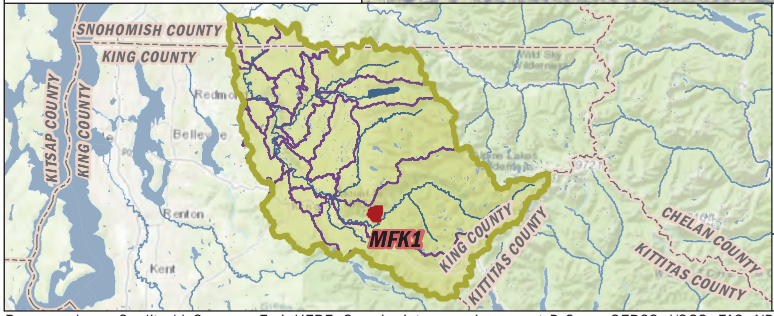
Table 3-22
Summary of Key Information for Site MFK1: DNR – Middle Fork Snoqualmie

Key Physical Characteristic	Value
Site ID	MFK1
Overall Ranking (See Section 4)	2
Description	Off-channel, Constructed Impoundment, Near Tributary
Parcel	King Co. 0423099009 King Co. 0523099011 King Co. 0823099005 King Co. 0923099009
Parcel Owner(s)	DNR
Full Water Surface Elevation	1,640
Estimated Full Water Surface Area	173.8
Estimated Full Water Surface Volume	3,311
Source of Inflow	Upstream Tributary Area, Diversions on Adjacent Tributaries
Categorization by Seepage Loss Potential	Moderate Seepage Loss/Infiltration Potential

Key Criteria	Notes
Project Footprint	• The project converts more than 100 acres of public timberland into a surface water reservoir. • The area would need to be logged and cleared prior to construction.
Available Storage Capacity	• The project concept would make approximately 3,311 acre-feet of storage available by creating a large impoundment.
Ability to Store High Flows	• The proposed lake is the largest storage reservoir identified by this screening study and could be used to capture peak flows from the upstream tributary areas going up the ridge east of Mount Si, but the tributary area is relatively small relative to the size of the overall watershed. • The project could be combined with a pumped diversion from the Middle Fork Snoqualmie River to enhance potential for capture of high flows from a larger tributary area.
Instream Flow Benefits	• Water would be released via an outlet pipeline and nearby tributary to the Middle Fork Snoqualmie River. • If the additional storage volume was released over a 4-week low-flow period, it could provide a nearly 60-cfs flow benefit to the tributary and to the Middle Fork and mainstem Snoqualmie Rivers downstream of the storage site.
Water Quality – Temperature, Dissolved Oxygen	• The lake would capture cold runoff from the tributaries that run along the north side of the site. • The lake would have a large surface area, which could result in warming of water stored in the lake during the summer. • Impacts could be mitigated by releasing from the bottom of the reservoir during the late summer. • The Middle Fork Snoqualmie River is listed as Category 4A for temperature where the tributary flows into the river.
Water Quality – Toxics	• No potential sources of contamination were noted within the lake's watershed.
Reliability/Resilience	• Although the proposed reservoir is large, the tributary area upstream of the reservoir would also be large and the ratio of the watershed to the volume of the lake would still be relatively high.
Constructability	• The site would be relatively easy to access via forest roads and logging roads, but construction would require a significant logging and clearing effort. • Construction would require a massive amount of earthwork and would likely take multiple years to complete.
Critical Areas and Resource Impacts	• No critical areas were noted within the project site. • The site is heavily forested and would need to be logged and cleared to provide space for the reservoir.

Key Criteria	Notes
Cost and Funding Potential	• Estimated cost: $89,950,000 to $134,930,000 (assumes a liner will be needed; if no liner is needed, cost would decrease) • Estimated cost per acre-foot: $27,200 to $40,800 • The cost per acre-foot of storage is low to moderate relative to the other sites that were evaluated.
Operation and Maintenance	• Would need to be operated in accordance with Ecology Dam Safety guidelines. • Would likely require regular maintenance for a large facility and operation of diversion and outlet control facilities.





Concept Map, Storage Site: MFK1

Screening Analysis Memo
Snoqualmie Valley Watershed Improvement District
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4 Ranking and Selection of Storage Sites for Further Analysis

The final step in the screening analysis was to combine the raster-based scoring from the GIS weighted overlay analysis with the scoring from the site-specific analysis. The goal of this final step was to develop an overall favorability score that incorporates 1) the scoring for each site based on the criteria that were evaluated and scored in GIS, with 2) the scoring for the criteria that were evaluated and scored on a site-specific basis outside of GIS. This section provides a summary of that final step and the overall favorability scoring and ranking of potential storage sites that were evaluated by the screening analysis.

4.1 GIS Weighted Overlay Analysis Favorability Scoring

The shapes for each reservoir that were developed and evaluated using AutoCAD Civil 3D were exported as shapefiles for incorporation into the GIS model. Over each potential project site footprint, a zonal statistics function was performed in GIS for each input raster layer. This function summarizes various information about the underlying value-based data, such as the average, maximum value, minimum value, and standard deviation. The mean value over each area was tabulated and included in the screening matrix tables provided in Appendix C. The overall GIS weighted overlay analysis scoring and weighted scoring for each category of criteria evaluated within the GIS for each site are summarized in Table 4-1.

4.2 Site-Specific Favorability Scoring

The site-specific criteria were scored for each site, as outlined in the Work Plan. The scoring is summarized in the screening matrix provided in Appendix C. The scoring for each criterion for each site was tabulated and weighted within each category. The favorability score for each category was then weighted and combined to develop an overall favorability scoring for each storage site based on the site-specific analysis. The overall site-specific analysis scoring and weighted scoring for each category of criteria from the site-specific analysis for each site are summarized in Table 4-2.

4.3 Storage Site Screening Ranking

The scoring from the GIS analysis and the site-specific analysis were then combined in a spreadsheet to calculate an overall favorability score for each potential storage site. The overall scores from each analysis were averaged to come up with an overall favorability score. Table 4-3 provides a summary of the overall favorability scoring and ranking. The sites in Table 4-3 are sorted by the overall ranking, from highest overall favorability score to lowest overall favorability score.

Table 4-1
Summary of Combined Scoring for Potential Storage Sites in GIS

Project ID	Overall Rank	Overall Score from GIS Weighted Overlay Analysis	Overall Score - Physical Criteria Measuring Out-of-Stream Use Benefits	Overall Score - Physical Criteria Measuring Instream Flow and Habitat Benefits	Overall Score - Other Cost/Benefit and Feasibility Criteria
			35%	*40%*	*25%*
SNO1	17	**3.57**	3.60	3.80	3.14
SNO2	19	**3.45**	3.60	3.45	3.24
SNO3	16	**3.33**	3.05	3.51	3.43
CCK1	12	**2.84**	2.70	2.74	3.20
CCK2	9	**3.52**	2.70	3.95	3.98
CCK3	20	**2.91**	2.70	2.71	3.54
LOT1	15	**3.41**	3.05	3.60	3.60
LOT2	18	**3.29**	2.35	3.60	4.12
NFT1	7	**4.05**	3.40	4.65	4.01
NFT2	13	**3.95**	3.40	4.65	3.58
NFT3	8	**4.05**	3.40	4.65	4.00
NFT4	1	**4.04**	2.83	5.00	4.20
TOK1	11	**3.91**	3.26	4.30	4.20
TOK2	6	**3.95**	3.40	4.65	3.60
TOK3	3	**3.95**	3.40	4.65	3.60
TOK4	10	**3.81**	3.40	4.30	3.60
NFK1	5	**3.96**	3.30	4.30	4.32
NFK2	4	**3.69**	3.00	3.95	4.23
NFK3	14	**3.80**	3.45	4.65	2.95
MFK1	2	**3.68**	2.71	3.95	4.60

Table 4-2
Summary of Scoring for Site-Specific Analysis

Project ID	Overall Rank	Overall Score from Site-Specific Analysis	Overall Score - Physical Criteria Measuring Out-of-Stream Use Benefits	Overall Score - Physical Criteria Measuring Instream Flow and Habitat Benefits	Overall Score - Other Cost/Benefit and Feasibility Criteria
			35%	*40%*	*25%*
SNO1	17	**2.91**	2.60	2.75	3.60
SNO2	19	**2.13**	1.80	2.30	2.30
SNO3	16	**3.18**	3.70	2.70	3.20
CCK1	12	**3.96**	3.60	4.05	4.30
CCK2	9	**3.56**	3.30	3.75	3.60
CCK3	20	**2.36**	1.30	3.00	2.80
LOT1	15	**3.26**	3.40	3.05	3.40
LOT2	18	**2.64**	3.10	2.70	1.90
NFT1	7	**3.14**	3.60	3.00	2.70
NFT2	13	**2.82**	2.60	2.95	2.90
NFT3	8	**3.07**	3.10	2.95	3.20
NFT4	1	**3.97**	4.30	3.90	3.60
TOK1	11	**2.93**	2.50	3.75	2.20
TOK2	6	**3.33**	2.90	3.15	4.20
TOK3	3	**3.76**	3.80	3.45	4.20
TOK4	10	**3.24**	3.10	2.70	4.30
NFK1	5	**3.34**	3.70	3.30	2.90
NFK2	4	**3.92**	4.50	3.60	3.60
NFK3	14	**2.94**	2.20	3.55	3.00
MFK1	2	**4.20**	4.70	4.20	3.50

Table 4-3
Overall Storage Site Favorability Scoring and Ranking

Project ID	Overall Rank	Description	Estimated Storage Volume (Acre-feet)	Maximum Water Surface Area (Acres)	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	**1**	Snoqualmie Timber - NF Tolt (C)	1,296	133.6	**4.00**	4.04	3.97
MFK1	**2**	DNR - MF Snoq	3,311	173.8	**3.94**	3.68	4.20
TOK3	**3**	Klaus Lake	121	70.2	**3.86**	3.95	3.76
NFK2	**4**	Snoqualmie Timber - NF Snoq (B)	482	26.9	**3.80**	3.69	3.92
NFK1	**5**	Snoqualmie Timber - NF Snoq (A)	449	47.3	**3.65**	3.96	3.34
TOK2	**6**	Bridges Lake	89	47.8	**3.64**	3.95	3.33
NFT1	**7**	DNR - NF Tolt (B)	113	11.6	**3.59**	4.05	3.14
NFT3	**8**	DNR - NF Tolt (D)	132	11.5	**3.56**	4.05	3.07
CCK2	**9**	Cherry Lake	173	22.2	**3.54**	3.52	3.56
TOK4	**10**	Black Lake	76	40.7	**3.53**	3.81	3.24
TOK1	**11**	Snoqualmie Timber - Tokul	38	8.1	**3.42**	3.91	2.93
CCK1	**12**	Lake Margaret	106	53.1	**3.40**	2.84	3.96
NFT2	**13**	Snoqualmie Timber - NF Tolt (A)	62	7.3	**3.38**	3.95	2.82
NFK3	**14**	Snoqualmie Timber - NF Snoq (D)	29	6.0	**3.37**	3.80	2.94
LOT1	**15**	Snoqualmie Timber - Tolt (A)	84	23.7	**3.33**	3.41	3.26
SNO3	**16**	Twin Peaks Timber - Snoq	197	17.9	**3.25**	3.33	3.18
SNO1	**17**	Loutsis Lake	38	18.8	**3.24**	3.57	2.91
LOT2	**18**	Snoqualmie Timber - Tolt (B)	130	19.4	**2.97**	3.29	2.64
SNO2	**19**	Nelson Pond	42	14.7	**2.79**	3.45	2.13
CCK3	**20**	Upper Margaret Creek	22	7.9	**2.63**	2.91	2.36

4.4 Selection of Highly Ranked Sites for Further Analysis

As noted earlier, the results of the screening analysis were reviewed with SVWID and interested members of the WRIA 7 WREC. Based on the final scoring and ranking of the sites included in the screening analysis, and additional discussions with SVWID and other stakeholders, 7 storage projects were selected for further, more detailed analysis. The sites selected are summarized Table 4-4. These sites do not represent the top 7 ranked storage projects. Rather, the 7 sites were selected based on rankings and discussion with SVWID and other stakeholders about downstream flow and water supply benefits, ability to coordinate with property owners, and generally which of the top ranked projects might have the best chance to move forward toward implementation. The other highly ranked sites may also warrant consideration and further study in the future, but they were not advanced further through the analysis as part of this study.

Table 4-4
Sites Selected for Further Analysis

Project ID	Overall Rank	Description	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	**1**	Snoqualmie Timber - NF Tolt (C)	**4.00**	4.04	3.97
MFK1	**2**	DNR - MF Snoq	**3.94**	3.68	4.20
TOK3	**3**	Klaus Lake	**3.86**	3.95	3.76
NFK2	**4**	Snoqualmie Timber - NF Snoq (B)	**3.80**	3.69	3.92
TOK2	**6**	Bridges Lake	**3.64**	3.95	3.33
CCK2	**9**	Cherry Lake	**3.54**	3.52	3.56
TOK4	**10**	Black Lake	**3.53**	3.81	3.24

5 Detailed Evaluation of Highly Ranked Sites

This section provides a summary of the detailed analysis of the seven storage projects that were selected for further evaluation. Additional background information for each site is provided, along with the following:

- A summary of the landowner outreach activities and site visit (if a site visit was completed)
- A more detailed description of the storage concept
- A summary of site access and other key constraints
- Identification of the source of water that would be used to fill the reservoir
- A summary of the hydrologic and hydraulic analyses completed
- A description of the anticipated operations and water balance/refill analysis
- A description of potential water quality impacts
- A summary of anticipated geologic conditions
- A description of potential constructability issues
- A summary of the refined opinion of implementation and long-term operating costs developed for this analysis

The projects discussed in the following sections are presented by subbasin and not in any order of preference or rank.

5.1 Site CCK2: Cherry Lake

5.1.1 Site Background

Site CCK2 (Cherry Lake) is a small existing lake located in the Cherry Creek subbasin in the northern part of the Snoqualmie River Watershed. The lake is located on a large parcel owned by DNR in a small valley with other ponds near the headwaters of Cherry Creek. Cherry Creek flows west from Cherry Lake through the narrow valley outlet. The valley floor is a mixture of forest and areas occupied by grass, vegetation, and ponds. Steep slopes rise from the valley floor on all sides and are heavily timbered. The site is managed by DNR as part of a large tract of land leased for timber harvest.

5.1.2 Landowner Coordination and Site Visit

DNR was contacted to review this site and other sites under consideration for water storage projects (Site MFK1; Section 5.7). Discussion specific to this property and other properties owned by DNR that are being evaluated in detail primarily occurred during fall 2021. During a virtual meeting on October 19, 2021, SVWID and Anchor QEA provided a summary of the potential project to DNR personnel. Notes from that meeting are included in Appendix D. Some of the primary concerns communicated by DNR with the proposed storage project include the following:

- **Loss of Harvestable Timber:** The property where Site CCK2 is located is managed by DNR as part of Washington State Trust Lands. The land is leased for timber harvest to generate income for the state, which is primarily used to support funding for education. Any reduction or impairment of DNR's ability to carry out this part of their mission would be considered incompatible with the intended use of the property by the State of Washington.
- **Liability:** DNR expressed concern that water storage could pose a risk to DNR infrastructure on the property in question and downstream property and infrastructure owned by others. Concerns were expressed regarding the potential for releases, spills, or even failure of the impoundment to cause damage to roads, culverts, and other infrastructure. There would need to be agreements in place for a storage project that would release DNR from any liability associated with the reservoir and its operation.
- **Impacts to Natural Resources:** DNR also expressed concern about whether the project would impact fish, wildlife, and other resources. DNR was interested in the level of coordination that had occurred about potential storage projects with the Snoqualmie Indian Tribe and the Tulalip Tribes, WDFW, and other regulatory agencies.
- **Lease or Sale of Land:** DNR indicated that when they lease or sell land for uses other than timber harvest, the annual lease amount or purchase of the land would have to fully compensate for the loss of revenue generated by leasing the land for timber harvest.

Following the initial presentation and discussion, DNR's Acting Assistant Region Manager responded with an email indicating that the projects proposed on DNR-managed land "would not be compatible" with DNR's management of the land due to the concerns that were expressed during the virtual meeting. The proposed storage projects would impede DNR's ability to carry out their trust responsibilities and obligations on those properties.

A follow-up discussion was scheduled with DNR's Acting Assistant Region Manager. She reiterated the concern that the proposed storage project at Site CCK2 would not be compatible with carrying out their trust responsibilities on the land. The land generates revenue because of the trees that can be harvested. A storage reservoir would reduce the area that can be harvested. At Site CCK2, inundating the existing Cherry Lake with a larger lake would increase the buffer around the lake that has to be maintained during timber harvest, reducing the area that can be harvested. Construction and operation of the reservoir would also require removal of trees in and around the narrow valley at the site. Removal of trees from the land renders it unusable to DNR.

Due to the concerns and position communicated by DNR relative to this potential project, a site visit was not completed to Site CCK2.

5.1.3 Proposed Storage Concept

The proposed storage concept for Site CCK2 is to construct an earthen embankment or some other type of impoundment across the outlet of the narrow valley downstream of Cherry Lake where Cherry Creek and an unnamed tributary converge. The proposed reservoir is shown relative to the basin that would be tributary to the reservoir in Figure 5-1A. The embankment and reservoir are shown over LiDAR topography in Figure 5-1B. The earthen embankment would be approximately 39 feet tall and would hold water to a maximum water surface elevation (WSEL) of 987 feet. The proposed reservoir would inundate approximately 22.2 acres when full, including Cherry Lake and portions of Cherry Creek and an unnamed tributary.

An outlet structure at the embankment would allow for controlled release of reservoir water through a low-level outlet pipeline to Cherry Creek downstream of the reservoir. Infrastructure would also include an emergency spillway, access roads, and monitoring equipment.

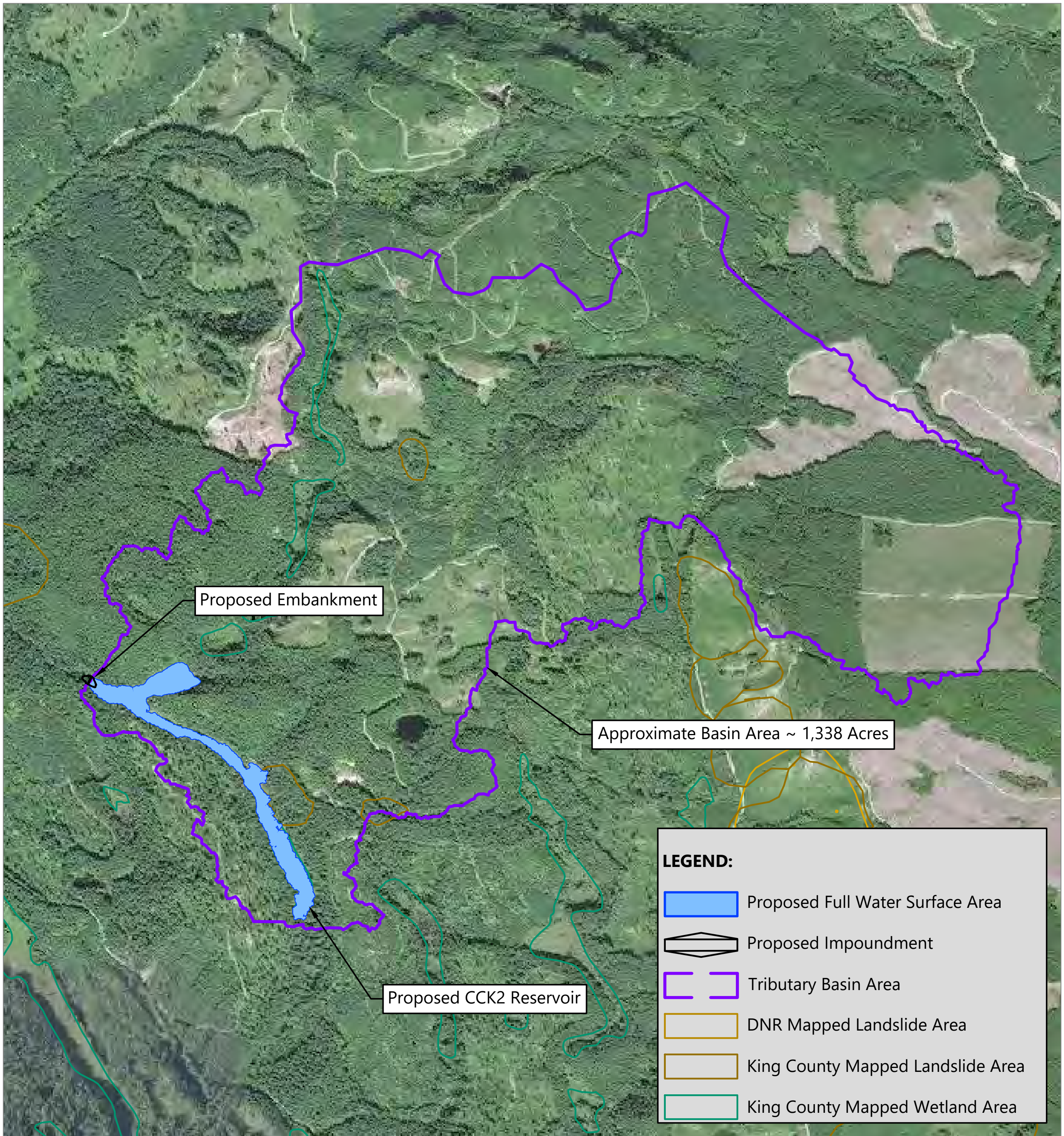
5.1.4 Site Access and Constraints

There are currently no existing roads to Cherry Lake or into the surrounding valley. The only access to the area is currently by foot from a DNR logging road located approximately 500 feet west of where the embankment would be constructed. The area where the embankment would be constructed is heavily forested. The condition of the nearby DNR logging road is unknown. The road is accessed via other DNR roads that extend north and east from Stossel Creek Road.

Relatively steep, heavily timbered slopes rise adjacent to the narrow valley where Cherry Lake is located. Other potential site constraints include nearby areas that may be prone to landslides.

5.1.5 Source of Stored Water

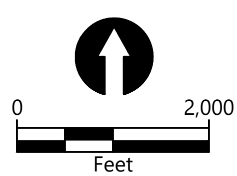
The proposed reservoir at Site CCK2 would capture water from a tributary area that naturally flows to Cherry Lake and the surrounding valley. The tributary basin extends primarily north and east from the reservoir up to the top of the Cherry Creek subbasin, as shown in Figure 5-1A. LiDAR data were used in ArcGIS to delineate the tributary basin that would contribute flow to the reservoir. The area of the tributary basin was estimated to be approximately 1,337 acres (2.09 square miles).



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88

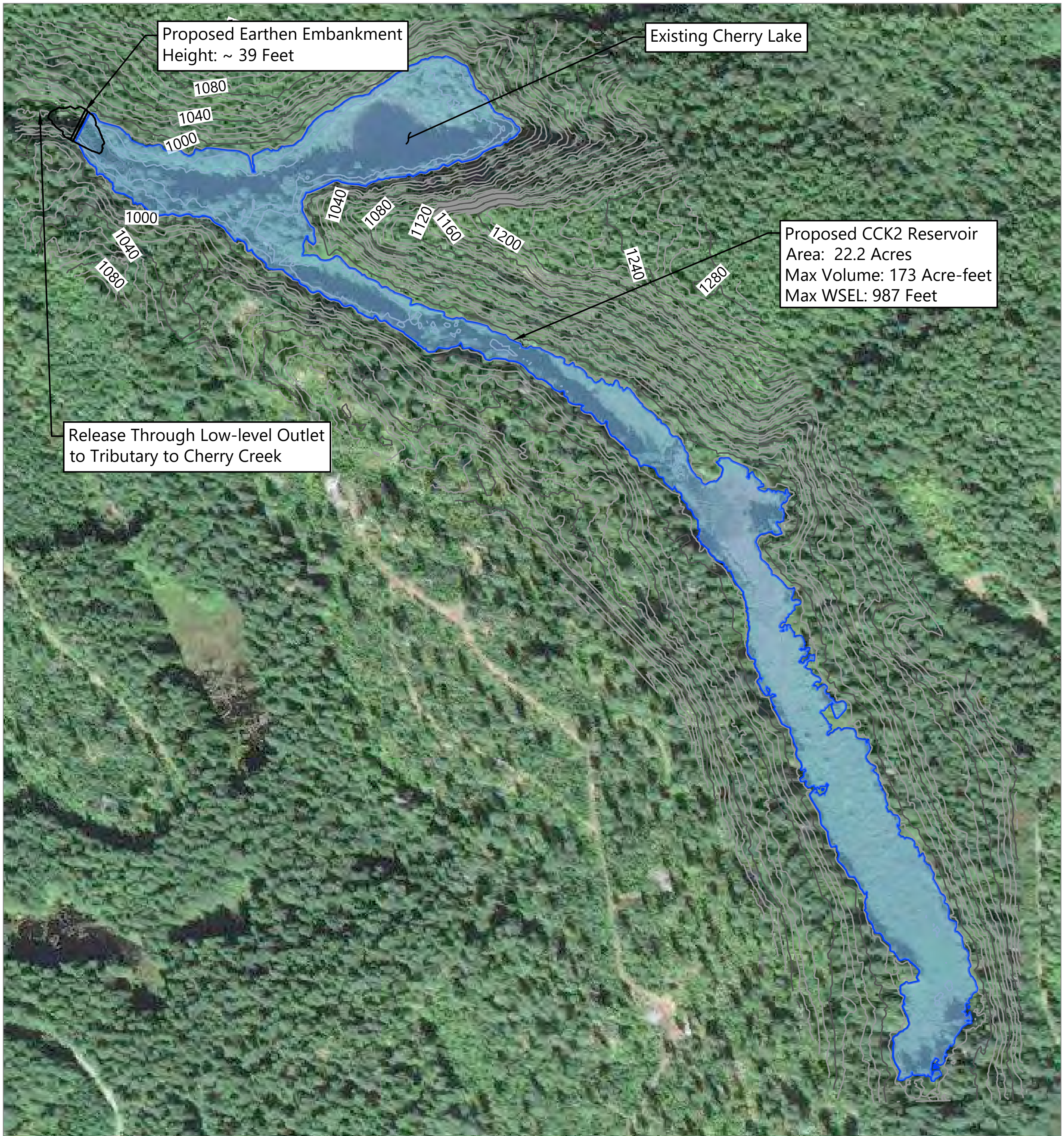


Publish Date: 2022/01/12 1:49 PM | User: drice
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site CCK2.dwg Figure 5-1A

ANCHOR QEA

Figure 5-1A
Tributary Basin Area Map - Storage Site CCK2

Snoqualmie Watershed
Comprehensive Storage Study



SOURCE: Aerial ©2021 Microsoft Corporation; LiDAR-based topography from Puget Sound LiDAR Consortium data

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88

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ANCHOR QEA

Figure 5-1B
Site Map - Storage Site CCK2

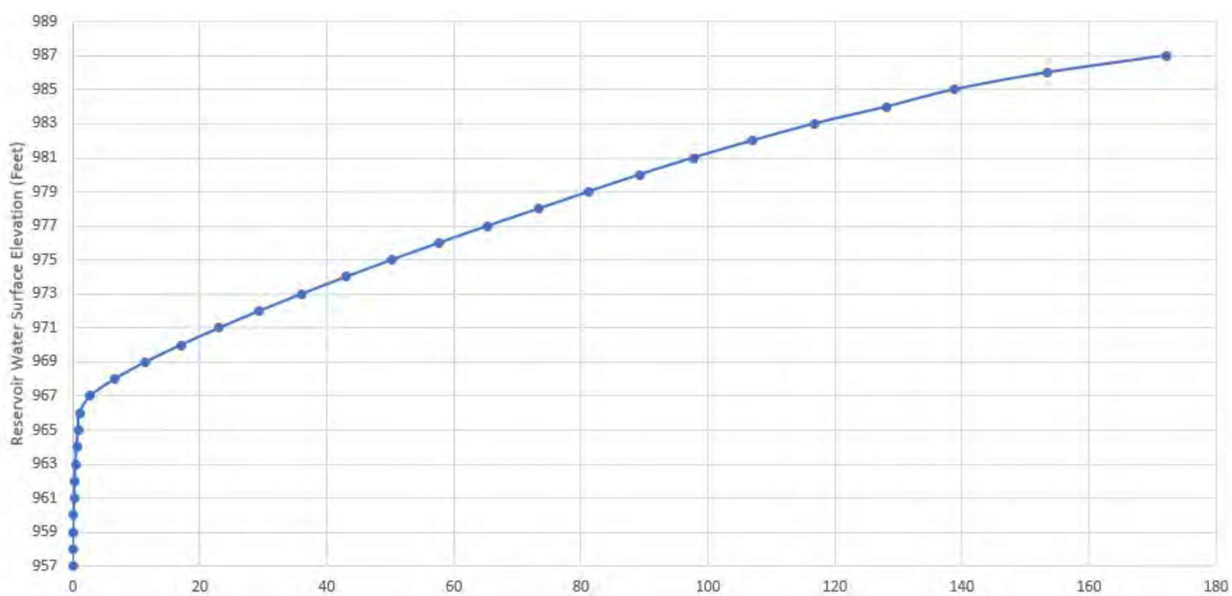
Snoqualmie Watershed
Comprehenisve Storage Study

5.1.6 *Hydrologic and Hydraulic Analyses*

The Western Washington Hydrologic Model (WWHM) was used to model the rate and volume of runoff that a reservoir at site CCK2 would capture from the tributary basin during the modeling period of record. The WWHM model uses historical precipitation data, evaporation data, ground cover, ground slope, and soil type to model runoff volumes for the modeling period of record, a 61-year period from October 1948 to September 2009 (Water Years 1949 to 2009). For the period of record modeled, the average annual runoff volume that drains to the reservoir area from the tributary area was estimated to be 139 acre-feet. The annual runoff volume was estimated to range from 77 to 277 acre-feet.

A stage-storage volume curve was also developed for the reservoir at Site CCK2 based on the configuration of the embankment and the surrounding topography, represented by contours generated from LiDAR data. The stage-storage volume curve is plotted in Figure 5-1C. The stage is represented in feet of elevation related to the storage volume in acre-feet of storage. As shown, the full reservoir would store 173 acre-feet at an elevation of 987 feet.

Figure 5-1C
Stage-Storage Curve – Storage Site CCK2



5.1.7 *Reservoir Operations*

The runoff volumes from the WWHM model were used, along with estimated evaporation rates and the estimated stage-storage volume curve, to develop a reservoir operations and water balance model. The purpose of the model was to estimate when flows would be captured and released from the reservoir, and to estimate the probability of refill given hydrology of the tributary basin and the targeted size and storage capacity of the reservoir. This model estimated the inflows and outflows from the reservoir at Site CCK2 on a monthly basis for the 61-year modeling period of record. Outflows include evaporation and reservoir releases from Cherry Lake reservoir to Cherry Creek. The water balance model was adjusted to determine potential release rates during the late summer as an example of how the reservoir could be operated to augment flows in Cherry Creek. Table 5-1 summarizes findings from the water balance model for Site CCK2.

Table 5-1
Water Balance Model Results – Site CCK2

Parameter Evaluated	Result
Targeted Capacity	173 acre-feet
Area of Tributary Basin	1,338 acres
Average Annual Runoff	139 acre-feet
Maximum Annual Runoff	277 acre-feet
Minimum Annual Runoff	77 acre-feet
Average Late-Summer Release Rate Available	2 cfs
Average Days Release Available in Late Summer	14.7 days
Average % of Targeted Reservoir Volume Filled	43.8%
Maximum % of Targeted Reservoir Volume Filled	100.0%

Based on inflows to the proposed reservoir, the size of the reservoir that was targeted, and other assumed inputs used for the water balance model, the model indicates that the reservoir would only fill completely during very wet years. During average and drier than average years, the reservoir would not refill. Based on the results from the water balance model, 2 cfs could be released from the reservoir for an average of 14.7 days during the late summer to increase streamflow in Cherry Creek. The model assumes that a limited baseflow of 0.1 cfs would be released throughout the year to maintain a constant baseflow from the reservoir to Cherry Creek. If this project were to be advanced for further analysis, smaller storage capacities would need to be evaluated to balance the size of the embankment, storage capacity, and cost of the reservoir with the volume of runoff volume that can reliably be captured and stored in the reservoir.

5.1.8 Potential Water Quality Impacts

During discussion about potential storage projects, stakeholders have consistently expressed concern about the potential for water storage reservoirs to impact water quality as they release water that may not be equal in quality to water that currently exists in the streams and rivers downstream of each reservoir. Of particular concern is the potential for increased water temperature in reservoir releases and degraded water quality in the reservoirs, including noxious algal blooms and depleted bottom water dissolved oxygen (DO) concentrations. A detailed evaluation and modeling or quantification of water quality impacts is beyond the scope of this study. However, in response to stakeholder comments, this study did consider the potential for impacts to water quality and describes those potential impacts, their applicability to each reservoir, and potential ways to mitigate those impacts through the design and operation of the reservoir. As different projects are advanced through feasibility-level study, water quality modeling and further study of these impacts and potential mitigation should be completed.

Increased temperature can result from thermal heating of the water as it is held in the reservoir. Lakes and reservoirs in the area experience seasonal thermal stratification, with warmer water near the surface during the warm summer months, when water would be released to augment instream flows. The epilimnion is the warmer water at the surface and the hypolimnion is the cooler water near the bottom. These layers are separated by a thermocline, defined as the depth corresponding to the maximum vertical change in temperature. The temperature profile in the lakes evaluated as part of this study has not been modeled. Thermocline depths in lakes in western Washington are likely to be a few feet below the lake surface in the spring and early summer, increasing to depths of 10 to 20 feet or more in the late summer. The temperature profile of each lake would be impacted by ambient temperature (higher ambient temperatures would typically be expected at lower elevations); depth of water stored (cooler water would be expected in deeper lakes); surface area (more thermal heating would occur in lakes with larger surface areas); and natural shading (less thermal heating would occur where lakes are shaded by trees, etc.).

Degraded lake water quality conditions can result from relatively high concentrations of the nutrient phosphorus, the typical limiting nutrient controlling algae growth in freshwater lakes. As algae sink to the bottom of the lake and decay, they decrease bottom water oxygen concentrations. Releases of water with low DO concentrations can impact the health of fish and other aquatic species downstream of the lake.

Considering the potential for these impacts, the following key characteristics that may influence water quality were noted for the proposed reservoir at Site CCK2:

- The reservoir elevation (full WSEL ~987 feet) would be low relative to the other six sites, which could mean capture and storage of slightly warmer water and warmer ambient temperatures in the summer.
- The reservoir would be deeper than the other six reservoirs and would have a relatively small surface area.
- The reservoir would be located in a narrow valley with heavily timbered slopes above.
- The reservoir does not appear to be downstream of any fertilized areas where high nutrient loading would be expected.

- The reservoir does not appear to be downstream of any sources of toxic contaminants.

Based on these key characteristics and observations, the following are anticipated relative to water quality impacts and potential ways to mitigate for those impacts through design and operation:

- Temperature could be impacted by water storage, but impacts are likely to be less significant relative to the other six reservoirs due to the small surface area and depth of the reservoir. The temperature of stored water and releases could be monitored, and a multi-port outlet could be provided to allow for releases from the coolest part of the reservoir. Additional analysis, including water quality modeling and research of water quality in similar nearby lakes, would be needed to better understand potential impacts to water temperature.
- Degradation of water quality due to nutrient loading, toxic algal blooms, and low DO concentrations are not anticipated to be any greater than they would be through any other natural lake in the system. However, additional analysis would be required to better understand the potential for nutrient impacts, algae growth, and reduced DO concentrations. Aeration or management techniques could be considered.
- No release of toxics or contamination in stored water is anticipated.

5.1.9 Non-Exploratory Soils and Geology

The primary soil and geology conditions to consider for Site CCK2 are the moderately high to high hydraulic conductivity of near-surface soils and the thick deposits of unconsolidated lithology. Geology at the site is mapped as recessional outwash deposits of the Vashon Stade of the Fraser glaciation, consisting of stratified sand and gravel, moderately to well sorted, and well-bedded silty sand to silty clay deposited in proglacial and ice-marginal environments abutted by till and volcanic bedrock.

The primary geologic hazards to consider in planning and development are the nearby landslide (Qls) deposits and steep slopes that abut the west and east sides of the site.

The primary seismic hazard is Moderate (MMI 5) to Very Strong (MMI 7) ground shaking as modeled during southern Whidbey Island, Seattle, Tacoma, and Cascadia events. The soils and rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density. Summaries of soil, geologic, and seismic conditions are included in Tables 5-2 to 5-4.

Table 5-2
Soil Conditions – Site CCK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped soil unit(s)	Foundation and reservoir	231—Seattle muck, 0% to 1% slopes
	Abutments and rim areas	
Soil Conditions		
USCS	Foundation and reservoir	PT – Peat
	Abutments and rim areas	
Depth to water table	Foundation and reservoir	About 0 inches
	Abutments and rim areas	
Capacity of the most limiting layer to transmit water (K_{sat})	Foundation and reservoir	Moderately high to high (0.57 to 1.98 inch/hour)
	Abutments and rim areas	
Drainage class	Foundation and reservoir	Very poorly drained
	Abutments and rim areas	
Depth to any soil restrictive layer	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Suitability		
Pond reservoir areas	Somewhat limited	Seepage

Table 5-3
Geologic Conditions – Site CCK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped geologic unit(s)	Foundation and reservoir	Pleistocene recessional outwash deposits (Qvr)
	Abutments and rim areas	Pleistocene recessional outwash deposits (Qvr); Pleistocene till (Qvt) (West Rim); Late Eocene volcanic rocks of Mount Persis (Tmp) (East Rim)
Slope Stability		
Landslides and existing slope movements	West and east sides abut mapped Quaternary mass wasting (Qls) deposits and potential steep slope hazard areas (> 40%)	
Structures		
Potentially active faults	None mapped at the site	
Folds, anticlines, etc.	None mapped at the site	

Table 5-4
Seismic Conditions – Site CCK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Ground motion	MMI 7 Very Strong (Seattle and Southern Whidbey Island); MMI 6 Strong (Cascadia); MMI 5 Moderate (Tacoma)	
Fault rupture	Unlikely	
Liquefaction/lateral spread	Foundation and reservoir	Low
	Abutments and rim areas	Low
NEHRP site soil class	Foundation and reservoir	C to D
	Abutments and rim areas	C to D

5.1.10 Constructability

The following constructability issues would need to be considered and addressed as part of further evaluation of a potential storage project at the Site CCK2:

- **Access:** As noted in Section 5.1.4, there is currently no vehicle access to the site where the proposed embankment would be constructed to impound water. A DNR road is located approximately 500 feet west of where the embankment would be constructed, and the condition of the road is unknown. Construction of an access road suitable for construction and maintenance would be required.
- **Vegetation and Clearing:** Construction would require clearing of trees and other vegetation for access, for embankment construction, and in the area to be inundated by the reservoir.
- **Materials:** Materials would likely need to be imported to create the proposed embankment, which would be built over the existing ground to create a barrier across the narrow outlet of the valley where Cherry Lake is located. Availability of earthen materials, pipe, mechanical control equipment, and other materials would need to be verified.
- **Seasonal Complications:** Construction during the wet season (October through April) would require installation of controls to prevent erosion of bare surfaces and stockpiles and the discharge of sediment-laden water from the site. In addition, placement and compaction of materials will be affected by excessive moisture or freezing temperatures. Because this site is at a relatively low elevation, the seasonal complications will not be as great as they would be for sites at higher elevations where precipitation is greater and winter weather persists longer.

5.1.11 Opinion of Cost

A preliminary opinion of the probable costs associated with implementing the project at Site CCK2 was prepared as part of the screening analysis (based on July 2020 dollars). The opinion of probable costs was updated and refined as part of this more detailed analysis. The following assumptions were built into the opinion of probable costs:

- Costs include rough estimates of the quantities of work that would likely be required, including site work, construction of an earthen embankment, construction of piping and controls needed to release water from the reservoir, and construction of an emergency spillway to pass excess water from the reservoir.
- Costs include the following allowances:
  - 7.5% for mobilization and demobilization
  - 10% for environmental mitigation
  - 30% for contingency, to reflect uncertainties at this conceptual level of evaluation
  - 15% for engineering, permitting, and administration
  - 9.5% for sales tax
  - $20,000 per acre for land acquisition
- Refined costs are based on December 2021 dollars. Construction labor and materials prices have been extremely volatile since early 2020 and very difficult to accurate estimate at this time. Costs will change due to labor costs, the availability of materials, and materials costs at the time of project implementation.

An evaluation of potential annual operations and maintenance (O&M) costs was also completed to quantify costs associated with operating and maintaining a reservoir at Site CCK2. These costs were estimated based on O&M costs of facilities that are similar in size and scope. The costs assume salary and benefits for a government employee at a rate of 1/5 full-time equivalency (FTE), administrative costs, transportation costs, supplies, and maintenance, repairs, and contracted labor. Table 5-5 provides a summary of the opinion of probable implementation and long-term operating costs for the project. Additional detail is included in Appendix E.

Table 5-5
Opinion of Probable Implementation and O&M Costs, Site CCK2

Cost Item	Opinion of Probable Cost
Project Implementation Costs:	
Site Work	$571,800
Construction of Earthen Embankment	$440,600
Construction of Piping and Conveyance Facilities	$116,900
Construction of Emergency Overflow Spillway	$60,000
Construction Subtotal	**$1,189,000**
Mobilization and Demobilization (7.5%)	$89,175
Construction Total	**$1,278,000**
Environmental Mitigation (10%)	$127,800
Contingency (30%)	$383,400
Engineering, Permitting, and Administration (15%)	$191,700
Sales Tax (9.5%)	$169,974
Allowance for Land Acquisition	$513,328
Total Project Implementation Cost	**$2,664,000**
Annual O&M Costs:	
Salaries	$16,000
Benefits	$6,400
Administration	$1,600
Transportation	$1,600
Supplies	$1,300
Maintenance and Repairs	$1,300
Contracted Labor	$1,300
Total Annual O&M Costs	**$29,500**

Notes:
1. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
2. The subtotals and construction total are rounded to the nearest $1,000.
3. Costs are based on planning-level concept evaluation for the reservoir. Costs will vary as the concepts are evaluated in more detail and additional information becomes available to support project development.

5.2 Site NFT4: Snoqualmie Timber – NF Tolt (C)

5.2.1 Site Background

Site NFT4 is located in the North Fork Tolt subbasin in the northeastern part of the Snoqualmie River Watershed. The site is a large, gently sloping tract of timberland owned by Snoqualmie Timber, LLC. The Snoqualmie Timber, LLC parcels in the Snoqualmie River Watershed are managed for timber harvest by Campbell Global, LLC. The property is an actively managed tree farm and appears to have been logged within the last 20 to 30 years.

5.2.2 Landowner Coordination and Site Visit

The private forest manager, Campbell Global, LLC, was contacted to review this site and other sites under consideration for water storage projects that are managed by Campbell Global, LLC (Sites TOK2, Section 5.3; TOK3, Section 5.4; TOK4, Section 5.5; and NFK2, Section 5.6). Discussion specific to this property and other properties managed by Campbell Global, LLC, that are being evaluated in detail by this study primarily occurred during fall 2021. During a virtual meeting on September 24, 2021, SVWID and Anchor QEA provided a summary of the potential project to Mike March, the Campbell Global, LLC timber property manager in the Snoqualmie River Watershed. Notes from that meeting are included in Appendix D. Some of the primary concerns communicated by Mr. March regarding the proposed storage project include the following:

- **Loss of Harvestable Timber:** The property in question is managed by Campbell Global, LLC, as an active tree farm. The land is relatively flat, accessible, and very productive as a tree farm. Campbell Global, LLC, indicated that there is limited productive timber harvest property left in the Snoqualmie River Watershed, and they are generally not open to transfer or lease of actively managed timber harvest property for a reservoir or any other use that would limit their ability to harvest the property.
- **Liability:** Campbell Global, LLC, expressed similar concerns to those expressed by DNR that water storage could pose a risk to DNR infrastructure on the property in question and downstream property and infrastructure owned by others. Concerns were expressed regarding the potential for releases, spills, or even failure of the impoundment to cause damage to roads, culverts, and other infrastructure. There would need to be agreements in place for a storage project that would release Campbell Global, LLC, and their client, Snoqualmie Timber, LLC, from any liability associated with the reservoir and its operation.
- **Impacts to Natural Resources:** Campbell Global, LLC, also expressed concern about whether the project would impact fish, wildlife, and other resources.

Based on comments and discussion during the initial presentation and discussion, Mr. March agreed to conduct a site visit with Anchor QEA to three other sites they manage (Sites TOK2, Section 5.3; TOK3, Section 5.4; TOK4, Section 5.5), which are all existing lakes on timber property. However, the property manager reiterated that there is limited productive timber harvest property left in the Snoqualmie River Watershed, and they are generally not open to transfer or lease of actively managed timber harvest property for a reservoir or any other use that would reduce or limit their ability to harvest the property.

Due to the concerns and position communicated by Campbell Global, LLC's property manager relative to this potential project, a site visit was not completed.

The Snoqualmie Indian Tribe indicated that they are completing an acquisition of lands in the North Fork Tolt subbasin that are part of the Tribe's ancestral forestlands. They believe that the property considered as Site NFT4 is within the lands acquired. If so, this would change the limitations on the use of the land expressed by Campbell Global, LLC.

5.2.3 Proposed Storage Concept

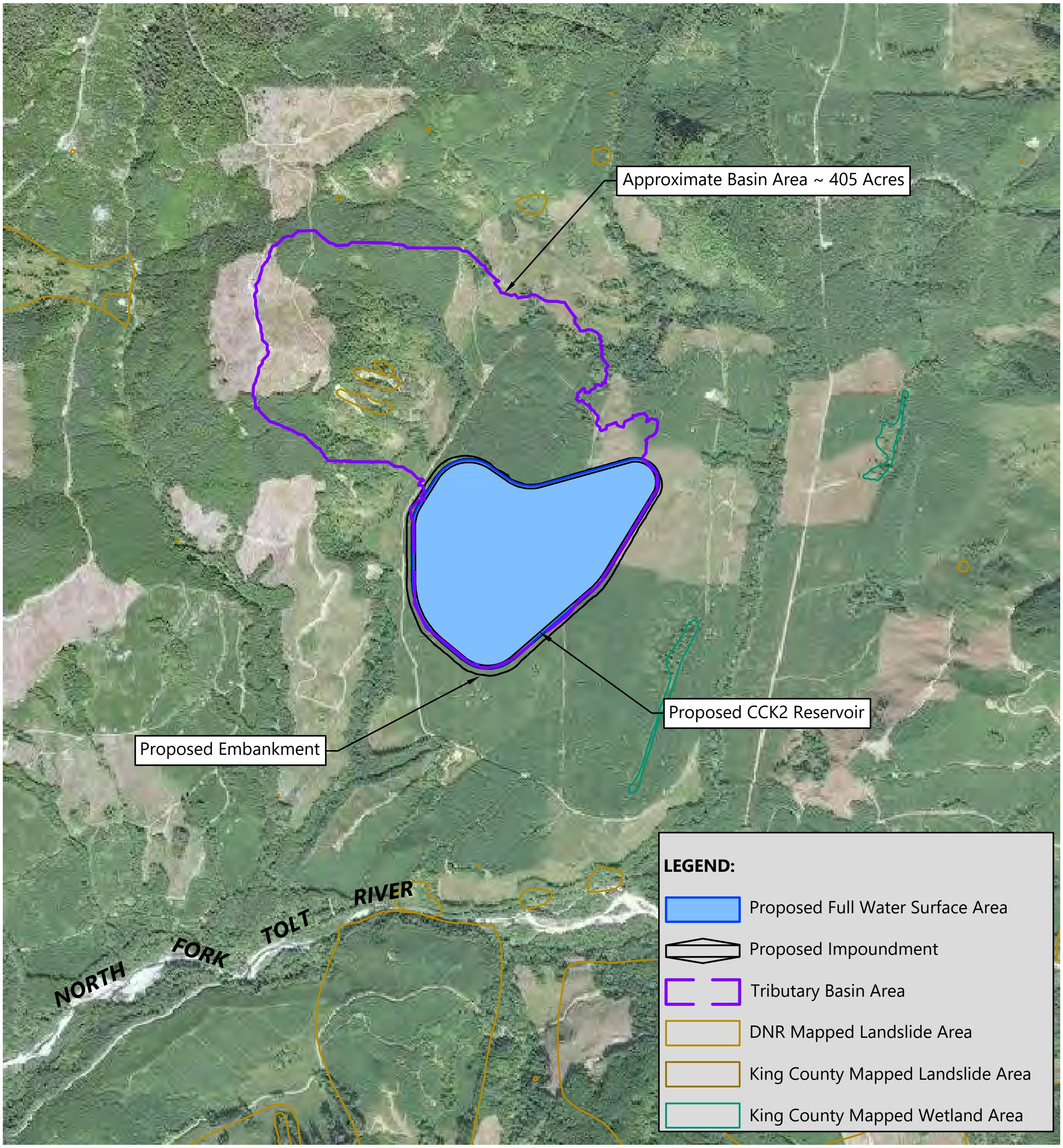
The proposed storage concept is to perform mass earthwork to construct a large impoundment to store water adjacent to Dry Creek and an unnamed tributary to the North Fork Tolt River. The proposed reservoir is shown relative to the basin that would be tributary to the point at which water would be diverted to the reservoir and areas upslope of the reservoir in Figure 5-2A. The embankment and reservoir are shown over LiDAR topography in Figure 5-2B.

Construction would likely be preceded by harvest of the timber and clearing within the relatively large project footprint. The impoundment would be approximately 10 feet deep and would store water to a maximum WSEL of 1,808 feet. The proposed reservoir would inundate approximately 134 acres when full. A diversion would be established on the unnamed tributary west of the site to supply water, and water would be released through a pipeline or other constructed conveyance down the unnamed tributary to the North Fork Tolt River.

5.2.4 Site Access and Constraints

Access to Site NFT4 is remote but there are several well-established logging roads that would make access to the site for construction and reservoir operations relatively easy. NFD 410 Road runs along the west and south sides of the proposed location; approximately 6 miles of forest roads connect the proposed location to the Tolt River South Fork Road.

The primary constraint at this site is the presence of the actively managed tree farm. As noted previously, the property manager is not currently interested in exploring a storage project that would result in loss of productive, harvestable tree farm. Other constraints may include availability of water to fill a reservoir of this size, and ability to release water without overwhelming the downstream tributary to the North Fork Tolt River.



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88

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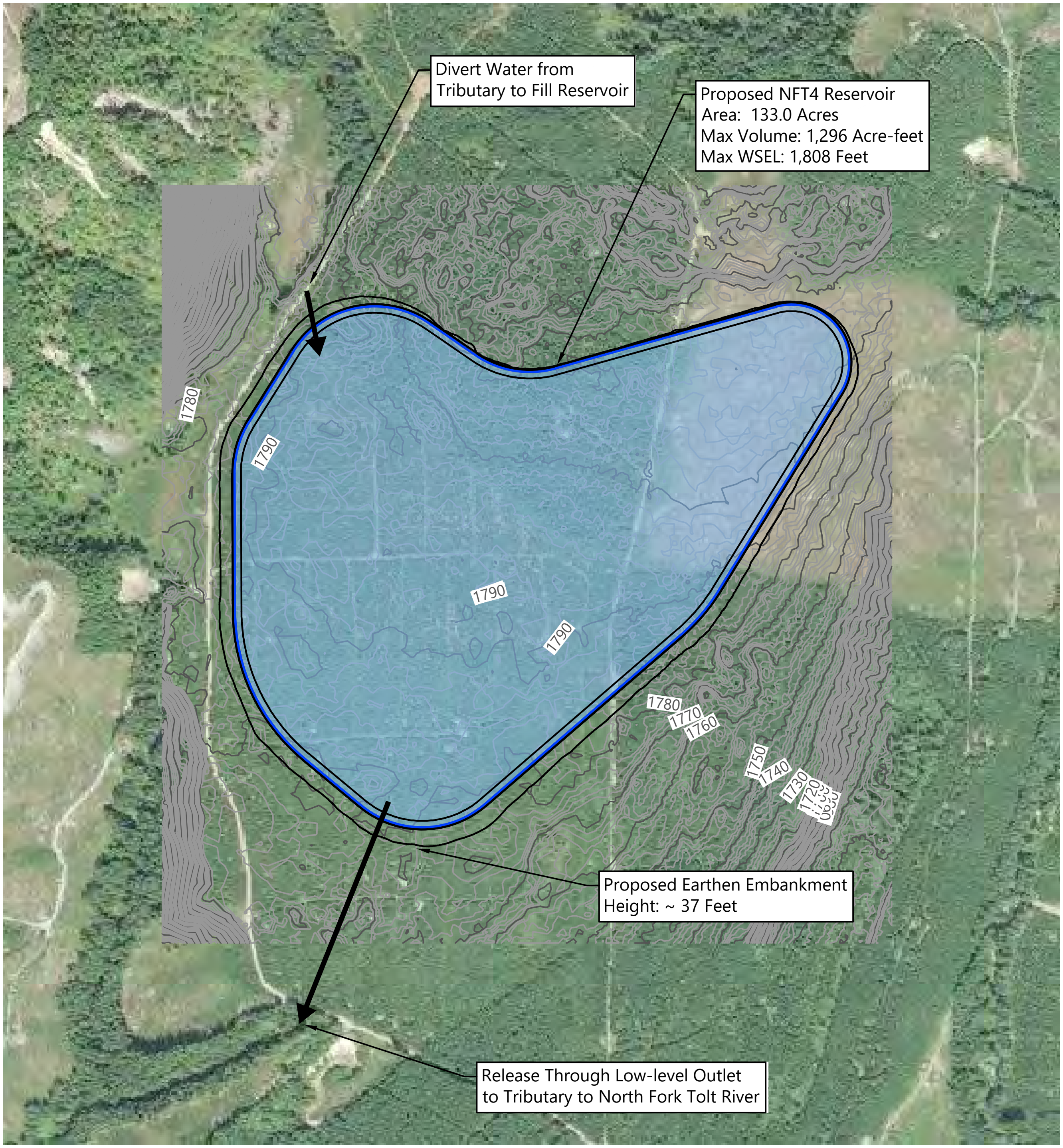
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site NFT4.dwg Figure 5-2A

ANCHOR QEA

Figure 5-2A
Tributary Basin Area Map - Storage Site NFT4

Snoqualmie Watershed
Comprehensive Storage Study



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HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

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Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site NFT4.dwg Figure 5-2B

ANCHOR QEA

Figure 5-2B
Site Map - Storage Site NFT4

Snoqualmie Watershed
Comprehensive Storage Study

5.2.5 *Source of Stored Water*

The proposed reservoir at Site NFT4 would be filled by diverting water from the unnamed tributary to the North Fork Tolt River that runs along the west edge of the proposed reservoir site. The tributary drains areas upstream (north and west) of the proposed reservoir site. LiDAR data were used in Arc GIS to delineate the tributary basin that flows to the unnamed tributary north and west of the proposed reservoir site. The area of the tributary basin was estimated to be approximately 405 acres (0.63 square mile).

5.2.6 *Hydrologic and Hydraulic Analyses*

A WWHM hydrologic model was prepared to model the rate and volume of runoff that could be captured in the adjacent tributary and diverted to the reservoir at Site NFT4 for storage. For the period of record modeled (Water Years 1949 to 2009), the estimated average annual runoff volume that could be captured at a diversion point on the adjacent tributary or from areas upslope of the proposed reservoir at Site NFT4 was estimated to be 924 acre-feet. The annual runoff volume was estimated to range from 597 to 1,483 acre-feet.

A stage-storage volume curve was also developed in AutoCAD Civil 3D for the reservoir based on the configuration of the proposed embankment and grading of the impounded area. The stage-storage volume curve is plotted in Figure 5-2C. The stage is represented in feet of elevation related to the storage volume in acre-feet of storage. As shown, the full reservoir would store 1,296 acre-feet at an elevation of 1,808 feet.

5.2.7 *Reservoir Operations*

The runoff volumes from the WWHM model were used, along with estimated evaporation rates and the estimated stage-storage volume curve, to develop a reservoir operations and water balance model. The purpose of the model was to estimate when flows would be captured and released from the reservoir at Site NFT4, and to estimate the probability of refill given hydrology of the tributary basin and the targeted size and storage capacity of the reservoir. This model estimated the inflows and outflows from the proposed reservoir at Site NFT4 on a monthly basis for the 61-year modeling period of record. Outflows include evaporation and reservoir release to the unnamed tributary of the North Fork Tolt River. The water balance model was adjusted to determine potential release rates during the late summer as an example of how a reservoir at Site NFT4 could be operated to augment flows in the North Fork Tolt River. Table 5-6 summarizes findings from the water balance model for Site NFT4.

Figure 5-2C
Stage-Storage Curve – Storage Site NFT4

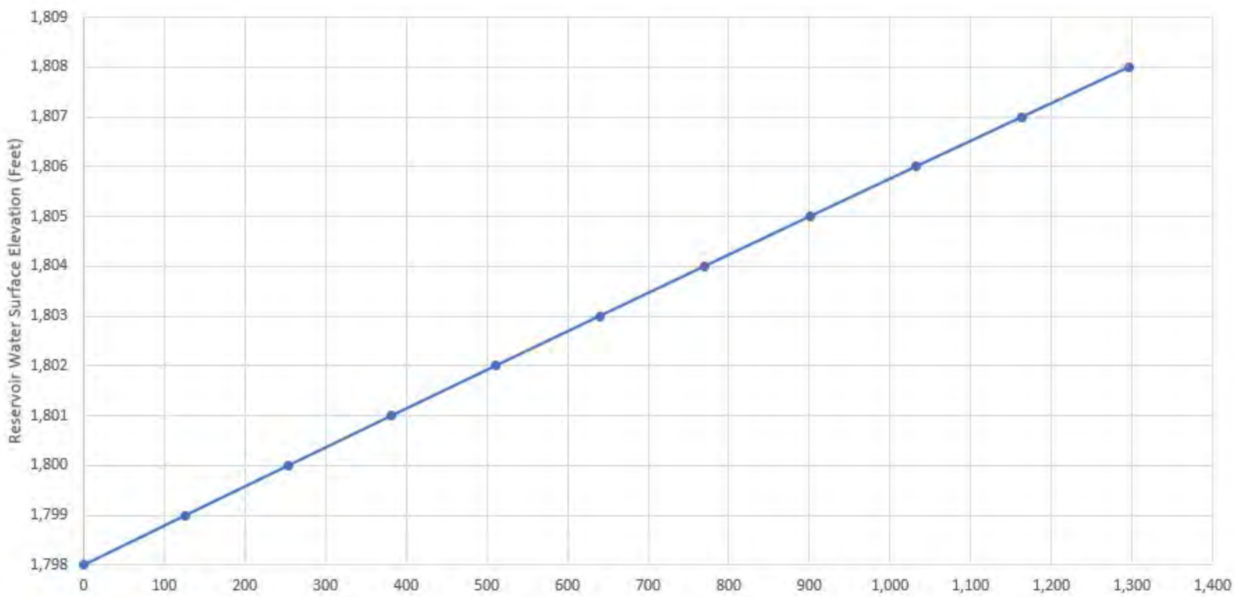


Table 5-6
Water Balance Model Results – Site NFT4

Parameter Evaluated	Result
Targeted Capacity	1,296 acre-feet
Area of Tributary Basin	405 acres
Average Annual Runoff	924 acre-feet
Maximum Annual Runoff	1,483 acre-feet
Minimum Annual Runoff	597 acre-feet
Average Late-Summer Release Rate Available	12 cfs
Average Days Release Available in Late Summer	26.1 days
Average % of Targeted Reservoir Volume Filled	58.4%
Maximum % of Targeted Reservoir Volume Filled	99.4%

Based on inflows to the proposed reservoir, the size of the reservoir that was targeted, and other assumed inputs used for the water balance model, the model indicates that there would not be enough flow in the adjacent tributary and upslope of the reservoir to completely fill a reservoir of this size, even during very wet years. The reservoir would mostly fill during the wettest year that was evaluated. During average and drier than average years, the reservoir would not refill. Based on the results from the water balance model, 12 cfs could be released from the reservoir for an average of

26.1 days during late-summer months to increase streamflow in the North Fork Tolt River. If this project were to be advanced for further analysis, smaller storage capacities would need to be evaluated to balance the size of the impoundment, storage capacity, and cost of the reservoir with the volume of runoff volume that can reliably be captured and stored in the reservoir.

5.2.8 Water Quality Impacts

Section 5.1.8 provided a general overview of potential water quality impacts that could result from construction of any reservoir with the Snoqualmie River Watershed. The potential impacts include increased temperature in the downstream streams and rivers caused by warming of water in the reservoir; degraded water quality conditions resulting from nutrient loading, algae growth, and a decrease in DO at the bottom of the reservoir; and accrual and release of toxic contaminants.

Considering the potential for these impacts, the following key characteristics that may influence water quality were noted for the proposed reservoir at Site NFT4:

- The reservoir elevation (full WSEL ~1,808 feet) would be high in the watershed relative to the other six sites, which would likely mean capture and storage of cooler water and cooler ambient temperatures in the summer.
- The reservoir would be relatively shallow compared to the other six reservoirs and would have a relatively large surface area.
- The reservoir would be created by clearing a large area and would have little potential for shading of the water surface.
- The reservoir does not appear to be downstream of any fertilized areas where high nutrient loading would be expected.
- The reservoir does not appear to be downstream of any sources of toxic contaminants.

Based on these key characteristics and observations, the following are anticipated relative to water quality impacts and potential ways to mitigate for those impacts through design and operation:

- Temperature could be impacted by water storage, largely due to the large surface area and relatively shallow depth of the reservoir targeted for this area. If a reservoir at this site were developed further, an evaluation of potential reservoir configurations would need to be completed to evaluate whether a deeper reservoir with less surface area would be feasible to minimize impacts on water temperatures. The temperature of stored water and releases could also be monitored, and a multi-port outlet could be provided to allow for releases from the coolest part of the reservoir. Additional analysis, including water quality modeling and research of water quality in similar nearby lakes, would be needed to better understand potential impacts to water temperature.
- Degradation of water quality due to nutrient loading, toxic algal blooms, and low DO concentrations is not anticipated to be any greater than they would be through any other

similarly sized natural lake in the system. However, additional analysis would be required to better understand the potential for nutrient impacts, algae growth, and reduced DO concentrations. Aeration or management techniques, such as planting of vegetation to discourage waterfowl from adding nutrients to the reservoir, could be considered.

- No release of toxics or contamination in stored water is anticipated.

5.2.9 Non-Exploratory Soils and Geology

The primary soil and geology conditions to consider for Site NFT4 are the high hydraulic conductivity of near-surface soils and the thick deposits of unconsolidated lithology. Geology at the site is mapped as recessional outwash deposits of the Vashon Stade of the Fraser glaciation, consisting of stratified sand and gravel, moderately to well sorted, and well-bedded silty sand to silty clay deposited in proglacial and ice-marginal environments.

The primary geologic hazard to consider in planning and development are nearby landslide (Qls) and mass wastage (Qmw) deposits that abut the north and west sides of the site.

The primary seismic hazard is Moderate (MMI 5) to Very Strong (MMI 7) ground shaking as modeled during southern Whidbey Island, Seattle, Tacoma, and Cascadia events. The soils and rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density. Summaries of soil, geologic, and seismic conditions are included in Tables 5-7 to 5-9.

Table 5-7
Soil Conditions – Site NFT4

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped soil unit(s)	Foundation and reservoir	237—Skykomish gravelly sandy loam, 0% to 30% slopes
	Abutments and rim areas	
Soil Conditions:		
USCS	Foundation and reservoir	SM – Silty Sand
	Abutments and rim areas	
Depth to water table	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Capacity of the most limiting layer to transmit water (K_{sat})	Foundation and reservoir	High (1.98 to 5.95 inches/hour)
	Abutments and rim areas	
Drainage class	Foundation and reservoir	Somewhat excessively drained
	Abutments and rim areas	
Depth to any soil restrictive layer	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Suitability:		
Pond reservoir areas	Very limited	Seepage, slope

Table 5-8
Geologic Conditions – Site NFT4

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped geologic unit(s)	Foundation and reservoir	Pleistocene recessional outwash deposits (Qvr)
	Abutments and rim areas	
Slope Stability:		
Landslides and existing slope movements	North side abuts rock avalanche deposits (Qls) and the west side abuts mass wastage deposits (Qmw) derived from the steep slope marine sandstone and argillite (TKwa) bedrock	
Structures:		
Potentially active faults	None mapped at the site	
Folds, anticlines, etc.	None mapped at the site	

Table 5-9
Seismic Conditions – Site NFT4

Conditions Researched	Applicability	Anticipated Geology or Conditions
Ground motion	MMI 7 Very Strong (Southern Whidbey Island); MMI 6 Strong (Seattle and Cascadia); MMI 5 Moderate (Tacoma)	
Fault rupture	Unlikely	
Liquefaction/lateral spread	Foundation and reservoir	Low
	Abutments and rim areas	Low
NEHRP site soil class	Foundation and reservoir	C to D
	Abutments and rim areas	C to D

5.2.10 Constructability

The following constructability issues would need to be considered and addressed as part of further evaluation of a potential storage project at Site NFT4:

- **Access:** As noted in Section 5.2.4, there is access directly to the site via forest roads. The condition of these roads is unknown, and the site is relatively remote, so the distance from the nearest paved road may be more than 6 miles. Transport of materials over these roads may be challenging and may require some maintenance.
- **Vegetation and Clearing:** Construction would require clearing of trees and other vegetation for embankment construction and in the area to be inundated by the reservoir. The portions of the tree farm that would be impacted by the reservoir would likely need to be harvested prior to construction of the reservoir.
- **Materials:** Reservoir construction would require substantial earthwork. The intent is that the excavation and fill amounts would be balanced such that only import of very specific materials, such as lining material and sands, would be required. However, a full geotechnical exploration and evaluation would be required to determine subsurface soil characteristics and evaluate the potential for sourcing embankment materials from the site. Availability of imported aggregate materials, liner material, pipe, mechanical control equipment, and other materials would need to be verified.
- **Seasonal Complications:** Construction during the wet season (October through April) would require installation of controls to prevent erosion of bare surfaces and stockpiles and the discharge of sediment-laden water from the site. In addition, placement and compaction of materials will be affected by excessive moisture or freezing temperatures. Because this site is at higher elevation, the seasonal complications may be more significant than they would be at lower sites where precipitation is less and winter weather does not last as long.

5.2.11 Opinion of Cost

A preliminary opinion of the probable costs associated with implementing the project at Site NFT4 was prepared as part of the screening analysis (based on July 2020 dollars). The opinion of probable costs was updated and refined as part of this more detailed analysis according to the assumptions and with the allowances noted for Site CCK2 in Section 5.1.11.

An evaluation of potential annual O&M costs was also completed in an effort to quantify costs associated with operating and maintaining a reservoir at Site NFT4. These costs were estimated based on O&M costs of facilities that are similar in size and scope. The costs assume salary and benefits for a government employee at a rate of 1/4 FTE, administrative costs, transportation costs, supplies, and maintenance, repairs, and contracted labor. Table 5-10 provides a summary of the opinion of probable implementation and long-term operating costs for the project. Additional detail is included in Appendix E.

Table 5-10
Opinion of Probable Implementation and O&M Costs, Site NFT4

Cost Item	Opinion of Probable Cost
Project Implementation Costs	
Site Work	$3,513,300
Construction of Earthen Embankment	$16,011,300
Construction of Piping and Conveyance Facilities	$873,500
Construction of Emergency Overflow Spillway	$180,000
Construction Subtotal	**$20,578,000**
Mobilization and Demobilization (7.5%)	$1,543,350
Construction Total	**$22,121,000**
Environmental Mitigation (10%)	$2,212,100
Contingency (30%)	$6,636,300
Engineering, Permitting, and Administration (15%)	$3,318,150
Sales Tax (9.5%)	$2,942,093
Allowance for Land Acquisition	$3,227,234
Total Project Implementation Cost	**$40,457,000**
Annual O&M Costs:	
Salaries	$20,000
Benefits	$8,000
Administration	$2,000
Transportation	$2,000
Supplies	$22,200
Maintenance and Repairs	$22,200
Contracted Labor	$22,200
Total Annual O&M Costs	**$98,600**

Notes:
1. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
2. The subtotals and construction total are rounded to the nearest $1,000.
3. Costs are based on planning-level concept evaluation for the reservoir. Costs will vary as the concepts are evaluated in more detail and additional information becomes available to support project development.

5.3 Site TOK2: Bridges Lake

5.3.1 Site Background

Site TOK2 (Bridges Lake) is the highest in a chain of lakes located on private timberland in the Tokul Creek subbasin in the central part of the Snoqualmie River Watershed. The site is an existing lake surrounded by timberland owned by Snoqualmie Timber, LLC. The Snoqualmie Timber, LLC parcels in the Snoqualmie River Watershed are managed for timber harvest by Campbell Global, LLC. The property surrounding the lake is an actively managed tree farm with nearby tracts that have recently been or are currently being harvested.

5.3.2 Landowner Coordination and Site Visit

As noted in Section 5.2.2, Campbell Global, LLC, was contacted to review this site and other sites under consideration for water storage projects that are managed by Campbell Global, LLC (Sites NFT4, Section 5.2; TOK3, Section 5.4; TOK4, Section 5.5; and NFK2, Section 5.6). Discussion specific to Site TOK2 and other properties managed by Campbell Global, LLC, that are being evaluated in detail by this study primarily occurred during fall 2021. During a virtual meeting on September 24, 2021, SVWID and Anchor QEA provided a summary of the potential project to Mike March, the Campbell Global, LLC timber property manager in the Snoqualmie River Watershed. Notes from that meeting are included in Appendix D. The concerns outlined by Campbell Global, LLC, regarding development of water storage on properties they manage are outlined in Section 5.2.2. Concerns applicable to this property are as follows:

- **Loss of Harvestable Timber:** The property surrounding Bridges Lake is managed by Campbell Global, LLC, as an active tree farm. Campbell Global, LLC, indicated that they are required to maintain a buffer (not harvest) around waterbodies, including Bridges Lake. That buffer would likely expand if the lake level were raised, which would increase the buffer and reduce the area from which they can harvest timber. If use of the lake was allowed for water storage, negotiations would need to include compensation for lost of harvestable timber.
- **Liability:** The general concerns outlined in Section 5.2.2. would apply.
- **Impacts to Natural Resources:** The general concerns outlined in Section 5.2.2 would apply.

Based on comments and discussion during the initial presentation and discussion, Mr. March agreed to conduct a site visit with Anchor QEA to this site and two other sites they manage (TOK2, Section 5.3; TOK4, Section 5.5), which are all existing lakes on timber property in the Tokul Creek subbasin. Notes and photographs from the site visit are included in Appendix D.

5.3.3 Proposed Storage Concept

The proposed storage concept for Site TOK2 is to construct a control structure at the outlet of Bridges Lake to allow additional water to be stored in the lake. The proposed lake is shown relative to the basin that would be tributary to the reservoir in Figure 5-3A. The modifications at the lake outlet and proposed lake footprint are shown over LiDAR topography in Figure 5-3B.

The outlet structure on Bridges Lake would likely be a reinforced concrete structure with automatic gates and stop logs that would be operated to raise the maximum WSEL in the lake by approximately 2 feet to elevation 1,061 feet. When full, the lake would inundate an additional 7.8 acres of area surrounding Bridges Lake (increasing the full water surface from approximately 40.0 acres to 47.8 acres). The outlet structure would control releases to an unnamed tributary that discharges to Ten Creek downstream of the lake.

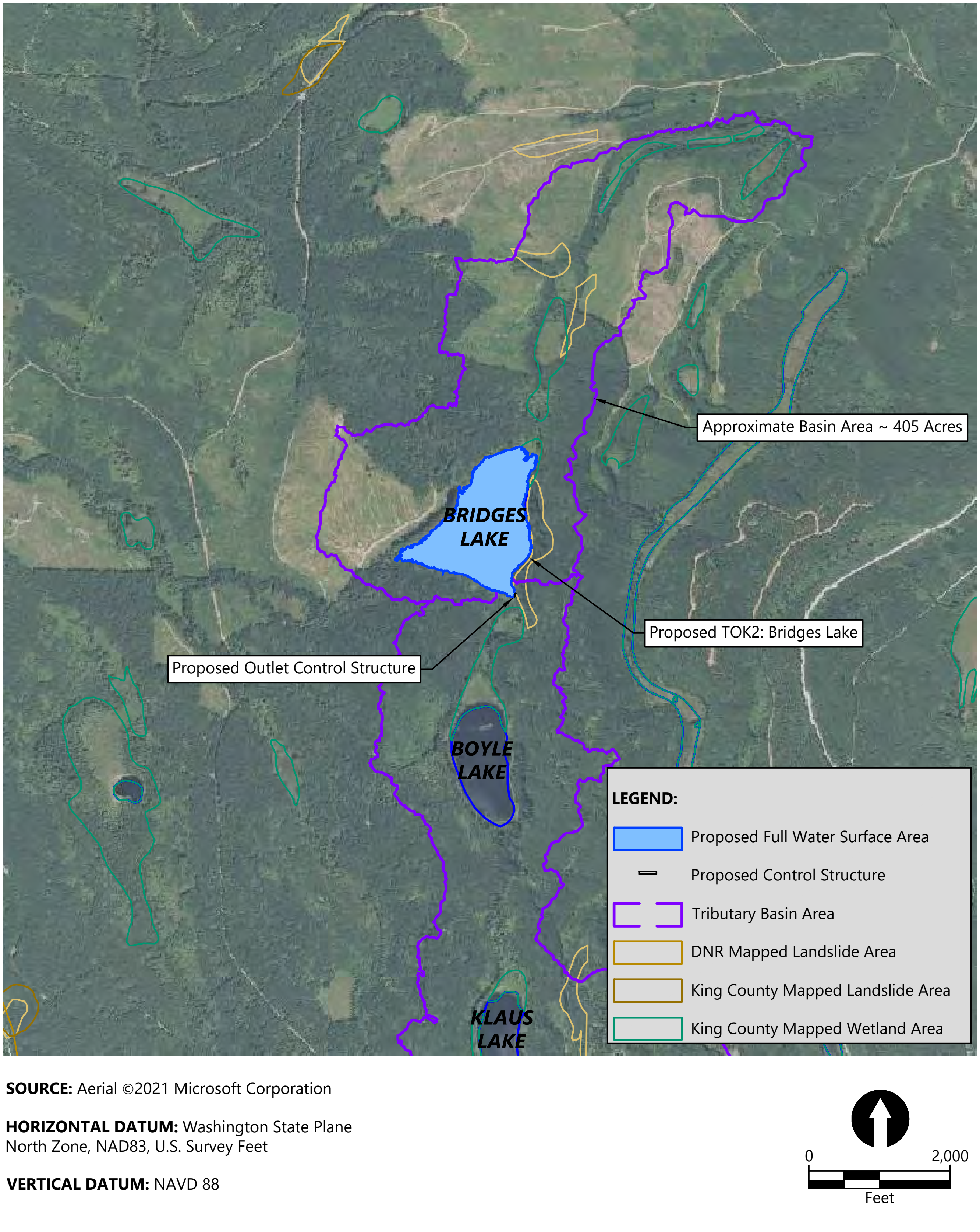
5.3.4 Site Access and Constraints

There are logging roads near Bridges Lake that pass within less than 1/4 mile of the lake, but the shoreline and outlet of the lake can only currently be accessed by foot through heavily wooded slopes. Forest roads are located east and west of the lake. These roads connect to the Tolt Reservoir Road more than 3 miles northeast of the lake.

The primary constraints at this site are the presence of actively managed tree farms that surround the lake, heavily forested buffers adjacent to the lake, and wetland areas adjacent to the lake.

5.3.5 Source of Stored Water

Bridges Lake captures runoff that naturally drains to the lake from areas upstream (north) of the lake. LiDAR data were used in ArcGIS to delineate the tributary basin that flows to the unnamed tributary north and west of the proposed reservoir site. The area of the tributary basin was estimated to be approximately 429 acres (0.67 square mile).



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HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88

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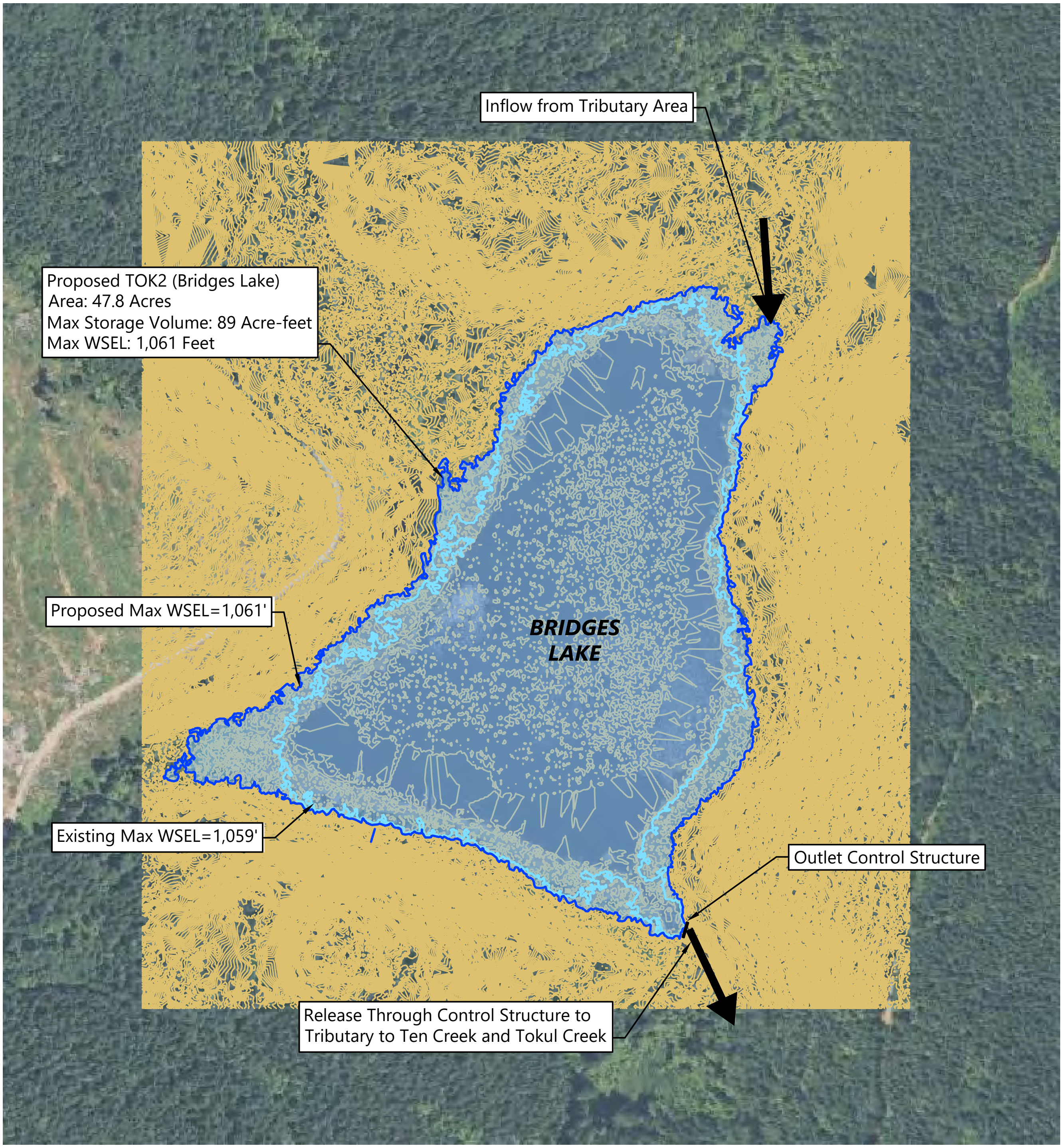
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site TOK2.dwg Figure 5-3A

ANCHOR QEA

Figure 5-3A
Tributary Basin Area Map - Storage Site TOK2

Snoqualmie Watershed
Comprehensive Storage Study



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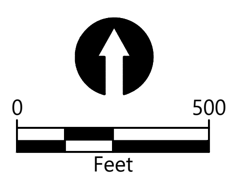
HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88



Publish Date: 2022/01/12 5:30 PM | User: drice
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site TOK2.dwg Figure 5-3B

ANCHOR QEA

Figure 5-3B
Site Map - Storage Site TOK2

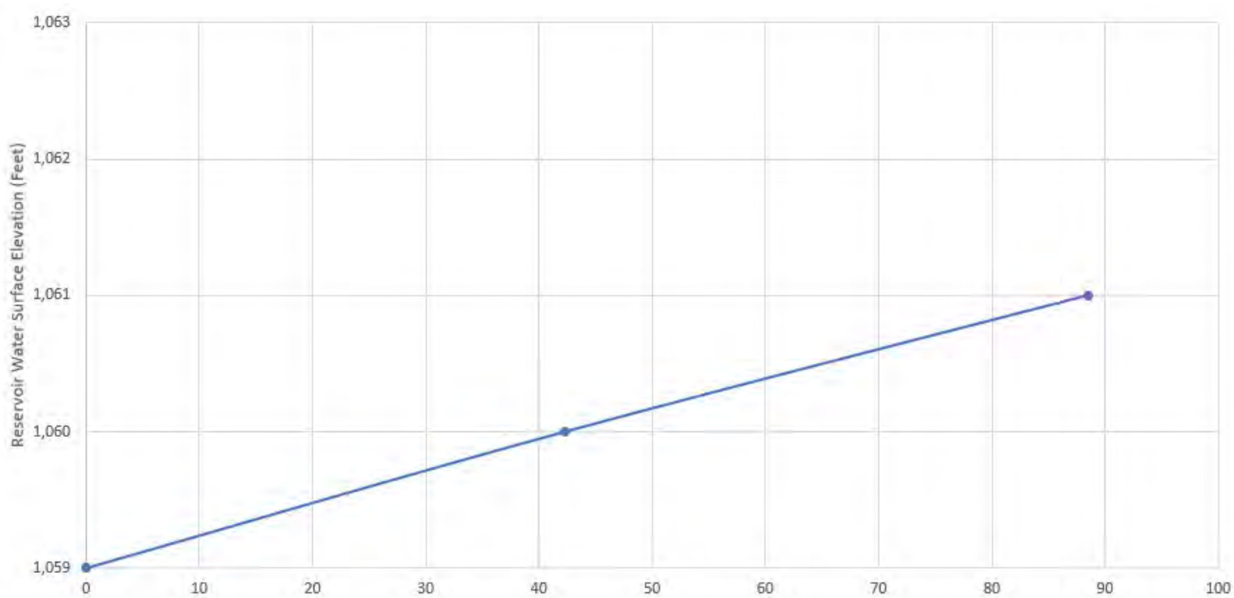
Snoqualmie Watershed
Comprehensive Storage Study

5.3.6 Hydrologic and Hydraulic Analyses

A WWHM hydrologic model was prepared to model the rate and volume of runoff that flows to Bridges Lake. For the period of record modeled (Water Years 1949 to 2009), the average annual runoff volume that drains to the Bridges Lake from the tributary area was estimated to be 229 acre-feet. The annual runoff volume was estimated to range from 139 to 404 acre-feet.

A stage-storage volume curve was also developed for the additional storage that would be created and managed in the lake at Site TOK2, based on installation of a structure that would raise the water level an additional 2 feet in elevation and manage that top 2 feet as water storage. The stage-storage volume curve is plotted in Figure 5-3C. The stage is represented in feet of elevation related to the storage volume in acre-feet of storage. As shown, the full reservoir would store 89 acre-feet of water in Bridges Lake that could be managed and released to support instream flows and create offset for out-of-stream uses to a maximum elevation of 1,059 feet.

Figure 5-3C
Stage-Storage Curve – Storage Site TOK2



5.3.7 Reservoir Operations

The runoff volumes from the WWHM model were used, along with estimated evaporation rates and the estimated stage-storage volume curve, to develop a reservoir operations and water balance model. This model estimated the inflows and outflows from Bridges Lake on a monthly basis for the 61-year modeling period of record. Outflows include evaporation and reservoir release to the unnamed tributary off of Ten Creek. The water balance model was adjusted to determine potential release rates during the late summer as an example of how the additional storage in Bridges Lake could be operated to augment flows in the tributary and downstream through Ten Creek to Tokul Creek. Table 5-11 summarizes findings from the water balance model for Bridges Lake.

Table 5-11
Water Balance Model Results – Site TOK2

Parameter Evaluated	Result
Targeted Capacity	89 acre-feet
Area of Tributary Basin	429 acres
Average Annual Runoff	229 acre-feet
Maximum Annual Runoff	404 acre-feet
Minimum Annual Runoff	139 acre-feet
Targeted Flow Through Rate (Base Flow)	0.2 cfs
Average Late-Summer Release Rate Available	0.6 cfs
Average Days Release Available in Late Summer	7.8 days
Average % of Targeted Reservoir Volume Filled	81.3%
Maximum % of Targeted Reservoir Volume Filled	100.0%

The analysis assumes that a constant base flow of 0.2 cfs would be routed through the outlet structure to maintain flows in the tributary downstream of Site TOK2. Based on the additional volume of storage, inflows to the reservoir, and assumed releases from the reservoir, the lake would fill to the maximum targeted water surface during wet years and would mostly fill during dry years. However, the volume stored would not sustain a very large increase in outflow during the late summer, and the duration of the increased outflow would be limited. Based on the results from the water balance model, 0.6 cfs could be released for an average of 7.8 days during late-summer months to increase streamflow in Ten Creek and Tokul Creek. It may be difficult to maintain additional lake storage through late summer. The lake may refill in the spring, but by the late summer, a portion of the water stored in the top 2 feet will be lost via base flows routed through the lake (assumed to be 0.2 cfs), evaporation, and other losses, leaving less storage volume available for release during the late summer.

5.3.8 Water Quality Impacts

Section 5.1.8 provided a general overview of potential water quality impacts that could result from construction of any reservoir with the Snoqualmie River Watershed. The potential impacts include increased temperature in the downstream streams and rivers caused by warming of water in the reservoir, streams, and rivers; degraded water quality conditions resulting from nutrient loading, algae growth, and a decrease in DO at the bottom of the reservoir; and accrual and release of toxic contaminants.

Considering the potential for these impacts, the following key characteristics that may influence water quality were noted for the proposed modifications to Bridges Lake:

- Bridges Lake (full WSEL ~1,061 feet) is at a moderate elevation in the watershed relative to the other six sites.
- The lake has a relatively large surface area.
- The lake is an existing lake with already existing water storage.
- The lake does not appear to be downstream of any fertilized areas where high nutrient loading would be expected.
- The lake does not appear to be downstream of any sources of toxic contaminants.

Based on these key characteristics and observations, the following are anticipated relative to water quality impacts and potential ways to mitigate for those impacts through design and operation:

- Because the lake is existing and currently releases water to downstream tributaries, very little, if any, impact to water temperature is anticipated. The increase in water surface would be very small, and the overall seasonal changes in lake temperature would persist from what currently occurs at the lake.
- Degradation of water quality due to nutrient loading, toxic algal blooms, and low DO concentrations is not anticipated to be any greater than what currently exists at the lake. No new nutrients or conditions would be introduced to cause additional water quality issues.
- No release of toxics or contamination of stored water is anticipated.

5.3.9 Non-Exploratory Soils and Geology

The primary soil and geology conditions to consider at Site TOK2 are the moderately high to high hydraulic conductivity of near-surface soils and the thick deposits of unconsolidated lithology. Geology at the site is mapped as recessional outwash deposits of the Vashon Stade of Fraser glaciation, consisting of stratified sand and gravel, moderately to well sorted, and well-bedded silty sand to silty clay deposited in proglacial and ice-marginal environments.

The primary geologic hazards to consider in planning and development are the nearby landslide (Qls) deposits and steep slopes that abut the east sides of the site.

The primary seismic hazard is Strong (MMI 6) to Very Strong (MMI 7) ground shaking as modeled during southern Whidbey Island, Seattle, Tacoma, and Cascadia events. The soils and rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density. Summaries of soil, geologic, and seismic conditions are included in Tables 5-12 to 5-14.

Table 5-12
Soil Conditions – Site TOK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped soil unit(s)	Foundation and reservoir	231—Seattle muck, 0% to 1% slopes
	Abutments and rim areas	
Soil Conditions		
USCS	Foundation and reservoir	PT – Peat
	Abutments and rim areas	
Depth to water table	Foundation and reservoir	About 0 inches
	Abutments and rim areas	
Capacity of the most limiting layer to transmit water (Ksat)	Foundation and reservoir	Moderately high to high (0.57 to 1.98 inches/hour)
	Abutments and rim areas	
Drainage class	Foundation and reservoir	Very poorly drained
	Abutments and rim areas	
Depth to any soil restrictive layer	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Suitability		
Pond reservoir areas	Somewhat limited	Seepage

Table 5-13
Geologic Conditions – Site TOK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped geologic unit(s)	Foundation and reservoir	Pleistocene recessional outwash deposits (Qvr)
	Abutments and rim areas	
Slope Stability		
Landslides and existing slope movements	East side abuts mapped Quaternary mass wasting (Qls) deposits and potential steep slope hazard areas (> 40%)	
Structures		
Potentially active faults	None mapped at the site	
Folds, anticlines, etc.	None mapped at the site	

Table 5-14
Seismic Conditions – Site TOK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Ground motion	MMI 7 Very Strong (Seattle); MMI 6 Strong (Tacoma, Southern Whidbey Island, and Cascadia)	
Fault rupture	Unlikely	
Liquefaction/lateral spread	Foundation and reservoir	Low
	Abutments and rim areas	Low
NEHRP site soil class	Foundation and reservoir	C to D
	Abutments and rim areas	C to D

5.3.10 Constructability

The following constructability issues would need to be considered and addressed as part of further evaluation of a potential storage project at Bridges Lake:

- **Access:** As noted in Section 5.3.4, there is currently no vehicle access to the lake outlet or shoreline. Construction of an access road suitable for construction and maintenance would be required through forested, relatively steep terrain to the lake outlet.
- **Vegetation and Clearing:** Construction would require limited clearing of trees and other vegetation for access and construction of the outlet structure. The portions of the tree farm that would be impacted by construction of reservoir access would likely need to be harvested prior to construction of the reservoir.
- **Materials:** Concrete and other materials would need to be transported to the site to create the outlet structure. Delivery of concrete to the site would require suitable access. Availability of concrete, mechanical control equipment, and other materials would need to be verified.
- **Seasonal Complications:** Construction during the wet season (October through April) would require installation of controls to prevent erosion of bare surfaces and stockpiles and the discharge of sediment-laden water from the site. In addition, placement and compaction of materials will be affected by excessive moisture or freezing temperatures. Because this site is at moderate elevation, the seasonal complications may be more significant than they would be at lower sites where precipitation is less and winter weather does not last as long.

5.3.11 Opinion of Cost

A preliminary opinion of the probable costs associated with implementing the project at Site TOK2 was prepared as part of the screening analysis (based on July 2020 dollars). The opinion of probable costs was updated and refined as part of this more detailed analysis according to the assumptions and with the allowances noted for Site CCK2 in Section 5.1.11.

An evaluation of potential annual O&M costs was also completed to quantify costs associated with operating and maintaining modifications to the outlet and managing storage at Site TOK2. These costs were estimated based on O&M costs of facilities that are similar in size and scope. The costs assume salary and benefits for a government employee at a rate of 1/8 FTE, administrative costs, transportation costs, supplies, and maintenance, repairs, and contracted labor. Table 5-15 provides a summary of the opinion of probable implementation and long-term operating costs for the project. Additional detail is included in Appendix E.

Table 5-15
Opinion of Probable Implementation and O&M Costs, Site TOK2

Cost Item	Opinion of Probable Cost
Project Implementation Costs	
Site Work	$769,600
Construction of Earthen Embankment	$0
Construction of Piping and Conveyance Facilities	$244,000
Construction of Emergency Overflow Spillway	$30,000
Construction Subtotal	**$1,044,000**
Mobilization and Demobilization (7.5%)	$78,300
Construction Total	**$1,122,000**
Environmental Mitigation (10%)	$112,200
Contingency (30%)	$336,600
Engineering, Permitting, and Administration (15%)	$168,300
Sales Tax (9.5%)	$149,226
Allowance for Land Acquisition	$164,794
Total Project Implementation Cost	**$2,053,000**
Annual O&M Costs:	
Salaries	$10,000
Benefits	$4,000
Administration	$1,000
Transportation	$1,000
Supplies	$1,200
Maintenance and Repairs	$1,200
Contracted Labor	$1,200
Total Annual O&M Costs	**$19,600**

Notes:

1. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
2. The subtotals and construction total are rounded to the nearest $1,000.
3. Costs are based on planning-level concept evaluation for the reservoir. Costs will vary as the concepts are evaluated in more detail and additional information becomes available to support project development.

5.4 Site TOK3: Klaus Lake

5.4.1 Site Background

Site TOK3 (Klaus Lake) is the lowest in a chain of lakes located on private timberland in the Tokul Creek subbasin in the central part of the Snoqualmie River Watershed. The site is an existing small lake surrounded by timberland owned by Campbell Global, LLC. As noted earlier, the Snoqualmie Timber, LLC parcels in the Snoqualmie River Watershed are managed for timber harvest by Campbell Global, LLC. The property surrounding the lake is an actively managed tree farm with nearby tracts that have recently been or are currently being harvested.

5.4.2 Landowner Coordination and Site Visit

As noted in Section 5.2.2, Campbell Global, LLC, was contacted to review this site and other sites under consideration for water storage projects that are managed by Campbell Global, LLC (Sites NFT4, Section 5.2; TOK2, Section 5.3; TOK4, Section 5.5; and NFK2, Section 5.6). Discussion specific to Site TOK3 and other properties managed by Campbell Global, LLC, that are being evaluated in detail primarily occurred during fall 2021. During a virtual meeting on September 24, 2021, SVWID and Anchor QEA provided a summary of the potential project to Mike March, the Campbell Global, LLC timber property manager in the Snoqualmie River Watershed. Notes from that meeting are included in Appendix D. The concerns outlined by Campbell Global, LLC, regarding development of water storage on properties they manage are outlined in Section 5.2.2. Concerns applicable to this property are as follows:

- **Loss of Harvestable Timber:** The property surrounding Klaus Lake is managed by Campbell Global, LLC, as an active tree farm. Campbell Global, LLC, indicated that they are required to maintain a buffer (not harvested) around waterbodies, including Klaus Lake. That buffer would likely expand if the lake level were raised, which would reduce the area from which they can harvest timber. If use of the lake was allowed for water storage, negotiations would need to include compensation for lost of harvestable timber.
- **Liability:** The general concerns outlined in Section 5.2.2. would apply.
- **Impacts to Natural Resources:** The general concerns outlined in Section 5.2.2 would apply.

Based on comments and discussion during the initial presentation and discussion, Mr. March agreed to conduct a site visit with Anchor QEA to this site and two other sites they manage (TOK3, Section 5.4; TOK4, Section 5.5), which are existing lakes on timber property in the Tokul Creek subbasin. Notes and photographs from the site visit are included in Appendix D.

5.4.3 Proposed Storage Concept

The proposed storage concept for Site TOK3 is to construct a control structure at the outlet of Klaus Lake to allow additional water to be stored in the lake. The proposed lake is shown relative to the basin that would be tributary to the reservoir in Figure 5-4A. The modifications at the lake outlet and proposed lake footprint are shown over LiDAR topography in Figure 5-4B.

The outlet structure on Klaus Lake would likely be a reinforced concrete structure with automatic gates and stop logs. It would be operated to raise the maximum WSEL in the lake by approximately 2 feet to elevation 991 feet. When full, the lake would inundate an additional 19.4 acres of area surrounding Klaus Lake (increasing the full water surface from approximately 50.8 acres to 70.2 acres). The outlet structure would control releases to the unnamed tributary that discharges to Ten Creek downstream of the lake.

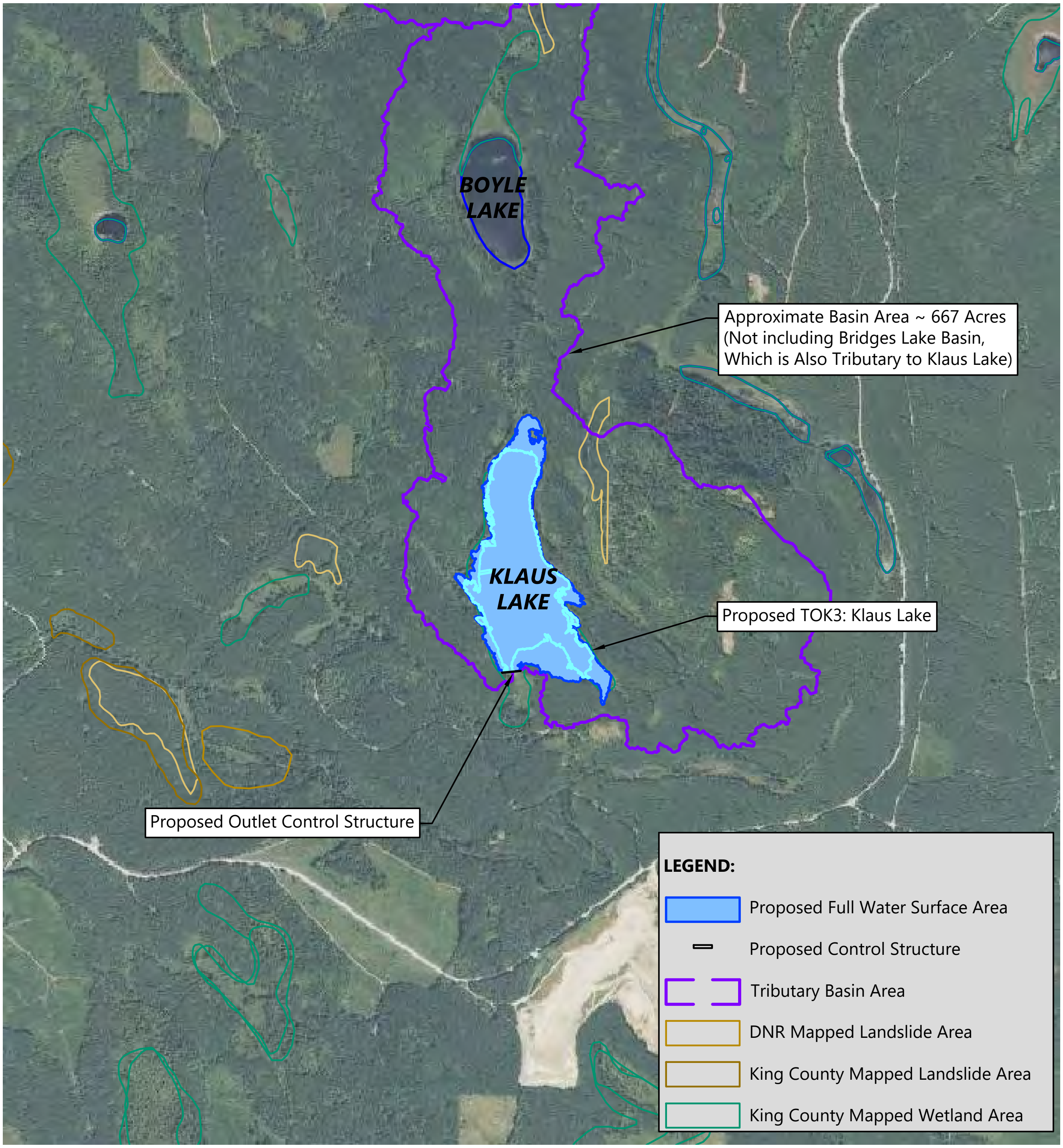
5.4.4 Site Access and Constraints

There are logging roads near Klaus Lake near the outlet; these roads connect to the Tolt Reservoir Road about 1 mile south of the lake. The shoreline and outlet of the lake can currently only be accessed by foot, but vehicle access is relatively close to the outlet (within approximately 300 feet).

The primary constraints at this site are the presence of actively managed tree farms surrounding the lake, and heavily forested buffers and wetland areas adjacent to the lake.

5.4.5 Source of Stored Water

Klaus Lake captures water from runoff that naturally drains to the lake from areas upstream (to the north). This includes the drainage from lakes farther upstream, including Bridges Lake. LiDAR data were used in Arc GIS to delineate the tributary basin that flows to the unnamed tributary north of the proposed reservoir site. The area of the tributary basin was estimated to be approximately 1,097 acres (1.71 square miles), including the 429 acres (0.67 square mile) tributary to Bridges Lake.



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88

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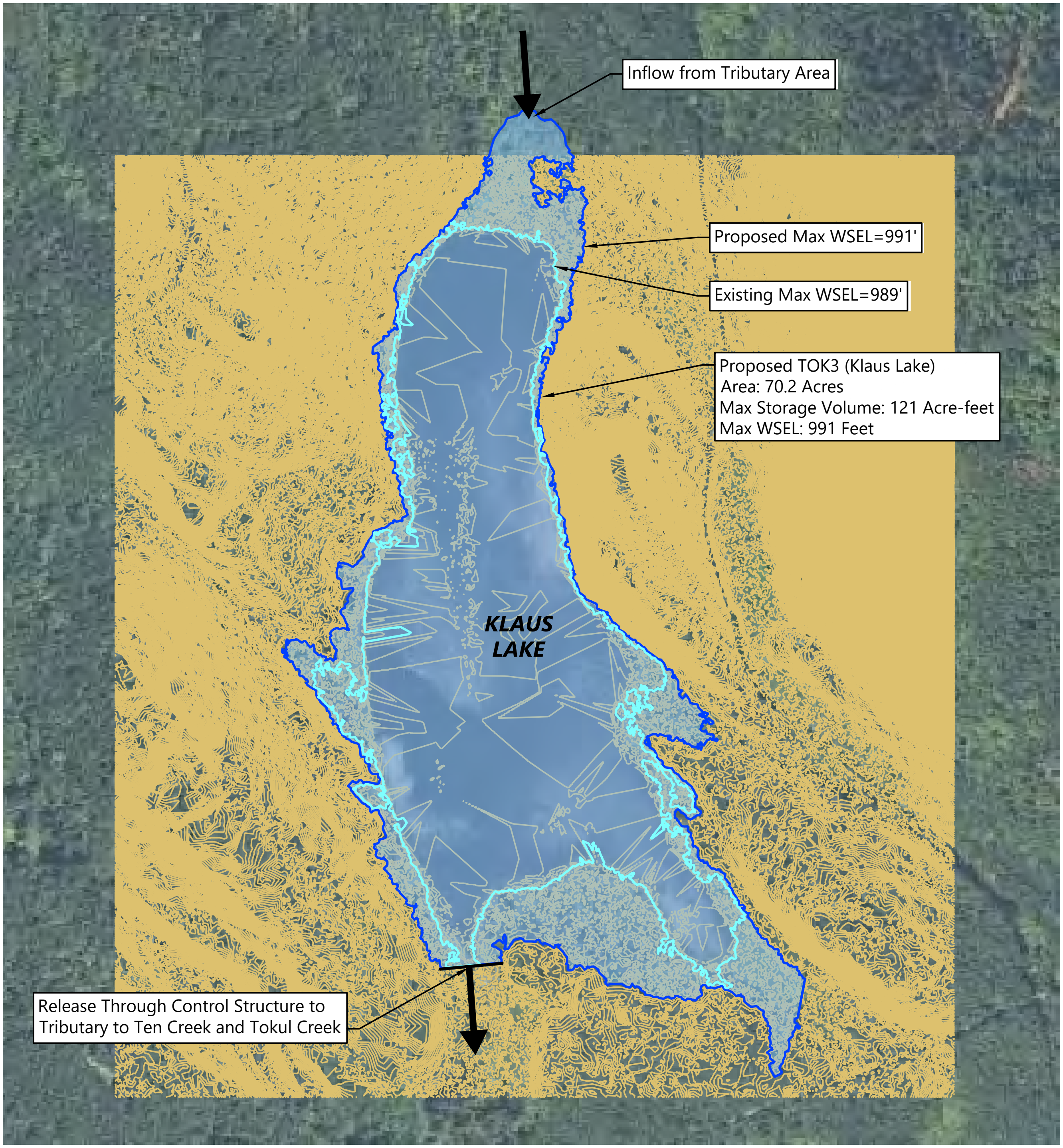
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site TOK3.dwg Figure 5-4A

ANCHOR QEA

Figure 5-4A
Tributary Basin Area Map - Storage Site TOK3

Snoqualmie Watershed
Comprehensive Storage Study



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88

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Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site TOK3.dwg Figure 5-4B

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Figure 5-4B
Site Map - Storage Site TOK3

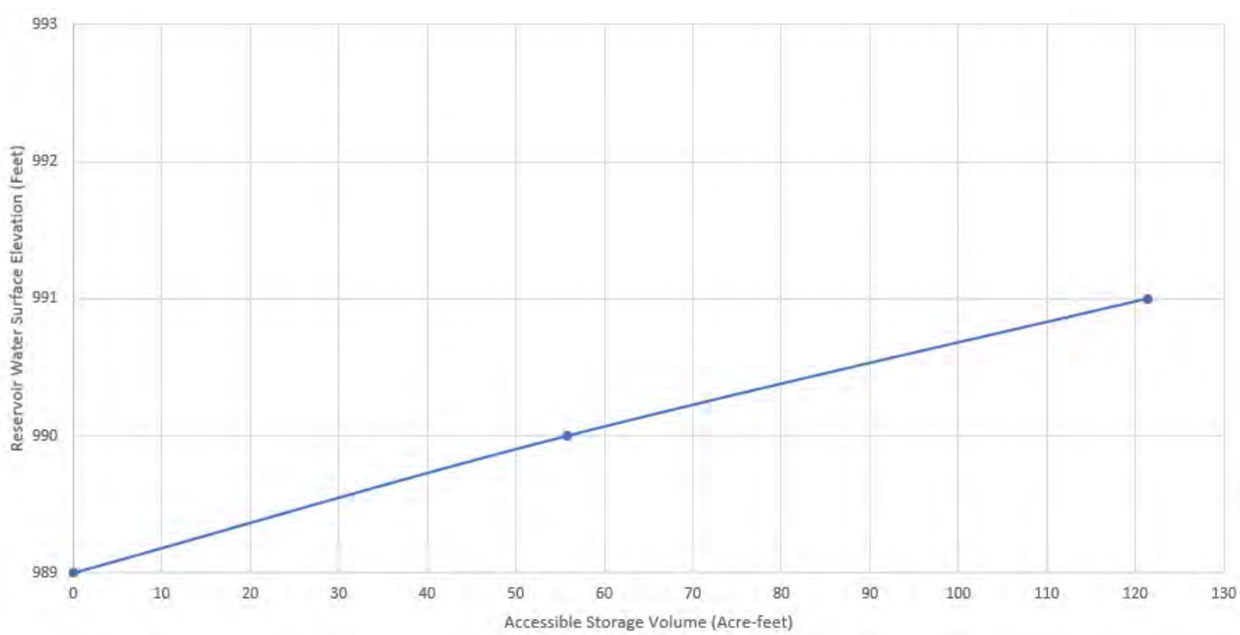
Snoqualmie Watershed
Comprehensive Storage Study

5.4.6 *Hydrologic and Hydraulic Analyses*

A WWHM hydrologic model was prepared to model the rate and volume of runoff that flows to Klaus Lake. For the period of record modeled (Water Years 1949 to 2009), the average annual runoff volume that drains to Klaus Lake from the tributary area was estimated to be 532 acre-feet. The annual runoff volume was estimated to range from 320 to 950 acre-feet.

A stage-storage volume curve was also developed for the additional storage that would be created and managed in the lake at Site TOK3, based on installation of a structure that would raise the water level an additional 2 feet in elevation and manage that top 2 feet as water storage. The stage-storage volume curve is plotted in Figure 5-4C. The stage is represented in feet of elevation related to the storage volume in acre-feet. As shown, the full reservoir would store 121 acre-feet of water in Klaus Lake that could be managed and released to support instream flows and create offset for out-of-stream uses to a maximum elevation of 991 feet.

Figure 5-4C
Stage-Storage Curve – Storage Site TOK3



5.4.7 *Reservoir Operations*

The runoff volumes from the WWHM model were used, along with estimated evaporation rates and the estimated stage-storage volume curve, to develop a reservoir operations and water balance model. This model estimated the inflows and outflows from Klaus Lake on a monthly basis for the 61-year modeling period of record. Outflows include evaporation and reservoir release to the unnamed tributary off of Ten Creek. The water balance model was adjusted to determine potential release rates during the late summer and other times of the year as an example of how Klaus Lake could be operated to augment flows in the tributary and downstream through Ten Creek to Tokul Creek. Table 5-16 summarizes findings from the water balance model for Klaus Lake.

Table 5-16
Water Balance Model Results – Site TOK3

Parameter Evaluated	Result
Targeted Capacity	121 acre-feet
Area of Tributary Basin	1,097 acres
Average Annual Runoff	532 acre-feet
Maximum Annual Runoff	950 acre-feet
Minimum Annual Runoff	320 acre-feet
Targeted Flow Through Rate (Base Flow)	0.6 cfs
Average Late-Summer Release Rate Available	0.8 cfs
Average Days Release Available in Late Summer	9.6 days
Average % of Targeted Reservoir Volume Filled	88.8%
Maximum % of Targeted Reservoir Volume Filled	100.0%

This analysis assumes that a constant base flow of 0.6 cfs would be routed through the outlet structure to maintain flows in the tributary downstream of Site TOK3. Based on the additional volume of storage, inflows to the reservoir, and assumed releases from the reservoir, the lake would fill to the maximum targeted water surface during wet years and would mostly fill during dry years. However, the volume stored would not sustain a very large increase in outflow during the late summer, and the duration of the increased outflow would be limited. Based on the results from the water balance model, 0.8 cfs could be released for an average of 9.6 days during late-summer months to increase streamflow in Ten Creek and Tokul Creek. It may be difficult to maintain additional lake storage through late summer. The lake may refill in the spring, but by the late summer, a portion of the water stored in the top 2 feet will be lost via base flows routed through the lake (assumed to be 0.6 cfs), evaporation, and other losses, leaving less storage volume available for release during the late summer.

5.4.8 Water Quality Impacts

Section 5.1.8 provided a general overview of potential water quality impacts that could result from construction of any reservoir with the Snoqualmie River Watershed. The potential impacts include increased temperature in downstream streams and rivers caused by warming of water in the reservoir; degraded water quality conditions resulting from nutrient loading, algae growth, and a decrease in DO at the bottom of the reservoir; and accrual and release of toxic contaminants.

Considering the potential for these impacts, the following key characteristics that may influence water quality were noted for the proposed modifications to Klaus Lake:

- Klaus Lake (full WSEL ~989 feet) is low in the watershed relative to the other six sites, which could mean capture and storage of slightly warmer water and warmer ambient temperatures in the summer.
- The lake has a relatively large surface area.
- The lake is an existing lake with already existing water storage.
- The lake does not appear to be downstream of any fertilized areas where high nutrient loading would be expected.
- The lake does not appear to be downstream of any sources of toxic contaminants.

Based on these key characteristics and observations, the following are anticipated relative to water quality impacts and potential ways to mitigate for those impacts through design and operation:

- Because the lake is existing and currently releases water to downstream tributaries, very little, if any, impact to water temperature is anticipated. The increase in water surface would be small, and the overall seasonal changes in lake temperature would persist from what currently occurs at the lake.
- Degradation of water quality due to nutrient loading, toxic algal blooms, and low DO concentrations is not anticipated to be any greater than what currently exists at the lake. No new nutrients or conditions would be introduced to cause additional water quality issues.
- No release of toxics or contamination of stored water is anticipated.

5.4.9 Non-Exploratory Soils and Geology

The primary soil and geology conditions to consider at Site TOK3 are the moderately high to high hydraulic conductivity of near-surface soils and the thick deposits of unconsolidated lithology. Geology at the site is mapped as recessional outwash deposits of the Vashon Stade of the Fraser glaciation, consisting of stratified sand and gravel, moderately to well sorted, and well-bedded silty sand to silty clay deposited in proglacial and ice-marginal environments abutted by till and metavolcanic bedrock.

The primary geologic hazards to consider in planning and development are steep slopes along the east side of the lake.

The primary seismic hazard is Strong (MMI 6) to Very Strong (MMI 7) ground shaking as modeled during southern Whidbey Island, Seattle, Tacoma, and Cascadia events. The soils and rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density. Summaries of soil, geologic, and seismic conditions are included in Tables 5-17 to 5-19.

Table 5-17
Soil Conditions – Site TOK3

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped soil unit(s)	Foundation and reservoir	231—Seattle muck, 0% to 1% slopes
	Abutments and rim areas	
Soil Conditions		
USCS	Foundation and reservoir	PT – Peat
	Abutments and rim areas	
Depth to water table	Foundation and reservoir	About 0 inches
	Abutments and rim areas	
Capacity of the most limiting layer to transmit water (Ksat)	Foundation and reservoir	Moderately high to high (0.57 to 1.98 inches/hour)
	Abutments and rim areas	
Drainage class	Foundation and reservoir	Very poorly drained
	Abutments and rim areas	
Depth to any soil restrictive layer	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Suitability		
Pond reservoir areas	Somewhat limited	Seepage

Table 5-18
Geologic Conditions – Site TOK3

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped geologic unit(s)	Foundation and reservoir	Pleistocene recessional outwash deposits (Qvr)
	Abutments and rim areas	Pleistocene recessional outwash deposits (Qvr); Middle Eocene and [or] Late Cretaceous metavolcanic rocks (TKwv) (West Rim); Pleistocene till (Qvt) (East Rim)
Slope Stability		
Landslides and existing slope movements	None mapped within the reservoir footprint; east side abuts potential steep slope hazard areas (> 40%)	
Structures		
Potentially active faults	None mapped at the site	
Folds, anticlines, etc.	None mapped at the site	

Table 5-19
Seismic Conditions – Storage Site TOK3

Conditions Researched	Applicability	Anticipated Geology or Conditions
Ground motion	MMI 7 Very Strong (Seattle); MMI 6 Strong (Tacoma, Southern Whidbey Island, and Cascadia)	
Fault rupture	Unlikely	
Liquefaction/lateral spread	Foundation and reservoir	Low
	Abutments and rim areas	Low
NEHRP site soil class	Foundation and reservoir	C to D
	Abutments and rim areas	C to D

5.4.10 Constructability

The following constructability issues would need to be considered and addressed as part of further evaluation of a potential storage project at Klaus Lake:

- **Access:** As noted in Section 5.4.4, there is currently no vehicle access to the lake outlet or shoreline, but there is vehicle access within approximately 300 feet of the lake outlet. Extension of an access road suitable for construction and maintenance would be required.
- **Vegetation and Clearing:** Construction would require limited clearing of trees and other vegetation for access near the lake outlet and construction of the outlet structure.

- **Materials:** Concrete and other materials would need to be transported to the site to create the outlet structure. Delivery of concrete to the site would require suitable access. Availability of concrete, mechanical control equipment, and other materials would need to be verified.
- **Seasonal Complications:** Construction during the wet season (October through April) would require installation of controls to prevent erosion of bare surfaces and stockpiles and the discharge of sediment-laden water from the site. In addition, placement and compaction of materials will be affected by excessive moisture or freezing temperatures. Because this site is at moderate elevation, the seasonal complications may be more significant than they would be at lower sites where precipitation is less and winter weather does not last as long.

5.4.11 Opinion of Cost

A preliminary opinion of the probable costs associated with implementing the project at Site TOK3 was prepared as part of the screening analysis (based on July 2020 dollars). The opinion of probable costs was updated and refined as part of this more detailed analysis according to the assumptions and with the allowances noted for Site CCK2 in Section 5.1.11.

An evaluation of potential annual O&M costs was also completed to quantify costs associated with operating and maintaining modifications to the outlet and managing storage at Site TOK3. These costs were estimated based on O&M costs of facilities that are similar in size and scope. The costs assume salary and benefits for a government employee at a rate of 1/8 FTE, administrative costs, transportation costs, supplies, and maintenance, repairs, and contracted labor. Table 5-20 provides a summary of the opinion of probable implementation and long-term operating costs for the project. Additional detail is included in Appendix E.

Table 5-20
Opinion of Probable Implementation and O&M Costs, Site TOK3

Cost Item	Opinion of Probable Cost
Project Implementation Costs	
Site Work	$1,092,000
Construction of Earthen Embankment	$0
Construction of Piping and Conveyance Facilities	$330,000
Construction of Emergency Overflow Spillway	$36,000
Construction Subtotal	**$1,458,000**
Mobilization and Demobilization (7.5%)	$109,350
Construction Total	**$1,567,000**
Environmental Mitigation (10%)	$156,700
Contingency (30%)	$470,100
Engineering, Permitting, and Administration (15%)	$235,050
Sales Tax (9.5%)	$208,411
Allowance for Land Acquisition	$242,157
Total Project Implementation Cost	**$2,879,000**
Annual O&M Costs:	
Salaries	$10,000
Benefits	$4,000
Administration	$1,000
Transportation	$1,000
Supplies	$1,600
Maintenance and Repairs	$1,600
Contracted Labor	$1,600
Total Annual O&M Costs	**$20,800**

Notes:
1. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
2. The subtotals and construction total are rounded to the nearest $1,000.
3. Costs are based on planning-level concept evaluation for the reservoir. Costs will vary as the concepts are evaluated in more detail and additional information becomes available to support project development.

5.5 Site TOK4: Black Lake

5.5.1 Site Background

Site TOK4 (Black Lake) is a small lake located on private timberland in the Tokul Creek subbasin in the central part of the Snoqualmie River Watershed. The site is an existing lake surrounded by timberland owned by Snoqualmie Timber, LLC. As noted earlier, the Snoqualmie Timber, LLC parcels in the Snoqualmie River Watershed are managed for timber harvest by Campbell Global, LLC. The property surrounding the lake is an actively managed tree farm with nearby tracts that have recently been or are currently being harvested.

5.5.2 Landowner Coordination and Site Visit

As noted in Section 5.2.2, Campbell Global, LLC, was contacted to review this site and other sites under consideration for water storage projects that are managed by Campbell Global, LLC (Sites NFT4, Section 5.2; TOK2, Section 5.3; TOK3, Section 5.4; and NFK2, Section 5.6). Discussion specific to Site TOK4 and other properties managed by Campbell Global, LLC, that are being evaluated in detail primarily occurred during fall 2021. During a virtual meeting on September 24, 2021, SVWID and Anchor QEA provided a summary of the potential project to Mike March, the Campbell Global, LLC timber property manager in the Snoqualmie River Watershed. Notes from that meeting are included in Appendix D. The concerns outlined by Campbell Global, LLC, regarding development of water storage on properties they manage are outlined in Section 5.2.2. Concerns applicable to this property are as follows:

- **Loss of Harvestable Timber:** The property surrounding Black Lake is managed by Campbell Global, LLC, as an active tree farm. Campbell Global, LLC, indicated that they are required to maintain a buffer (not harvested) around waterbodies, including Bridges Lake. That buffer would likely expand if the lake level were raised, which would reduce the area from which they can harvest timber. If use of the lake was allowed for water storage, negotiations would need to include compensation for lost of harvestable timber.
- **Monument:** A historical monument was placed near the shoreline of the lake to memorialize victims of a plane crash. Any improvements should be designed to protect the monument.
- **Liability:** The general concerns outlined in Section 5.2.2. would apply.
- **Impacts to Natural Resources:** The general concerns outlined in Section 5.2.2 would apply.

Based on comments and discussion during the initial presentation and discussion, Mr. March agreed to conduct a site visit with Anchor QEA to this site and two other sites they manage (TOK2; Section 5.3; TOK3, Section 5.4), which are all existing lakes on timber property in the Tokul Creek subbasin. Notes and photographs from the site visit are included in Appendix D.

5.5.3 Proposed Storage Concept

The proposed storage concept for Site TOK4 is to construct a control structure at the outlet of Black Lake to allow additional water to be stored in the lake. The proposed lake is shown relative to the basin that would be tributary to the reservoir in Figure 5-5A. The modifications at the lake outlet and proposed lake footprint are shown over LiDAR topography in Figure 5-5B.

The outlet structure on Black Lake would likely be a reinforced concrete structure with automatic gates and stop logs. It would be operated to raise the maximum WSEL in the lake by approximately 2 feet to elevation 1,222 feet. Some earthwork and grading may be needed to raise elevations adjacent to the outlet structure. When full, the lake would inundate an additional 5.5 acres of area surrounding Black Lake (increasing the full water surface from approximately 35.2 acres to 40.7 acres). The outlet structure would control releases to an unnamed tributary that discharges to Beaver Creek downstream of the lake.

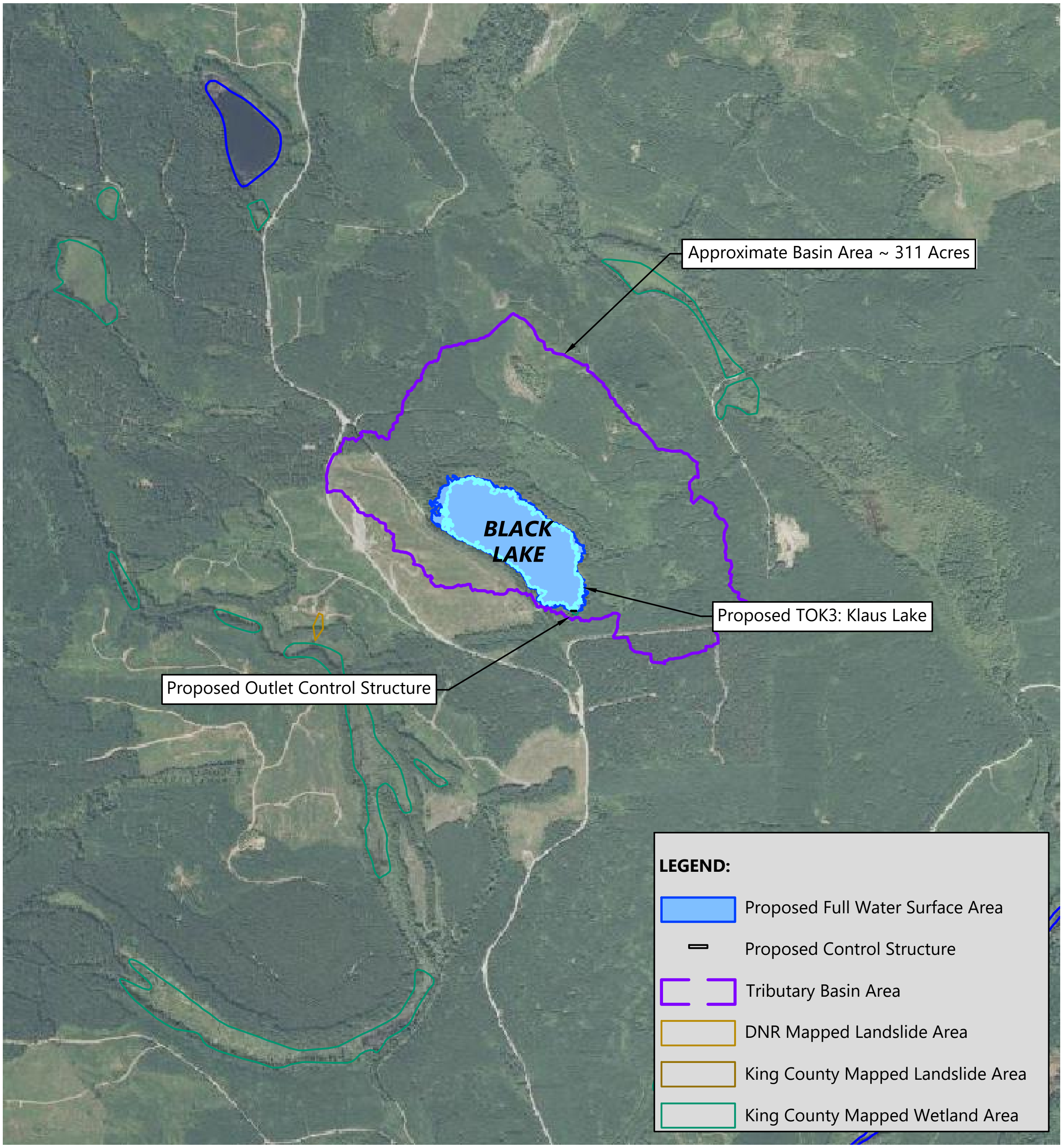
5.5.4 Site Access and Constraints

A logging and access road near Black Lake passes within 100 feet of the outlet. The road extends from Tolt Reservoir Road, located within close proximity of the west shoreline of Blake Lake and Forest Road NFD 5700-1, which runs east approximately 0.1 mile south of the outlet. The area from the main roads to the outlet would have to be cleared for full access.

The primary constraints at this site are the presence of actively managed tree farms surrounding the lake, and forested buffers and wetland areas adjacent to the lake.

5.5.5 Source of Stored Water

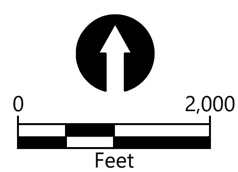
Black Lake captures runoff that naturally drains to the lake from areas upstream (generally to the north and east). LiDAR data were used in ArcGIS to delineate the tributary basin that flows to the unnamed tributary north of the proposed reservoir site. The area of the tributary basin was estimated to be approximately 311 acres (0.49 square mile).



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88



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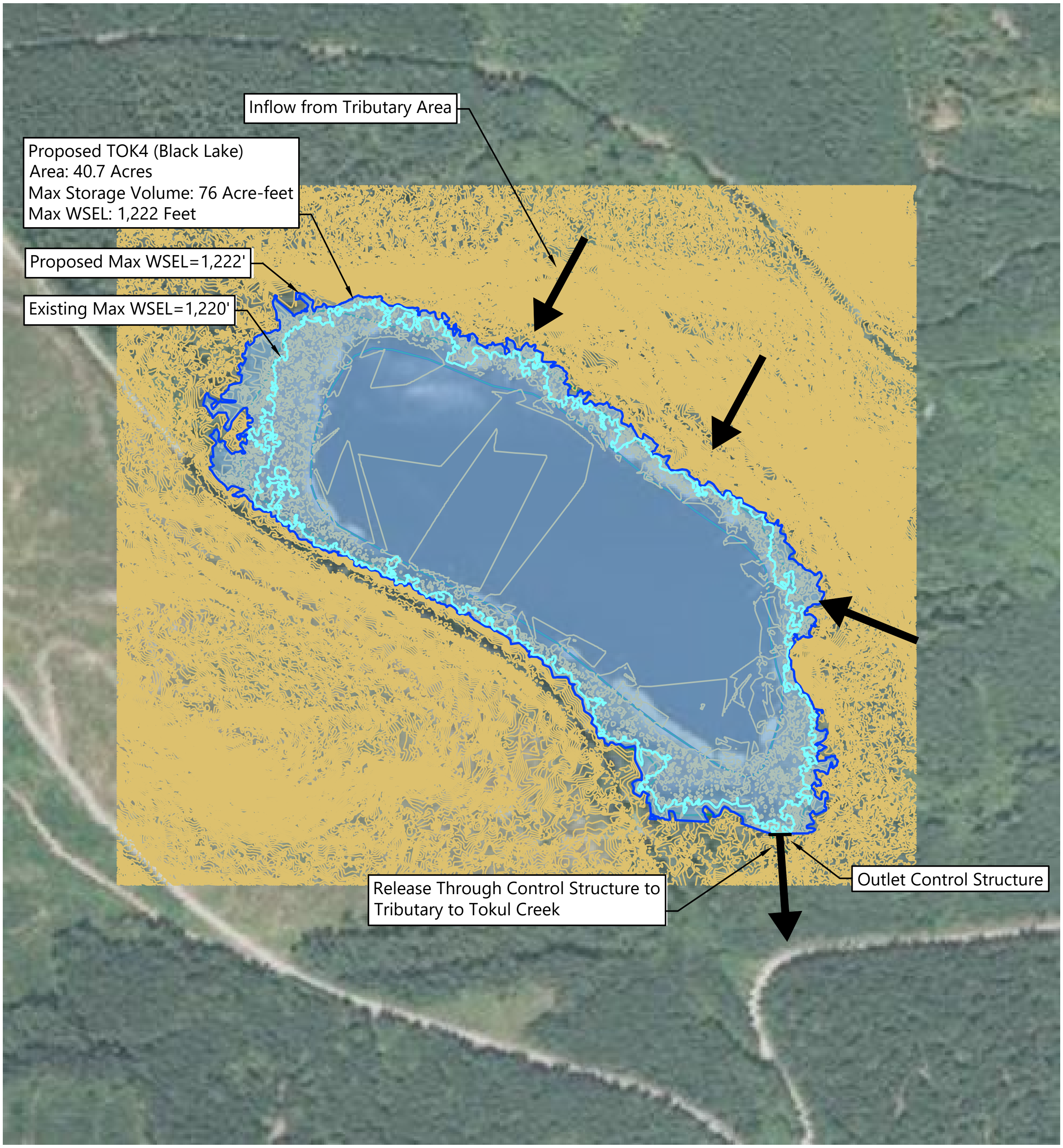
ANCHOR QEA

Figure 5-5A
Tributary Basin Area Map - Storage Site TOK4

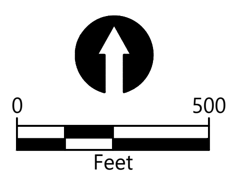
Snoqualmie Watershed
Comprehensive Storage Study



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88



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ANCHOR QEA

Figure 5-5B
Tributary Basin Area Map - Storage Site TOK4

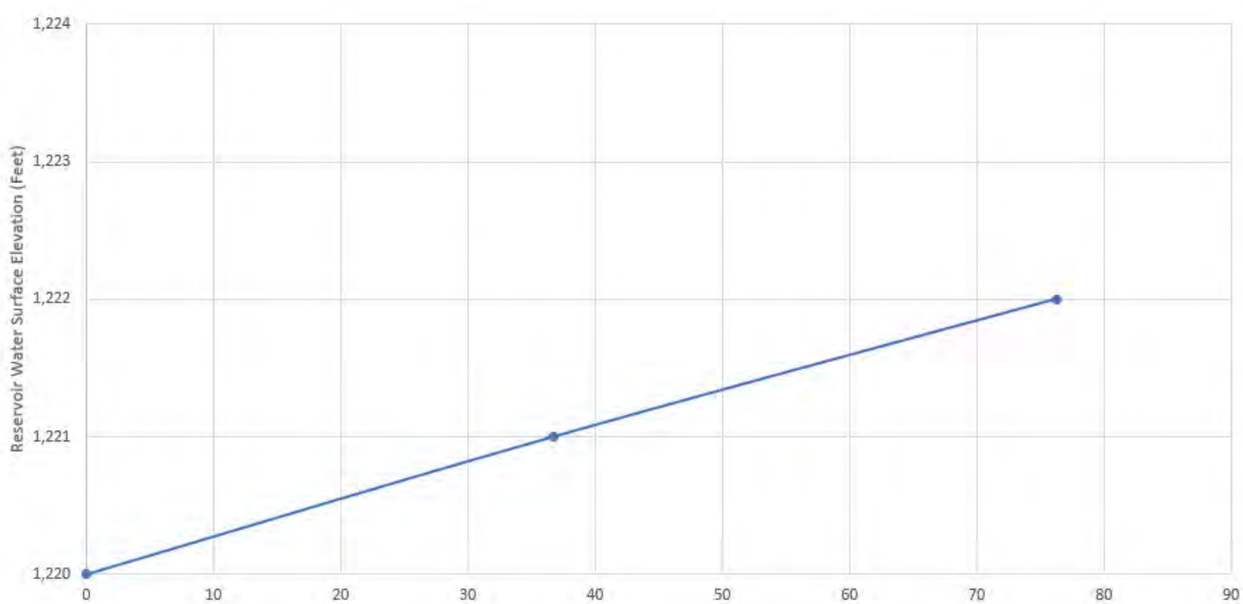
Snoqualmie Watershed
Comprehensive Storage Study

5.5.6 *Hydrologic and Hydraulic Analyses*

A WWHM hydrologic model was prepared to model the rate and volume of runoff that flows to Black Lake. For the period of record modeled (Water Years 1949-2009), the average annual runoff volume that drains to the Black Lake from the tributary area was estimated to be 229 acre-feet. The annual runoff volume was estimated to range from 145 to 379 acre-feet.

A stage-storage volume curve was also developed for the additional storage that would be created and managed in the lake at Site TOK4, based on installation of a structure that would raise the water level an additional 2 feet in elevation and manage that top 2 feet as water storage. The stage-storage volume curve is plotted in Figure 5-5C. The stage is represented in feet of elevation related to the storage volume in acre-feet. As shown, the full reservoir would store 76 acre-feet of water in Black Lake that could be managed and released to support instream flows and create offset for out-of-stream uses to a maximum elevation of 1,222 feet.

Figure 5-5C
Stage-Storage Curve – Storage Site TOK4



5.5.7 *Reservoir Operations*

The runoff volumes from the WWHM model were used, along with estimated evaporation rates and the estimated stage-storage volume curves, to develop a reservoir operations and water balance model. This model estimated the inflows and outflows from Black Lake on a monthly basis for the 61-year modeling period of record. Outflows include evaporation and reservoir release to the unnamed tributary off of Beaver Creek. The water balance model was adjusted to determine potential release rates during the late summer as an example of how the additional storage in Black Lake could be operated to augment flows in the tributary and downstream through Beaver Creek to Tokul Creek. Table 5-21 summarizes findings from the water balance model for Black Lake.

Table 5-21
Water Balance Model Results – Site TOK4

Parameter Evaluated	Result
Targeted Capacity	76 acre-feet
Area of Tributary Basin	311 acres
Average Annual Runoff	229 acre-feet
Maximum Annual Runoff	379 acre-feet
Minimum Annual Runoff	145 acre-feet
Targeted Flow Through Rate (Base Flow)	0.2 cfs
Average Late-Summer Release Rate Available	0.6 cfs
Average Days Release Available in Late Summer	7.9 days
Average % of Targeted Reservoir Volume Filled	87.5%
Maximum % of Targeted Reservoir Volume Filled	100.0%

This analysis assumes that a constant base flow of 0.2 cfs would be routed through the outlet structure to maintain flows in the tributary downstream of Site TOK4. Based on the additional volume of storage, inflows to the reservoir, and assumed releases from the reservoir, the lake would fill to the maximum targeted water surface during wet years and would mostly fill during dry years. However, the volume stored would not sustain a very large increase in outflow during the late summer, and the duration of the increased outflow would be limited. Based on the results from the water balance model, 0.6 cfs could be released for an average of 7.9 days during late-summer months to increase streamflow in Beaver Creek and Tokul Creek. It may be difficult to maintain additional lake storage through late summer. The lake may refill in the spring, but by the late summer, a portion of the water stored in the top 2 feet will be lost via base flows routed through the lake (assumed to be 0.2 cfs), evaporation, and other losses, leaving less storage volume available for release during the late summer.

5.5.8 Water Quality Impacts

Section 5.1.8 provided a general overview of potential water quality impacts that could result from construction of any reservoir with the Snoqualmie River Watershed. The potential impacts include increased temperature in downstream streams and rivers caused by warming of water in the reservoir; degraded water quality conditions resulting from nutrient loading, algae growth, and a decrease in DO at the bottom of the reservoir; and accrual and release of toxic contaminants.

Considering the potential for these impacts, the following key characteristics that may influence water quality were noted for the proposed modifications to Black Lake:

- Black Lake (full WSEL ~1,222 feet) is moderately high in the watershed relative to the other six sites, which could mean capture and storage of slightly colder water and colder ambient temperatures in the summer.
- The lake has a relatively large surface area.
- The lake is an existing lake with already existing water storage.
- The lake does not appear to be downstream of any fertilized areas where high nutrient loading would be expected.
- The lake does not appear to be downstream of any sources of toxic contaminants.

Based on these key characteristics and observations, the following are anticipated relative to water quality impacts and potential ways to mitigate for those impacts through design and operation:

- Because the lake is existing and currently releases water to downstream tributaries, very little, if any, impact to water temperature is anticipated. The increase in water surface would be small, and the overall seasonal changes in lake temperature would persist from what currently occurs at the lake.
- Degradation of water quality due to nutrient loading, toxic algal blooms, and low DO concentrations is not anticipated to be any greater than what currently exists at the lake. No new nutrients or conditions would be introduced to cause additional water quality issues.
- No release of toxics or contamination of stored water is anticipated.

5.5.9 Non-Exploratory Soils and Geology

The primary soil and geology conditions to consider at Site TOK4 are the moderately high to high hydraulic conductivity of near-surface soils and the thick deposits of unconsolidated lithology. Geology at the site is mapped as recessional outwash deposits of the Vashon Stade of the Fraser glaciation, consisting of stratified sand and gravel, moderately to well sorted, and well-bedded silty sand to silty clay deposited in proglacial and ice-marginal environments.

The primary geologic hazards to consider in planning and development are the nearby landslide (Qls) deposits and steep slopes that abut the west and east sides of the site.

The primary seismic hazard is Strong (MMI 6) to Very Strong (MMI 7) ground shaking as modeled during southern Whidbey Island, Seattle, Tacoma, and Cascadia events. The soils and rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density. Summaries of soil, geologic, and seismic conditions are included in Tables 5-22 to 5-24.

Table 5-22
Soil Conditions – Site TOK4

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped soil unit(s)	Foundation and reservoir	231—Seattle muck, 0% to 1% slopes
	Abutments and rim areas	
Soil Conditions		
USCS	Foundation and reservoir	PT – Peat
	Abutments and rim areas	
Depth to water table	Foundation and reservoir	About 0 inches
	Abutments and rim areas	
Capacity of the most limiting layer to transmit water (Ksat)	Foundation and reservoir	Moderately high to high (0.57 to 1.98 inches/hour)
	Abutments and rim areas	
Drainage class	Foundation and reservoir	Very poorly drained
	Abutments and rim areas	
Depth to any soil restrictive layer	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Suitability		
Pond reservoir areas	Somewhat limited	Seepage

Table 5-23
Geologic Conditions – Site TOK4

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped geologic unit(s)	Foundation and reservoir	Pleistocene recessional outwash deposits (Qvr)
	Abutments and rim areas	
Slope Stability		
Landslides and existing slope movements	None mapped within the reservoir footprint	
Structures		
Potentially active faults	None mapped at the site	
Folds, anticlines, etc.	None mapped at the site	

Table 5-24
Seismic Conditions – Site TOK4

Conditions Researched	Applicability	Anticipated Geology or Conditions
Ground motion	MMI 7 Very Strong (Seattle and Southern Whidbey Island); MMI 6 Strong (Tacoma and Cascadia)	
Fault rupture	Unlikely	
Liquefaction/lateral spread	Foundation and reservoir	Low
	Abutments and rim areas	Low
NEHRP site soil class	Foundation and reservoir	C to D
	Abutments and rim areas	C to D

5.5.10 Constructability

The following constructability issues would need to be considered and addressed as part of further evaluation of a potential storage project at Black Lake:

- **Access:** As noted in Section 5.5.4, there is currently vehicle access to within about 100 feet of the lake outlet. Extension of an access road suitable for construction and maintenance would be required to the lake outlet.
- **Vegetation and Clearing:** Construction would require limited clearing of trees and other vegetation for access near the lake outlet and construction of the outlet structure.
- **Materials:** Concrete and other materials would need to be transported to the site to create the outlet structure. Delivery of concrete to the site would require suitable access. Availability of concrete, mechanical control equipment, and other materials would need to be verified.
- **Seasonal Complications:** Construction during the wet season (October through April) would require installation of controls to prevent erosion of bare surfaces and stockpiles and the discharge of sediment-laden water from the site. In addition, placement and compaction of materials will be affected by excessive moisture or freezing temperatures. Because this site is at moderate elevation, the seasonal complications may be more significant than they would be at lower sites where precipitation is less and winter weather does not last as long.

5.5.11 Opinion of Cost

A preliminary opinion of the probable costs associated with implementing the project at Site TOK4 was prepared as part of the screening analysis (based on July 2020 dollars). The opinion of probable costs was updated and refined as part of this more detailed analysis according to the assumptions and with the allowances noted for Site CCK2 in Section 5.1.11.

An evaluation of potential annual O&M costs was also completed to quantify costs associated with operating and maintaining modifications to the outlet and managing storage at Site TOK4. These costs were estimated based on O&M costs of facilities that are similar in size and scope. The costs assume salary and benefits for a government employee at a rate of 1/8 FTE, administrative costs, transportation costs, supplies, and maintenance, repairs, and contracted labor. Table 5-25 provides a summary of the opinion of probable implementation and long-term operating costs for the project. Additional detail is included in Appendix E.

Table 5-25
Opinion of Probable Implementation and O&M Costs, Site TOK4

Cost Item	Opinion of Probable Cost
Project Implementation Costs	
Site Work	$629,700
Construction of Earthen Embankment	$0
Construction of Piping and Conveyance Facilities	$244,000
Construction of Emergency Overflow Spillway	$30,000
Construction Subtotal	**$904,000**
Mobilization and Demobilization (7.5%)	$67,800
Construction Total	**$972,000**
Environmental Mitigation (10%)	$97,200
Contingency (30%)	$291,600
Engineering, Permitting, and Administration (15%)	$145,800
Sales Tax (9.5%)	$129,276
Allowance for Land Acquisition	$140,283
Total Project Implementation Cost	**$1,776,000**
Annual O&M Costs:	
Salaries	$10,000
Benefits	$4,000
Administration	$1,000
Transportation	$1,000
Supplies	$1,000
Maintenance and Repairs	$1,000
Contracted Labor	$1,000
Total Annual O&M Costs	**$19,000**

Notes:
1. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
2. The subtotals and construction total are rounded to the nearest $1,000.
3. Costs are based on planning-level concept evaluation for the reservoir. Costs will vary as the concepts are evaluated in more detail and additional information becomes available to support project development.

5.6 Site NFK2: Snoqualmie Timber – NF Snoq (B)

5.6.1 Site Background

Site NFK2 is located in the North Fork Snoqualmie subbasin in the central part of the Snoqualmie River Watershed. The site is a large timberland area, mostly cleared, high on a bluff just north of the North Fork Snoqualmie River. As noted earlier, the Snoqualmie Timber, LLC parcels in the Snoqualmie River Watershed are managed for timber harvest by Campbell Global, LLC. The property is an actively managed tree farm and most of the property appears to have been logged within the last 5 years.

5.6.2 Landowner Coordination and Site Visit

As noted in Section 5.2.2, Campbell Global, LLC, was contacted to review this site and other sites under consideration for water storage projects that are managed by Campbell Global, LLC (Sites NFT4, Section 5.2; TOK2, Section 5.3; TOK3, Section 5.4; and TOK4, Section 5.5). Discussion specific to Site NFK2 and other properties managed by Campbell Global, LLC, that are being evaluated in detail primarily occurred during fall 2021. During a virtual meeting on September 24, 2021, SVWID and Anchor QEA provided a summary of the potential project to Mike March, the Campbell Global, LLC timber property manager in the Snoqualmie River Watershed. Notes from that meeting are included in Appendix D. The concerns outlined by Campbell Global, LLC, regarding development of water storage on properties they manage are outlined in Section 5.2.2. Concerns applicable to this property are as follows:

- **Loss of Harvestable Timber:** The general concerns outlined in Section 5.2.2 would apply.
- **Liability:** The general concerns outlined in Section 5.2.2. would apply.
- **Impacts to Natural Resources:** The general concerns outlined in Section 5.2.2 would apply.

Based on comments and discussion during the initial presentation and discussion, Mr. March agreed to conduct a site visit with Anchor QEA to three other sites they manage (Sites TOK2, Section 5.3; TOK3, Section 5.4; TOK4, Section 5.5), which are all existing lakes on timber property. However, just as with Site NFT4, the property manager reiterated that there is limited productive timber harvest property left in the Snoqualmie River Watershed, and they are generally not open to transfer or lease of actively managed timber harvest property for a reservoir at Site NFT2 or any other use that would reduce or limit their ability to harvest the property.

5.6.3 Proposed Storage Concept

The proposed storage concept is to perform mass earthwork to construct a large impoundment to store water that flows to the site from a tributary area upslope of the site. The proposed reservoir is shown relative to the basin that would be tributary to the reservoir in Figure 5-6A. The embankment and reservoir are shown over LiDAR topography in Figure 5-6B.

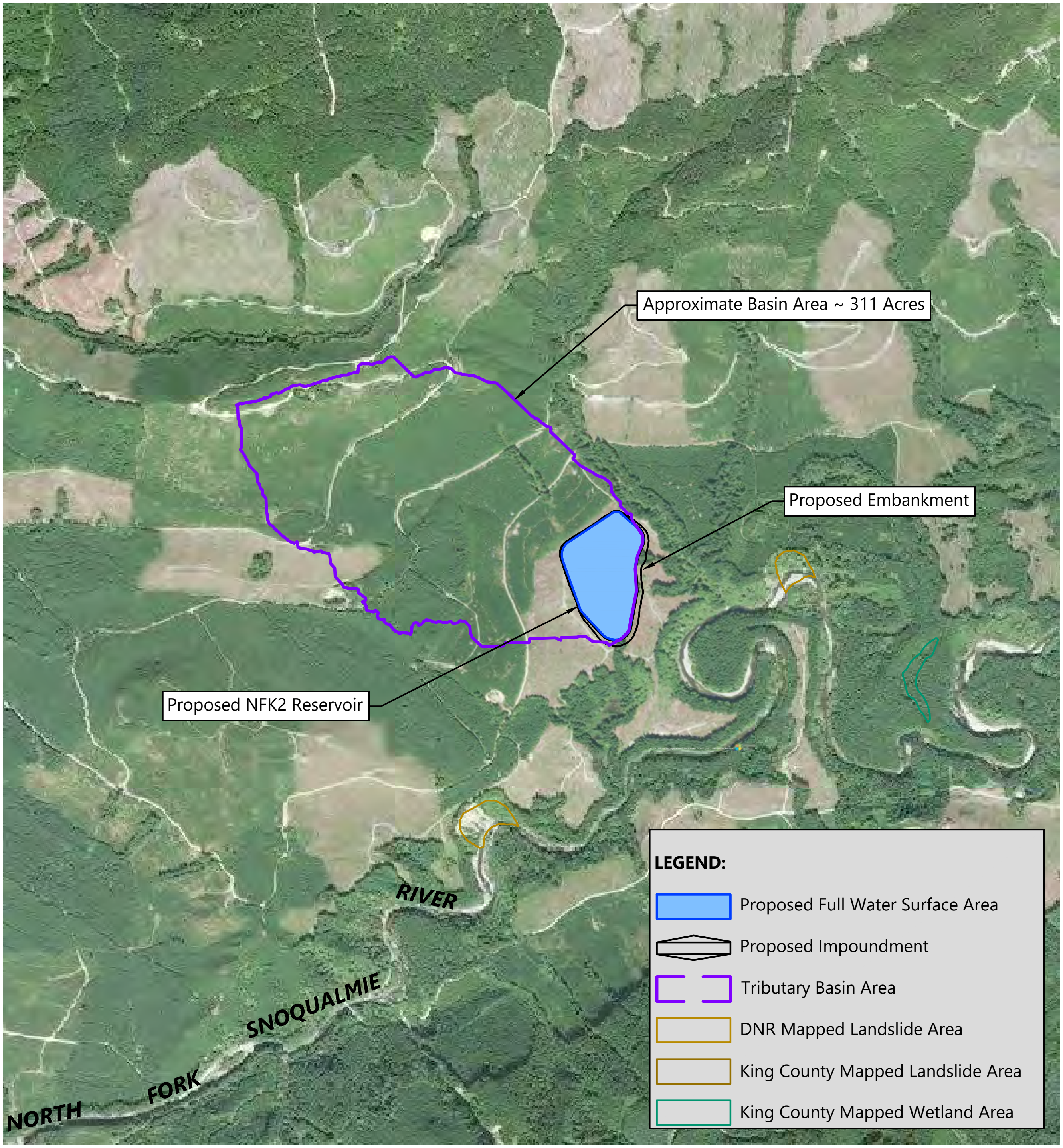
Construction would likely be preceded by harvest of the remaining timber and clearing within the relatively large project footprint. The impoundment would be approximately 20 feet deep and would store water to a maximum WSEL of 1,600 feet. The proposed reservoir would inundate approximately 27 acres when full. Water would be released through a pipeline or other constructed conveyance to a small unnamed tributary that flows to the North Fork Snoqualmie River.

5.6.4 Site Access and Constraints

Access to Site NFK2 is remote but there are several well-established logging roads that would make access to the site for construction and reservoir operations relatively easy. NFD 5700-1 Road runs along the west side of Site NFK2, and other logging roads connect the interior of the site to NFD 5700-1 Road. Approximately 4.5 miles of forest roads connect the site to Tolt Reservoir Road.

5.6.5 Source of Stored Water

The proposed reservoir at Site NFK2 would be filled by capturing water from areas upslope (west) of the site. LiDAR data were used in ArcGIS to delineate the tributary basin that flows to the proposed reservoir site. The area of the tributary basin was estimated to be approximately 311 acres (0.49 square mile).



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

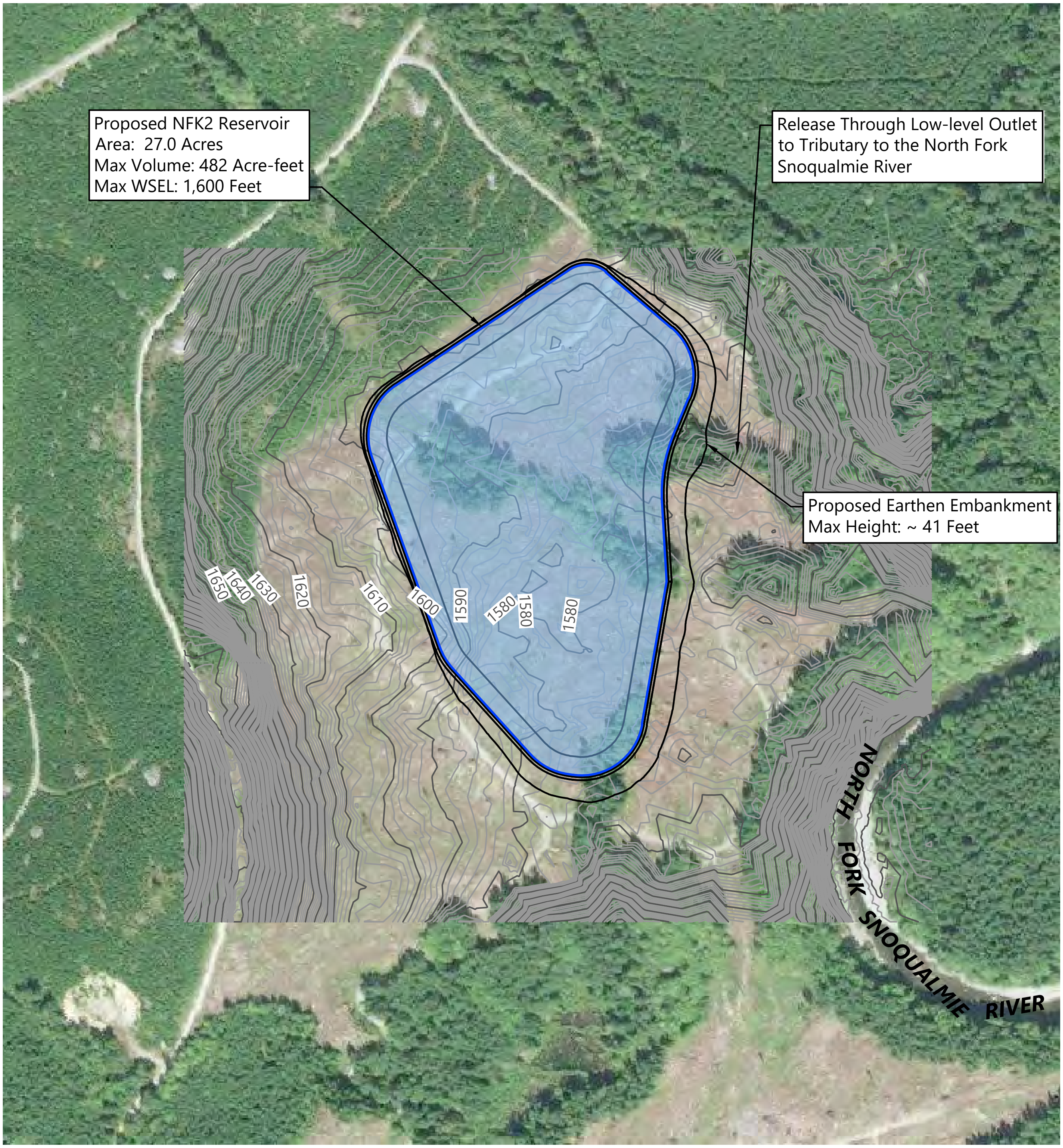
VERTICAL DATUM: NAVD 88

Publish Date: 2022/01/12 2:03 PM | User: drice
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site NFK2.dwg Figure 5-6A

ANCHOR QEA

Figure 5-6A
Tributary Basin Area Map - Storage Site NFK2

Snoqualmie Watershed
Comprehensive Storage Study



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88

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Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site NFK2.dwg Figure 5-6B

ANCHOR QEA

Figure 5-6B
Site Map - Storage Site NFK2

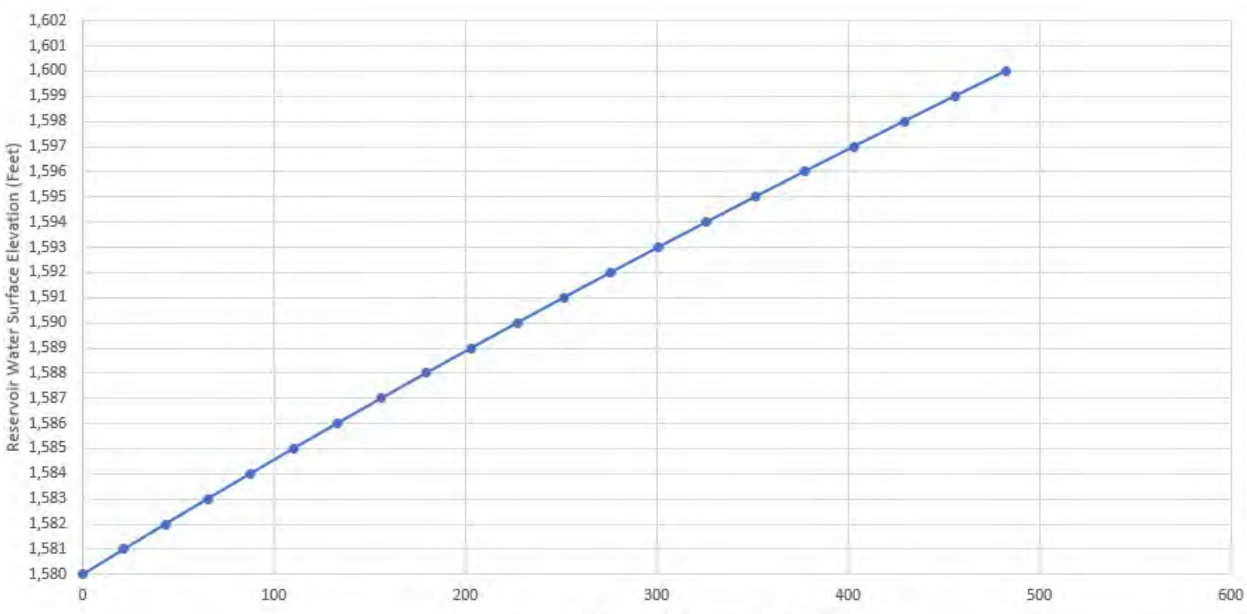
Snoqualmie Watershed
Comprehensive Storage Study

5.6.6 *Hydrologic and Hydraulic Analyses*

A WWHM hydrologic model was prepared to model the rate and volume of runoff that could be captured from a tributary area upslope of the reservoir for storage. For the period of record modeled (Water Years 1949 to 2009), the average annual runoff volume that drains to the reservoir at Site NFK2 from the tributary area was estimated to be 205 acre-feet. The annual runoff volume was estimated to range from 122 to 369 acre-feet.

A stage-storage volume curve was also developed in AutoCAD Civil 3D for the reservoir based on the configuration of the proposed embankment and grading of the impounded area. The stage-storage volume curve is plotted in Figure 5-6C. The stage is represented in feet of elevation related to the storage volume in acre-feet. As shown, the full reservoir would store 482 acre-feet at an elevation of 1,600 feet.

Figure 5-6C
Stage-Storage Curve – Storage Site NFK2



5.6.7 *Reservoir Operations*

The runoff volumes from the WWHM model were used, along with estimated evaporation rates and the estimated stage-storage volume curve, to develop a reservoir operations and water balance model. The purpose of the model was to estimate when flows would be captured and released from the reservoir at Site NFK2, and to estimate the probability of refill given hydrology of the tributary basin and the targeted size and storage capacity of the reservoir. This model estimated the inflows and outflows from the proposed reservoir at Site NFK2 on a monthly basis for the 61-year modeling period of record. Outflows include evaporation and reservoir release to the unnamed tributary of the North Fork Snoqualmie River. The water balance model was adjusted to determine potential release rates during the late summer as an example of how a reservoir at Site NFK2 could be operated to augment flows in the North Fork Snoqualmie River. Table 5-26 summarizes findings from the water balance model for the Site NFK2.

Table 5-26
Water Balance Model Results – Site NFK2

Parameter Evaluated	Result
Targeted Capacity	482 acre-feet
Area of Tributary Basin	311 acres
Average Annual Runoff	205 acre-feet
Maximum Annual Runoff	369 acre-feet
Minimum Annual Runoff	122 acre-feet
Average Late-Summer Release Rate Available	4 cfs
Average Days Release Available in Late Summer	19.2 days
Average % of Targeted Reservoir Volume Filled	34.8%
Maximum % of Targeted Reservoir Volume Filled	60.8%

Based on inflows to the proposed reservoir, the size of the reservoir that was targeted, and other assumed inputs used for the water balance model, the model indicates that there would not be enough flow upslope of the reservoir to completely fill a reservoir of this size, even during very wet years. The reservoir would only partially fill during the wettest year that was evaluated. During average and drier than average years, the reservoir would not refill. Based on the results from the water balance model, 4 cfs could be released from the reservoir for an average of 19.2 days during late-summer months to increase streamflow in the North Fork Snoqualmie River. If this project were to be advanced for further analysis, smaller storage capacities would need to be evaluated to balance the size of the impoundment, storage capacity, and cost of the reservoir with the volume of runoff volume that can reliably be captured and stored in the reservoir.

5.6.8 Water Quality Impacts

Section 5.1.8 provided a general overview of potential water quality impacts that could result from construction of any reservoir with the Snoqualmie River Watershed. The potential impacts include increased temperature in downstream streams and rivers caused by warming of water in the reservoir; degraded water quality conditions resulting from nutrient loading, algae growth, and a decrease in DO at the bottom of the reservoir; and accrual and release of toxic contaminants.

Considering the potential for these impacts, the following key characteristics that may influence water quality were noted for the proposed reservoir at Site NFK2:

- The reservoir elevation (full WSEL ~1,600 feet) would be high in the watershed relative to the other six sites, which would likely mean capture and storage of cooler water and cooler ambient temperatures in the summer.
- The reservoir would be relatively deep compared to the other six reservoirs and would have a relatively small surface area.
- The reservoir would be created by clearing the reservoir area and would have little potential for shading of the water surface.
- The reservoir does not appear to be downstream of any fertilized areas where high nutrient loading would be expected.
- The reservoir does not appear to be downstream of any sources of toxic contaminants.

Based on these key characteristics and observations, the following are anticipated relative to water quality impacts and potential ways to mitigate for those impacts through design and operation:

- Temperature could be impacted by water storage, but impacts are likely to be less significant relative to the other six reservoirs due to the small surface area and depth of the reservoir. The temperature of stored water and releases could be monitored, and a multi-port outlet could be provided to allow for releases from the coolest part of the reservoir. Additional analysis, including water quality modeling and research of water quality in similar nearby lakes, would be needed to better understand potential impacts to water temperature.
- Degradation of water quality due to nutrient loading, toxic algal blooms, and low DO concentrations is not anticipated to be any greater than it would be through any other similarly sized natural lake in the system. However, additional analysis would be required to better understand the potential for nutrient impacts, algae growth, and reduced DO concentrations. Aeration or management techniques, such as planting of vegetation to discourage waterfowl from adding nutrients to the reservoir, could be considered.
- No release of toxics or contamination in stored water is anticipated.

5.6.9 Non-Exploratory Soils and Geology

The primary soil and geology conditions to consider for Site NFK2 are the moderately high to high hydraulic conductivity of near-surface soils and the thick deposits of unconsolidated lithology. Geology at the site is mapped as recessional outwash deposits of the Vashon Stade of the Fraser glaciation, consisting of stratified sand and gravel, moderately to well sorted, and well-bedded silty sand to silty clay deposited in proglacial and ice-marginal environments.

The primary geologic hazard to consider in planning and development is the mapped alluvial fan (Qf) deposits that abut the north side of the site.

The primary seismic hazard is Moderate (MMI 5) to Very Strong (MMI 7) ground shaking as modeled during southern Whidbey Island, Seattle, Tacoma, and Cascadia events. The soils and rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density. Summaries of soil, geologic, and seismic conditions are included in Tables 5-27 to 5-29.

Table 5-27
Soil Conditions – Site NFK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped soil unit(s)	Foundation and reservoir	175—Persis sandy loam, 0% to 8% slopes
	Abutments and rim areas	
Soil Conditions:		
USCS	Foundation and reservoir	SM – Silty Sand
	Abutments and rim areas	
Depth to water table	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Capacity of the most limiting layer to transmit water (K_{sat})	Foundation and reservoir	Moderately high to high (0.57 to 1.98 inches/hour)
	Abutments and rim areas	
Drainage class	Foundation and reservoir	Well drained
	Abutments and rim areas	
Depth to any soil restrictive layer	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Suitability:		
Pond reservoir areas	Very limited	Seepage, slope

Table 5-28
Geologic Conditions – Site NFK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped geologic unit(s)	Foundation and reservoir	Pleistocene recessional outwash deposits (Qvr)
	Abutments and rim areas	
Slope Stability:		
Landslides and existing slope movements	None mapped within the reservoir footprint; alluvial fan (Qf) deposits abut north side of site	
Structures:		
Potentially active faults	None mapped at the site	
Folds, anticlines, etc.	None mapped at the site	

Table 5-29
Seismic Conditions – Site NFK2

Conditions Researched	Applicability	Anticipated Geology or Conditions
Ground motion	MMI 7 Very Strong (Seattle); MMI 6 Strong (Southern Whidbey Island and Cascadia); MMI 5 Moderate (Tacoma)	
Fault rupture	Unlikely	
Liquefaction/lateral spread	Foundation and reservoir	Low
	Abutments and rim areas	Low
NEHRP site soil class	Foundation and reservoir	D
	Abutments and rim areas	D

5.6.10 Constructability

The following constructability issues would need to be considered and addressed as part of further evaluation of a potential storage project at Site NFK2:

- **Access:** As noted in Section 5.6.4, there is access directly to the site via forest roads. The condition of these roads is unknown, and the site is relatively remote. Transport of materials over these roads may be challenging and may require some maintenance.
- **Vegetation and Clearing:** Construction would require clearing of remaining trees and other vegetation for embankment construction and in the area to be inundated by the reservoir.
- **Materials:** Reservoir construction would require substantial earthwork. The intent is that the excavation and fill amounts would be balanced such that only import of very specific materials, such as lining material and sands, would be required. However, a full geotechnical exploration and evaluation would be required to determine subsurface soil characteristics and evaluate the potential for sourcing embankment materials from the site. Availability of

imported aggregate materials, liner material, pipe, mechanical control equipment, and other materials would need to be verified.

- **Seasonal Complications:** Construction during the wet season (October through April) would require installation of controls to prevent erosion of bare surfaces and stockpiles and the discharge of sediment-laden water from the site. In addition, placement and compaction of materials will be affected by excessive moisture or freezing temperatures. Because this site is at higher elevation, the seasonal complications may be more significant than they would be at lower sites where precipitation is less and winter weather does not last as long.

5.6.11 Opinion of Cost

A preliminary opinion of the probable costs associated with implementing the project at Site MFK2 was prepared as part of the screening analysis (based on July 2020 dollars). The opinion of probable costs was updated and refined as part of this more detailed analysis according to the assumptions and with the allowances noted for Site CCK2 in Section 5.1.11.

An evaluation of potential annual O&M costs was also completed to quantify costs associated with operating and maintaining a reservoir at Site NFK2. These costs were estimated based on O&M of facilities that are similar in size and scope. The costs assume salary and benefits for a government employee at a rate of 1/4 FTE, administrative costs, transportation costs, supplies, and maintenance, repairs, and contracted labor. Table 5-30 provides a summary of the opinion of probable implementation and long-term operating costs for the project. Additional detail is included in Appendix E.

Table 5-30
Opinion of Probable Implementation and O&M Costs, Site NFK2

Cost Item	Opinion of Probable Cost
Project Implementation Costs	
Site Work	$754,200
Construction of Earthen Embankment	$8,652,900
Construction of Piping and Conveyance Facilities	$133,800
Construction of Emergency Overflow Spillway	$120,000
Construction Subtotal	**$9,661,000**
Mobilization and Demobilization (7.5%)	$724,575
Construction Total	**$10,386,000**
Environmental Mitigation (10%)	$1,038,600
Contingency (30%)	$3,115,800
Engineering, Permitting, and Administration (15%)	$1,557,900
Sales Tax (9.5%)	$1,381,338
Allowance for Land Acquisition	$650,831
Total Project Implementation Cost	**$18,130,000**
Long-Term Operating Costs:	
Salaries	$20,000
Benefits	$8,000
Administration	$2,000
Transportation	$2,000
Supplies	$10,400
Maintenance and Repairs	$10,400
Contracted Labor	$10,400
Total Long-Term Operating Costs	**$63,200**

Notes:
1. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
2. The subtotals and construction total are rounded to the nearest $1,000.
3. Costs are based on planning-level concept evaluation for the reservoir. Costs will vary as the concepts are evaluated in more detail and additional information becomes available to support project development.

5.7 Site MFK1: DNR – MF Snoq

5.7.1 Site Background

Site MFK1 is located in the Middle Fork Snoqualmie subbasin in the southern part of the Snoqualmie River Watershed. The site is a large, gently sloping, heavily forested area near the base of a steep ridge east of Mount Si. The site is owned by DNR and is part of a large tract of land managed as trust lands acquired through the Forest Legacy Program.

5.7.2 Landowner Coordination and Site Visit

DNR was contacted to review this site and other sites under consideration for water storage projects (Site CCK2; Section 5.1). Discussion specific to this property and other properties owned by DNR that are being evaluated in detail primarily occurred during fall 2021. During a virtual meeting on October 19, 2021, SVWID and Anchor QEA provided a summary of the potential project to DNR personnel. Notes from that meeting are included in Appendix D. The primary concerns expressed by DNR specific to this property are similar to those outlined in Section 5.1.2.

In addition, DNR indicated that properties that are managed under trust acquired through the Forest Legacy Program have conditions that restrict the use of the land to primarily forest uses and timber harvest. DNR believes that construction of storage on lands acquired through the Forest Legacy Program, including Site MFK1, would not be allowed under the uses prescribed in deeds for those lands.

As noted in Section 5.1.2, Anchor QEA engaged in a follow-up discussion with DNR. DNR's Acting Assistant Region Manager reiterated the concern that the proposed storage project at Site MFK1 would not be compatible with carrying out their trust responsibilities on the land and the restricted uses of the land.

Due to the concerns and position communicated by DNR relative to this potential project, a site visit was not completed to Site MFK1.

5.7.3 Proposed Storage Concept

The proposed storage concept is to harvest timber from a large area of the property and perform mass earthwork to construct a large impoundment to store water from areas upslope of the reservoir and water captured from tributaries that flow from the ridge north of the site. The proposed reservoir is shown relative to the basin that would be tributary to the point at which water would be diverted to the reservoir and areas upslope of the reservoir in Figure 5-7A. The embankment and reservoir are shown over LiDAR topography in Figure 5-7B.

Construction would likely be preceded by harvest of the timber and clearing within the relatively large project footprint. The impoundment would be approximately 20 feet deep and would store water to a maximum WSEL of 1,640 feet. The proposed reservoir would inundate approximately 174 acres when full. Water would be released through a pipeline or other constructed conveyance down the unnamed tributary to the Middle Fork Snoqualmie River.

5.7.4 Site Access and Constraints

Site MFK1 is less remote than other sites and there are several well-established roads that would make access to the site relatively easy. SE Mount Si Road and NFD 9010-1 Road run through the vicinity, and existing forest roads further connect the site to established main roads.

The primary constraint at this site is the presence of the actively managed tree farm and trust lands with restricted uses. As noted previously, DNR has indicated that use of the site for water storage would not be compatible with their management of the site, trust obligations, and the uses of the site allowed under the deed for the property. Other constraints may include availability of water to fill a reservoir of this size, and ability to release water without overwhelming the downstream tributary to the Middle Fork Snoqualmie River.

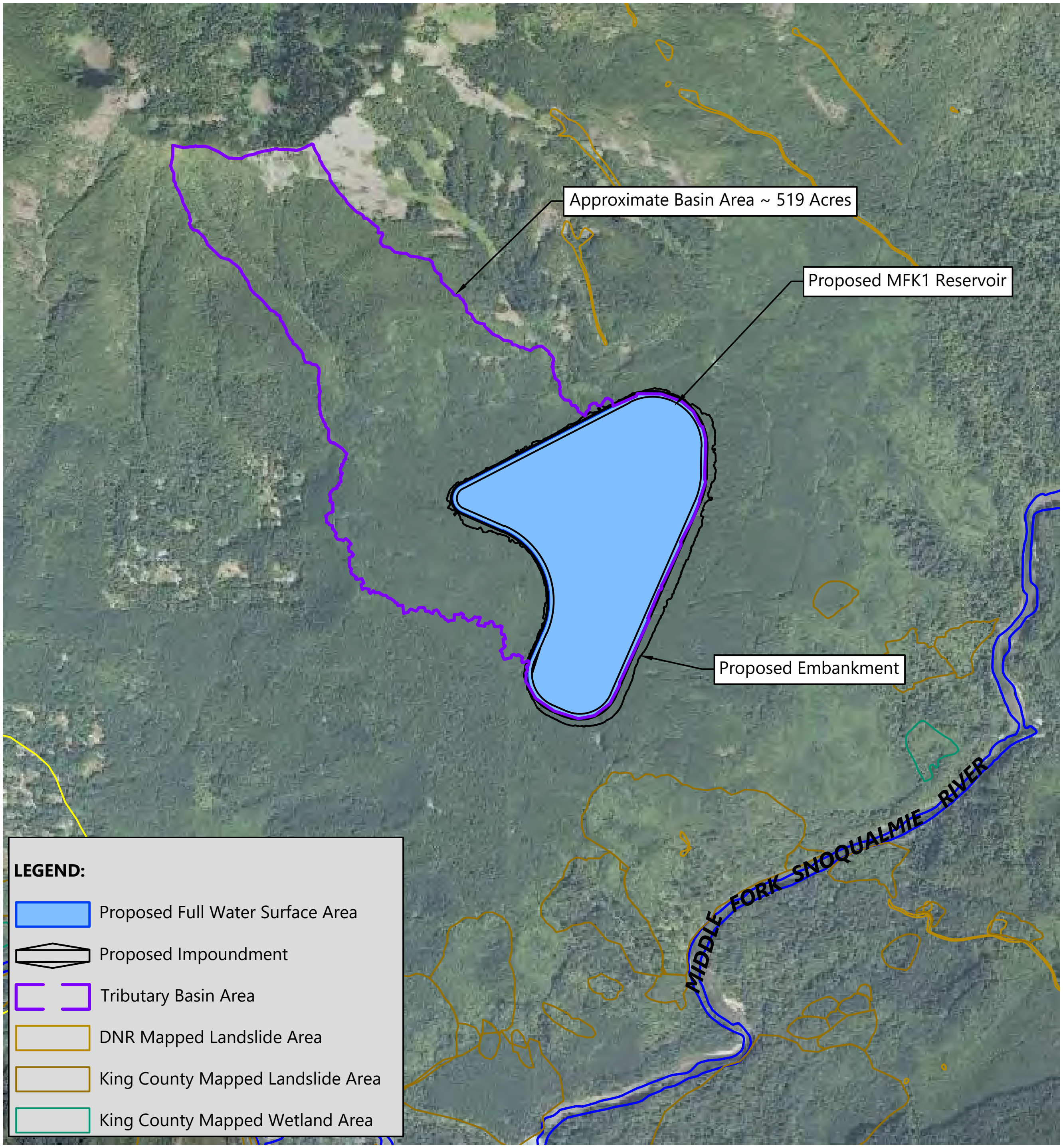
5.7.5 Source of Stored Water

The proposed reservoir at Site MFK1 would be filled by capturing runoff from areas upslope (northwest) of the site, and by diverting water from tributaries that convey runoff from the ridge just north of the site. LiDAR data were used in ArcGIS to delineate the tributary basin that flows to the proposed reservoir site. The area of the tributary basin was estimated to be approximately 519 acres (0.81 square mile).

5.7.6 Hydrologic and Hydraulic Analyses

A WWHM hydrologic model was prepared to model the rate and volume of runoff that could be captured by or diverted to the reservoir at Site MFK1 for storage. For the period of record modeled (Water Years 1949 to 2009), the estimated average annual runoff volume that could be captured at points of diversion on the adjacent tributaries, or from areas upslope of the proposed reservoir at Site MFK1, was estimated to be 1,218 acre-feet. The annual runoff volume was estimated to range from 787 to 1,953 acre-feet.

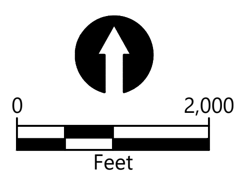
A stage-storage volume curve was also developed in AutoCAD Civil 3D for the reservoir based on the configuration of the proposed embankment and grading of the impounded area. The stage-storage volume curve is plotted in Figure 5-7C. The stage is represented in feet of elevation related to the storage volume in acre-feet. As shown, the full reservoir would store 3,311 acre-feet at an elevation of 1,640 feet.



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

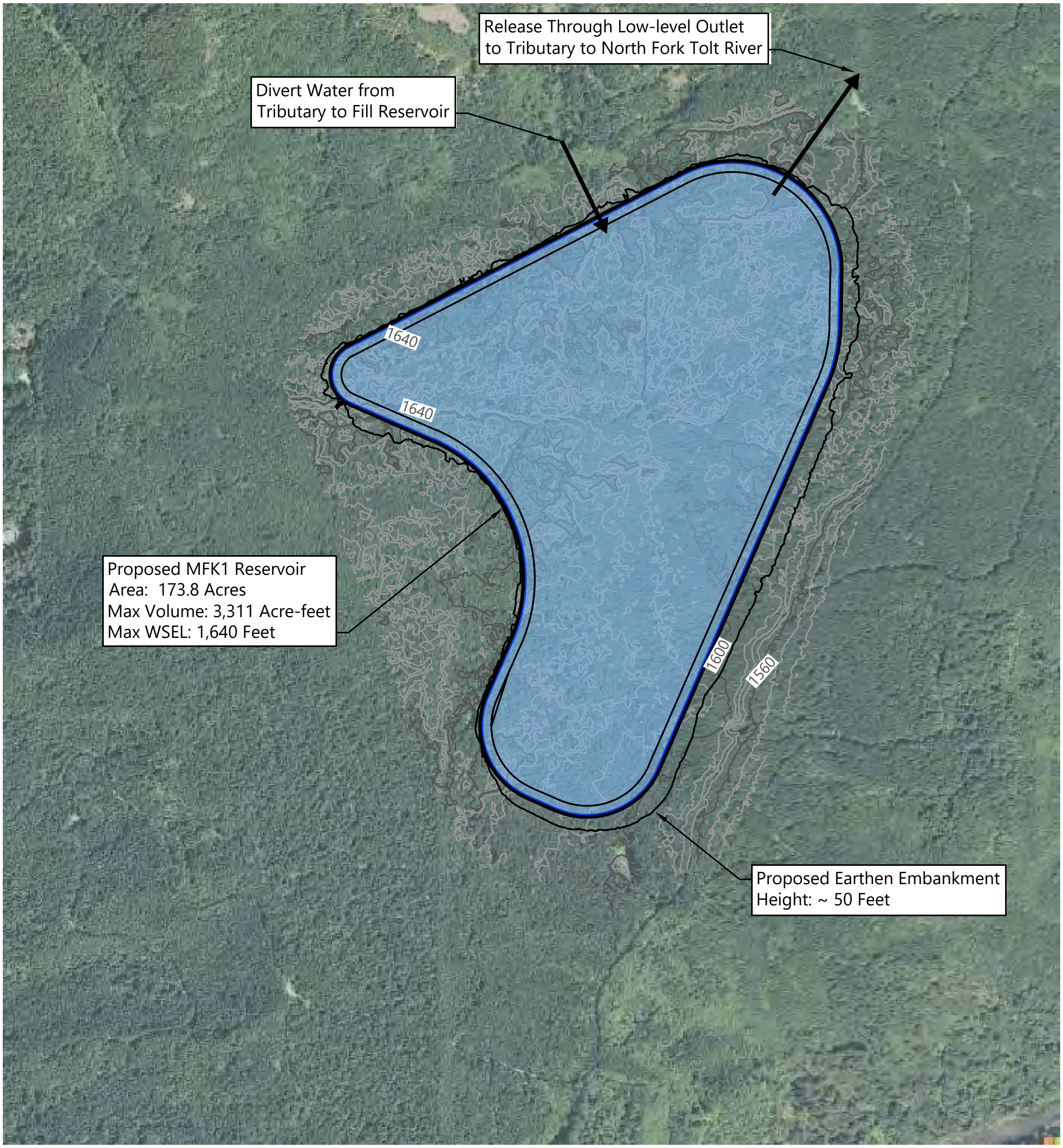
VERTICAL DATUM: NAVD 88



Publish Date: 2022/01/12 3:38 PM | User: drice
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site MFK1.dwg Figure 5-7A

ANCHOR QEA

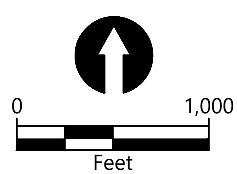
Figure 5-7A
Tributary Basin Area Map - Storage Site MFK1



SOURCE: Aerial ©2021 Microsoft Corporation

HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet

VERTICAL DATUM: NAVD 88



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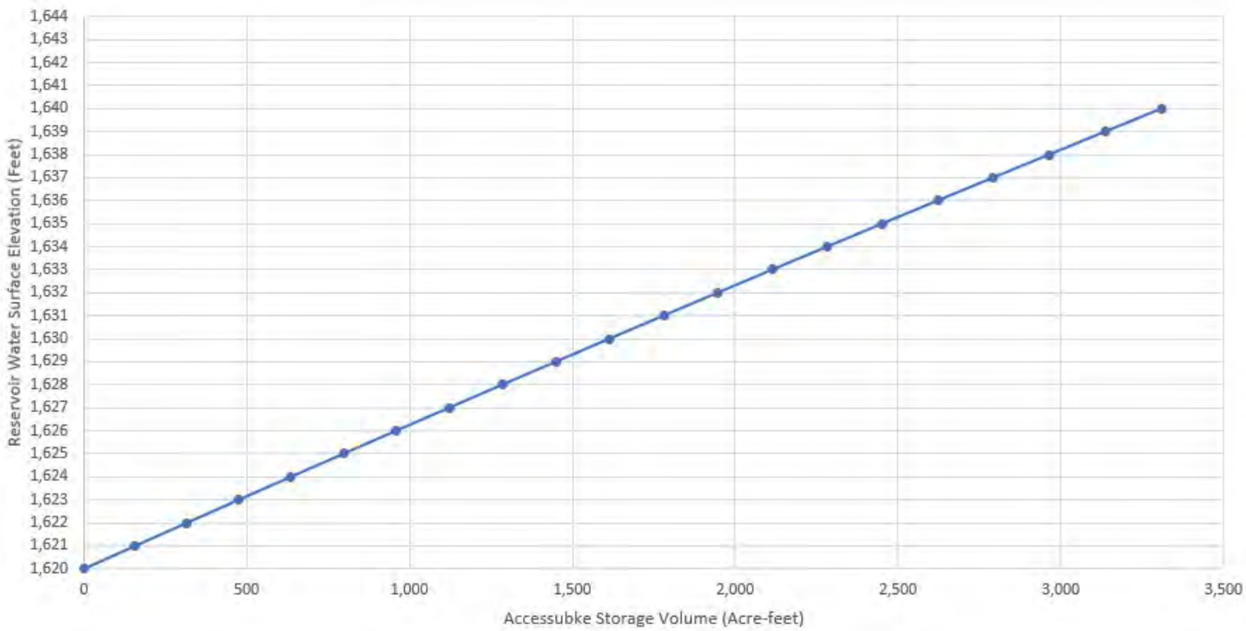
Filepath: L:\Projects\SVWID\Comprehensive Water Storage Study\CAD\SVWID Comp Storage_Site MFK1.dwg Figure 5-7B

ANCHOR QEA

Figure 5-7B
Site Map - Storage Site MFK1

Snoqualmie Watershed
Comprehensive Storage Study

Figure 5-7C
Stage-Storage Curve – Storage Site MFK1



5.7.7 Reservoir Operations

The runoff volumes from the WWHM model were used, along with estimated evaporation rates and the estimated stage-storage volume curve, to develop a reservoir operations and water balance model. The purpose of the model was to estimate when flows would be captured and released from the reservoir at Site MFK1, and to estimate the probability of refill given hydrology of the tributary basin and the targeted size and storage capacity of the reservoir. This model estimated the inflows and outflows from the proposed reservoir at Site MFK1 on a monthly basis for the 61-year modeling period of record. Outflows include evaporation and reservoir release to the unnamed tributary of the Middle Fork Snoqualmie River. The water balance model was adjusted to determine potential release rates during the late summer as an example of how a reservoir at Site MFK1 could be operated to augment flows in the Middle Fork Snoqualmie River. Table 5-31 summarizes findings from the water balance model for Site MFK1.

Table 5-31
Water Balance Model Results – Site MFK1

Parameter Evaluated	Result
Targeted Capacity	3,311 acre-feet
Area of Tributary Basin	519 acres
Average Annual Runoff	1,218 acre-feet
Maximum Annual Runoff	1,953 acre-feet
Minimum Annual Runoff	787 acre-feet
Average Late-Summer Release Rate Available	14 cfs
Average Days Release Available in Late Summer	29.5 days
Average % of Targeted Reservoir Volume Filled	34.7%
Maximum % of Targeted Reservoir Volume Filled	59.4%

Based on inflows to the proposed reservoir, the size of the reservoir that was targeted, and other assumed inputs used for the water balance model, the model indicates that there would not be enough flow upslope of the reservoir to completely fill a reservoir of this size, even during very wet years. The reservoir would only partially fill during the wettest year that was evaluated. During average and drier than average years, the reservoir would not refill. Based on the results from the water balance model, 14 cfs could be released from the reservoir for an average of 29.5 days during late-summer months to increase streamflow in the Middle Fork Snoqualmie River. If this project were to be advanced for further analysis, smaller storage capacities would need to be evaluated to balance the size of the impoundment, storage capacity, and cost of the reservoir with the volume of runoff volume that can reliably be captured and stored in the reservoir.

5.7.8 Water Quality Impacts

Section 5.1.8 provided a general overview of potential water quality impacts that could result from construction of any reservoir with the Snoqualmie River Watershed. The potential impacts include increased temperature in downstream streams and rivers caused by warming of water in the reservoir; degraded water quality conditions resulting from nutrient loading, algae growth, and a decrease in DO at the bottom of the reservoir; and accrual and release of toxic contaminants.

Considering the potential for these impacts, the following key characteristics that may influence water quality were noted for the proposed reservoir at Site MFK1:

- The reservoir elevation (full WSEL ~1,600 feet) would be high in the watershed relative to the other six sites, which would likely mean capture and storage of cooler water and cooler ambient temperatures in the summer.
- The reservoir would be moderately deep compared to the other six reservoirs and would have the largest surface area.

- The reservoir would be created by clearing a large area and would have little potential for shading of the water surface.
- The reservoir does not appear to be downstream of any fertilized areas where high nutrient loading would be expected.
- The reservoir does not appear to be downstream of any sources of toxic contaminants.

Based on these key characteristics and observations, the following are anticipated relative to water quality impacts and potential ways to mitigate for those impacts through design and operation:

- Temperature could be impacted by water storage because of the large surface area and moderate depth of the reservoir. If a reservoir at this site were developed further, an evaluation of potential reservoir configurations would need to be completed to evaluate whether a deeper reservoir with less surface area would be feasible to minimize impacts on water temperatures. The temperature of stored water and releases could also be monitored, and a multi-port outlet could be provided to allow for releases from the coolest part of the reservoir. Additional analysis, including water quality modeling and research of water quality in similar nearby lakes, would be needed to better understand potential impacts to water temperature.
- Degradation of water quality due to nutrient loading, toxic algal blooms, and low DO concentrations is anticipated to be less likely in this reservoir due to the overall size and volume of the reservoir. However, additional analysis would be required to better understand the potential for nutrient impacts, algae growth, and reduced DO concentrations. Aeration or management techniques, such as planting of vegetation to discourage waterfowl from adding nutrients to the reservoir, could be considered.
- No release of toxics or contamination in stored water is anticipated.

5.7.9 Non-Exploratory Soils and Geology

The primary soil and geology conditions to consider for Site MFK1 are the high hydraulic conductivity of the near-surface soils and the thick deposits of unconsolidated lithology. Geology at the site is mapped as recessional outwash deposits of the Vashon Stade of the Fraser glaciation, consisting of stratified sand and gravel, moderately to well sorted, and well-bedded silty sand to silty clay deposited in proglacial and ice-marginal environments.

The primary geologic hazards to consider in planning and development are nearby steep slopes, and potential and mapped landslides that abut the north and south sides of the site.

The primary seismic hazard is Strong (MMI 6) to Very Strong (MMI 7) ground shaking as modeled during southern Whidbey Island, Seattle, Tacoma, and Cascadia events. The soils and rocks near the surface can modify bedrock ground shaking caused by an earthquake. This modification can increase (or decrease) the strength of shaking or change the frequency of the shaking. The nature of the modifications is determined by the thickness of the geologic materials and their physical properties, such as stiffness or relative density. Summaries of soil, geologic, and seismic conditions are included in Tables 5-32 to 5-34.

Table 5-32
Soil Conditions – Site MFK1

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped soil unit(s)	Foundation and reservoir	237—Skykomish gravelly sandy loam, 0% to 30% slopes
	Abutments and rim areas	
Soil Conditions:		
USCS	Foundation and reservoir	SM – Silty Sand
	Abutments and rim areas	
Depth to water table	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Capacity of the most limiting layer to transmit water (K_{sat})	Foundation and reservoir	High (1.98 to 5.95 inches/hour)
	Abutments and rim areas	
Drainage class	Foundation and reservoir	Somewhat excessively drained
	Abutments and rim areas	
Depth to any soil restrictive layer	Foundation and reservoir	More than 80 inches
	Abutments and rim areas	
Suitability:		
Pond reservoir areas	Very limited	Seepage, slope

Table 5-33
Geologic Conditions – Site MFK1

Conditions Researched	Applicability	Anticipated Geology or Conditions
Mapped geologic unit(s)	Foundation and reservoir	Pleistocene recessional outwash deposits (Qvr)
	Abutments and rim areas	
Slope Stability:		
Landslides and existing slope movements	None mapped within the reservoir footprint; descending slopes toward the Middle Fork Snoqualmie River on the south of the site are mapped as high risk, potential landslide, or landslide areas; small landslides are mapped on the ascending slopes north of the site	
Structures:		
Potentially active faults	None mapped at the site	
Folds, anticlines, etc.	None mapped at the site	

Table 5-34
Seismic Conditions – Site MFK1

Conditions Researched	Applicability	Anticipated Geology or Conditions
Ground motion	MMI 7 Very Strong (Seattle); MMI 6 Strong (Tacoma, Southern Whidbey Island, and Cascadia)	
Fault rupture	Unlikely	
Liquefaction/lateral spread	Foundation and reservoir	Low
	Abutments and rim areas	Low
NEHRP site soil class	Foundation and reservoir	C to D
	Abutments and rim areas	C to D

5.7.10 Constructability

The following constructability issues would need to be considered and addressed as part of further evaluation of a potential storage project at Site MFK1:

- **Access:** As noted in Section 5.7.4, there is access directly to the site via forest roads. DNR has indicated that access to a portion of the site would be through private land, which may complicate identification of haul routes and transport of materials.
- **Vegetation and Clearing:** Construction would require clearing of trees and other vegetation for embankment construction and in the area to be inundated by the reservoir. The portions of Site MFK1 that would be impacted by the reservoir would likely need to be harvested prior to construction of the reservoir.
- **Materials:** Reservoir construction would require substantial earthwork. This reservoir would be larger and would require more earthwork than any of the other reservoirs considered. The intent is that the excavation and fill amounts would be balanced such that only import of very specific materials, such as lining material and sands, would be required. However, a full geotechnical exploration and evaluation would be required to determine subsurface soil characteristics and evaluate the potential for sourcing embankment materials from the site. Availability of imported aggregate materials, liner material, pipe, mechanical control equipment, and other materials would need to be verified.
- **Seasonal Complications:** Construction during the wet season (October through April) would require installation of controls to prevent erosion of bare surfaces and stockpiles and the discharge of sediment-laden water from the site. In addition, placement and compaction of materials will be affected by excessive moisture or freezing temperatures. Because this site is at higher elevation, the seasonal complications may be more significant than they would be at lower sites where precipitation is less and winter weather does not last as long.

5.7.11 Opinion of Cost

A preliminary opinion of the probable costs associated with implementing the project at Site MFK1 was prepared as part of the screening analysis (based on July 2020 dollars). The opinion of probable costs was updated and refined as part of this more detailed analysis according to the assumptions and with the allowances noted for Site CCK2 in Section 5.1.11.

An evaluation of potential annual O&M costs was also completed in an effort to quantify costs associated with operating and maintaining a reservoir at Site MFK1. These costs were estimated based on O&M costs of facilities that are similar in size and scope. The costs assume salary and benefits for a government employee at a rate of 1 FTE, administrative costs, transportation costs, supplies, and maintenance, repairs, and contracted labor. Table 5-35 provides a summary of the opinion of probable implementation and long-term operating costs for the project. Additional detail is included in Appendix E.

Table 5-35
Opinion of Probable Implementation and O&M Costs, Site MFK1

Cost Item	Opinion of Probable Cost
Project Implementation Costs	
Site Work	$4,592,300
Construction of Earthen Embankment	$60,505,800
Construction of Piping and Conveyance Facilities	$1,194,600
Construction of Emergency Overflow Spillway	$360,000
Construction Subtotal	**$66,653,000**
Mobilization and Demobilization (7.5%)	$4,998,975
Construction Total	**$71,652,000**
Environmental Mitigation (10%)	$7,165,200
Contingency (30%)	$21,495,600
Engineering, Permitting, and Administration (15%)	$10,747,800
Sales Tax (9.5%)	$9,529,716
Allowance for Land Acquisition	$4,196,861
Total Project Implementation Cost	**$124,787,000**
Annual Operations and Maintenance Costs:	
Salaries	$80,000
Benefits	$32,000
Administration	$8,000
Transportation	$4,000
Supplies	$71,700
Maintenance and Repairs	$71,700
Contracted Labor	$71,700
Annual Operations and Maintenance Costs	**$339,100**

Notes:
1. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
2. The subtotals and construction total are rounded to the nearest $1,000.
3. Costs are based on planning-level concept evaluation for the reservoir. Costs will vary as the concepts are evaluated in more detail and additional information becomes available to support project development.

5.8 Scoring, Ranking, and Comparison of Highly Ranked Sites

Another round of scoring and ranking of the sites was completed based on the additional analysis of these sites using the same methodology that was used for the screening analysis. Scoring of site-specific criteria was revised based on updated costs, input from landowners about the potential use of each site and restrictions, calculations to estimate the flows and volumes of water available to fill each reservoir, an estimate of the rate and volume of water that could be released from each reservoir to improve instream flows, potential water quality impacts, constraints, and constructability issues. The updated scoring was then recombined with the scoring from the GIS weighted overlay analysis to determine a revised overall scoring for each of the seven sites and a ranking relative to the other sites that were evaluated in detail. Table 5-36 provides a summary of the revised scoring and ranking of the sites resulting from the detailed evaluation.

Table 5-36
Revised Storage Site Favorability Scoring and Ranking – Detailed Evaluation

Project ID	Overall Rank from Screening Analysis	Rank from Detailed Analysis	Description	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	1	1	Snoqualmie Timber - NF Tolt (C)	3.69	4.04	3.34
TOK3	3	2	Klaus Lake	3.61	3.95	3.27
MFK1	2	3	DNR - MF Snoq	3.48	3.68	3.28
TOK2	6	4	Bridges Lake	3.45	3.95	2.96
NFK2	4	5	Snoqualmie Timber - NF Snoq (B)	3.40	3.69	3.11
TOK4	10	6	Black Lake	3.38	3.81	2.96
CCK2	9	7	Cherry Lake	3.32	3.52	3.12

5.9 Land Use Considerations

In response to comments provided by the landowners of the properties targeted for water storage by this analysis, Anchor QEA worked with AMP Insights to outline specific considerations related to land use and potential for securing land for water storage. This information is outlined in a memorandum included in Appendix F. The memorandum outlines considerations for sites located on DNR and private timberland. Information is also provided for future consideration of water service on lands managed by the U.S. Forest Service (USFS). In general, storage on USFS lands was not considered for this study because it was anticipated that securing a special use authorization for storage on USFS-managed lands would likely not be feasible.

It is apparent from the results of this detailed analysis and discussion with landowners that successful development and implementation of a storage project within the watershed will require purchasing or leasing land that has an existing use. For the projects identified in this study, the primary land use that would be impacted by a storage project is timber harvest. That impact would need to be reflected in the land purchase or lease agreement. Land purchase or lease will require a major financial commitment from project funders and watershed partners. More discussion and study are needed to better understand the cost of purchasing and leasing land for water storage, and to determine the level of investment that project funders and watershed partners are willing to make in this pursuit.

6 Permitting and Regulatory Requirements

This section summarizes anticipated permitting and regulatory requirements for implementation of a storage project at the seven storage sites that were advanced through the detailed evaluation outlined in Section 5. Likely permits that would be required, the thresholds that trigger permit requirements, and anticipated timing for permit reviews were identified for each site. Table 6-1 at the end of this section summarizes the information.

6.1.1 Federal Permits and Approvals

If federal funding is received for a storage project, the agency providing funding would be the lead agency for the project. If no federal funding is provided, the U.S. Army Corps of Engineers (USACE) would be the federal lead agency for the project, due to in-water work that would likely be required for each project in tributaries, streams, or rivers designated as Waters of the United States. An individual permit (Clean Water Act Section 404 permit) would likely be required for each project. A Joint Aquatic Resources Permit Application (JARPA) form would be prepared and submitted to the USACE to initiate review. As the federal lead agency, the USACE would initiate consultation with other agencies requiring permits and approvals. Agency consultation may include the following:

- National Marine Fisheries Service and U.S. Fish and Wildlife Service (known as "the Services"), for ESA Section 7 compliance
- Washington Department of Archaeology and Historic Preservation (DAHP), for National Historic Preservation Act Section 106 compliance
- Ecology, for Clean Water Act Section 401 water quality certification

The USACE Section 404 permit is required for any discharge of dredge or fill material into designated Waters of the United States. This permit may not be required if in-water excavation or filling activities are not required as part of the project. However, it is anticipated that some in-water work will be required for each of the projects.

Should the project activities impact less than ¼ acre of Waters of the United States, the USACE has a Nationwide Permit (NWP) 40, which is a programmatic permit that allows several types of activities and would take the place of an individual permit. Coverage of the Section 401 permit is determined in consultation with Ecology during the permit review process. The review timeframe for individual permits is typically 9 to 18 months from a complete application determination and includes a public notice process. If a Clean Water Act Section 401 Water Quality Certification is required, a joint public notice process may occur in coordination with Ecology. For NWPs, the review timeframe is reduced (generally 6 to 12 months from complete application determination). The NWP process does not include a public notice. These timeframes are contingent on the consultation process with other agencies.

ESA-listed aquatic and terrestrial species are likely to be impacted by the projects considered. To demonstrate ESA Section 7 compliance, a Biological Assessment is typically prepared for projects that require individual permits or are determined to have an effect on listed species. The consultation process is initiated by USACE and a concurrence letter or Biological Opinion is issued by the Services. For repair and maintenance projects, or a project with limited potential effects, a short-form Biological Evaluation may be applicable to initiate consultation with the Services. The timeframe for ESA review is incorporated within the USACE permit timeframe because USACE permits are not issued until consultation is complete.

USACE also consults with Ecology for Clean Water Act Section 401 compliance as part of the federal permitting review process. Clean Water Act Section 401 compliance is required for projects that propose discharge of dredge or fill material in Waters of the United States and for projects requiring compliance with Washington State Water Quality Surface Water Standards (WAC 173-201A). Projects proposing discharge of dredge or fill material are typically issued a Water Quality Certification. If the project qualifies as repair and maintenance, Section 401 compliance can be incorporated with the NWP, and a separate Water Quality Certification is not issued. The timeframe for Clean Water Act Section 401 review is incorporated within the USACE permit timeframe because USACE permits are not issued until consultation is complete.

The USACE will review the project under Section 106, which requires federal agencies to evaluate the effects of their undertakings on historic properties in consultation with the State Historic Preservation Officer (SHPO) and Native American Tribes. The USACE will make determinations of NRHP eligibility for any potential historic properties, and a determination of project effects. SHPO and Tribes have the opportunity to comment on determinations. If adverse effects to historic properties are identified, the USACE will consult to avoid, minimize, and mitigate the effects.

6.1.2 State Permits and Approvals

The Washington Department of Fish and Wildlife (WDFW) regulates work that uses, diverts, obstructs, or changes the natural flow or bed of any of the salt or fresh waters of the state, including projects landward of the ordinary high-water mark (OHWM) (e.g., activities outside the OHWM that will directly impact fish life and habitat). Because the proposed storage projects include work in and adjacent to waters of the state, a WDFW Hydraulic Project Approval (HPA) would be required. HPA review begins once a State Environmental Policy Act (SEPA) determination is issued and takes up to 45 days. No public notice is required.

Additional state permit reviews for potential storage projects would likely include the following:

- National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit coverage, to ensure that planned construction activities meet Ecology’s requirements for prevention and control of stormwater pollution during construction of the projects.

- If the project requires that on-site sand and gravel be quarried for embankment construction, an Ecology Sand and Gravel Permit will be required.
- For use of state-owned aquatic lands, including rivers and streams where DNR owns the land, an Aquatic Lands use Authorization Notification is required from DNR.
- Water rights (see Section 6.1.6).
- Dam Construction Permit (see Section 6.1.7).

6.1.3 Local Permits and Approvals

A local jurisdiction, such as King County, would likely be the lead agency for SEPA compliance and could issue a Determination of Non-Significance (DNS) or Mitigated DNS for the project. A completed SEPA checklist is required to make this determination. The SEPA review will require a minimum 14-day public notice period. If a threshold determination is made that the project would have significant impacts that cannot be avoided or mitigated to nonsignificance, a SEPA environmental impact statement (EIS) would be required and compensatory mitigation for significant impacts may be required.

King County would also be the lead agency for other local permits and approvals, providing review for Shoreline Management Act consistency, critical areas regulations compliance, floodplain permit consistency, and building code compliance. Consultation, including a pre-application meeting, would be required with King County to review project concepts and confirm which permits and associated deliverables are required for the project. It is anticipated that the following local permits or approvals could be required:

- Clearing and Grading Permit – Would be required for all of the projects because they would require clearing and grading in close proximity to streams and lakes.
- Critical Areas Ordinance Compliance – Would be required for projects affecting designated critical areas and buffers.
- Floodplain Permit – Would be required for work within a designated floodplain.
- Building Permit – May be required for structures associated with impounding water.

6.1.4 Permitting Requirements Summary

Table 6-1 provides a summary of local, state, and federal permits and approvals that may be required for the seven projects considered by the detailed evaluation outlined in Section 5. These are summarized based on professional experience, the high-level concept developed for each project, and review of regulatory requirements. The requirements will need to be confirmed through additional consultation with regulatory agencies and may change when the details of each project and their impacts are better understood. The summary table outlines permit triggers, the anticipated time frame for agency review, and general permit submittal requirements.

Table 6-1
Summary – Anticipated Permitting Requirements for Selected Storage Projects

Summary of Permits for Water Storage Projects					Anticipated Requirements for Highly Ranked Storage Projects						
Permit	**Agency**	**Trigger**	**Review Time Frame**	**Notes**	**CCK2**	**NFT4**	**TOK2**	**TOK3**	**TOK4**	**NFK2**	**MFK1**
Federal Permits or Approvals											
Section 404 Permit	USACE	Discharge of dredged or fill material to waters of the United States under Clean Water Act Section 404.	9 to 18 months.	This permit would apply to proposed impacts to a tributary or waterbody that is considered a water of the United States. A JARPA form would be prepared for USACE. USACE takes jurisdiction for any activities below the OHWM and adjacent freshwater wetlands.	✓	✓	✓	✓	✓	✓	✓
Section 7 ESA	USACE with Services	Proposed activity that may affect species listed under ESA Section 7 (triggered through Section 404 permit application).	9 to 18 months.	USACE coordinates with Services to ensure potential impacts on fish and wildlife species are adequately addressed. A Biological Assessment would be prepared and submitted with the JARPA.	✓	✓	✓	✓	✓	✓	✓
National Historic Preservation Act Section 106 Concurrence	DAHP	Application for Section 404 permit for projects with the potential to affect historic properties (including archaeological sites).	9 to 18 months.	If impacts are identified, a Section 106-compliant Cultural Resources Assessment would be prepared and submitted with the JARPA.	✓	✓	✓	✓	✓	✓	✓
State Permits or Approvals											
Section 401 Water Quality Certification	Ecology	Proposed discharge of dredged or fill materials in water or non-isolated wetlands.	6 to 12 months.	A JARPA would be prepared and submitted to Ecology.	✓	✓	✓	✓	✓	✓	✓
State of Washington Administrative Order to Conduct Work in Isolated Wetlands or Other Waters	Ecology	Proposed discharge of fill material to non-federally jurisdictional wetlands and other waters under the Washington State Water Pollution Control Act.	9 to 12 months.	A JARPA would be prepared and submitted to Ecology.	✓	✓[1]	✓	✓	✓	✓[1]	✓
Hydraulic Project Approval	WDFW	Proposed work below the OHWM in waters of the State of Washington. Required for work that uses, diverts, obstructs, or changes the flow or bed of state waters or affects fish habitat.	Up to 45 days after SEPA determination.	An online application would be submitted to WDFW. Compliance would be handled through the JARPA review process.	✓	✓	✓	✓	✓	✓	✓
NPDES Construction Stormwater General Permit	Ecology	Proposed clearing, grading, and/or excavation resulting in the disturbance of 1 acre or more of land and discharge of stormwater to surface waters of the state.	Approximately 60 days.	Application would be prepared and submitted online using Ecology's WQWebPortal.	✓	✓	✓	✓	✓	✓	✓
Ecology Sand and Gravel Permit	Ecology	Proposed projects that quarry on-site sand and gravel for use in construction to reduce construction costs.	Approximately 60 days.	Application would be prepared and submitted to Ecology.	✓	✓				✓	✓
Aquatic Lands Use Authorization Notification	DNR	Proposed use of state-owned aquatic lands, including adjacent lands. Aquatic lands include the beds of Puget Sound; navigable rivers, lakes, and other waters; and much of the tidelands (land covered and exposed by the tide) and shorelands of lakes and other fresh waters. Coordination with DNR is required to verify whether the Project will require an Aquatic Land Use Authorization.	6 to 9 months.	A JARPA and JARPA Attachment E would need to be submitted to DNR.	✓						✓

Summary of Permits for Water Storage Projects					Anticipated Requirements for Highly Ranked Storage Projects						
Permit	**Agency**	**Trigger**	**Review Time Frame**	**Notes**	**CCK2**	**NFT4**	**TOK2**	**TOK3**	**TOK4**	**NFK2**	**MFK1**
Water Right	Ecology	Proposal to divert, capture, and store water.	Depends on the complexity of the application. There is no prescribed decision timeline.	Application for a new interruptible water right would be prepared to divert water to storage. Application for a surface reservoir permit would be required to store water in a reservoir.	✓	✓	✓	✓	✓	✓	✓
Dam Construction Permit	Ecology	Proposed dams and supplemental structures that impound or control more than 10 acre-feet of water.	Approximately 60 days.	Coordination with Ecology's Dam Safety Office would be required early in project development. An Application for Dam Construction Permit would be prepared and submitted to Ecology. Final review of design drawings, specifications, and reports outlined in guidance manuals would be required prior to issuing a Dam Construction Permit.	✓	✓	✓	✓	✓	✓	✓
Local Permits or Approvals											
SEPA Determination	SEPA Lead Agency to be determined (Potentially Snoqualmie Valley Watershed Improvement District)	Projects that require a local agency decision.	Approximately 9 to 18 months.	Any proposal that requires a state or local agency decision to license, fund, or undertake a project, or the proposed adoption of a policy, plan, or program can trigger environmental review under SEPA. For proposals unlikely to have a significant adverse environmental impact or that include sufficient mitigation, the lead agency will issue a DNS. This action may trigger a public and agency comment period. When mitigation cannot be easily identified, an EIS is required to assess the proposal and identify reasonable alternatives to reduce or eliminate adverse environmental impacts.	✓	✓	✓	✓	✓	✓	✓
Clearing and Grading Permit	King County	Any amount of grading around a critical area.	Approximately 90 days.	A preapplication meeting may be required. Permit application can be submitted online through mybuildingpermit.com.	✓	✓	✓	✓	✓	✓	✓
Critical Areas Ordinance Compliance	King County	Projects affecting designated critical areas or buffers.	Approximately 3 to 6 months.	A Critical Areas Report may be required and would be submitted to King County with the SEPA checklist.	✓	✓	✓	✓	✓	✓	✓
Floodplain Development Permit	King County	Work within a County-designated floodplain or channel migration hazard area, or work on a site or lot that contains or is adjacent to a flood hazard area even if the flood hazard area has not yet been delineated by King County or FEMA. Includes streams, lakes, and closed depressions having a surface area of 5,000 square feet or more.	6 to 9 months	A floodplain development permit will expire if no work occurs after 180 days.	✓	✓	✓	✓	✓	✓	✓
Building Permit	King County	Proposed development within King County.	6 to 9 months.	A pre-application meeting may be required. Permit application can be submitted online through mybuildingpermit.com.	✓	✓	✓	✓	✓	✓	✓

6.1.5 Water Rights

Application for a new interruptible water right would be required to divert water from a tributary or to capture runoff from an upslope tributary area for storage. Application for a surface reservoir permit would be required to store water in a reservoir and control the release of that water to meet downstream needs. If a storage project was developed and funded with the intent of providing an instream flow benefit, documentation would be needed to demonstrate that a mechanism would be provided for protecting that water in stream (such as a trust water right agreement). If water was made available from storage for specific uses downstream, new water right applications would need to be prepared for those diversions as well. As noted in Section 2.1, subbasins that are closed to future water rights appropriations under WAC 173-507 were not considered for storage projects.

6.1.6 Dam Safety Consultation, Dam Construction Permit

Ecology's Dam Safety Office (DSO) regulates all structures that impound more than 10 acre-feet of water measured above the downstream elevation of the outlet or toe of the impounding structure. Early and frequent coordination with DSO will be key to the success of any of the storage projects that were evaluated. A Dam Construction Permit application would need to be completed and submitted with the supporting design documentation. The final Dam Construction Permit application and supporting documents will include the following:

- A cover letter summarizing the project and introducing the deliverables
- A Dam Construction Permit application
- Engineering reports, including:
  - Geotechnical engineering reports
  - Hydraulics and Hydrology Report
  - Detailed design drawings
  - Technical specifications
  - Construction Inspection Plan
  - O&M Plan
  - Emergency Action Plan

7 Overview of Natural Storage Project on Stossel Creek

As noted earlier, as part of the scope of work funded through Ecology's Streamflow Restoration Grant, the design team developed preliminary designs for a "natural storage" project. The idea of "natural storage" was introduced in the Small-Scale Storage Study and would generally consist of placing natural materials, such as a beaver dam analog (BDA) or large wood, near the outlets of natural ponds or wetlands to store additional water. Natural storage projects, including installation of BDAs, have been used in watersheds throughout the Pacific Northwest to achieve the following:

- Reverse downcutting
- Enhance groundwater recharge
- Reduce channel velocities and attenuate peak flow rates
- Increase natural storage of water at the surface and in the shallow aquifer

The concept of natural storage, as envisioned when it was introduced in the Small-Scale Storage Study, would be to raise the maximum water surface in an existing pond or wetland by 1 to 2 feet to enhance groundwater recharge, attenuate the release of water, and increase the storage in these natural features. The intended result would be to improve flows throughout the tributary and mainstem during low-flow periods. Increasing natural storage would also enhance fish and wildlife habitat, including habitat for ESA-listed fish species.

The Small-Scale Storage Study identified potential natural storage enhancement project sites in the headwaters of the Cherry Creek and Stossel Creek subbasins. Those sites were reviewed, and ultimately a site on Stossel Creek was selected for further evaluation and preliminary design. A memorandum was prepared that outlines observations made during a site visit, selection of the site on Stossel Creek for the project, and hydrologic and hydraulic analysis completed to support the preliminary design of the natural storage enhancement project. A draft memorandum was submitted to SVWID and Ecology for review in March 2021. The memorandum has since been updated and is included as Appendix B with preliminary design drawings of the natural storage project. This section provides a summary of the information provided in that memorandum.

7.1.1 Site Background

Anchor QEA and SVWID met with DNR to discuss the potential for natural storage projects on DNR property, and then completed a site visit to look at potential natural storage sites in the Cherry Creek and Stossel Creek headwaters. DNR personnel expressed similar concerns to those outlined in Section 5.1 regarding the use of the land and potential liability issues, but were open to looking at the potential for a natural storage project.

The Stossel Creek natural storage enhancement site is located on DNR land on King County Parcel Nos. 1226079005 and 1226079002, in the north half of Section 12, Township 26 North, Range 07

East. It is located approximately 10 miles north-northeast of Carnation on a DNR road, referred to on maps as Stossel Creek Road, that extends north along Stossel Creek from Stossel Creek Way Northeast. The site consists of two distinct, but hydraulically connected, ponds/wetland areas surrounded by brush and trees in the headwaters of Stossel Creek. The lower pond outlets to Stossel Creek approximately 5 miles upstream of its confluence with the Tolt River. The outlet discharges through a relatively narrow channel and crosses the road in a culvert downstream of the site.

7.1.2 Summary of Evaluation

The study of the natural storage site included mapping and evaluation of soils and geology, delineation of the tributary area that contributes flow to the existing pond, calculation of runoff from the tributary area using a hydrologic model, and development of a water balance model to estimate flows to and from the site. Hydrogeology was also reviewed to characterize the likely changes that would result from increased infiltration to the shallow aquifer as a result of the project. Preliminary design drawings were prepared to illustrate the natural storage project.

A watershed of approximately 410 acres drains through the site. Raising the pond level at the site 2 feet by placing natural elements at the outlet would provide approximately 15 acre-feet of additional storage volume. Soils underlying the site are mostly Seattle muck, which has a low hydraulic conductivity and flat slopes, making conditions suitable for ponding of additional water. The site is surrounded by steep slopes and could be prone to slope instabilities and landslides. However, the project is not expected to significantly change conditions and could improve landslide conditions by capturing high-energy peak flows and reducing local erosion.

A WWHM model was developed to estimate existing hydrologic conditions and developed conditions for the enhanced site. Peak flow runoff at the pond outlet would be reduced because peak flows would be attenuated by the enhanced storage. Infiltration would increase after capture from high runoff events. Water infiltrated to the shallow aquifer at the site would likely contribute to baseflow downgradient along the Stossel Creek channel. The distance and timing to zones of increased baseflow are contingent on the presence and thickness of an unsaturated zone beneath the site. Thinner unsaturated zones would result in more immediate contributions to downstream baseflow, whereas thicker unsaturated zones could potentially result in year-round benefits occurring at distances farther downstream. These zones and subsurface geology that would influence the movement of groundwater are not yet well understood.

Additional site investigations, such as test hole drilling or similar, could be completed in order to verify the underlying soil conditions at the site, which will have a significant impact on the benefits of the project. In addition, monitoring of a natural storage project could be done after initial installation of the natural elements at the outlet of the pond, and the project could be adapted to achieve desired benefits. Flows could be measured downstream of the project, and pond levels could be monitored to determine the resulting benefit.

7.1.3 Opinion of Cost

One of the reasons a natural storage project was evaluated is because it has potential to provide instream flow and shallow groundwater enhancement benefits at a relatively low cost. An opinion of the probable cost to install the elements shown in the preliminary design drawings is provided in the memorandum in Appendix B. Table 7-1 summarizes those costs.

Table 7-1
Natural Storage Enhancement on Stossel Creek – Opinion of Probable Cost

Cost Item	Opinion of Cost
Site Access and Staging	$2,000
Equipment Rental (Post Pounder, Small Excavator)	$1,000
Labor (1 Crew, 2 Days)[2]	$8,000
Materials; Wood Posts (35 total)	$500
Materials; Streambed Boulders and Cobbles (20 CY total)	$1,500
Subtotal	**$13,000**
Mobilization and Demobilization (7.5%)	$975
Construction Total	**$14,000**
Contingency (30%)	$4,200
Sales Tax (9.5%)	$1,330
Total Project Implementation Cost	**$20,000**

Notes:
1. These costs do not include additional costs for engineering, permitting, construction management, or administration.
2. Mobilization/Demobilization estimated as 7.5% of Construction Subtotal
3. Labor costs assume that a construction contractor would be hired to complete the installation. An alternative may be to contract with a volunteer crew to provide the labor, which would significantly reduce the cost of labor and the overall cost of the project.
4. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
5. The subtotals and construction total are rounded to the nearest $1,000.

7.1.4 Permitting and Regulatory Requirements

Anticipated permitting and regulatory requirements applicable to the natural storage project are outlined in the memorandum provided in Appendix B. The permitting for a natural storage project should be simpler than permitting for one of the larger storage projects, as summarized in Section 6. However, the placement of materials in the Stossel Creek channel will trigger many of the same permit requirements, including review by the USACE and WDFW. Local permits would also be required.

8 Recommended Next Steps and Conclusions

This Comprehensive Storage Study is intended to be a first step toward investigating the potential for storage in the Snoqualmie River Watershed. Success in implementing a larger scale storage project will require broad support by a wide range of stakeholders, and it will need to offer multiple benefits, potentially including the ability to augment instream flows during the late-summer low-flow period, the ability to offset out-of-stream consumptive use, potential for attenuating peak flows to reduce flooding downstream, ability to enhance or at least maintain habitat and passage conditions for fish and wildlife, and potential to offer recreational benefits.

Future discussions about storage and the opportunities that were identified and evaluated in this report should focus on finding ways to meet multiple needs with a storage project. Where storage is being seriously considered or successfully implemented on a larger scale elsewhere in the state, the process has often involved years of outreach and consensus building, coordination with other beneficial projects, refinement of storage concepts to meet multiple needs, and long-term engagement with property owners, water users, water managers, and others who manage natural resources. It may take time to identify the right project, complete studies and planning, and design, permit, and construct a storage project. SVWID is committed to being actively involved in this process and will continue to work with the WRIA 7 WREC members and other interested stakeholders to plan for storage.

8.1 Recommended Next Steps

As a follow up to this study, the following activities are recommended.

8.1.1 Additional Study of Land Acquisition Strategies

The primary challenge to implementing the storage projects outlined in this report include landowner concerns about loss of harvestable timber land and compatibility with the current use of the land. DNR has indicated that they cannot support further study of water storage on the properties they manage because they do not feel it is compatible with DNR’s trust obligations and may not be permitted by the restrictions placed on the land when they acquired it. Campbell Global, LLC, has also indicated that they would not consider the sale or lease of productive timber properties that would result in a loss of revenue and limit their ability to harvest trees from the land.

Successful development and implementation of a storage project within the watershed will require purchasing or leasing land that has an existing use. For the projects identified in this study, the primary land use that would be impacted by a storage project is timber harvest. That impact would need to be reflected in the land purchase or lease agreement. Land purchase or lease will require a major financial commitment from project funders and watershed partners.

Evaluating the value of land that would need to be acquired for water storage, and understanding what it would take to purchase or lease land for storage, is beyond the scope of this study. However, that information will be critical to future decision-making, pursuit of funding, and planning for a successful water storage project. Additional discussion and study will be required to better understand those costs and the level of investment that potential funders and watershed partners are willing to make in pursuit of water storage in the Snoqualmie River Watershed. As a next step, we recommend additional study of land acquisition strategies and the economics of purchasing or leasing land for water storage projects to better understand what it would take to purchase or lease land for water storage. Consultation with someone who has expertise in forestry economics and real estate transactions for a variety of land uses will be key to completing that study.

8.1.2 Continued Landowner Coordination

Discussions with key landowners in the watershed regarding the potential for locating water storage on their lands should continue. At this point, additional discussion of the use of productive timber harvest lands may not be effective or warranted. However, Campbell Global, LLC, has indicated that they are open to further evaluation of use of existing lakes for water storage, as proposed at Sites TOK2 (Bridges Lake), TOK3 (Klaus Lake), and TOK4 (Black Lake). Discussion about those projects should continue.

8.1.3 Continued Stakeholder Coordination

Continued coordination with stakeholders, include those from the WRIA 7 WREC, will be critical to identifying a successful storage project and building the broad support that will be needed to fund and implement the project. Discussion should continue among the members of the WRIA 7 WREC regarding water storage and the potential for water storage to meet multiple existing needs and to provide resiliency in the future.

8.1.4 Project-Level Feasibility Study and Further Project Development

Several potential storage projects have been identified as part of this study. The next step in evaluating a storage project would be to complete feasibility-level analysis. Feasibility-level analysis would include looking in more detail at some of the constraints and challenges identified in this report, including land constraints, access, flow benefits, geology, impacts to critical areas, impacts to natural resources, and costs, to determine whether there are any obstacles to implementation that would constitute a fatal flaw or make project implementation not feasible. Once consensus builds around a particular storage project, we recommend completing a detailed project-level feasibility study.

8.1.5 Continued Implementation of Small-Scale Storage

One of the reasons SVWID began studying storage by looking at small-scale storage opportunities was to build momentum by implementing one or more smaller projects to show how storage can provide benefits for water users and address streamflow issues. Three potential projects were identified in the Small-Scale Storage Study that could be advanced through design, permitting, and implementation. They included repurposing the Foster Pond for storage, repurposing an old manure pond on the Goose and Gander Farm for storage, and constructing a small reservoir on property managed for timber harvest by the Green Crow Corporation. SVWID has been pursuing development of the Foster Pond project and has had continued discussions about the other projects. It is recommended that SVWID continue to work toward implementation of one or more of these projects to help build momentum around water storage in the Snoqualmie River Watershed.

8.1.6 Continued Consideration for Ecological Restoration

The focus of this study was on surface water storage. Several WRIA 7 WREC members have expressed interest in continued study and development of restoration projects that can also provide hydrologic benefit, such as adding wood to channels to promote alluvial and floodplain storage. These projects are typically smaller, less engineered, and may provide hydrologic benefits that are more difficult to quantify. However, these projects can be done cooperatively with landowners at a much lower cost than the storage projects evaluated by this study. Continued consideration should be given both to water storage and to smaller-scale projects that restore hydrologic functions through process-based ecological restoration.

8.2 Conclusions

Water storage has been an effective tool in helping to meet multiple water resource needs in basins where chronic late-summer low-flow issues, insufficient or unreliable water supply, flooding, and other challenges are worsening in the face of changing climate conditions. In many watersheds throughout the state, the challenges are more dire, and the need for water storage is more urgent. However, there are significant challenges to managing water in the Snoqualmie River Watershed that will become even more difficult as demands increase, growth continues, and the impacts of climate change become more permanent. Proactively planning for water storage and other projects that can meet multiple water resources needs is important to the future of the watershed. This Comprehensive Water Storage Study is an important first step toward engaging stakeholders in a discussion about the potential benefits of water storage and the likely challenges that will be encountered in planning for and implementing water storage projects in the watershed.

9 References

Anchor QEA, 2018. *Screening Criteria and Methodology*. Draft Memorandum to: Snoqualmie Valley Watershed Improvement District. September 11, 2018.

Anchor QEA, 2019a. *SVWID Small-Scale Storage Screening Analysis of Potential Storage Sites*. Memorandum to: Snoqualmie Valley Watershed Improvement District. March 6, 2019.

Anchor QEA, 2019b. *SVWID Foster Pond Storage Project – Conceptual Design*. Memorandum to: Snoqualmie Valley Watershed Improvement District. October 29, 2019.

Anchor QEA, 2020a. *Small-Scale Storage Study Summary Report.* Prepared for Snoqualmie Valley Watershed Improvement District. January 2020.

Anchor QEA, 2020b. *Snoqualmie River Watershed Comprehensive Storage Study, Work Plan*. Prepared for Snoqualmie Valley Watershed Improvement District. April 2020.

Anchor QEA, 2020c. *Snoqualmie River Watershed Comprehensive Storage Study, Screening Analysis Summary*. Prepared for Snoqualmie Valley Watershed Improvement District. July 2020.

Anchor QEA, 2021. *Preliminary Design Analyses, Snoqualmie River Watershed – Natural Storage Enhancement*. Memorandum to: Snoqualmie Valley Watershed Improvement District. December 30, 2021.

DAHP (Washington Department of Archeology and Historic Preservation), 2020. DAHP Register Properties. Accessed February 3, 2020. Available at: https://www.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=7dd4553e2a6c489c9778d4a3a34a289d.

DNR (Washington State Department of Natural Resources), 2020a. Geology GIS Data and Databases. Accessed February 3, 2020. Available at: https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases.

DNR, 2020b. DNR Hydrography - Waterbodies. Washington Department of Natural Resources GIS Open Data. Accessed February 3, 2020. Available at: http://data-wadnr.opendata.arcgis.com/datasets/dnr-hydrography-water-bodies.

DNR, 2020c. Washington DNR Managed Land Parcels. Washington Department of Natural Resources GIS Open Data. Accessed January 28, 2020. Available at: http://data-wadnr.opendata.arcgis.com/datasets/wa-dnr-managed-land-parcels.

DNR, 2020d. WADNR Active Roads. Washington Department of Natural Resources GIS Open Data. Accessed June, 2020. Available at http://data-wadnr.opendata.arcgis.com/datasets/bfdb0455c3b24aa6ae46c9502f814c25_5?geometry=-135.533%2C44.462%2C-105.979%2C49.693.

DNR, 2020e. Washington Major Public Lands (non-DNR). Washington GIS Open Data Portal. Accessed June, 2020. Available at http://geo.wa.gov/datasets/87a1642dbd1d4beab9758fc1d87eb17b_1?geometry=-135.646%2C44.627%2C-105.917%2C49.843.

Ecology (Washington State Department of Ecology), 2015. *Watershed Characterization for WRIA 7*. Publication No. 15-06-009. March 2015. Accessed February 4, 2020. Available at: https://fortress.wa.gov/ecy/publications/documents/1506009.pdf.

King County, 2020a. Public Parcels in King County. King County GIS Open Data Portal. Accessed February 3, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/public-parcels-in-king-county-public-parcels-area.

King County, 2020b. Comprehensive Plan Land Use Designations for King County – 20 Categories. King County GIS Open Data Portal. Accessed February 3, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/comprehensive-plan-land-use-designations-for-king-county-20-categories-landuse-kc-consol-20-area.

King County, 2020c. Tribal Lands in King County. King County GIS Open Data Portal. Accessed February 3, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/tribal-lands-in-king-county-tribal-lands-area.

King County, 2020d. Street Address. King County GIS Open Data Portal. Accessed January 28, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/street-address-st-address-line.

King County, 2020e. Zoning Designations for King County – 20 Category Scheme. King County GIS Open Data Portal. Accessed January 28, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/zoning-designations-for-king-county-20-category-scheme-zoning-kc-consol-20-area.

King County, 2020f. Potential landslide hazard areas 2016. King County GIS Open Data Portal. Accessed January 31, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/potential-landslide-hazard-areas-2016-landslide-hazard-area.

King County, 2020g. Potential Steep Slope Hazard Areas. King County GIS Open Data Portal. Accessed January 31, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/potential-steep-slope-hazard-areas-steep-slope-hazard-area.

NHC and GeoEngineers, 2020. *WRIA 7 Consumptive Use Estimates – Final Draft*. Prepared for Washington State Department of Ecology. January 20, 2020.

Snohomish County, 2020. Snohomish County Zoning Dataset. Snohomish County FTP Site. Accessed May 7, 2020. Available at ftp://ftp.snoco.org/Planning_and_Development_Services/zoning/Current%20Shape%20Files/.

USDA (U.S. Department of Agriculture), 2020. Wilderness Area Dataset. National Dataset Portal. Accessed May 24, 2020. Available at: https://data.fs.usda.gov/geodata/edw/edw_resources/meta/S_USA.Wilderness.xml

USGS (U.S. Geological Survey), 2006. LiDAR Elevation Dataset. Washington DNR Division of Geology and Earth Resources – Washington LiDAR Portal. Accessed April, 2020. Available at https://lidarportal.dnr.wa.gov/.

USGS, 2020. Watershed Boundary Dataset. National Hydrography Products. Accessed February 2, 2020. Available at: https://www.usgs.gov/core-science-systems/ngp/national-hydrography/access-national-hydrography-products.

WDFW (Washington Department of Fish and Wildlife), 2020. Statewide Washington Integrated Fish Distribution. Washington Geospatial Open Data Portal. Accessed February 3, 2020. Available at: https://geo.wa.gov/datasets/wdfw::statewide-washington-integrated-fish-distribution.

WSDA (Washington State Department of Agriculture), 2018. Agricultural Land Use GIS Data. Agricultural Land Use Data Portal. Accessed February 2, 2020. Available at: https://agr.wa.gov/departments/land-and-water/natural-resources/agricultural-land-use.

WSDOT (Washington State Department of Transportation), 2019. WSDOT - City Limits. Washington Geospatial Open Data Portal. Accessed November, 2019. Available at: http://geo.wa.gov/datasets/0b12f000a66f4d75a43ea3ac4ead01dc_1.

Appendix A
Work Plan

April 2020
Snoqualmie River Watershed Comprehensive Storage Study

ANCHOR QEA

Work Plan

Prepared for Snoqualmie Valley Watershed Improvement District

April 2020
Snoqualmie River Watershed Comprehensive Storage Study

Work Plan

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ABBREVIATIONS

Comprehensive Storage Study	Snoqualmie River Watershed Comprehensive Water Storage Study
DNR	Washington Department of Natural Resources
Ecology	Washington State Department of Ecology
GIS	geographic information system
LiDAR	Light Detection and Ranging
SVWID	Snoqualmie Valley Watershed Improvement District
Tribes	Snoqualmie and Tulalip Tribes
WAC	Washington Administrative Code
WREC	Watershed Restoration and Enhancement Committee
WRIA	Water Resource Inventory Area

1 Introduction

This work plan was prepared to summarize criteria and describe the methodology proposed for identifying, screening, and ranking potential surface water storage sites within the Snoqualmie River Watershed as part of Task 2 of the Snoqualmie River Watershed Comprehensive Water Storage Study (Comprehensive Storage Study). The purpose of the Comprehensive Storage Study is to identify opportunities to store high flows during winter and spring, when water is available, for release during the late summer low-flow period to augment instream flows and provide additional water supply for out-of-stream water uses.

The focus of the Comprehensive Storage Study will be primarily on surface water storage. Other types of projects are being considered by the Water Resource Inventory Area (WRIA) 7 Watershed Restoration and Enhancement Committee (WREC), including managed aquifer recharge, water rights acquisitions, and other actions designed to increase water availability, offset out-of-stream uses, and improve instream flows. Surface water storage will likely be used in combination with other types of projects to enhance these benefits. Opportunities for combining surface water storage with other types of projects to enhance benefits may be identified in the Comprehensive Storage Study, but the study will primarily identify and evaluate opportunities for surface water storage.

Water storage would provide multiple benefits throughout the watershed, including offsets for domestic permit-exempt wells. A screening analysis will be completed as the first step toward completing the Comprehensive Storage Study in an effort to identify the most promising opportunities for surface water storage within the Snoqualmie River Watershed. This work plan was circulated to key stakeholders and the Snoqualmie and Tulalip Tribes (Tribes) for review to ensure that the screening criteria and methodology are consistent with the watershed planning goals and objectives in WRIA 7.

1.1 Background

The Washington State Department of Ecology (Ecology) manages water in the State of Washington by watershed and has split the state into WRIAs for coordination of water resource planning and management. Each WRIA consists of a major watershed or combinations of adjacent watersheds. WRIA 7 is located in western Washington and encompasses the Snoqualmie River Basin, the Skykomish River Basin, and the Lower Snohomish River Basin. The Snoqualmie River merges with the Skykomish River to form the Snohomish River near Monroe, Washington. The Snoqualmie River drains approximately 700 square miles within a basin that extends from the Snoqualmie River Valley to the crest of the Cascade Mountains.

The Snoqualmie Valley Watershed Improvement District (SVWID) was formed by farmers and rural landowners in the Snoqualmie River Valley to assist landowners in finding solutions to water supply problems. SVWID serves approximately 14,000 acres of rural and agricultural lands in the Snoqualmie River Basin, including properties primarily within the floodplain of the Snoqualmie River and its tributaries, from just below Snoqualmie Falls to the King County line near Duvall.

The Snoqualmie River is a critical resource that provides water for multiple needs, including water supply for domestic water use, irrigation water for agriculture, and instream flows that support fish and wildlife. Like other rivers in western Washington, the Snoqualmie River is influenced by seasonal rains; mountain snowmelt; and a relatively dry, warm summer. Heavy autumn and winter rains cause frequent flooding in the Snoqualmie River Valley. Snowmelt results in high flows through the late winter and spring. The late summer brings warmer, drier weather and low-flow conditions that prevail at the time when water is needed most for both instream and out-of-stream uses. With changing climate and shifting weather patterns, the availability of the Snoqualmie River to meet instream and out-of-stream needs is not as certain.

Water storage has become an increasingly valuable tool for water resource managers. Water stored during high-flow periods in the autumn, winter, and spring can be released during the late summer, when water is needed to provide additional and more reliable water supply and to augment streamflows to support fish and wildlife. To date, no comprehensive study of the feasibility of storage projects in WRIA 7 has been completed.

1.2 Prior Studies – Small-Scale Storage Study

SVWID received a Watershed Implementation and Flow Achievement Grant Award from Ecology in 2018 to investigate the potential for creating small-scale water storage within the lower Snoqualmie River Valley. A storage assessment was recently completed with this funding, focused on identifying and evaluating potential sites for small-scale water storage (facilities with capacities of less than 10 acre-feet), for benefit of instream flows and agriculture (Anchor QEA 2020). The Small-Scale Storage Study was focused on tributaries that feed the Snoqualmie River and areas near the mainstem Snoqualmie River within the SVWID service area. The need for a more robust, comprehensive storage study was identified early during the small-scale storage assessment.

As part of the Small-Scale Storage Study, screening criteria and methodology were developed to rank and compare sites (Anchor QEA 2018). The criteria and methodology were applied to screen and rank 16 potential small-scale storage sites (Anchor QEA 2019a). Of these 16 sites, 3 sites were selected to advance to more detailed design development: Foster's Pond, Goose and Gander Farm, and Green Crow Parcel. Foster's Pond was advanced to more detailed design development through a separate grant from the Washington State Department of Agriculture (Anchor QEA 2019b), while Goose and Gander Farm and Green Crow Parcel sites were further developed as part of the Small-Scale Storage Study (Anchor QEA 2020). This work is preliminary, and additional work to develop at least one small-scale storage site will move forward when additional funding is secured.

2 Comprehensive Storage Study and Work Plan Overview

In 2019, SVWID secured funding under Ecology's Streamflow Restoration Grant Funding program to complete the Comprehensive Storage Study. The objectives of the Comprehensive Storage Study are to advance a specific natural storage project to the preliminary design stage (not the focus of this document) and to conduct a comprehensive study of a wide range of potential surface water storage projects throughout the Snoqualmie River Watershed for the benefit of instream flows.

The Small-Scale Storage Study identified opportunities for enhancing natural ponds or wetlands in the headwaters of tributaries to the lower Snoqualmie River, referred to in that document as "natural storage" projects. Natural storage projects would consist of placing natural materials, such as large wood or beaver dam analogs, near the outlet of a natural pond or wetland to attenuate the release of water and increase the storage in these natural features. Other projects identified in the Small-Scale Storage Study would require excavation and construction of an impoundment to store water. Those projects were identified as "constructed storage" projects. The grant funding provided by Ecology's Streamflow Restoration Grant program will advance at least one of the natural storage projects identified in the Small-Scale Storage Study to the preliminary design phase.

The grant funding provided by Ecology's Streamflow Restoration Grant program will also support a comprehensive study of surface water storage opportunities in the Snoqualmie River Watershed, which is the focus of this work plan. The study will build on the work initiated in the Small-Scale Storage Study by identifying new storage opportunities for surface water storage throughout the watershed. The Comprehensive Storage Study will focus on a wide range of potential storage projects that maximize the benefit to instream flows and provide offsets to consumptive domestic permit-exempt well use. Unlike the Small-Scale Storage Study, the Comprehensive Storage Study will look at a wide range of sizes and configurations of surface water storage reservoirs. Also, the Small-Scale Storage Study was focused on the lower Snoqualmie River Watershed, whereas the Comprehensive Storage Study will also look for storage opportunities throughout the watershed. While it is understood that off-channel storage is generally preferred and will likely be easier to permit and implement, the Comprehensive Storage Study will identify and evaluate both off-channel and on-channel storage opportunities.

The scope of work for the Comprehensive Storage Study is included in Appendix A. Task 2 in the scope of work includes development of this work plan to define criteria and summarize the methodology that will be used to identify and evaluate potential storage sites throughout the watershed.

This work plan is the initial step towards completing the Comprehensive Storage Study. The work plan is intended to build on the methodology for screening and ranking potential storage sites developed as part of SVWID's Small-Scale Storage Study. Although the Comprehensive Storage

Study is intended to be more broadly focused on a wide range of potential storage projects throughout the watershed, the screening criteria and methodology developed for the small-scale storage assessment were used as a starting point for developing this work plan. This work plan defines the criteria and methodology to be used in completing the screening and ranking of storage sites for the Comprehensive Storage Study. The work plan will be refined with input from SVWID, Ecology, the Tribes, and other key stakeholders. Then it will be used as a guide for evaluating potential storage sites using a more robust geographic information system (GIS)-based analysis approach. The work plan includes the following:

- A summary of proposed storage analysis criteria
- A summary of the proposed storage analysis characterization, scoring, and ranking
- A summary of existing information collected and identification of data gaps
- A summary of the proposed storage analysis methodology
- A summary of next steps toward completing the analysis

3 Storage Analysis Criteria Scoring and Ranking

3.1 Storage Analysis Criteria

Several criteria have been identified for use in characterizing, scoring, and ranking potential storage sites as part of the screening analysis for the Comprehensive Storage Study:

- **Proximity to water source:** The closer to a water source a storage project is, the less infrastructure will be required to deliver water to storage. The location can be evaluated in GIS and rated relative to its location and proximity to its source of water supply.
- **Location within watershed:** The location of a storage site within the watershed affects the potential extent of the benefits that releases from storage can offer to the downstream portions of the watershed. The potential downstream benefits of storage would increase the higher the storage facility is within the watershed. The location can be evaluated in GIS and rated relative to its location in the watershed and proximity to its source of water supply.
- **Ability to offset domestic well use:** The offset of domestic well use is not the primary focus of this study, but would be a resulting benefit of future storage projects. The potential benefit of the ability to offset domestic well use is dependent on the projected use by subbasin.
- **Project footprint:** The project footprint and surface area of the proposed storage reservoir represents the impact to the parcel on which it is created. The size and footprint of the reservoir would be evaluated and considered relative to the configuration of the parcel on which it is located and impact to other resources.
- **Available storage capacity:** The potential storage capacity of each storage project identified will be estimated based on topography as part of the selected site and grading that can be accomplished to create a storage reservoir.
- **Ability to store high flows:** The potential for and complexity of capturing and storing high flows from the Snoqualmie River or one of its tributaries to reduce flood flows downstream of the site will be evaluated as part of a site-specific analysis.
- **Fish habitat:** Fish habitat in various streams and rivers within WRIA 7 have been mapped quantitatively by Ecology. Siting of storage facilities should avoid or minimize negative impacts on highly valued fish habitat. The impact of potential storage locations on highly valued fish habitat can be evaluated and rated in GIS relative to mapped fish habitat conditions.
- **Fish presence:** Siting of storage projects should avoid reaches of streams and rivers where salmonids are present. The location of potential storage sites relative to streams and rivers where salmonids are present can be evaluated and rated in GIS.
- **Wetland presence:** Wetland inventory mapping can be used to determine the potential impact storage sites would have on existing wetlands. The location of potential storage sites can be evaluated and rated in GIS relative to mapped wetland locations.

- **Current vegetation/land use:** The current vegetation and land use may indicate the potential impact that construction of a storage facility would have on existing natural resources. The location of potential storage sites can be evaluated and rated in GIS relative to current vegetation and land use.
- **Instream flow benefits:** Releases from storage reservoirs directly to a tributary or to the main stem Snoqualmie River will increase instream flows downstream of the reservoirs. Increased late summer instream flow will be evaluated for each site based on a site-specific analyses of potential water releases.
- **Water quality – temperature, dissolved oxygen:** Impacts of storage releases may include changes in water temperature and dissolved oxygen. The scope of work does not include water quality modeling or a detailed evaluation of water quality for potential projects, but impacts will be characterized based on location, retention time, and exposure to sunlight. Storage sites will be rated based on the overall potential impacts to water quality.
- **Water quality – toxics:** Impacts may also include changes in water quality due to potential contaminants within a reservoir's watershed, such as heavy metals, petroleum byproducts, or other constituents of concern listed in Ecology's 303D database of impaired waterbodies. The scope of work does not include water quality modeling or a detailed evaluation of water quality for potential projects, but impacts will be characterized based on exposure to potential contaminants. Storage sites will be rated based on the overall potential impacts to water quality.
- **Reliability/Resilience:** Each potential storage project will be evaluated and rated based on the project's ability to provide long-term reliable, resilient water supply and improvement to instream flow. A site-specific analysis will be completed to assess reliability based on the ratio of the size of the upstream watershed to the size of the storage reservoir. Consideration will be given to the likely impact that climate change may have on the ability of the storage project to capture and store water to meet instream and out-of-stream water needs.
- **Property ownership:** Property ownership of potential storage locations will be identified in GIS. Potential storage locations will be evaluated and rated in GIS based on the type of property owner and use of the property.
- **Site accessibility:** The distance to existing roads or access routes can have an impact on the feasibility of constructing storage within the watershed. Potential storage locations will be evaluated and rated in GIS based on the distance from mapped roadways and access routes.
- **Storage type:** Types of storage may include impoundments that store water on a tributary or in an off-channel reservoir. The likely impact to instream resources are not as great for off-channel storage reservoirs. Potential storage sites will be evaluated in GIS based on whether they are on-channel or off-channel, with preference given to off-channel storage.
- **Constructability:** The project sites will also be rated based on the complexity of construction. Constructability can be, in part, evaluated in GIS based on likely soil conditions, which relate

to the ability to move earth to create storage. Constructability will also be characterized through site-specific analyses by considering factors such as materials availability, likely schedule and duration of construction, access, and extent of infrastructure.

- **Critical areas and resource impacts:** The presence or proximity to critical areas and resources, including wetlands, cultural resource sites, geologic hazards, and other critical areas, will be evaluated. This criterion will inform the overall feasibility of a project and potential mitigations required for permitting and implementation.
- **Cost and funding potential:** A concept-level opinion of probable costs will be developed for each potential project site. The opinion of costs will primarily reflect the volume of earthwork and quantities of other major materials needed to create storage at the site. A 30% contingency will be included to reflect the conceptual nature of the opinion of cost. Allowances will also be included for non-project costs (e.g., permitting, engineering, administration, and land acquisition). Costs will be compared based on cost per acre-foot of water storage capacity. Sites will be also be evaluated and rated based on their potential to attract funding from grant funding programs. Projects that will be more likely to attract funding will offer storage that meets multiple needs (e.g., water supply offsets, instream flows, and habitat enhancement).
- **Operation and maintenance:** Each project will be rated based on the likely difficulty of operating and maintaining the storage facility. Considerations will include whether storage requires electrical and mechanical equipment, extent of infrastructure, access, need for sediment and debris management, and public exposure.

3.2 Storage Analysis Characterization, Scoring, and Ranking

The proposed storage analysis, detailed in the following sections, will include the following steps:

1. Characterize raster cells in GIS as having conditions that indicate a high potential for infiltration or a low potential for infiltration.
2. Complete a GIS-weighted overlay analysis that will rank each raster as favorable for water storage based on scoring of criteria that can be easily evaluated using GIS-based data.
3. Use the GIS-weighted overlay analysis results and mapped GIS data to identify potential storage sites where there is a concentration of raster cells that indicate favorable conditions for water storage.
4. Complete site-specific engineering analyses and other analyses that cannot readily be done in GIS for each site identified through the weighted overlay analysis. Rank each site based on scoring of criteria evaluated as part of the site-specific analyses.
5. Feed the site-specific data into the GIS and combine the rankings for the GIS-weighted overlay analysis and site-specific analyses to determine an overall ranking of each site.

Two key site characteristics—topography and soils—will first be overlaid in GIS using geology and Light Detection and Ranging (LiDAR) coverages from local government GIS databases. These will be used to characterize locations in the gridded GIS model by the locations' potential to support one of two types of storage that offer contrasting conditions: 1) impoundments constructed over soils and topography that have a higher potential for seepage and provide recharge and benefits to shallow groundwater systems; and 2) storage reservoirs constructed in soils and topography that have a lower potential for seepage and will result in negligible losses to groundwater. The initial overlay will highlight preliminary hot spots favorable for one of these two types of water storage.

Additional coverages will then be overlaid with the topography and soils. Several criteria listed in Section 3.1 will be evaluated and scored based on data in these GIS coverages. The analysis and scoring will be completed entirely in GIS. Evaluation and scoring will be applied to each cell of the gridded GIS model based on the GIS data within each grid cell. The overlaid GIS data will then be reviewed and evaluated for scoring based on the GIS analysis to identify potential sites where mapped data indicate the potential for favorable storage conditions. Site-specific analysis will then be done to evaluate criteria that cannot easily be evaluated within the GIS. Once preliminary storage sites have been identified, analysis and calculations will be performed outside GIS to evaluate each site and score these criteria.

Table 1 lists the proposed criteria and the type of analysis that will be used to evaluate each. For each criterion, a rating will be provided based on data from the GIS overlay or characteristics identified as part of the site-specific analysis. Ratings will vary from low to high, with a corresponding numerical score (1 to 5). The higher the rating, the more favorably a site is expected to perform for a given criteria, as shown in Table 2. The criteria will be grouped into one of the following categories:

- Physical criteria that measure benefit to out-of-stream uses
- Physical criteria that measure benefit to instream flows and habitat conditions
- Other cost/benefit and feasibility criteria

The ratings within each category will be weighted based on its importance within a particular category. The weighted ratings will then be combined to generate an overall rating for each category. A separate rating will be generated for each category as part of the GIS overlay analysis and as part of the site-specific analysis. The rating from each category will be weighted to produce an overall rating for a storage site from both the GIS analysis and the site-specific analysis, as follows:

- Physical criteria that measure benefit to out-of-stream uses (40%)
- Physical criteria that measure benefit to instream flows and habitat conditions (40%)
- Other cost/benefit and feasibility criteria (20%)

Scoring for criteria evaluated through the GIS weighted overlay analysis will completed first to help identify potential storage sites for site-specific analysis. The site-specific analysis will provide additional scoring for the potential storage sites; scores from the site-specific analysis will be averaged with the scores from the GIS analysis for each potential storage site to get a final ranking that utilizes criteria from both the GIS analysis and the site-specific analysis.

Table 1
Screening Criteria, Analyses, and Categories

Criteria	GIS Analysis	Site-Specific Analysis
Physical Criteria That Measure Benefit to Out-of-Stream Uses (40% weighting)		
Proximity to Water Source	✓	
Location within Watershed	✓	
Ability to Offset Domestic Well Use	✓	
Project Footprint		✓
Available Storage Capacity		✓
Ability to Store High Flows		✓
Physical Criteria that Measure Benefit to Instream Flows and Habitat Conditions (40% weighting)		
Fish Habitat	✓	
Fish Presence	✓	
Current Vegetation/Land Use	✓	
Instream Flow Benefits		✓
Water Quality – Temperature, Dissolved Oxygen		✓
Water Quality – Toxics		✓
Reliability/Resilience		✓
Other Cost/Benefit and Feasibility Criteria (20% weighting)		
Property Ownership	✓	
Site Accessibility	✓	
Storage Type	✓	
Constructability		✓
Critical Areas and Resource Impacts		✓
Cost and Funding Potential		✓
Operation and Maintenance		✓

Table 2
Screening Criteria Ratings

Rating	Rating Symbol/Number
Low (Least Beneficial)	1
Medium Low	2
Medium	3
Medium High	4
High (Most Beneficial)	5

4 Existing Information and Data Gaps

Table 3 provides a summary of data that have been collected for the analysis. The data include expanded GIS coverages that were compiled and used for the Small-Scale Storage Study and additional publicly available data. A comprehensive review of publicly available GIS data found numerous datasets that will be used for the GIS overlay analysis. Any additional resources known or available to SVWID should be shared with the project team.

Table 3
Summary of GIS Data Available

Criteria	Dataset
Initial Site Characterization	
Potential Reservoir Sites with Low Seepage Potential, Negligible Seepage Loss	
Impervious Surficial Geology	Surficial Geologic Units (DNR 2020a)
Steep Slopes	LiDAR (King County 2016)
Potential Reservoir Sites with High Seepage Potential, Losses to Groundwater	
Pervious Surficial Geology	Surficial Geologic Units (DNR 2020a)
Gradual Slopes	LiDAR (King County 2016)
GIS Site Suitability Overlay Analysis	
Physical criteria that measure benefit to out-of-stream uses	
Proximity to Water Source	Watercourses and Waterbodies (DNR 2020b)
Location within Watershed	Watershed Boundary Dataset (USGS 2020)
Ability to Offset Domestic Well Use	WRIA 7 Consumptive Use (NHC and GeoEngineers 2020)
Physical criteria that measure benefit to instream flows and habitat conditions	
Fish Habitat	Local salmonid habitat Index (Ecology 2015)
Fish Presence	Statewide Washington Integrated Fish Distribution (SWIFD) (WDFW 2020)
Current Vegetation / Land Use	Land Use (King County 2020b)
Other cost/benefit and feasibility criteria	
Property Ownership	Zoning and Public Parcels (King County 2020a and 2020e) and DNR-Managed Lands (DNR 2020c)
Proximity to Existing Infrastructure	Streets (King County 2020d)
Critical Areas and Resource Impacts	Waterbodies (DNR 2020b)
Critical Areas and Resource Impacts	Washington State Historic Place (DAHP 2020) and Tribal Land (King County 2020c)
Critical Areas and Resource Impacts	Potential Landslide Hazard Area (King County 2020f) and Steep Slope Hazard Area (King County 2020g)
Storage Type	Watercourses and Waterbodies (DNR 2020b)
Other Site Characterization	
Instream Flow Limitations	Instream Flow Rules – HUC Subbasins (USGS 2020)

5 Storage Analysis Methodology

5.1 GIS Analysis

The GIS analysis will include an initial site characterization using topography and soils, and scoring and ranking of raster grid cells based on other characteristics that can be evaluated using overlaid GIS data. In all phases of the GIS overlay analysis, GIS data will be scored and/or reclassified and converted to a raster dataset. This involves giving numeric score values to data that may be textual or coded. Each dataset will be interpolated as a continuous grid of raster data where each cell represents a numerical value related to or interpreted from the data in the original dataset. Raster file formats facilitate *raster math*, or the ability to conduct mathematical functions on spatial data. The raster math processes will sum and weight the datasets. The outputs will act as a decision-making tool for the project team. Grid cells will be sized based on existing data and processing time.

The initial overlay will produce two basin-wide coverages that will be symbolized to highlight areas favorable for the different types of water storage. From visually screening the maps, preliminary hot spots will be selected. These hot spot areas will be reviewed against the more in-depth screening criteria produced in the next phase of the GIS overlay analysis. This weighted overlay analysis phase will produce a basin-wide favorability score for raster grid cells within the GIS overlay based on scoring of criteria that can easily be assigned a score based on data within the GIS dataset. Potential sites will be identified by looking at areas with a high concentration of raster cells with high scoring indicating favorability for water storage. The dataset will be used as a screening tool to help identify 15 to 25 potential storage sites and can also be used for sites that may be considered in the future.

The site screening and favorability dataset will be uploaded into an ArcGIS Online webmap for sharing with the project team and stakeholders during the duration of the project. This can serve to facilitate revising the scoring and weighting. The final favorability scoring will be applied to the 15 to 25 selected sites in subsequent stages of the project. This favorability scoring can also be used as a resource for other proposed storage sites in future work within the subbasin.

The GIS database delivery will contain the original source data clipped to the subbasin as well as the converted numeric datasets, and the GIS overlay analysis output data. ESRI ModelBuilder Models can also be delivered.

5.1.1 *Site Characterization*

Figures 1 and 2 provide a summary of an initial step in the GIS weighted overlay analysis that will be used to screen for two different types of potential storage sites: 1) storage reservoirs constructed over soils and topography that have a higher potential for seepage and may provide recharge and benefits to shallow groundwater systems; and 2) storage reservoirs constructed in soils and topography that have a lower potential for seepage and will result in negligible losses to groundwater.

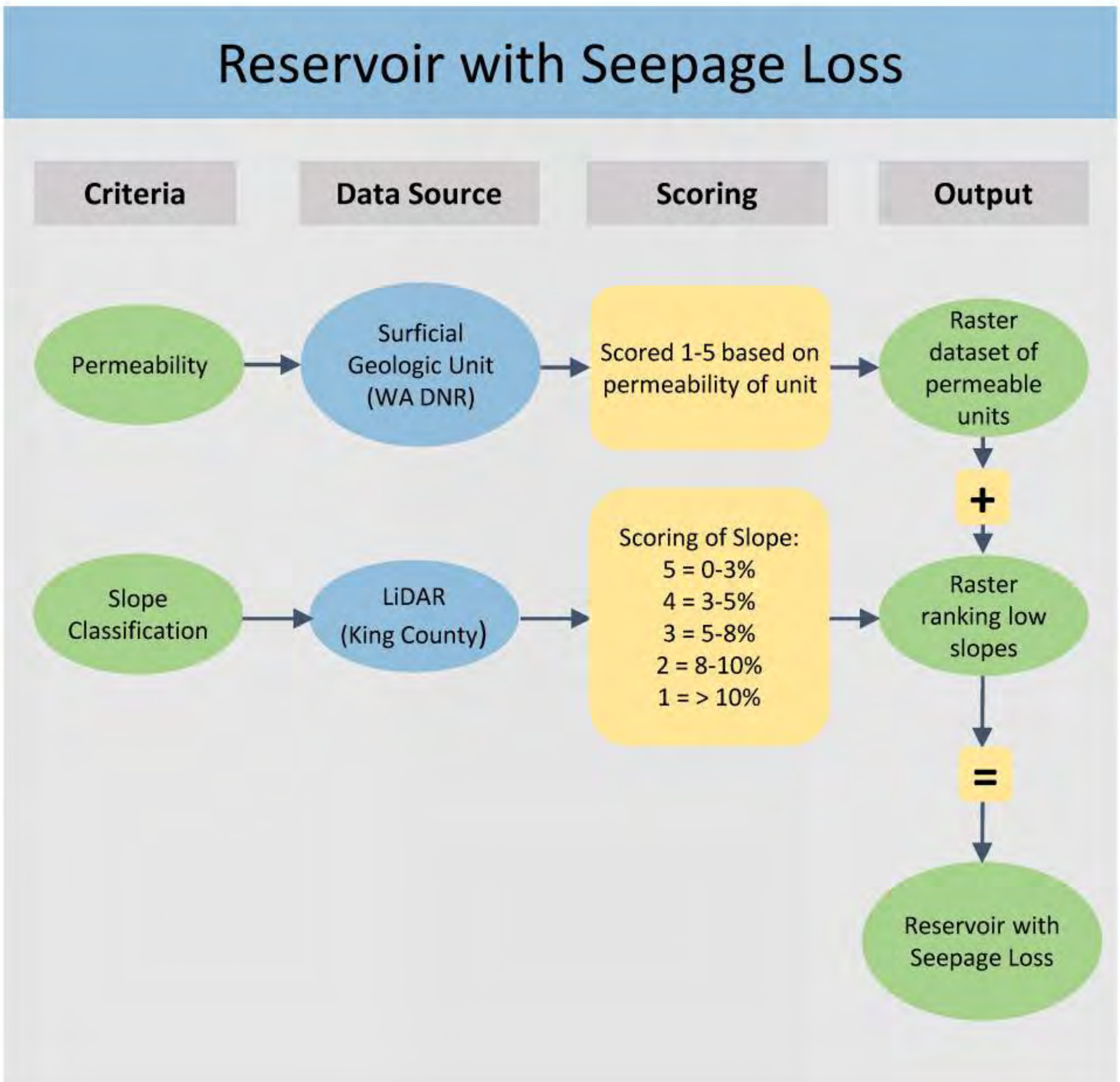
A system that induces groundwater recharge generally requires low-gradient slopes and permeable soils which improve the rate of infiltration. Storage reservoirs that do not leak generally require areas of non-permeable surficial geology, like bedrock or glacial till, and steep or narrow-valley topography that provides natural features where water can be impounded.

Due to the contrasting criteria of two different types of reservoirs, we propose to conduct a two-pronged GIS overlay analysis for the first stage of the assessment. In both processes, vector surficial geologic data will be reclassified based on permeability characteristics and converted into raster data. Raster slope data will be reclassified based on the slope scores. For each reservoir type, the two datasets, at a resolution of 20-foot grid cell size, will be added together to produce a numeric coverage across the subbasin. The coverage will be used to screen for potential reservoir sites with and without seepage loss.

5.1.1.1 Potential Reservoir with Seepage Loss

To assess the potential for recharging reservoir sites we will review and rank areas within the Snoqualmie Watershed based on their surface slope and permeability. Because mapped surficial geology estimates the permeability of surface soils, it is a major factor in assessing the feasibility of infiltration. Infiltrating storage facilities are considered more feasible in flat areas and less feasible on steep slopes due to the capacity of a shallow-gradient depression to provide more surface area for infiltration. Steep slopes have the potential for shallow infiltration to migrate along a perching layer, and infiltrated water can problematically daylight elsewhere. Steep slopes can also affect the cost of construction in designing to address these factors. LiDAR across the study area will be used to rank slope classifications that benefit infiltration. These two factors will be combined equally to create a dataset highlighting areas more and less feasible for further consideration for recharging reservoirs.

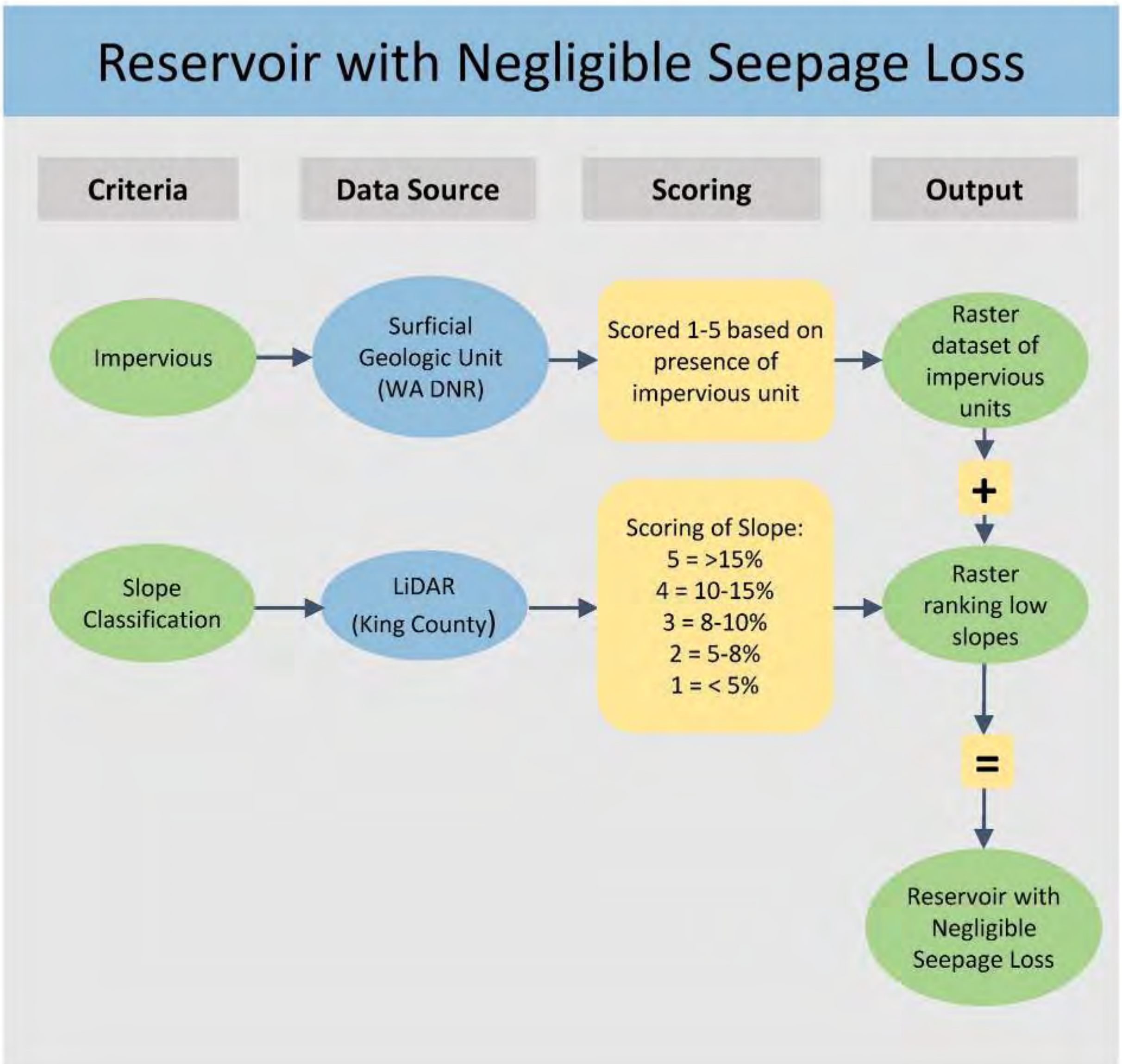
Figure 1
Criteria and Scoring for Siting Reservoirs with High Potential for Seepage Loss



5.1.1.2 Potential Reservoir with Negligible Seepage Loss

Surficial geology and slope are also major factors in siting locations that would perform well for water storage facilities without recharge. A similar approach to the impoundment/recharge assessment, but with different input values, is proposed for locating potential storage reservoir locations without recharge. A table of existing surficial geologic units will be assessed and ranked on their capacity to hold water and not allow it to infiltrate through the soil. Steep slopes benefit the constructability of reservoirs by creating naturally bound zones where water can be stored and contained without dispersing or infiltrating. LiDAR slopes will be rated for their ability to facilitate storage conditions and combined equally with soil information to create a feasibility layer for reservoir siting.

Figure 2
Criteria and Scoring for Siting Reservoirs with Low Potential for Seepage Loss



5.1.2 *GIS Criteria Scoring*

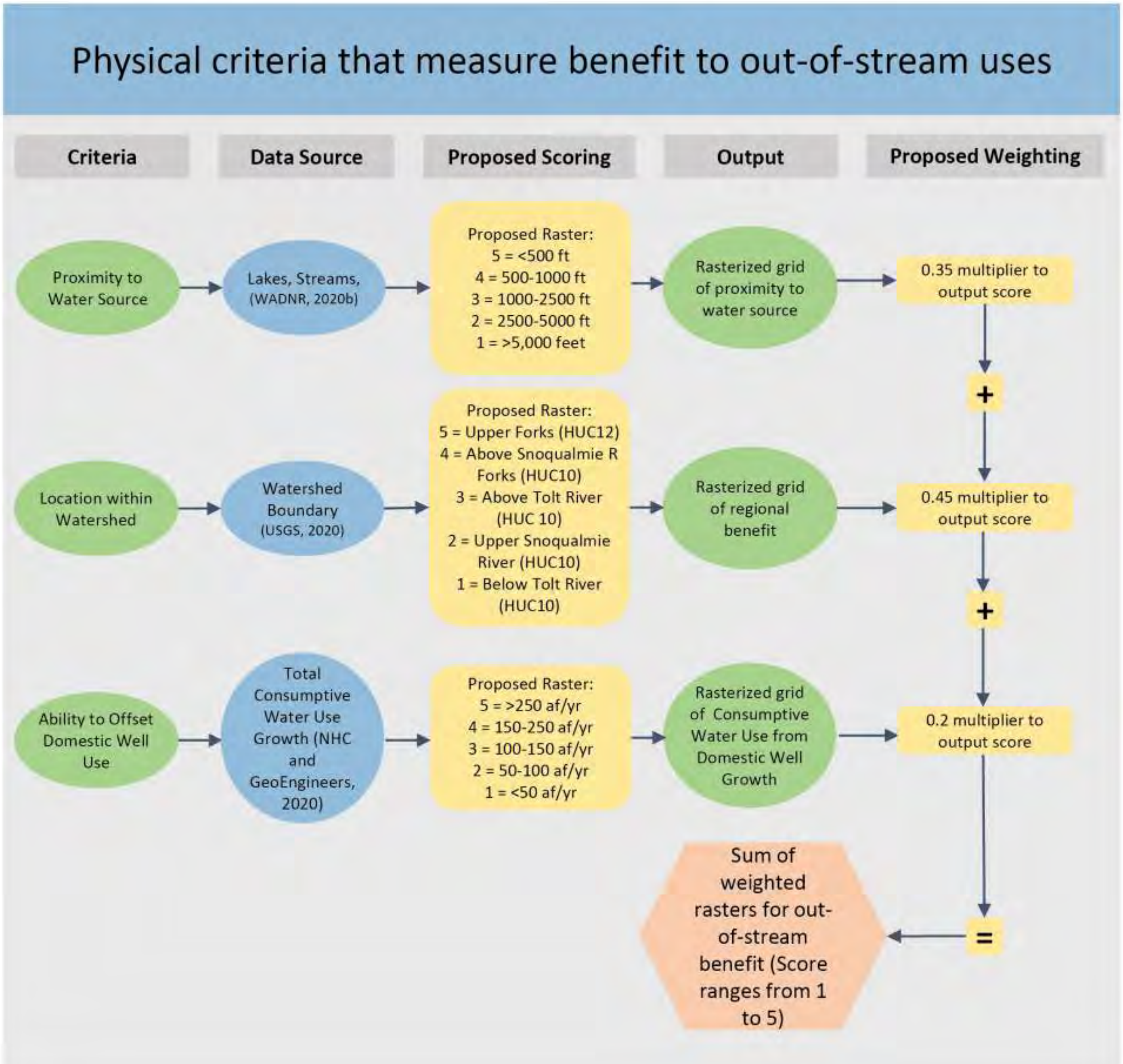
The criteria and methodology originally outlined in a memorandum to SVWID (Anchor QEA 2018) has been reviewed with SVWID and the Tribes. The resulting criteria were grouped into three categories that address benefits to out-of-stream uses, benefits to instream flows and habitat, and feasibility and cost benefits. We reviewed publicly available GIS data for its ability to address these categories and outlined an approach of how they can be scored, processed into numeric raster datasets, and weighted in the following sections.

5.1.2.1 Proposed Scoring for Physical Criteria That Measure Benefit to Out-of-Stream Uses

The project team has identified key physical criteria that would benefit a proposed reservoir location. The proximity to water that can be used to fill the reservoir, the location within the watershed, and the potential benefits to agricultural and municipal water use. The following descriptions and scoring of these criteria are can also be found in Figure 3.

- **Proximity to water source:** The extents of proximity to water source will be created by buffering water bodies and waterways to represent the ease or difficulty of planning a facility within distances from water sources.
- **Location within watershed:** This benefit of location within the watershed will be modeled by creating a raster grid that scores upstream subbasins higher and downstream subbasins lower, to represent the potential benefit to downstream water needs. A raster grid will be created that scores subbasin boundaries based on location within the basin.
- **Ability to offset domestic well use:** The locations of potential future exempt domestic wells in WRIA 7 have been mapped by GeoEngineers as part of the analysis being completed for the update of the WRIA 7 Watershed Plan. A raster grid will be created that scores each grid cell based on the total domestic well use within the subbasin where the cell is located.

Figure 3
Criteria, Data Source, and Scoring and Weighting for Out-of-Stream Uses

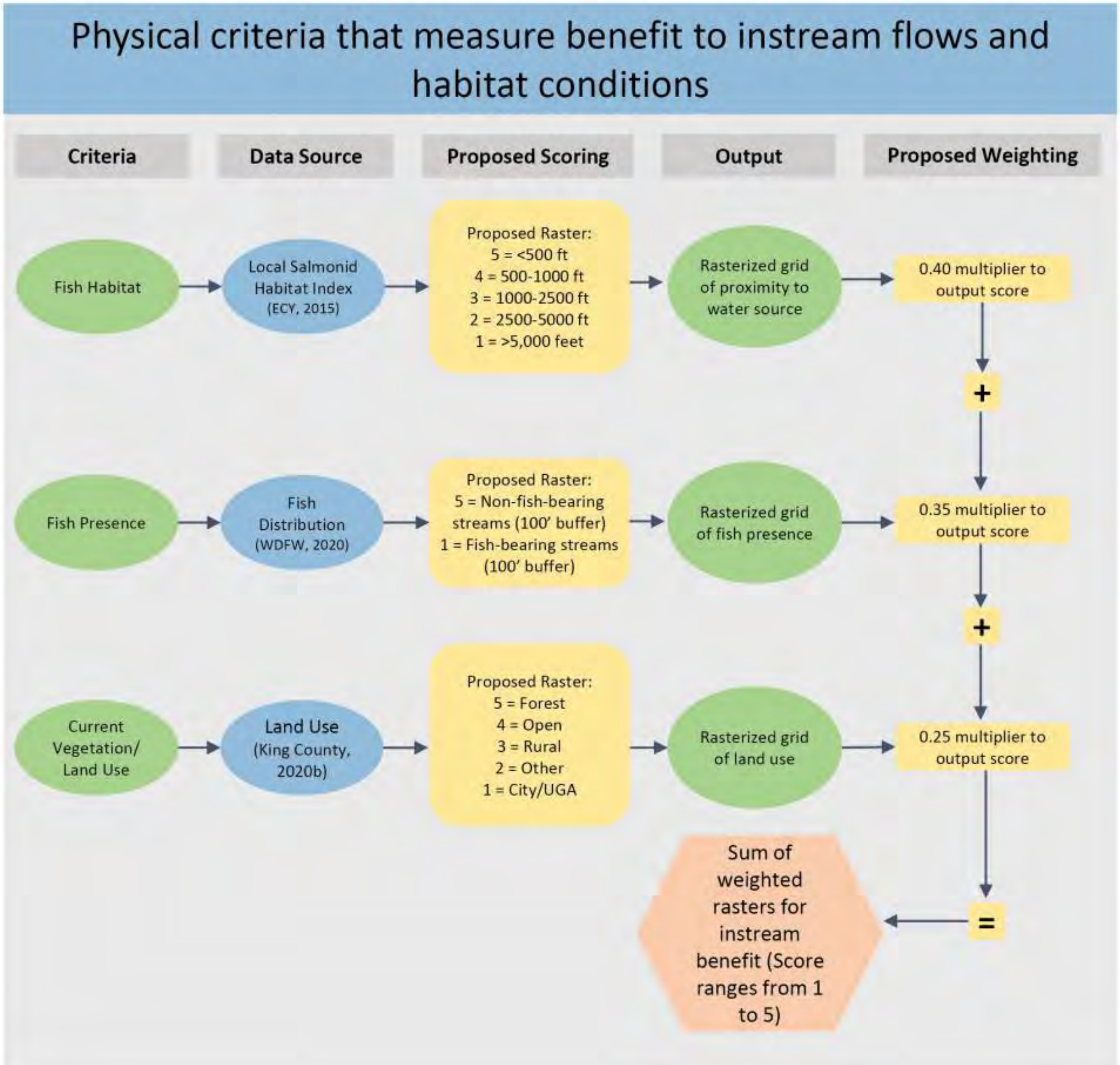


5.1.2.2 Proposed Scoring for Physical Criteria that Measure Benefit to Instream Flows and Habitat Conditions

The following criteria will be used to score the data on protection of critical fish habitat and the ability to improve instream flows. The scoring and weighting of the data can be seen in Figure 4.

- **Fish habitat:** Ecology has developed scorings of habitat for salmonids within WRIA 7 (Ecology 2015). We will use the ranking of value to habitat over Assessment Units within the Snoqualmie Basin to rank protection to habitat. The highest score would be given to Assessment Units with the lowest habitat value. This approach would be protective of existing salmonid habitat.
- **Fish presence:** The presence of fish within the Snoqualmie River or its tributaries is mapped by the Statewide Washington Integrated Fish Database. The dataset will be buffered by 100 feet to better capture the presence of fish in the model; fish-bearing streams will score lower than non-fish-bearing streams.
- **Current vegetation/land use:** The location of potential storage sites will be evaluated and rated in GIS relative to current vegetation and land use, where forest and open land use will be scored higher than municipal land use.

Figure 4
Criteria, Data Source, and Scoring and Weighting for Instream Benefit

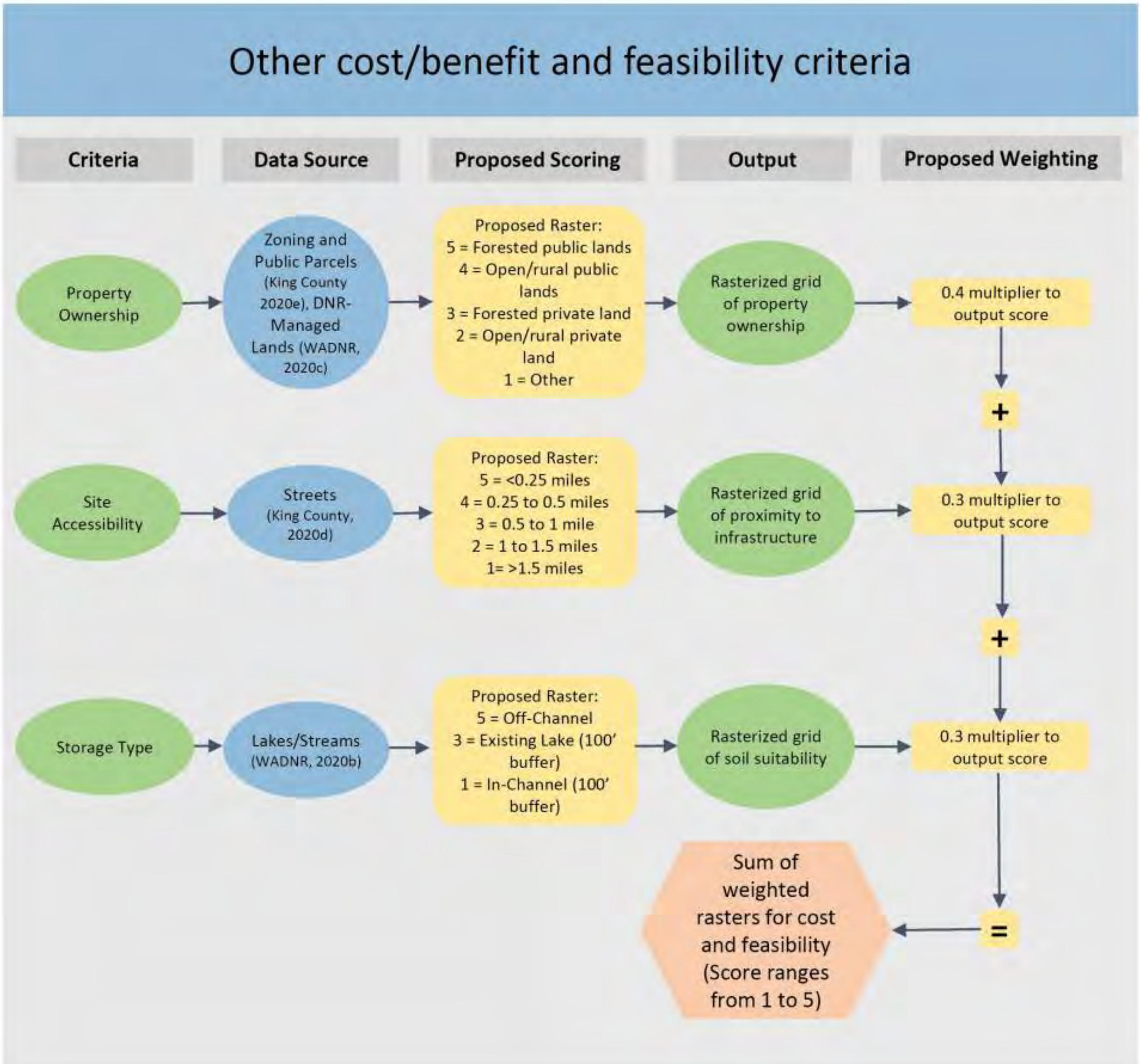


5.1.2.3 Proposed Scoring for Criteria that Measure Cost/Benefit and Feasibility

The feasibility of permitting and constructing a storage site is a critical component to its success. We propose to look at permitting complexity and constructability with a compilation of datasets that are scored, weighted, and added to create a final weighted raster score for the category (Figure 5).

- **Property ownership**: Property ownership will be evaluated based on the type of property owner, which may indicate ease in acquiring land for storage. Public lands within forested areas lend themselves to projects of this nature, so they will be scored high. Rural and open areas can also be favorable locations for a storage facility. Private lands score lower and the remaining built-up lands will be scored lowest.
- **Site accessibility:** This criterion will be evaluated to assess the need for constructing new access routes by determining the distance from existing roads and access routes. Shorter distances to existing roads will score better than longer distances to existing roads.
- **Storage type:** Scoring will help rank locations based on the type of storage that can be built at a particular location. On-channel locations will be scored lower and off-channel locations will be scored higher.

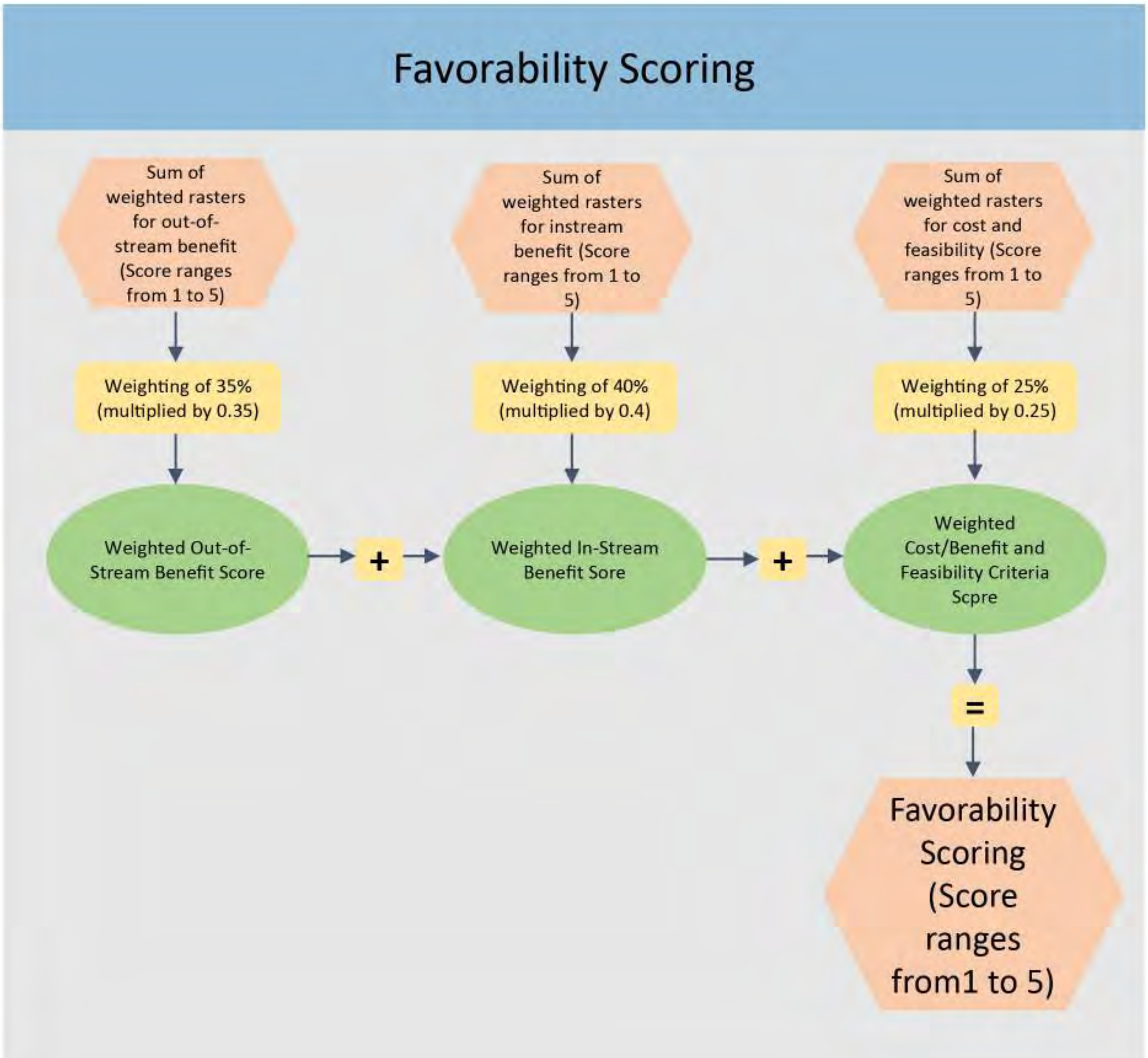
Figure 5
Criteria, Data Source, Scoring, and Weighting for Cost/Benefit and Other Feasibility Criteria



5.1.2.4 Favorability Scoring

The resulting raster dataset from each of the three categories, at a resolution of 20-foot cell size, will in turn be weighted and added together (Figure 6). This final coverage will model the favorability score across the basin and will assist in ranking the 15 to 25 potential projects. As part of this task the team reviewed the proposed work plan and data schematics with SVWID, worked with SVWID to circulate the plan, and reviewed the work plan with key stakeholders (i.e., Ecology, water users, Tribes, and others). The plan has been finalized and the GIS analysis has been initiated.

Figure 6
Weighting and Scoring of Criteria



5.2 Site-Specific Analysis

After completion of the GIS model, the site favorability scores and additional stakeholder feedback will be incorporated into a site-specific analysis. A total of 15 to 25 potential storage sites will be identified, including specific parcels or groups of parcels with a high concentration of raster grid cells identified as most favorable for water storage in the GIS database. Topography will be reviewed again to assess potential storage capacity and potential to achieve the primary goal of enhancing streamflow and mitigating for domestic well groundwater withdrawals. Storage capacity and stage-storage-surface area curves will be developed using digital elevation models of existing terrain based on LiDAR or other available topographic data using GIS or AutoCAD. Potential storage release rates and timing will also be evaluated to estimate the potential to provide water for instream flows and/or to meet out-of-stream needs. To estimate potential seepage and induced groundwater recharge, analyses will follow the water, including groundwater flux and storage components of the water balance. Determining the timing and rate at which seepage and infiltration will impact instream flows will require detailed groundwater modeling, which is beyond the scope of this study, but the site-specific analyses will characterize the potential benefit to groundwater and surface water. Storage sites and the scoring of each site based on these site-specific analyses will be added to the GIS model to facilitate the reporting and stakeholder collaboration process.

Similar to the criteria scored through the GIS weighted overlay analysis, criteria evaluated through the site-specific analyses will be included in one of the following three categories previously discussed:

- Physical criteria that measure benefit to out-of-stream uses
- Physical criteria that measure benefit to instream flows and habitat conditions
- Other cost/benefit and feasibility criteria

These analyses will be scored based on criteria described in the following section. Each criterion will have a score from 1 to 5; more beneficial rankings will have higher scores and less beneficial rankings will have lower scores. Scores will be weighted within each category, and a category score from the site-specific analysis will be developed for each of the 15 to 25 sites.

5.2.1 *Physical Criteria Measuring Out-of-Stream Use Benefits*

The following criteria (and weighting) are proposed for site-specific analyses to measure benefit to out-of-stream uses:

- **Project footprint (30%):** Projects that span multiple parcels are typically less feasible than those within a single parcel, so projects with larger footprints across multiple parcels will be scored lower than projects that fit in a single parcel.
- **Available storage capacity (50%):** A large project has the potential to provide more out-of-stream benefits than a small project. Therefore, projects with higher storage capacities will score higher than projects with lower storage capacities.
- **Ability to store high flows (20%):** Projects with high potential to capture and store high flows will score higher than projects will little potential to capture and store high flows.

5.2.2 *Physical Criteria Measuring Instream Flow and Habitat Benefits*

The following criteria (and weighting) is proposed for site-specific analyses to measure benefit to instream flow and habitat benefits:

- **Instream flow benefits (30%):** Storage sites will be scored based on the overall balance of benefits and impacts; sites with higher benefits compared to impacts will be scored higher than sites with lower benefits compared to impacts.
- **Water Quality – temperature, dissolved oxygen (25%):** Storage sites will be evaluated based on location, retention time, and exposure to sunlight to assess potential impacts on the temperature and dissolved oxygen in downstream surface waters.
- **Water Quality – toxics (15%):** Storage sites will be evaluated based on location relative to contaminated sites and exposure to contamination to assess potential impacts on other key water quality parameters of downstream surface waters.
- **Reliability/Resilience (30%):** Sites with high reliability and resilience will be scored higher than sites with low reliability and resilience.

5.2.3 *Other Cost/Benefit and Feasibility Criteria*

The following criteria (and weighting) are proposed for site-specific analyses to measure other cost/benefits and project feasibility:

- **Constructability (10%):** The project sites will be rated based on the complexity of construction. Projects with more constructability issues will be scored lower than projects with less constructability issues.
- **Critical areas and resource impacts (20%):** The presence or proximity to critical areas and resources, including wetlands, cultural resource sites, geologic hazards, and other critical areas, will be evaluated. Those sites with high potential to impact these areas and resources will score lower than those with low potential for impact.
- **Cost and funding potential (50%):** Costs will be compared based on cost per acre-foot of water storage capacity; projects with low costs per acre-foot of water storage will be scored higher than projects with high costs per acre-foot of water storage. Projects that will be more likely to attract funding, and will score higher on this criterion, will offer storage that meets multiple needs at a high cost per acre-foot value.
- **Operation and Maintenance (20%):** Each project will be rated based on the likely difficulty of operating and maintaining the storage facility. Projects with more operation and maintenance difficulties will be scored lower than projects with less operation and maintenance difficulties.

5.3 Storage Site Scoring and Ranking

After the site-specific analysis is complete and the 15 to 25 sites are scored, the scoring will be placed in the GIS database at the specific site locations and a final scoring of the sites will be ranked. Raster grid cell scores from the GIS analysis scores will be averaged within each site to get a single score for the site. The GIS analysis and site-specific analysis will each have an overall criteria score from 1 to 5; these scores will be averaged to provide a final scoring and ranking of storage sites.

Once the scores are tabulated, the data from the GIS analyses and site-specific analyses will be used to prepare a screening matrix that summarizes the results of the analysis, including an overall score, a rank of the sites analyzed, and scoring from each of the criteria.

5.4 Instream Flow Limitations

One of the potential limitations on development of storage projects within the Snoqualmie River Watershed will be whether there is an instream flow limitation within a particular tributary basin. An instream flow rule was adopted for rivers and streams within the larger Snohomish River Watershed that includes the study area. That instream flow rule is codified in the Washington Administrative Code (WAC) 173-507. Minimum instream flows are established for the South Fork Snoqualmie River, the North Fork Snoqualmie River, and the mainstem Snoqualmie River at key locations. Minimum streamflow limitations also exist for several tributaries to the Snoqualmie River. Some tributaries to the Snoqualmie River are closed year-round to further appropriation under the instream flow rule (WAC 173-507-030), including the following:

- Griffin Creek
- Harris Creek
- Patterson Creek
- Raging River

Instream flow limitations were not included as a criterion in the GIS weighted-overlay analysis or site-specific analysis. Although instream flow limitations could impact the feasibility of a storage project, there might be opportunities for storage designed to specifically enhance instream flows (without providing any out-of-stream benefit) within basins that have limitations or are closed to further water right appropriations due to lack of available streamflow. The analysis will identify promising storage opportunities without limiting consideration by whether there is an instream flow limitation. Following the scoring and ranking of potential storage sites, the sites will be overlaid with a map layer of basins and areas where instream flow closures and limitations apply to determine which potential sites are subject to these limitations. This will be noted in the comparison matrix and used to help inform which projects move forward through design development and what type of benefit will be provided with the stored water.

6 Summary and Next Steps

This work plan summarizes the criteria and methodology proposed to identify, screen, and rank potential storage sites within the Snoqualmie River watershed to meet multiple water benefits throughout the watershed. GIS analyses will provide a mapped-based scoring using criteria to narrow the number of potential storage sites (15 to 25), which will be further scored and ranked through site-specific analyses. This work plan was reviewed by key stakeholders and revised based on stakeholder input to ensure that the analyses meet the goals and objectives for the Comprehensive Storage Study and are consistent with WRIA 7 watershed planning efforts. The GIS analyses will move forward using the proposed methodology outlined in this updated work plan.

7 References

Anchor QEA (Anchor QEA, LLC), 2018. Draft Memorandum to: Snoqualmie Valley Watershed Improvement District. Regarding: Screening Criteria and Methodology. September 11, 2018.

Anchor QEA, 2019a. Memorandum to: Snoqualmie Valley Watershed Improvement District. Regarding: SVWID Small-Scale Storage Screening Analysis of Potential Storage Sites. March 6, 2019.

Anchor QEA, 2019b. Memorandum to: Snoqualmie Valley Watershed Improvement District. Regarding: SVWID Foster Pond Storage Project – Conceptual Design. October 29, 2019.

Anchor QEA, 2020. *Small-Scale Storage Study Summary Report.* Prepared for Snoqualmie Valley Watershed Improvement District. January 2020.

DAHP (Washington Department of Archeology and Historic Preservation), 2020. DAHP Register Properties. Accessed February 3, 2020. Available at: https://www.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=7dd4553e2a6c489c9778d4a3a34a289d.

DNR (Washington Department of Natural Resources), 2020a. Geology GIS Data and Databases. Accessed February 3, 2020. Available at: https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases.

DNR, 2020b. Hydrography Data. GIS Open Data. Accessed February 3, 2020. Available at: http://data-wadnr.opendata.arcgis.com/datasets/dnr-hydrography-water-bodies.

DNR, 2020c. Washington DNR Managed Land Parcels. GIS Open Data. Accessed January 28, 2020. Available at: http://data-wadnr.opendata.arcgis.com/datasets/wa-dnr-managed-land-parcels.

Ecology (Washington State Department of Ecology), 2015. Watershed Characterization for WRIA 7. Accessed February 4, 2020. Available at: https://fortress.wa.gov/ecy/publications/documents/1506009.pdf.

King County, 2016. LiDAR Elevation Dataset. Washington DNR LiDAR Portal. Accessed February 10, 2020. Available at: https://lidarportal.dnr.wa.gov/.

King County, 2020a. Public Parcels in King County. King County GIS Open Data Portal. Accessed February 3, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/public-parcels-in-king-county-public-parcels-area.

King County, 2020b. Comprehensive Plan Land Use Designations for King County – 20 Categories. Land Use King County GIS Open Data Portal. Accessed February 3, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/comprehensive-plan-land-use-designations-for-king-county-20-categories-landuse-kc-consol-20-area.

King County, 2020c. Tribal Lands in King County. King County GIS Open Data Portal. Accessed February 3, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/tribal-lands-in-king-county-tribal-lands-area.

King County, 2020d. Street Address. King County GIS Open Data Portal. Accessed January 28, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/street-address-st-address-line.

King County, 2020e. Zoning Designations for King County – 20 Category Scheme. King County GIS Open Data Portal. Accessed January 28, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/zoning-designations-for-king-county-20-category-scheme-zoning-kc-consol-20-area.

King County, 2020f. King County GIS Open Data Portal. Accessed January 31, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/potential-landslide-hazard-areas-2016-landslide-hazard-area.

King County, 2020g. King County GIS Open Data Portal. Accessed January 31, 2020. Available at: https://gis-kingcounty.opendata.arcgis.com/datasets/potential-steep-slope-hazard-areas-steep-slope-hazard-area.

NHC and GeoEngineers, 2020. *WRIA 7 Consumptive Use Estimates –Final Draft.* Prepared for Washington State Department of Ecology. January 20, 2020.

USGS (United States Geological Survey), 2020. Watershed Boundary Dataset. National Hydrography Products. Accessed February 2, 2020. Available at: https://www.usgs.gov/core-science-systems/ngp/national-hydrography/access-national-hydrography-products.

WDFW (Washington Department of Fish and Wildlife), 2020. Statewide Washington Integrated Fish Distribution (SWIFD). Washington Geospatial Open Data Portal. Accessed February 3, 2020. Available at: https://geo.wa.gov/datasets/wdfw::statewide-washington-integrated-fish-distribution.

WSDA (Washington State Department of Agriculture), 2018. Agricultural Land Use GIS Data. Agricultural Land Use Data Portal. Accessed February 2, 2020. Available at: https://agr.wa.gov/departments/land-and-water/natural-resources/agricultural-land-use.

Appendix B

Natural Storage Memorandum

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Memorandum

December 30, 2021

To: Erin Ericson, Executive Director – Snoqualmie Valley Watershed Improvement District

From: Adam Hill, PE – Anchor QEA, LLC
David Rice, PE – Anchor QEA, LLC
Emelie Crumbaker – Aspect Consulting, LLC

cc: Ingria Jones, WRIA 7 Streamflow Restoration Lead – Washington State Department of Ecology

Re: Preliminary Design Analyses
Snoqualmie River Watershed – Natural Storage Enhancement Project

Introduction

The Snoqualmie Valley Watershed Improvement District (SVWID) has embarked on an assessment of potential storage projects that could benefit water supply and enhance instream flows within the Snoqualmie River Watershed. This effort initially included an assessment of the potential for small-scale storage projects that culminated in the *Small-Scale Storage Study Summary Report* (Anchor QEA 2020). That study focused on small storage projects that were targeted to provide limited benefits within the SVWID service area. One of the ideas identified through the Small-Scale Storage Study was the potential for enhancing natural storage ponds and wetland areas in the headwaters of tributaries to the Snoqualmie River through the use of natural elements. These projects were referred to in the study as "natural storage." In 2019, SVWID secured funding under the Streamflow Restoration Grant funding program to develop a natural storage project to the preliminary design level and complete a more comprehensive study of storage opportunities in the Snoqualmie River Watershed.

Natural storage projects would consist of placing natural materials, such as large wood or beaver dam analogs (BDAs), near the outlets of natural ponds or wetlands. Natural storage projects, including installation of BDAs, have been used in watersheds throughout the Pacific Northwest to achieve the following benefits:

- Reverse downcutting
- Enhance groundwater recharge
- Reduce channel velocities and attenuate peak flow rates
- Increase natural storage of water at the surface and in the shallow aquifer

The concept of natural storage, as envisioned when it was introduced in the Small-Scale Storage Study, would be to install something natural at the outlet of an existing pond or wetland to enhance groundwater recharge, attenuate the release of water, and increase the storage in these natural features. The intended result would be to improve flows throughout the tributary and mainstem during low-flow periods. Increasing natural storage would also enhance fish and wildlife habitat, including habitat for Endangered Species Act-listed fish species. This memorandum describes how a natural storage site was selected for further evaluation and summarizes the analyses that have been completed to advance the potential natural storage project to the preliminary design stage.

Previous Work

Water resource managers in the Snoqualmie River Watershed (Water Resource Inventory Area [WRIA] 7) have long discussed the potential for creating new storage within the watershed to improve management of winter flood flows and late summer low flows. Prior to 2019, no thorough study of the feasibility of storage proposals in WRIA 7 had been completed.

Small-Scale Storage Study

In 2018, SVWID received a Watershed Plan Implementation and Flow Achievement Grant award from the Washington State Department of Ecology (Ecology) to investigate the potential for creating small-scale water storage within the Snoqualmie Valley. SVWID engaged Anchor QEA, LLC, to complete an assessment of small-scale surface water storage facilities that were limited in size, with targeted storage capacities generally smaller than 10 acre-feet (AF), with a focus on the lower Snoqualmie River and its tributaries that flow through the SVWID service area from just upstream of Fall City to just downstream of Duvall.

As part of the Small-Scale Storage Study, screening criteria and methodology were developed to rank and compare small-scall storage projects (Anchor QEA 2018). The criteria and methodology were applied to screen and rank 16 potential small-scale storage projects (Anchor QEA 2019). Three of the 16 potential small-scale storage projects were selected to advance to more detailed design development (Anchor QEA 2020). Other potential storage projects that were highly ranked by the Small-Scale Storage Study included natural storage projects in the Cherry Creek, Stossel Creek, and Langlois Creek subbasins. The study recommended additional evaluation and development of natural storage projects as part of a future study.

Comprehensive Storage Study

After initiating the Small-Scale Storage Study, it became apparent that there would be value in a more comprehensive study that would assess the potential for a wide range of surface water storage options, including small to large storage opportunities throughout the watershed. In 2019, SVWID secured funding under Ecology's Streamflow Restoration Grant funding program to complete the Snoqualmie River Watershed Comprehensive Storage Study (Comprehensive Storage Study). The Comprehensive Storage Study is currently underway and will expand on the Small-Scale Storage Study to identify and evaluate storage projects of all sizes to meet multiple water benefits throughout the Snoqualmie River Watershed.

As part of the Comprehensive Storage Study, the *Work Plan, Snoqualmie River Watershed Comprehensive Storage Study* (Work Plan) was developed to summarize the criteria and methodology proposed to identify, screen, and rank potential storage sites within the Snoqualmie River Watershed (Anchor QEA and Aspect 2020). Criteria included physical criteria that measure benefits to out-of-stream uses, physical criteria that measure benefits to instream flows and habitat conditions, and other cost/benefit and feasibility criteria. The Work Plan was circulated to key stakeholders and the Snoqualmie and Tulalip Tribes for review to ensure that the screening criteria and methodology developed were consistent with watershed planning goals and objectives in WRIA 7.

The *Screening Analysis Summary, Snoqualmie River Watershed Comprehensive Storage Study* (Screening Analysis Summary) was then developed as outlined in the Work Plan to identify and evaluate potential water storage sites (Anchor QEA et al. 2020). Data were collected and mapped in GIS, and a model was built to characterize, score, and rank grid cells within the watershed based on criteria developed in the Work Plan. The outcome of the GIS analysis was used as a basis to identify and screen for 20 storage sites, which were analyzed for site criteria not easily evaluated in GIS. Scoring from the site-specific analysis was combined with GIS-based analysis to develop overall favorability scores for each site. The results of the Screening Analysis Summary will be used to select a list of 5 to 10 storage projects to move forward to a more detailed analysis. A final report will be completed later this year to summarize the Comprehensive Storage Study.

Scope and Purpose

The first task outlined in the scope of work to be completed under the 2019 Streamflow Restoration Grant secured by SVWID includes phased implementation and preliminary design of a natural storage enhancement project in one of the upper tributaries within the Snoqualmie River Watershed. The tasks to be completed include the following:

- **Identification of a Natural Storage Enhancement Site:** As an initial step, Anchor QEA worked with SVWID to review opportunities identified for enhancing natural storage in the Small-Scale Storage Study. The outcome of this task was selection of a preferred natural storage enhancement project to be carried forward through preliminary design in the headwaters of Stossel Creek.
- **Engineering Analyses to Support Preliminary Design:** Anchor QEA and Aspect Consulting, LLC, completed analyses to characterize hydrologic conditions, site geologic and soil properties, the existing water balance in the wetland at the site, and potential impacts to the water balance that would result from implementation of a natural storage project at the site. This memorandum summarizes the findings of these analyses.
- **Preliminary Design of the Natural Storage Enhancement Project:** The scope of work for the natural storage enhancement task will culminate in the development of preliminary design drawings for a natural storage project.

The purpose of this technical memorandum is to summarize analyses completed to support the preliminary design process of the selected natural storage enhancement project.

Background

As noted in the Previous Work section, the Small-Scale Storage Study identified opportunities for enhancing natural ponds or wetlands near the headwaters of tributaries to the Snoqualmie River by placing natural materials, such as large wood or BDAs, to enhance groundwater recharge, attenuate the release of water, and increase storage in these natural features. The Small-Scale Storage Study identified potential for natural storage projects at headwater ponds or wetlands in the Cherry Creek, Stossel Creek, and Langlois Creek subbasins. As an initial step in completing this study, the sites identified in the Small-Scale Storage Study were further evaluated based on communication with landowners, site visits, and further discussion with SVWID. The following summarizes the work completed to select a natural storage site for preliminary design.

Site Visit and Natural Storage Project Site Selection

The primary landowner of natural storage sites in the headwaters of the Cherry Creek and Stossel Creek watersheds is the Washington Department of Natural Resources (DNR). The sites are located on property managed by DNR for timber harvest. Anchor QEA and SVWID met with DNR to discuss opportunities for natural storage in March 2020. Anchor QEA then visited various potential natural storage sites with DNR land manager Paul Footen on May 29, 2020. Notes and photographs from the site visit are included in Attachment A.

Prior to the site visit, Anchor QEA and SVWID identified seven potential locations to stop and view the natural storage sites identified on DNR property in the Stossel Creek headwaters (Site D from the Small-Scale Storage Study) and Cherry Creek headwaters (Site C from the Small-Scale Storage Study). During the site visit, six stops were made. The following summarizes the observations from the site visit.

Stossel Creek

Stop 1 (see Attachment A) is located near a pond and associated wetlands near the upstream end of Stossel Creek. The pond and wetland discharge through a relatively narrow channel at the south end of the area where natural materials could be placed in an effort to enhance the natural storage in the pond. At the date of the site visit, the pond was much larger than shown in the aerial photograph in Attachment A. An additional pond was observed approximately 1/4 mile upstream of the lower pond. The site is accessible from a DNR road, referred to on maps as Stossel Creek Road, that extends north along Stossel Creek from Northeast Stossel Creek Way.

Stop 6 (see Attachment A) is located along Stossel Creek upstream of the pond and wetland complex viewed at Stop 1. There did not appear to be a suitable site for natural storage enhancement at this location.

Cherry Creek

Stop 2 (see Attachment A) was accessed via DNR roads that extend west and south from the upper end of Stossel Creek. Stop 2 is located near the outlet of a headwater pond. The pond discharges at the south end through a 24-inch culvert that passes under a DNR road. The surface of the road was at least 2 to 3 feet above the surface of the pond at the time of the site visit. There may be potential for modification of the culvert to raise the water surface in this pond to store additional water. Controls could be placed on the culvert to control the water surface and discharge from the pond.

Stop 3 (see Attachment A) was accessed via DNR roads and is located to the west of Stop 2. The pond at Stop 3 was the largest of the ponds observed during the site visit. The long, narrow pond discharges through a culvert under a former forest road that appears to no longer be in use and is not passable east of the pond. At the time of the site visit, the pond water surface was slightly higher than the surface of the road and was overtopping the road.

An additional natural storage location identified in the Small-Scale Storage Study is another pond located south of Stop 3. This pond was not accessible from the DNR road. The pond outlet is far from the road through dense regrowth area and mature forest. Due to the difficult access, this site did not appear to be ideal for natural storage enhancement.

Stop 4 was not originally identified in the Small-Scale Storage Study as a potential natural storage site. However, the site was observed by following the DNR road to the south and west of Stop 3. A small wetland discharges to a tributary to Cherry Creek through a culvert under the DNR road at this location. There may be potential for modification of the culvert to raise the water surface in this wetland area to store additional water. Controls could be placed on the culvert to control the water surface and discharge from the pond.

Stop 5 is located near a pond located upstream and north of the large pond observed at Stop 3. This pond was also identified as a potential natural storage location in the Small-Scale Storage Study. The group attempted to access the pond, but access was challenging through thick bushes and undergrowth. The outlet of the pond was a long way from the DNR road and would be very difficult to access. Due to the difficult access, this site did not appear to be ideal for natural storage enhancement.

Site Selection

After conditions from the site visit were reviewed and discussed with SVWID staff, the Stossel Creek site (Stop 1) was selected as a preferred natural storage site to move forward through additional analysis and preliminary design. The site was easy to access and appears to offer topographic and hydrologic conditions that would be well suited for natural storage enhancement. The pond appears to be currently functioning as a natural storage site that would be able to store additional water with placement of natural material at the outlet. The site also offers the potential benefit of recharging the shallow aquifer at the upstream end of Stossel Creek, attenuation of peak flows in the creek, and improved hydrologic conditions that would extend down Stossel Creek to the Tolt River and beyond.

Existing Site Conditions

The Stossel Creek natural storage enhancement site is located on DNR land on King County Parcel Nos. 1226079005 and 1226079002, in the north half of Section 12, Township 26 North, Range 07 East. It is located approximately 10 miles north-northeast of Carnation on a DNR road that extends north along Stossel Creek from Stossel Creek Way Northeast.

The current site consists of two distinct but hydraulically connected ponds/wetland areas surrounded by brush and trees in the headwaters of Stossel Creek. The lower pond outlets to Stossel Creek approximately 5 miles upstream of its confluence with the Tolt River.

Site conditions can be described from several sources, including topography from light detection and ranging (LiDAR) data, precipitation from precipitation gages and maps, soils from the Natural Resources Conservation Service (NRCS), geology from DNR, and other information (such as ownership data and sensitive areas data) from King County. Additional relevant data are described in following sections.

Analyses

Analyses were completed to determine site geologic and hydrologic conditions to be able to provide an understanding of conditions at the site, estimate the existing water balance at the site, and approximate the impact that a natural enhancement project would have on the water balance in the pond system at the site.

Soils and Geology

Soils underlying the Stossel Creek site and area geology are described in the following sections.

Soil Unit Descriptions and Ratings

NRCS provides information from local soil surveys through the U.S. Department of Agriculture Web Soil Survey portal (USDA 2021). The soil surveys provide the mapped soil unit that includes soil type, soil profiles, soil quality, and soil engineering characteristics. In addition, the soil survey also has suitabilities and limitations for various land use purposes based on the mapped soil units. Figures 1 and 2 illustrate the soil unit layers that are applicable to the project. Note that the NRCS soil descriptions are generalizations of the soil characteristics and do not always provide site-specific information for features, such as the depth to groundwater, because the soil units may cover a larger area than that being studied. Table 1 provides the soil units mapped within the study area and applicable information to assist in determining the suitability and limitations of development to consider in planning; soils with more than 5% of the total area are included.

Based on the soil survey, soils near the ground surface at the Stossel Creek site primarily consist of the Seattle muck unit, which should provide suitable conditions for ponding, with low hydraulic conductivities and flat slope. The Seattle muck unit consists of very poorly drained soils that release water so slowly that free water remains at or near the ground surface, causing frequent ponding. The Seattle muck unit has very long ponding times (more than 30 days). Underlying the Seattle muck is a relatively thin veneer of glacial deposits and sedimentary bedrock, which are both relatively impermeable.

The long-term infiltration rate for the site was estimated based on empirical information of the soils described in the soil profile (organic clay/silty clay/clay loam). Long-term infiltration rates are estimated to range from 0.014 to 0.5 inches per hour (in/hr).

The site is a natural depression, and the surrounding slopes vary between 5% and 65%. The steeper slopes may be prone to occasional instability, depending on the pre-existing conditions, type of vegetation, and water flow energy the bank may be exposed to in the future.

Table 1
Summary of Applicable Soil Information for the Stossel Creek Site

Parameter	Soil Unit		
	Blethen Gravelly Loam	**Seattle Muck/Water[1]**	**Tokul Gravelly Medial Loam**
Soil Number	23 and 24	231 and 285	257
Percentage of Area	15	80	5
Parent Material	Volcanic ash and slope alluvium derived from glacial drift	Herbaceous organic material and woody organic material	Volcanic ash mixed with loess over glacial till
Typical Profile (inches)	0 to 5: gravelly loam 5 to 24: very gravelly sandy loam 24 to 42: extremely gravelly sandy loam 42 to 60: extremely gravelly loamy sand	0 to 8: muck 8 to 60: stratified mucky peat to muck	0 to 1: slightly decomposed plant material 1 to 2: highly decomposed plant material 2 to 24: gravelly medial loam 24 to 33: gravelly medial fine sandy loam 33 to 62: cemented material
Unified Soil Classification (surface)	SM	PT	PT
Slope (percentage)	23: 5 to 30 24: 30 to 65	0 to 1	30 to 65
Depth to Restrictive Layer	More than 80 inches	More than 80 inches	20 to 39 inches to cemented horizon
Natural Drainage Class	Well drained	Very poorly drained	Moderately well drained
Depth to Water Table	More than 80 inches	At surface	Approximately 18 to 36 inches

Parameter	Soil Unit		
	Blethen Gravelly Loam	Seattle Muck/Water[1]	Tokul Gravelly Medial Loam
Frequency of Ponding	None	Frequent	None
Hydrologic Soil Group	B	B/D	B
Pond Reservoir Areas	Very limited	Somewhat limited	Very limited

Notes:

1. The mapped 285 – Water soil unit is assumed to be underlain by the 231 – Seattle muck soil unit.

SM: silty sand
PT: peat

Regional Geology

The Stossel Creek site lies in the western foothills of the northern portion of the Cascade Range physiographic province near the transition with the Puget Lowland physiographic province. The Cascade Range is part of a vast mountain chain that spans more than 500 miles, from Mount Shasta in northern California to British Columbia in the north, and consists of an active volcanic arc superimposed upon bedrock of Paleozoic to Tertiary age. Pliocene to recent uplift created high topographic relief. A major east–west geologic break, tracing generally between Ellensburg and Seattle, Washington, separates the Cascades into northern (North Cascades) and southern portions.

The North Cascades are composed of faulted and folded Mesozoic and Paleozoic crystalline and metamorphic rocks and Tertiary intrusive, volcanic, and sedimentary rocks. On the east side, the Methow Valley contains the thickest stratigraphic section of Cretaceous marine sedimentary rocks in the state. To the west, Paleozoic and Mesozoic marine sedimentary and volcanic rocks were deformed by complex thrust faulting during late Cretaceous subduction. Lower Tertiary sedimentary rocks, such as the Chuckanut Formation, were deposited in rapidly subsiding, fault-bounded basins. Tertiary plutons cut and altered older rock throughout the North Cascades. Two Quaternary stratovolcanoes dominate the North Cascades—Mount Baker and Glacier Peak—both less than 1 million years old. The rugged topography of the North Cascades is a result of Pleistocene and Holocene glaciation. Approximately 25,000 to 13,000 years ago, much of the North Cascade Range was covered by glaciers. During this time, the Cordilleran ice sheet was advancing south from British Columbia, and most of the range was covered by a thick sheet of ice. As the ice sheet retreated, massive amounts of water ran off the glacier, eroding the mountains, carving U-shaped valleys, creating lakes, and depositing massive amounts of glacial sediment.

Local Geology

Based on the geology map (Figure 3), the lower valley floor at the site is underlain by Quaternary bog, marsh, swamp, or lake deposits consisting of loose or soft peat, muck, and organic silt and clay with local thin beds of Mazama ash (Dragovich et al. 2013; Knoll 1967). Peat is also interstratified with alluvial deposits along low-energy-river valleys and deposited in upland depressions and kettles over low-permeability glacial deposits or in abandoned channel depressions. Quaternary continental glacial drift deposits mapped upstream and downstream of the site in the lower and flatter elevations consist of bouldery pebble cobble gravel to pebbly sand that are loose and massive to crudely bedded. The slopes surrounding the valley are primarily exposed Eocene volcanic and sedimentary (Evs[p] and Eva[p]) bedrock of interbedded andesitic to basaltic flows and lesser andesitic to rhyolitic tuff and tuff breccia, volcanic and tuffaceous sandstone and siltstone, lahar deposits, volcanic conglomerate, shale, organic-matter-rich siltstone, and coal (Tabor et al. 1993; Dragovich et al. 2009a, 2009b, 2010a, 2010b, 2011a, 2011b, 2012).

Landslide deposits are also mapped along the valley slopes, with the nearest feature adjacent to the right abutment area of the proposed BDA. It is assumed that the landslide debris is an amalgamation of Evs(p) and Eva(p) units, potentially including Quaternary continental till, which is mapped topographically above bedrock units.

To estimate deep groundwater recharge that may result from the enhanced system, site topography and Stossel Creek channel elevations were reviewed along with assumptions for the site-specific geology based on the available regional datasets. The most significant assumption is the presence and thickness of an unsaturated zone beneath the site and an underlying aquifer unit within the unconsolidated sediments overlying bedrock. If that zone is saturated throughout the year, the potential benefits from aquifer storage decrease significantly. However, the presence of an unsaturated zone, even if only seasonally, would result in additional infiltration from the larger deeper ponding generated from the enhanced system.

Based on the assumed site soil infiltration rates and peak month infiltration, the maximum groundwater mounding from the enhanced pond condition is approximately 6 to 35 feet. In other words, an unsaturated zone with a thickness between 6 and 35 feet or more would provide the greatest benefit of aquifer storage from the increased induced groundwater recharge. The assumed thickness of the unsaturated zone is also critical to estimating the location and timing of downstream benefits from aquifer recharge. For example, assuming an unsaturated zone thickness of 20 feet beneath the site, the Stossel Creek channel intersects the same elevation at distances between 1,000 and 3,000 feet downstream. At these distances, the potential benefit of increased baseflow in Stossel Creek would reach a new equilibrium after approximately 7 to 8 years and provide year-round benefit. Similarly, a thin unsaturated zone would result in increased baseflow in Stossel Creek closer to the site and reach equilibrium sooner and may only provide seasonal benefits.[1]

[1] Groundwater mounding estimated following the methods described by Zomorodi (2005). Seepage to groundwater and downgradient transport estimated from Darcy's Law and modified Darcy flux calculations.

Slope and Bank Stability

The area surrounding the site has high relief, particularly the slopes descending east toward the proposed pond outlet and along the bounds of the existing channel, which appear to be over-steepened from ongoing streambank erosion. Aside from the landslide described earlier in the Local Geology section, several other features are mapped by DNR (2021) and King County (2021) in close proximity upstream and downstream of the project. The slopes also are mapped by King County within their Environmentally Sensitive Areas for Erosion Hazard and for Potential Steep Slope Hazard. The Sensitive Areas Ordinance defines significant Erosion Hazard areas as those soils in King County that may experience severe to very severe erosion hazard, and steep slopes are defined as slopes that are greater than 40% grade and more than 10 feet high, which are generally reflected in Figure 2, which shows the Representative Slope.

In general, the Stossel Creek site should be considered prone to slope instabilities, and landslides have historically occurred within similar geologic units surrounding the proposed BDA area. However, the project, as currently planned, should not significantly change the surface and subsurface conditions so upper slope stability and deep-seated landslides should not worsen. Additionally, reducing the water flow energy by impounding the lake should lessen the local streambank erosion. At an appropriate phase, slope stability analyses should be completed to verify these findings.

Hydrology

Hydrology at the Stossel Creek site was evaluated by delineating the watershed area and using a continuous hydrologic model to simulate the rainfall-runoff relationship in the watershed. The Western Washington Hydrologic Model (WWHM) version 4.2.17 (WWHM2012; Clear Creek Solutions 2019) was used to develop hydrology for the Stossel Creek site. WWHM is a continuous simulation hydrology model that uses location data to estimate rainfall for a 61-year period of record from October 1, 1948, to September 30, 2009. The model then simulates the rainfall-runoff relationship through that period of record based on land cover and soil characteristics for the watershed and includes surface runoff, interflow, groundwater, soil moisture, and evapotranspiration.

The watershed area was delineated using LiDAR data (King County 2003) and processed using ArcGIS hydrology tools. Watershed boundaries developed from the LiDAR data are shown in Figures 1 through 3. Table 2 summarizes the watershed characteristics at the existing Stossel Creek site.

Table 2
Stossel Creek Site Characteristics – Existing Conditions

Parameter	Value
Minimum pond area (elevation 572 feet)	3.5 acres
Maximum pond area (elevation 575 feet)	13.5 acres

Parameter	Value
Outlet surface elevation	572 feet
Outlet width	40 feet
Pond area infiltration rates	0.014 and 0.5 in/hr
Tributary watershed area (not including pond area)	397 acres
Tributary watershed conditions	A/B soil, forest, steep slopes
Precipitation gage	Landsburg
Precipitation factor	1.286

As noted in Table 2, the watershed tributary to the site was input as Hydrologic Soil Group B with forested land and steep slopes. The pond site was simulated with two different infiltration rates—0.014 in/hr and 0.5 in/hr—based on soil conditions underlying the pond, as described previously. The site outlets through a confined channel approximately 40 feet wide. The Landsburg gage was used to estimate precipitation with a precipitation factor of 1.286; these values were determined by the site location.

Areas and volumes based on elevations for the site were estimated using LiDAR data; Table 3 shows the site elevations, areas, and volumes.

Table 3
Stossel Creek Pond Elevations, Areas, and Volumes

Elevation (feet)	Area (acres)	Volume (AF)[1]
572	3.5	0
573	7.6	5.5
574	11.4	15.0
575	13.5	27.5

Note:

1. Volume does not include existing pond, which has an unknown depth. This volume is assumed to remain constant with or without the project.

A summary of the flow results for the Stossel Creek site modeled under existing conditions is included in Table 4. The WWHM model results are included in Attachment B.

Table 4
Stossel Creek Site Flow Results – Existing Conditions

Flow Frequency	Peak Runoff at Existing Outlet – Lower Infiltration (0.014 in/hr) (cfs)	Peak Runoff at Existing Outlet – Higher Infiltration (0.5 in/hr) (cfs)
2-year	7.1	8.0
5-year	20.1	21.4
10-year	36.7	37.8
25-year	72.8	72.2
50-year	116.1	112.4
100-year	179.8	170.2

Notes:
Flow frequency based on the Log Pearson Type III Bulletin 17B method in the WWHM model (Clear Creek Solutions 2019).
cfs: cubic feet per second

These flow results include surface water runoff and interflow (shallow groundwater) runoff but do not include infiltration to deep groundwater.

For enhanced conditions, the pond outlet was adjusted to have a weir 40 feet wide and 2 feet high to simulate the placement of natural materials at the outlet that would result in increased storage. The natural materials placed at the pound outlet would not be designed as a fully impervious barrier but would be something like a BDA or other materials that would slow the release of water but would always pass some surface flow. A 3-inch orifice was added at the outlet to simulate the small amount of surface flow that would pass through the outlet during low flows. Actual conditions at the site may vary. Table 5 summarizes the characteristics of the enhanced Stossel Creek site with emphasis on changed parameters.

Table 5
Stossel Creek Site Characteristics – Enhanced Conditions

Parameter	Value
Minimum pond area (elevation 572 feet)	3.5 acres
Maximum pond area (elevation 575 feet)	13.5 acres
Outlet surface elevation	572 feet
Outlet width	40 feet
Outlet weir height	2 feet
Outlet orifice diameter	3 inches
Pond area infiltration rates	0.014 and 0.5 in/hr
Tributary watershed area (not including pond area)	397 acres
Tributary watershed conditions	A/B soil, forest, steep slopes
Precipitation gage	Landsburg
Precipitation factor	1.286

Note:
Parameters and values in **bold** are changes from existing conditions.

A summary of flow results for the Stossel Creek site for enhanced conditions is included in Table 6.

Table 6
Stossel Creek Site Flow Results – Enhanced Conditions

Flow Frequency	Peak Runoff at Proposed Outlet – Lower Infiltration (0.014 in/hr) (cfs)	Peak Runoff at Proposed Outlet – Higher Infiltration (0.5 in/hr) (cfs)
2-year	0.3	2.2
5-year	0.6	3.3
10-year	0.9	4.0
25-year	1.6	5.1
50-year	2.2	6.0
100-year	3.1	6.9

Note:
Flow frequency based on the Log Pearson Type III Bulletin 17B method in the WWHM model (Clear Creek Solutions 2019).

Based on the model results, increasing the storage volume of the pond by placing natural materials at the outlet would result in decreased peak flows at the pond outlet. The pond would overflow when the outlet materials are overtopped. Flow would also leave the pond by passing through the outlet at a reduced rate or seep to shallow groundwater and flow downgradient as shallow groundwater interflow. As noted previously, two seepage rates were assumed based on soil conditions – 0.014 in/hr and 0.5 in/hr. At these rates, it would take 2 to 36 days to infiltrate 2 feet of storage to groundwater. Actual seepage rates at the site may vary from the rate assumed but would likely be very low based on the soils that were reported previously and shown in Figures 1, 2, and 3.

Long-Term Hydrologic Model Results

Existing Conditions

The WWHM model results provided hourly surface runoff and infiltration volumes for the Stossel Creek site for existing conditions. These data were analyzed and summarized by month to obtain an understanding of potential changes in runoff from the site due to enhanced storage. Analyses started in Water Year 1950 (October 1949) to give the model a year to establish equilibrium after initial precipitation events in the first year.

Monthly surface flow volumes and infiltration flow volumes at the downstream end of the Stossel Creek site were analyzed over the 60-year modeling period of record. Surface flow will travel downstream in Stossel Creek, whereas infiltration flow will travel downgradient and return to Stossel Creek at a later time, as described in previous sections. The average flow volume and range of flow volumes (minimum and maximum) in each month are reported in Table 7 for the lower infiltration rate scenario and in Table 8 for the higher infiltration rate scenario. These values are also summarized in Figure 4.

For existing conditions, flows are highest in the winter and early spring and lowest in the summer. Infiltration is heavily dependent on the rate assumed—for the lower infiltration rate, approximately 1% of flow reaching the site is infiltrated; for the higher infiltration rate, 25% to 30% of flow reaching the site is infiltrated. The higher infiltration rates assume that the thickness of an unsaturated zone beneath the site does not constrain the infiltration rate.

Table 7
Stossel Creek Site Flow Volume Summary – Existing Conditions, Lower Infiltration Rate

Month	Surface Flow Volume (AF)			Infiltration Flow Volume (AF)		
	Avg	Min	Max	Avg	Min	Max
October	1.50	0.05	5.91	0.02	0.00	0.06
November	3.50	0.35	12.83	0.04	0.00	0.12
December	3.94	0.62	21.62	0.04	0.01	0.10
January	4.60	0.30	23.46	0.05	0.00	0.12
February	3.01	0.02	13.70	0.03	0.00	0.13
March	2.58	0.27	16.24	0.03	0.00	0.11
April	1.71	0.03	8.68	0.02	0.00	0.08
May	0.87	0.03	4.39	0.01	0.00	0.04
June	0.75	0.00	6.41	0.01	0.00	0.04
July	0.36	0.00	5.78	0.00	0.00	0.03
August	0.37	0.00	2.15	0.00	0.00	0.02
September	0.72	0.00	6.94	0.01	0.00	0.03

Table 8
Stossel Creek Site Flow Volume Summary – Existing Conditions, Higher Infiltration Rate

Month	Surface Flow Volume (AF)			Infiltration Flow Volume (AF)		
	Avg	Min	Max	Avg	Min	Max
October	1.07	0.03	4.26	0.43	0.01	1.67
November	2.56	0.25	9.55	0.95	0.10	3.33
December	2.91	0.42	18.55	1.04	0.17	3.11
January	3.40	0.21	20.49	1.22	0.08	3.05
February	2.19	0.02	10.28	0.83	0.01	3.51
March	1.87	0.20	13.31	0.70	0.08	3.01
April	1.23	0.02	6.55	0.48	0.01	2.16
May	0.63	0.02	3.75	0.24	0.01	1.07
June	0.55	0.00	5.28	0.20	0.00	1.08
July	0.27	0.00	5.01	0.09	0.00	0.79
August	0.26	0.00	1.55	0.10	0.00	0.61
September	0.53	0.00	6.27	0.18	0.00	0.68

Impacts on Hydrology from Natural Storage Enhancement Project

Using the assumed parameters for the pond with the natural storage enhancement project in place, analyses were completed for the Stossel Creek site for enhanced conditions. Monthly surface flow volumes and infiltration flow volumes at the downstream end of the Stossel Creek site were analyzed over the 60-year modeling period of record. The average flow volume and range of flow volumes (minimum and maximum) in each month are reported in Table 9 for the lower infiltration rate scenario and in Table 10 for the higher infiltration rate scenario. These values are also summarized in Figure 5.

Table 9
Stossel Creek Site Flow Volume Summary – Enhanced Conditions, Lower Infiltration Rate

Month	Surface Flow Volume (AF)			Infiltration Flow Volume (AF)		
	Avg	Min	Max	Avg	Min	Max
October	0.99	0.01	4.76	0.64	0.01	2.38
November	2.39	0.26	12.42	1.41	0.18	5.49
December	3.08	0.46	19.63	1.70	0.31	6.12
January	3.37	0.28	22.02	1.82	0.19	6.80
February	2.24	0.02	11.35	1.30	0.02	5.16
March	1.94	0.24	13.37	1.16	0.16	5.90
April	1.13	0.02	5.51	0.70	0.01	2.80
May	0.56	0.01	4.27	0.36	0.01	2.12
June	0.45	0.00	4.18	0.28	0.00	2.06
July	0.21	0.00	3.91	0.13	0.00	1.88
August	0.19	0.00	1.34	0.13	0.00	0.88
September	0.43	0.00	4.71	0.27	0.00	2.20

Table 10
Stossel Creek Site Flow Volume Summary – Enhanced Conditions, Higher Infiltration Rate

Month	Surface Flow Volume (AF)			Infiltration Flow Volume (AF)		
	Avg	Min	Max	Avg	Min	Max
October	0.06	0.00	0.29	1.50	0.11	6.00
November	0.15	0.01	0.63	3.49	0.35	12.98
December	0.18	0.03	1.75	3.92	0.63	22.22
January	0.20	0.01	1.34	4.55	0.30	22.95
February	0.13	0.00	0.76	3.00	0.02	14.11
March	0.11	0.01	0.89	2.57	0.27	16.20
April	0.07	0.00	0.39	1.69	0.03	8.65
May	0.04	0.00	0.23	0.86	0.04	4.23
June	0.03	0.00	0.36	0.74	0.00	6.26
July	0.02	0.00	0.31	0.35	0.00	5.56
August	0.01	0.00	0.09	0.36	0.00	2.11
September	0.03	0.00	0.41	0.71	0.00	6.82

Comparisons between existing and enhanced conditions are presented in Table 11 for the lower infiltration rate scenario and in Table 12 for the higher infiltration rate scenario. These comparisons are also summarized in Figure 6.

Table 11
Stossel Creek Site Flow Volume Comparison Between Existing and Enhanced Conditions, Lower Infiltration Rate

Month	Change in Surface Flow Volume (AF)			Change in Infiltration Flow Volume (AF)		
	Avg	Min	Max	Avg	Min	Max
October	-0.51	-1.37	-0.04	0.62	0.01	2.31
November	-1.11	-4.90	-0.05	1.37	0.17	5.36
December	-0.86	-4.47	2.71	1.66	0.30	6.01
January	-1.23	-4.00	1.23	1.78	0.19	6.69
February	-0.77	-5.77	2.06	1.27	0.02	5.03
March	-0.63	-2.88	3.80	1.13	0.16	5.79
April	-0.57	-3.17	0.07	0.68	0.01	2.72
May	-0.30	-1.33	0.31	0.35	0.01	2.10
June	-0.30	-2.22	0.03	0.27	0.00	2.02
July	-0.15	-1.87	0.01	0.12	0.00	1.86
August	-0.17	-0.81	0.03	0.13	0.00	0.86
September	-0.28	-2.23	0.04	0.27	0.00	2.18

Table 12
Stossel Creek Site Flow Volume Comparison Between Existing and Enhanced Conditions, Higher Infiltration Rate

Month	Change in Surface Flow Volume (AF)			Change in Infiltration Flow Volume (AF)		
	Avg	Min	Max	Avg	Min	Max
October	-1.01	-3.97	-0.02	1.07	0.09	4.33
November	-2.40	-8.92	-0.24	2.54	0.25	9.66
December	-2.73	-16.80	-0.40	2.89	0.46	19.10
January	-3.19	-19.14	-0.19	3.33	0.22	19.94
February	-2.06	-9.52	-0.01	2.17	0.01	10.60
March	-1.76	-12.42	-0.19	1.86	0.19	13.19
April	-1.16	-6.15	-0.02	1.21	0.02	6.49
May	-0.60	-3.51	-0.02	0.62	0.03	3.56
June	-0.52	-4.92	0.00	0.54	0.00	5.18
July	-0.25	-4.70	0.00	0.26	0.00	4.77
August	-0.25	-1.46	0.00	0.25	0.00	1.50
September	-0.50	-5.86	0.00	0.53	0.00	6.14

As shown in Figure 6, the enhanced condition would, on average, cause a slight decrease in surface flow volume in all months for the lower infiltration rate scenario; decreases are less from late spring to early fall than in the late fall through early spring. Slight increases in infiltration occur in all months. Although surface flow volumes are decreased, infiltration volumes are increased for all months for a total of 9.6 AF per year on average. Increases in infiltration are highest in winter and spring and lowest in summer. The duration of benefit is dependent on the underlying geology.

For the higher infiltration rate scenario, the enhanced condition would, on average, cause decreases in surface flow volume in all months; decreases are higher in magnitude than in the lower infiltration rate scenario. Infiltration volumes are also higher in magnitude than in the lower infiltration rate scenario, averaging 17.3 AF per year. As with the lower infiltration rate scenario, the duration of benefit is dependent on underlying geology.

As discussed in the Local Geology section, water infiltrated from the Stossel Creek site would likely contribute to baseflow downgradient along the Stossel Creek channel. The distance and timing to zones of increased baseflow is contingent on the presence and thickness of an unsaturated zone beneath the site. Thinner unsaturated zones would result in more immediate contributions to downstream baseflow, whereas thicker unsaturated zones could potentially result in year-round benefits occurring at distances farther downstream.

The analysis that was completed is sensitive to the assumptions that were made about soils, infiltration rates, evaporation, and other site conditions. Additional site investigations would be needed to confirm the accuracy of these values.

Preliminary Design

Preliminary design drawings for the natural storage enhancement project on Stossel Creek are included as Attachment C to this memorandum. The design includes a site plan showing the proposed natural storage enhancement elements in plan view. They also include a profile and section showing the proposed natural storage enhancement elements. Key elements include the following:

- 3-inch-diameter log poles installed at 18-inch (on center) spacing across most of the outlet channel, with willow, alder, or cottonwood branches woven into the base of the poles to form the base of a BDA
- Placement of streambed cobbles upstream and downstream of the log poles
- Placement of a narrow channel using streambed boulders and gravels to provide a path for the pond to overflow as the BDA changes over time

Opinion of Probable Costs

One of the reasons a natural storage project was evaluated is because it has potential to provide instream flow and shallow groundwater enhancement benefits at a relatively low cost. Although it will be more difficult to predict and assess how flows will change with the natural storage enhancement in place, it is anticipated that the materials placed will change over time and can be adapted to target the desired benefits. An opinion of the probable cost to install the elements is shown Table 13. It should be noted that the costs assume that the project will be contracted and that the contractor will provide labor and procure the materials. These types of installations have been completed elsewhere by volunteer crews or by nonprofit groups to reduce the cost of labor.

Table 13
Natural Storage Enhancement on Stossel Creek – Opinion of Probable Cost

Cost Item	Opinion of Cost
Site Access and Staging	$2,000
Equipment Rental (Post Pounder, Small Excavator)	$1,000
Labor (1 Crew, 2 Days)[2]	$8,000
Materials; Wood Posts (35 total)	$500
Materials; Streambed Boulders and Cobbles (20 CY total)	$1,500
Subtotal	**$13,000**
Mobilization and Demobilization (7.5%)	$975
Construction Total	**$14,000**
Contingency (30%)	$4,200
Sales Tax (9.5%)	$1,330
Total Project Implementation Cost	**$20,000**

Notes:
1. These costs do not include additional costs for engineering, permitting, construction management, or administration.
2. Mobilization/Demobilization estimated as 7.5% of Construction Subtotal
3. Labor costs assume that a construction contractor would be hired to complete the installation. An alternative may be to contract with a volunteer crew to provide the labor, which would significantly reduce the cost of labor and the overall cost of the project.
4. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
5. The subtotals and construction total are rounded to the nearest $1,000.

Permitting

Typically, restoration projects require permits from the U.S. Army Corps of Engineers (USACE), Endangered Species Act (ESA) consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), a Hydraulic Permit Approval (HPA) from the Washington Department of Fish and Wildlife (WDFW), State Environmental Policy Act (SEPA) review, and various local permits. These permits are triggered by placement of materials in the stream channel and work below the ordinary high-water mark (OHWM).

The natural storage enhancement project will add fill to the Stossel Creek stream channel and modify the channel, which will likely trigger the need for the following permit approvals:

- **Clean Water Act Section 404 Compliance.** This would require submittal of a Joint Aquatic Resources Permit Application (JARPA) form to the USACE if the project includes discharge of fill material into Waters of the United States, such as Stossel Creek.
- **ESA Section 7 Compliance.** If a JARPA is submitted, the USACE would consult with NMFS and USFWS to comply with ESA.

- **National Historic Preservation Act, Section 106 Compliance.** Submittal of a JARPA and application for a Section 404 permit would trigger consultation with the Washington Department of Archaeology and Historic Preservation for cultural resources compliance.
- **Section 401 Compliance.** Submittal of a JARPA would also trigger consultation with Ecology for a Section 401 Water Quality Certification.
- **HPA.** An HPA from WDFW would be required because work will need to be completed below the OHWM in Stossel Creek.
- **SEPA Compliance.** The project would require a local agency (e.g., King County) to make a SEPA determination based on information provided about the project in a SEPA checklist.
- **Local Permits.** This would likely include Critical Areas Ordinance compliance and potentially other King County permits.

Because the project is relatively straightforward and the intent of the project is restoration of ecological functions and streamflow enhancement, effort should be made to identify programmatic or streamlined approaches to permitting that can be employed to minimize the time and effort required to secure permits for the natural storage enhancement project.

Summary and Next Steps

Analyses were completed to help support the preliminary design phase of a natural storage enhancement project site in the Snoqualmie River Watershed. Site visits were completed in the Stossel and Cherry Creek subbasins to observe and evaluate the potential for natural storage enhancement at sites identified in the Small-Scale Storage Study. A site near the headwaters of Stossel Creek was chosen for further analysis and preliminary design development after the site visit and discussions with the landowner and SVWID.

The Stossel Creek site is located on DNR land approximately 5 miles upstream of Stossel Creek's confluence with the Tolt River. A watershed of approximately 410 acres drains through the site, and raising the pond level at the site 2 feet by placing natural elements at the outlet would provide approximately 15 ac-ft of additional storage volume compared to existing conditions. Soils underlying the site are mostly Seattle muck, which has a low hydraulic conductivity and flat slopes, making conditions suitable for ponding of additional water. The site is surrounded by steep slopes and could be prone to slope instabilities and landslides. However, the current project is not expected to significantly change conditions and could improve landslide conditions by capturing high-energy peak flows and reducing local erosion.

A WWHM model (Clear Creek Solutions 2019) was developed to estimate existing hydrologic conditions and develop conditions for the enhanced site. Peak flow runoff would be reduced because peak flows would be attenuated by the enhanced storage. Infiltration would increase after capture from high runoff events and would likely contribute to baseflow downgradient along the

Stossel Creek channel. The distance and timing to zones of increased baseflow is contingent on the presence and thickness of an unsaturated zone beneath the site. Thinner unsaturated zones would result in more immediate contributions to downstream baseflow, whereas thicker unsaturated zones could potentially result in year-round benefits occurring at distances farther downstream.

Preliminary designs were developed for the proposed natural storage project. The project as designed is intended to raise the maximum water surface in the pond by approximately 2 feet and increase storage in the pond complex by as much as 15 acre-feet. The natural storage enhancement will increase the overall water storage in the wetland complex using natural materials and reverse the effects of downcutting and erosion.

Next steps would be to complete additional site investigations, refine the design as informed by the additional site information, and initiate permitting. The site investigations may need to include survey of the site and test hole drilling or similar to verify the underlying soil conditions at the site, which will have a significant impact on the benefits of the project.

References

Anchor QEA (Anchor QEA, LLC), 2018. Draft Memorandum to: Snoqualmie Valley Watershed Improvement District. Regarding: Screening Criteria and Methodology. September 11, 2018.

Anchor QEA, 2019. Memorandum to: Snoqualmie Valley Watershed Improvement District. Regarding: SVWID Small-Scale Storage Screening Analysis of Potential Storage Sites. March 6, 2019.

Anchor QEA, 2020. *Small-Scale Storage Study Summary Report.* Prepared for Snoqualmie Valley Watershed Improvement District. January 2020.

Anchor QEA and Aspect (Aspect Consulting, LLC), 2020. *Work Plan, Snoqualmie River Watershed Comprehensive Storage Study*. Prepared for Snoqualmie Valley Watershed Improvement District. April 2020.

Anchor QEA, Aspect, and AMP Insights, 2020. *Screening Analysis Summary, Snoqualmie River Watershed Comprehensive Storage Study*. Prepared for Snoqualmie Valley Watershed Improvement District. July 2020.

Clear Creek Solutions, 2019. Western Washington Hydrology Model (WWHM2012). Version 4.2.17. Version Date: September 13, 2019.

DNR (Washington Department of Natural Resources), 2021. Geologic Information Portal. Accessed February 22, 2021. Available at: https://www.dnr.wa.gov/geologyportal.

Dragovich, J.D.; H.A. Littke; M.L. Anderson; R. Hartog; G.R. Wessel; S.A. DuFrane; T.J. Walsh; J.H. MacDonald, Jr.; J.F. Mangano; and R. Cakir, 2009a. Geologic Map of the Snoqualmie 7.5-Minute Quadrangle, King County, Washington. Washington Division of Geology and Earth Resources Geologic Map GM-75. Available at: http://www.dnr.wa.gov/publications/ger_gm75_snoqualmie_24k.zip.

Dragovich, J.D.; H.A. Littke; J.H. MacDonald, Jr.; S.A. DuFrane; M.L. Anderson; G.R. Wessel; and R. Hartog, 2009b. *Geochemistry, Geochronology, and Sand Point Count Data for the Snoqualmie 7.5-Minute Quadrangle, King County, Washington*. Washington Division of Geology and Earth Resources Open File Report 2009-4. Available at: http://www.dnr.wa.gov/Publications/ger_ofr2009-4_snoqualmie_suppl.zip.

Dragovich, J.D.; M.L. Anderson; J.H. MacDonald, Jr.; S.A. Mahan; S.A. DuFrane, H.A. Littke; G.R. Wessel, J.H. Saltonstall, C.J. Koger; and R. Cakir, 2010a. *Supplement to the Geologic Map of the Carnation 7.5-Minute Quadrangle, King County, Washington—Geochronologic, Geochemical, Point Count, Geophysical, Earthquake, Fault, and Neotectonic Data*. Washington Division of Geology and Earth Resources Open File Report 2010-2. Available at: http://www.dnr.wa.gov/publications/ger_ofr2010-2_carnation_supplement.zip.

Dragovich, J.D.; H.A. Littke; M.L. Anderson; G.R. Wessel; C.J. Koger; J.H. Saltonstall; J.H. MacDonald, Jr.; S.A. Mahan; and S.A. DuFrane, 2010b. Geologic Map of the Carnation 7.5-Minute Quadrangle, King County, Washington. Washington Division of Geology and Earth Resources Open File Report 2010-1. Available at: http://www.dnr.wa.gov/Publications/ger_ofr2010-1_geol_map_carnation_24k.zip.

Dragovich, J.D., M.L. Anderson; S.A. Mahan; C.J. Koger; J.H. Saltonstall; J.H. MacDonald, Jr.; G.R. Wessel; B.A. Stoker; J.P. Bethel; J.E. Labadie; R. Cakir; J.D. Bowman; and S.A. DuFrane, 2011a. Geologic Map of the Monroe 7.5-Minute Quadrangle, King and Snohomish Counties, Washington. Washington Division of Geology and Earth Resources Open File Report 2011-1. Available at: http://www.dnr.wa.gov/publications/ger_ofr2011-1_geol_map_ monroe_24k.zip.

Dragovich, J.D.; S.A. Mahan; M.L. Anderson; J.H. MacDonald, Jr.; G.R. Wessel; S.A. DuFrane; R. Cakir; J.D. Bowman; and H.A. Littke, 2011b. *Analytical Data from the Monroe 7.5-Minute Quadrangle, King and Snohomish Counties, Washington—Supplement to Open File Report 2011-1*. Washington Division of Geology and Earth Resources Open File Report 2011-2. Available at: http://www.dnr.wa.gov/publications/ger_ofr2011-2_monroe_ supplement.zip.

Dragovich, J.D., M.L. Anderson; S.A. Mahan; J.H. MacDonald, Jr.; C.P. McCabe; R. Cakir; B.A. Stoker, N.M. Villeneuve; D.T. Smith; and J.P. Bethel, 2012. Geologic Map of the Lake Joy 7.5-Minute Quadrangle, King County, Washington. Washington Division of Geology and Earth Resources

Map Series 2012-01. Available at: http://www.dnr.wa.gov/publications/ger_ms2012-01_geol_map_lake_joy_24k.zip.

Dragovich, J.D.; H.A. Littke; S.A. Mahan; M.L. Anderson; J.H. MacDonald, Jr.; R. Cakir; B.A. Stoker; C.J. Koger; J.P. Bethel; S.A. DuFrane; D.T. Smith; and N.M. Villeneuve, 2013. Geologic Map of the Sultan 7.5-Minute Quadrangle, King and Snohomish Counties, Washington. Washington State Department of Natural Resources, Map Series 2013-01. Scale: 1:24,000. Available at: http://www.dnr.wa.gov/Publications/ger_ms2013-01_geol_map_sultan_24k.zip.

King County, 2003. LiDAR Digital Ground Model (DGM) Elevation and Hillshade. Obtained from Puget Sound LiDAR Consortium and King County Endangered Species Act/Sensitive Areas Ordinance Project. Published July 2003.

King County, 2021, King County iMap. Accessed February 22, 2021. Available at: https://gismaps.kingcounty.gov/iMap/.

Knoll, K.M., 1967. *Surficial Geology of the Tolt River Area, Washington*. Master of Science thesis. University of Washington.

Tabor, R.W.; V.A. Frizzell, Jr.; D.B. Booth; R.B. Waitt; J.T. Whetten; and R.E. Zartman, 1993. Geologic Map of the Skykomish River 30 x 60 Minute Quadrangle, Washington. U.S. Geological Survey Miscellaneous Investigations Series Map I-1963. Available at: http://pubs.usgs.gov/imap/i1963/.

USDA (United States Department of Agriculture), 2021. Web Soil Survey. Accessed February 23, 2021. Available at: http://websoilsurvey.sc.egov.usda.gov/.

Zomorodi, K., 2005. *Simplified Solutions for Groundwater Mounding Under Stormwater Infiltration Facilities*. Paper presented at AWRA Annual Water Resources Conference (Seattle, Washington); November 2005.

.

Figures

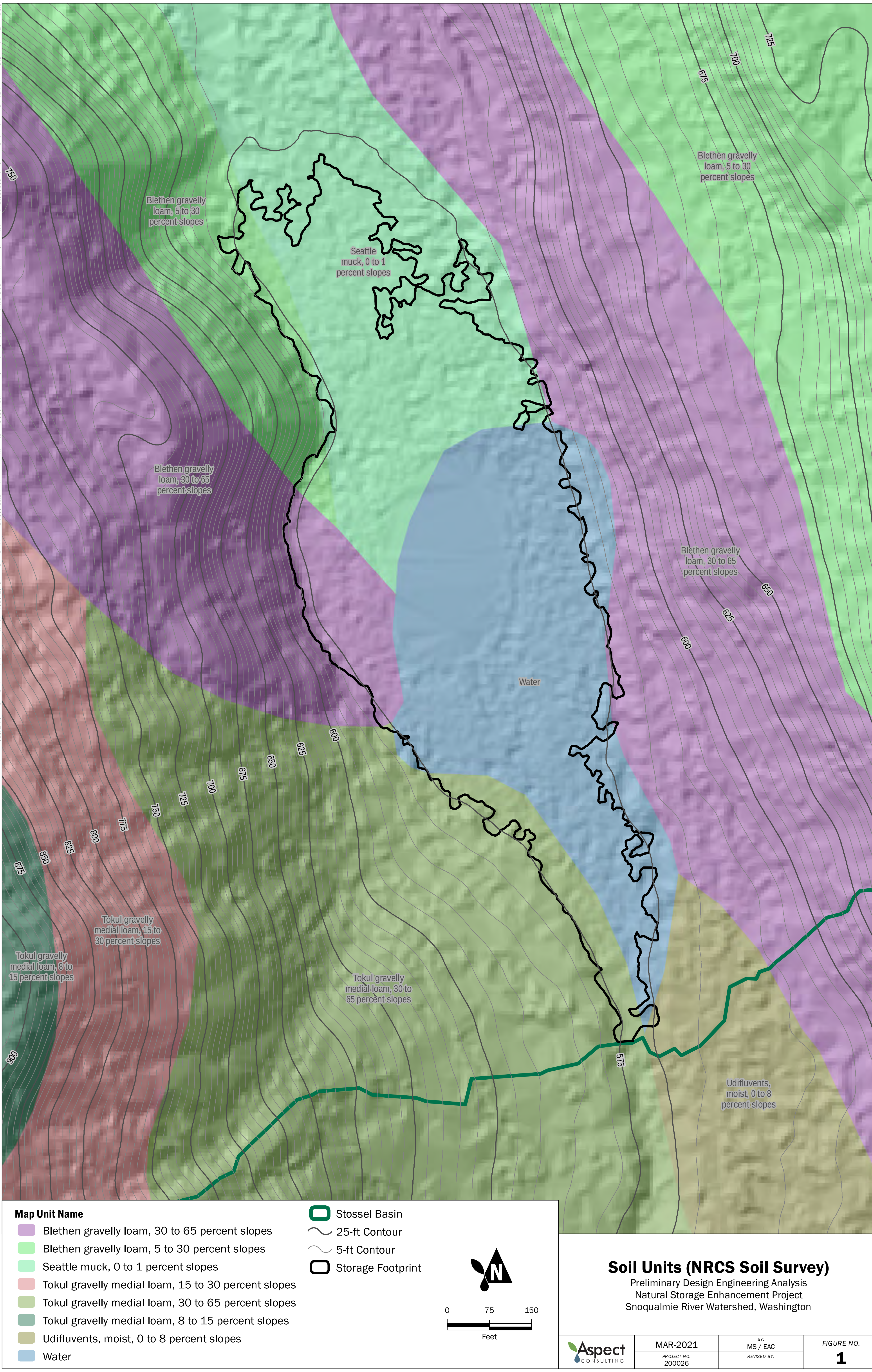
Attachments

Attachment A Field Notes and Photographs from Site Visit – DNR Property in Headwaters of Cherry Creek and Stossel Creek – May 29, 2020

Attachment B WWHM Model Results

Attachment C Preliminary Design Drawings

Figures



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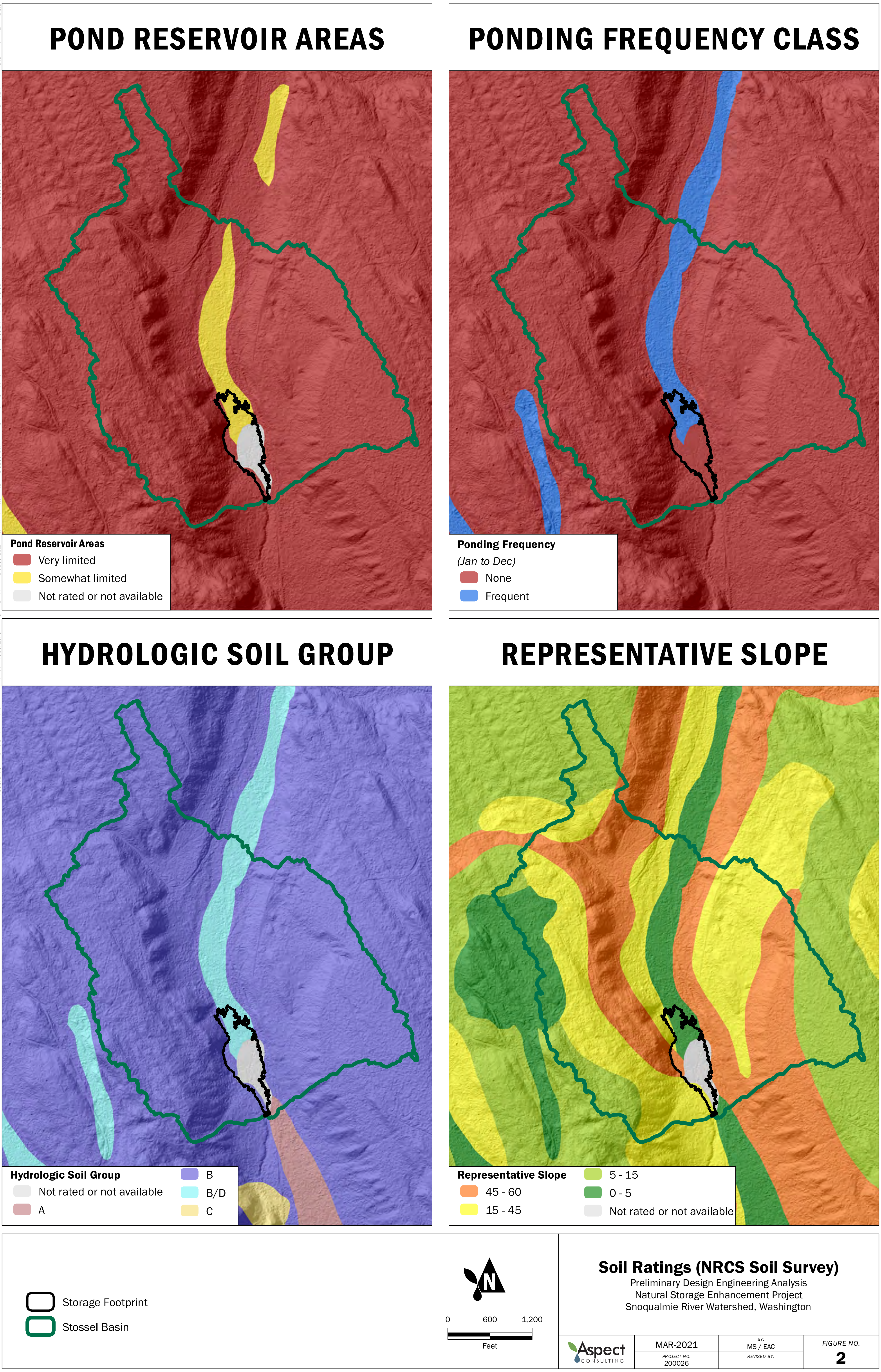
Soil Units (NRCS Soil Survey)

Preliminary Design Engineering Analysis
Natural Storage Enhancement Project
Snoqualmie River Watershed, Washington

Aspect CONSULTING	MAR-2021	BY: MS / EAC	FIGURE NO.
	PROJECT NO. 200026	REVISED BY: - - -	1



Soil Ratings (NRCS Soil Survey)

Preliminary Design Engineering Analysis
Natural Storage Enhancement Project
Snoqualmie River Watershed, Washington

Aspect CONSULTING

MAR-2021	BY: MS / EAC	FIGURE NO. 2
PROJECT NO. 200026	REVISED BY: - - -	

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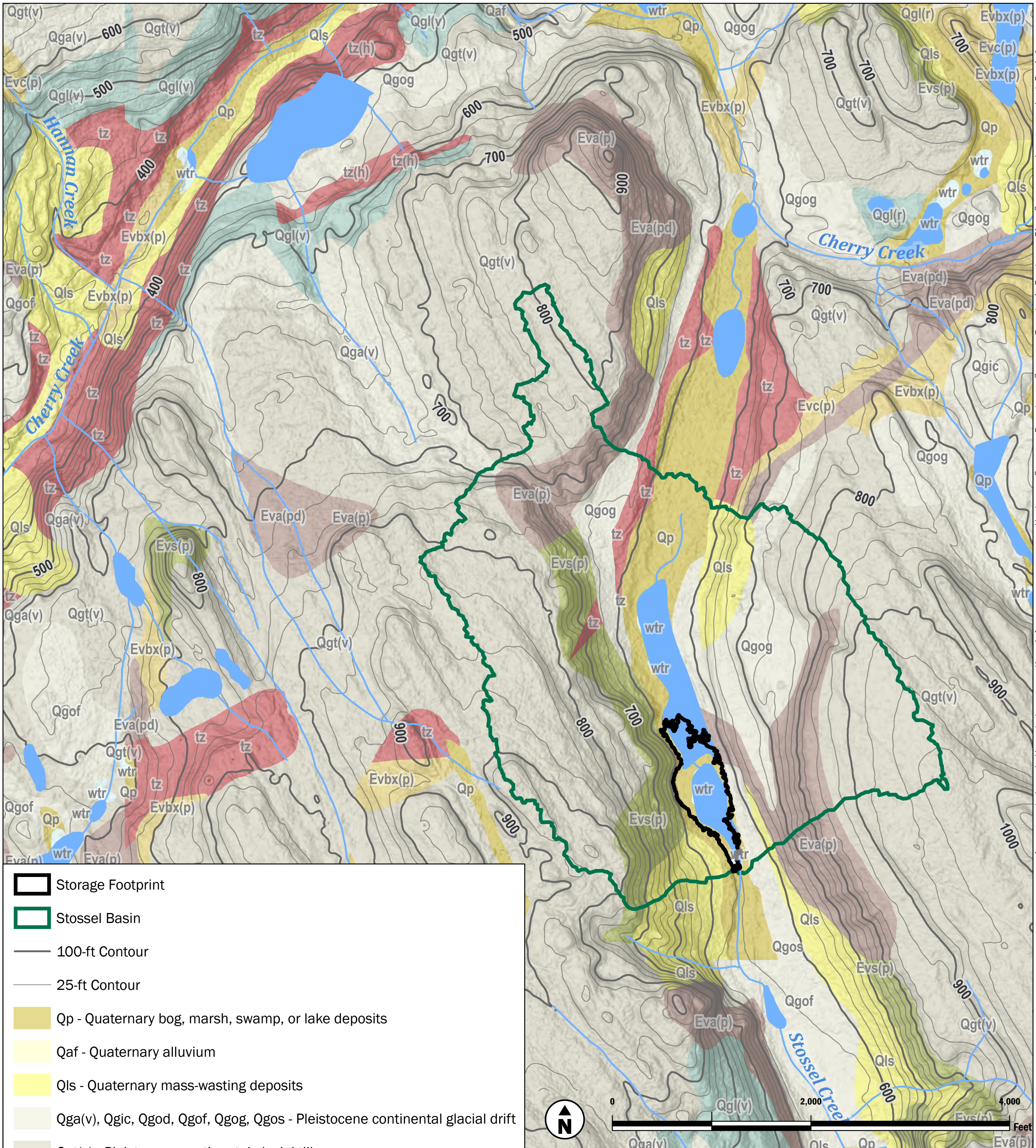


Storage Footprint

Stossel Basin

100-ft Contour

25-ft Contour

Qp - Quaternary bog, marsh, swamp, or lake deposits

Qaf - Quaternary alluvium

Qls - Quaternary mass-wasting deposits

Qga(v), Qgic, Qgod, Qgof, Qgog, Qgos - Pleistocene continental glacial drift

Qgt(v) - Pleistocene continental glacial till

Qgl(r), Qgl(v) - Pleistocene glaciolacustrine deposits

Evs(p) - Tertiary volcanic and sedimentary rocks

Evbx(p), Evc(p) - Tertiary fragmental volcanic rocks and deposits (includes lahars)

Eva(p), Eva(pd) - Tertiary volcanic rocks

tz, tz(h) - Tectonic zones

Water

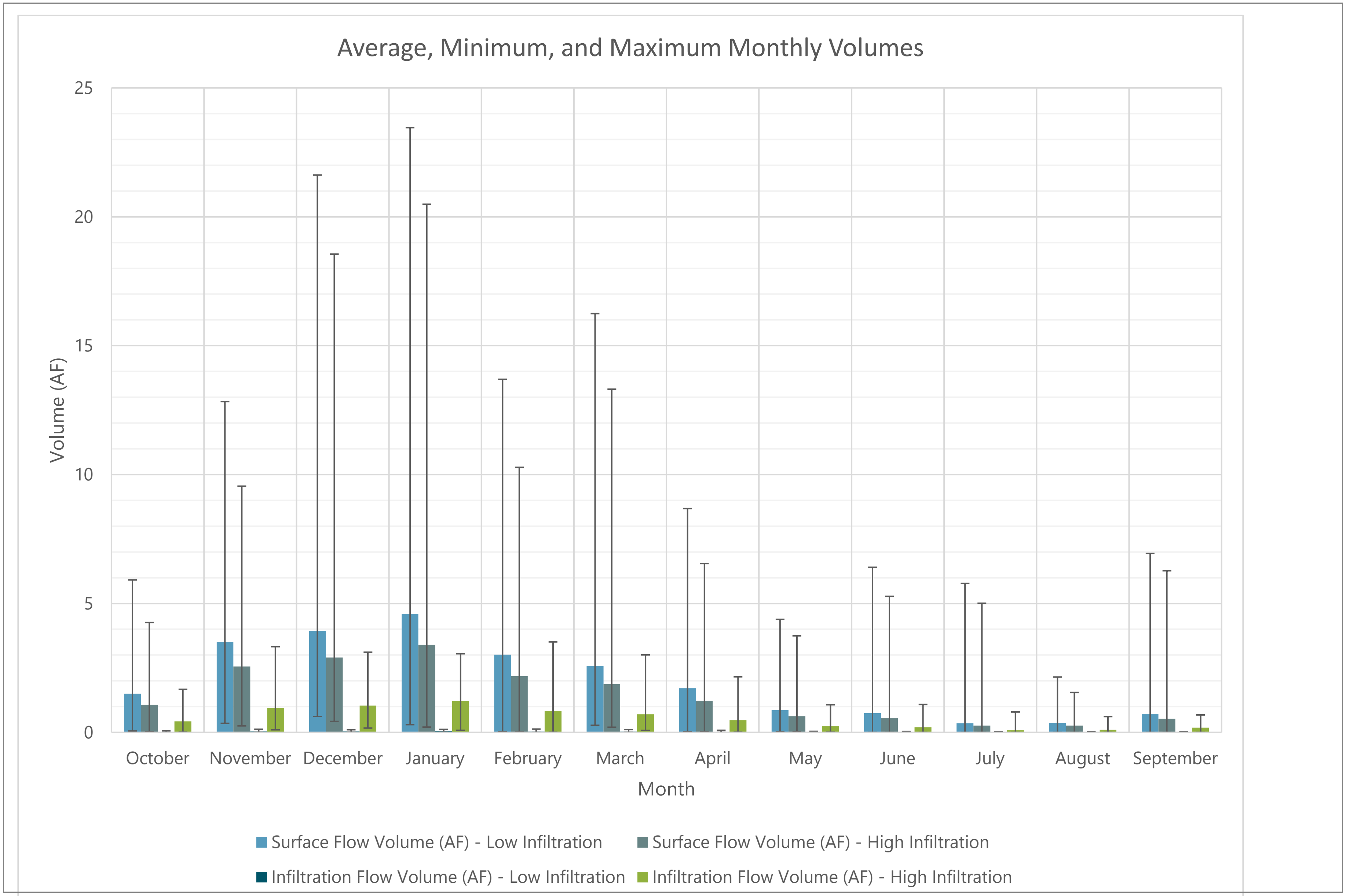
ArcGIS Pro: T:\projects_8\SnoqualmieRiverComprehensiveStorageStudy_200026\Data_Project\SVWID_NaturalStorageReview\SVWID_NaturalStorageReview.aprx || WGS 1984 Web Mercator Auxiliary Sphere || Date Saved: 3/17/2021 || Exported 3/17/2021 09:19 by ecrumbaker

Surficial Geologic Map

Preliminary Design Engineering Analysis
Natural Storage Enhancement Project
Snoqualmie River Watershed, Washington

Aspect CONSULTING	MAR-2021	BY: MS / EAC	FIGURE NO. 3
	PROJECT NO. 200026	REVISED BY: - - - / - - -	

Data source credits: None || Basemap Service Layer Credits: NA



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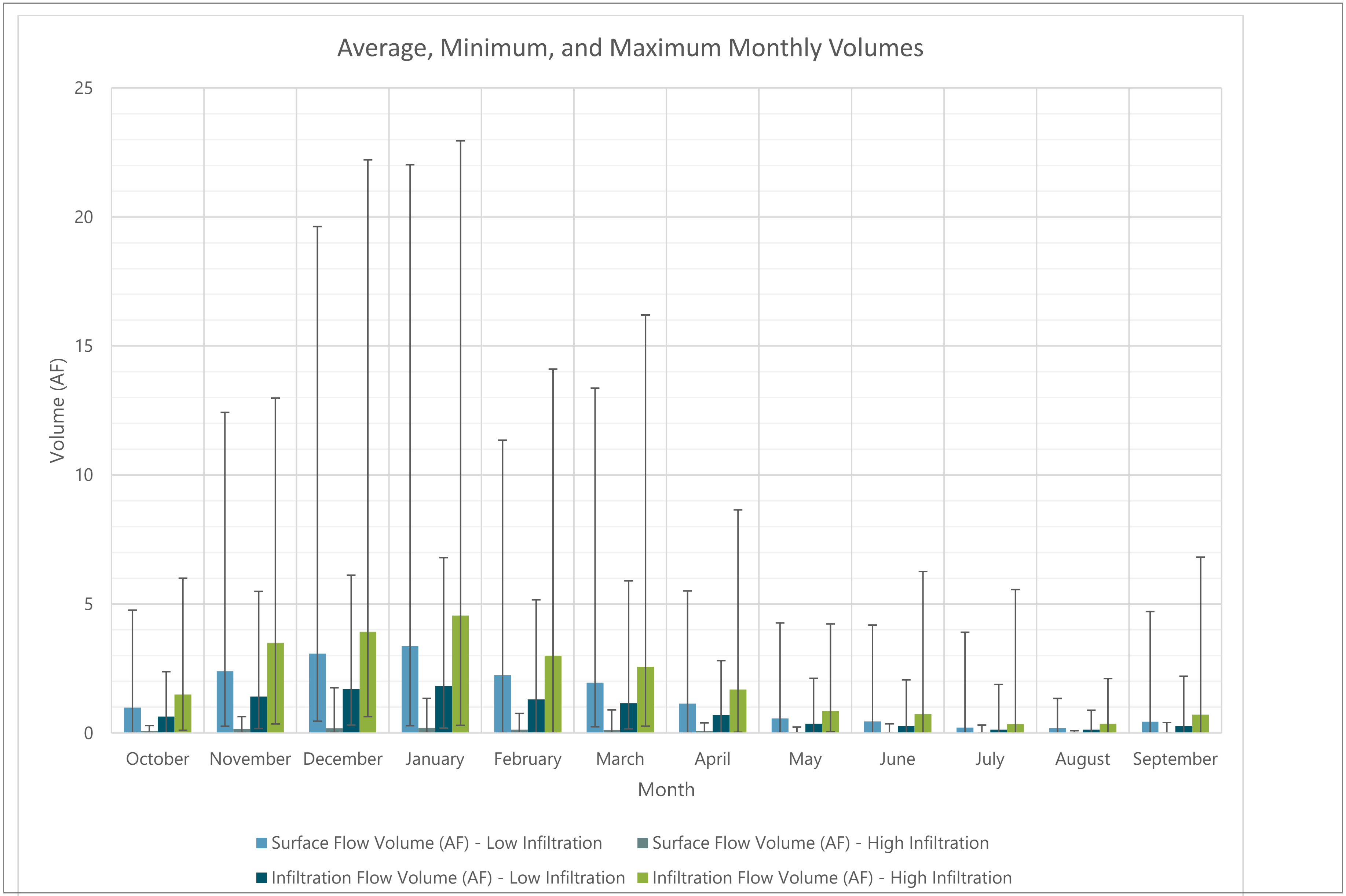
ANCHOR QEA

Figure 4
Stossel Creek Site Hydrology Summary – Modeled Existing Conditions

Preliminary Design Analyses
Snoqualmie River Watershed – Natural Storage Enhancement Project



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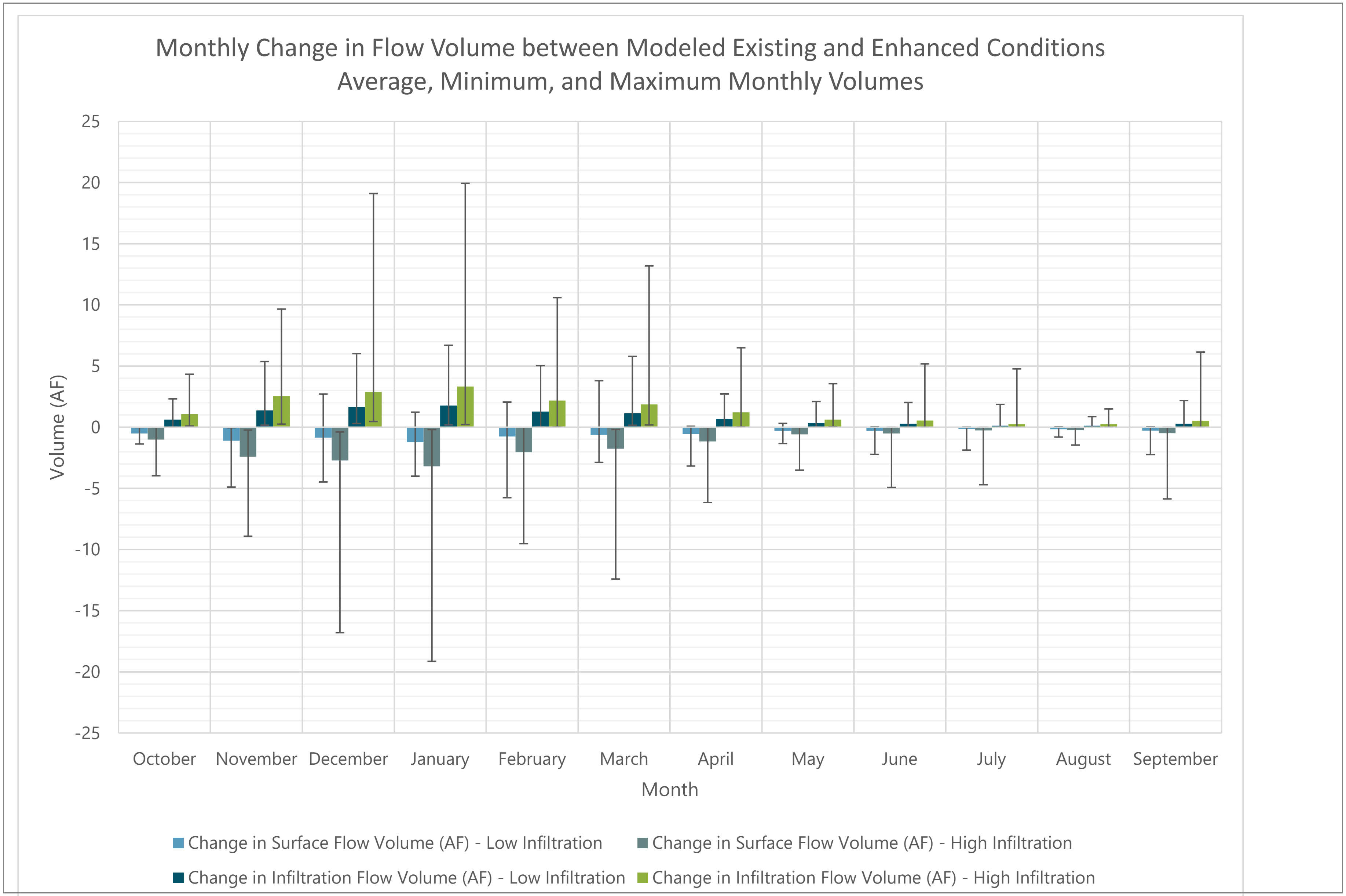
ANCHOR QEA

Figure 5
Stossel Creek Site Hydrology Summary – Modeled Enhanced Conditions



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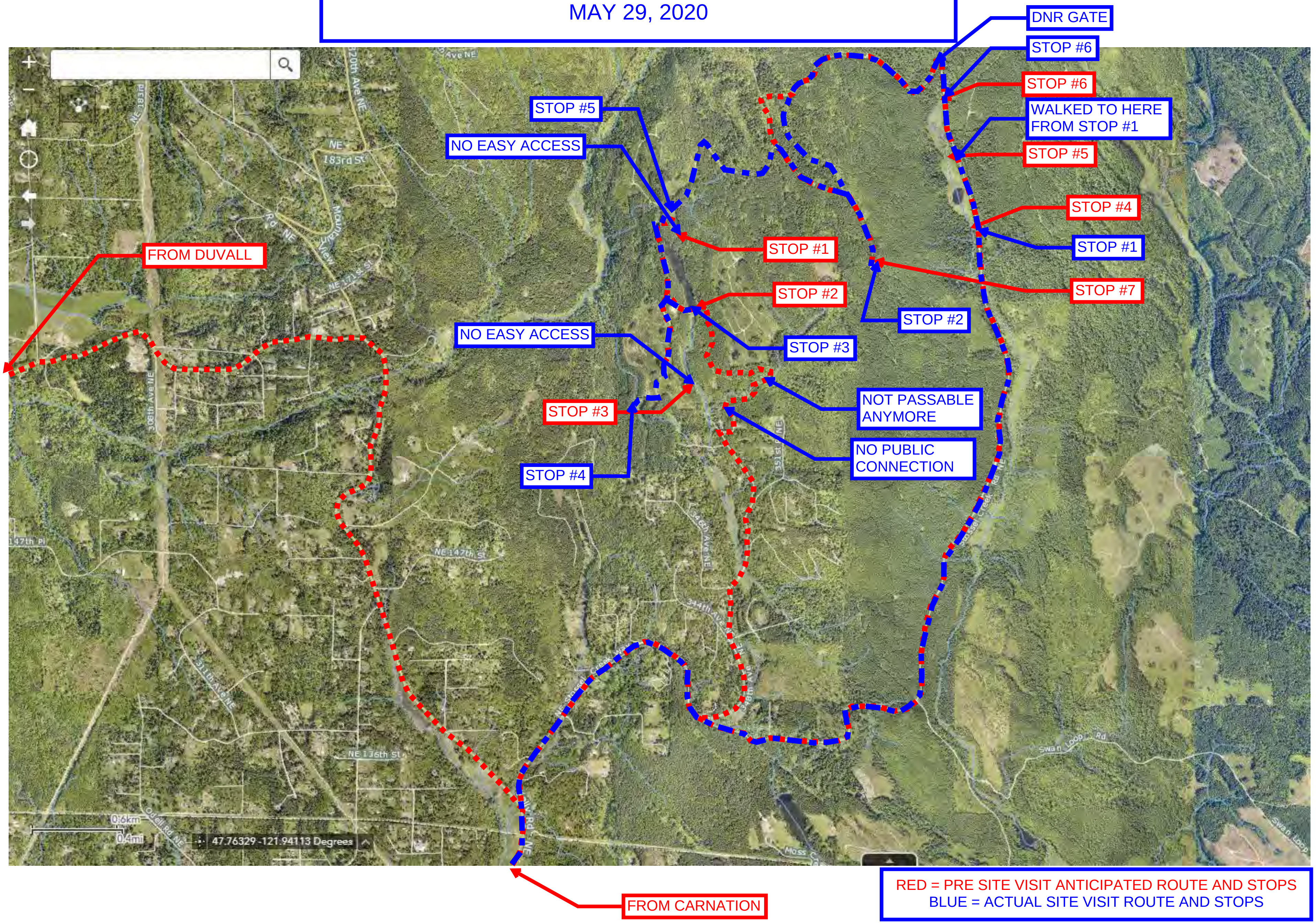
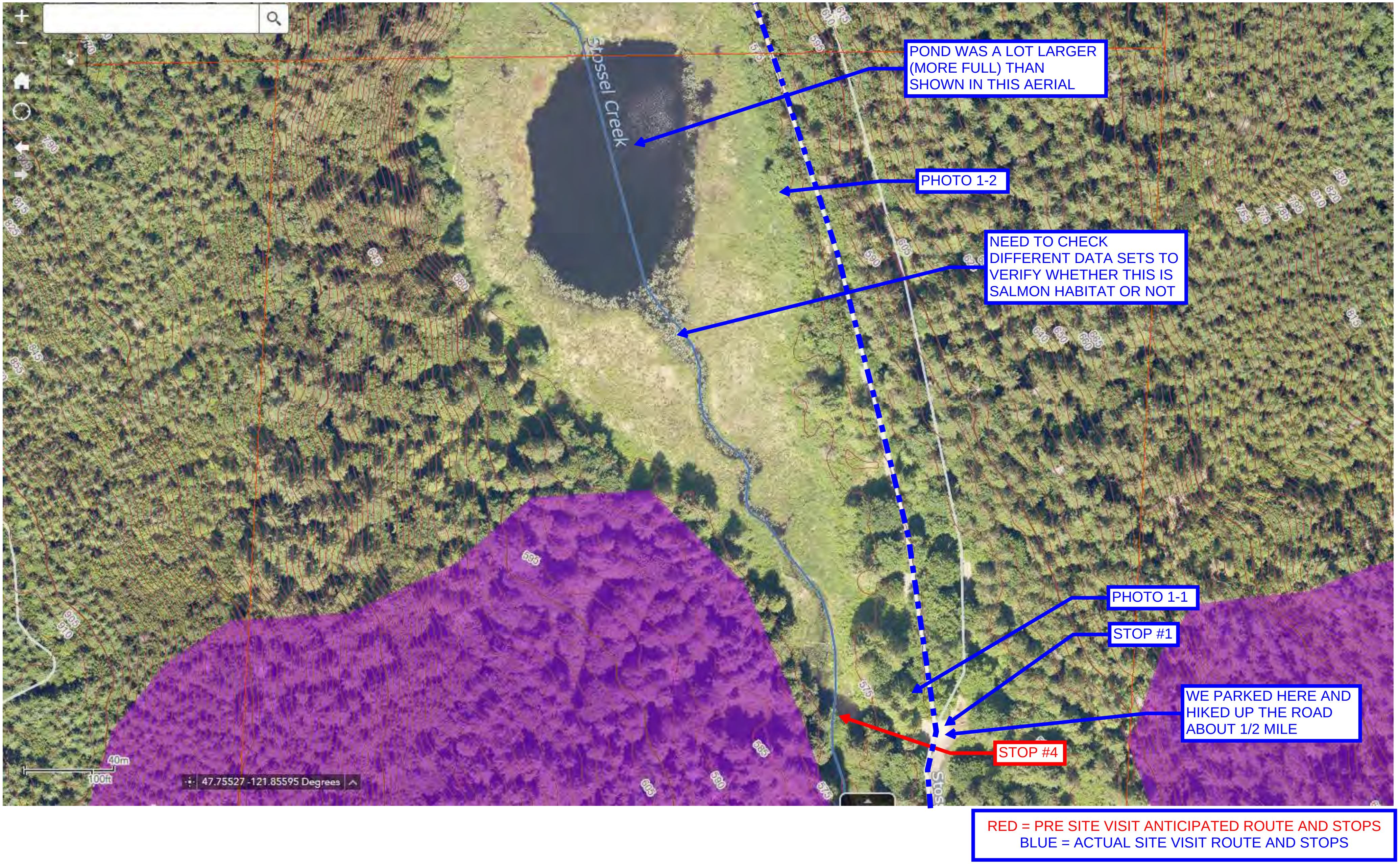
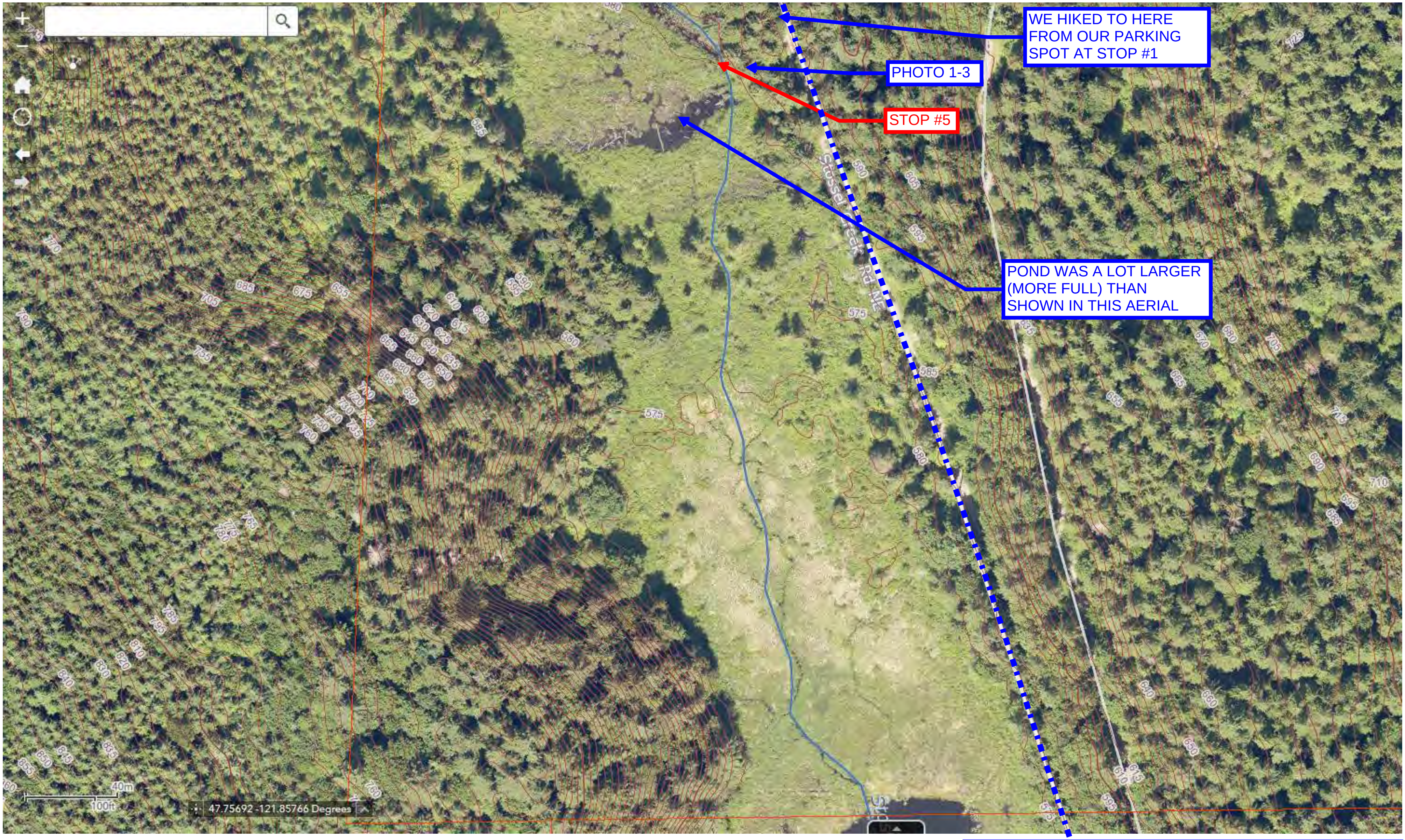
Attachment A
Field Notes and Photographs from Site Visit – DNR Property in Headwaters of Cherry Creek and Stossel Creek – May 29, 2020

FIELD NOTES FROM SITE VISIT
DNR PROPERTY IN HEADWATERS OF CHERRY CREEK AND STOSSEL CREEK
MAY 29, 2020



RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS


POND WAS A LOT LARGER (MORE FULL) THAN SHOWN IN THIS AERIAL
PHOTO 1-2
NEED TO CHECK DIFFERENT DATA SETS TO VERIFY WHETHER THIS IS SALMON HABITAT OR NOT
PHOTO 1-1
STOP #1
WE PARKED HERE AND HIKED UP THE ROAD ABOUT 1/2 MILE
STOP #4
Stossel Creek
47.75527 -121.85595 Degrees
40m
100ft
RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS

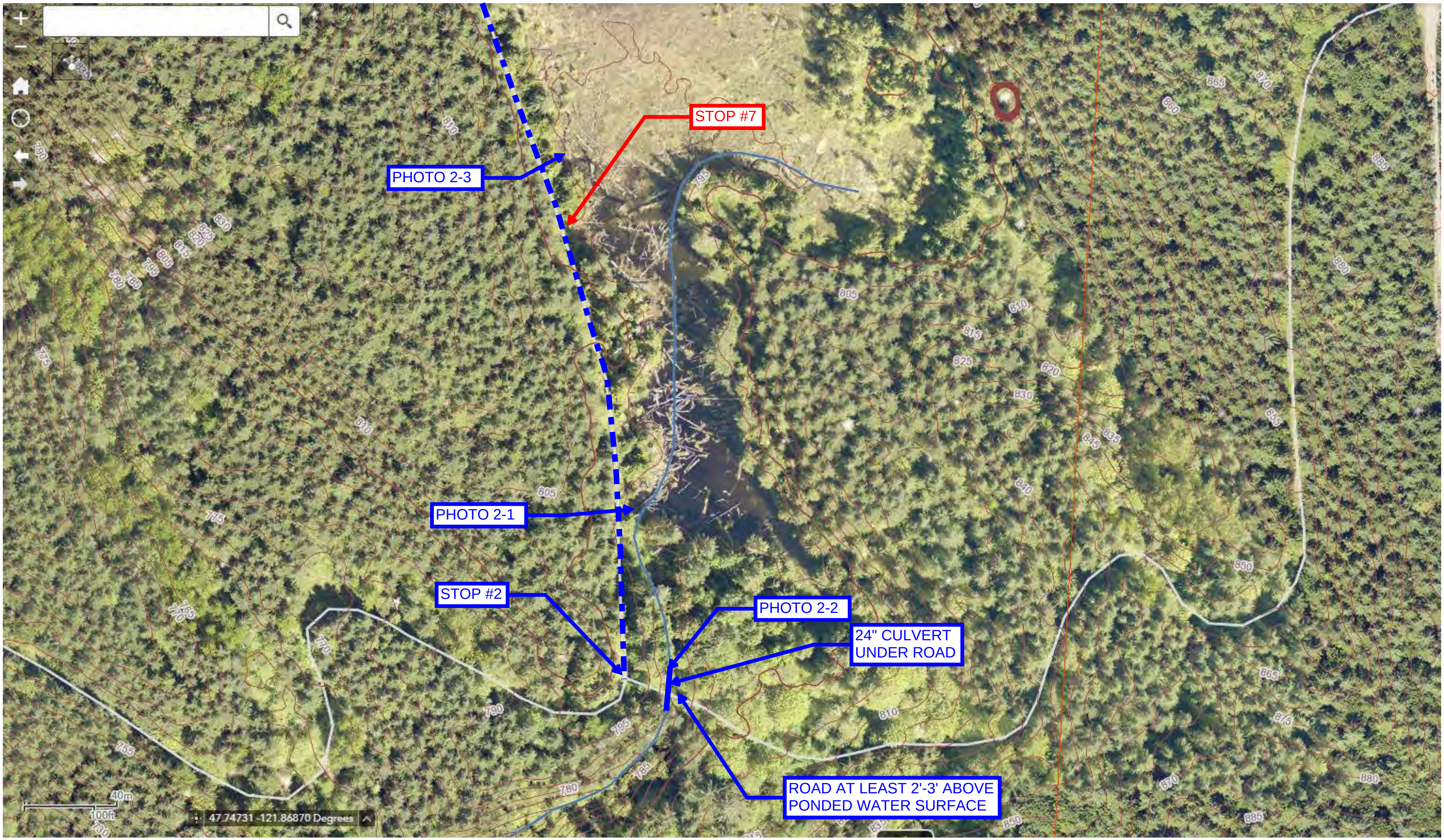


RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS

Photograph 1-1
Stop No. 1 – Stossel Creek – Downstream of Ponds

Photograph 1-2
Stop No. 1 – Stossel Creek – Downstream Pond

Photograph 1-3
Stop No. 1 – Stossel Creek – Upstream Pond

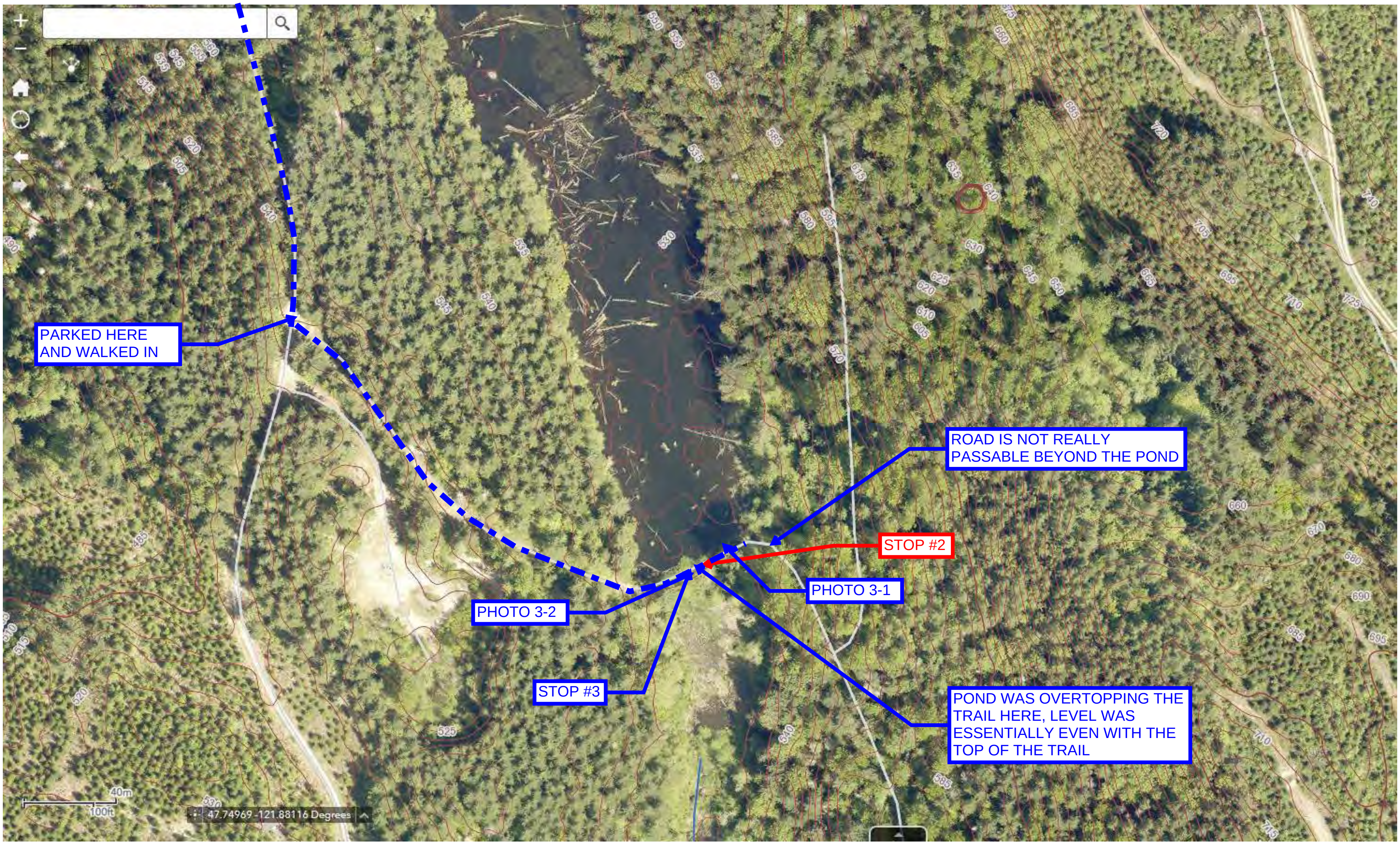


RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS

Photograph 2-1
Stop No. 2 – Cherry Creek Tributary Pond – Furthest East

Photograph 2-2
Stop No. 2 – Cherry Creek Tributary Pond Outlet – Furthest East

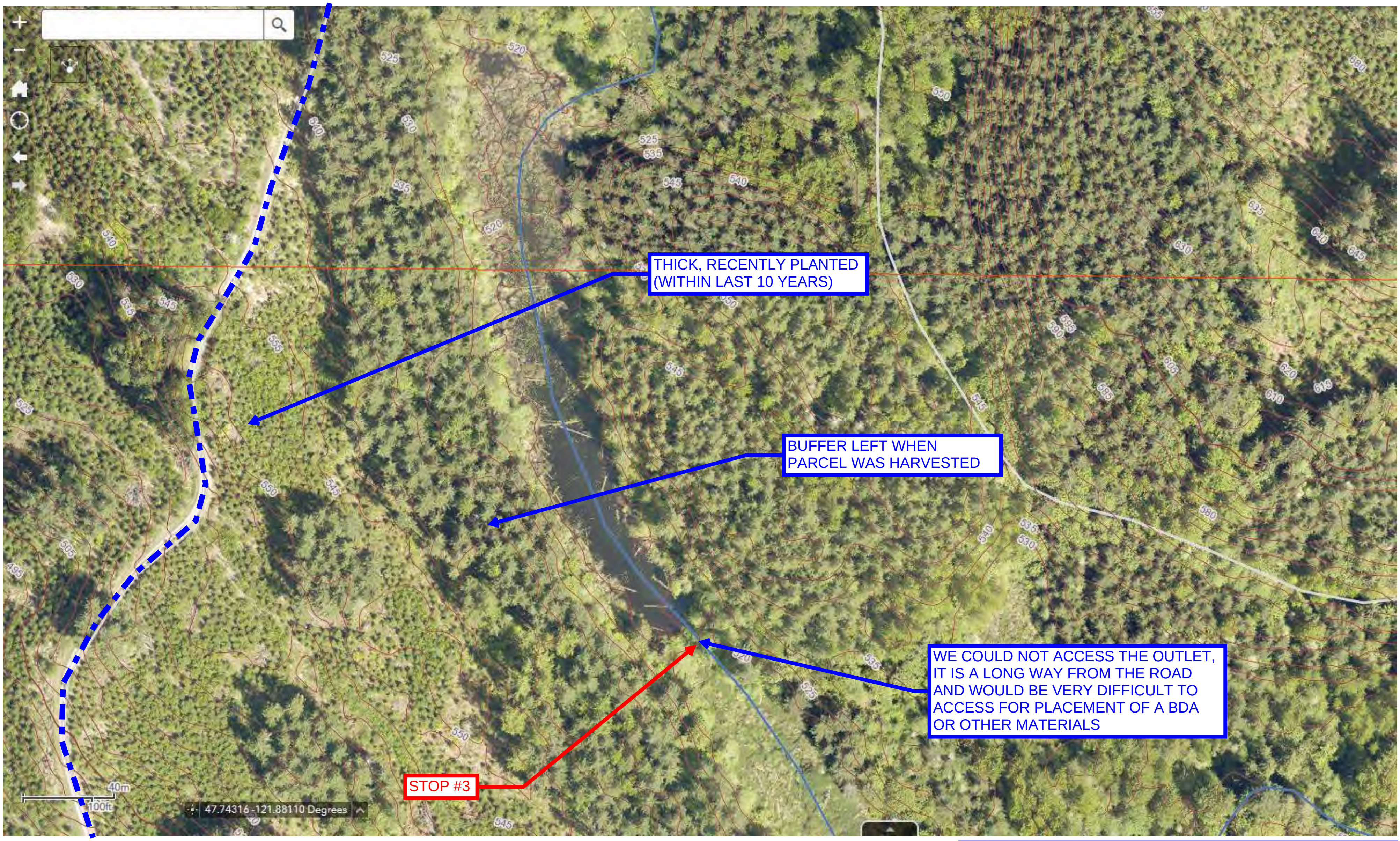
Photograph 2-3
Stop No. 2 – Cherry Creek Tributary Pond – Furthest East



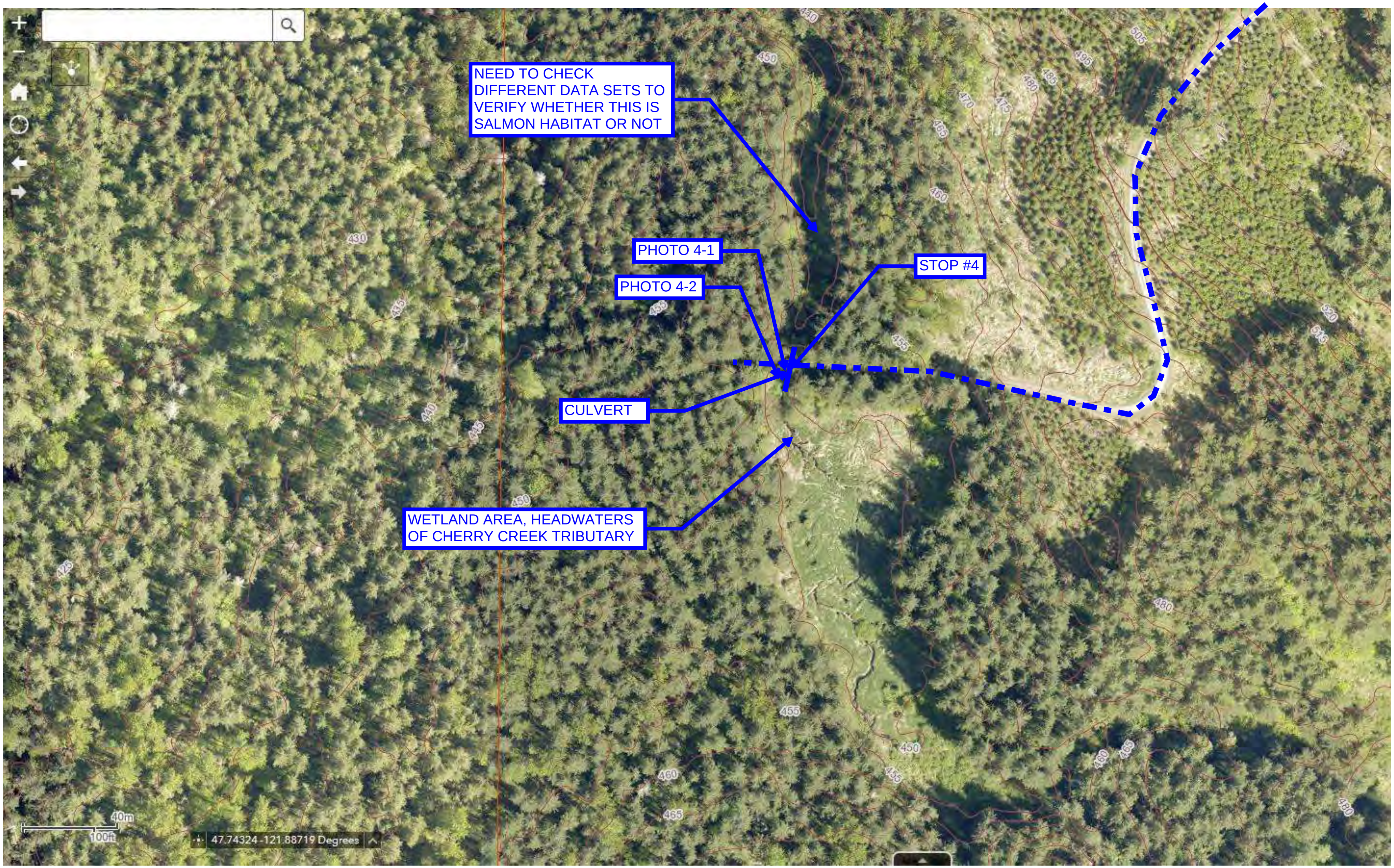
RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS

Photograph 3-1
Stop No. 3 – Cherry Creek Tributary Middle Pond

Photograph 3-2
Stop No. 3 – Cherry Creek Tributary Middle Pond



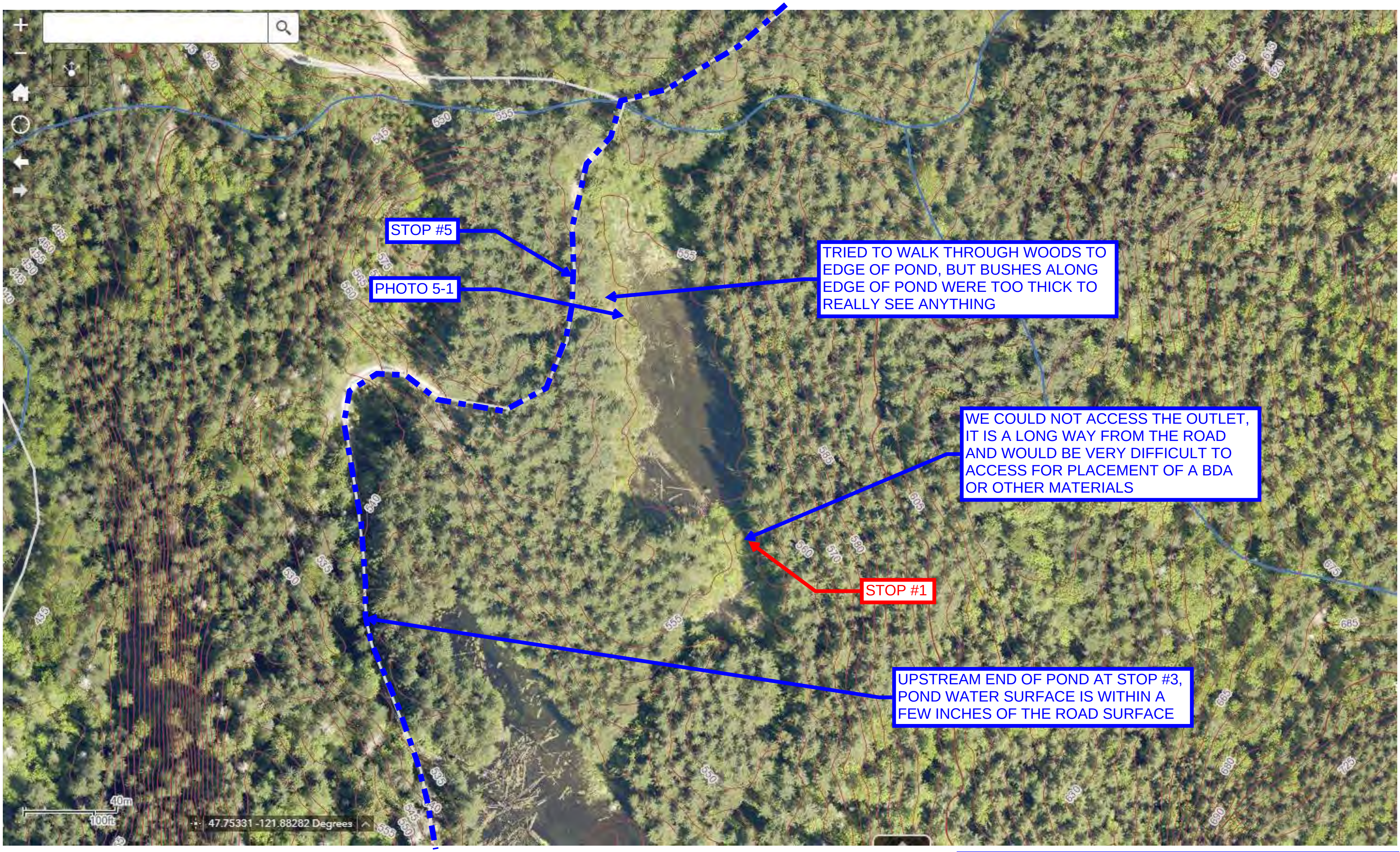
RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS



RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS

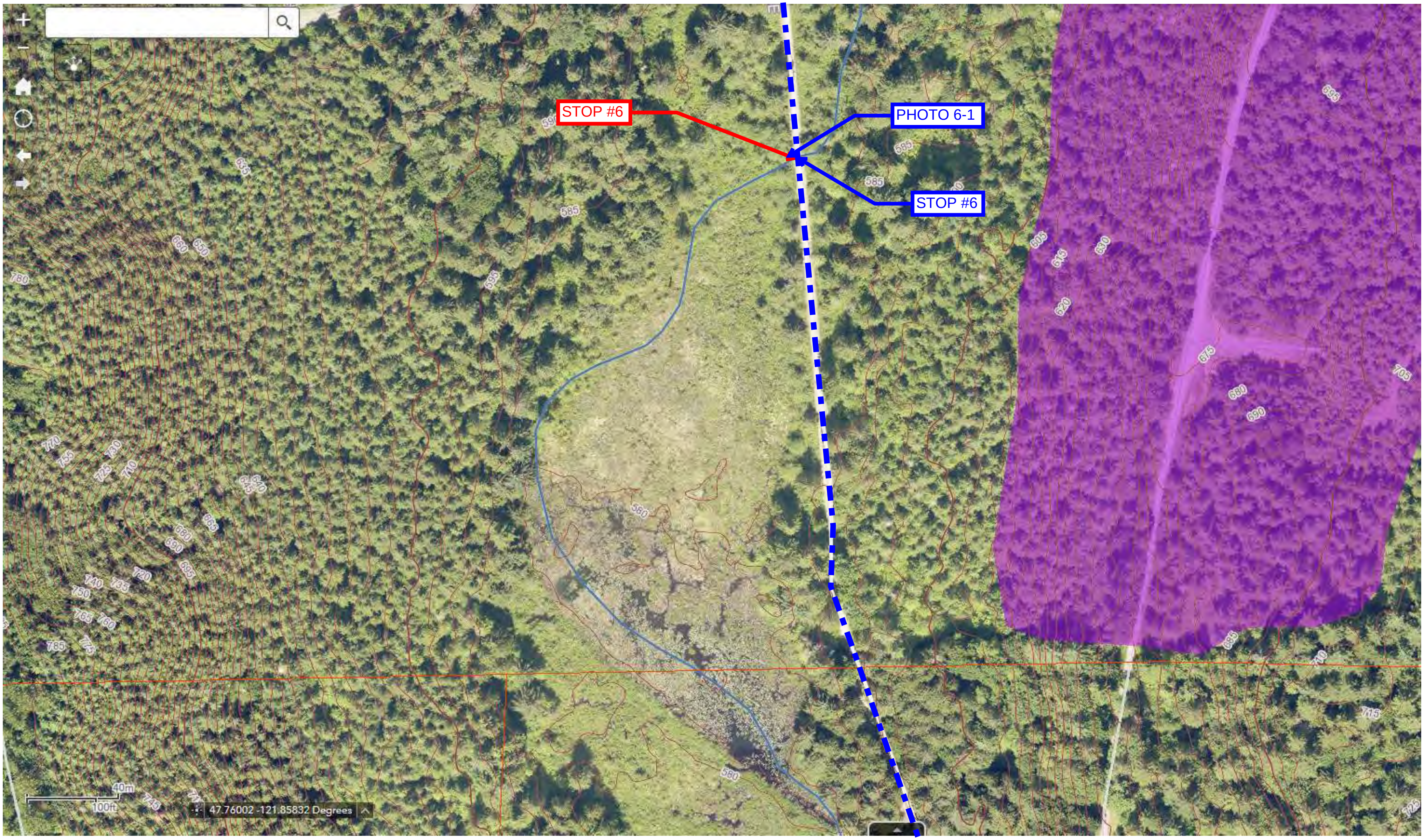
Photograph 4-1
Stop No. 4 – Cherry Creek Tributary Wetland

Photograph 4-2
Stop No. 4 – Cherry Creek Tributary Wetland



RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS

Photograph 5-1
Stop No. 5 – Cherry Creek Tributary Upper Pond



RED = PRE SITE VISIT ANTICIPATED ROUTE AND STOPS
BLUE = ACTUAL SITE VISIT ROUTE AND STOPS

Photograph 6-1
Stop No. 6 – Stossel Creek – Upstream End of Pond Complex

Attachment B
WWHM Model Results

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Stossel_2021_03_16
Site Name:	
Site Address:	
City:	
Report Date:	3/26/2021
Gage:	Landsburg
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.286
Version Date:	2019/09/13
Version:	4.2.17

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year
Low Flow Threshold for POC2:	50 Percent of the 2 Year
High Flow Threshold for POC2:	50 Year

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Steep	397
Pervious Total	397
Impervious Land Use	acre
Impervious Total	0
Basin Total	397

Element Flows To:

Surface	Interflow	Groundwater
SSD Table 1	SSD Table 1	

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Steep	397
Pervious Total	397
Impervious Land Use	acre
Impervious Total	0
Basin Total	397

Element Flows To:

Surface	Interflow	Groundwater
SSD Table 1	SSD Table 1	

Routing Elements

Predeveloped Routing

SSD Table 1

Depth: 1 ft.
Discharge Structure: 1
Riser Height: 3 ft.
Riser Diameter: 480 in.
Notch Type: Rectangular
Notch Width: 40.000 ft.
Notch Height: 3.000 ft.
Element Flows To:
Outlet 1 Outlet 2

SSD Table Hydraulic Table

Stage (feet)	Area (ac.)	Volume (ac-ft.)	Outlet Struct	Infilt/ Recharge	NotUsed	NotUsed	NotUsed
0.000	3.491	0.000	0.000	0.049	0.000	0.000	0.000
0.111	3.885	0.410	4.933	0.055	0.000	0.000	0.000
0.222	4.294	0.864	13.95	0.061	0.000	0.000	0.000
0.333	4.717	1.365	25.63	0.067	0.000	0.000	0.000
0.444	5.153	1.913	39.47	0.073	0.000	0.000	0.000
0.556	5.604	2.511	55.16	0.079	0.000	0.000	0.000
0.667	6.069	3.159	72.50	0.086	0.000	0.000	0.000
0.778	6.548	3.860	91.37	0.092	0.000	0.000	0.000
0.889	7.042	4.615	111.6	0.099	0.000	0.000	0.000
1.000	7.549	5.426	133.2	0.107	0.000	0.000	0.000

Mitigated Routing

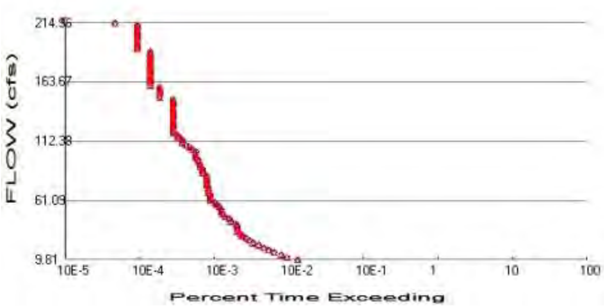
SSD Table 1

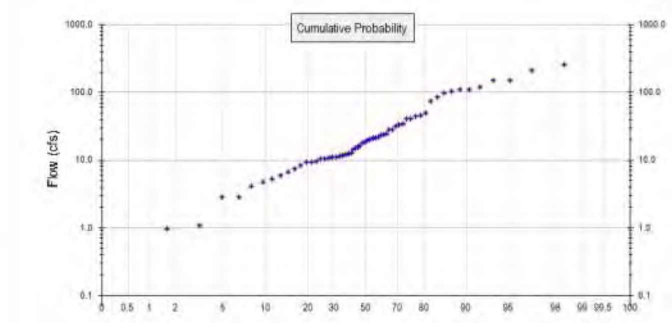
Depth: 1 ft.
Discharge Structure: 1
Riser Height: 3 ft.
Riser Diameter: 480 in.
Notch Type: Rectangular
Notch Width: 40.000 ft.
Notch Height: 1.000 ft.
Orifice 1 Diameter: 3 in. Elevation:0 ft.
Element Flows To:
Outlet 1 Outlet 2

SSD Table Hydraulic Table

Stage (feet)	Area (ac.)	Volume (ac-ft.)	Outlet Struct	Infilt/ Recharge	NotUsed	NotUsed	NotUsed
0.000	3.491	0.000	0.000	0.049	0.000	0.000	0.000
0.111	3.885	0.410	0.081	0.055	0.000	0.000	0.000
0.222	4.294	0.864	0.115	0.061	0.000	0.000	0.000
0.333	4.717	1.365	0.141	0.067	0.000	0.000	0.000
0.444	5.153	1.913	0.163	0.073	0.000	0.000	0.000
0.556	5.604	2.511	0.182	0.079	0.000	0.000	0.000
0.667	6.069	3.159	0.199	0.086	0.000	0.000	0.000
0.778	6.548	3.860	0.215	0.092	0.000	0.000	0.000
0.889	7.042	4.615	0.230	0.099	0.000	0.000	0.000
1.000	7.549	5.426	0.244	0.107	0.000	0.000	0.000

Analysis Results
POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 397
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 397
Total Impervious Area: 0

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	19.610571
5 year	54.535353
10 year	90.952129
25 year	154.2482
50 year	214.963412
100 year	287.955834

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	19.610571
5 year	54.535353
10 year	90.952129
25 year	154.2482
50 year	214.963412
100 year	287.955834

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	34.075	34.075
1950	97.062	97.062
1951	31.515	31.515
1952	11.477	11.477
1953	11.214	11.214
1954	21.465	21.465
1955	10.984	10.984
1956	11.859	11.859
1957	21.571	21.571
1958	5.254	5.254

1959	10.362	10.362
1960	9.603	9.603
1961	20.702	20.702
1962	0.783	0.783
1963	45.159	45.159
1964	108.927	108.927
1965	8.284	8.284
1966	4.725	4.725
1967	23.366	23.366
1968	15.321	15.321
1969	16.496	16.496
1970	21.405	21.405
1971	19.595	19.595
1972	24.727	24.727
1973	9.226	9.226
1974	12.164	12.164
1975	17.921	17.921
1976	12.819	12.819
1977	0.972	0.972
1978	10.838	10.838
1979	2.829	2.829
1980	10.325	10.325
1981	41.338	41.338
1982	6.001	6.001
1983	33.358	33.358
1984	103.345	103.345
1985	4.101	4.101
1986	18.398	18.398
1987	118.343	118.343
1988	15.376	15.376
1989	14.170	14.170
1990	50.431	50.431
1991	149.987	149.987
1992	9.421	9.421
1993	12.234	12.234
1994	2.868	2.868
1995	6.580	6.580
1996	84.139	84.139
1997	258.138	258.138
1998	7.484	7.484
1999	148.616	148.616
2000	23.993	23.993
2001	1.064	1.064
2002	28.350	28.350
2003	73.727	73.727
2004	44.440	44.440
2005	20.059	20.059
2006	27.889	27.889
2007	214.010	214.010
2008	110.961	110.961
2009	40.980	40.980

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	258.1380	258.1380
2	214.0100	214.0100
3	149.9870	149.9870

4	148.6160	148.6160
5	118.3430	118.3430
6	110.9610	110.9610
7	108.9270	108.9270
8	103.3450	103.3450
9	97.0617	97.0617
10	84.1393	84.1393
11	73.7265	73.7265
12	50.4314	50.4314
13	45.1593	45.1593
14	44.4398	44.4398
15	41.3375	41.3375
16	40.9799	40.9799
17	34.0751	34.0751
18	33.3581	33.3581
19	31.5150	31.5150
20	28.3497	28.3497
21	27.8890	27.8890
22	24.7274	24.7274
23	23.9934	23.9934
24	23.3664	23.3664
25	21.5709	21.5709
26	21.4645	21.4645
27	21.4046	21.4046
28	20.7016	20.7016
29	20.0592	20.0592
30	19.5946	19.5946
31	18.3980	18.3980
32	17.9213	17.9213
33	16.4958	16.4958
34	15.3758	15.3758
35	15.3206	15.3206
36	14.1697	14.1697
37	12.8193	12.8193
38	12.2336	12.2336
39	12.1644	12.1644
40	11.8591	11.8591
41	11.4766	11.4766
42	11.2139	11.2139
43	10.9838	10.9838
44	10.8383	10.8383
45	10.3621	10.3621
46	10.3254	10.3254
47	9.6028	9.6028
48	9.4211	9.4211
49	9.2257	9.2257
50	8.2844	8.2844
51	7.4836	7.4836
52	6.5800	6.5800
53	6.0011	6.0011
54	5.2538	5.2538
55	4.7255	4.7255
56	4.1007	4.1007
57	2.8679	2.8679
58	2.8287	2.8287
59	1.0645	1.0645
60	0.9719	0.9719
61	0.7833	0.7833

Duration Flows
The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
9.8053	281	281	100	Pass
11.8776	203	203	100	Pass
13.9499	169	169	100	Pass
16.0222	135	135	100	Pass
18.0945	115	115	100	Pass
20.1668	100	100	100	Pass
22.2391	85	85	100	Pass
24.3114	72	72	100	Pass
26.3837	63	63	100	Pass
28.4560	57	57	100	Pass
30.5283	51	51	100	Pass
32.6006	48	48	100	Pass
34.6729	44	44	100	Pass
36.7452	44	44	100	Pass
38.8175	43	43	100	Pass
40.8899	42	42	100	Pass
42.9622	36	36	100	Pass
45.0345	34	34	100	Pass
47.1068	30	30	100	Pass
49.1791	28	28	100	Pass
51.2514	27	27	100	Pass
53.3237	27	27	100	Pass
55.3960	25	25	100	Pass
57.4683	23	23	100	Pass
59.5406	22	22	100	Pass
61.6129	19	19	100	Pass
63.6852	19	19	100	Pass
65.7575	19	19	100	Pass
67.8298	18	18	100	Pass
69.9021	18	18	100	Pass
71.9744	18	18	100	Pass
74.0467	17	17	100	Pass
76.1190	17	17	100	Pass
78.1913	17	17	100	Pass
80.2636	17	17	100	Pass
82.3359	17	17	100	Pass
84.4082	15	15	100	Pass
86.4805	15	15	100	Pass
88.5528	15	15	100	Pass
90.6252	14	14	100	Pass
92.6975	14	14	100	Pass
94.7698	13	13	100	Pass
96.8421	13	13	100	Pass
98.9144	12	12	100	Pass
100.9867	12	12	100	Pass
103.0590	12	12	100	Pass
105.1313	11	11	100	Pass
107.2036	10	10	100	Pass
109.2759	9	9	100	Pass
111.3482	8	8	100	Pass
113.4205	8	8	100	Pass
115.4928	7	7	100	Pass
117.5651	7	7	100	Pass

119.6374	6	6	100	Pass
121.7097	6	6	100	Pass
123.7820	6	6	100	Pass
125.8543	6	6	100	Pass
127.9266	6	6	100	Pass
129.9989	6	6	100	Pass
132.0712	6	6	100	Pass
134.1435	6	6	100	Pass
136.2158	6	6	100	Pass
138.2882	6	6	100	Pass
140.3605	6	6	100	Pass
142.4328	6	6	100	Pass
144.5051	6	6	100	Pass
146.5774	6	6	100	Pass
148.6497	6	6	100	Pass
150.7220	4	4	100	Pass
152.7943	4	4	100	Pass
154.8666	4	4	100	Pass
156.9389	4	4	100	Pass
159.0112	4	4	100	Pass
161.0835	3	3	100	Pass
163.1558	3	3	100	Pass
165.2281	3	3	100	Pass
167.3004	3	3	100	Pass
169.3727	3	3	100	Pass
171.4450	3	3	100	Pass
173.5173	3	3	100	Pass
175.5896	3	3	100	Pass
177.6619	3	3	100	Pass
179.7342	3	3	100	Pass
181.8065	3	3	100	Pass
183.8788	3	3	100	Pass
185.9512	3	3	100	Pass
188.0235	3	3	100	Pass
190.0958	3	3	100	Pass
192.1681	2	2	100	Pass
194.2404	2	2	100	Pass
196.3127	2	2	100	Pass
198.3850	2	2	100	Pass
200.4573	2	2	100	Pass
202.5296	2	2	100	Pass
204.6019	2	2	100	Pass
206.6742	2	2	100	Pass
208.7465	2	2	100	Pass
210.8188	2	2	100	Pass
212.8911	2	2	100	Pass
214.9634	1	1	100	Pass

Water Quality

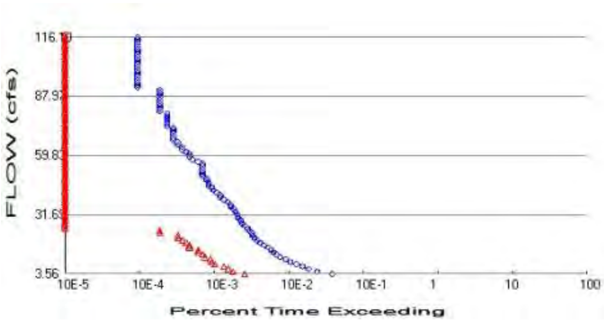
Water Quality BMP Flow and Volume for POC #1

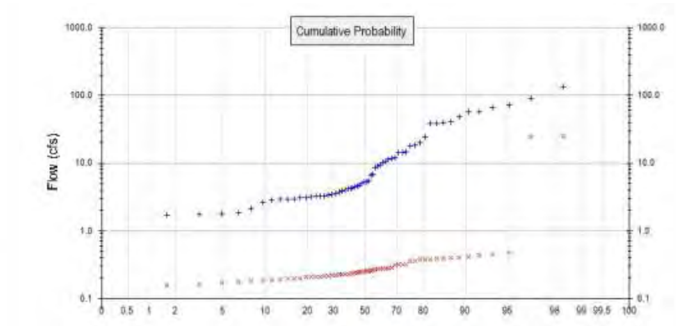
On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

POC 2





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #2
Total Pervious Area: 397
Total Impervious Area: 0

Mitigated Landuse Totals for POC #2
Total Pervious Area: 397
Total Impervious Area: 0

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	**Flow(cfs)**
2 year	7.118266
5 year	20.128536
10 year	36.690387
25 year	72.765698
50 year	116.101008
100 year	179.766298

Flow Frequency Return Periods for Mitigated. POC #2

Return Period	**Flow(cfs)**
2 year	0.278614
5 year	0.60446
10 year	0.945461
25 year	1.574766
50 year	2.230503
100 year	3.089412

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #2

Year	**Predeveloped**	**Mitigated**
1949	12.125	0.279
1950	66.473	0.431
1951	17.909	0.470
1952	3.724	0.206
1953	3.535	0.186
1954	6.870	0.273
1955	3.813	0.255
1956	4.274	0.231
1957	8.590	0.227
1958	2.631	0.193
1959	2.934	0.244

1960	4.406	0.240
1961	6.632	0.236
1962	1.108	0.158
1963	14.264	0.225
1964	38.346	0.355
1965	3.361	0.288
1966	1.860	0.152
1967	10.232	0.197
1968	4.163	0.200
1969	4.218	0.220
1970	5.502	0.195
1971	5.021	0.254
1972	8.988	0.383
1973	3.168	0.212
1974	3.409	0.206
1975	5.210	0.257
1976	4.732	0.277
1977	1.705	0.172
1978	3.109	0.255
1979	1.756	0.184
1980	2.791	0.250
1981	14.634	0.318
1982	2.915	0.239
1983	9.463	0.317
1984	41.143	0.396
1985	2.122	0.227
1986	4.522	0.227
1987	39.653	0.391
1988	3.925	0.206
1989	5.351	0.206
1990	18.353	0.378
1991	57.118	0.406
1992	3.276	0.219
1993	3.255	0.213
1994	2.891	0.163
1995	3.077	0.263
1996	49.044	0.445
1997	91.465	0.379
1998	3.277	0.181
1999	72.945	0.388
2000	11.575	0.272
2001	1.782	0.174
2002	11.371	0.274
2003	24.615	0.267
2004	38.928	0.416
2005	10.679	0.310
2006	14.198	0.323
2007	135.903	25.032
2008	57.990	24.811
2009	19.793	0.360

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #2

Rank	Predeveloped	Mitigated
1	135.9030	25.0319
2	91.4648	24.8107
3	72.9450	0.4704
4	66.4734	0.4451

5	57.9899	0.4310
6	57.1179	0.4156
7	49.0440	0.4056
8	41.1433	0.3961
9	39.6527	0.3908
10	38.9284	0.3878
11	38.3456	0.3831
12	24.6147	0.3792
13	19.7925	0.3780
14	18.3525	0.3597
15	17.9087	0.3547
16	14.6342	0.3226
17	14.2641	0.3185
18	14.1984	0.3166
19	12.1247	0.3104
20	11.5748	0.2881
21	11.3708	0.2793
22	10.6792	0.2766
23	10.2319	0.2745
24	9.4628	0.2735
25	8.9883	0.2715
26	8.5905	0.2672
27	6.8702	0.2628
28	6.6322	0.2568
29	5.5016	0.2548
30	5.3511	0.2547
31	5.2100	0.2541
32	5.0214	0.2501
33	4.7319	0.2437
34	4.5224	0.2396
35	4.4059	0.2386
36	4.2741	0.2359
37	4.2182	0.2315
38	4.1629	0.2273
39	3.9251	0.2271
40	3.8132	0.2271
41	3.7241	0.2255
42	3.5349	0.2200
43	3.4091	0.2192
44	3.3610	0.2128
45	3.2773	0.2116
46	3.2763	0.2063
47	3.2552	0.2062
48	3.1677	0.2061
49	3.1085	0.2056
50	3.0773	0.1996
51	2.9345	0.1971
52	2.9151	0.1951
53	2.8910	0.1925
54	2.7908	0.1860
55	2.6312	0.1840
56	2.1225	0.1814
57	1.8601	0.1739
58	1.7821	0.1717
59	1.7557	0.1628
60	1.7050	0.1579
61	1.1084	0.1517

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
3.5591	810	55	6	Pass
4.6959	515	38	7	Pass
5.8327	398	33	8	Pass
6.9695	327	29	8	Pass
8.1063	272	22	8	Pass
9.2431	223	20	8	Pass
10.3799	194	19	9	Pass
11.5166	164	16	9	Pass
12.6534	144	15	10	Pass
13.7902	134	13	9	Pass
14.9270	124	13	10	Pass
16.0638	113	10	8	Pass
17.2006	100	10	10	Pass
18.3374	88	9	10	Pass
19.4741	80	8	10	Pass
20.6109	74	7	9	Pass
21.7477	71	7	9	Pass
22.8845	68	4	5	Pass
24.0213	64	4	6	Pass
25.1581	60	0	0	Pass
26.2949	55	0	0	Pass
27.4317	51	0	0	Pass
28.5684	49	0	0	Pass
29.7052	47	0	0	Pass
30.8420	44	0	0	Pass
31.9788	43	0	0	Pass
33.1156	41	0	0	Pass
34.2524	39	0	0	Pass
35.3892	36	0	0	Pass
36.5259	35	0	0	Pass
37.6627	33	0	0	Pass
38.7995	29	0	0	Pass
39.9363	26	0	0	Pass
41.0731	26	0	0	Pass
42.2099	23	0	0	Pass
43.3467	21	0	0	Pass
44.4835	20	0	0	Pass
45.6202	18	0	0	Pass
46.7570	18	0	0	Pass
47.8938	17	0	0	Pass
49.0306	17	0	0	Pass
50.1674	15	0	0	Pass
51.3042	15	0	0	Pass
52.4410	15	0	0	Pass
53.5777	15	0	0	Pass
54.7145	15	0	0	Pass
55.8513	15	0	0	Pass
56.9881	13	0	0	Pass
58.1249	11	0	0	Pass
59.2617	10	0	0	Pass
60.3985	10	0	0	Pass
61.5353	9	0	0	Pass
62.6720	8	0	0	Pass

63.8088	8	0	0	Pass
64.9456	7	0	0	Pass
66.0824	7	0	0	Pass
67.2192	6	0	0	Pass
68.3560	6	0	0	Pass
69.4928	6	0	0	Pass
70.6295	6	0	0	Pass
71.7663	6	0	0	Pass
72.9031	6	0	0	Pass
74.0399	5	0	0	Pass
75.1767	5	0	0	Pass
76.3135	5	0	0	Pass
77.4503	5	0	0	Pass
78.5870	5	0	0	Pass
79.7238	5	0	0	Pass
80.8606	4	0	0	Pass
81.9974	4	0	0	Pass
83.1342	4	0	0	Pass
84.2710	4	0	0	Pass
85.4078	4	0	0	Pass
86.5446	4	0	0	Pass
87.6813	4	0	0	Pass
88.8181	4	0	0	Pass
89.9549	4	0	0	Pass
91.0917	4	0	0	Pass
92.2285	2	0	0	Pass
93.3653	2	0	0	Pass
94.5021	2	0	0	Pass
95.6388	2	0	0	Pass
96.7756	2	0	0	Pass
97.9124	2	0	0	Pass
99.0492	2	0	0	Pass
100.1860	2	0	0	Pass
101.3228	2	0	0	Pass
102.4596	2	0	0	Pass
103.5964	2	0	0	Pass
104.7331	2	0	0	Pass
105.8699	2	0	0	Pass
107.0067	2	0	0	Pass
108.1435	2	0	0	Pass
109.2803	2	0	0	Pass
110.4171	2	0	0	Pass
111.5539	2	0	0	Pass
112.6906	2	0	0	Pass
113.8274	2	0	0	Pass
114.9642	2	0	0	Pass
116.1010	2	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #2

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
SSD Table 1 POC	☐	1486.19			☐	36.84			
Total Volume Infiltrated		1486.19	0.00	0.00		36.84	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

Model Default Modifications

Total of 0 changes have been made.

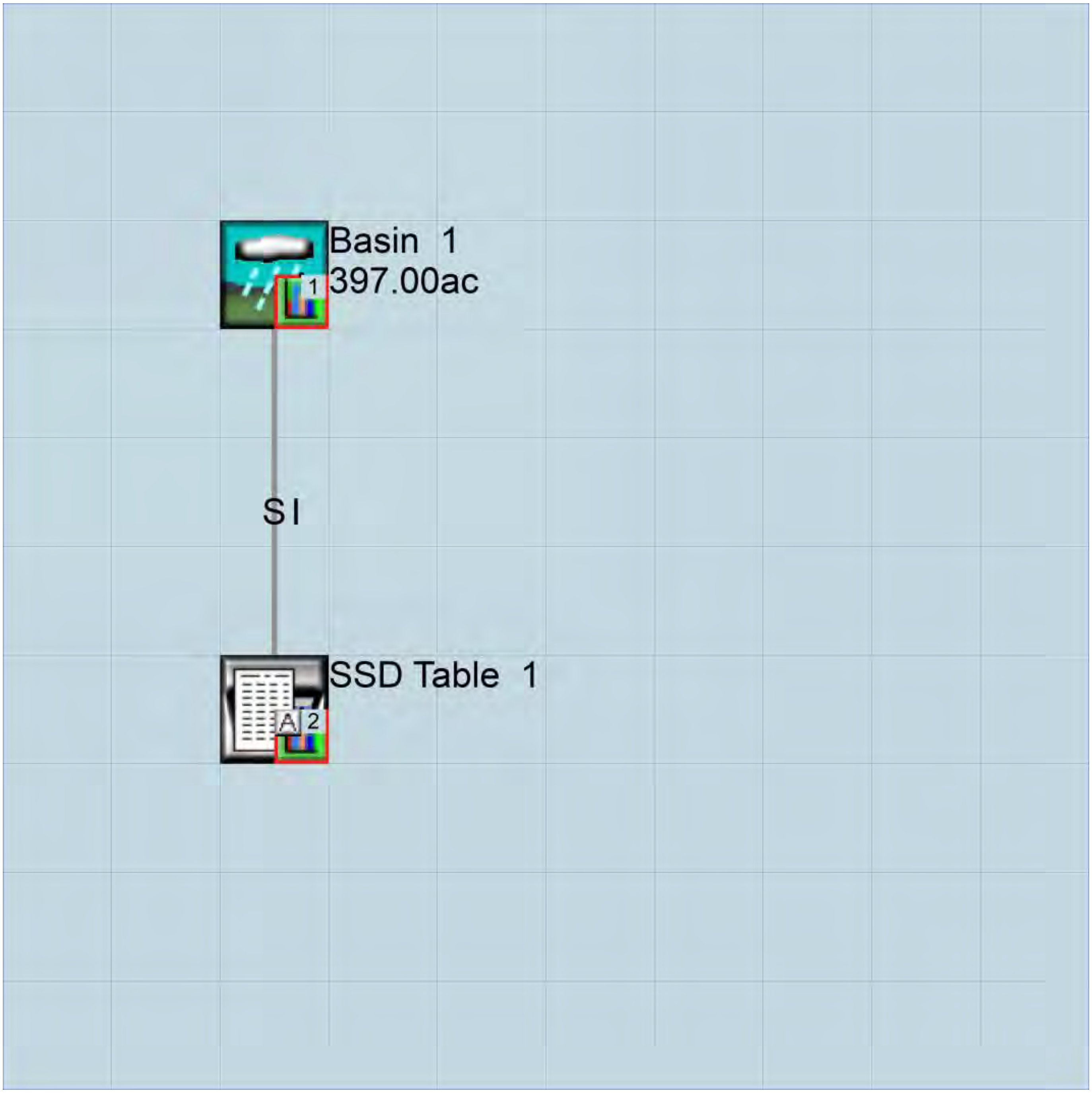
PERLND Changes

No PERLND changes have been made.

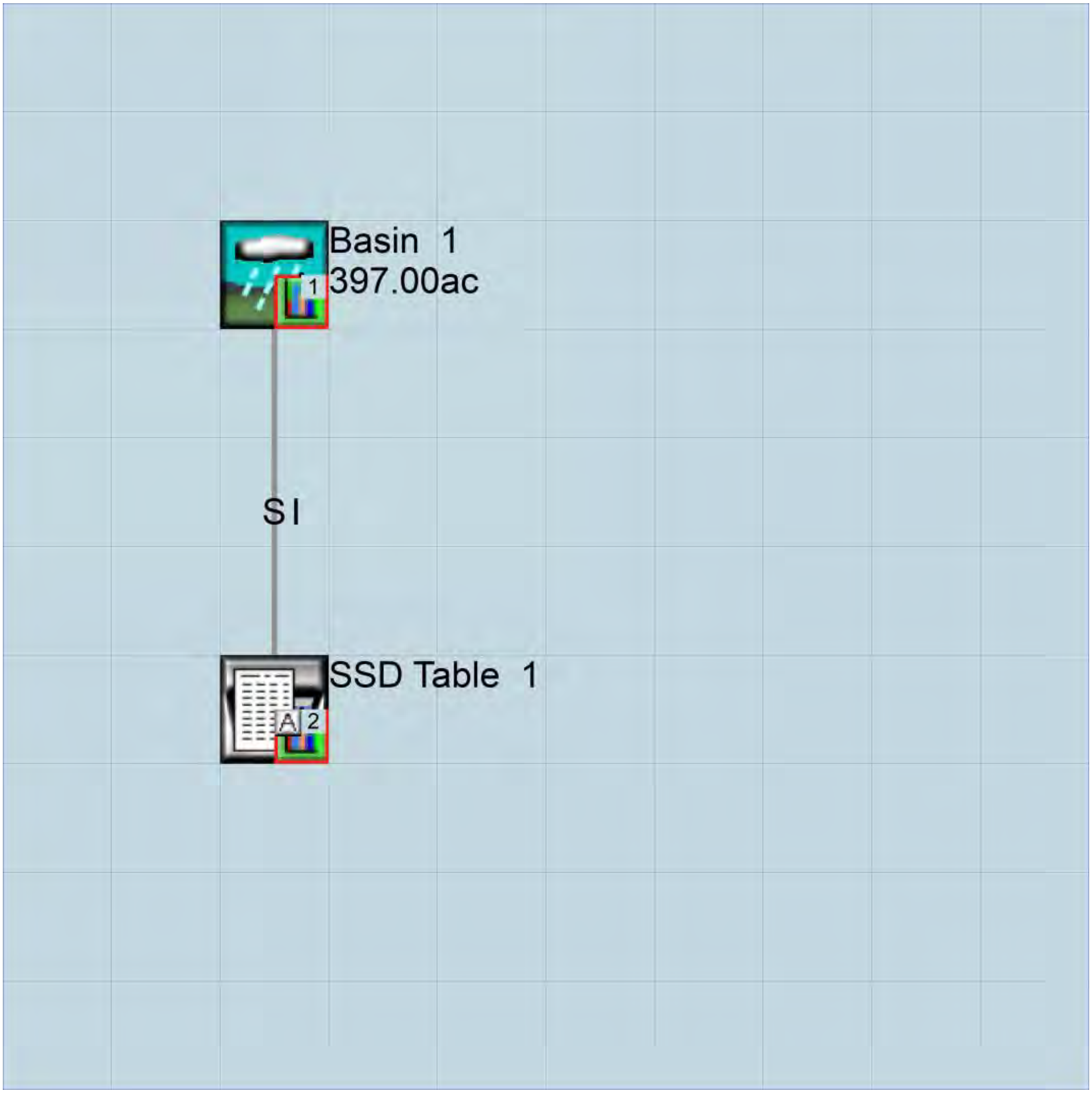
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                  UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   Stossel_2021_03_16.wdm
MESSU      25   PreStossel_2021_03_16.MES
           27   PreStossel_2021_03_16.L61
           28   PreStossel_2021_03_16.L62
           30   POCStossel_2021_03_161.dat
           31   POCStossel_2021_03_162.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND       3
      RCHRES       1
      COPY       501
      COPY       502
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                    1    2   30    9
    2        SSD Table  1                MAX                    1    2   31    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1        1    1
  501        1    1
  502        1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
    3     A/B, Forest, Steep      1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
    3         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
    3         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
    3         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
    3              0         5         2       400      0.15       0.3     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
    3              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
    3            0.2       0.5      0.35         0       0.7       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
    3              0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
  END IWAT-PARM3
```

```
  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND   3                         397     RCHRES   1      2
PERLND   3                         397     RCHRES   1      3
Basin  1***
PERLND   3                         397     COPY   501     12
PERLND   3                         397     COPY   501     13

******Routing******
RCHRES   1                           1     COPY   502     16
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1
COPY   502 OUTPUT MEAN   1 1   48.4        DISPLY   2     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                           in  out                           ***
    1     SSD Table  1            2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *     *  *  *  *  *       *  *  *  *  *        ***
    1        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1            1       0.2       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
```

```
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit      for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1          0          4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   29    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
  0.000000  3.490518  0.000000  0.000000  0.000000
  0.111111  3.885160  0.409760  4.933326  0.054846
  0.222222  4.293868  0.864150  13.95355  0.060615
  0.333333  4.716643  1.364734  25.63431  0.066583
  0.444444  5.153485  1.913075  39.46661  0.072750
  0.555555  5.604393  2.510734  55.15626  0.079115
  0.666666  6.069367  3.159277  72.50479  0.085679
  0.777777  6.548409  3.860264  91.36647  0.092442
  0.888888  7.041517  4.615260  111.6284  0.099403
  1.000000  7.548691  5.425827  133.2000  0.106562
  1.111111  7.940095  6.286315  156.0057  0.112088
  1.222222  8.340891  7.190814  179.9822  0.117746
  1.333333  8.751080  8.140368  205.0748  0.123536
  1.444444  9.170663  9.136021  231.2360  0.129459
  1.555556  9.599638  10.17882  258.4238  0.135515
  1.666667  10.03801  11.26980  286.6008  0.141703
  1.777778  10.48577  12.41001  315.7333  0.148024
  1.888889  10.94292  13.60049  345.7911  0.154478
  2.000000  11.40947  14.84229  376.7465  0.161064
  2.100000  11.61166  15.99334  405.3528  0.163918
  2.200000  11.81531  17.16469  434.6486  0.166793
  2.300000  12.02044  18.35648  464.6179  0.169688
  2.400000  12.22703  19.56885  495.2461  0.172605
  2.500000  12.43508  20.80196  526.5192  0.175542
  2.600000  12.64461  22.05594  558.4242  0.178500
  2.700000  12.85560  23.33095  590.9488  0.181478
  2.800000  13.06806  24.62714  624.0814  0.184477
  2.900000  13.28199  25.94464  657.8111  0.187497
  3.000000  13.49738  27.28361  692.1275  0.190538
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.286          PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.286          IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1.286          RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           RCHRES   1     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1      WDM   1008 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1009 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      2 1        1      WDM   1010 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1011 STAG     ENGL      REPL
COPY   502 OUTPUT MEAN   1 1     48.4      WDM    502 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
```

```
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK   16

END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                             ***
WDM        26   Stossel_2021_03_16.wdm
MESSU      25   MitStossel_2021_03_16.MES
           27   MitStossel_2021_03_16.L61
           28   MitStossel_2021_03_16.L62
           30   POCStossel_2021_03_161.dat
           31   POCStossel_2021_03_162.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND       3
      RCHRES       1
      COPY       501
      COPY         2
      COPY       502
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                   MAX                     1    2   30    9
    2        SSD Table  1               MAX                     1    2   31    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
    2         1    1
  502         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                         in  out           ***
    3     A/B, Forest, Steep      1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
    3         0    0    1    0    0    0    0    0    0    0    0    0
```

```
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
    3         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
    3         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
    3               0         5         2       400      0.15       0.3     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
    3               0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
    3            0.2       0.5      0.35         0       0.7       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
    3              0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
```

```
    # -  # ***PETMAX    PETMIN
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND   3                         397     RCHRES   1      2
PERLND   3                         397     RCHRES   1      3
Basin  1***
PERLND   3                         397     COPY   501     12
PERLND   3                         397     COPY   501     13

******Routing******
PERLND   3                         397     COPY     2     12
PERLND   3                         397     COPY     2     13
RCHRES   1                           1     COPY   502     16
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1
COPY   502 OUTPUT MEAN   1 1   48.4        DISPLY   2     INPUT  TIMSER 1


<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                          in  out                            ***
    1     SSD Table  1           2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR   *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *     *  *  *  *  *       *  *  *  *  *        ***
    1        0  1  0  0     4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
```

```
    1              1       0.2       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1          0          4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   29    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)      (cfs)   (ft/sec)    (Minutes)***
  0.000000  3.490518  0.000000  0.000000  0.000000
  0.111111  3.885160  0.409760  0.081410  0.054846
  0.222222  4.293868  0.864150  0.115132  0.060615
  0.333333  4.716643  1.364734  0.141007  0.066583
  0.444444  5.153485  1.913075  0.162821  0.072750
  0.555555  5.604393  2.510734  0.182039  0.079115
  0.666666  6.069367  3.159277  0.199414  0.085679
  0.777777  6.548409  3.860264  0.215392  0.092442
  0.888888  7.041517  4.615260  0.230263  0.099403
  1.000000  7.548691  5.425827  0.244231  0.106562
  1.111111  7.940095  6.286315  0.257442  0.112088
  1.222222  8.340891  7.190814  0.270008  0.117746
  1.333333  8.751080  8.140368  0.282014  0.123536
  1.444444  9.170663  9.136021  0.293529  0.129459
  1.555556  9.599638  10.17882  0.304610  0.135515
  1.666667  10.03801  11.26980  0.315301  0.141703
  1.777778  10.48577  12.41001  0.325642  0.148024
  1.888889  10.94292  13.60049  0.335664  0.154478
  2.000000  11.40947  14.84229  0.345395  0.161064
  2.100000  11.61166  15.99334  4.566079  0.163918
  2.200000  11.81531  17.16469  12.27602  0.166793
  2.300000  12.02044  18.35648  22.25739  0.169688
  2.400000  12.22703  19.56885  34.07559  0.172605
  2.500000  12.43508  20.80196  47.47948  0.175542
  2.600000  12.64461  22.05594  62.29958  0.178500
  2.700000  12.85560  23.33095  78.41149  0.181478
  2.800000  13.06806  24.62714  95.71884  0.184477
  2.900000  13.28199  25.94464  114.1441  0.187497
  3.000000  13.49738  27.28361  133.6230  0.190538
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.286          PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.286          IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1.286          RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           RCHRES   1     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1      48.4     WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1      48.4     WDM    801 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1         1     WDM   1012 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      1 1         1     WDM   1013 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      2 1         1     WDM   1014 FLOW     ENGL      REPL
```

```
RCHRES    1 HYDR   STAGE   1 1         1       WDM   1015 STAG      ENGL       REPL
COPY      2 OUTPUT MEAN    1 1      48.4       WDM    702 FLOW      ENGL       REPL
COPY    502 OUTPUT MEAN    1 1      48.4       WDM    802 FLOW      ENGL       REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK   16

END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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WWHM2012

PROJECT REPORT

General Model Information

Project Name: Stossel_2021_03_16_HighInfilt
Site Name:
Site Address:
City:
Report Date: 3/26/2021
Gage: Landsburg
Data Start: 1948/10/01
Data End: 2009/09/30
Timestep: 15 Minute
Precip Scale: 1.286
Version Date: 2019/09/13
Version: 4.2.17

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year
Low Flow Threshold for POC2:	50 Percent of the 2 Year
High Flow Threshold for POC2:	50 Year

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Steep	397
Pervious Total	397
Impervious Land Use	acre
Impervious Total	0
Basin Total	397

Element Flows To:

Surface	Interflow	Groundwater
SSD Table 1	SSD Table 1	

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Steep	397
Pervious Total	397
Impervious Land Use	acre
Impervious Total	0
Basin Total	397

Element Flows To:

Surface	Interflow	Groundwater
SSD Table 1	SSD Table 1	

Routing Elements
Predeveloped Routing

SSD Table 1

Depth: 1 ft.
Discharge Structure: 1
Riser Height: 3 ft.
Riser Diameter: 480 in.
Notch Type: Rectangular
Notch Width: 40.000 ft.
Notch Height: 3.000 ft.
Element Flows To:
Outlet 1 Outlet 2

SSD Table Hydraulic Table

Stage (feet)	Area (ac.)	Volume (ac-ft.)	Outlet Struct	Infilt/ Recharge	NotUsed	NotUsed	NotUsed
0.000	3.491	0.000	0.000	1.760	0.000	0.000	0.000
0.111	3.885	0.410	4.933	1.959	0.000	0.000	0.000
0.222	4.294	0.864	13.95	2.165	0.000	0.000	0.000
0.333	4.717	1.365	25.63	2.378	0.000	0.000	0.000
0.444	5.153	1.913	39.47	2.598	0.000	0.000	0.000
0.556	5.604	2.511	55.16	2.826	0.000	0.000	0.000
0.667	6.069	3.159	72.50	3.060	0.000	0.000	0.000
0.778	6.548	3.860	91.37	3.301	0.000	0.000	0.000
0.889	7.042	4.615	111.6	3.550	0.000	0.000	0.000
1.000	7.549	5.426	133.2	3.806	0.000	0.000	0.000

Mitigated Routing

SSD Table 1

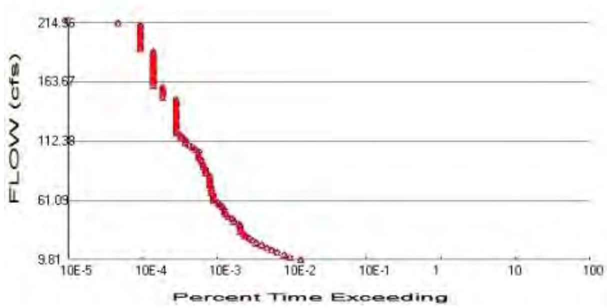
Depth: 1 ft.
Discharge Structure: 1
Riser Height: 3 ft.
Riser Diameter: 480 in.
Notch Type: Rectangular
Notch Width: 40.000 ft.
Notch Height: 1.000 ft.
Orifice 1 Diameter: 3 in. Elevation:0 ft.
Element Flows To:
Outlet 1 Outlet 2

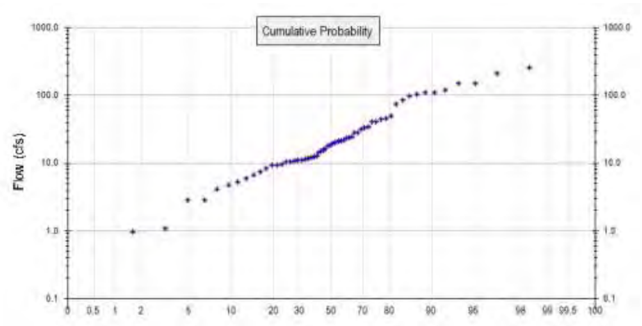
SSD Table Hydraulic Table

Stage (feet)	**Area (ac.)**	**Volume (ac-ft.)**	**Outlet Struct**	**Infilt/ Recharge**	**NotUsed**	**NotUsed**	**NotUsed**
0.000	3.491	0.000	0.000	1.760	0.000	0.000	0.000
0.111	3.885	0.410	0.081	1.959	0.000	0.000	0.000
0.222	4.294	0.864	0.115	2.165	0.000	0.000	0.000
0.333	4.717	1.365	0.141	2.378	0.000	0.000	0.000
0.444	5.153	1.913	0.163	2.598	0.000	0.000	0.000
0.556	5.604	2.511	0.182	2.826	0.000	0.000	0.000
0.667	6.069	3.159	0.199	3.060	0.000	0.000	0.000
0.778	6.548	3.860	0.215	3.301	0.000	0.000	0.000
0.889	7.042	4.615	0.230	3.550	0.000	0.000	0.000
1.000	7.549	5.426	0.244	3.806	0.000	0.000	0.000

Analysis Results

POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1

Total Pervious Area:	397
Total Impervious Area:	0

Mitigated Landuse Totals for POC #1

Total Pervious Area:	397
Total Impervious Area:	0

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	19.610571
5 year	54.535353
10 year	90.952129
25 year	154.2482
50 year	214.963412
100 year	287.955834

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	19.610571
5 year	54.535353
10 year	90.952129
25 year	154.2482
50 year	214.963412
100 year	287.955834

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	34.075	34.075
1950	97.062	97.062
1951	31.515	31.515
1952	11.477	11.477
1953	11.214	11.214
1954	21.465	21.465
1955	10.984	10.984
1956	11.859	11.859
1957	21.571	21.571
1958	5.254	5.254

1959	10.362	10.362
1960	9.603	9.603
1961	20.702	20.702
1962	0.783	0.783
1963	45.159	45.159
1964	108.927	108.927
1965	8.284	8.284
1966	4.725	4.725
1967	23.366	23.366
1968	15.321	15.321
1969	16.496	16.496
1970	21.405	21.405
1971	19.595	19.595
1972	24.727	24.727
1973	9.226	9.226
1974	12.164	12.164
1975	17.921	17.921
1976	12.819	12.819
1977	0.972	0.972
1978	10.838	10.838
1979	2.829	2.829
1980	10.325	10.325
1981	41.338	41.338
1982	6.001	6.001
1983	33.358	33.358
1984	103.345	103.345
1985	4.101	4.101
1986	18.398	18.398
1987	118.343	118.343
1988	15.376	15.376
1989	14.170	14.170
1990	50.431	50.431
1991	149.987	149.987
1992	9.421	9.421
1993	12.234	12.234
1994	2.868	2.868
1995	6.580	6.580
1996	84.139	84.139
1997	258.138	258.138
1998	7.484	7.484
1999	148.616	148.616
2000	23.993	23.993
2001	1.064	1.064
2002	28.350	28.350
2003	73.727	73.727
2004	44.440	44.440
2005	20.059	20.059
2006	27.889	27.889
2007	214.010	214.010
2008	110.961	110.961
2009	40.980	40.980

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	258.1380	258.1380
2	214.0100	214.0100
3	149.9870	149.9870

4	148.6160	148.6160
5	118.3430	118.3430
6	110.9610	110.9610
7	108.9270	108.9270
8	103.3450	103.3450
9	97.0617	97.0617
10	84.1393	84.1393
11	73.7265	73.7265
12	50.4314	50.4314
13	45.1593	45.1593
14	44.4398	44.4398
15	41.3375	41.3375
16	40.9799	40.9799
17	34.0751	34.0751
18	33.3581	33.3581
19	31.5150	31.5150
20	28.3497	28.3497
21	27.8890	27.8890
22	24.7274	24.7274
23	23.9934	23.9934
24	23.3664	23.3664
25	21.5709	21.5709
26	21.4645	21.4645
27	21.4046	21.4046
28	20.7016	20.7016
29	20.0592	20.0592
30	19.5946	19.5946
31	18.3980	18.3980
32	17.9213	17.9213
33	16.4958	16.4958
34	15.3758	15.3758
35	15.3206	15.3206
36	14.1697	14.1697
37	12.8193	12.8193
38	12.2336	12.2336
39	12.1644	12.1644
40	11.8591	11.8591
41	11.4766	11.4766
42	11.2139	11.2139
43	10.9838	10.9838
44	10.8383	10.8383
45	10.3621	10.3621
46	10.3254	10.3254
47	9.6028	9.6028
48	9.4211	9.4211
49	9.2257	9.2257
50	8.2844	8.2844
51	7.4836	7.4836
52	6.5800	6.5800
53	6.0011	6.0011
54	5.2538	5.2538
55	4.7255	4.7255
56	4.1007	4.1007
57	2.8679	2.8679
58	2.8287	2.8287
59	1.0645	1.0645
60	0.9719	0.9719
61	0.7833	0.7833

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
9.8053	281	281	100	Pass
11.8776	203	203	100	Pass
13.9499	169	169	100	Pass
16.0222	135	135	100	Pass
18.0945	115	115	100	Pass
20.1668	100	100	100	Pass
22.2391	85	85	100	Pass
24.3114	72	72	100	Pass
26.3837	63	63	100	Pass
28.4560	57	57	100	Pass
30.5283	51	51	100	Pass
32.6006	48	48	100	Pass
34.6729	44	44	100	Pass
36.7452	44	44	100	Pass
38.8175	43	43	100	Pass
40.8899	42	42	100	Pass
42.9622	36	36	100	Pass
45.0345	34	34	100	Pass
47.1068	30	30	100	Pass
49.1791	28	28	100	Pass
51.2514	27	27	100	Pass
53.3237	27	27	100	Pass
55.3960	25	25	100	Pass
57.4683	23	23	100	Pass
59.5406	22	22	100	Pass
61.6129	19	19	100	Pass
63.6852	19	19	100	Pass
65.7575	19	19	100	Pass
67.8298	18	18	100	Pass
69.9021	18	18	100	Pass
71.9744	18	18	100	Pass
74.0467	17	17	100	Pass
76.1190	17	17	100	Pass
78.1913	17	17	100	Pass
80.2636	17	17	100	Pass
82.3359	17	17	100	Pass
84.4082	15	15	100	Pass
86.4805	15	15	100	Pass
88.5528	15	15	100	Pass
90.6252	14	14	100	Pass
92.6975	14	14	100	Pass
94.7698	13	13	100	Pass
96.8421	13	13	100	Pass
98.9144	12	12	100	Pass
100.9867	12	12	100	Pass
103.0590	12	12	100	Pass
105.1313	11	11	100	Pass
107.2036	10	10	100	Pass
109.2759	9	9	100	Pass
111.3482	8	8	100	Pass
113.4205	8	8	100	Pass
115.4928	7	7	100	Pass
117.5651	7	7	100	Pass

119.6374	6	6	100	Pass
121.7097	6	6	100	Pass
123.7820	6	6	100	Pass
125.8543	6	6	100	Pass
127.9266	6	6	100	Pass
129.9989	6	6	100	Pass
132.0712	6	6	100	Pass
134.1435	6	6	100	Pass
136.2158	6	6	100	Pass
138.2882	6	6	100	Pass
140.3605	6	6	100	Pass
142.4328	6	6	100	Pass
144.5051	6	6	100	Pass
146.5774	6	6	100	Pass
148.6497	6	6	100	Pass
150.7220	4	4	100	Pass
152.7943	4	4	100	Pass
154.8666	4	4	100	Pass
156.9389	4	4	100	Pass
159.0112	4	4	100	Pass
161.0835	3	3	100	Pass
163.1558	3	3	100	Pass
165.2281	3	3	100	Pass
167.3004	3	3	100	Pass
169.3727	3	3	100	Pass
171.4450	3	3	100	Pass
173.5173	3	3	100	Pass
175.5896	3	3	100	Pass
177.6619	3	3	100	Pass
179.7342	3	3	100	Pass
181.8065	3	3	100	Pass
183.8788	3	3	100	Pass
185.9512	3	3	100	Pass
188.0235	3	3	100	Pass
190.0958	3	3	100	Pass
192.1681	2	2	100	Pass
194.2404	2	2	100	Pass
196.3127	2	2	100	Pass
198.3850	2	2	100	Pass
200.4573	2	2	100	Pass
202.5296	2	2	100	Pass
204.6019	2	2	100	Pass
206.6742	2	2	100	Pass
208.7465	2	2	100	Pass
210.8188	2	2	100	Pass
212.8911	2	2	100	Pass
214.9634	1	1	100	Pass

Water Quality

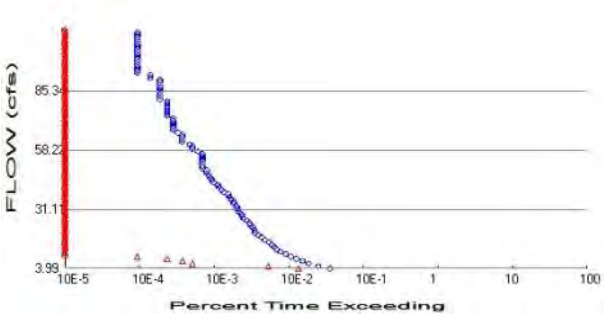
Water Quality BMP Flow and Volume for POC #1

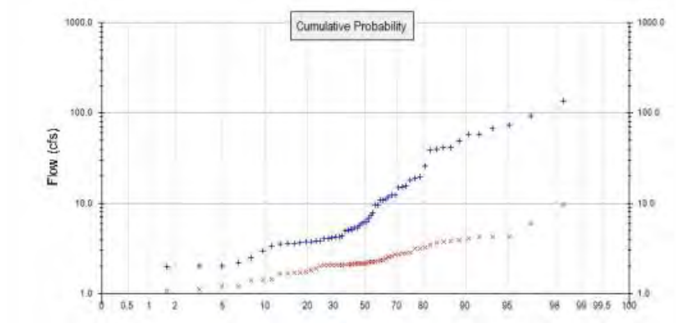
On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

POC 2





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #2
Total Pervious Area: 397
Total Impervious Area: 0

Mitigated Landuse Totals for POC #2
Total Pervious Area: 397
Total Impervious Area: 0

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	Flow(cfs)
2 year	7.984267
5 year	21.376741
10 year	37.755033
25 year	72.229843
50 year	112.449956
100 year	170.157164

Flow Frequency Return Periods for Mitigated. POC #2

Return Period	Flow(cfs)
2 year	2.247069
5 year	3.256282
10 year	4.018093
25 year	5.091875
50 year	5.975715
100 year	6.934213

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #2

Year	Predeveloped	Mitigated
1949	12.215	2.709
1950	67.079	4.197
1951	17.939	3.452
1952	4.245	2.085
1953	4.116	2.055
1954	7.868	2.282
1955	4.320	2.162
1956	4.986	2.123
1957	9.489	2.250
1958	2.937	1.665
1959	3.660	1.710

1960	5.105	2.117
1961	7.357	2.231
1962	1.254	0.789
1963	15.487	2.450
1964	39.875	3.699
1965	3.773	2.059
1966	2.209	1.065
1967	11.128	2.314
1968	5.177	2.038
1969	5.307	2.088
1970	6.705	2.131
1971	6.007	2.215
1972	9.573	2.354
1973	3.772	1.805
1974	4.221	1.697
1975	6.254	2.136
1976	5.364	2.122
1977	2.004	1.118
1978	3.732	1.995
1979	1.982	1.200
1980	3.489	1.398
1981	15.138	2.539
1982	3.327	1.739
1983	10.718	2.260
1984	41.223	3.653
1985	2.513	1.442
1986	5.730	2.056
1987	41.150	3.127
1988	4.928	2.069
1989	6.154	2.143
1990	18.759	3.225
1991	57.701	3.827
1992	3.717	2.078
1993	4.035	2.039
1994	3.591	1.421
1995	3.611	1.874
1996	49.241	3.882
1997	93.284	4.193
1998	4.085	1.649
1999	74.034	4.097
2000	12.146	2.708
2001	2.003	1.208
2002	11.646	2.604
2003	25.699	2.756
2004	39.021	4.230
2005	10.807	2.805
2006	14.882	2.791
2007	137.245	5.926
2008	58.007	9.780
2009	19.641	3.145

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #2

Rank	Predeveloped	Mitigated
1	137.2450	9.7803
2	93.2843	5.9261
3	74.0339	4.2299
4	67.0792	4.1968

5	58.0066	4.1931
6	57.7006	4.0970
7	49.2409	3.8824
8	41.2230	3.8274
9	41.1498	3.6995
10	39.8752	3.6531
11	39.0211	3.4516
12	25.6994	3.2251
13	19.6411	3.1450
14	18.7591	3.1269
15	17.9385	2.8055
16	15.4867	2.7910
17	15.1377	2.7561
18	14.8819	2.7088
19	12.2150	2.7077
20	12.1456	2.6042
21	11.6456	2.5389
22	11.1280	2.4504
23	10.8067	2.3543
24	10.7182	2.3140
25	9.5729	2.2822
26	9.4890	2.2603
27	7.8675	2.2503
28	7.3567	2.2310
29	6.7052	2.2145
30	6.2538	2.1623
31	6.1539	2.1433
32	6.0065	2.1363
33	5.7298	2.1309
34	5.3644	2.1227
35	5.3071	2.1223
36	5.1768	2.1169
37	5.1046	2.0883
38	4.9864	2.0848
39	4.9280	2.0778
40	4.3196	2.0688
41	4.2446	2.0588
42	4.2208	2.0563
43	4.1162	2.0546
44	4.0853	2.0392
45	4.0352	2.0378
46	3.7730	1.9947
47	3.7721	1.8737
48	3.7316	1.8054
49	3.7170	1.7391
50	3.6596	1.7100
51	3.6115	1.6974
52	3.5905	1.6645
53	3.4887	1.6490
54	3.3269	1.4416
55	2.9372	1.4207
56	2.5134	1.3978
57	2.2094	1.2080
58	2.0041	1.2001
59	2.0028	1.1181
60	1.9816	1.0651
61	1.2545	0.7891

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
3.9921	766	287	37	Pass
5.0877	530	114	21	Pass
6.1832	398	11	2	Pass
7.2787	329	8	2	Pass
8.3743	272	5	1	Pass
9.4698	228	2	0	Pass
10.5653	196	0	0	Pass
11.6609	168	0	0	Pass
12.7564	147	0	0	Pass
13.8519	135	0	0	Pass
14.9475	127	0	0	Pass
16.0430	116	0	0	Pass
17.1385	103	0	0	Pass
18.2341	93	0	0	Pass
19.3296	84	0	0	Pass
20.4251	76	0	0	Pass
21.5207	74	0	0	Pass
22.6162	70	0	0	Pass
23.7117	65	0	0	Pass
24.8073	64	0	0	Pass
25.9028	59	0	0	Pass
26.9983	53	0	0	Pass
28.0939	51	0	0	Pass
29.1894	48	0	0	Pass
30.2849	45	0	0	Pass
31.3805	44	0	0	Pass
32.4760	43	0	0	Pass
33.5715	39	0	0	Pass
34.6671	39	0	0	Pass
35.7626	36	0	0	Pass
36.8581	34	0	0	Pass
37.9537	33	0	0	Pass
39.0492	29	0	0	Pass
40.1447	27	0	0	Pass
41.2403	25	0	0	Pass
42.3358	24	0	0	Pass
43.4313	21	0	0	Pass
44.5269	20	0	0	Pass
45.6224	19	0	0	Pass
46.7179	18	0	0	Pass
47.8135	17	0	0	Pass
48.9090	17	0	0	Pass
50.0045	15	0	0	Pass
51.1001	15	0	0	Pass
52.1956	15	0	0	Pass
53.2911	15	0	0	Pass
54.3867	15	0	0	Pass
55.4822	15	0	0	Pass
56.5777	15	0	0	Pass
57.6733	13	0	0	Pass
58.7688	11	0	0	Pass
59.8643	11	0	0	Pass
60.9599	10	0	0	Pass

62.0554	8	0	0	Pass
63.1509	8	0	0	Pass
64.2465	8	0	0	Pass
65.3420	8	0	0	Pass
66.4375	7	0	0	Pass
67.5331	6	0	0	Pass
68.6286	6	0	0	Pass
69.7241	6	0	0	Pass
70.8197	6	0	0	Pass
71.9152	6	0	0	Pass
73.0107	6	0	0	Pass
74.1063	5	0	0	Pass
75.2018	5	0	0	Pass
76.2973	5	0	0	Pass
77.3929	5	0	0	Pass
78.4884	5	0	0	Pass
79.5839	5	0	0	Pass
80.6795	5	0	0	Pass
81.7750	4	0	0	Pass
82.8705	4	0	0	Pass
83.9661	4	0	0	Pass
85.0616	4	0	0	Pass
86.1572	4	0	0	Pass
87.2527	4	0	0	Pass
88.3482	4	0	0	Pass
89.4438	4	0	0	Pass
90.5393	4	0	0	Pass
91.6348	3	0	0	Pass
92.7304	3	0	0	Pass
93.8259	2	0	0	Pass
94.9214	2	0	0	Pass
96.0170	2	0	0	Pass
97.1125	2	0	0	Pass
98.2080	2	0	0	Pass
99.3036	2	0	0	Pass
100.3991	2	0	0	Pass
101.4946	2	0	0	Pass
102.5902	2	0	0	Pass
103.6857	2	0	0	Pass
104.7812	2	0	0	Pass
105.8768	2	0	0	Pass
106.9723	2	0	0	Pass
108.0678	2	0	0	Pass
109.1634	2	0	0	Pass
110.2589	2	0	0	Pass
111.3544	2	0	0	Pass
112.4500	2	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #2

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
SSD Table 1 POC	☐	1368.42			☐	95.78			
Total Volume Infiltrated		1368.42	0.00	0.00		95.78	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

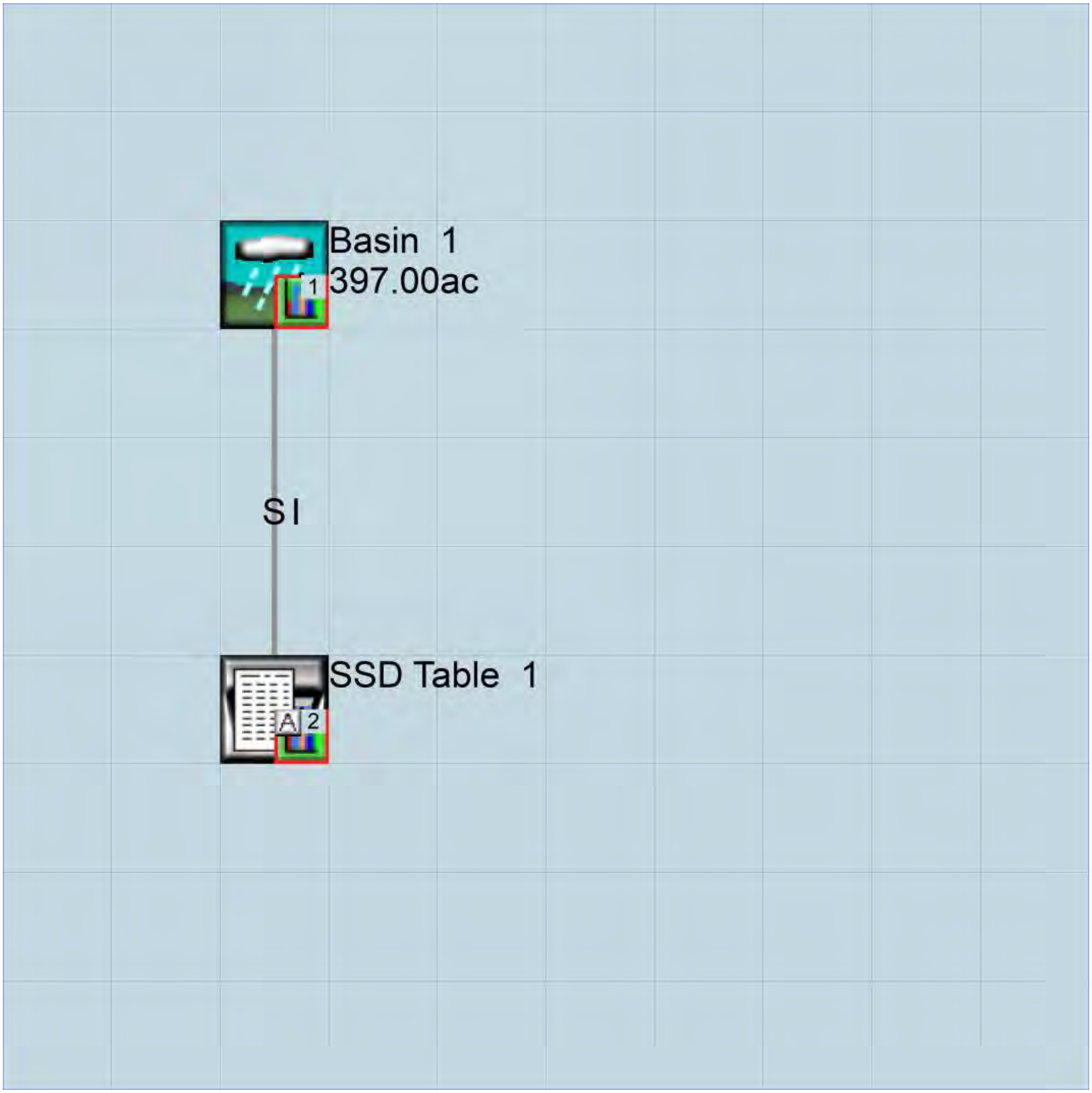
PERLND Changes

No PERLND changes have been made.

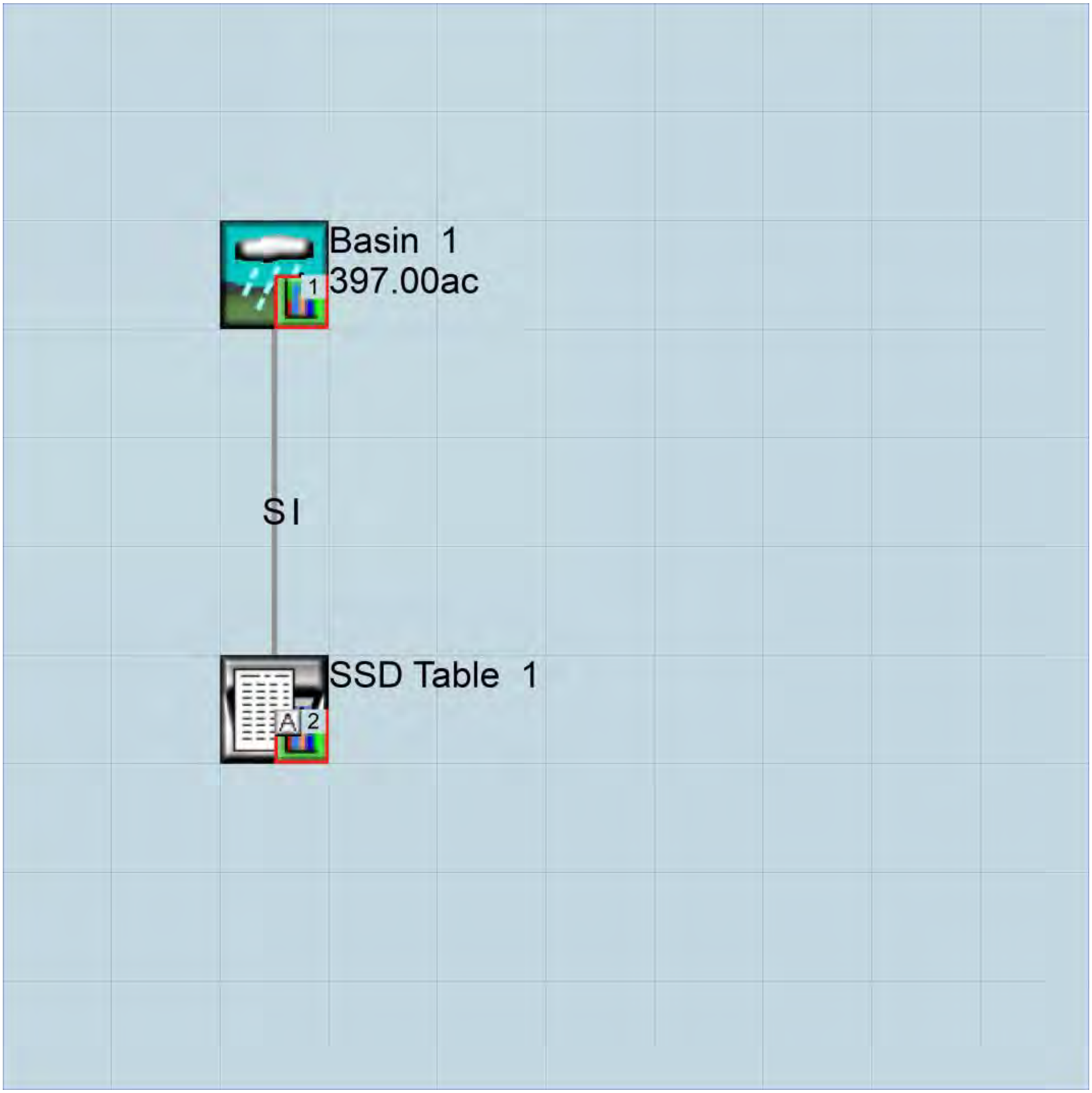
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   Stossel_2021_03_16_HighInfilt.wdm
MESSU      25   PreStossel_2021_03_16_HighInfilt.MES
           27   PreStossel_2021_03_16_HighInfilt.L61
           28   PreStossel_2021_03_16_HighInfilt.L62
           30   POCStossel_2021_03_16_HighInfilt1.dat
           31   POCStossel_2021_03_16_HighInfilt2.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND       3
      RCHRES       1
      COPY       501
      COPY       502
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                    1    2   30    9
    2        SSD Table  1                MAX                    1    2   31    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1        1    1
  501        1    1
  502        1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
    3     A/B, Forest, Steep      1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
    3         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
    3         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
    3         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
    3              0         5         2       400      0.15       0.3     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
    3              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                                     ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
    3            0.2       0.5      0.35         0       0.7       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
    3              0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
  END IWAT-PARM3
```

```
  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND   3                         397     RCHRES   1      2
PERLND   3                         397     RCHRES   1      3
Basin  1***
PERLND   3                         397     COPY   501     12
PERLND   3                         397     COPY   501     13

******Routing******
RCHRES   1                           1     COPY   502     16
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY    501 OUTPUT MEAN   1 1   48.4       DISPLY   1     INPUT  TIMSER 1
COPY    502 OUTPUT MEAN   1 1   48.4       DISPLY   2     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                         in  out                             ***
    1     SSD Table  1           2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
    1        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1       0.2       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
```

```
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1          0          4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   29    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
  0.000000  3.490519  0.000000  0.000000  0.000000
  0.111111  3.885161  0.409760  4.933333  1.958768
  0.222222  4.293869  0.864150  13.95357  2.164826
  0.333333  4.716644  1.364735  25.63435  2.377975
  0.444444  5.153485  1.913075  39.46667  2.598215
  0.555556  5.604393  2.510735  55.15634  2.825548
  0.666667  6.069368  3.159277  72.50490  3.059973
  0.777778  6.548409  3.860265  91.36661  3.301490
  0.888889  7.041517  4.615261  111.6286  3.550098
  1.000000  7.548691  5.425828  133.2000  3.805799
  1.111111  7.940095  6.286316  156.0057  4.003131
  1.222222  8.340891  7.190815  179.9822  4.205199
  1.333333  8.751080  8.140369  205.0748  4.412003
  1.444444  9.170663  9.136022  231.2360  4.623542
  1.555556  9.599638  10.17882  258.4238  4.839817
  1.666667  10.03801  11.26980  286.6008  5.060828
  1.777778  10.48577  12.41001  315.7333  5.286575
  1.888889  10.94292  13.60049  345.7911  5.517057
  2.000000  11.40947  14.84229  376.7465  5.752274
  2.100000  11.61166  15.99334  405.3528  5.854211
  2.200000  11.81531  17.16469  434.6486  5.956887
  2.300000  12.02044  18.35648  464.6179  6.060303
  2.400000  12.22703  19.56885  495.2461  6.164459
  2.500000  12.43508  20.80196  526.5192  6.269355
  2.600000  12.64461  22.05594  558.4242  6.374990
  2.700000  12.85560  23.33095  590.9488  6.481366
  2.800000  13.06806  24.62714  624.0814  6.588481
  2.900000  13.28199  25.94464  657.8111  6.696336
  3.000000  13.49738  27.28361  692.1275  6.804931
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC      ENGL    1.286          PERLND   1 999 EXTNL  PREC
WDM      2 PREC      ENGL    1.286          IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP      ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP      ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC      ENGL    1.286          RCHRES   1     EXTNL  PREC
WDM      1 EVAP      ENGL    0.76           RCHRES   1     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4       WDM    501 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1       WDM   1008 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1       WDM   1009 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      2 1        1       WDM   1010 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1       WDM   1011 STAG     ENGL      REPL
COPY   502 OUTPUT MEAN   1 1     48.4       WDM    502 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
```

```
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK   16


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                             ***
WDM        26   Stossel_2021_03_16_HighInfilt.wdm
MESSU      25   MitStossel_2021_03_16_HighInfilt.MES
           27   MitStossel_2021_03_16_HighInfilt.L61
           28   MitStossel_2021_03_16_HighInfilt.L62
           30   POCStossel_2021_03_16_HighInfilt1.dat
           31   POCStossel_2021_03_16_HighInfilt2.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND       3
      RCHRES       1
      COPY       501
      COPY         2
      COPY       502
      DISPLY       1
      DISPLY       2
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                        1    2   30    9
    2        SSD Table  1                MAX                        1    2   31    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
    2         1    1
  502         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                            User  t-series Engl Metr ***
                                             in  out           ***
    3     A/B, Forest, Steep      1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
    3         0    0    1    0    0    0    0    0    0    0    0    0
```

```
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
    3         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
    3         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
    3              0         5         2       400      0.15       0.3     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
    3              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
    3            0.2       0.5      0.35         0       0.7       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
    3              0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                    User  t-series Engl Metr ***
                                    in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
```

```
    # -  # ***PETMAX    PETMIN
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                    <--Area-->     <-Target->   MBLK   ***
<Name>   #                    <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND   3                           397     RCHRES   1      2
PERLND   3                           397     RCHRES   1      3
Basin  1***
PERLND   3                           397     COPY   501     12
PERLND   3                           397     COPY   501     13

******Routing******
PERLND   3                           397     COPY     2     12
PERLND   3                           397     COPY     2     13
RCHRES   1                             1     COPY   502     16
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1
COPY   502 OUTPUT MEAN   1 1   48.4        DISPLY   2     INPUT  TIMSER 1


<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                         in  out                             ***
    1     SSD Table  1           2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *     *  *  *  *  *        *  *  *  *  *        ***
    1        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
```

```
    1              1       0.2       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1          0          4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   29    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)     (cfs)    (ft/sec)    (Minutes)***
  0.000000  3.490518  0.000000  0.000000  0.000000
  0.111111  3.885160  0.409760  0.081410  1.958768
  0.222222  4.293868  0.864150  0.115132  2.164825
  0.333333  4.716643  1.364734  0.141007  2.377974
  0.444444  5.153485  1.913075  0.162821  2.598215
  0.555555  5.604393  2.510734  0.182039  2.825548
  0.666666  6.069367  3.159277  0.199414  3.059973
  0.777777  6.548409  3.860264  0.215392  3.301490
  0.888888  7.041517  4.615260  0.230263  3.550098
  1.000000  7.548691  5.425827  0.244231  3.805798
  1.111111  7.940095  6.286315  0.257442  4.003131
  1.222222  8.340891  7.190814  0.270008  4.205199
  1.333333  8.751080  8.140368  0.282014  4.412003
  1.444444  9.170663  9.136021  0.293529  4.623542
  1.555556  9.599638  10.17882  0.304610  4.839817
  1.666667  10.03801  11.26980  0.315301  5.060828
  1.777778  10.48577  12.41001  0.325642  5.286575
  1.888889  10.94292  13.60049  0.335664  5.517057
  2.000000  11.40947  14.84229  0.345395  5.752274
  2.100000  11.61166  15.99334  4.566079  5.854211
  2.200000  11.81531  17.16469  12.27602  5.956887
  2.300000  12.02044  18.35648  22.25739  6.060303
  2.400000  12.22703  19.56885  34.07559  6.164459
  2.500000  12.43508  20.80196  47.47948  6.269355
  2.600000  12.64461  22.05594  62.29958  6.374990
  2.700000  12.85560  23.33095  78.41149  6.481366
  2.800000  13.06806  24.62714  95.71884  6.588481
  2.900000  13.28199  25.94464  114.1441  6.696336
  3.000000  13.49738  27.28361  133.6230  6.804931
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.286          PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.286          IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1.286          RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           RCHRES   1     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1      WDM   1012 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1013 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      2 1        1      WDM   1014 FLOW     ENGL      REPL
```

```
RCHRES    1 HYDR   STAGE   1 1         1       WDM   1015 STAG     ENGL      REPL
COPY      2 OUTPUT MEAN    1 1      48.4       WDM    702 FLOW     ENGL      REPL
COPY    502 OUTPUT MEAN    1 1      48.4       WDM    802 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK   16


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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Attachment C
Preliminary Design Drawings

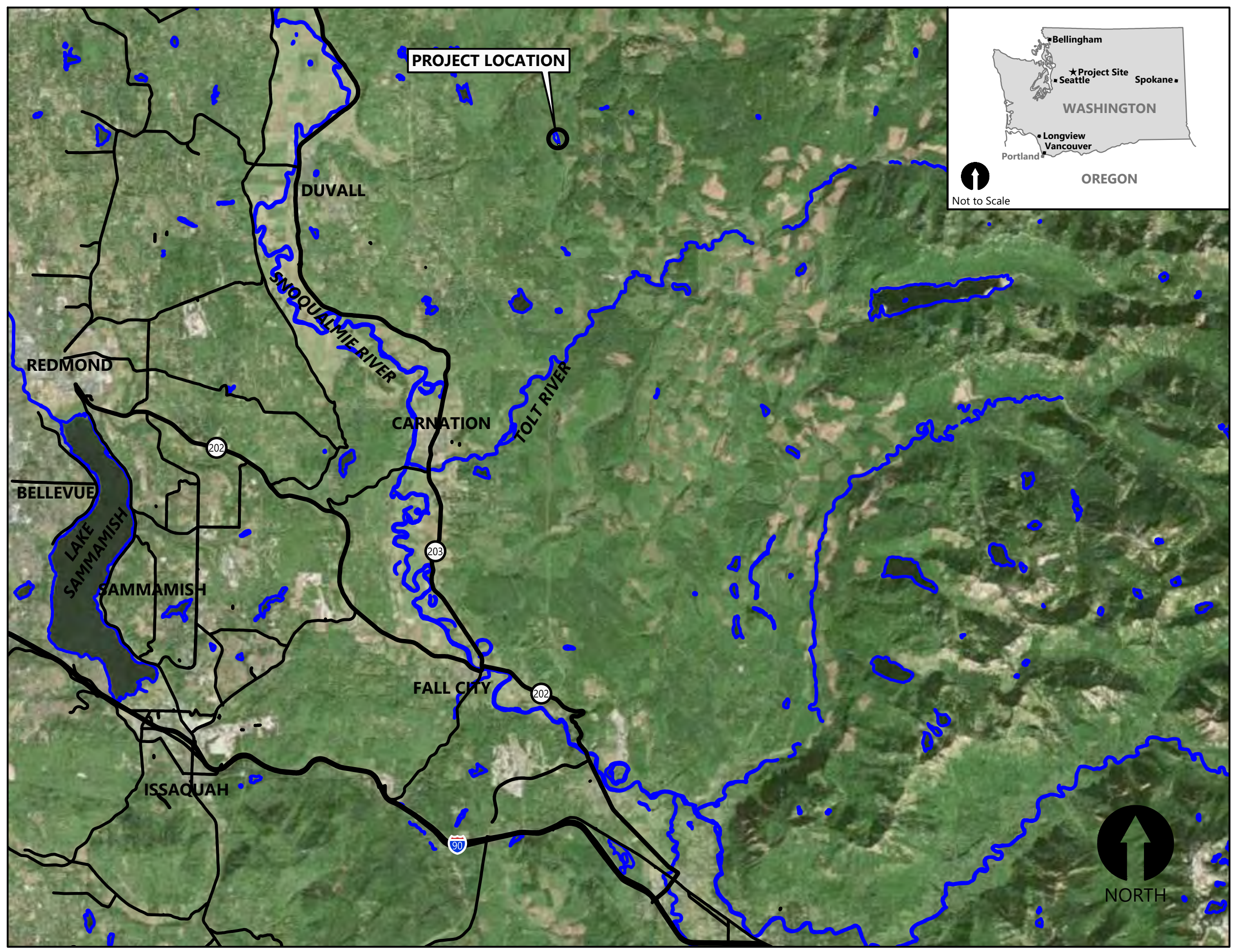
PRELIMINARY DESIGN SUBMITTAL

STOSSEL CREEK NATURAL STORAGE ENHANCEMENT

SNOQUALMIE VALLEY WATERSHED IMPROVEMENT DISTRICT

DRAWING INDEX

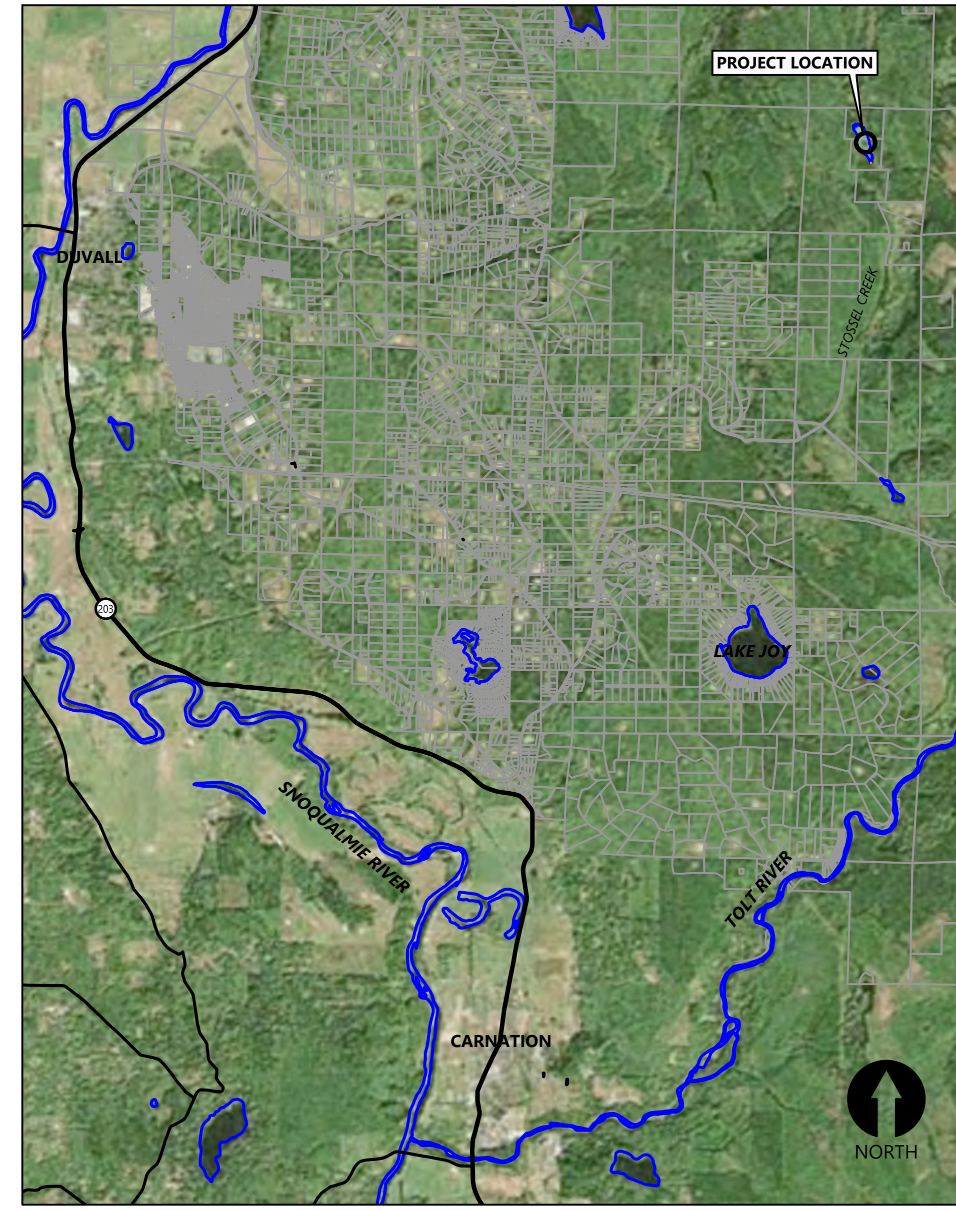
SHEET #	DRAWING #	SHEET TITLE
1	G01	COVER SHEET
2	C01	NATURAL STORAGE ENHANCEMENT PLAN
3	C02	NATURAL STORAGE SECTIONS AND DETAILS



LOCATION MAP

0 12,000 24,000

SCALE IN FEET



VICINITY MAP

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SCALE IN FEET

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH

AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

K:\Projects\1884-SVWID\Snoqualmie Valley Comprehensive Storage Study\Construction Plans\1884-PL-001_STOSSEL_NATURAL_STORAGE.dwg G01

Sep 30, 2021 7:08pm drice

DRAFT-NOT FOR CONSTRUCTION

ANCHOR QEA

SNOQUALMIE VALLEY Watershed Improvement District

REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION

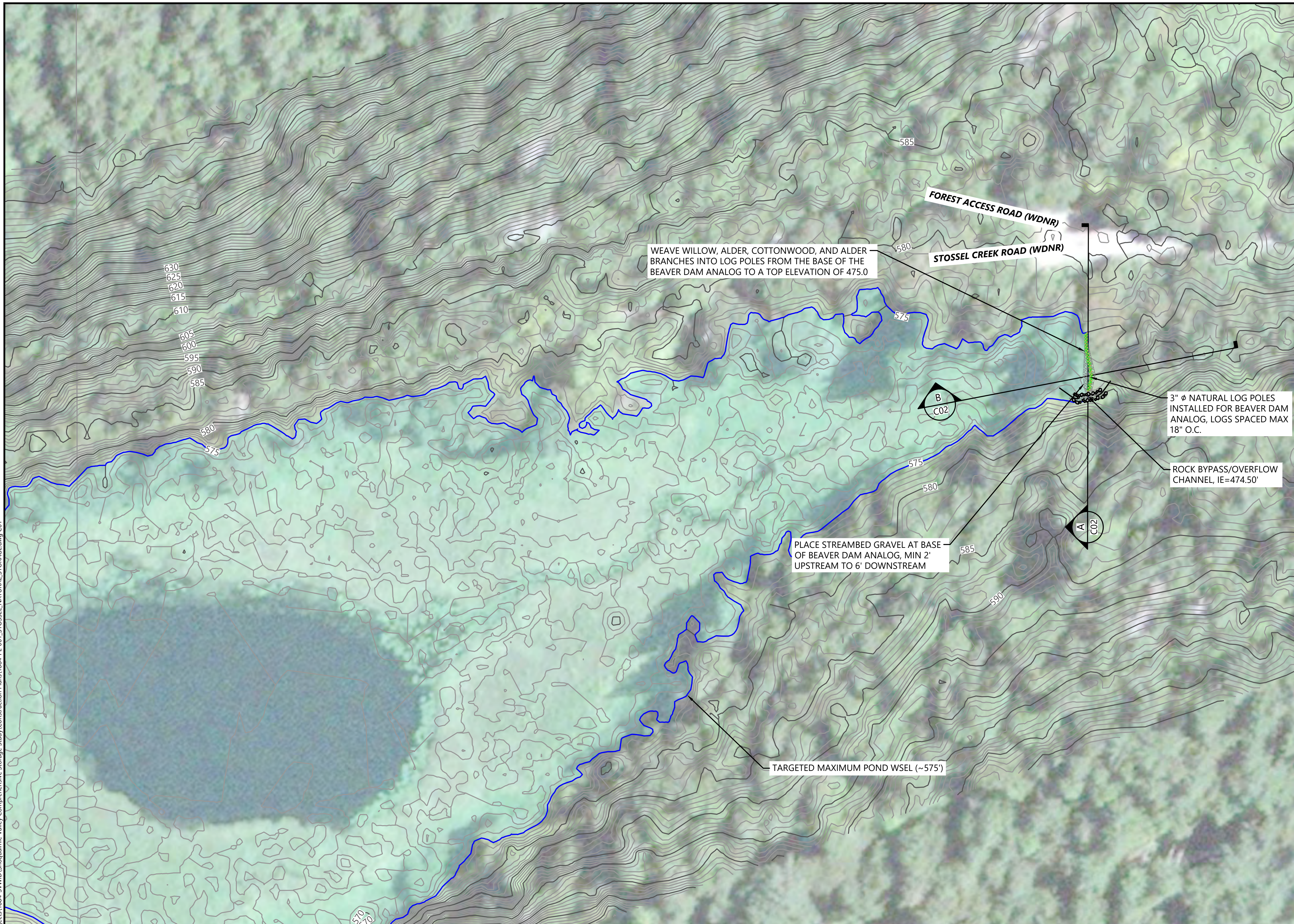
DESIGNED BY: D. RICE
DRAWN BY: J BIGSBY
CHECKED BY: D. RICE
APPROVED BY: D. RICE
SCALE: AS NOTED
DATE: SEPTEMBER 30, 2021

STOSSEL CREEK NATURAL STORAGE ENHANCEMENT

COVER SHEET

G01

SHEET # 1 OF 3



LEGEND:

- NATURAL LOG POLES FOR BEAVER DAM ANALOG
- WILLOW, COTTONWOOD, AND ALDER BRANCHES
- STREAMBED BOULDERS
- STREAMBED COBBLES AND GRAVEL
- EXISTING CONTOURS (1' & 5' INTERVALS)

NORTH

0 50 100
SCALE IN FEET

NOTES:

1. CONTOURS ARE 1-FOOT INTERVAL CONTOURS GENERATED FROM LIDAR DATA.
2. AERIAL ©2021 MICROSOFT CORPORATION ©2021 MAXAR ©CNES (2021) DISTRIBUTION AIRBUS DS
3. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
4. VERTICAL DATUM: NAVD88

DRAFT-NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH

AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

K:\Projects\1884-SVWID\Snoqualmie Valley Comprehensive Storage Study\Construction Plans\1884-PL-001_STOSSEL_NATURAL_STORAGE.dwg C01

Sep 30, 2021 7:08pm drice

ANCHOR QEA

SNOQUALMIE VALLEY Watershed Improvement District

REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION

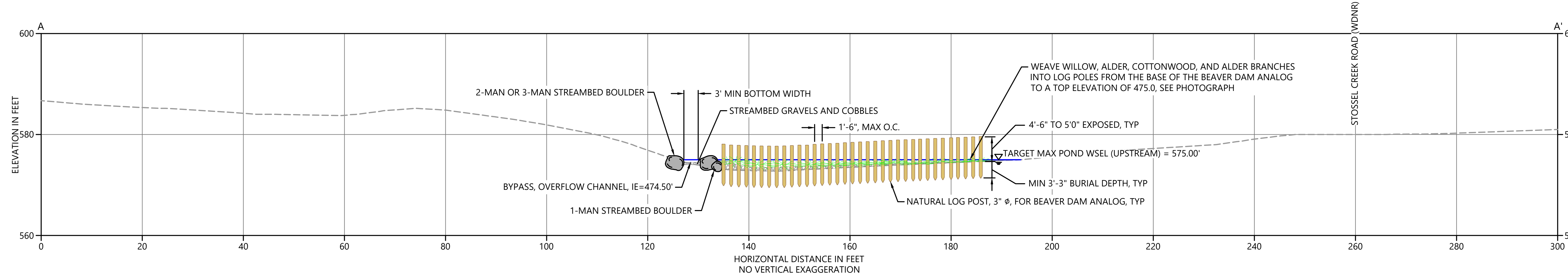
DESIGNED BY: D. RICE
DRAWN BY: J BIGSBY
CHECKED BY: D. RICE
APPROVED BY: D. RICE
SCALE: AS NOTED
DATE: SEPTEMBER 30, 2021

STOSSEL CREEK NATURAL STORAGE ENHANCEMENT

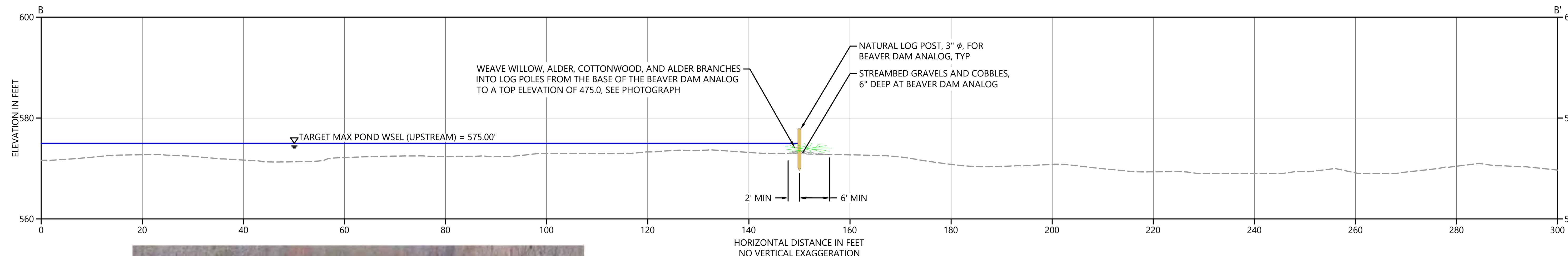
NATURAL STORAGE ENHANCEMENT PLAN

C01

SHEET # 2 OF 3



A - SECTION
SCALE: 1" = 10'



B - SECTION
SCALE: 1" = 10'

EXAMPLE BDA POST LINE WITH WILLOW WEAVE, NOAA FISHERIES, "WORKING WITH BEAVERS TO RESTORE SALMON HABITAT", 2003

K:\Projects\1884-SVWID\Snoqualmie Valley Comprehensive Storage Study\Construction Plans\1884-PL-001_STOSSEL_NATURAL_STORAGE.dwg C02

Sep 30, 2021 7:08pm drice

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH

AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

DRAFT-NOT FOR CONSTRUCTION

ANCHOR QEA

SNOQUALMIE VALLEY Watershed Improvement District

REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: D. RICE
DRAWN BY: J BIGSBY
CHECKED BY: D. RICE
APPROVED BY: D. RICE
SCALE: AS NOTED
DATE: SEPTEMBER 30, 2021

STOSSEL CREEK NATURAL STORAGE ENHANCEMENT

NATURAL STORAGE SECTIONS AND DETAILS

C02

SHEET # 3 OF 3

Appendix C
Scoring and Ranking Tables

SVWID Comprehensive Storage Study
Screening Analysis
Draft Screening Matrix - Overall Scoring and Ranking Summary

Project ID	Overall Rank	Description	Estimated Storage Volume (Acre-feet)	Maximum Water Surface Area (Acres)	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	**1**	Snoqualmie Timber - NF Tolt (C)	1,296	133.6	**4.00**	4.04	3.97
MFK1	**2**	DNR - MF Snoq	3,311	173.8	**3.94**	3.68	4.20
TOK3	**3**	Klaus Lake	121	70.2	**3.86**	3.95	3.76
NFK2	**4**	Snoqualmie Timber - NF Snoq (B)	482	26.9	**3.80**	3.69	3.92
NFK1	**5**	Snoqualmie Timber - NF Snoq (A)	449	47.3	**3.65**	3.96	3.34
TOK2	**6**	Bridges Lake	89	47.8	**3.64**	3.95	3.33
NFT1	**7**	DNR - NF Tolt (B)	113	11.6	**3.59**	4.05	3.14
NFT3	**8**	DNR - NF Tolt (D)	132	11.5	**3.56**	4.05	3.07
CCK2	**9**	Cherry Lake	173	22.2	**3.54**	3.52	3.56
TOK4	**10**	Black Lake	76	40.7	**3.53**	3.81	3.24
TOK1	**11**	Snoqualmie Timber - Tokul	38	8.1	**3.42**	3.91	2.93
CCK1	**12**	Lake Margaret	106	53.1	**3.40**	2.84	3.96
NFT2	**13**	Snoqualmie Timber - NF Tolt (A)	62	7.3	**3.38**	3.95	2.82
NFK3	**14**	Snoqualmie Timber - NF Snoq (D)	29	6.0	**3.37**	3.80	2.94
LOT1	**15**	Snoqualmie Timber - Tolt (A)	84	23.7	**3.33**	3.41	3.26
SNO3	**16**	Twin Peaks Timber - Snoq	197	17.9	**3.25**	3.33	3.18
SNO1	**17**	Loutsis Lake	38	18.8	**3.24**	3.57	2.91
LOT2	**18**	Snoqualmie Timber - Tolt (B)	130	19.4	**2.97**	3.29	2.64
SNO2	**19**	Nelson Pond	42	14.7	**2.79**	3.45	2.13
CCK3	**20**	Upper Margaret Creek	22	7.9	**2.63**	2.91	2.36

SVWID Comprehensive Storage Study
Screening Analysis
Draft Screening Matrix - Scoring Summary from GIS Weighted Overlay Analysis

						Physical Criteria Measuring Out-of-Stream Use Benefits			Physical Criteria Measuring Instream Flow and Habitat			Other Cost/Benefit and Feasibility		
Project ID	**Overall Rank**	**Overall Score from GIS Weighted Overlay Analysis**	**Overall Score - Physical Criteria Measuring Out-of-Stream Use Benefits**	**Overall Score - Physical Criteria Measuring Instream Flow and Habitat Benefits**	**Overall Score - Other Cost/Benefit and Feasibility Criteria**	***Proximity to Water Source***	***Location Within Watershed***	***Ability to Offset Consumptive Use***	***Fish Habitat***	***Fish Presence***	***Current Vegetation/ Land Use***	***Property Ownership***	***Site Accessibility***	***Storage Type***
			35%	*40%*	*25%*	*35%*	*35%*	*30%*	*35%*	*40%*	*25%*	*40%*	*30%*	*30%*
SNO1	**17**	**3.57**	3.60	3.80	3.14	5.00	1.00	5.00	3.00	5.00	3.00	2.00	4.79	3.01
SNO2	**19**	**3.45**	3.60	3.45	3.24	5.00	1.00	5.00	2.00	5.00	3.00	2.00	5.00	3.12
SNO3	**16**	**3.33**	3.05	3.51	3.43	5.00	2.00	2.00	2.00	4.86	3.48	2.24	5.00	3.46
CCK1	**12**	**2.84**	2.70	2.74	3.20	5.00	1.00	2.00	1.00	4.10	3.00	2.00	5.00	3.00
CCK2	**9**	**3.52**	2.70	3.95	3.98	5.00	1.00	2.00	2.00	5.00	5.00	4.00	5.00	2.93
CCK3	**20**	**2.91**	2.70	2.71	3.54	5.00	1.00	2.00	1.00	2.77	5.00	3.00	5.00	2.81
LOT1	**15**	**3.41**	3.05	3.60	3.60	5.00	2.00	2.00	1.00	5.00	5.00	3.00	5.00	3.01
LOT2	**18**	**3.29**	2.35	3.60	4.12	3.00	2.00	2.00	1.00	5.00	5.00	3.00	5.00	4.75
NFT1	**7**	**4.05**	3.40	4.65	4.01	5.00	3.00	2.00	4.00	5.00	5.00	4.00	5.00	3.03
NFT2	**13**	**3.95**	3.40	4.65	3.58	5.00	3.00	2.00	4.00	5.00	5.00	3.00	5.00	2.94
NFT3	**8**	**4.05**	3.40	4.65	4.00	5.00	3.00	2.00	4.00	5.00	5.00	4.00	5.00	3.00
NFT4	**1**	**4.04**	2.83	5.00	4.20	3.36	3.00	2.00	5.00	5.00	5.00	3.00	5.00	5.00
TOK1	**11**	**3.91**	3.26	4.30	4.20	4.59	3.00	2.00	3.00	5.00	5.00	3.00	5.00	5.00
TOK2	**6**	**3.95**	3.40	4.65	3.60	5.00	3.00	2.00	4.00	5.00	5.00	3.00	5.00	3.01
TOK3	**3**	**3.95**	3.40	4.65	3.60	5.00	3.00	2.00	4.00	5.00	5.00	3.00	5.00	3.00
TOK4	**10**	**3.81**	3.40	4.30	3.60	5.00	3.00	2.00	3.00	5.00	5.00	3.00	5.00	3.00
NFK1	**5**	**3.96**	3.30	4.30	4.32	4.58	4.00	1.00	3.00	5.00	5.00	3.78	5.00	4.36
NFK2	**4**	**3.69**	3.00	3.95	4.23	3.71	4.00	1.00	2.00	5.00	5.00	3.58	5.00	4.34
NFK3	**14**	**3.80**	3.45	4.65	2.95	5.00	4.00	1.00	4.00	5.00	5.00	2.10	5.00	2.03
MFK1	**2**	**3.68**	2.71	3.95	4.60	2.88	4.00	1.00	2.00	5.00	5.00	4.00	5.00	5.00

SVWID Comprehensive Storage Study
Screening Analysis
Draft Screening Matrix - Scoring Summary for Site-Specific Analysis

						Physical Criteria Measuring Out-of-Stream Use Benefits			Physical Criteria Measuring Instream Flow and Habitat Benefits				Other Cost/Benefit and Feasibility Criteria			
Project ID	**Overall Rank**	**Overall Score from Site-Specific Analysis**	**Overall Score - Physical Criteria Measuring Out-of-Stream Use Benefits**	**Overall Score - Physical Criteria Measuring Instream Flow and Habitat Benefits**	**Overall Score - Other Cost/Benefit and Feasibility Criteria**	***Project Footprint***	***Available Storage Capacity***	***Ability to Store High Flows***	***Instream Flow Benefits***	***Water Quality - Temperature & Dissolved Oxygen***	***Water Quality - Toxics***	***Reliability/ Resilience***	***Constructability***	***Critical Areas and Resource Impacts***	***Cost and Funding Potential***	***Operation and Maintenance***
			35%	*40%*	*25%*	*30%*	*50%*	*20%*	*30%*	*25%*	*15%*	*30%*	*10%*	*20%*	*50%*	*20%*
SNO1	**17**	**2.91**	2.60	2.75	3.60	4	2	2	2	2	3	4	4	2	4	4
SNO2	**19**	**2.13**	1.80	2.30	2.30	2	2	1	2	2	4	2	3	2	2	3
SNO3	**16**	**3.18**	3.70	2.70	3.20	5	4	1	4	3	3	1	2	3	4	2
CCK1	**12**	**3.96**	3.60	4.05	4.30	4	4	2	5	3	4	4	4	3	5	4
CCK2	**9**	**3.56**	3.30	3.75	3.60	3	4	2	5	3	4	3	1	2	5	3
CCK3	**20**	**2.36**	1.30	3.00	2.80	2	1	1	3	3	3	3	1	3	3	3
LOT1	**15**	**3.26**	3.40	3.05	3.40	5	3	2	4	2	3	3	2	3	4	3
LOT2	**18**	**2.64**	3.10	2.70	1.90	3	4	1	4	3	3	1	2	4	1	2
NFT1	**7**	**3.14**	3.60	3.00	2.70	4	4	2	4	3	3	2	2	2	3	3
NFT2	**13**	**2.82**	2.60	2.95	2.90	3	3	1	3	4	3	2	1	2	4	2
NFT3	**8**	**3.07**	3.10	2.95	3.20	3	4	1	4	4	3	1	2	2	4	3
NFT4	**1**	**3.97**	4.30	3.90	3.60	4	5	3	5	3	3	4	2	5	4	2
TOK1	**11**	**2.93**	2.50	3.75	2.20	3	2	3	3	3	4	5	3	5	1	2
TOK2	**6**	**3.33**	2.90	3.15	4.20	4	3	1	4	3	4	2	3	3	5	4
TOK3	**3**	**3.76**	3.80	3.45	4.20	4	4	3	4	3	4	3	3	3	5	4
TOK4	**10**	**3.24**	3.10	2.70	4.30	4	3	2	3	3	3	2	4	3	5	4
NFK1	**5**	**3.34**	3.70	3.30	2.90	3	4	4	4	3	3	3	2	3	3	3
NFK2	**4**	**3.92**	4.50	3.60	3.60	5	4	5	3	3	3	5	2	5	4	2
NFK3	**14**	**2.94**	2.20	3.55	3.00	3	1	4	2	4	3	5	1	4	3	3
MFK1	**2**	**4.20**	4.70	4.20	3.50	4	5	5	5	3	3	5	1	5	4	2

SVWID Comprehensive Storage Study
Detailed Analysis of Highly Ranked Sites
Overall Summary of Analysis

Project ID	Overall Rank From Screening Analysis	Rank from Detailed Analysis	Description	Estimated Storage Volume (Acre-feet)	Maximum Water Surface Area (Acres)	From Detailed Analysis of 7 Sites		
						Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	**1**	**1**	Snoqualmie Timber - NF Tolt (C)	1,296	133.6	**3.69**	4.04	3.34
TOK3	**3**	**2**	Klaus Lake	121	70.2	**3.61**	3.95	3.27
MFK1	**2**	**3**	DNR - MF Snoq	3,311	173.8	**3.48**	3.68	3.28
TOK2	**6**	**4**	Bridges Lake	89	47.8	**3.45**	3.95	2.96
NFK2	**4**	**5**	Snoqualmie Timber - NF Snoq (B)	482	26.9	**3.40**	3.69	3.11
TOK4	**10**	**6**	Black Lake	76	40.7	**3.38**	3.81	2.96
CCK2	**9**	**7**	Cherry Lake	173	22.2	**3.32**	3.52	3.12

Appendix D
Landowner Coordination Notes

Meeting Notes

Coordination with Campbell Global – Snoqualmie Storage Study

Snoqualmie Comprehensive Storage Study

September 24. 2021, 10:00 AM

- Participants
  - Erin Ericson – SVWID Executive Director
  - David Rice – Anchor QEA, LLC
  - Mike March – Campbell Global, LLC (Property Manager for Snoqualmie Timber, LLC)
- Overview
  - Erin provided an Overview of the Comprehensive Storage Study work.
  - The project is being funded through a grant from Ecology's Streamflow Restoration Grant Program and includes screening potential storage sites and selecting a few for more detailed evaluation, including landowner coordination and site visits.
  - Five potential storage sites that are being pursued for more detailed evaluation as part of this study are on Snoqualmie Timber, LLC property:
    - Site NFT4 – This site is on a large tract of actively managed tree farm north of the North Fork Tolt River and would consist of constructing an off-channel reservoir.
    - Site NFK2 – This site is on land that appears to have been recently harvested north of the North Fork Snoqualmie River and would also consist of construction an off-channel reservoir.
    - Sites TOK2 (Bridges Lake), TOK3 (Klaus Lake), and TOK4 (Black Lake) – These are all existing lakes surrounded by forest managed for timber harvest. The concept would be to increase the water levels in each lake ~2 feet by constructing a small control structure at the outlet and manage that top 2 feet in each lake as water storage.
- Additional Discussion and Feedback from Campbell Global
  - Sites NFT4 and NFK2 would inundate relatively flat, productive tree farms that are actively managed for timber harvest.
  - They have limited actively managed timber harvest property that is as productive and accessible as these two sites.

- They would not be supportive of giving up productive timber harvest property and the revenue that the property generates to accommodate water storage.
- They are open to the idea of expanding existing lakes but are concerned about the buffer around each lake. The buffer would expand if the ordinary high-water level of the lake expands, which would result in loss of harvestable timber property.
- There would need to be compensation for future loss of timber revenues.
- Expressed concern about any of the projects rendering a parcel unusable or limiting tree harvest on the parcel.
- The is a monument at Black Lake memorializing a navy plane that went down in the lake that would need to be protected. The lake is relatively accessible and there is heavy recreational use at the lake.
- The outlets of Bridges Lake and Klaus Lake are less accessible.
- He would be open to taking SVWID and Anchor QEA on a site visit to visit Bridges Lake, Klaus Lake, and Black Lake.

- Next Steps
  - Time set up for a site visit on October 11, 2021 (meet at Safeway in Snoqualmie Ridge).

Meeting Notes

Coordination with DNR – Snoqualmie Storage Study

Snoqualmie Comprehensive Storage Study

October 19. 2021, 1:00 PM

- Participants
  - Erin Ericson – SVWID Executive Director
  - David Rice – Anchor QEA, LLC
  - Katie Woolsey – Washington Department of Natural Resources (DNR)
  - Lee Roach – Washington DNR
  - Paul Footen – Washington DNR
  - Daniel Eide – Washington DNR
- Overview
  - Erin provided an Overview of the Comprehensive Storage Study work.
  - The project is being funded through a grant from Ecology's Streamflow Restoration Grant Program and includes screening potential storage sites and selecting a few for more detailed evaluation, including landowner coordination and site visits.
  - Two potential storage sites that are being pursued for more detailed evaluation as part of this study are on DNR property:
    - Site MFK1 – This site is on a large tract of DNR timber land near the base of the ridge that extends east from Mount Si, south of the Middle Fork Snoqualmie River.
    - Site CCK2 – This site is located at Cherry Lake in the headwaters of the Cherry Creek Subbasin.
- Initial Questions and Concerns from DNR
  - Are the tribes and other resource managers involved in the study?
  - Lands in question are trust lands, used for timber harvest to generate revenue for the State of Washington that is primarily used for education.
  - Proposed water storage projects would reduce harvestable timber land.
  - Concerns about liability and potential damage to downstream roads, culverts, and property owned by others from releases, spilling, or potential failure of an impoundment.

- Concerns about impacts to fish. There goal is to remove fish blockages and not construct things that would impede fish migration.
- Land transactions require that trust be fairly compensated for loss of timber revenue.
- Land leases require that annual lease amount compensate for loss of timber revenue.
- MFK1 was owned by Weyerhaeuser and was acquired through the Forest Legacy Program.
- Lands acquired through that program may have deeds that restrict most uses beyond timber harvest/forestry.
- How would a storage project be managed for recreation? Are there liability issues with that?
- DNR has access via forest roads to the property where MFK1 is located, but some of the access passes through private property.

- Next Steps
  - Discussed potential for a site visit.
  - DNR will review, discuss with others on their end and get back to SVWID.

Meeting Notes

Coordination with DNR – Snoqualmie Storage Study

Snoqualmie Comprehensive Storage Study

November 12. 2021, 1:00 PM

- Participants
  - Erin Ericson – SVWID Executive Director
  - David Rice – Anchor QEA, LLC
  - Amanda Cronin – AMP Insights
  - Katie Woolsey – Washington Department of Natural Resources (DNR)
- Overview
  - This meeting was scheduled as a follow up to communication between DNR and SVWID and a prior meeting on October 10, 2021, regarding potential for water storage on DNR-managed properties in the Snoqualmie River Watershed.
  - Katie had communicated in an email that DNR was not supportive of water storage projects on their property because the projects would not be compatible with use of the properties for timber harvest and would limit their ability to meet their trust obligations on the properties in question.
- Additional Discussion and Feedback from DNR
  - Katie reiterated that DNR is not supportive of water storage on these properties because the projects would not be compatible with use of the properties for timber harvest and would limit their ability to meet their trust obligations on the properties in question.
  - The projects proposed are large projects and would have a big impact on DNR's ability to harvest timber and meet their trust obligations.
  - They are generally concerned about liability issues related to storage.
  - They do lease parcels but are concerned about losing forest area that is productive timber harvest land.
  - The properties in question generate revenue because they have large trees growing on them. Using the land for water storage would change that.
  - Removal of forest from the land would render the properties unusable to DNR, especially for the large reservoir proposed at Site MFK1. They would also be concerned about loss of

forest, timber harvest revenue, and increased buffers around the proposed reservoir a Site CCK2 (Cherry Lake).

- In their opinion, the Forest Legacy deeds for the property where Site MFK1 would be located, near the base of the ridge east of Mount Si, would not allow for use of the land for water storage. The Forest Legacy deeds are very restrictive.
- DNR does sell property, but the sell has to be for a fair market value that compensates for the loss of future timber revenue. They also are unlikely to sell parcels that can be harvested and are within large tracts of land managed for timber harvest by DNR. The two sites we have identified are within large tracts managed for timber harvest by DNR.

- Next Steps
  - Finish Comprehensive Storage Study report and share with DNR.

SITE VISIT NOTES AND PHOTOGRAPHS
SITE VISIT WITH CAMPBELL GLOBAL, LLC TO BLACK LAKE, BRIDGES LAKE, AND KLAUS LAKE
OCTOBER 11, 2021

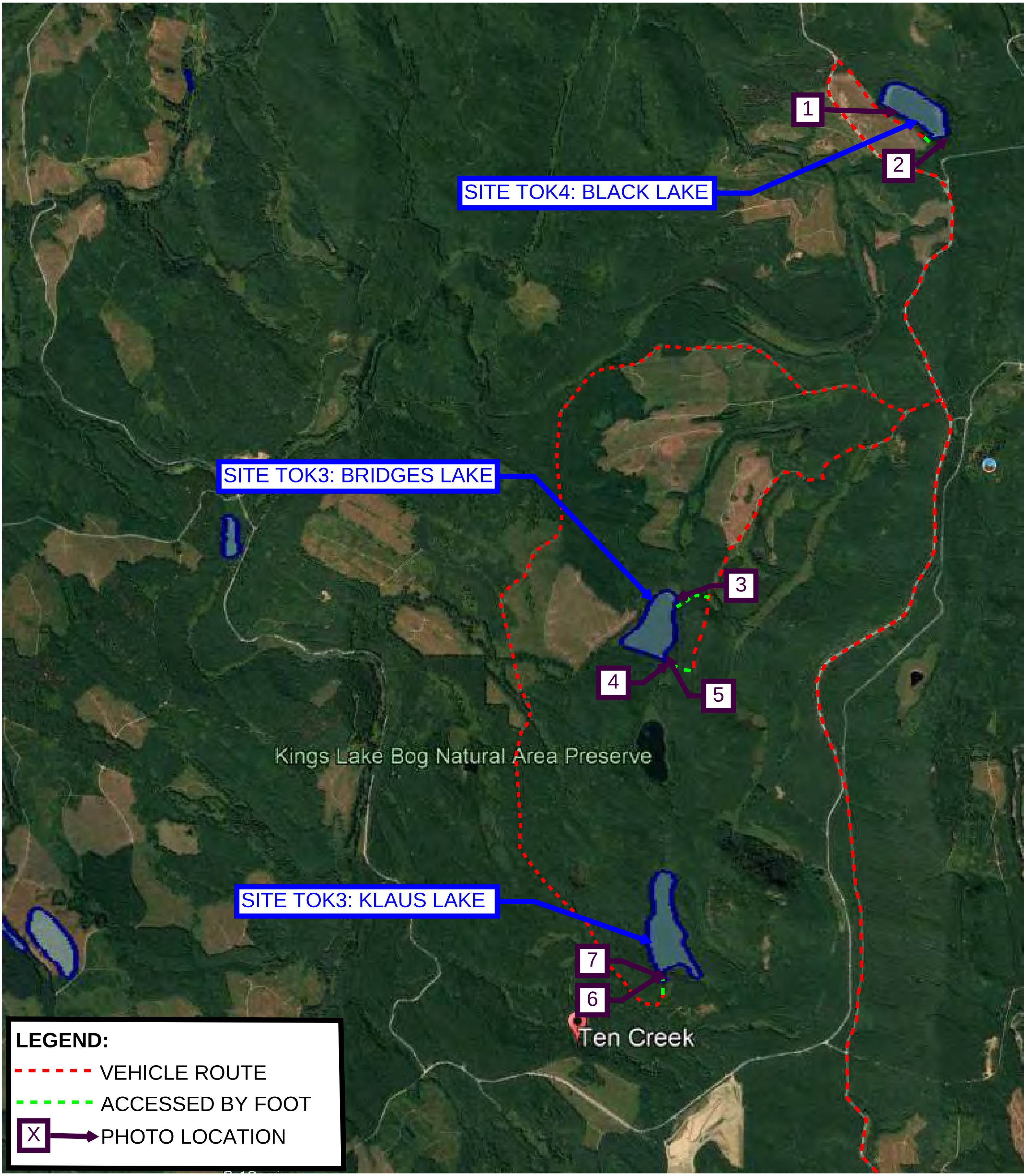


PHOTO 1 - BLACK LAKE LOOKING EAST FROM WEST SHORLINE

PHOTO 2 - BLACK LAKE OUTLET STREAM CHANNEL

PHOTO 3 - BRIDGES LAKE LOOKING SOUTHWEST FROM EAST SHORELINE

PHOTO 4 - BRIDGES LAKE OUTLET STREAM CHANNEL


PHOTO 5 - BRIDGES LAKE LOOKING NORTH FROM OUTLET


PHOTO 6 - KLAUS LAKE OUTLET LOOKING EAST FROM OUTLET


PHOTO 7 - KLAUS LAKE OUTLET

Appendix E
Opinions of Probable Cost

Table E-1
Opinion of Probable Costs for Potential Surface Water Storage Reservoir Projects - Screening Analysis
Snoqualmie Watershed Comprehensive Storage Study

			Storage Site SNO1		Storage Site SNO2		Storage Site SNO3		Storage Site CCK1		Storage Site CCK2		Storage Site CCK3		Storage Site LOT1		Storage Site LOT2	
ITEM	**UNIT**	**UNIT COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**
Site Work																		
Construction Surveying	LS	VARIES	1	$20,700	1	$16,200	1	$20,600	1	$58,400	1	$24,500	1	$8,800	1	$27,300	1	$22,300
Utilities Locate and Protection	LS	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000
Temporary & permanent access	LF	$12.00	1,200	$14,400	1,600	$19,200	1,100	$13,200	200	$2,400	800	$9,600	1,800	$21,600	1,700	$20,400	1,900	$22,800
Temporary Erosion and sediment control	AC	$4,000	20.7	$82,732	16.2	$64,715	20.5	$82,141	58.4	$233,500	24.4	$97,777	8.8	$35,151	27.2	$108,842	22.3	$89,169
Diversion and care of water	AC	$4,000	20.7	$82,732	16.2	$64,715	20.5	$82,141	58.4	$233,500	24.4	$97,777	8.8	$35,151	27.2	$108,842	22.3	$89,169
Clearing and grubbing (footprint)	AC	$5,000	3.1	$15,512	16.2	$80,894	20.5	$102,676	8.8	$43,781	24.4	$122,221	8.8	$43,939	27.2	$136,053	22.3	$111,461
Stripping/Stockpiling organic material	CY	$5.00	2,503	$12,513	13,051	$65,255	16,565	$82,825	7,063	$35,317	19,718	$98,591	7,089	$35,444	21,950	$109,749	17,982	$89,912
Revegetation	AC	$7,500	1.0	$7,756	0.8	$6,067	1.0	$7,701	2.9	$21,891	1.2	$9,167	0.4	$3,295	1.4	$10,204	1.1	$8,360
Subtotal - Site Work				**$238,300**		**$319,000**		**$393,300**		**$630,800**		**$461,600**		**$185,400**		**$523,400**		**$435,200**
Earthen Embankment																		
Foundation excavation and stockpile, soil	CY	$10.00	0	$0	1,890	$18,900	7,272	$72,722	0	$0	1,299	$12,989	918	$9,178	334	$3,344	14,513	$145,133
Foundation excavation and stockpile, rock	CY	$25.00	0	$0	810	$20,250	3,117	$77,917	0	$0	557	$13,917	393	$9,833	143	$3,583	6,220	$155,500
Foundation grouting allowance	SF	$10.00	0	$0	1,215	$12,150	4,675	$46,750	0	$0	835	$8,350	590	$5,900	215	$2,150	9,330	$93,300
Cutoff trench excavation and stockpile, soil	CY	$9.00	0	$0	497	$4,469	722	$6,500	0	$0	79	$713	160	$1,438	190	$1,706	1,532	$13,788
Toe and finger drains	LS	VARIES	0	$0	1	$2,500	1	$9,400	0	$0	1	$1,700	1	$1,200	1	$500	1	$18,700
Reservoir excavation (cut)	CY	$5.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Reservoir embankment (imported fill)	CY	$18.00	0	$0	68,631	$1,235,358	127,960	$2,303,280	0	$0	19,024	$342,432	23,456	$422,208	14,973	$269,514	260,580	$4,690,440
Reservoir embankment (fill with native material)	CY	$10.00	0	$0	3,197	$31,965	11,111	$111,111	0	$0	1,935	$19,347	1,471	$14,708	667	$6,674	22,265	$222,653
Disposal of excess cut material	CY	$6.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Reservoir Lining	SF	$1.15	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	886,606	$1,019,597
Dam crest surfacing	CY	$25.00	0	$0	265	$6,620	385	$9,630	0	$0	42	$1,056	85	$2,130	101	$2,528	817	$20,426
Subtotal - Earthen Embankment				**$0**		**$1,332,200**		**$2,637,300**		**$0**		**$400,500**		**$466,600**		**$290,000**		**$6,379,500**
Piping and Conveyance Facilities																		
New Intake and Diversion Facilities	LS	VARIES	0	$0	0	$0	1	$60,000	0	$0	0	$0	0	$0	0	$0	0	$0
Outlet Control Structure	LS	VARIES	1	$150,000	1	$40,000	1	$70,000	1	$200,000	1	$60,000	1	$60,000	1	$60,000	1	$60,000
Miscellaneous Gates and Control Equipment	LS	VARIES	1	$10,000	1	$10,000	1	$20,000	1	$20,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000
6-inch Water Supply or Low-level Outlet Pipeline	LF	$27.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
8-inch Water Supply or Low-level Outlet Pipeline	LF	$36.00	0	$0	0	$0	0	$0	0	$0	0	$0	150	$5,400	0	$0	0	$0
10-inch Water Supply or Low-level Outlet Pipeline	LF	$45.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
12-inch Water Supply or Low-level Outlet Pipeline	LF	$54.00	0	$0	130	$7,020	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
15-inch Water Supply or Low-level Outlet Pipeline	LF	$68.00	0	$0	0	$0	600	$40,800	0	$0	0	$0	0	$0	100	$6,800	0	$0
18-inch Water Supply or Low-level Outlet Pipeline	LF	$81.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
20-inch Water Supply or Low-level Outlet Pipeline	LF	$90.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	260	$23,400
24-inch Water Supply or Low-level Outlet Pipeline	LF	$108.00	0	$0	0	$0	150	$16,200	0	$0	230	$24,840	0	$0	0	$0	0	$0
30-inch Water Supply or Low-level Outlet Pipeline	LF	$135.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
36-inch Water Supply or Low-level Outlet Pipeline	LF	$162.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
48-inch Water Supply or Low-level Outlet Pipeline	LF	$216.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
60-inch Water Supply or Low-level Outlet Pipeline	LF	$270.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Subtotal - Piping and Convyance Facilities				**$160,000**		**$57,000**		**$207,000**		**$220,000**		**$94,800**		**$75,400**		**$76,800**		**$93,400**
Emergency Overflow Spillway																		
Spillway Structure and Conveyance	LS	VARIES	1	$20,000	1	$20,000	1	$50,000	1	$40,000	1	$50,000	1	$15,000	1	$25,000	1	$35,000
Subtotal - Emergency Overflow Spillway				**$20,000**		**$20,000**		**$50,000**		**$40,000**		**$50,000**		**$15,000**		**$25,000**		**$35,000**
Construction Subtotal				**$418,000**		**$1,728,000**		**$3,288,000**		**$891,000**		**$1,007,000**		**$742,000**		**$915,000**		**$6,943,000**
Mobilization / Demobilization	7.5%			$31,350		$129,600		$246,600		$66,825		$75,525		$55,650		$68,625		$520,725
Construction Total				**$449,000**		**$1,858,000**		**$3,535,000**		**$958,000**		**$1,083,000**		**$798,000**		**$984,000**		**$7,464,000**
Environmental Mitigation	10.0%			$44,900		$185,800		$353,500		$95,800		$108,300		$79,800		$98,400		$746,400
Contingency	30.0%			$134,700		$557,400		$1,060,500		$287,400		$324,900		$239,400		$295,200		$2,239,200
Engineering, Permitting and Administration	15.0%			$67,350		$278,700		$530,250		$143,700		$162,450		$119,700		$147,600		$1,119,600
Sales Tax	9.5%			$59,717		$247,114		$470,155		$127,414		$144,039		$106,134		$130,872		$992,712
Allowance for Land Acquisition	AC	$20,000	3.1	$62,049	17.0	$339,756	21.6	$431,238	8.8	$175,125	25.7	$513,328	9.2	$184,543	28.6	$571,421	23.4	$468,135
Total Project Cost				**$818,000**		**$3,467,000**		**$6,381,000**		**$1,787,000**		**$2,336,000**		**$1,528,000**		**$2,227,000**		**$13,030,000**
Maximum WSEL	**FT**			**151**		**252**		**615**		**810**		**987**		**908**		**542**		**500**
Total Storage Capacity	**AF**			**37.6**		**42.3**		**197.4**		**106.1**		**172.9**		**22.2**		**83.6**		**129.8**
Constant Flow Available (4-Week Low-Flow Period)	**CFS**			**0.68**		**0.76**		**3.55**		**1.91**		**3.11**		**0.40**		**1.51**		**2.34**
Total Project Unit Cost per AF	**$/AF**			**$21,752**		**$81,996**		**$32,330**		**$16,837**		**$13,509**		**$68,973**		**$26,636**		**$100,366**
Total Project Unit Cost per CFS for 4 Weeks	**$/CFS**			**$1,208,100**		**$4,553,800**		**$1,795,500**		**$935,100**		**$750,200**		**$3,830,600**		**$1,479,300**		**$5,574,000**

Table E-1
Opinion of Probable Costs for Potential Surface Water Storage Reservoir Projects - Screening Analysis
Snoqualmie Watershed Comprehensive Storage Study

			Storage Site NFT1		Storage Site NFT2		Storage Site NFT3		Storage Site NFT4		Storage Site TOK1		Storage Site TOK2		Storage Site TOK3		Storage Site TOK4	
ITEM	**UNIT**	**UNIT COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**
Site Work																		
Construction Surveying	LS	VARIES	1	$12,900	1	$8,500	1	$12,700	1	$153,700	1	$9,400	1	$55,000	1	$80,800	1	$46,800
Utilities Locate and Protection	LS	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000
Temporary & permanent access	LF	$12.00	1,000	$12,000	3,000	$36,000	1,500	$18,000	300	$3,600	1,000	$12,000	2,600	$31,200	1,300	$15,600	500	$6,000
Temporary Erosion and sediment control	AC	$4,000	12.8	$51,236	8.4	$33,728	12.7	$50,687	153.7	$614,711	9.4	$37,481	54.9	$219,726	80.7	$322,877	46.8	$187,044
Diversion and care of water	AC	$4,000	12.8	$51,236	8.4	$33,728	12.7	$50,687	153.7	$614,711	9.4	$37,481	54.9	$219,726	80.7	$322,877	46.8	$187,044
Clearing and grubbing (footprint)	AC	$5,000	12.8	$64,045	8.4	$42,160	12.7	$63,359	153.7	$768,389	9.4	$46,851	8.2	$41,199	12.1	$60,539	7.0	$35,071
Stripping/Stockpiling organic material	CY	$5.00	10,333	$51,663	6,802	$34,009	10,222	$51,110	123,967	$619,834	7,559	$37,793	6,647	$33,234	9,767	$48,835	5,658	$28,290
Revegetation	AC	$7,500	0.6	$4,803	0.4	$3,162	0.6	$4,752	7.7	$57,629	0.5	$3,514	2.7	$20,599	4.0	$30,270	2.3	$17,535
Subtotal - Site Work				**$249,900**		**$193,300**		**$253,300**		**$2,834,600**		**$186,500**		**$622,700**		**$883,800**		**$509,800**
Earthen Embankment																		
Foundation excavation and stockpile, soil	CY	$10.00	6,238	$62,378	2,131	$21,311	4,044	$40,444	58,333	$583,333	2,956	$29,556	0	$0	0	$0	0	$0
Foundation excavation and stockpile, rock	CY	$25.00	2,673	$66,833	913	$22,833	1,733	$43,333	25,000	$625,000	1,267	$31,667	0	$0	0	$0	0	$0
Foundation grouting allowance	SF	$10.00	4,010	$40,100	1,370	$13,700	2,600	$26,000	37,500	$375,000	1,900	$19,000	0	$0	0	$0	0	$0
Cutoff trench excavation and stockpile, soil	CY	$9.00	577	$5,194	253	$2,281	233	$2,094	4,715	$42,438	601	$5,406	0	$0	0	$0	0	$0
Toe and finger drains	LS	VARIES	1	$8,100	1	$2,800	1	$5,200	1	$75,000	1	$3,800	0	$0	0	$0	0	$0
Reservoir excavation (cut)	CY	$5.00	0	$0	0	$0	0	$0	304,150	$1,520,750	0	$0	0	$0	0	$0	0	$0
Reservoir embankment (imported fill)	CY	$18.00	125,692	$2,262,456	40,969	$737,442	60,522	$1,089,396	0	$0	84,633	$1,523,394	0	$0	0	$0	0	$0
Reservoir embankment (fill with native material)	CY	$10.00	9,488	$94,882	3,298	$32,979	6,010	$60,104	392,199	$3,921,986	4,823	$48,229	0	$0	0	$0	0	$0
Disposal of excess cut material	CY	$6.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Reservoir Lining	SF	$1.15	0	$0	0	$0	0	$0	6,112,101	$7,028,917	372,677	$428,578	0	$0	0	$0	0	$0
Dam crest surfacing	CY	$25.00	308	$7,694	135	$3,380	124	$3,102	2,515	$62,870	320	$8,009	0	$0	0	$0	0	$0
Subtotal - Earthen Embankment				**$2,547,600**		**$836,700**		**$1,269,700**		**$14,235,300**		**$2,097,600**		**$0**		**$0**		**$0**
Piping and Conveyance Facilities																		
New Intake and Diversion Facilities	LS	VARIES	1	$60,000	0	$0	0	$0	1	$150,000	1	$30,000	0	$0	0	$0	0	$0
Outlet Control Structure	LS	VARIES	1	$60,000	1	$60,000	1	$60,000	1	$60,000	1	$60,000	1	$200,000	1	$250,000	1	$200,000
Miscellaneous Gates and Control Equipment	LS	VARIES	1	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$20,000	1	$25,000	1	$20,000
6-inch Water Supply or Low-level Outlet Pipeline	LF	$27.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
8-inch Water Supply or Low-level Outlet Pipeline	LF	$36.00	0	$0	0	$0	0	$0	0	$0	600	$21,600	0	$0	0	$0	0	$0
10-inch Water Supply or Low-level Outlet Pipeline	LF	$45.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
12-inch Water Supply or Low-level Outlet Pipeline	LF	$54.00	250	$13,500	0	$0	0	$0	0	$0	150	$8,100	0	$0	0	$0	0	$0
15-inch Water Supply or Low-level Outlet Pipeline	LF	$68.00	0	$0	250	$17,000	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
18-inch Water Supply or Low-level Outlet Pipeline	LF	$81.00	160	$12,960	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
20-inch Water Supply or Low-level Outlet Pipeline	LF	$90.00	0	$0	0	$0	330	$29,700	0	$0	0	$0	0	$0	0	$0	0	$0
24-inch Water Supply or Low-level Outlet Pipeline	LF	$108.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
30-inch Water Supply or Low-level Outlet Pipeline	LF	$135.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
36-inch Water Supply or Low-level Outlet Pipeline	LF	$162.00	0	$0	0	$0	0	$0	1,500	$243,000	1,500	$243,000	0	$0	0	$0	0	$0
48-inch Water Supply or Low-level Outlet Pipeline	LF	$216.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
60-inch Water Supply or Low-level Outlet Pipeline	LF	$270.00	0	$0	0	$0	0	$0	1,000	$270,000	1,000	$270,000	0	$0	0	$0	0	$0
Subtotal - Piping and Convyance Facilities				**$156,500**		**$87,000**		**$99,700**		**$733,000**		**$642,700**		**$220,000**		**$275,000**		**$220,000**
Emergency Overflow Spillway																		
Spillway Structure and Conveyance	LS	VARIES	1	$35,000	1	$25,000	1	$35,000	1	$150,000	1	$15,000	1	$25,000	1	$30,000	1	$25,000
Subtotal - Emergency Overflow Spillway				**$35,000**		**$25,000**		**$35,000**		**$150,000**		**$15,000**		**$25,000**		**$30,000**		**$25,000**
Construction Subtotal				**$2,989,000**		**$1,142,000**		**$1,658,000**		**$17,953,000**		**$2,942,000**		**$868,000**		**$1,189,000**		**$755,000**
Mobilization / Demobilization	7.5%			$224,175		$85,650		$124,350		$1,346,475		$220,650		$65,100		$89,175		$56,625
Construction Total				**$3,213,000**		**$1,228,000**		**$1,782,000**		**$19,299,000**		**$3,163,000**		**$933,000**		**$1,278,000**		**$812,000**
Environmental Mitigation	10.0%			$321,300		$122,800		$178,200		$1,929,900		$316,300		$93,300		$127,800		$81,200
Contingency	30.0%			$963,900		$368,400		$534,600		$5,789,700		$948,900		$279,900		$383,400		$243,600
Engineering, Permitting and Administration	15.0%			$481,950		$184,200		$267,300		$2,894,850		$474,450		$139,950		$191,700		$121,800
Sales Tax	9.5%			$427,329		$163,324		$237,006		$2,566,767		$420,679		$124,089		$169,974		$107,996
Allowance for Land Acquisition	AC	$20,000	13.4	$268,991	8.9	$177,071	13.3	$266,109	161.4	$3,227,234	9.8	$196,776	8.2	$164,794	12.1	$242,157	7.0	$140,283
Total Project Cost				**$5,676,000**		**$2,244,000**		**$3,265,000**		**$35,707,000**		**$5,520,000**		**$1,735,000**		**$2,393,000**		**$1,507,000**
Maximum WSEL	**FT**			**808**		**1,503**		**1,179**		**1,808**		**730**		**1,061**		**991**		**1,222**
Total Storage Capacity	**AF**			**112.6**		**62.2**		**132.2**		**1,296.1**		**38.0**		**88.6**		**121.4**		**76.3**
Constant Flow Available (4-Week Low-Flow Period)	**CFS**			**2.03**		**1.12**		**2.38**		**23.34**		**0.68**		**1.59**		**2.19**		**1.37**
Total Project Unit Cost per AF	**$/AF**			**$50,408**		**$36,098**		**$24,701**		**$27,550**		**$145,175**		**$19,589**		**$19,711**		**$19,762**
Total Project Unit Cost per CFS for 4 Weeks	**$/CFS**			**$2,799,500**		**$2,004,800**		**$1,371,800**		**$1,530,100**		**$8,062,600**		**$1,087,900**		**$1,094,700**		**$1,097,500**

Table E-1
Opinion of Probable Costs for Potential Surface Water Storage Reservoir Projects - Screening Analysis
Snoqualmie Watershed Comprehensive Storage Study

			Storage Site NFK1		Storage Site NFK2		Storage Site NFK3		Storage Site MFK1	
ITEM	**UNIT**	**UNIT COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**
Site Work										
Construction Surveying	LS	VARIES	1	$54,400	1	$31,000	1	$7,000	1	$199,900
Utilities Locate and Protection	LS	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000
Temporary & permanent access	LF	$12.00	5,000	$60,000	3,000	$36,000	3,500	$42,000	2,000	$24,000
Temporary Erosion and sediment control	AC	$4,000	54.3	$217,386	31.0	$123,968	6.9	$27,647	199.9	$799,402
Diversion and care of water	AC	$4,000	54.3	$217,386	31.0	$123,968	6.9	$27,647	199.9	$799,402
Clearing and grubbing (footprint)	AC	$5,000	54.3	$271,732	31.0	$154,960	6.9	$34,559	199.9	$999,253
Stripping/Stockpiling organic material	CY	$5.00	43,839	$219,197	25,000	$125,001	5,575	$27,877	161,213	$806,064
Revegetation	AC	$7,500	2.7	$20,380	1.5	$11,622	0.3	$2,592	10.0	$74,944
Subtotal - Site Work				**$1,062,500**		**$608,500**		**$171,300**		**$3,705,000**
Earthen Embankment										
Foundation excavation and stockpile, soil	CY	$10.00	27,222	$272,222	38,889	$388,889	1,944	$19,444	155,556	$1,555,556
Foundation excavation and stockpile, rock	CY	$25.00	11,667	$291,667	16,667	$416,667	833	$20,833	66,667	$1,666,667
Foundation grouting allowance	SF	$10.00	17,500	$175,000	25,000	$250,000	1,250	$12,500	100,000	$1,000,000
Cutoff trench excavation and stockpile, soil	CY	$9.00	2,396	$21,563	1,792	$16,125	268	$2,413	5,063	$45,563
Toe and finger drains	LS	VARIES	1	$35,000	1	$50,000	1	$2,500	1	$200,000
Reservoir excavation (cut)	CY	$5.00	567,918	$2,839,590	416,692	$2,083,460	0	$0	2,590,500	$12,952,500
Reservoir embankment (imported fill)	CY	$18.00	0	$0	0	$0	41,728	$751,104	0	$0
Reservoir embankment (fill with native material)	CY	$10.00	609,203	$6,092,027	474,039	$4,740,392	3,046	$30,458	2,817,785	$28,177,847
Disposal of excess cut material	CY	$6.00	0	$0	0	$0	0	$0	0	$0
Reservoir Lining	SF	$1.15	2,161,475	$2,485,697	0	$0	0	$0	7,948,491	$9,140,764
Dam crest surfacing	CY	$25.00	1,278	$31,944	956	$23,889	143	$3,574	2,700	$67,500
Subtotal - Earthen Embankment				**$12,244,700**		**$7,969,400**		**$842,800**		**$54,806,400**
Piping and Conveyance Facilities										
New Intake and Diversion Facilities	LS	VARIES	1	$75,000	0	$0	0	$0	1	$300,000
Outlet Control Structure	LS	VARIES	1	$60,000	1	$60,000	1	$60,000	1	$60,000
Miscellaneous Gates and Control Equipment	LS	VARIES	1	$10,000	1	$10,000	1	$10,000	1	$10,000
6-inch Water Supply or Low-level Outlet Pipeline	LF	$27.00	0	$0	0	$0	0	$0	0	$0
8-inch Water Supply or Low-level Outlet Pipeline	LF	$36.00	0	$0	0	$0	0	$0	0	$0
10-inch Water Supply or Low-level Outlet Pipeline	LF	$45.00	0	$0	0	$0	10	$450	0	$0
12-inch Water Supply or Low-level Outlet Pipeline	LF	$54.00	0	$0	0	$0	0	$0	0	$0
15-inch Water Supply or Low-level Outlet Pipeline	LF	$68.00	0	$0	0	$0	0	$0	0	$0
18-inch Water Supply or Low-level Outlet Pipeline	LF	$81.00	0	$0	0	$0	0	$0	0	$0
20-inch Water Supply or Low-level Outlet Pipeline	LF	$90.00	0	$0	0	$0	0	$0	0	$0
24-inch Water Supply or Low-level Outlet Pipeline	LF	$108.00	600	$64,800	0	$0	0	$0	0	$0
30-inch Water Supply or Low-level Outlet Pipeline	LF	$135.00	0	$0	0	$0	0	$0	0	$0
36-inch Water Supply or Low-level Outlet Pipeline	LF	$162.00	320	$51,840	240	$38,880	0	$0	0	$0
48-inch Water Supply or Low-level Outlet Pipeline	LF	$216.00	0	$0	0	$0	0	$0	0	$0
60-inch Water Supply or Low-level Outlet Pipeline	LF	$270.00	0	$0	0	$0	0	$0	2,400	$648,000
Subtotal - Piping and Convyance Facilities				**$261,600**		**$108,900**		**$70,500**		**$1,018,000**
Emergency Overflow Spillway										
Spillway Structure and Conveyance	LS	VARIES	1	$100,000	1	$100,000	1	$15,000	1	$300,000
Subtotal - Emergency Overflow Spillway				**$100,000**		**$100,000**		**$15,000**		**$300,000**
Construction Subtotal				**$13,669,000**		**$8,787,000**		**$1,100,000**		**$59,829,000**
Mobilization / Demobilization	7.5%			$1,025,175		$659,025		$82,500		$4,487,175
Construction Total				**$14,694,000**		**$9,446,000**		**$1,183,000**		**$64,316,000**
Environmental Mitigation	10.0%			$1,469,400		$944,600		$118,300		$6,431,600
Contingency	30.0%			$4,408,200		$2,833,800		$354,900		$19,294,800
Engineering, Permitting and Administration	15.0%			$2,204,100		$1,416,900		$177,450		$9,647,400
Sales Tax	9.5%			$1,954,302		$1,256,318		$157,339		$8,554,028
Allowance for Land Acquisition	AC	$20,000	57.1	$1,141,275	32.5	$650,831	7.3	$145,147	209.8	$4,196,861
Total Project Cost				**$25,871,000**		**$16,548,000**		**$2,136,000**		**$112,441,000**
Maximum WSEL	**FT**			**1,263**		**1,600**		**2,403**		**1,640**
Total Storage Capacity	**AF**			**448.9**		**481.8**		**29.0**		**3,310.9**
Constant Flow Available (4-Week Low-Flow Period)	**CFS**			**8.08**		**8.68**		**0.52**		**59.62**
Total Project Unit Cost per AF	**$/AF**			**$57,636**		**$34,344**		**$73,765**		**$33,961**
Total Project Unit Cost per CFS for 4 Weeks	**$/CFS**			**$3,201,000**		**$1,907,400**		**$4,096,700**		**$1,886,100**

Table E-2
Opinion of Probable Costs for Potential Surface Water Storage Reservoir Projects - Detailed Evaluation of Highly Ranked Projects
Snoqualmie Watershed Comprehensive Storage Study

			Storage Site CCK2		Storage Site NFT4		Storage Site TOK2		Storage Site TOK3		Storage Site TOK4		Storage Site NFK2		Storage Site MFK1	
ITEM	**UNIT**	**UNIT COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**
Site Work																
Construction Surveying	LS	VARIES	1	$29,400	1	$184,500	1	$66,000	1	$96,900	1	$56,200	1	$37,200	1	$239,900
Utilities Locate and Protection	LS	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000	1	$2,000
Temporary & permanent access	LF	$15.00	800	$12,000	300	$4,500	2,600	$39,000	1,300	$19,500	500	$7,500	3,000	$45,000	2,000	$30,000
Temporary Erosion and sediment control	AC	$5,000	24.4	$122,221	153.7	$768,389	54.9	$274,657	80.7	$403,596	46.8	$233,805	31.0	$154,960	199.9	$999,253
Diversion and care of water	AC	$5,000	24.4	$122,221	153.7	$768,389	54.9	$274,657	80.7	$403,596	46.8	$233,805	31.0	$154,960	199.9	$999,253
Clearing and grubbing (footprint)	AC	$6,000	24.4	$146,665	153.7	$922,067	8.2	$49,438	12.1	$72,647	7.0	$42,085	31.0	$185,952	199.9	$1,199,103
Stripping/Stockpiling organic material	CY	$6.50	19,718	$128,169	123,967	$805,784	6,647	$43,204	9,767	$63,486	5,658	$36,778	25,000	$162,501	161,213	$1,047,883
Revegetation	AC	$7,500	1.2	$9,167	7.7	$57,629	2.7	$20,599	4.0	$30,270	2.3	$17,535	1.5	$11,622	10.0	$74,944
Subtotal - Site Work				**$571,800**		**$3,513,300**		**$769,600**		**$1,092,000**		**$629,700**		**$754,200**		**$4,592,300**
Earthen Embankment																
Foundation excavation and stockpile, soil	CY	$10.00	1,299	$12,989	58,333	$583,333	0	$0	0	$0	0	$0	38,889	$388,889	155,556	$1,555,556
Foundation excavation and stockpile, rock	CY	$25.00	557	$13,917	25,000	$625,000	0	$0	0	$0	0	$0	16,667	$416,667	66,667	$1,666,667
Foundation grouting allowance	SF	$12.00	835	$10,020	37,500	$450,000	0	$0	0	$0	0	$0	25,000	$300,000	100,000	$1,200,000
Cutoff trench excavation and stockpile, soil	CY	$10.00	79	$792	4,715	$47,153	0	$0	0	$0	0	$0	1,792	$17,917	5,063	$50,625
Toe and finger drains	LS	VARIES	1	$1,700	1	$75,000	0	$0	0	$0	0	$0	1	$50,000	1	$200,000
Reservoir excavation (cut)	CY	$6.50	0	$0	304,150	$1,976,975	0	$0	0	$0	0	$0	416,692	$2,708,498	2,590,500	$16,838,250
Reservoir embankment (imported fill)	CY	$20.00	19,024	$380,480	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Reservoir embankment (fill with native material)	CY	$10.00	1,935	$19,347	392,199	$3,921,986	0	$0	0	$0	0	$0	474,039	$4,740,392	2,817,785	$28,177,847
Disposal of excess cut material	CY	$6.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Reservoir Lining	SF	$1.35	0	$0	6,112,101	$8,251,337	0	$0	0	$0	0	$0	0	$0	7,948,491	$10,730,462
Dam crest surfacing	CY	$32.00	42	$1,351	2,515	$80,474	0	$0	0	$0	0	$0	956	$30,578	2,700	$86,400
Subtotal - Earthen Embankment				**$440,600**		**$16,011,300**		**$0**		**$0**		**$0**		**$8,652,900**		**$60,505,800**
Piping and Conveyance Facilities																
New Intake and Diversion Facilities	LS	VARIES	0	$0	1	$170,000	0	$0	0	$0	0	$0	0	$0	1	$330,000
Outlet Control Structure	LS	VARIES	1	$75,000	1	$75,000	1	$220,000	1	$300,000	1	$220,000	1	$75,000	1	$75,000
Miscellaneous Gates and Control Equipment	LS	VARIES	1	$12,000	1	$12,000	1	$24,000	1	$30,000	1	$24,000	1	$12,000	1	$12,000
24-inch Water Supply or Low-level Outlet Pipeline	LF	$130.00	230	$29,900	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
30-inch Water Supply or Low-level Outlet Pipeline	LF	$162.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
36-inch Water Supply or Low-level Outlet Pipeline	LF	$195.00	0	$0	1,500	$292,500	0	$0	0	$0	0	$0	240	$46,800	0	$0
48-inch Water Supply or Low-level Outlet Pipeline	LF	$260.00	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
60-inch Water Supply or Low-level Outlet Pipeline	LF	$324.00	0	$0	1,000	$324,000	0	$0	0	$0	0	$0	0	$0	2,400	$777,600
Subtotal - Piping and Convyance Facilities				**$116,900**		**$873,500**		**$244,000**		**$330,000**		**$244,000**		**$133,800**		**$1,194,600**
Emergency Overflow Spillway																
Spillway Structure and Conveyance	LS	VARIES	1	$60,000	1	$180,000	1	$30,000	1	$36,000	1	$30,000	1	$120,000	1	$360,000
Subtotal - Emergency Overflow Spillway				**$60,000**		**$180,000**		**$30,000**		**$36,000**		**$30,000**		**$120,000**		**$360,000**
Construction Subtotal				**$1,189,000**		**$20,578,000**		**$1,044,000**		**$1,458,000**		**$904,000**		**$9,661,000**		**$66,653,000**
Mobilization / Demobilization	7.5%			$89,175		$1,543,350		$78,300		$109,350		$67,800		$724,575		$4,998,975
Construction Total				**$1,278,000**		**$22,121,000**		**$1,122,000**		**$1,567,000**		**$972,000**		**$10,386,000**		**$71,652,000**
Environmental Mitigation	10.0%			$127,800		$2,212,100		$112,200		$156,700		$97,200		$1,038,600		$7,165,200
Contingency	30.0%			$383,400		$6,636,300		$336,600		$470,100		$291,600		$3,115,800		$21,495,600
Engineering, Permitting and Administration	15.0%			$191,700		$3,318,150		$168,300		$235,050		$145,800		$1,557,900		$10,747,800
Sales Tax	9.5%			$169,974		$2,942,093		$149,226		$208,411		$129,276		$1,381,338		$9,529,716
Allowance for Land Acquisition	AC	$20,000	25.7	$513,328	161.4	$3,227,234	8.2	$164,794	12.1	$242,157	7.0	$140,283	32.5	$650,831	209.8	$4,196,861
Total Project Cost				**$2,664,000**		**$40,457,000**		**$2,053,000**		**$2,879,000**		**$1,776,000**		**$18,130,000**		**$124,787,000**
Maximum WSEL	**FT**			**987**		**1,808**		**1,061**		**991**		**1,222**		**1,600**		**1,640**
Targeted Storage Capacity	**AF**			**173**		**1,296**		**89**		**121**		**76**		**482**		**3,311**
Average Annual Inflow from Water Balance Model	**AF**			**139**		**924**		**229**		**532**		**229**		**205**		**1,218**
Targeted Release Rate from Water Balance Model	**CFS**			**2.0**		**12.0**		**0.6**		**0.8**		**0.6**		**4.0**		**14.0**
Average Number of Release Days	**Days**			**14.7**		**26.1**		**7.8**		**9.6**		**7.9**		**19.2**		**29.5**
Total Project Unit Cost per AF of Storage	**$/AF**			**$15,405**		**$31,215**		**$23,179**		**$23,715**		**$23,290**		**$37,627**		**$37,690**
Total Project Unit Cost per CFS of Release	**$/CFS**			**$1,332,000**		**$3,371,400**		**$3,421,700**		**$3,598,800**		**$2,960,000**		**$4,532,500**		**$8,913,400**

Table E-3

Opinion of Probable Annual Operations and Maintenance Costs for Potential Surface Water Storage Reservoir Projects - Detailed Evaluation of Highly Ranked Sites

Snoqualmie Watershed Comprehensive Storage Study

			Storage Site CCK2		Storage Site NFT4		Storage Site TOK2		Storage Site TOK3		Storage Site TOK4		Storage Site NFK2		Storage Site MFK1	
ITEM	**UNIT**	**UNIT COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**	**QTY**	**COST**
Salaries	FTE	$80,000	0.20	$16,000	0.25	$20,000	0.13	$10,000	0.13	$10,000	0.13	$10,000	0.25	$20,000	1.00	$80,000
Benefits	FTE	$32,000	0.20	$6,400	0.25	$8,000	0.13	$4,000	0.13	$4,000	0.13	$4,000	0.25	$8,000	1.00	$32,000
Administration	LS	VARIES	1	$1,600	1	$2,000	1	$1,000	1	$1,000	1	$1,000	1	$2,000	1	$8,000
Transportation	MILES	$1.00	1,600	$1,600	2,000	$2,000	1,000	$1,000	1,000	$1,000	1,000	$1,000	2,000	$2,000	4,000	$4,000
Supplies	LS	VARIES	1	$1,300	1	$22,200	1	$1,200	1	$1,600	1	$1,000	1	$10,400	1	$71,700
Maintenance and Repairs	LS	VARIES	1	$1,300	1	$22,200	1	$1,200	1	$1,600	1	$1,000	1	$10,400	1	$71,700
Contracted Labor	LS	VARIES	1	$1,300	1	$22,200	1	$1,200	1	$1,600	1	$1,000	1	$10,400	1	$71,700
Total Operations and Maintenance				**$29,500**		**$98,600**		**$19,600**		**$20,800**		**$19,000**		**$63,200**		**$339,100**

Appendix F
Land Use Memorandum

TECHNICAL MEMORANDUM

To: David Rice, AnchorQE and Erin Ericson, Snoqualmie Valley Watershed Improvement District
From: Amanda Cronin and Andrew Purkey, AMP Insights
Date: December 28, 2021
Subject: Land acquisition considerations for potential water storage projects in the Snoqualmie Watershed

1. Introduction

This memo complements AnchorQEA's Comprehensive Storage Study for the Snoqualmie Valley Watershed Improvement District which systemically assesses and screens parcels throughout the watershed for their suitability as water storage facilities to provide additional water supply to irrigated agriculture and benefit streamflows in the Snoqualmie River watershed. The storage study narrowed down a preliminary list of 26 potential storage sites to 20 that received additional screening analysis. The screening analysis further winnowed the list to 7 highly ranked sites which were given additional consideration. Table 1 includes a list of these potential storage sites.

Table 1. List of highly ranked storage sites with highest ranking sites highlighted in blue

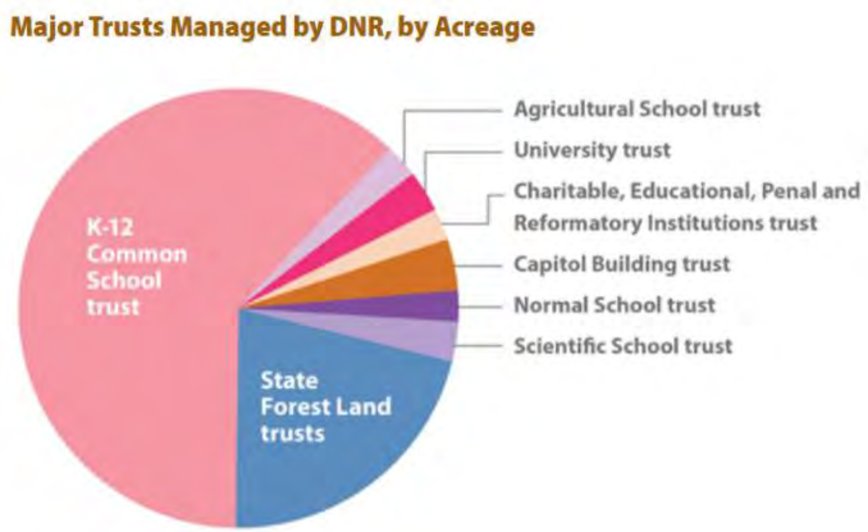
Project ID	Rank	Description	Total Score	Overall Score from GIS Weighted Overlay Analysis	Overall Score from Site-Specific Analysis
NFT4	1	Snoqualmie Timber - NF Tolt (C)	4.00	4.04	3.97
MFK1	2	DNR - MF Snoq	3.94	3.68	4.20
TOK3	3	Klaus Lake	3.85	3.95	3.76
NFK2	4	Snoqualmie Timber - NF Snoq (B)	3.80	3.69	3.92
NFK1	5	Snoqualmie Timber - NF Snoq (A)	3.65	3.96	3.34
TOK2	6	Bridges Lake	3.64	3.95	3.33
NFT1	7	DNR - NF Tolt (B)	3.59	4.05	3.14
NFT3	8	DNR - NF Tolt (D)	3.56	4.05	3.07
CCK2	9	Cherry Lake	3.54	3.52	3.56
TOK4	10	Black Lake	3.52	3.81	3.24
TOK1	11	Snoqualmie Timber - Tokul	3.42	3.91	2.93
CCK1	12	Lake Margaret	3.40	2.84	3.96
NFT2	13	Snoqualmie Timber - NF Tolt (A)	3.38	3.95	2.82
NFK3	14	Snoqualmie Timber - NF Snoq (D)	3.37	3.80	2.94
LOT1	15	Snoqualmie Timber - Tolt (A)	3.33	3.41	3.26
SNO3	16	Twin Peaks Timber - Snoq	3.25	3.33	3.18
SNO1	17	Loutsis Lake	3.24	3.57	2.91
LOT2	18	Snoqualmie Timber - Tolt (B)	2.97	3.29	2.64
SNO2	19	Nelson Pond	2.79	3.45	2.13
CCK3	20	Upper Margaret Creek	2.63	2.91	2.36

The sites are located in the upper forested tributary reaches of the Snoqualmie River watershed (Cherry Creek, North Fork Tolt, Tokul Creek, North Fork Snoqualmie, Tate Creek and Middle Fork of the Snoqualmie). The sites vary based on a number of factors, including land ownership, potential storage capacity, and the presence of existing storage at the site in the form of wetlands or lakes/ponds. Some of the preliminary site designs include dams to raise the existing level of a lake, while others require construction of off-channel reservoirs or on-channel impoundments at the upper ends of tributaries. Each of these site characteristics brings a unique set of potential land use considerations and issues which are explored in more depth in this memo. The memo is organized into three sections focused on Washington State Department of Natural Resources owned lands, US forest service owned lands, and privately owned lands held by Snoqualmie Timber/Campbell Global. A short concluding section wraps up the memo.

2. Considerations for sites located on Department of Natural Resources Land

Washington State Department of Natural Resources (DNR) manages roughly 5.6 million acres of state lands. DNR's managed lands fall into three primary categories; state trust lands, state owned aquatic lands, and state natural areas. State Trust lands represent about 3 million acres in Washington and are managed to generate revenue for specific beneficiaries (Figure 1). The majority of state trust lands are considered common school trust and are managed to provide revenue for school construction projects across Washington State.

Figure 1. Distribution of DNR State Trust Lands



While there are many compatible uses of DNR managed lands the management directive to generate funding for the beneficiaries is the agency's guiding objective. However, DNR does have three mechanisms by which their state trust lands can be reclassified or transferred to other uses. These mechanisms are described below.

2.1 DNR Trust Land Transfer

The Trust Land Transfer program was established in 1989 to provide a mechanism to transfer DNR owned lands that possess significant cultural or social value to other public agencies **(WA DNR 2021)**. The program is legislatively funded and funding from the land value is used by DNR to acquire replacement lands while the value of the timber is directly invested into the common school account. DNR leads the development of sites to be considered for the Trust Land Transfer program developing a list of recommendations to the legislature on a biennial basis. The legislature considers DNR's proposed list of lands and agrees on an appropriation amount and the package for land transfers is funded under the capital budget. Each transfer must be approved by the Board of Natural Resources and DNR endeavors to complete the transfers within the biennium after they are approved.

The 2019-2021Trust Land Transfer list included two potential sites with relevance to the Snoqualmie Storage Site Assessment-a site in the Dungeness watershed that will be used to build a storage reservoir and a site on the Middle Fork of the Snoqualmie. In the Dungeness watershed a DNR parcel on River Road South of Sequim will be transferred to Clallam County. The River Road project will include building an off-channel reservoir for storing water during the high flow period which will be used for irrigation in lieu of diversion of Dungeness River water in the late summer when streamflows are lowest and salmon are returning to spawn. The project will also include the creation of a new county park and aquifer recharge facilities and will result in decreased flooding risk and improved stormwater management for the City of Sequim.

The Middle Fork of the Snoqualmie Trust Land Transfer parcel incudes prime forest and riparian habitat and is located south of the MFK1 site and south of the Snoqualmie River. The 26-acre site is within the Middle Fork of the Snoqualmie Natural Conservation Area (SRCA). It was transferred to King County in 2020 to benefit fish, wildlife, and recreation. The legislature provided $140,000 in funding to DNR to compensate for lost timber revenue and support for purchasing a replacement property.

The project team met with DNR staff to discuss their interest in cooperating on a potential reservoir project located on DNR lands and agency staff identified a number of concerns. The Middle Fork parcel was previously owned by Weyerhauser and there were plans to develop a gravel pit on site which did not materialize. DNR noted that the Middle Fork parcel is in an area of heavy recreation use given its proximity to the SRCA and expressed concerns about liability resulting from a storage project. DNR also expressed concern about the loss of timber harvest revenue to meet state trust responsibilities.

2.2 DNR Land Exchanges

DNR may also enter into mutually beneficial land exchanges with a private or public party. To be considered for a land exchange the lands being exchanged to DNR must also provide revenue to meet State Trust responsibilities. One example of a DNR land exchange was the Dabob Bay Inter-Trust Exchange (located on the Olympic Peninsula) in which DNR is exchanging several parcels with high ecological value for State Forest Land for equal valued “Common School Trust” forest land in the same geographic area.

2.3 DNR Land Transactions

A third type of land transaction is the sale of state trust lands by public agencies with the proceeds used to purchase replacement properties to maintain revenue generating opportunities for DNR. Candidates for land transactions may be DNR lands with high conservation values that are transferred to others public entities. The River Road parcel (future site of the Dungeness Off-Channel Reservoir) in Sequim may ultimately be acquired by Clallam County via this process rather than the Trust Land Transfer Program.

2.4 DNR Land Leases

DNR has an active leasing program for its aquatic lands including leases for aquaculture, research, monitoring and public utilities. The agency also enters into leases of lands for agricultural purposes (total of 1 million acres) including grazing, and dry and irrigated agriculture leases and lease for communication sites, mining and mineral exploration and energy production and other commercial uses. DNR maintains a list and map of current agricultural lease opportunities all of which are currently east of the Cascades.

There are a handful of opportunities for grazing on forested lands and agricultural use on non-forested agricultural lands. However, leases on forest land west of the cascades do not appear to be available and uncommon. Any analogous examples in which DNR entered into a long-term lease to build a structure and thus convert forest land to a new use were unavailable.

2.5 Overall Considerations for DNR Sites

Both the Middle Fork Snoqualmie site (MFK1) and Cherry creek site (CCK2) are also on DNR land which is classified as State Trust Land in Common School. In a video conference Katie Woolsey with DNR noted that the Cherry Creek DNR land is part of the Forest Legacy area (Woolsey 2021) (it appears that the MFK1 Site may also be within the Forest Legacy Area but confirmation with DNR is needed). The Forest Legacy Fund is a federally funded grant program, administered by DNR, designed to protect working forest lands particularly those that are at risk of being developed in perpetuity (Department of Natural Resources 2004). Under the Forest legacy program, the USDA requires each participating state to prepare an Assessment of Need. DNR's 2004 assessment of need which was reaffirmed in 2017 established a priority area for the Forest Legacy Fund which includes much of DNR's land through the King County Puget Sound region. Katie Woolsey observed that the Forest Legacy program does not support development of humanmade structures on Forest Legacy lands or conversion from non-forested uses. While the Cherry Creek Lake area is owned by DNR it does not appear to have been acquired via the Forest Legacy grant program however it is included as a Priority Area A by DNR under the greater Forest Legacy Fund Program.

3. Considerations for Sites Located on US Forest Service (USFS) Land

While none of the 7 highly ranked storage sites are located on US Forest Service Land it is worth a brief consideration of the opportunity (and challenges) for working with USFS. Under federal policy, entities other than the Forest Service cannot construct wells and pipelines (water developments) on National Forest System (NFS) lands without Forest Service authorization through a Special Use Permit.

A special-use authorization is a legal document such as a permit, lease, or easement, which allows occupancy, use, rights, or privileges of agency land. The authorization is granted for a specific use of the land for a specific period of time. The Agency's special-uses program authorizes uses on NFS land that provide a benefit to the general public and protect public and natural resources values. Currently there are over 74,000 authorizations on the NFS lands for over 180 types of uses.

Each year, the Forest Service receives thousands of individual and business applications for authorization for use of NFS land for such activities as water transmission, agriculture, outfitting and guiding, recreation, telecommunication, research, photography and video productions, and granting road and utility rights-of-ways. The Forest Service carefully reviews each application to determine how the request affects the public's use of NFS land. Normally, NFS land is not made available if the overall needs of the individual or business can be met on nonfederal lands. (USFS, n.d.)

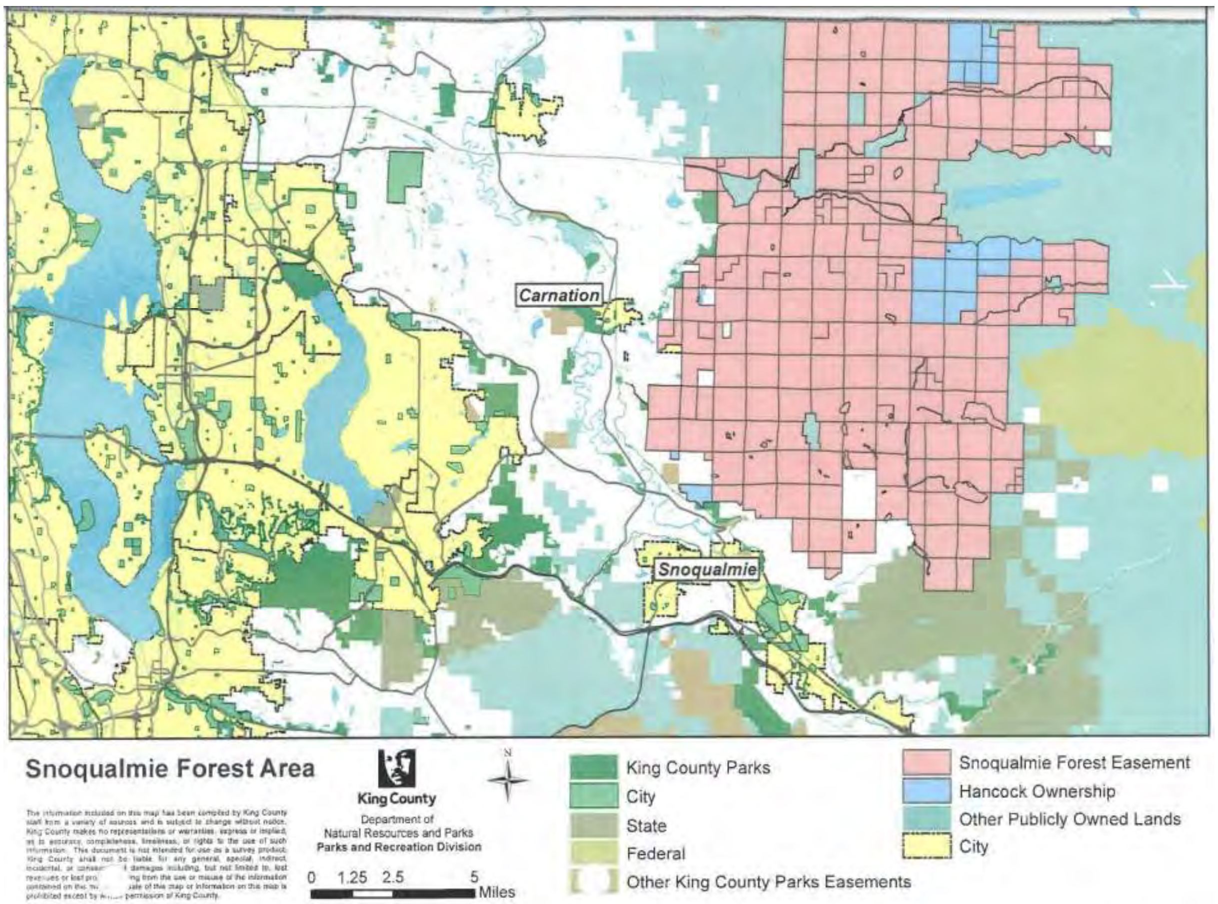
Special Use authorizations for water development projects on NFS lands can be approved only when the long-term protection of NFS streams, springs, seeps, and associated riparian and aquatic ecosystems can be assured. Legislation passed by Congress in 1986 (Public Law 99-545) amended the Federal Land Policy and Management Act of 1976 in order to authorize the Secretary of Agriculture to issue permanent conservation easements for existing water systems (defined as reservoirs, canals, ditches, flumes, laterals, pipes, pipelines, tunnels, and other facilities and systems for the impoundment, storage, transportation, or distribution of water. Under the statute, the Secretary of Agriculture was authorized to "issue a permanent easement…for a water system…traversing Federal lands within the National Forest System, constructed and in operation or placed into operation prior to October 21, 1976.” The statute also states that “any future extension or enlargement of facilities after October 21, 1976, shall require the issuance of a separate authorization”. (United States Congress, n.d.) Such authorization to expand an existing facility would presumably occur through the Forest Service’s special use permitting process. Additional research is needed to determine if there is an existing storage facility in the Snoqualmie National Forest that could be expanded to store water for use by SVWID. If so, this could potentially be a viable option. Otherwise, it is unlikely that a special use permit for a new facility could be obtained given the opportunities to develop such a facility on nonfederal lands.

4. Consideration for Privately Owned Sites (Snoqualmie Timber/Campbell Global)

4.1 Options for Aquisition

Snoqualmie Timber, LLC, owns the Snoqualmie Forest, the location of five of the seven highly ranked sites in AnchorQEA’s Comprehensive Storage Study (2021). Snoqualmie Timber is a subsidiary of Campbell Global, based in Portland, OR. Campbell Global was recently acquired by JP Morgan, the multinational financial services company. King County purchased a $22 million conservation easement from previous owner Hancock Timber Resources Group in 2004, in a deal negotiated by the Cascade Land Conservancy. The easement, which is in perpetuity, protected the approximately 90,000 acre Snoqualmie Forest, a contiguous chunk of land east of Carnation and north of Snoqualmie, from being subdivided and sold off to developers (Kunkler 2019).

Figure 2. Snoqualmie Forest Easement-owned by Snoqualmie Timber, Easement held by King County



The county's easement preserves the property as a working forest, meaning Campbell Global and any subsequent landowner can only generate revenue from timber harvest and payment received for other qualified land management activities. King County is authorized to monitor compliance with the easement on an annual basis. (Kunkler 2019)

Public use of the Snoqualmie Forest is only allowed by private permit or fee. In order to provide better public access between Moss Lake and the Marckworth State Forest via the Tolt Pipeline Trail, King County has prioritized fee simple acquisition of up to 1,435 acres of the Snoqualmie Forest from Campbell Global. Per a March 6, 2019 application for 2020 funding under the King County Conservation Futures tax levy, King County was engaging with Campbell Global staff on a limited basis and the company had agreed to appraise the parcel and consider an offer (Kelly Heintz 2019).

These recent negotiations with King County indicate a willingness by Campbell Global to consider selling small parcels of the Snoqualmie Forest. Presumably any sale would have to result in Campbell Global recouping the revenue it could generate from timber management on the parcel, representing a lower rate of return relative to the potential development of the parcel in the absence of the conservation easement. Such a sale would likely be consistent with one of Campbell Global's stated goals of "optimizing alternative revenue sources (CampbellGlobal, n.d.)."

Campbell Global's social impact statement would seem to indicate an openness to addressing the needs of downstream family farmers and the ecological needs of the watershed. It states: "Our Company serves others. We serve our clients, our employees, and the communities where we live" (CampbellGlobal, n.d.).

Campbell Global has also demonstrated a conservation ethic, particularly through its active engagement with the Flagstaff Watershed Protection Project and the Four Forest Restoration Initiative in Northern Arizona. Demonstrating instream flow and other ecological benefits resulting from the siting of an off-channel reservoir could encourage Campbell Global's willingness to negotiate either sale or lease of a storage site for acquisition and use by SVWID.

An outright purchase of land from Campbell Global would presumably mean that the new site owner would have to comply with the terms of the conservation easement held by King County to protect the Snoqualmie Forest. A long-term site lease would presumably subject both Campbell Global and the lessee to the easement. At a minimum, the terms of the lease and site development agreement would need to comply with King County's management objectives and requirements detailed in the easement.

The King County easement is broadly understood to prevent subdivision and development of the roughly 90,000-acre parcel but the specific terms would need to be reviewed and understood, in particular any that could limit expansion of existing waterbodies or development of new storage. During initial conversations with SVWID, Campbell Global has raised concerns regarding substantial site clearing of productive timber land, reservoir construction and access issues, and site and downstream liability from the new or expanded water storage.

For example, while the NF Tolt (C) site can be accessed via forest and logging roads, construction of the reservoir would require a significant logging and clearing effort of a very timbered parcel as well as a massive amount of earthwork. The TOK2 site would increase storage at an existing lake, reducing the amount of timber available for harvest. In addition, improving access to the lake outlet for management of storage releases, increases Campbell Global's liability concerns. While these and other issues may or may not result from the specific terms of the King County easement, each would need to be addressed under any future negotiations with Campbell Global for lease or purchase of one of their sites to be viable for a storage project.

5. Conclusions

This memo has detailed some considerations for the various classes of land ownership under consideration for potential storage sites. As expected, there is not a straightforward path toward working with any of these large public or private landowners. As initial interviews with land managers suggest, the chief concerns among both private and public timber managers associated with potential water storage facilities constructed on their land include, loss of timber harvest potential, negative impact to adjacent timber lands, liability concerns due to increased access and downstream flooding potential. Furthermore, the timber revenue associated with these lands as well as restrictions related to maintaining them in working forest lands status make acquisition of both privately and publicly held lands challenging.

Initial conversations with DNR staff indicated the agency has significant concerns related to potential reservoir development on their managed lands. As detailed above, the primary barrier is the DNR's mandate to continue to generate revenue to meet state trust responsibilities on forest land. Any development such as a reservoir would limit timber production and thus revenue and make management of that particular parcel more challenging. DNR also cited potential liability concerns particularly related to recreational access which is greatest on the Middle Fork site as well as liability associated with the structural integrity of an impoundment and risks of downstream flooding.

Snoqualmie Timber/Campbell Global is the largest private forest landowner in the area of interest for a potential storage site and working with the company on a potential storage site may actually be more straightforward then pursuing a project on DNR land due to fewer management constraints on private timber lands. However, a more thorough examination of the language of the conservation easement held by King County on Snoqualmie timber lands is a logical next step towards further understanding how a transaction with the private landowner might work. If private forest land were to be acquired SVWID would want to carefully consider who the most logical landowner would be, which could be SVWID, King County or another entity. Daily operation, long-term management, maintenance and management for multiple objectives would all weigh heavily in deciding on a long-term landowner.

However, the most immediate challenge for SVWID in finding a storage site that could be moved forward to implementation is, crafting a compelling narrative with multiple benefits and a broad base of support. New and enhanced water storage projects in Washington that have succeeded or gained traction in recent years all have one thing in common- they meet multiple water management objectives and are widely supported. Finding a storage site that can help address multiple water management issues in the Snoqualmie is critical to SVWID's success. SVWID may also strengthen their case for agricultural water storage by further articulating the need for water storage and clearly stating both the benefits to agriculture and other benefits which could be related to boosting streamflows, providing flood management, increasing recreational opportunities in a growing metropolitan area, improving water quality or providing mitigation credits for groundwater use.

6. References

CampbellGlobal. n.d. "Forest Management." https://www.campbellglobal.com/forest-investing/forest-management.

———. n.d. "Social Impact." https://www.campbellglobal.com/about/social-impact.

Department of Natural Resources. 2004. "Forest Legacy Program Assessment of Need."

Kelly Heintz. 2019. "Conservation Futures Tax Levy Application for 2020 Funds; Moss Lake Natural Areas Additions."

Kunkler, Aaron. 2019. "Who Owns King County Forestlands?," December 26, 2019. https://www.valleyrecord.com/news/who-owns-king-county-forestlands/.

United States Congress. n.d. *Grant, Issue, or Renewal of Rights-of-Way*. Vol. 43 U.S. Code § 1761.

USFS. n.d. "Obtaining a Special-Use Authorization with the Forest Service." https://www.fs.fed.us/specialuses/documents/broch.htm.

WA DNR. 2021. "Department of Natural Resources Website." December 22, 2021. www.dnr.wa.gov.

Woolsey, Katie. 2021. Video Conference: Katie Woolsey, South Puget Sound Region Natural Areas Manager, Washington State Department of Natural Resources.