

Dungeness Off-Channel Reservoir Project Background – Summary of Work Completed

This packet of information and the presentation given to the Clallam County Board of Commissioners on August 14, 2023, summarize work completed on the Dungeness Reservoir project since the preliminary design was finished early in 2022. Key items of work have included the following:

Public Comment and Response

- **Public Meeting:** A presentation and open house were held in Sequim on December 6, 2022, to present the preliminary design to the public.
- **Comment Review and FAQ Document Preparation:** Comments and questions provided by the public during the open house, via email, or through the project web site were reviewed and a frequently asked questions (FAQ) document was prepared to respond to questions about the project from the public. The FAQ document is available via the project web site.
- **Reservoir Configuration:** One key public comment was a request that the height of the embankment and volume of water stored aboveground be reviewed and reduced, if possible, to improve the public perception of reservoir safety. Additional work has been completed to further evaluate reservoir configuration options, as outlined in this packet.

Coordination with the Dungeness Reservoir Work Group

- **Meetings with Dungeness Reservoir Work Group:** The County and the consultant team are engaged in regular (monthly) meetings with the Dungeness Reservoir Work Group to discuss the work and address comments from members of the Work Group.
- **Response to Work Group Comments:** The County and consultant team have been tracking and responding to written comments from the Dungeness Reservoir Work Group.

Field Work

- **Topographic Survey:** Additional topographic survey data have been collected to supplement survey data collected in 2021.
- **Cultural Resources:** Additional areas have been surveyed for cultural resources by an archaeological consultant that were not surveyed in detail by prior work.
- **Geotechnical:** Additional geotechnical work is underway to better understand site conditions. Work completed since the preliminary design phase has included the following:
 - **Geophysical Survey:** A survey was completed using geophysical scanning equipment to better characterize sub-surface soil conditions and to determine the depth to the glacial till layer that might be used as a source for the low-permeability reservoir liner and embankment core material.
 - **Seismic Reconnaissance:** One key question asked by the public is whether there is seismic faulting at the site. A seismic site reconnaissance was completed to develop

information to help answer that question. The following information on seismic hazards was collected and reviewed prior to initiation of the preliminary design:

- **2007 United States Geological Survey (USGS) Study:** A fault line was mapped across the site by USGS geologists (Nelson et al. 2007). The study referred to the fault as the Sequim fault but did not provide any explanation or basis for mapping a fault at this location.
- **2020 Pan Geo Report:** The county consulted with Pan Geo to perform an initial geotechnical engineering feasibility review of the project prior to engaging in the preliminary design. The study included a review of available information and a site visit with USGS geologists to look for the presence of features that might suggest ground instability or past movement from faulting. The study did not identify any fatal flaws and found “no identifiable evidence of faulting in the project area.” The report did recommend that excavations for the project be reviewed for any “soil anomalies that might have origins in a seismic feature.”

A more detailed seismic reconnaissance was performed by Shannon & Wilson in April 2023 with the anticipation that the results would confirm the findings of the Pan Geo Report. This seismic reconnaissance included the following:

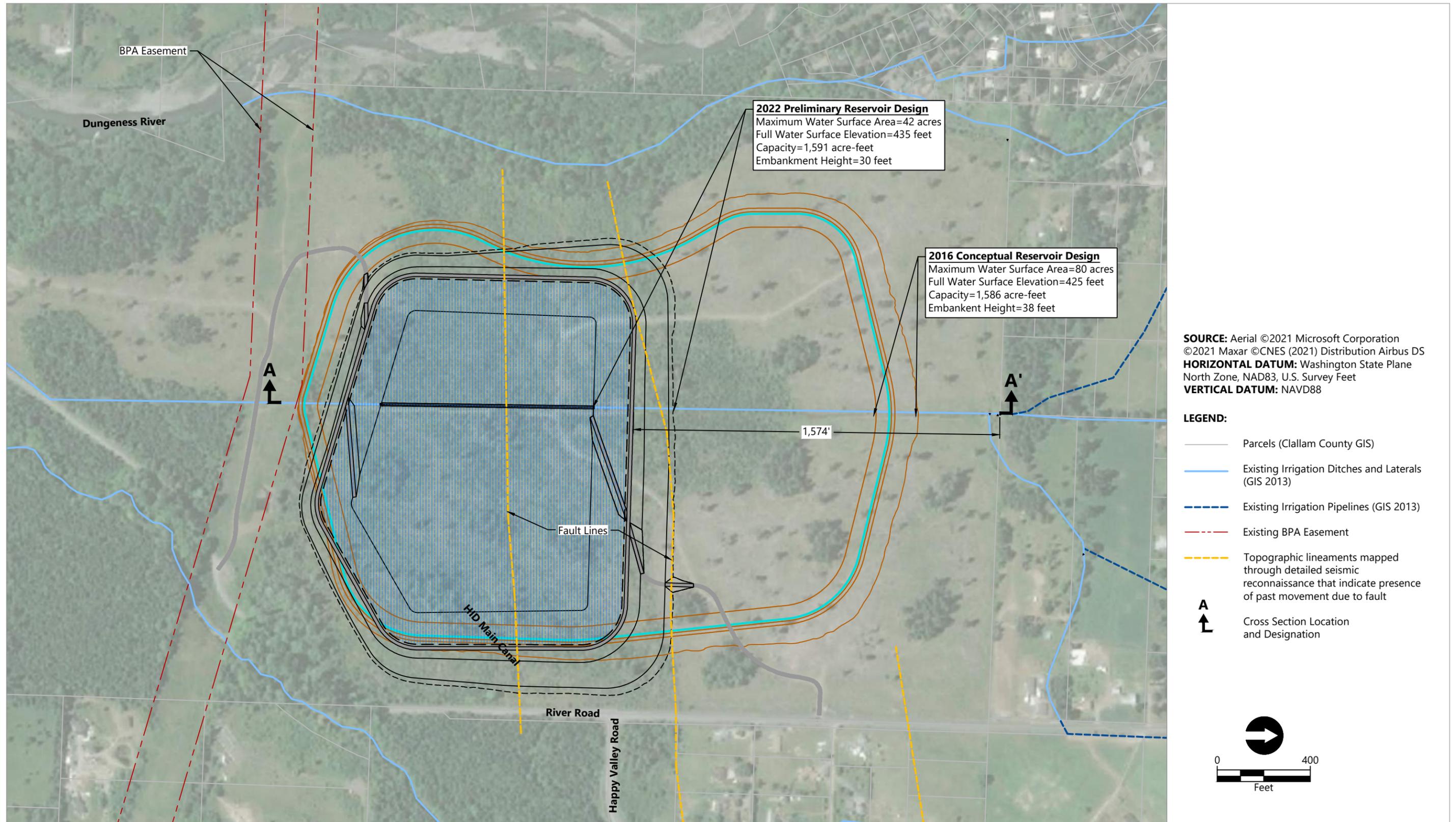
- **Site Review:** A detailed review of the site by geologists with specific expertise in identifying and evaluating seismic features.
- **Desktop Review:** Existing information on geologic conditions at the site was reviewed, similar to what had been done by Pan Geo. A detailed review of LiDAR data was also completed to identify whether there are any topographic features at the site that may indicate the presence of past movement from faulting.

The detailed review of LiDAR data indicates that there are subtle linear features, or lineaments, that do suggest a fault zone may cross the site. Additional work is needed to confirm the locations and understand the characteristics of these features and verify whether the topographic features are, or are not, associated with fault offset.

Evaluation of Additional Reservoir Configuration Options

- **Review of Embankment Height and Aboveground Water Storage Volume:** Additional reservoir configurations were evaluated to address the key public comment about the height of the embankment and that the volume of water stored aboveground. Options A through C, summarized in this packet, were evaluated specifically with this concern in mind.
- **In Response to Seismic Reconnaissance Findings:** Following the seismic reconnaissance by Shannon & Wilson, an additional option (Option D) was evaluated to look at the potential for shifting the reservoir to the south to avoid overlap of the reservoir embankment with the fault zone identified by Shannon & Wilson.

Reservoir Configuration Summary: 2022 Preliminary (30%) Design	
Key Design Parameters:	
• Maximum Water Surface Elevation/Overflow Elevation	435.0 feet
• Top of Embankment Elevation	438.0 feet
• Low-level Outlet Invert Elevation	384.6 feet
• Approximate Existing Ground Elevation at North Embankment	408 feet±
• Approximate Embankment Height at North End of Reservoir	30 feet±
• Maximum Depth of Water Above Ground at North End of Reservoir	27 feet±
• Interior Embankment Slope	3H:1V
• Exterior Embankment Slope	2.5H:1V, With Toe Berm
• Estimated Storage Capacity	1,591 acre-feet
• Storage Volume Below Ground Elevation at North End of Reservoir	592 acre-feet
• Storage Volume Above Ground Elevation at North End of Reservoir	999 acre-feet
• Total Estimated Cut Required	1,243,501 CY
• Total Estimated Fill Required	642,529 CY
• Total Excess Material to be Placed On-site or Hauled Away	600,972 CY
Summary:	
<p>The preliminary (30% complete) design, as outlined in the Preliminary Basis of Design Report for the project, included a 1,591-acre-foot reservoir that would be constructed by excavating material and placing an embankment to impound water. The reservoir water surface would cover approximately 41.6 acres when full. The top of the embankment would extend to a top elevation of 438 feet and the reservoir would be designed to maintain a full water surface at an elevation of 435 feet. Based on the existing ground surface elevation at the north end of the reservoir, where the embankment crosses the existing Highland Irrigation District (HID) H-1 Lateral, the north side of the embankment would be approximately 30 feet tall above the existing ground. The depth of water stored above the existing ground at that location would be approximately 27 feet. The top of the embankment would be located approximately 1,574 feet south of the north property boundary.</p> <p>The project would include the following key elements:</p> <ul style="list-style-type: none"> • The 1,591-acre-foot reservoir. • Upgrades to HID intake and screening facilities near the Dungeness River. • A settling basin downstream of the HID intake and screening facilities. • A 36-inch pipeline that would replace the existing HID Main Canal between the settling basin and a new flow control structure at the upstream end of the H-1 Lateral. • A 36-inch inlet pipeline that would replace the H-1 Lateral from the HID Main Canal to the reservoir. • A 36-inch outlet pipeline that would replace the H-1 Lateral from the reservoir to a discharge point in the H-1 Lateral near the north property boundary. • An 18-inch bypass pipeline that would convey water around the reservoir during construction and when the reservoir is down for maintenance. • An emergency spillway structure with a crest elevation of 435 feet and 36-inch discharge pipeline to the river. • Other structures, controls, and appurtenances needed to control the flow of water to and from the reservoir. 	
Opinion of Cost for All Key Elements of the Project (including HID Pipeline)	\$38.8 million



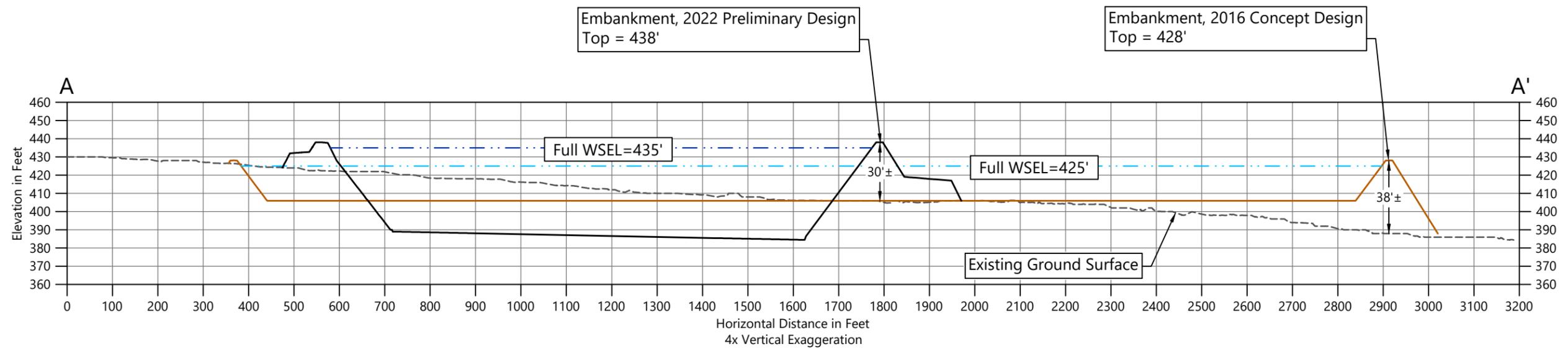
SOURCE: Aerial ©2021 Microsoft Corporation
 ©2021 Maxar ©CNES (2021) Distribution Airbus DS
HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88

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 Filepath: K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\1439-WK-011-Reservoir Comparison.dwg Figure 1



Figure 1
Reservoir Comparison - 2016 Concept and 2022 Preliminary Design - Plan View

Public Outreach
 Dungeness Reservoir Irrigation Improvement Project



SOURCE: Aerial ©2021 Microsoft Corporation ©2021 Maxar
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HORIZONTAL DATUM: Washington State Plane North Zone,
NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88



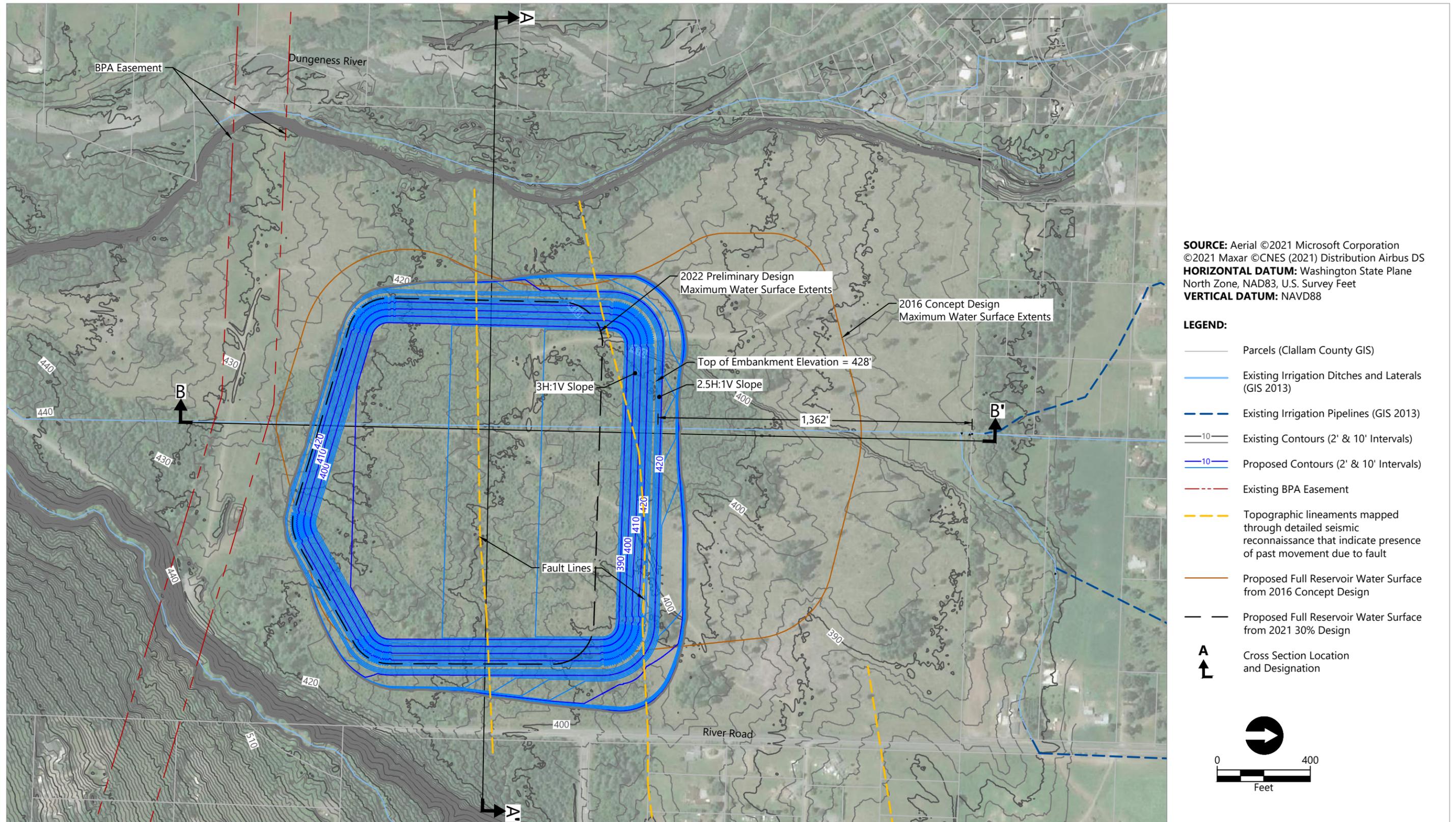
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Figure 2
Reservoir Comparison - 2016 Concept and 2022 Preliminary Design - Profile

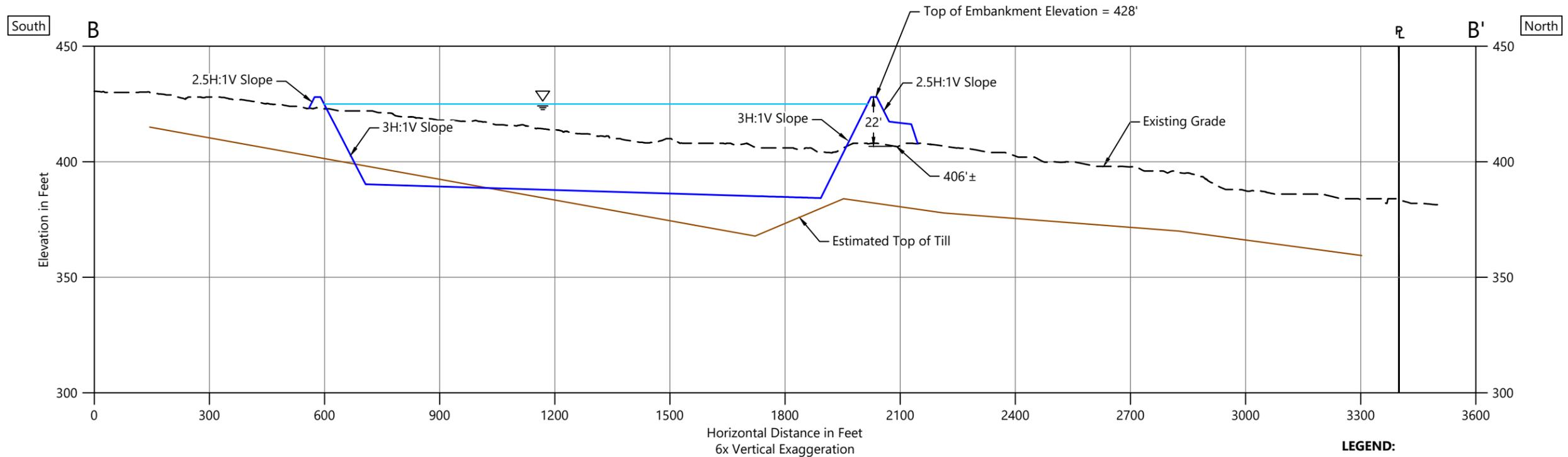
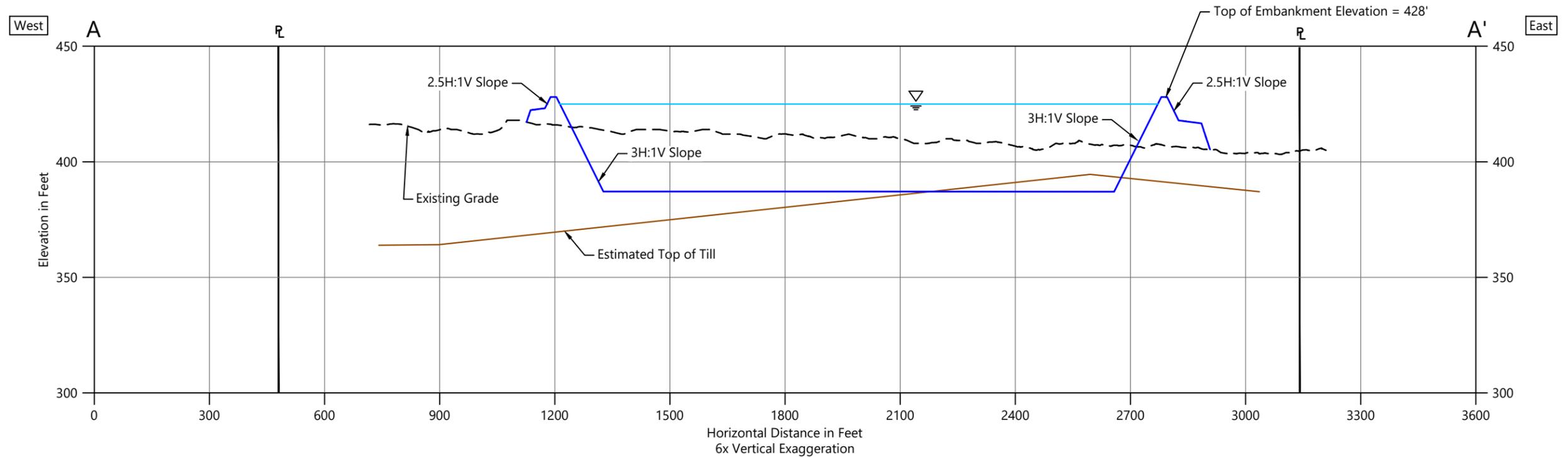
Public Outreach
Dungeness Reservoir Irrigation Improvement Project

Reservoir Configuration Summary: Option A – Max WSEL at 425 feet	
Key Design Parameters:	
• Maximum Water Surface Elevation/Overflow Elevation	425.0 feet
• Top of Embankment Elevation	428.0 feet
• Low-level Outlet Invert Elevation	384.6 feet
• Approximate Existing Ground Elevation at North Embankment	406 feet±
• Approximate Embankment Height at North End of Reservoir	22 feet±
• Maximum Depth of Water Above Ground at North End of Reservoir	19 feet±
• Interior Embankment Slope	3H:1V
• Exterior Embankment Slope	2.5H:1V, With Toe Berm
• Estimated Storage Capacity	1,595 acre-feet
• Storage Volume Below Ground Elevation at North End of Reservoir	729 acre-feet
• Storage Volume Above Ground Elevation at North End of Reservoir	866 acre-feet
• Total Estimated Cut Required	1,590,557 CY
• Total Estimated Fill Required	364,723 CY
• Total Excess Material to be Placed On-site or Hauled Away	1,225,834 CY
Summary:	
<p>Option A would be similar to the preliminary design, but the top elevation and full water surface elevation would be reduced 10 feet, while maintaining the same bottom elevation. To maintain a similar storage capacity, the north embankment would need to shift to the north. The analysis of Option A resulted in a 1,595-acre-foot reservoir, similar in shape to the preliminary design. However, the reservoir water surface would cover approximately 49.0 acres when full (an increase of 7.4 acres over the preliminary design). The top of the embankment would only extend to a top elevation of 428 feet and the reservoir would be designed to maintain a full water surface at an elevation of 425 feet. Based on the existing ground surface elevation at the north end of the reservoir, where the embankment crosses the existing Highland Irrigation District (HID) H-1 Lateral, the north side of the embankment would be approximately 22 feet tall above the existing ground. The depth of water stored above the existing ground at that location would be approximately 19 feet. The top of the embankment would be located approximately 1,362 feet south of the north property boundary.</p> <p>The project would include the following key elements:</p> <ul style="list-style-type: none"> • The 1,595-acre-foot reservoir. • Upgrades to HID intake and screening facilities near the Dungeness River. • A settling basin downstream of the HID intake and screening facilities. • A 36-inch pipeline that would replace the existing HID Main Canal between the settling basin and a new flow control structure at the upstream end of the H-1 Lateral. • A 36-inch inlet pipeline that would replace the H-1 Lateral from the HID Main Canal to the reservoir. • A 36-inch outlet pipeline that would replace the H-1 Lateral from the reservoir to a discharge point in the H-1 Lateral near the north property boundary. • An 18-inch bypass pipeline that would convey water around the reservoir during construction and when the reservoir is down for maintenance. • An emergency spillway structure with a crest elevation of 425 feet and 36-inch discharge pipeline to the river. • Other structures, controls, and appurtenances needed to control the flow of water to and from the reservoir. 	
Opinion of Cost for All Key Elements of the Project (including HID Pipeline)	\$41.2 million



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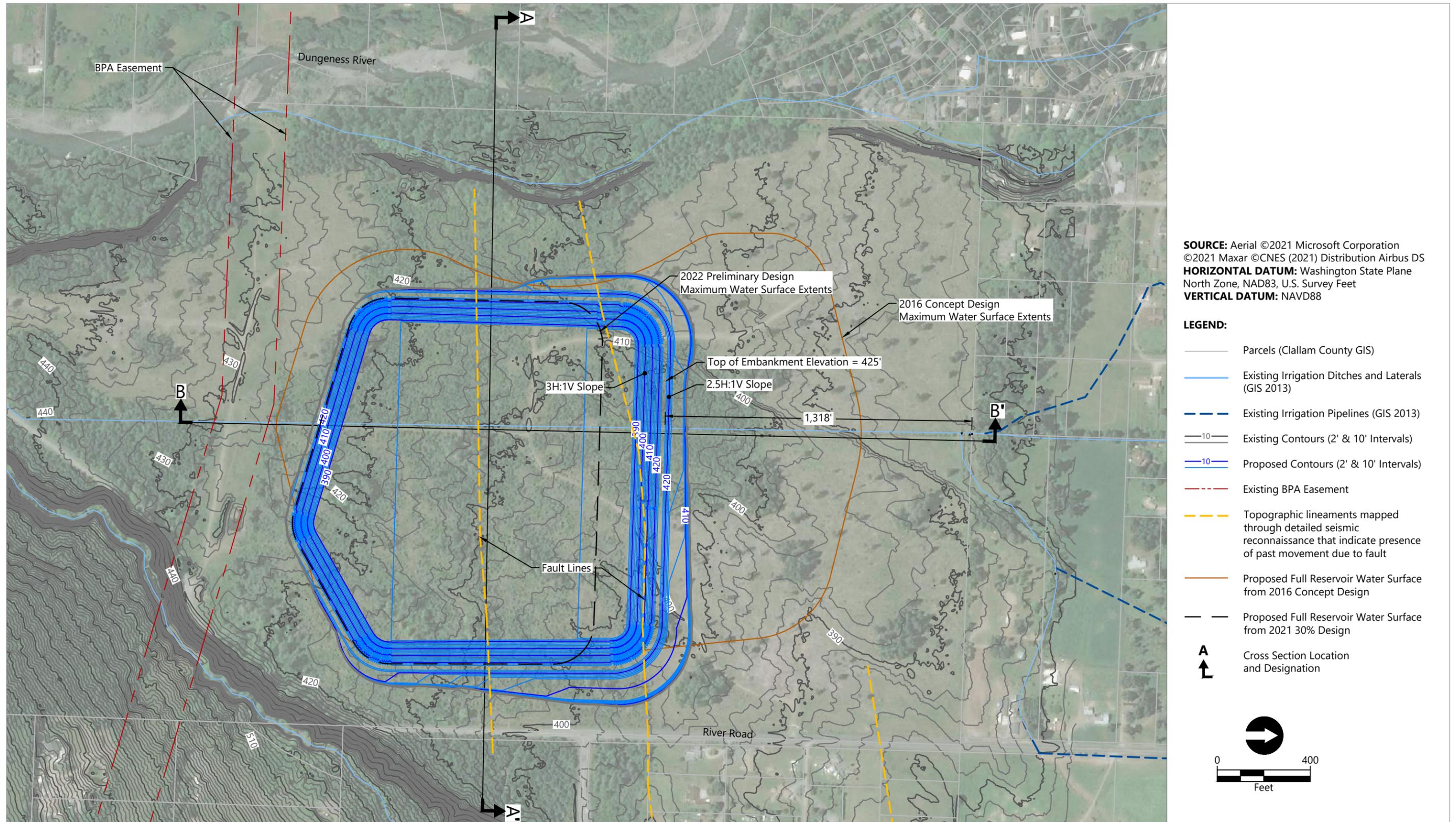
- LEGEND:**
- Existing Grade
 - Proposed Grade
 - ▽ Proposed Water Surface Elevation
 - Estimated Till

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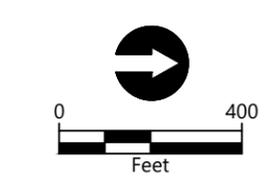


Figure A-2
Cross Sections: Option A
 Dungeness Off-Channel Reservoir

Reservoir Configuration Summary: Option B – Max WSEL at 422 feet	
Key Design Parameters:	
• Maximum Water Surface Elevation/Overflow Elevation	422.0 feet
• Top of Embankment Elevation	425.0 feet
• Low-level Outlet Invert Elevation	384.6 feet
• Approximate Existing Ground Elevation at North Embankment	405 feet±
• Approximate Embankment Height at North End of Reservoir	20 feet±
• Maximum Depth of Water Above Ground at North End of Reservoir	17 feet±
• Interior Embankment Slope	3H:1V
• Exterior Embankment Slope	2.5H:1V, With Toe Berm
• Estimated Storage Capacity	1,544 acre-feet
• Storage Volume Below Ground Elevation at North End of Reservoir	739 acre-feet
• Storage Volume Above Ground Elevation at North End of Reservoir	805 acre-feet
• Total Estimated Cut Required	1,681,850 CY
• Total Estimated Fill Required	280,226 CY
• Total Excess Material to be Placed On-site or Hauled Away	1,401,624 CY
Summary:	
<p>Option B would be similar to Option A, but the top elevation and full water surface elevation would be reduced an additional 3 feet, while maintaining the same bottom elevation. To maintain a similar storage capacity, the north embankment would need to shift to the north. The analysis of Option B resulted in a 1,544-acre-foot reservoir, similar in shape to the preliminary design and Option A. However, the reservoir water surface would cover approximately 50.5 acres when full (an increase of 8.9 acres over the preliminary design). The top of the embankment would only extend to a top elevation of 425 feet and the reservoir would be designed to maintain a full water surface at an elevation of 422 feet. Based on the existing ground surface elevation at the north end of the reservoir, where the embankment crosses the existing Highland Irrigation District (HID) H-1 Lateral, the north side of the embankment would be approximately 20 feet tall above the existing ground. The depth of water stored above the existing ground at that location would be approximately 17 feet. The top of the embankment would be located approximately 1,320 feet south of the north property boundary.</p> <p>The project would include the following key elements:</p> <ul style="list-style-type: none"> • The 1,595-acre-foot reservoir. • Upgrades to HID intake and screening facilities near the Dungeness River. • A settling basin downstream of the HID intake and screening facilities. • A 36-inch pipeline that would replace the existing HID Main Canal between the settling basin and a new flow control structure at the upstream end of the H-1 Lateral. • A 36-inch inlet pipeline that would replace the H-1 Lateral from the HID Main Canal to the reservoir. • A 36-inch outlet pipeline that would replace the H-1 Lateral from the reservoir to a discharge point in the H-1 Lateral near the north property boundary. • An 18-inch bypass pipeline that would convey water around the reservoir during construction and when the reservoir is down for maintenance. • An emergency spillway structure with a crest elevation of 422 feet and 36-inch discharge pipeline to the river. • Other structures, controls, and appurtenances needed to control the flow of water to and from the reservoir. 	
Opinion of Cost for All Key Elements of the Project (including HID Pipeline)	\$42.4 million



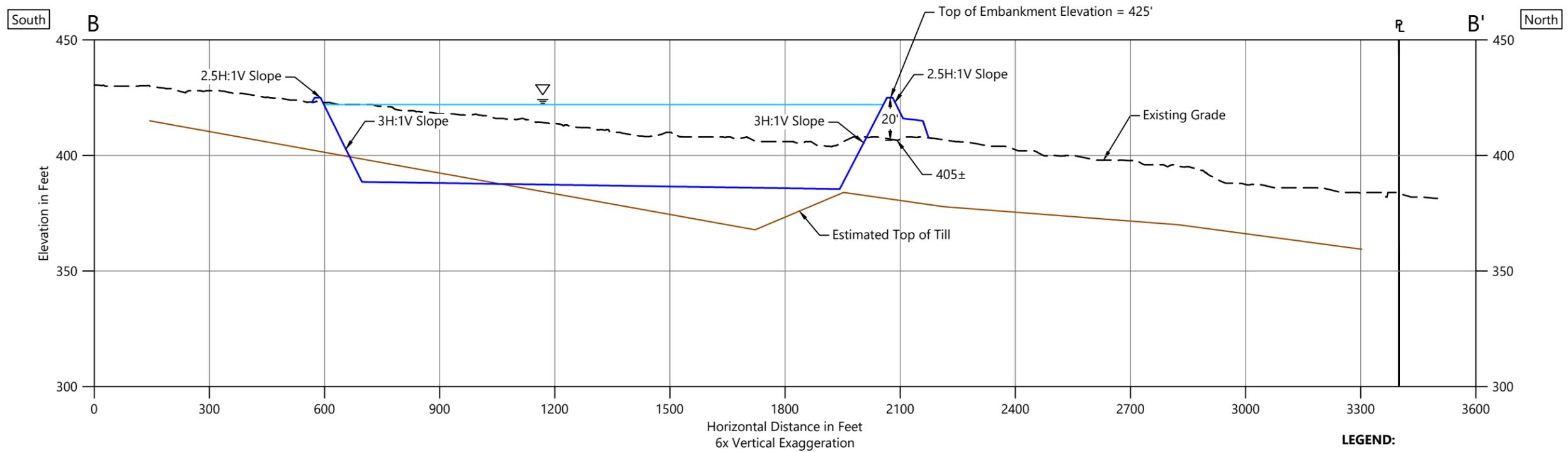
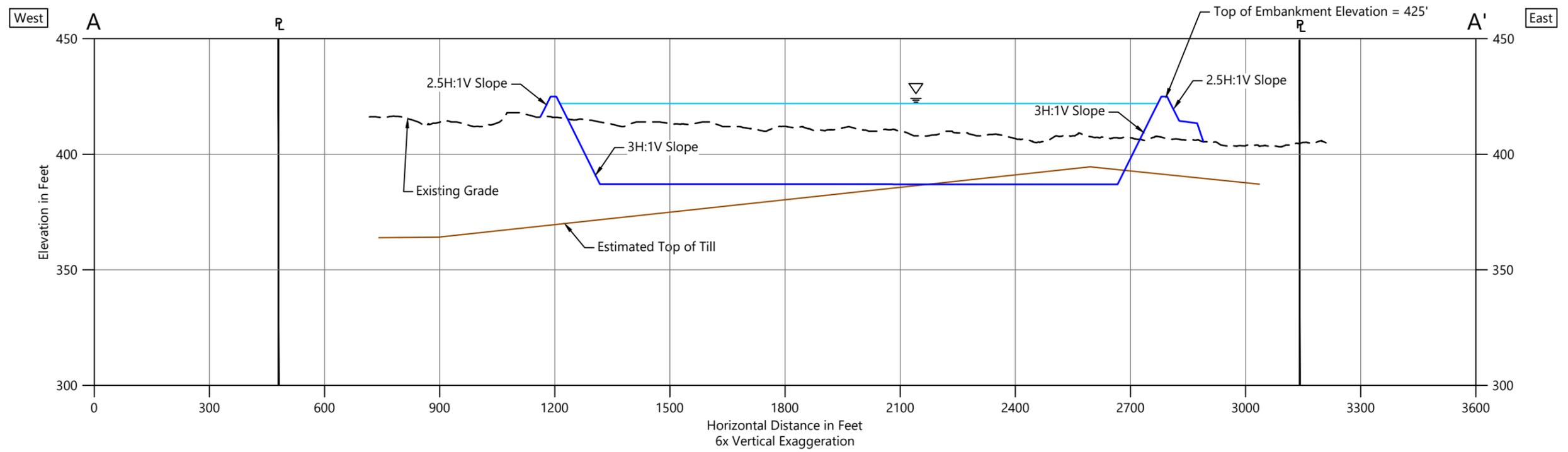
- LEGEND:**
- Parcels (Clallam County GIS)
 - Existing Irrigation Ditches and Laterals (GIS 2013)
 - Existing Irrigation Pipelines (GIS 2013)
 - Existing Contours (2' & 10' Intervals)
 - Proposed Contours (2' & 10' Intervals)
 - Existing BPA Easement
 - Topographic lineaments mapped through detailed seismic reconnaissance that indicate presence of past movement due to fault
 - Proposed Full Reservoir Water Surface from 2016 Concept Design
 - Proposed Full Reservoir Water Surface from 2021 30% Design
 - Cross Section Location and Designation



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Figure B-1
Plan View: Option B
 Dungeness Off-Channel Reservoir



LEGEND:

- Existing Grade
- Proposed Grade
- ▽ Proposed Water Surface Elevation
- Estimated Till

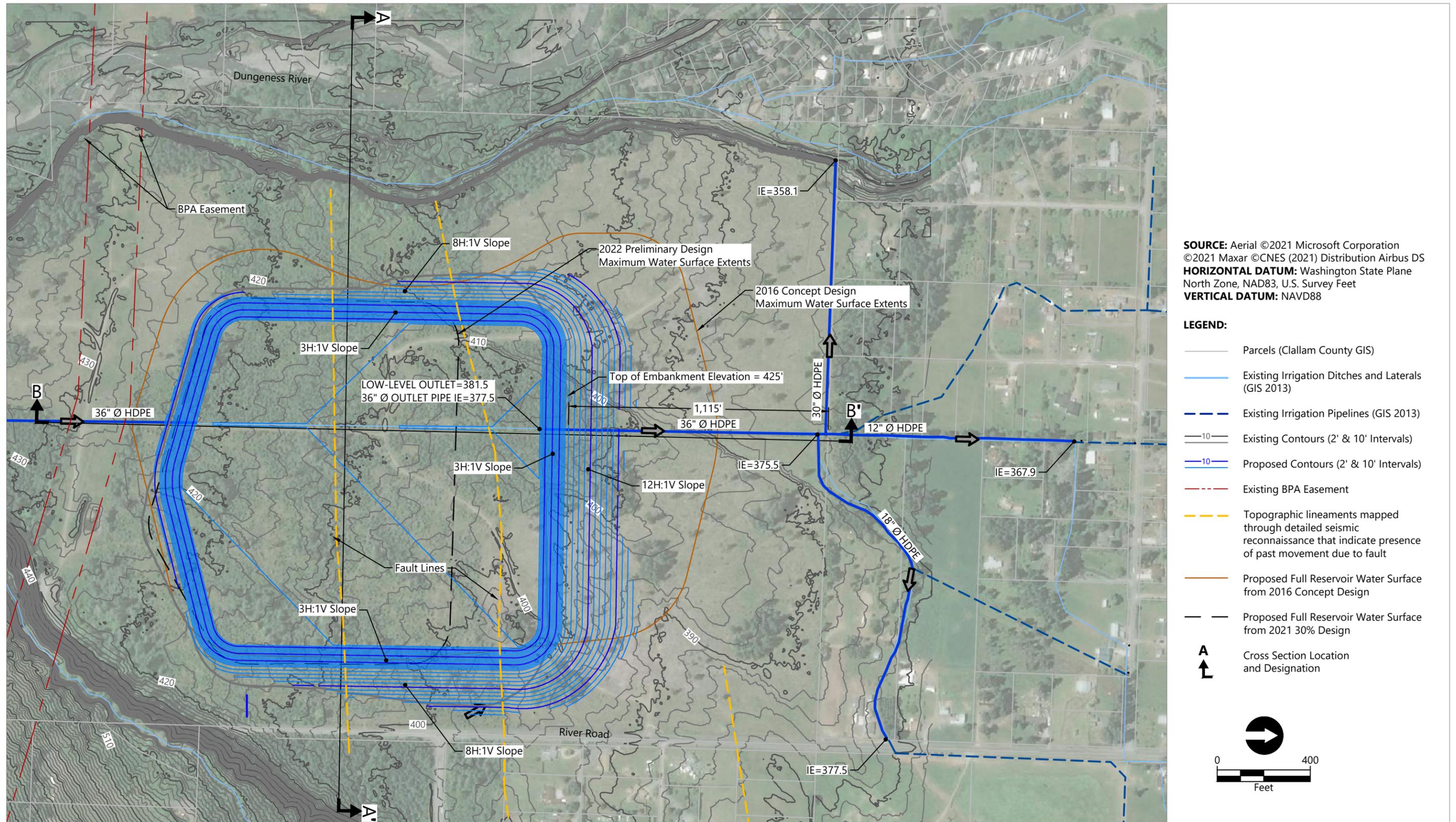
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Figure B-2
Cross Sections: Option B
 Dungeness Off-Channel Reservoir

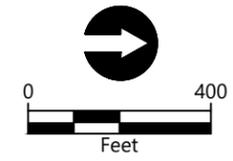
Reservoir Configuration Summary: Option C – Max WSEL at 415 feet, Pipe Extended North, Lower Bottom	
Key Design Parameters:	
• Maximum Water Surface Elevation/Overflow Elevation	415.0 feet
• Top of Embankment Elevation	418.0 feet
• Low-level Outlet Invert Elevation	381.5 feet
• Approximate Existing Ground Elevation at North Embankment	404 feet±
• Approximate Embankment Height at North End of Reservoir	14 feet±
• Maximum Depth of Water Above Ground at North End of Reservoir	11 feet±
• Interior Embankment Slope	3H:1V
• Exterior Embankment Slope	12H:1V (N) 8H:1V (E and W)
• Estimated Storage Capacity	1,591 acre-feet
• Storage Volume Below Ground Elevation at North End of Reservoir	979 acre-feet
• Storage Volume Above Ground Elevation at North End of Reservoir	612 acre-feet
• Total Estimated Cut Required	2,603,569 CY
• Total Estimated Fill Required	274,989 CY
• Total Excess Material to be Placed On-site or Hauled Away	2,328,580 CY
Summary:	
<p>Option C assumes that the discharge pipelines from the reservoir would be extended beyond the north property boundary and lowered to allow the bottom of the reservoir to be lowered. The reservoir would be configured to provide a similar storage capacity to the preliminary design, while lowering the top of the embankment as much as possible. For this option, the top of the reservoir was set at an elevation of 418.0 feet (20 feet lower than the preliminary design). The low-level outlet invert elevation was reduced by almost 3 feet, to an elevation of 381.5 feet. It was assumed that the 36-inch discharge pipeline from the reservoir would branch near the north property boundary and the following pipelines would be added to extend the discharge system:</p> <ul style="list-style-type: none"> • An 18-inch pipeline would extend northeast in the Eureka Canal to an existing culvert at River Road. The invert at the discharge location at River Road would be the same as the existing culvert (377.5 feet). • A 30-inch pipeline would extend west parallel to the north property boundary to convey water to the Independent Canal. The invert at the discharge location at the Independent Canal would be 358.1 feet. • A 12-inch pipeline would extend approximately 1,100 north of the property boundary in the HID H-1 Lateral. That pipeline would discharge at an invert elevation of 367.9 feet. <p>For the reservoir to release water by gravity, the low-level outlet at the reservoir would need to be higher than the elevations at the three points of discharge identified above. The highest of those would be the 18-inch pipe in the Eureka Canal, with a discharge outlet invert elevation of 377.5 feet. To ensure that there would be capacity to release reservoir water when the reservoir is low and allow for pressure losses in the discharge pipelines, the low-level outlet at the reservoir was set at an elevation of 381.5 feet.</p> <p>The analysis of Option C resulted in a 1,591-acre-foot reservoir. The reservoir water surface would cover approximately 57.8 acres when full (an increase of 16.2 acres over the preliminary design). The top of the embankment would only extend to a top elevation of 418 feet and the reservoir would be designed to maintain a full water surface at an elevation of 415 feet. Based on the existing ground surface elevation at the north end of the reservoir, where the embankment crosses the existing Highland Irrigation District (HID) H-1 Lateral, the north side of the embankment would be approximately 14 feet tall above the existing ground. The depth of water stored</p>	

Reservoir Configuration Summary: Option C – Max WSEL at 415 feet, Pipe Extended North, Lower Bottom	
<p>above the existing ground at that location would be approximately 11 feet. The top of the embankment would be located approximately 1,115 feet south of the north property boundary.</p> <p>The project would include the following key elements:</p> <ul style="list-style-type: none"> • The 1,591-acre-foot reservoir. • Upgrades to HID intake and screening facilities near the Dungeness River. • A settling basin downstream of the HID intake and screening facilities. • A 36-inch pipeline that would replace the existing HID Main Canal between the settling basin and a new flow control structure at the upstream end of the H-1 Lateral. • A 36-inch inlet pipeline that would replace the H-1 Lateral from the HID Main Canal to the reservoir. • A 36-inch outlet pipeline that would replace the H-1 Lateral from the reservoir to a discharge point in the H-1 Lateral near the north property boundary. • The discharge pipelines listed earlier in this summary, branching from the 36-inch outlet pipeline near the north property boundary. • An 18-inch bypass pipeline that would convey water around the reservoir during construction and when the reservoir is down for maintenance. • An emergency spillway structure with a crest elevation of 415 feet and 36-inch discharge pipeline to the river. • Other structures, controls, and appurtenances needed to control the flow of water to and from the reservoir. 	
Opinion of Cost for All Key Elements of the Project (including HID Pipeline)	\$44.5 million



SOURCE: Aerial ©2021 Microsoft Corporation
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HORIZONTAL DATUM: Washington State Plane
 North Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88

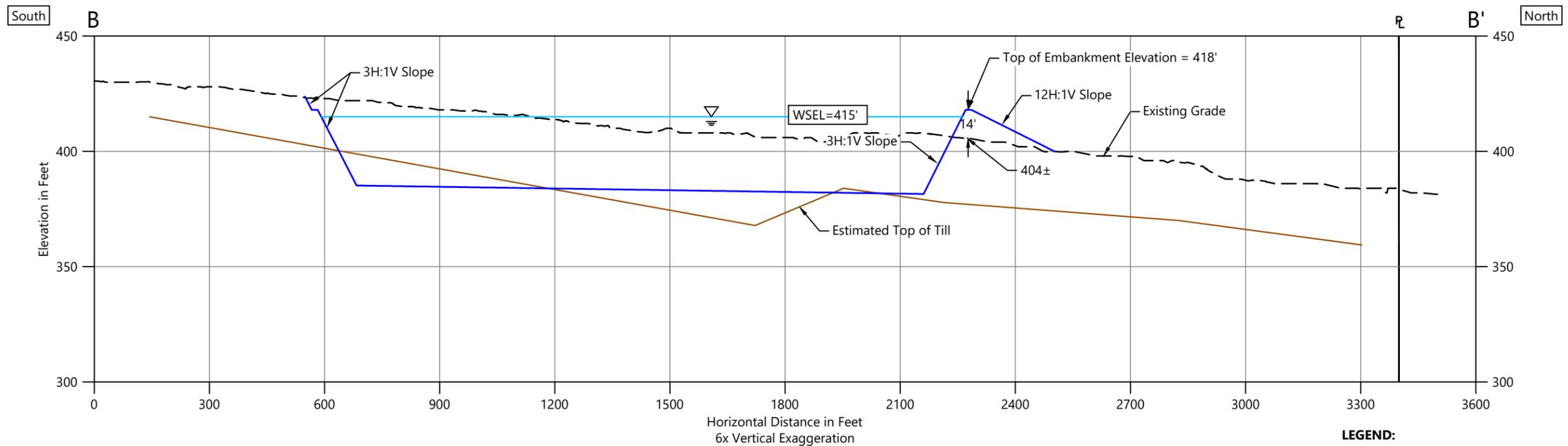
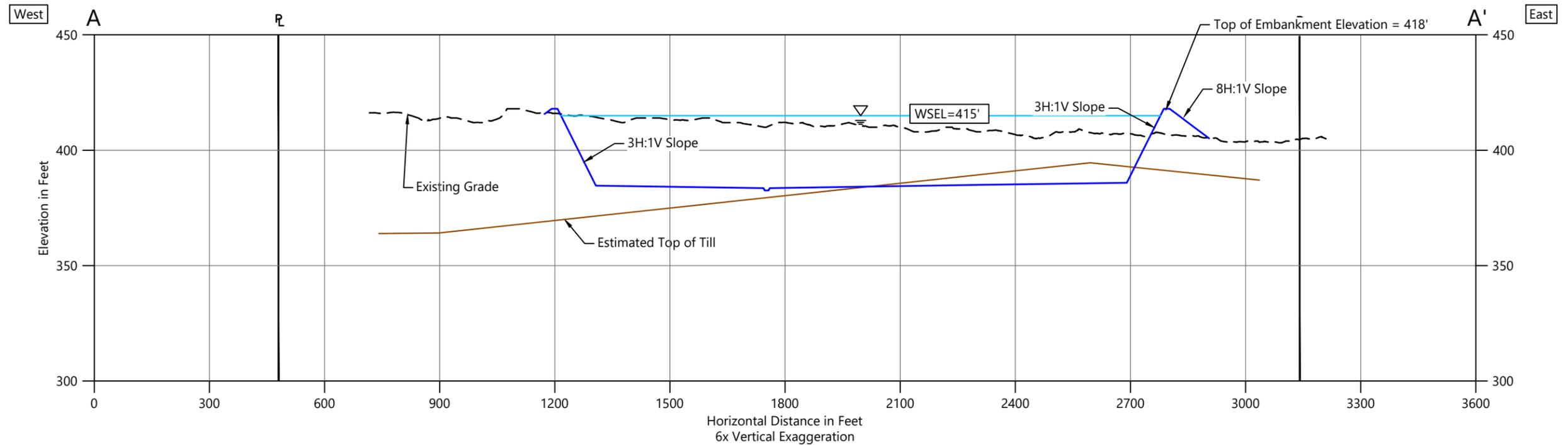
- LEGEND:**
- Parcels (Clallam County GIS)
 - Existing Irrigation Ditches and Laterals (GIS 2013)
 - - - Existing Irrigation Pipelines (GIS 2013)
 - Existing Contours (2' & 10' Intervals)
 - Proposed Contours (2' & 10' Intervals)
 - - - Existing BPA Easement
 - - - Topographic lineaments mapped through detailed seismic reconnaissance that indicate presence of past movement due to fault
 - Proposed Full Reservoir Water Surface from 2016 Concept Design
 - Proposed Full Reservoir Water Surface from 2021 30% Design
 - A
L
Cross Section Location and Designation



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Figure C-1
Plan View: Option C
 Dungeness Off-Channel Reservoir



- LEGEND:**
- Existing Grade
 - Proposed Grade
 - ▽ Proposed Water Surface Elevation
 - Estimated Till

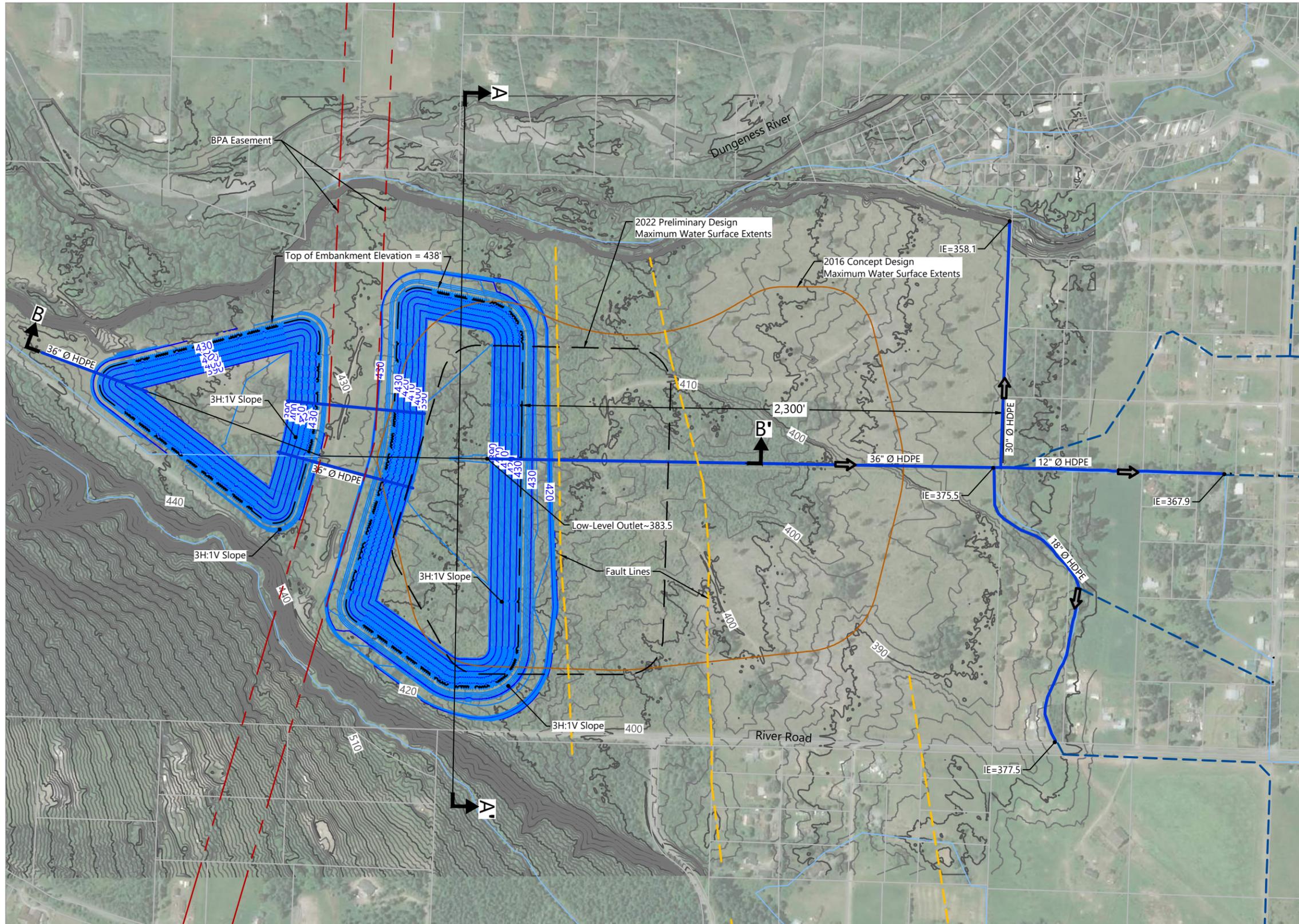
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Figure C-2
Cross Sections: Option C
 Dungeness Off-Channel Reservoir

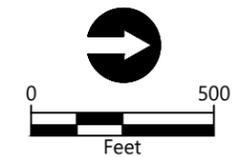
Reservoir Configuration Summary: Option D – Max WSEL at 435 feet, Shifted to South to Avoid Fault Zone	
Key Design Parameters:	
• Maximum Water Surface Elevation/Overflow Elevation	435.0 feet
• Top of Embankment Elevation	438.0 feet
• Low-level Outlet Invert Elevation	383.5 feet
• Approximate Existing Ground Elevation at North Embankment	415 feet±
• Approximate Embankment Height at North End of Reservoir	23 feet±
• Maximum Depth of Water Above Ground at North End of Reservoir	20 feet±
• Interior Embankment Slope	3H:1V
• Exterior Embankment Slope	3H:1V, With Toe Berm
• Estimated Storage Capacity	1,420 acre-feet
• Storage Volume Below Ground Elevation at North End of Reservoir	696 acre-feet
• Storage Volume Above Ground Elevation at North End of Reservoir	724 acre-feet
• Total Estimated Cut Required	1,745,452 CY
• Total Estimated Fill Required	363,563 CY
• Total Excess Material to be Placed On-site or Hauled Away	1,381,889 CY
Summary:	
<p>Option D would result in the reservoir footprint being shifted to the south to avoid overlap with a fault zone that was identified by the recently completed seismic reconnaissance. The reservoir would include two separate sections of reservoir connected by pipe through the BPA easement; one section of reservoir would be located north of the BPA easement but south of the fault zone and the other would be located south of the BPA easement.</p> <p>This option also assumes that the discharge pipelines from the reservoir would be extended beyond the north property boundary and lowered to allow the bottom of the reservoir to be lower than it would be if the outlet had to daylight at the north property boundary. For this option, the top of the reservoir was set at an elevation of 438.0 feet (the same as the preliminary design). The low-level outlet invert elevation would be approximately 383.5 feet. It was assumed that the 36-inch discharge pipeline from the reservoir would branch near the north property boundary and the following pipelines would be added to extend the discharge system:</p> <ul style="list-style-type: none"> • An 18-inch pipeline would extend northeast in the Eureka Canal to an existing culvert at River Road. The invert at the discharge location at River Road would be the same as the existing culvert (377.5 feet). • A 30-inch pipeline would extend west parallel to the north property boundary to convey water to the Independent Canal. The invert at the discharge location at the Independent Canal would be 358.1 feet. • A 12-inch pipeline would extend approximately 1,100 north of the property boundary in the HID H-1 Lateral. That pipeline would discharge at an invert elevation of 367.9 feet. <p>For the reservoir to release water by gravity, the low-level outlet at the reservoir would need to be higher than the elevations at the three points of discharge identified above. The highest of those would be the 18-inch pipe in the Eureka Canal, with a discharge outlet invert elevation of 377.5 feet. To ensure that there would be capacity to release reservoir water when the reservoir is low and allow for pressure losses in the discharge pipelines, the low-level outlet at the reservoir was set at an invert elevation of 383.5 feet.</p> <p>The analysis of Option D resulted in a 1,420-acre-foot reservoir, which is slightly smaller than the other options. The capacity of the reservoir could be increased by raising the top elevation, lowering the bottom elevation further, or constructing additional capacity and causing additional impacts within the BPA easement. The reservoir water surface would cover approximately 41.8 acres when full (similar in area to the preliminary design). The top of the</p>	

Reservoir Configuration Summary: Option D – Max WSEL at 435 feet, Shifted to South to Avoid Fault Zone	
<p>embankment would extend to a top elevation of 438 feet and the reservoir would be designed to maintain a full water surface at an elevation of 435 feet. Based on the existing ground surface elevation at the north end of the reservoir, where the embankment crosses the existing Highland Irrigation District (HID) H-1 Lateral, the north side of the embankment would be approximately 23 feet tall above the existing ground. The depth of water stored above the existing ground at that location would be approximately 20 feet. The top of the embankment would be located approximately 2,285 feet south of the north property boundary.</p> <p>The project would include the following key elements:</p> <ul style="list-style-type: none"> • The 1,420-acre-foot reservoir. • Upgrades to HID intake and screening facilities near the Dungeness River. • A settling basin downstream of the HID intake and screening facilities. • A 36-inch pipeline that would replace the existing HID Main Canal between the settling basin and a new flow control structure at the upstream end of the H-1 Lateral. • A 36-inch inlet pipeline that would replace the H-1 Lateral from the HID Main Canal to the reservoir. • A 36-inch outlet pipeline that would replace the H-1 Lateral from the reservoir to a discharge point in the H-1 Lateral near the north property boundary. • The discharge pipelines listed earlier in this summary, branching from the 36-inch outlet pipeline near the north property boundary. • An 18-inch bypass pipeline that would convey water around the reservoir during construction and when the reservoir is down for maintenance. • An emergency spillway structure with a crest elevation of 435 feet and 36-inch discharge pipeline to the river. • Other structures, controls, and appurtenances needed to control the flow of water to and from the reservoir. 	
Opinion of Cost for All Key Elements of the Project (including HID Pipeline)	\$43.6 million



LEGEND:

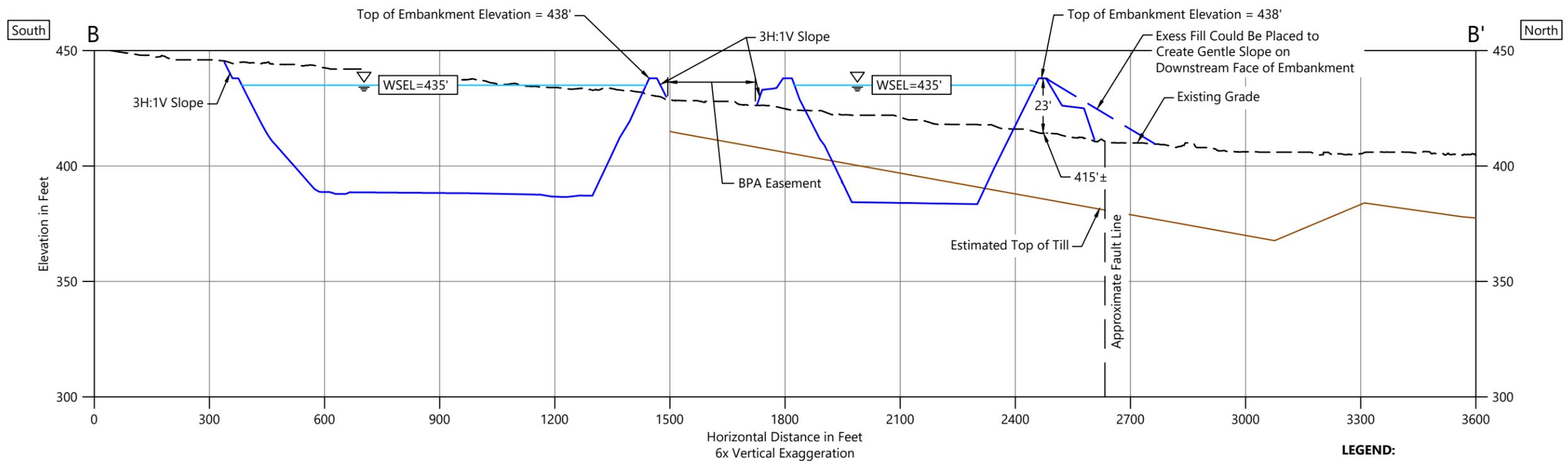
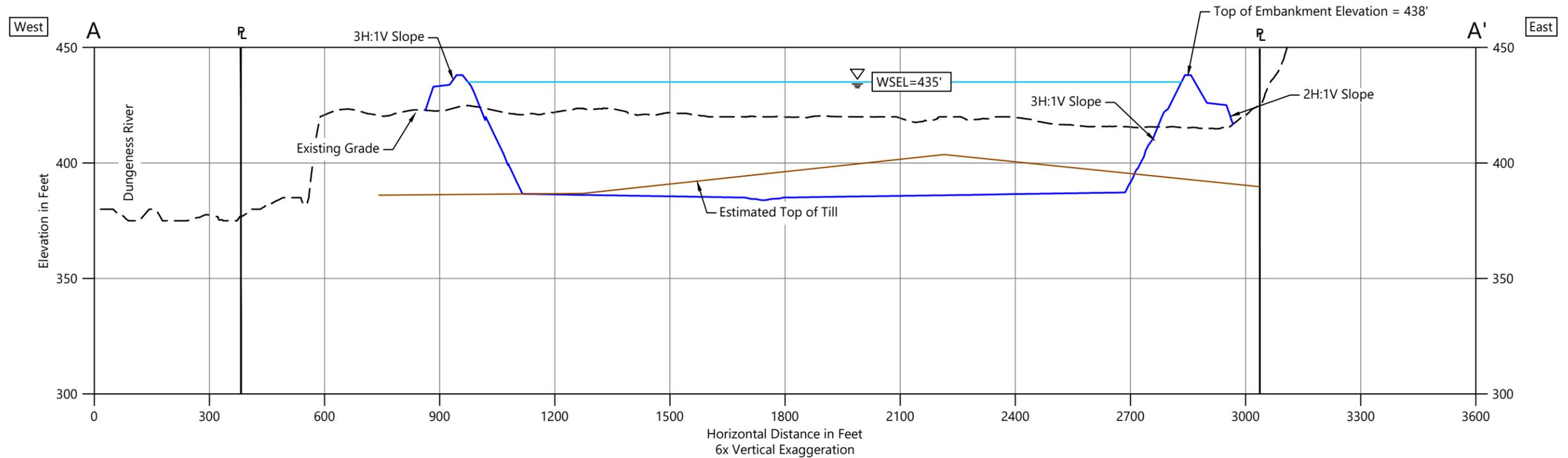
- Parcels (Clallam County GIS)
- Existing Irrigation Ditches and Laterals (GIS 2013)
- Existing Irrigation Pipelines (GIS 2013)
- Existing Contours (2' & 10' Intervals)
- Proposed Contours (2' & 10' Intervals)
- Existing BPA Easement
- Topographic lineaments mapped through detailed seismic reconnaissance that indicate presence of past movement due to fault
- Proposed Full Reservoir Water Surface from 2016 Concept Design
- Proposed Full Reservoir Water Surface from 2021 30% Design
- Cross Section Location and Designation



Publish Date: 2023/08/09 7:57 AM | User: drice
 Filepath: K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\1439-WK-016 Design Charrette-OptionD.dwg Figure D-1



Figure D-1
Plan View: Option D
 Dungeness Off-Channel Reservoir



- LEGEND:**
- Existing Grade
 - Proposed Grade
 - ▽ Proposed Water Surface Elevation
 - Estimated Till

Table 1A
Comparison of Optional Reservoir Configurations to Preliminary Design

Design Parameter	Reservoir Configuration				
	2022 Preliminary (30%) Design	Revised Configuration Option A	Revised Configuration Option B	Revised Configuration Option C	Revised Configuration Option D
Maximum Water Surface Elevation/Overflow Elevation (feet)	435.0	425.0	422.0	415.0	435.0
Top of Embankment Elevation (feet)	438.0	428.0	425.0	418.0	438.0
Average Reservoir Bottom Elevation (feet) ¹	388.0	388.0	388.0	384.2	386.0 (North Reservoir) 387.9 (South Reservoir)
Low-level Outlet Invert Elevation (feet)	384.6	384.6	384.6	381.5	383.5
Approximate Existing Ground Elevation at North Embankment (feet) ²	408±	406±	405±	404±	415± (North Reservoir) 430± (South Reservoir)
Approximate Existing Ground Elevation at South Embankment (feet) ²	423±	423±	423±	423±	425± (North Reservoir) 445± (South Reservoir)
Approximate Embankment Height at North End of Reservoir (feet)	30±	22±	20±	14±	23± (North Reservoir) 8± (South Reservoir)
Approximate Embankment Height at South End of Reservoir (feet)	15±	5±	2±	No Embankment	10± (North Reservoir) No Embankment (South Reservoir)
Maximum Depth of Water Above Ground at North End of Reservoir (feet)	27±	19±	17±	11±	20± (North Reservoir)
Maximum Depth of Water Above Ground at South End of Reservoir (feet)	12±	2±	-1±	-8±	-10± (South Reservoir)
Interior Embankment Slope (feet/feet) ³	3H:1V	3H:1V	3H:1V	3H:1V	3H:1V
Exterior Embankment Slope (feet/feet) ³	2.5H:1V	2.5H:1V	2.5H:1V	12H:1V (N) 8H:1V (E and W)	3H:1V
Estimated Storage Capacity (acre-feet)	1,591	1,595	1,544	1,591	1,420
Storage Volume Below Ground Elevation at North End of Reservoir (acre-feet) ⁴	592	729	739	979	696
Storage Volume Above Ground Elevation at North End of Reservoir (acre-feet) ⁴	999	866	805	612	724
Distance from Top of Embankment to North Property Boundary (feet)	1,574	1,362	1,320	1,115	2,285
Maximum Water Surface Area, Full Reservoir (acres)	41.6	49.0	50.5	57.8	41.8 (Both Reservoirs)
Surface Area, Bottom of Reservoir (acres)	26.6	35.8	38.0	45.9	18.6 (Both Reservoirs)
Estimated Area Required for Low Permeability Layer or Liner (acres)	42.4	50.1	51.5	59.8	44.0 (Both Reservoirs)
Estimated Area of Till Exposed by Excavation (acres) ⁵	14.3	16.0	16.9	22.5	16.5 (Both Reservoirs)
Total Estimated Cut Required (CY)	1,243,501	1,590,557	1,681,850	2,603,569	1,745,452
Total Estimated Cut in Till Layer (CY) ⁵	149,295	174,749	204,684	272,700	474,898
Total Estimated Fill Required (CY)	642,529	364,723	280,226	274,989	363,563
Total Estimated Excess Material to be Placed On-site or Hauled Away (CY) ⁶	600,972	1,225,834	1,401,624	2,328,580	1,381,889
Opinion of Cost for All Key Elements of the Project (including HID Pipeline)⁷	\$38.8 million	\$41.2 million	\$42.4 million	\$44.5 million	\$43.6 million
Other Potential Project Costs, for Design or Construction Work Not Included in Opinion of Costs Listed Above:⁸					
Costs Related to Seismic Reconnaissance Findings:					
Trenching to Confirm Sequim Fault Location and Characteristics ⁹ :	\$500,000-\$800,000	\$500,000-\$800,000	\$500,000-\$800,000	\$500,000-\$800,000	\$300,000-\$600,000
Seismic Displacement (Fault Rupture) Modeling and Analyses ¹⁰ :	\$50,000-\$100,000	\$50,000-\$100,000	\$50,000-\$100,000	\$50,000-\$100,000	\$50,000-\$100,000
Design of Reservoir Embankment to Accommodate Fault Rupture ¹¹ :	\$30,000-\$50,000	\$30,000-\$50,000	\$30,000-\$50,000	\$30,000-\$50,000	\$10,000-\$20,000

Design Parameter	Reservoir Configuration				
	2022 Preliminary (30%) Design	Revised Configuration Option A	Revised Configuration Option B	Revised Configuration Option C	Revised Configuration Option D
Additional Consultation and Effort Needed to Meet Dam Safety Requirements ¹² :	\$40,000-\$60,000	\$40,000-\$60,000	\$40,000-\$60,000	\$40,000-\$60,000	\$20,000-\$30,000
Costs Related to Shifting the Design Away from the Preliminary Design:					
Additional Consultation with BPA for Impacts to BPA Easement ¹³ :					\$5,000-\$10,000
Additional Borings, Test Pits, Revisions to Phase 2 Geotechnical Investigation ¹⁴ :					\$50,000-\$80,000
Reservoir Grading and Site Layout Re-design ¹⁵ :		\$5,000-\$10,000	\$5,000-\$10,000	\$10,000-\$20,000	\$20,000-\$40,000
Additional Wetland Survey and Permitting Effort ¹⁶ :					\$5,000-\$10,000
Costs Related to Other Elements the Dungeness Reservoir Work Group Has Requested that We Include in the Project:					
Detailed Design of Downstream Irrigation Pipelines ¹⁷ :	\$450,000-\$600,000	\$450,000-\$600,000	\$450,000-\$600,000	\$450,000-\$600,000	\$450,000-\$600,000
Detailed Design of Drought Relief Pump Station ¹⁸ :	\$100,000-\$150,000	\$100,000-\$150,000	\$100,000-\$150,000	\$100,000-\$150,000	\$100,000-\$150,000
Subtotal – Potential Design and Permitting Costs:	\$1,170,000-\$1,760,000	\$1,175,000-\$1,770,000	\$1,175,000-\$1,770,000	\$1,180,000-\$1,780,000	\$1,010,000-\$1,640,000
Costs Related to Seismic Reconnaissance Findings:					
Impact to Embankment Construction to Address Fault Rupture ¹⁹ :	\$3,900,000-\$7,800,000	\$4,100,000-\$8,200,000	\$4,200,000-\$8,400,000	\$4,500,000-\$9,000,000	\$2,200,000-\$4,400,000
Costs Related to Other Elements the Dungeness Reservoir Work Group Has Requested that We Include in the Project:					
Construction of Downstream Irrigation Pipelines, Not Included in Prior Costs ¹⁷ :	\$4,500,000-\$5,000,000	\$4,500,000-\$5,000,000	\$4,500,000-\$5,000,000	\$3,700,000-\$4,400,000	\$3,700,000-\$4,400,000
Construction of Drought Relief Pump Station, Not Included in Prior Costs ¹⁸ :	\$850,000-\$1,000,000	\$850,000-\$1,000,000	\$850,000-\$1,000,000	\$850,000-\$1,000,000	\$850,000-\$1,000,000
Other Costs:					
Inflation ²⁰ :	\$1,900,000-\$3,900,000	\$2,000,000-\$4,100,000	\$2,100,000-\$4,200,000	\$2,200,000-\$4,400,000	\$2,200,000-\$4,400,000
Subtotal – Potential Construction Cost Impact:	\$11,150,000-\$17,700,000	\$11,450,000-\$18,300,000	\$11,650,000-\$18,600,000	\$11,250,000-\$18,800,000	\$8,950,000-\$14,200,000

Notes:

- The reservoir bottom of each configuration is sloped. This represents the approximate average bottom elevation.
- The ground elevation was estimated from LiDAR under the embankment near where the HID H-1 Lateral crosses the north and south embankments. The existing ground elevations vary around across the reservoir and embankment area.
- The interior and exterior slopes shown may need to be increased to match the recommendations from the final geotechnical engineering reports.
- The volumes of storage above and below the ground elevation at the north end of the reservoir were estimated based on the elevation listed as the "Approximate Existing Ground Elevation at North Embankment."
- The area and volume of till that would be disturbed or removed by the excavation was based on a comparison of the bottom of the reservoir with an assumed till layer that is only based on data from the Phase 1 borings. A refined till surface layer is being developed and will be used at 60% design to refine these numbers.
- The total estimated excess material represents the difference between the total estimated cut or excavation required and the total estimated fill required. The opinion of probable costs assumes that the excess material will be excavated, placed, and compacted somewhere on site. The exact method for handling excess material (placement on-site, hauling away, or marketing to someone else for processing) will need to be addressed as the design progresses.
- All costs are based on the unit costs developed for the opinion of probable cost that was submitted with the preliminary design in February 2022. Unit costs reflect our understanding of what materials and labor costs were at that time and are only provided for comparison. Costs have not been inflated to reflect current (August 2023) materials and labor costs. Costs will be updated as the design progresses to reflect materials and labor costs at the time of each deliverable. Costs include an allowance for items not yet identified, a 15% contingency, sales tax (8.5%), and an allowance for construction management (8% of the total estimated construction cost).
- Other potential project costs include additional field work, design, permitting, and construction-related work for items that are not currently included in the opinion of probable costs, but will likely be required, for key elements included in the project. These represent work or impacts that could be incurred by the project to address recent comments received from the Dungeness Reservoir Work Group or in response to the results of the recently complete seismic reconnaissance effort. These costs have not been evaluated in detail yet, but order of magnitude cost ranges have been provided to help Clallam County compare the potential reservoir configurations.
- If the reservoir embankment is constructed across the location of the fault zone identified by the recently completed seismic reconnaissance (preliminary design and Revised Configurations A, B, and C), seismic trenching will likely be required to confirm the location of the faults and fault zone on the site and better understand the characteristics of the faults and fault zone. If the reservoir embankment is shifted to the south (Option D), assessment of the fault system will likely still be required, though may be reduced in scope. This line item provides an order-of-magnitude range for the cost of seismic trenching and other field work and reporting that may be required for each case. These costs have not been developed in detail yet through consultation with an excavation contractor. Input from Ecology's Dam Safety Office and additional effort will be needed to estimate these costs.
- Additional analyses would be required, beyond the effort currently reflected in Anchor QEA's approved scope of work, to determine the vertical and horizontal displacement due to fault rupture, and the corresponding impact to the reservoir embankment. If the reservoir is shifted to the south (Option D), evaluations of potential displacements due to nearby fault rupture, and the impact on the dam embankment will likely still be required.
- Additional design work would be required to develop an embankment zoning design to accommodate the calculated vertical and horizontal displacement due to fault rupture or nearby fault rupture.
- This item represents additional effort that may be required, beyond the effort currently reflected in Anchor QEA's approved scope of work, to consult with Ecology's Dam Safety Office regarding the identified fault zone and corresponding evaluations.
- This item represents additional effort that may be required to consult with Bonneville Power Administration (BPA) regarding reservoir-related work within their easement. Option D, which shifts the reservoir to the south, may result in additional impacts to BPA's easement across the reservoir site and will likely require additional consultation to understand their requirements and confirm that the reservoir can be constructed around their infrastructure.
- The Phase 2 geotechnical investigation includes additional borings and test pits that have not yet been completed due to delays in getting an updated land use license from the Washington Department of Natural Resources. If the reservoir is shifted to the south (Option D), the Phase 2 geotechnical investigation would need to be revised to reflect the revised footprint of the project. This item reflects the likely change in cost in the Phase 2 geotechnical investigation, as additional borings and test pits would be needed to characterize subsurface conditions within the new project footprint.
- The scope of work approved for the Phase 2 design effort assumed that the detailed design would build off of the preliminary design and that the reservoir footprint and configuration would be generally the same as what is shown in the preliminary design documents. Additional costs have already been incurred to evaluate alternative reservoir configurations shown in the figures presented with this table. This item does not include costs already incurred to evaluate alternative reservoir configurations or participate in multiple discussions related to identification of the faults and preliminary assessment of reservoir alternatives, but reflects costs that would be incurred moving forward to bring the design of the selected reservoir configuration up to the same level of detail as the preliminary design and get the drawings ready for permitting.

16. A wetland survey was completed at the site in 2021, but that survey did not extend throughout the south end of the site (south of the BPA easement). In addition, if the reservoir is shifted to the south (Option D) there will likely be impacts to the wetland that was identified at the site. Some additional costs would be incurred to perform the additional wetland survey and identify mitigation for impacts to the small wetland on site.
17. The Dungeness Water Users Association has indicated that they would like the design and construction of irrigation pipelines downstream of the reservoir to be completed as part of the reservoir project and accounted for within the reservoir project costs. The costs allocated for design and construction of these pipelines reflect costs that were originally developed in June 2021, when the preliminary design of the pipelines was developed by Anchor QEA under a separate agreement with Clallam Conservation District. The detailed design of these pipelines is not included in Anchor QEA's Phase 2 scope of work for the detailed design of the reservoir and related facilities. The construction of some of the pipelines, immediately downstream of the reservoir, was included in the opinion of costs for Options C and D because they would be required to lower the bottom elevation of the reservoir. The cost of the additional downstream irrigation pipelines are included in the additional items referenced by this note.
18. The Dungeness Water Users Association have also expressed interest in including a pump station and related facilities that would supply water from the reservoir to the Highland Irrigation District Canal so that the portions of the HID delivery system that are not downstream of the reservoir can be served with reservoir water, when desired. Anchor QEA's Phase 2 scope of work includes a high-level feasibility evaluation of these facilities, but does not include detailed design of the facilities. The costs indicated are rough estimates of what it would take to design and build these facilities. Refined opinions of cost are being completed as part of the high-level feasibility evaluation of the drought pumping facilities.
19. Additional construction costs would result from modifications to the embankment design that would be needed to accommodate fault rupture if the reservoir embankment is constructed across the location of the fault zone identified by the recently completed seismic reconnaissance (preliminary design and Revised Configurations A, B, and C). If the reservoir embankment is shifted to the south (Option D), additional construction costs for embankment design to accommodate nearby fault rupture, would be less than the other configurations. For example, the thickness of the core and filter materials in the embankment may need to be increased to accommodate horizontal displacement that may occur, and freeboard may need to be increased to accommodate vertical displacement that may occur. The cost of these additional materials will need to be evaluated in more detail as the design is revised based on the additional analyses noted above. This item includes an allowance of 10%-20% of the opinion of probable cost for the additional cost of materials that may need to be processed and placed to accommodate fault rupture (preliminary design and Revised Configurations A, B, and C) and 5%-10% of the opinion of probable cost for Option D.
20. As noted above, all costs are based on the unit costs developed for the opinion of probable cost that was submitted with the preliminary design in February 2022. Inflation has drive construction labor and materials costs up since February 2022. The Engineering News Record (ENR) Construction Cost Index, for example, has increased more than 5% since February 2022. An inflation item was included as a potential additional construction cost to account for the likely increase in the cost of construction from February 2022 to the time the project is constructed. An allowance of 5% to 10% of the opinion of probable construction cost was included as the item referred to be this note.

Table 1B
Comparison of Optional Reservoir Configurations to Preliminary Design

Key Design Consideration	Reservoir Configuration				
	2022 Preliminary (30%) Design	Revised Configuration Option A	Revised Configuration Option B	Revised Configuration Option C	Revised Configuration Option D
Reservoir Operation	<ul style="list-style-type: none"> Would fill and release water by gravity. 	<ul style="list-style-type: none"> Would fill and release water by gravity. 	<ul style="list-style-type: none"> Would fill and release water by gravity. 	<ul style="list-style-type: none"> Would fill and release water by gravity. Would require construction of a lower outlet pipeline and irrigation pipelines extending north of the reservoir property to release water by gravity. 	<ul style="list-style-type: none"> Would fill and release water by gravity. Would require construction of a lower outlet pipeline and irrigation pipelines extending north of the reservoir property to release water by gravity.
Reservoir Safety	<ul style="list-style-type: none"> Would be designed to meet the most stringent Dam Safety Office guidelines and requirements. Safety features include controlled reservoir inflow and releases, emergency spillway designed for 1 in 1,000,000-year storm, embankment designed for extreme seismic event, seepage control measures, and operation that will limit time reservoir is full. Embankment design would need to be refined to be stable with potential fault activity on the site through the reservoir footprint. 	<ul style="list-style-type: none"> Would be designed to meet the most stringent Dam Safety Office guidelines and requirements. Safety features include controlled reservoir inflow and releases, emergency spillway designed for 1 in 1,000,000-year storm, embankment designed for extreme seismic event, seepage control measures, and operation that will limit time reservoir is full. Embankment design would need to be refined to be stable with potential fault activity on the site through the reservoir footprint. 	<ul style="list-style-type: none"> Would be designed to meet the most stringent Dam Safety Office guidelines and requirements. Safety features include controlled reservoir inflow and releases, emergency spillway designed for 1 in 1,000,000-year storm, embankment designed for extreme seismic event, seepage control measures, and operation that will limit time reservoir is full. Embankment design would need to be refined to be stable with potential fault activity on the site through the reservoir footprint. 	<ul style="list-style-type: none"> Would be designed to meet the most stringent Dam Safety Office guidelines and requirements. Safety features include controlled reservoir inflow and releases, emergency spillway designed for 1 in 1,000,000-year storm, embankment designed for extreme seismic event, seepage control measures, and operation that will limit time reservoir is full. Embankment design would need to be refined to be stable with potential fault activity on the site through the reservoir footprint. 	<ul style="list-style-type: none"> Would be designed to meet the most stringent Dam Safety Office guidelines and requirements. Safety features include controlled reservoir inflow and releases, emergency spillway designed for 1 in 1,000,000-year storm, embankment designed for extreme seismic event, seepage control measures, and operation that will limit time reservoir is full. Shifted south to avoid overlap with anticipated fault zone. Would still need to be designed to accommodate fault activity on the site.
Site Constraints	<ul style="list-style-type: none"> Private properties (north) River Road (east) BPA easement, wetland (south) Shoreline buffer, bluff (west) 	<ul style="list-style-type: none"> Private properties (north) River Road (east) BPA easement, wetland (south) Shoreline buffer, bluff (west) 	<ul style="list-style-type: none"> Private properties (north) River Road (east) BPA easement, wetland (south) Shoreline buffer, bluff (west) 	<ul style="list-style-type: none"> Private properties (north) River Road (east) BPA easement, wetland (south) Shoreline buffer, bluff (west) 	<ul style="list-style-type: none"> Private properties (north) River Road (east, south) BPA Easement - Reservoir designed on both sides of BPA easement. Wetland - Will be impacted. Shoreline buffer, bluff (west, south)
Reservoir Footprint and Impact on Site	<ul style="list-style-type: none"> Smallest footprint Least impact on site Higher, more visible embankment 	<ul style="list-style-type: none"> Increased footprint from preliminary design Slightly more impact on site Lower, less visible embankment 	<ul style="list-style-type: none"> Increased footprint from preliminary design Slightly more impact on site Lower, less visible embankment 	<ul style="list-style-type: none"> Increased footprint from preliminary design Slightly more impact on site Lowest, least visible embankment 	<ul style="list-style-type: none"> Small footprint Impact right up to BPA easement Impact to small wetland Lower, less visible embankment, especially for south reservoir
Distance from North Property Boundary	<ul style="list-style-type: none"> 1,574 feet 	<ul style="list-style-type: none"> 1,362 feet North embankment shifted closer to north property boundary from the preliminary design. 	<ul style="list-style-type: none"> 1,320 feet North embankment shifted closer to north property boundary from the preliminary design. 	<ul style="list-style-type: none"> 1,115 feet North embankment shifted closer to north property boundary from the preliminary design. 	<ul style="list-style-type: none"> 2,285 feet Entire reservoir shifted south to avoid overlap with anticipated fault zone.
Reservoir Storage Capacity	<ul style="list-style-type: none"> 1,591 acre-feet 	<ul style="list-style-type: none"> 1,595 acre-feet 	<ul style="list-style-type: none"> 1,544 acre-feet 	<ul style="list-style-type: none"> 1,591 acre-feet 	<ul style="list-style-type: none"> 1,420 acre-feet
Flow Restoration Benefit	<ul style="list-style-type: none"> Up to 25 cfs for 32.1 days 	<ul style="list-style-type: none"> Up to 25 cfs for 32.2 days 	<ul style="list-style-type: none"> Up to 25 cfs for 31.1 days 	<ul style="list-style-type: none"> Up to 25 cfs for 32.1 days 	<ul style="list-style-type: none"> Up to 25 cfs for 38.6 days

Key Design Consideration	Reservoir Configuration				
	2022 Preliminary (30%) Design	Revised Configuration Option A	Revised Configuration Option B	Revised Configuration Option C	Revised Configuration Option D
Materials and Construction	<ul style="list-style-type: none"> • Smallest excavation volume required. • Largest fill volume required. • Lowest anticipated till volume generated by excavation. • Most efficient design, would require least earthwork effort and cost. 	<ul style="list-style-type: none"> • Larger excavation volume required. • Smaller fill volume required. • Larger anticipated till volume generated by excavation. • Less efficient design, would require more earthwork effort and cost. 	<ul style="list-style-type: none"> • Larger excavation volume required. • Smaller fill volume required. • Larger anticipated till volume generated by excavation. • Less efficient design, would require more earthwork effort and cost. 	<ul style="list-style-type: none"> • Largest excavation volume required. • Smallest fill volume required. • Larger anticipated till volume generated by excavation. • Least efficient design, would require most earthwork effort and cost. 	<ul style="list-style-type: none"> • Larger excavation volume required. • Fill volume required comparable to Option B. • Largest anticipated till volume generated by excavation. • Less efficient design, would require more earthwork effort and cost
Cost	<ul style="list-style-type: none"> • Lowest Cost • Cost would increase to design, analyze, and construct embankment overlapping with fault zone. • Cost would increase for coordination with BPA, revisions to geotechnical exploration plan to cover new areas, re-design of reservoir, and mitigating for impacts to wetland. • Additional cost included for design and construction of downstream irrigation pipelines and drought pumping station. 	<ul style="list-style-type: none"> • 4th Highest Cost • Cost would increase to design, analyze, and construct embankment overlapping with fault zone. • Cost would increase for coordination with BPA, revisions to geotechnical exploration plan to cover new areas, re-design of reservoir, and mitigating for impacts to wetland. • Additional cost included for design and construction of downstream irrigation pipelines and drought pumping station. 	<ul style="list-style-type: none"> • 3rd Highest Cost • Cost would increase to design, analyze, and construct embankment overlapping with fault zone. • Cost would increase for coordination with BPA, revisions to geotechnical exploration plan to cover new areas, re-design of reservoir, and mitigating for impacts to wetland. • Additional cost included for design and construction of downstream irrigation pipelines and drought pumping station. 	<ul style="list-style-type: none"> • Highest Cost • Cost would increase to design, analyze, and construct embankment overlapping with fault zone. • Cost would increase for coordination with BPA, revisions to geotechnical exploration plan to cover new areas, re-design of reservoir, and mitigating for impacts to wetland. • Additional cost included for design and construction of downstream irrigation pipelines and drought pumping station. 	<ul style="list-style-type: none"> • 2nd Highest Cost • There would be a more modest increase in cost to design, analyze, and construct embankment in proximity to fault zone. • Cost would increase for coordination with BPA, revisions to geotechnical exploration plan to cover new areas, re-design of reservoir, and mitigating for impacts to wetland. • Additional cost included for design and construction of downstream irrigation pipelines and drought pumping station.