DRAFT PRELIMINARY DESIGN REPORT
WHITEMAN COVE ESTUARY RESTORATION

Prepared for

South Puget Sound Salmon Enhancement Group

Prepared by

Anchor QEA, LLC

1605 Cornwall Avenue

Bellingham, Washington

December 2015 (Revised)

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LIST OF ACRONYMS AND ABBREVIATIONS

CFU/100 mL	colony forming unit per 100 milliliters
Cove	Whiteman Cove
DGPS	differential global positioning system
ft/s	foot per second
HEC-RAS	Hydrologic Engineering Centers River Analysis System
mph	miles per hour
mg/L	milligram per liter
MHHW	mean higher high water
MLLW	mean lower low water
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
ppt	parts per thousand
SPSSEG	South Puget Sound Salmon Enhancement Group
USACE	U.S. Army Corps of Engineers
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources

1 PROJECT BACKGROUND

Whiteman Cove (Cove), the project site, is a historic barrier estuary whose natural connection to Puget Sound has been closed by a roadway berm (see Figure 1). Water levels in the Cove are regulated by two gated culverts. Properties adjacent to the Cove include Joemma Beach State Park to the northwest, and private properties inland along the south shoreline of the Cove. The Cove itself includes Washington Department of Natural Resources (WDNR) property along the northwest portion, YMCA Camp Colman to the south of the WDNR parcel, and private residential properties on the northeast portion of the Cove. The roadway berm, which separates Whiteman Cove from Case Inlet (part of South Puget Sound), is owned by WDNR at the north segment of Bay Road KP South and owned by YMCA Camp Colman along the southern segment of the access road, which leads to Camp Coleman to the west (see Figure 2).

Fish passage options at the north culvert are being studied in response to WDNR's obligations under the Permanent Injunction against the State or Washington in *United States of America et al. v. State of Washington et al.*, Western District of Washington Case No. C70-9213, Subproceeding 01-01. An earlier feasibility study, performed by Anchor QEA in 2010, evaluated restoration potential of the site and flood risk to adjacent properties. Anchor QEA was contracted in 2015 by the South Puget Sound Salmon Enhancement Group (SPSSEG) to work with them to enhance the earlier feasibility study through the collection of site-specific information, tidal hydraulics modeling, alternatives analysis, and community outreach efforts. The results of this work (referred to as the Whiteman Cove Restoration Project) are summarized in this report.

2 SITE DESCRIPTION

Whiteman Cove is a historic barrier estuary. Based on reference documents (source unknown) provided to SPSSEG by the Washington Department of Fish and Wildlife (WDFW; shown in Figures 1 and 2 in Appendix A), in 1961 to 1962, the outlet of the estuary was filled with a large dike, and two culverts equipped with intake/outlet valves, stop logs, and rotary screens were installed through breaches in the barrier spit by the Department of Fisheries for operation of Whiteman Cove as a saltwater fish-rearing facility. The base of the control structures was installed at +4.0 feet mean lower low water (MLLW) and the top at +14 feet MLLW with several stop logs to operate surface water levels between +5 feet MLLW and +13 feet MLLW. The culvert structures were designed to control water surface elevation and flow into and out of the Cove to assess and maintain optimum salinity and temperature parameters for fish rearing. Sometime after 1970, the Department of Fisheries terminated their program at this site, and an easement to the road dike and two culverts was assigned to the Fauntleroy YMCA, presently Camp Coleman. The valve and rotary screen on the northern structure on WDNR-owned land is inoperable. The southern structure falls within YMCA ownership, and camp representatives have noted that, when tide levels become high in the lagoon, the Camp is often asked by neighbors to remove stop logs to manually control water levels. At present, there does not appear to be an operational water surface elevation enforced in the Lagoon.

Fresh water inflows to the site from upland drainage at the eastern end of the Cove. The Cove is used for recreation and educational programs managed by the YMCA through Camp Coleman, which occupies a large portion of the southern shoreline of the Cove. The Cove is also used for recreation (primarily small, non-motorized boat use) by private home owners and the public. This feature is a remnant of a trolley ramp that was used to portage small boats between Whiteman Cove and Puget Sound.

The shoreline, submerged area, and upland areas of Whiteman Cove have varied ownership, including WDNR, YMCA Camp Coleman, and private property owners. Figure 2 shows property boundaries adjacent to and within Whiteman Cove as of November 2010. Site topography, tidal hydraulics, and coastal processes within the Cove are described in more detail in the following sections.

2.1 Topography and Bathymetry

Historical bathymetry data in the Cove are scarce; however, an older bathymetry map was provided to SPSSEG by the WDFW (source unknown) and is shown in Figure 1 in Appendix A. Current bathymetry data within the Cove were collected by Anchor QEA as part of this feasibility and design work. Anchor QEA staff collected bathymetry data in the lagoon on September 15, 2014, on a lead line, in conjunction with a differential global positioning system (DGPS), to develop a bathymetric dataset, which was combined with existing topographic data (Puget Sound Lidar Consortium 2006) to estimate shoreline and topography. Lead line data were converted to bed elevations (in North American Vertical Datum of 1988 [NAVD88]) based on a reference elevation at the northern gated culvert head wall. These elevations were converted to MLLW based on tidal datum information provided in Table 1. Figure 3 shows the locations of collected bathymetry data points and the combined bathymetry/topography contours developed for the project site.

Bed elevations in the Cove generally slope upwards moving inland, from 5 to 7 feet MLLW at the toe of the roadway berm to 10 feet MLLW at the back end of the Cove. Water depths in the Cove at the time of data collection ranged from 6 to 7 feet at the western end of the Cove to 2 to 3 feet at the back end of the Cove, with one deeper area (about 9 feet) just east of the YMCA dock. The surrounding upland area is steeply sloped away from the shoreline over a majority of the Cove.

2.2 Tidal Hydraulics and Upland Drainage

Tidal datum information for the site was estimated from the tidal station at Olympia, Washington (No. 9446969). This tidal station was chosen because it was the closest station to the site that includes a conversion to NAVD88. Table 1 below provides the tidal datum information from the Olympia, Washington, station.

Extreme high tide elevation at the site was taken from tidal predications from the National Oceanic and Atmospheric Administration (NOAA) tide station at McMicken Island in Case Inlet (No. 9446583). Elevations in MLLW were converted to NAVD88 for comparison with existing LiDAR data using the conversion shown in Table 1 (0 feet MLLW= -4.0 feet

NAVD88). Extreme high tide (not including the influence of storm surge) was found to be approximately 13.5 feet NAVD88.

Table 1
Tidal Datums at Olympia, Washington (No. 9446969)

Tidal Datum	Value (feet relative to MLLW)	Value (feet relative to NAVD88)
Mean Higher High Water (MHHW)	14.5	10.5
Mean High Water (MHW)	13.5	9.5
Mean Tide Level (MTL)	8.3	4.3
North American Vertical Datum of 1988 (NAVD88)	4.0	0.0
Mean Low Water (MLW)	3.0	-1.0
Mean Lower Low Water (MLLW)	0.0	-4.0

Freshwater input to the Cove comes from a small intermittent stream (Figure 3) that drains the approximately 1.7-square-mile upland watershed. Hydrology predicted for the watershed based on Washington StreamStats (USGS 2012) is shown in Table 2.

Table 2
Predicted Hydrology for Whiteman, Washington StreamStats

Return Period (years)	Flow (cubic feet per second)
2	55
10	100
25	120
50	140
100	161
500	210

Source: USGS 2012

Average and seasonal salinity in the Cove is not known; however, salinity data were collected as part of the water quality sampling effort conducted as part of our services and are described in detail in Section 4.3 of this report. Those data were collected on April, 15, 2015, and on that date salinity ranged from 17.5 to 22.4 parts per thousand (ppt), with higher salinities near the gated culvert locations. Sample WQ-04, located at the back end of the Cove, had a surface salinity of about 2 ppt; due to freshwater inflow at that location.

2.3 Coastal Processes

Whiteman Cove is located along the eastern shoreline of Case Inlet. Littoral drift along the shoreline is from south to north (Ecology 1991), both currently and historically, due to predominant winds from the southwest. Historically, Whiteman Cove was separated from Case Inlet by a spit that extended from the south to the north, with the outlet of the Cove to the north. The spit forms as sediment is transported along the shoreline from the south to the north due to littoral drift; this process also maintains the Cove outlet to the north. Figure 4a provides a topography sheet ("T-sheet") from 1878 and Figure 4b provides a hydrography sheet ("H-sheet) from 1935 for Whiteman Cove. Both the T- and H-sheets show the spit extending to the north with the opening to the Cove to the north. The H-sheet (Figure 4b) shows depths along the shoreline at the opening to the Cove and no depth information within the Cove itself. This implies that the Cove may not have been navigable at the time the survey was taken. Water depths identified along the shoreline near the opening of the lagoon in Figure 4b are shallow, ranging from 0 feet MLLW to approximately -1 foot MLLW. (Elevations on the H-sheet are positive down and are in fathoms relative to MLLW). No deeper channel into the Cove is identified in either the T-sheet or the H-sheet.

Figure 5 shows an aerial photograph of the Cove from 1951, which was taken prior to the Cove being closed off with additional roadway fill and construction of the gated culverts. Figure 5 also shows bathymetry (bed elevation) data in the Cove collected as part of this project (Anchor QEA 2014). The 1951 photograph shows a similar configuration for the Cove as shown in both the T-sheet (Figure 4a) and the H-sheet (Figure 4b). The spit extends to the north, and the opening to the lagoon is also to the north. The 1951 photograph also shows an approximately 260-foot opening; however, the channel system within the opening is braided with two low flow channels that are less than 50 feet in width. A large flood shoal is visible in the 1951 photograph; this is the large sediment deposit located inside the lagoon adjacent to the opening. A flood shoal is formed when sediment is transported via tidal currents or waves into the lagoon through the opening, and then settles out in the lagoon where the tidal currents are smaller and wave energy is lower. Bed elevation data collected in 2014 follow the shape of the lagoon as shown in the 1951 photograph; these data also point to shallow areas of sediment deposition and deeper areas where ponded water is visible in the photograph. This implies that the bed elevations within the Cove had not changed significantly since it was closed off in 1951.

Freshwater input to the Cove comes from upland drainage and is minimal (see Table 2). The historical flows into the Cove may have been higher because of the lack of both local development and stormwater retention in the watershed. However, it is unlikely that it was significantly higher than at present. Prior to closure, the Cove inlet appears to have been maintained primarily by tidal currents associated with filling and emptying of the Cove.

The historic and present day sediment source to the nearshore area adjacent to the Cove is from coastal bluffs located to the south of the project site. These areas are identified as unstable and as having historic and recent slide activity (Ecology 2006). These sediments are introduced to the nearshore areas south of the project site through bluff erosion and landslides and are transported to the project site through littoral drift.

2.4 Wind-generated Waves

The nearshore area at Whiteman Cove is subject to impact from storm waves within Case Inlet. The roadway berm separating the Cove from Case Inlet protects the Cove from wave energy. If the roadway berm is opened to tidal flows, waves could potentially travel into the Cove, especially during flood tides when water levels are high. Impacts in the Cove from these storm waves would be minimal if the opening were placed in its historical location to the north (see Figure 5). If the opening were moved farther south into the middle of the spit, wave energy might move into the Cove during storms, and this would need to be taken into consideration during final design. For the purpose of this preliminary design report, storm waves are estimated in Case Inlet for a variety of return periods for use in final design of a preferred alternative.

The primary type of waves expected to impact the Cove would be wind-generated waves during high wind events. The sustained wind that acts over a waterbody imparts energy to the water surface, which results in wave formation. The amount of wind energy transferred to the water determines wave height, which can be estimated based on the wind speed, water depth, and distance over which the wind can act on the water (fetch distance). To determine the potential wind speeds and wind-generated waves that could affect the roadway berm and potentially the Cove, a statistical analysis of local wind data was conducted and wind-generated wave height and period were estimated for the computed return period wind speeds.

Wind data were obtained from the National Climatic Data Center for the Olympia Municipal Airport (WBAN station I.D. 24227). This station provided the most complete historical wind record within the general vicinity of the site (approximately 17 miles south of Whiteman Cove). The hourly measurements of wind speed and direction were available for 1948 through 2015 (68 years). The wind rose diagram in Figure 6 shows the direction, frequency, and magnitude of the wind data. The wind rose indicates the winds are primarily blowing from the south and southwest (approximately 45% of the time). A statistical analysis was performed based on the wind direction, with the wind direction and wind speed grouped into 30-degree directional bins for fetch directions that could result in waves impacting the Cove. The directional bins selected for the analysis were south and southwest (195 to 225 degrees), west (255 to 285 degrees), and west and northwest (285 to 315 degrees). Figure 7 shows the fetch distances for potential wind-generated waves at the site. Five candidate probability distribution functions (Fisher-Tippet Type I and Weibull distributions with exponent k varying from 1.0 to 2.0) were then fitted to the maximum yearly wind speed for each directional bin. The 10-, 20-, 50-, and 100-year return-interval wind speed was calculated by applying the best fit distribution. The best fit return period wind speed distributions for each directional bin are shown in Figure 8.

The 10-, 20-, 50-, and 100-year return period wind speed in each evaluated directional bin was used to compute the corresponding return interval wave height using the U.S. Army Corps of Engineers (USACE) Automated Coastal Engineering System (ACES) computer program (USACE 1992). The predicted wave height and period was computed based on the return interval wind speed, fetch length for each direction, average fetch water depth, and observed wind duration (recorded hourly and assumed to be a 15-minute duration for wave generation). The fetch distance, average fetch depth, return period wind speeds, wave height, and wave period results are summarized in Table 3.

The results of the wind-generated wave analysis indicate that the 100-year wind speed of 58 miles per hour (mph) from the southwest (225 degrees) has the potential to produce waves with a height of up to 5.1 feet with a period of 3.9 seconds. However, it would be unlikely for these large waves to travel through any opening into the Cove or impact the Cove shoreline directly, based on the shoreline orientation facing the northwest. The potential fetch directions from the west and northwest have significantly lower 100-year wind speeds (33.7 and 34.7 mph, respectively) and shorter fetch distances, and therefore have significantly smaller 100-year wave heights of 1.6 and 2.3 feet, respectively.

Table 3
Wind-generated Wave Return Period Analysis

Fetch Direction (degrees)	Fetch Distance (miles)	Average Fetch Depth (feet)	Wind Speed (mph)				Wave Height (feet)				Wave Period (seconds)			
			10-year	20-year	50-year	100-year	10-year	20-year	50-year	100-year	10-year	20-year	50-year	100-year
Southwest (225)	4.3	135	40.0	45.4	52.6	58.0	3.1	3.7	4.5	5.1	3.3	3.5	3.7	3.9
West (270)	2.0	132	28.8	30.5	32.4	33.7	1.4	1.5	1.6	1.7	2.2	2.3	2.3	2.4
Northwest (315)	3.9	110	25.9	28.6	32.1	34.7	1.7	2.0	2.3	2.5	2.6	2.7	2.9	3.0

Notes:
Average fetch depth was computed based on the NOAA (1998) 30-meter resolution digital elevation model (DEM) water depths.
mph = miles per hour

3 CONCEPTUAL ALTERNATIVES ASSESSMENT

Conceptual alternatives for restoration of Whiteman Cove to provide tidal exchange and fish passage were developed through discussion with SPSSEG and representatives from the Squaxin Island Tribe, WDNR, and YMCA Camp Coleman. Concepts that were considered ranged from partial restoration (i.e., tide gates, culverts) to full restoration (i.e., open channels). Openings (structural or open channels) in the roadway berm were considered at two locations (shown in Figure 9): Location 1, which is the historical (1951) Cove opening shown in Figure 5; and Location 2, which is the location of the existing northern gated culvert. A preliminary evaluation of the bathymetry data in the Cove suggested that full restoration would fully drain most of the Cove during lower tide periods; therefore, concepts were considered that would retain a higher water surface elevation in the Cove during lower tide periods. Concepts that were developed as part of these discussions, and moved forward in the analysis, are summarized below:

- Self-regulating tide gate constructed at Location 2
- Various types of weirs at Location 2
- Larger box culvert at Location 2
- Open channels at Locations 1 and 2 of various widths (10 feet to 260 feet)

These concepts were further evaluated using hydraulic modeling and reference site analysis, as discussed in Sections 3.1 and 3.2 of this report.

3.1 Hydraulic Assessment

Conceptual level hydrodynamic modeling (one-dimensional) was used to evaluate the water surface elevations and average velocities within the Cove under a series of restoration options. The purpose of the modeling effort was to identify potential impacts to property owners within the Cove due to proposed restoration actions and to inform selection of a preferred restoration alternative for the site. The results of the modeling were also used to evaluate potential changes in sediment transport along the adjacent marine shoreline and within Whiteman Cove post-restoration. The HEC-RAS model developed by the U.S. Army Corps of Engineers (USACE 2010) was used to conduct the hydraulic assessment. HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels, including hydraulic structures.

3.1.1 Model Development

The HEC-RAS model for Whiteman Cove was developed using the topography and bathymetry data shown in Figure 3 and included all of Whiteman Cove, the shoreline of the Cove up to 5 feet above mean higher high water (MHHW) elevation, and the marine shoreline area fronting the roadway berm (Case Inlet). Constant freshwater input was added to the model at the eastern end of the Cove, as the upstream boundary condition, and varied between 2 and 5 cubic feet per second. Low flows, rather than storm-event level flows (i.e., 55 cubic feet per second for a 2-year event, per Table 2) were used in the model simulations to better represent typical, everyday conditions in the Cove because this hydrology can provide a better evaluation of potential fish passage. Tidal elevations in Case Inlet, based on hourly tide data at NOAA gage No. 9446484, Tacoma, Washington, were used as the unsteady downstream boundary condition for all model runs. Hourly tide data from January 30, 2015, to February 14, 2015, were used as the downstream boundary condition because this time period includes king tide elevations, as well as semi-diurnal and diurnal variation in water surface elevation, to provide a wide range of tidal conditions over the model simulation. Model simulation time for each model scenario was approximately 14 days; the tidal boundary condition is provided in Figure 10. The frequency distribution of tidal elevations over the 14-day model simulation time (percent of time a select tidal elevation is exceeded) is provided in Figure 11.

3.1.2 Model Scenarios

Restoration options modeled as part of the Whiteman Cove Restoration Project include gated culverts, weirs, and open channels of various widths (10 feet through 260 feet). Open channel options included confined openings, which are smaller than the historical opening width (as shown in the 1951 photograph in Figure 5) and would be confined by construction of a bridge over the opening to retain the existing roadway. An unconfined open channel option was also considered, which had a width of 260 feet, approximately the opening size in 1951, and would not be confined by a bridge. The list of model scenarios is provided in Table 4; all scenarios were conducted with tidal and inflow conditions described in Section 3.1.1. Typical sections of channel and weir openings used in the model are provided in Figure 12.

Table 4
Hydraulic Model Simulations

Type of Opening	Width/Diameter	Thalweg/Invert Elevation	Notes
Culvert/Tide Gate	4 foot Dia.	+5 feet MLLW	Geometry of culvert is the same as existing north gated culvert outlet. Modeled as culvert to evaluate fish passage in gated culvert when open.
V-Weir	40 feet	+9 feet MLLW	Purpose of V-Weir simulation was to evaluate potential for fish passage coupled with a perched water surface elevation in Cove at lower tides.
Confined Open Channel	10 feet	+7 feet MLLW	Thalweg elevation set to approximately 1 foot below mean tide level, the approximate elevation of the Cove bottom at the opening location.
Confined Open Channel	25 feet	+7 feet MLLW	(See note for 10-foot open channel.)
Confined Open Channel	25 feet	+9 feet MLLW	Thalweg elevation set to approximately 1 foot above mean tide level, to evaluate potential for fish passage coupled with a perched water surface elevation in Cove at lower tides.
Confined Open Channel	40 feet	+7 feet MLLW	(See note for 10-foot open channel.)
Unconfined Open Channel	260 feet	+6.6 feet MLLW	Approximate opening size and thalweg elevation in 1951.

Note:
MLLW = mean lower low water

The results of the model are not dependent on the opening location (Location 1 or 2); water surface elevations within the Cove and average velocities in the openings are expected to be the same for both opening locations. Therefore, the hydraulic model was set up to place all proposed openings at Location 1.

3.1.3 Model Results

For each model simulation listed in Table 4, water surface elevations and average velocities in the Cove and/or proposed opening were extracted from the model to evaluate tidal flushing of the Cove and potential for fish passage into the Cove post-restoration.

3.1.3.1 Predicted Tidal Flushing of the Cove

Time-series of water surface elevations for the various model simulations over a portion of the simulation time are provided in Figure 13 (for culvert and V-Weir options), Figure 14 (for confined open channel options), and Figure 15 (for the 260-foot opening). These figures show the water surface elevations (tides) in Case Inlet compared to water surface elevations predicted within the Cove due to various restoration options (different openings into the Cove). Some of the proposed restoration options limit tidal flushing within the Cove, while others provide full tidal inundation and restoration of estuary processes with the Cove.

Model results show that the culvert option limits tidal inundation into the Cove, both for high and low tides, at low freshwater inflow rates which are typical of the system (see Figure 13). Water surface elevations within the Cove are up to 4 feet lower than high tide elevations in Case Inlet. During ebb tide, the water surface elevation in the Cove decreases linearly with the culvert option (instead of sinusoidally) and remains perched approximately 4 feet above the invert elevation of the culvert even at the lowest tides. The V-Weir option allows for full tidal inundation (high tide elevations) within the Cove during higher tides and allows the water elevation to remain perched slightly above the invert elevation of the weir during lower tides (+9 feet MLLW) (see Figure 13).

The confined channel options (Figure 14) all provide full tidal inundation at high tides but result in different water levels in the Cove during lower tides. The 10-foot opening acts similar to the culvert option; the water level decreases linearly and remains perched above the invert elevation of the channel (+7 feet MLLW) by up to 2 feet (during low inflows). However, unlike the culvert option, the 10-foot channel allows high tide elevations to exceed the current elevations. The 25-foot opening allows for additional draining of the Cove during low tides, but the water surface elevation in the Cove remains about 1 foot above the channel thalweg at lowest tide for both the +7 and +9 feet MLLW channel elevations modeled. The 40-foot opening allows the water surface elevation in the Cove to lower sinusoidally and reach the thalweg elevation of the channel (+7 feet MLLW) at lowest tides. Therefore, a 40-foot opening should be considered the minimum opening size to provide full tidal inundation to the Cove (not considering velocities in the channel).

The 260-foot open channel option (Figure 15) is similar to the 40-foot opening in that it provides full tidal inundation at high tides but drains slightly lower to +6.6 feet MLLW at lowest tides.

Figures 16 and 17 provide a frequency distribution of velocities within (or in the vicinity) of the controlled and open channel openings, respectively, to evaluate potential for fish passage and sediment transport for each of the restoration options considered. Maximum velocities in the culvert can reach up to 15 feet per second (ft/s), and 2 to 3 ft/s just upstream or downstream of the V-Weir. In addition, the V-Weir exhibits a drop in water surface elevation (spilling) of more than 1 foot 44% of the simulation time. Maximum velocities within the open channels range from 7.5 ft/s for the 10-foot open channel to 2 ft/s for the 260-foot open channel. Velocities quickly drop off for all opening sizes considered inside the lagoon, where the channel opens up to the entire width of the lagoon. Velocities inside the Cove are similar for all opening sizes at less than 0.5 ft/s.

Appendix B provides images that illustrate what the lagoon may look like post-restoration (open channel), including an oblique aerial photograph of the current condition of the lagoon and renderings of the lagoon at mean tide level and MLLW.

3.1.3.2 Potential for Fish Passage

Based on discussions with the SPSSEG, the Squaxin Island Tribe, and WDNR, the percent of time velocities were equal to -1 to 1 ft/s and -2 to 2 ft/s were summarized in each of the figures, where negative velocities are into the Cove (flood tide). Since this is a tidal system, and not a freshwater creek system, -2 to 2 ft/s was considered an appropriate metric for fish passage into the Cove. The 10-foot open channel has velocities less than or equal to 2 ft/s 40% of the simulation time; this increases to 77% of the time for the 40-foot open channel (see Figure 16). The 40-foot channel also has velocities less than or equal to 1 ft/s 43% of the time. Therefore, based on in-channel average velocities, the 40-foot-wide opening is adequate for fish passage into the lagoon during approximately one-half to three-quarters of the tidal cycle, depending on the velocity metric used. The 260-foot channel has much lower velocities predicted in the model than the smaller channels (see Figure 16), but this channel is unconfined and would likely develop multiple channels that would have higher velocities than predicted by the HEC-RAS model. However, the 260-foot channel is considered the natural "bank-full" width of the system prior to its closure and is therefore considered appropriate to meet restoration goals for this system.

Velocities in the culvert exceed 2 ft/s a majority of the time over both ebb and flood tides, with maximum velocities reaching 15 ft/s. This renders the culvert impassable to fish for more than 75% of the tidal cycle, except for fish that may be swept into or out of the culvert. The V-Weir option has lower approach velocities to the structure (1 to 2 feet per second most of the tidal cycle); however, the weir itself has a drop of water surface elevation (spilling) of at least 0.5 foot or more 44% of the tidal cycle. The V-Weir option could be passable to fish at higher tides, but the drop in water surface elevation during much of the tidal cycle would create a barrier to fish passage into or out of the Cove unless multiple weirs were installed.

3.1.3.3 Potential for Sediment Transport

It is generally accepted that velocities of greater than 1 ft/s are large enough to move sand-sized sediments, and areas with velocities less than 1 ft/s will tend to be deposition areas for sands. From the model results for the open channel options, sands can be transported through the Cove opening during flood tide, with a higher transport rate expected for the 10-foot opening (per linear foot of channel). However, once the sandy sediments are transported into the Cove, they will likely deposit just inside the opening due to the sharp decrease in velocity inside the opening. This is in line with the 1951 photograph of the Cove prior to its closure (Figure 5) that shows the presence of a flood shoal inside the opening of the Cove.

3.1.3.4 Inundation of Cove at Lower Tides

Presently, the water surface elevation in the Cove remains relatively constant at +13 feet MLLW. For all proposed restoration actions, the water surface elevation in the Cove will be lower than the current elevation when the tidal height in Case Inlet is less than 13 feet MLLW. Based on the frequency distribution shown in Figure 11, this is approximately 85% of the time. Figure 18 shows the predicted inundation extent (extent of ponded water) in the Cove during different tidal phases based on existing bathymetry and the proposed thalweg channel elevation of 7 feet MLLW. As shown in Figure 18, the majority of the eastern end and northern shoreline of the Cove will be dry during tides of +7 feet MLLW or less. This pattern is consistent with ponded water visible in the 1951 photograph (Figure 5).

3.2 Reference Site Analysis

Two reference sites were examined for comparison with the project site to evaluate long-term changes to the site post-restoration. Reference site No. 1 is located approximately 3 miles to the south (unnamed lagoon) and reference site No. 2 is located approximately 5 miles to the north of Whiteman Cove (Haley State Park), as shown in Figure 19. These sites are shallow coastal lagoons that have similar characteristics to Whiteman Cove, although both are smaller in surface area than Whiteman Cove. The reference sites are located along the eastern shoreline of Case Inlet, have littoral drift rates from south to north, do not have significant inflow from upland rivers or streams, are triangle shaped, and are separated from Case Inlet by a sand spit that extends from the south to the north with an opening to the north. The historic and present day sediment sources downdrift of each reference site (to the south) appear to be unstable and eroding coastal bluffs, similar to Whiteman Cove (Ecology 2006).

Figures 20 and 21 show an aerial photograph and T-sheet for reference site No. 1, respectively, and Figures 22 and 23 show an aerial photograph and T-sheet for reference site No. 2, respectively. The T-sheet images for both reference sites show a spit extending from the south to the north fronting the lagoon with a relatively small outlet channel connecting the lagoon to Case Inlet to the north. The presence and orientation of the spits, as well as the shape of each lagoon, is quite similar between the late 1800s (T-sheet) and the present day (aerial photographs) for both reference sites.

Figure 24 shows a comparison of aerial photographs from 1994, 2010, and 2013 for reference site No. 1. The size of the outlet appears to be relatively stable over that time frame. However, the outlet location migrates slowly northward from 1994 to 2013, and in the 2013 photograph there is only one channel within the lagoon (as opposed to two channels visible in the previous years shown). Figure 25 shows a similar comparison for reference site No. 2, for the years 1990, 2009, and 2013. The location of the outlet at this references site appears to be more dynamic than at reference site No. 1. (This may be due to larger freshwater inflow at this location than at reference site No. 1.) In 1990, the outlet is located far to the north and appears to be a narrow channel. In 2009, the channel appears to be larger and is located south of its location in 1990. This change in location may have been due to a large rainfall event or a wind-wave event that caused erosion of the spit and/or migration of the channel. In the 2013 photograph, the channel has migrated back towards the north and narrowed, similar to the 1990 photograph.

4 OTHER CONSIDERATIONS

4.1 Cultural Resources

There have been no archaeological surveys in the project area; however, there have been two surveys nearby, and one of those recorded an archaeological site. A survey at Camp Coleman in 2009 located no archaeological resources (Ferris et al. 2009). A 1948 survey located site 45PI37, a shell midden on a low bluff near the base of the spit that forms Whiteman Cove. However, the site area was part of a landslide during the 2001 Nisqually earthquake, and no evidence of the site remained post-quake (Avey 2001).

Currently, it is unknown whether there are archaeological materials present in native sediments, where they remain under fill along the spit. If alternatives for improving fish passage at Whiteman Cove are compared, the potential to impact archaeological materials will increase with increased disturbance of native sediments. Alternatives that include more disturbance of native sediments have greater potential to impact unrecorded resources.

4.2 Water Quality

Anchor QEA completed sampling and analysis of water samples from Whiteman Cove to evaluate the potential effect of local septic systems on water quality and resident shellfish beds as part of this project. The Sampling and Analysis Plan developed for this effort is provided in Appendix C.

Anchor QEA collected water quality samples from four locations in Whiteman Cove (Figure 26) for chemical analysis, including one near the northern gated culvert, one near the shoreline dock adjacent to YMCA Camp Coleman, and two at the back end of Whiteman Cove (see WQ-01 to WQ-04, Figure 26). Representative surface water samples were collected by Anchor QEA personnel using a Kemmerer bottle, a grab sampling device that allows water to be collected at a specific depth. To evaluate for potential impacts of local septic systems on surface water quality, five surface water samples (includes one field duplicate) were analyzed for total coliform bacteria, fecal coliform bacteria, and *Escherichia coli* (*E. coli*) bacteria (see Table 5). Samples were also analyzed for the nutrients ammonia, chloride, nitrate, and total phosphorous. Water quality parameters measured in the field at each station prior to sampling included temperature, salinity, dissolved oxygen, pH, and conductivity (Table 6). Salinity profiles were measured at select additional locations within Whiteman Cove as shown in Figure 1 and Table 6.

At each station, the total water depth was measured using a lead line. Water quality samples were collected from the middle (mid-depth) of the water column at each station. Sample depths for each station are presented in Table 6. For the profiling purposes, salinity was measured at the surface and middle depths at all stations and also at the bottom (i.e., just above the mudline) at two additional stations (Sal-1 and Sal-2; Figure 26 and Table 6).

Salinity levels for water quality samples in Whiteman Cove range from 17.5 to 22.4 parts per thousand (ppt); these results fall within the expected range for brackish waters (0.5 to 30 ppt; Tables 5 and 6). Due to the salinity levels and tidal influence of Puget Sound, water quality results for Whiteman Cove are compared to marine surface water quality criteria for Washington State (Washington Administrative Code [WAC] 173-201A-210).

Fecal coliform bacteria levels range from non-detect to 120 colony forming units per 100 milliliters (CFU/100 mL; Table 5). One sample (WQ-04; 120 CFU/100 mL) was above the Washington State marine surface water criterion for *primary* contact recreation (43 CFU/100 mL). Station WQ-04 is located at the back (most inland) end of Whiteman Cove, farthest from the gated culvert). All other sample stations (WQ-01, -02, and -03) had fecal coliform bacteria levels at or below 5 CFU/100 mL.

Nutrient levels for all samples are below Washington State recommended criteria (Table 5). Dissolved oxygen levels range from 9.21 to 10.6 milligrams per liter (mg/L); the lowest 1-day minimum value for aquatic life to categorize as "extraordinary" quality is 7.0 mg/L (WAC 172-201A-210). Measured pH levels at stations WQ-01, -03, and -04 range from 7.27 to 8.09; aquatic life criteria for marine water that qualify as "extraordinary" quality must range from 7.0 to 8.5 (WAC 172-201A-210). One sample (WQ-02) had a pH level of 6.05, below the recommended marine criteria.

For quality assurance, one field duplicate sample was collected at station WQ-01 (sample WQ-51). Results for the field duplicate sample (WQ-51) are comparable to those of the parent sample (WQ-01; Table 5). All samples were submitted for analysis within the recommended hold time(s) of all testing parameters (e.g., no more than 6 hours for fecal coliform bacteria).

Table 5

Whiteman Cove Surface Water Sample Results

	Station ID	WQ-01		WQ-02	WQ-03	WQ-04
	Sample ID	WQ-01	WQ-51	WQ-02	WQ-03	WQ-04
	Sample Date	4/15/2015	4/15/2015	4/15/2015	4/15/2015	4/15/2015
	Sample Depth	3.5 feet	3.5 feet	3.5 feet	2.0 feet	2.0 feet
	Sample Type	Normal	Field Duplicate	Normal	Normal	Normal
Field Parameters						
Temperature (°C)		**13.3**	**13.3**	**13.5**	**12.7**	**11.6**
Salinity (ppt)		**22.4**	**22.4**	**22.3**	**18.7**	**17.5**
Dissolved Oxygen (mg/L)		**10.3**	**10.3**	**9.23**	**9.21**	**10.6**
pH (su)		**7.27**	**7.27**	**6.05**	**8.05**	**8.09**
Conductivity (µS/cm)		**35,583**	**35,583**	**35,371**	**30,313**	**28,360**
Nutrients (mg/L)						
Ammonia		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Nitrate		0.01 U	0.01 U	0.01	0.01 U	**0.07**
Chloride		**11,000**	**9,800**	**10,000**	**9,000**	**6,900**
Total Phosphorous		0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Coliform Bacteria (CFU/100 mL)						
Total Coliform Bacteria		**10**	ND	**30**	**110**	**720**
Fecal Coliform Bacteria		ND	ND	ND	**5**	**120**
Escherichia coli		ND	ND	ND	ND	**90**

Notes:
U = Compound analyzed, but not detected above detection limit (shown at reporting limit)
ND = analyte not detected (no reporting limit)

°C = degrees Celsius
mg/L = milligram per liter
su = standard units

CFU/100 mL = colony forming units per 100 milliliters of water
ppt = parts per thousand
µS/cm = microsiemens per centimeter

Table 6
Salinity, Temperature, DO, and pH Profile for Whiteman Cove

Station ID[1]	Total Water Depth	Sample Depth	Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (mg/L)	pH (su)
WQ-01	7.0 feet	Surface	16.7	11.5	10.5	7.5
WQ-01	7.0 feet	3.5 feet	22.4	13.3	10.3	7.3
WQ-02	7.0 feet	Surface	17	11	9.7	6.7
WQ-02	7.0 feet	3.5 feet	22.3	13.5	9.3	6.0
WQ-03	4.3 feet	Surface	17.5	12.7	10.2	8.1
WQ-03	4.3 feet	2.0 feet	18.7	12.7	9.2	8.09
WQ-04	3.5 feet	Surface	2.3	9.5	11.2	8.6
WQ-04	3.5 feet	2.0 feet	17.5	11.6	10.6	8
South Tide Gate (Sal-1)	7.5 feet	Surface	20.4	n/a	n/a	n/a
South Tide Gate (Sal-1)	7.5 feet	3.5 feet	22.1	n/a	n/a	n/a
South Tide Gate (Sal-1)	7.5 feet	Near Bottom	23.6	n/a	n/a	n/a
Middle Cove (Sal-2)	7.5 feet	Surface	17.3	n/a	n/a	n/a
Middle Cove (Sal-2)	7.5 feet	3.5 feet	22.7	n/a	n/a	n/a
Middle Cove (Sal-2)	7.5 feet	Near Bottom	24	n/a	n/a	n/a

Notes:
1. See Figure 1 for Station Locations.
°C = degrees Celsius
ppt = parts per thousand
mg/L = milligram per liter
su = standard units

5 CONCLUSIONS AND RECOMMENDATIONS

Proposed restoration options in Whiteman Cove were evaluated to determine potential for fish passage, impacts to property owners within the Cove, and impacts to sediment transport patterns within the Cove. The results of the evaluation were used to inform discussion of a preferred alternative for the project.

Hydraulic modeling was conducted for various openings for the Cove out to Case Inlet, including a culvert, weir, and various open channels. The results of the modeling show that a 40-foot-wide channel opening would provide full tidal inundation (at high and low tides) within the Cove and provide adequate velocities (less than 2 ft/s) within the opening to allow fish passage a majority of the time over the tidal cycle. The thalweg elevation of +7 feet MLLW is consistent with the bed elevation inside the Cove at the proposed opening location and should be sustainable in the long-term based on evaluation of reference sites and the lack of freshwater input to the Cove, making the system tidally driven post-restoration.

Opening sizes of less than 40 feet are predicted to attenuate the tide at lower tides (perch the water surface elevation in the Cove) and increase velocities in the channel, thus limiting fish passage compared to the 40-foot opening. The culvert option attenuates the tide at both the high and low end of the tidal range, which can limit the water surface elevations that are reached for both high and low tide within the Cove. For example, once the water level within the Cove drops during low tides, the culvert option may attenuate the tide in such a way that it will not completely fill at high tide before the subsequent low tide occurs. In addition to impacts to water surface elevations within the Cove, high predicted velocities in the culvert over most of the tidal cycle would preclude fish passage into the Cove. The V-Weir option has lower velocities during most of the tidal cycle compared to the culvert option, but the weir spills over at both flood and ebb tide at heights equal to or greater than 0.5 foot during almost half of the tidal cycle. The V-Weir option does perch the water surface elevation slightly in the Cove at lower tides, but it is not a significant enough gain to offset the lack of fish-passable time for that option.

All proposed restoration options will significantly lower the elevation of the water in the Cove for a significant amount of time. At the mean tide level in Case Inlet, most of the back end of the Cove will be dry and water depths will be much shallower in the vicinity of the YMCA dock than at present (see Renderings in Appendix B). The current water elevation is approximately 13 feet MLLW; post restoration water elevations will be less than this value approximately 85% of the time.

The longer-term post-restoration behavior of the outlet of Whiteman Cove can be evaluated though examination of the historical condition of the Cove itself, the dynamic behavior of similar sites, and review of modeling results for the restoration options.

The historical information available for Whiteman Cove prior to its closure (Figures 4a, 4b, and 5) show consistent presence of a spit extending to the north with a narrow and shallow opening to the Cove towards the north. It is possible that the Cove opening closed off due to northern littoral drift at some point in the past; however, this was not found in any of the historical information reviewed.

In order to obtain a better understanding of the sustainability of the proposed outlet channel for Whiteman Cove, two reference sites were examined. These reference sites have similar characteristics to Whiteman Cove prior to its closure. Information available from the late 1800s (T-sheet, Figures 21 and 23) through the present (aerial photographs, Figures 20 and 22) shows that each of the reference sites have had an active outlet channel in all years where information was available. The channel sizes and locations varied slightly over time at both reference sites; however, the lagoon was never completely disconnected from Case Inlet at either site. It is likely that Whiteman Cove will behave in a similar manner to the reference sites if it is connected to Case Inlet via an open channel. The channel width and depth may vary over time, but the outlet channel should remain self-sustaining over time. In addition, the opening location should remain oriented to the north (its historical location) and will trend towards the north if it is either constructed in a different location or migrates south due to a rainfall or wind-wave event.

Modeling results, along with the 1951 photograph of Whiteman Cove, were used to evaluate potential for shoaling inside the Cove post-restoration. The 1951 photograph shows evidence of flood shoal creation within the Cove just inside the opening. This is substantiated by the current model results, which show a significant decrease in predicted velocities between the opening and the interior of the Cove. If the Cove is connected to Case Inlet with an open channel of any width, a flood shoal is expected to form inside the lagoon and grow over time dependent on the sediment supply in the nearshore area to the south of the project site.

This preliminary evaluation serves as a building block for a more comprehensive restoration feasibility study. Additional studies needed for a more comprehensive analysis include the following:

- Assessing impacts to existing residential and camp improvements, including structures, docks, septic systems, and wells
- Considering a "worst case" scenario within the hydraulic model simulations including high water elevations and high wind-generated waves

6 CONCEPTS AND PROBABLE OPINIONS OF CONSTRUCTION COST

Results and recommendations summarized in Section 5 were used to develop a range of conceptual alternatives to provide graphics and probable opinions of construction cost to inform future feasibility evaluation and/or design efforts. These concepts include an open channel option (where the road is abandoned), and two different culvert options and a bridge option (where the road is retained). Appendix D provides figures that illustrate each of the proposed concepts and a table showing the probable opinions of construction cost for each of the concepts. Descriptions of each of the concepts, and assumptions used to develop the costs, are provided in the following sections.

6.1 Option 1: Open Channel

Figure 1 in Appendix D shows an open channel concept that provides tidal connection to Whiteman Cove. This concept provides a 150-foot open channel with a bed elevation +7 feet MLLW with approximate slide slopes of 5H:1V within the intertidal elevation range. This concept minimizes excavation of the existing spit in order to minimize impacts to existing shoreline habitat in the vicinity of the opening. This concept would require that the existing roadway be abandoned. Costs for this concept include clearing of vegetation, demolition of existing structure within the new opening, demolition and/or filling of the existing north gated culvert, excavation of the opening itself and a small channel from the opening to Case Inlet, and stabilization of the opening size slopes with beach gravels/cobbles. Cost for this option is anticipated to be around $320,000 (see Appendix D).

6.2 Option 2: Pre-cast Box Culverts

Figure 2 in Appendix D shows a 45-foot channel opening to the Cove that is spanned by four 10-foot-wide box culverts (three sections each) used to create a minimum 28-foot-wide roadway (Pierce County 2011). For this concept, the roadway can remain in place and will be constructed over the four box culverts once they have been set into place. Each of the sections of the pre-cast box culvert can be placed without dewatering the site. The culvert invert elevations (bed elevation for the channel) will be set to +7 feet MLLW. For final design, the bottom of the culverts may be placed lower and backfilled to +7 feet MLLW if a stream bed is desired within the culverts. This provides the minimum hydraulic opening (40 feet, as determined in modeling conducted as part of this study) for the Cove to provide full tidal inundation to the Cove without any muting of the flood or ebb tide. This concept does not provide a clear span of 40 to 45 feet, which would be the preferred concept for restoration of the Cove. However, this concept is provided here as a cost comparison to the open channel (see Section 6.1) and pre-cast bridge and traditional bridge concepts (see Sections 6.3 and 6.4). The concept as shown does not adjust the height of the culverts based on predicted sea level rise, because the entire roadway would need to be increased in elevation and width to accommodate future sea level rise. This will need to be considered in final design of this concept based on the proposed design life for the roadway. Costs for this concept include clearing of vegetation, demolition of existing structure within the new opening, demolition and/or filling of the existing north gated culvert, excavation of the opening itself and a small channel from the opening to Case Inlet, and construction of the culverts and overlying roadway section. Cost for this option is anticipated to be around $820,000 (see Appendix D).

6.3 Option 3: Pre-cast Bridge Structure

Figure 3 in Appendix D shows a 35-foot channel opening to the Cove that is spanned by one 35-foot-wide pre-cast bridge structure (assumed to be a pre-cast inverted short-span bridge in three sections) used to create a minimum 28-foot-wide roadway (Pierce County 2011). For this concept, the roadway can remain in place and will be constructed over the pre-cast bridge structure once it has been set into place. Each of the sections of the pre-cast structure can be placed without dewatering the site. The culvert invert elevation (bed elevation for the channel) will be set to +7 feet MLLW. For final design, the bottom of the culvert may be placed lower and backfilled to +7 feet MLLW if a stream bed is desired within the culvert. This provides a slightly smaller opening (35 feet) than the minimum hydraulic opening (40 feet, as determined in modeling conducted as part of this study) for the Cove, but does provide a clear 35-foot span with no vertical supports (unlike Option 2). The size of the culvert was based on review of available products and discussions with manufacturers. It may be possible to meet the full 40-foot width during the final design phase with a single pre-cast bridge unit, depending on what is available at that time.

As with Concept 2, this concept as shown does not adjust the height of the culvert based on predicted sea level rise, because the entire roadway would need to be increased in elevation and width to accommodate future sea level rise. This will need to be considered in final design of this concept based on the proposed design life for the roadway. Costs for this concept include clearing of vegetation, demolition of existing structure within the new opening, demolition and/or filling of the existing north gated culvert, excavation of the opening itself and a small channel from the opening to Case Inlet, and construction of the culvert and overlying roadway section. Cost for this option is anticipated to be around $970,000 (see Appendix D).

6.4 Option 4: Bridge Structure

Figure 4 in Appendix D shows an 85-foot-wide bridge option, which includes a single 40-foot clear middle span and two 22.5-foot abutment spans, to create the opening for Whiteman Cove. As with Options 2 and 3, the roadway will remain in place and will be constructed to a minimum of 28 fee wide over the bridge (Pierce County 2011). The channel within the 40-foot clear span under the bridge will be excavated +7 feet MLLW, and the slopes in both abutment spans will be armored to provide erosion protection for the bridge structure. This provides the minimum hydraulic opening (40 feet, as determined in modeling conducted as part of this study) for the Cove, within the clear middle span and some additional conveyance in both of the abutment spans.

As with Options 2 and 3, this concept as shown does not adjust the height of the bridge based on predicted sea level rise, because the entire roadway would need to be increased in elevation and width to accommodate future sea level rise. This will need to be considered in final design of this concept based on the proposed design life for the roadway. Costs for this concept include clearing of vegetation, demolition of existing structure within the new opening, demolition and/or filling of the existing north gated culvert, excavation of the opening itself and a small channel from the opening to Case Inlet, and construction of the bridge and roadway section. Cost for this option is anticipated to be around $1,600,000 (see Appendix D).

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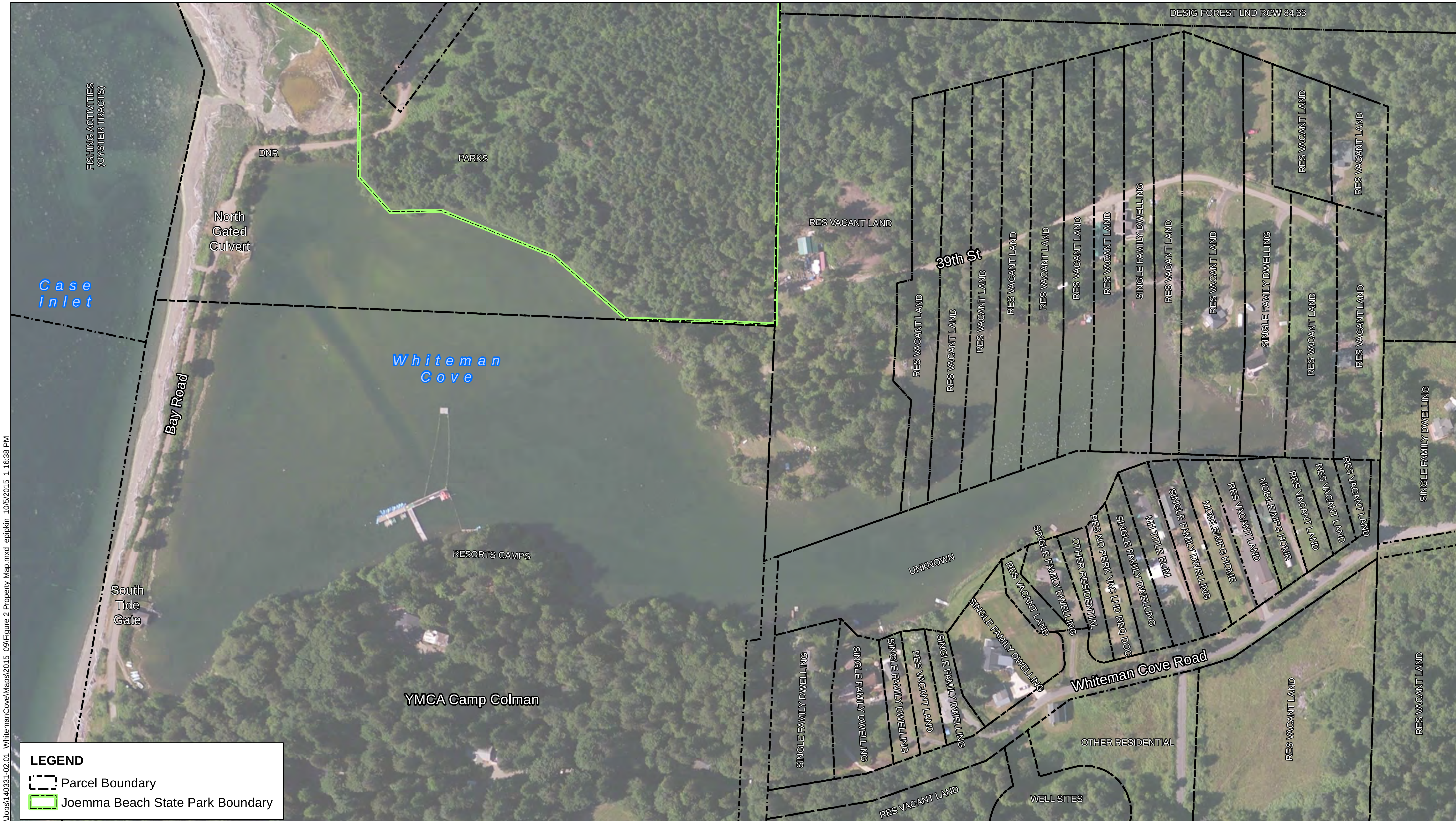
FIGURES

NOTES:
1. Horizontal datum: WA State Plane North, NAD83, Feet.
2. Aerial photo provided by ESRI.

Feet
0 100 200

ANCHOR QEA

Figure 1
Site Map
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



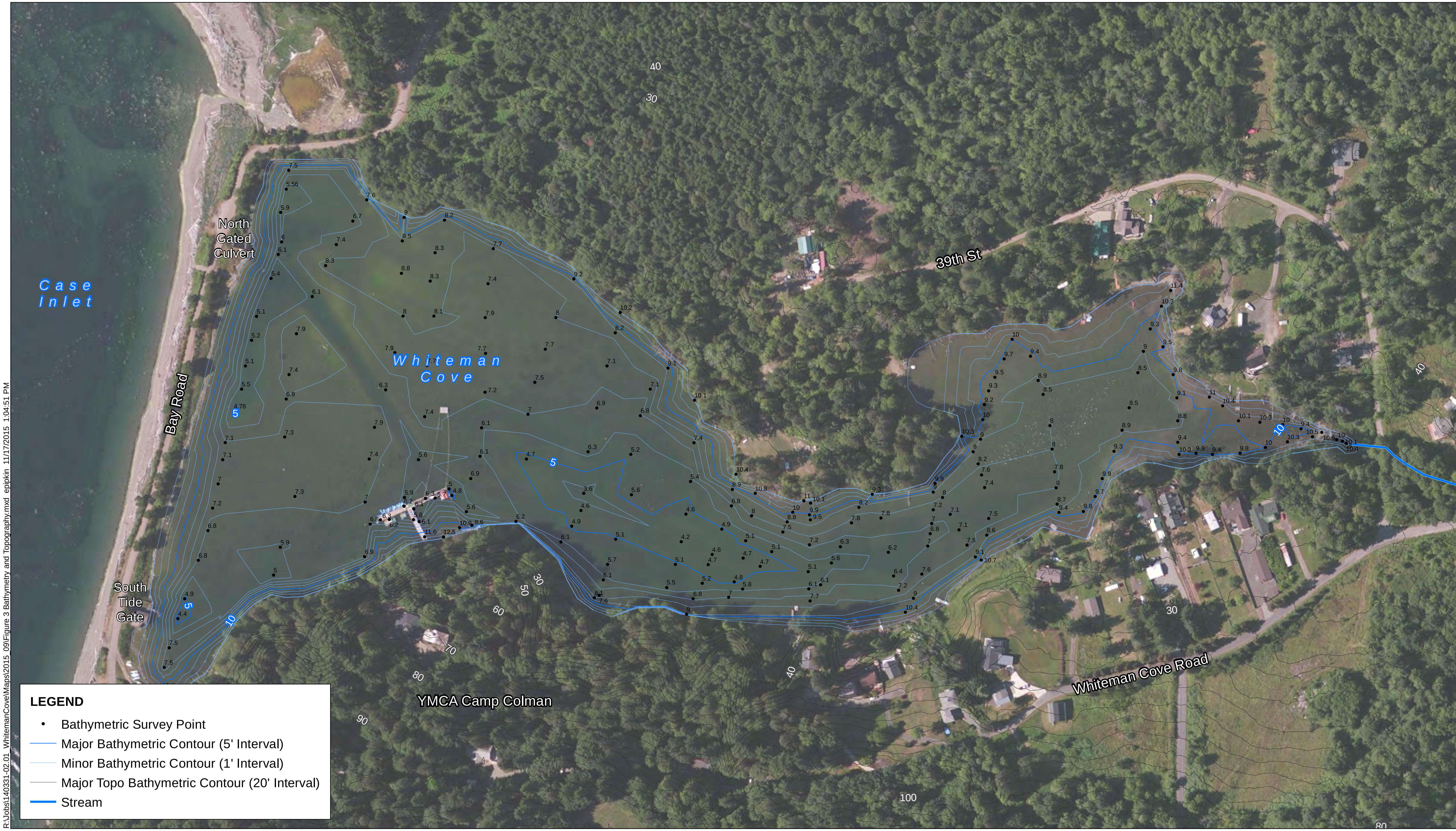
R:\Jobs\140331-02.01_WhitemanCove\Maps\2015_09\Figure 2 Property Map.mxd epipkin 10/5/2015 1:16:38 PM

ANCHOR QEA

NOTES:
1. Horizontal datum: WA State Plane North, NAD83, Feet.
2. Aerial photo provided by ESRI.
3. Tax parcels from Pierce County (acquried 9/4/2015).
4. Joemma Beach State Park boundary estimated from data provided by SPSSEG and WA DNR.

Feet
0 100 200

Figure 2
Property Lines
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



ANCHOR QEA

NOTES:
1. Elevations are MLLW, feet.
2. Bathymetry from survey conducted 9/15/2014, upland topography from Puget Sound Lidar Consortium, 2000-2005.
3. Aerial photo provided by ESRI.
4. Stream data acqquried from Washington Department of Natural Resources.

Feet
0 100 200

Figure 3
Bathymetric and Topographic Conditions
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

ANCHOR QEA

NOTE: Aerial photo provided by ESRI.

Feet
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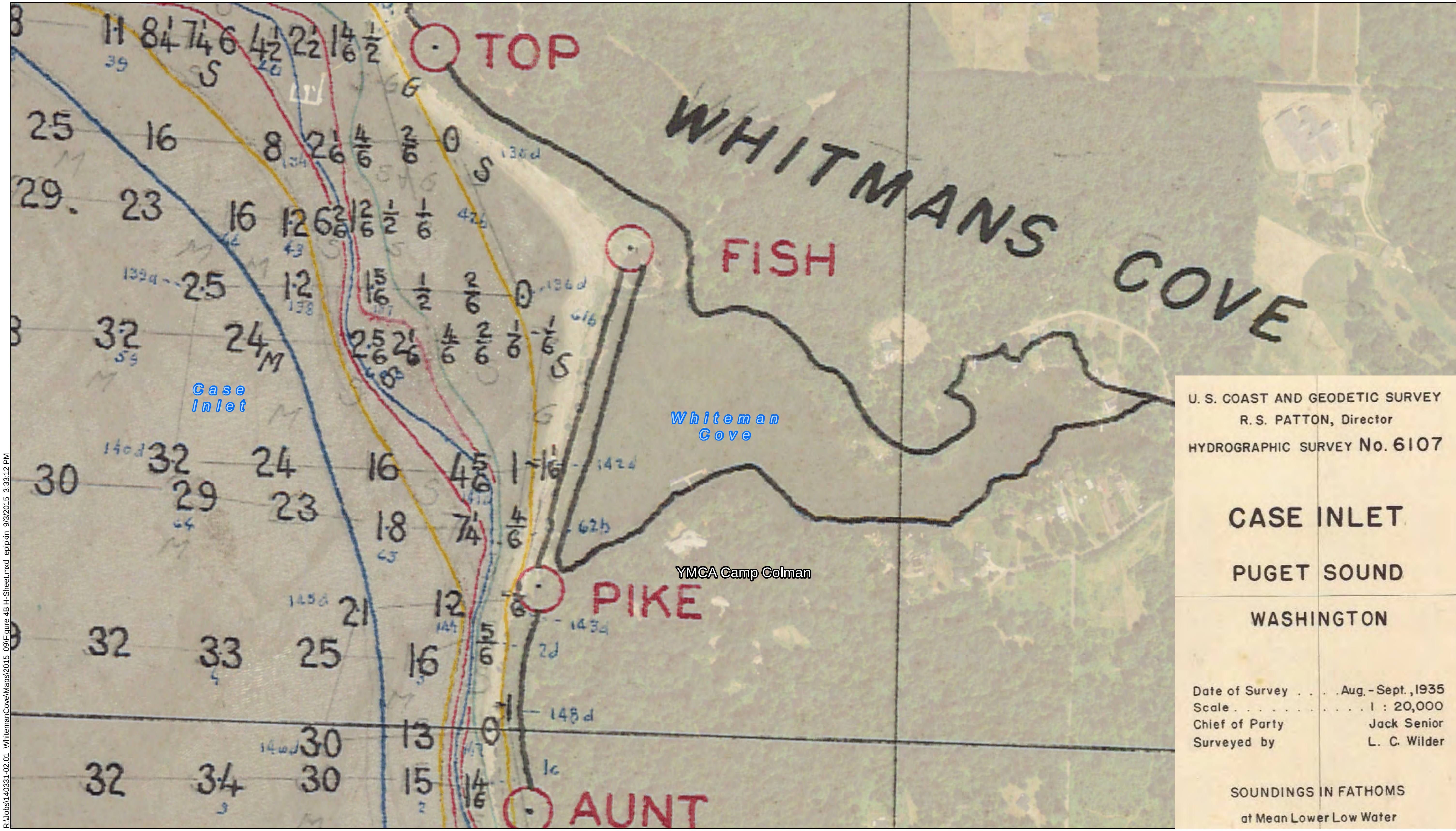
Figure 4A
Historical T-Sheet
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



ANCHOR QEA

NOTE: Aerial photo provided by ESRI.

Feet
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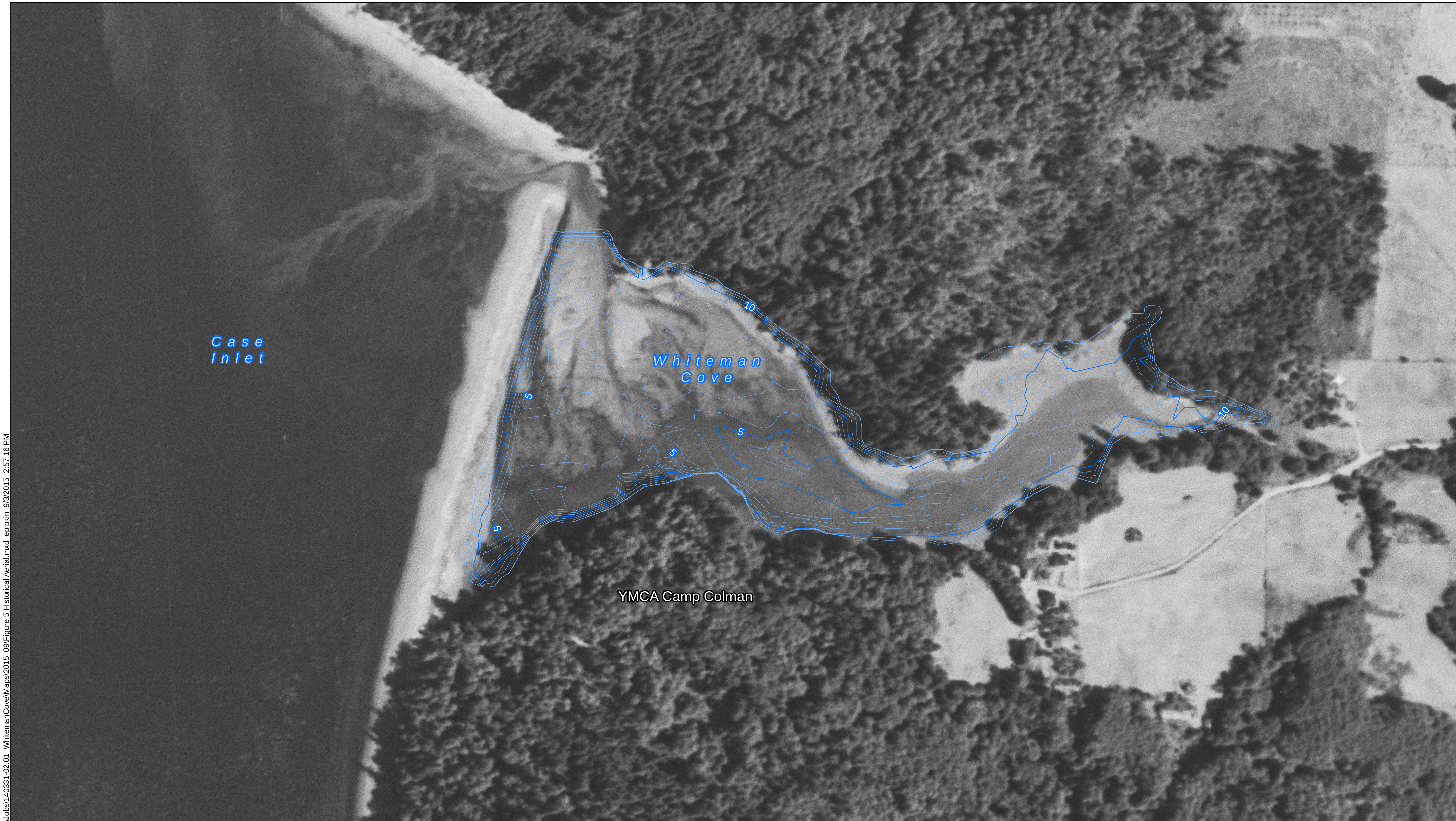
Figure 4B
Historical H-Sheet
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



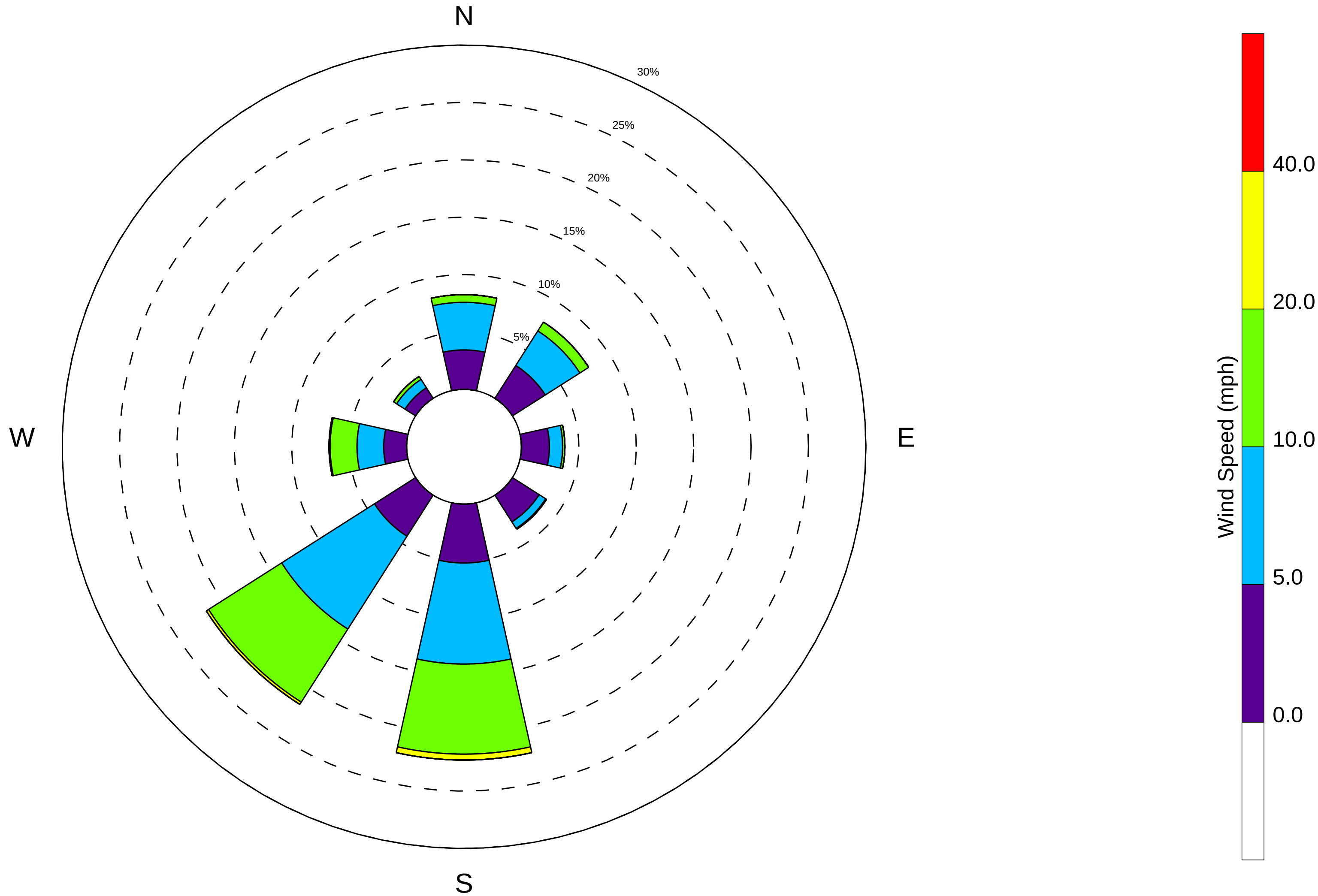
R:\Jobs\140331-02.01_WhitemanCove\Maps\2015_09\Figure 5 Historical Aerial.mxd epipkin 9/3/2015 2:57:16 PM

ANCHOR QEA

NOTES:
1. Bathymetry from survey conducted 9/15/2014.
2. Aerial photo provided by USGS (1951).

Feet
0 150 300

Figure 5
Historical Aerial Photograph (1951) and Current Bathymetry
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



Calm and Variable Winds 23.6%
Maximum Recorded Wind Speed: 66.7 mph

Figure 6
Wind Rose Diagram
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

Note: Wind data are presented as the "blowing from" direction.

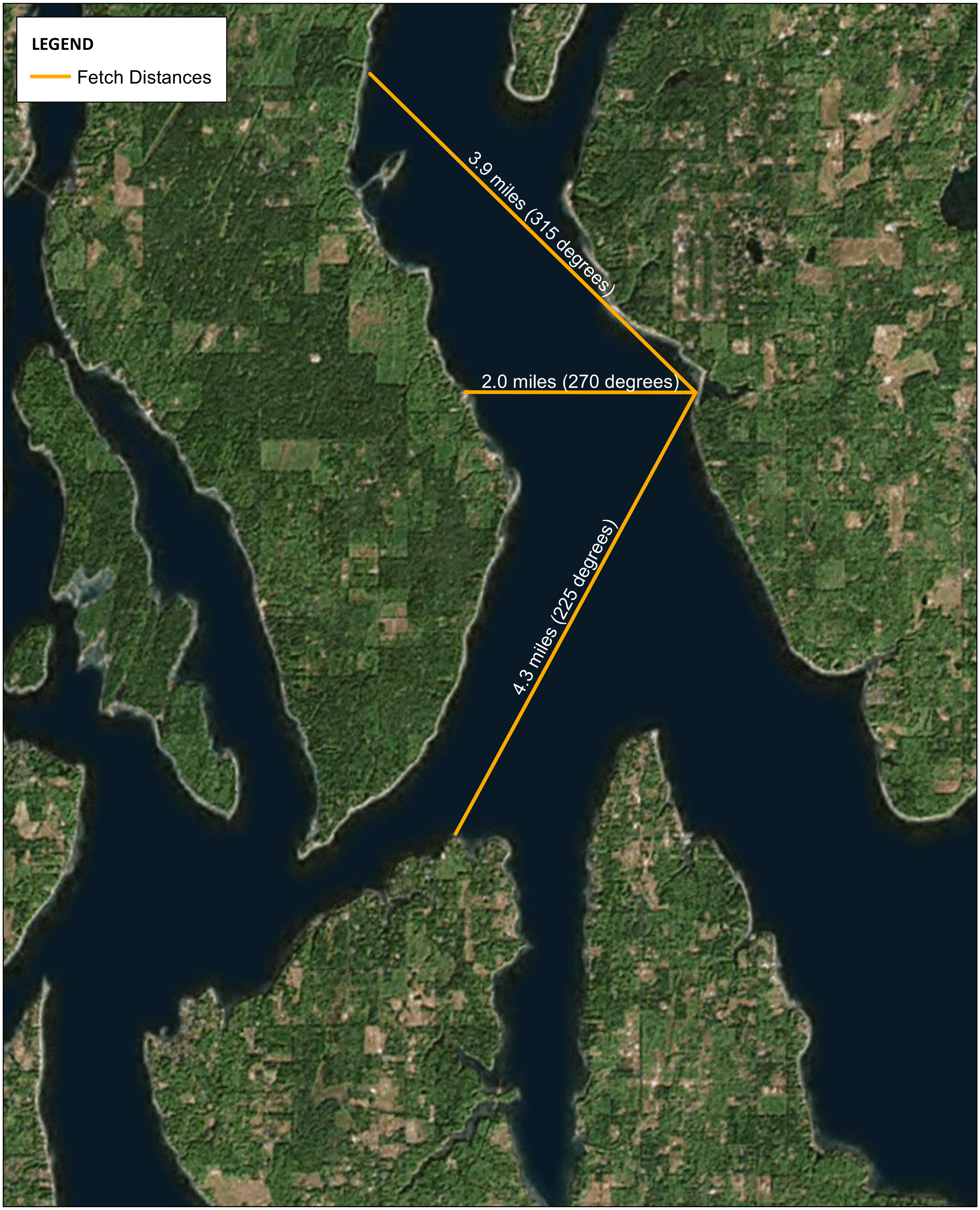
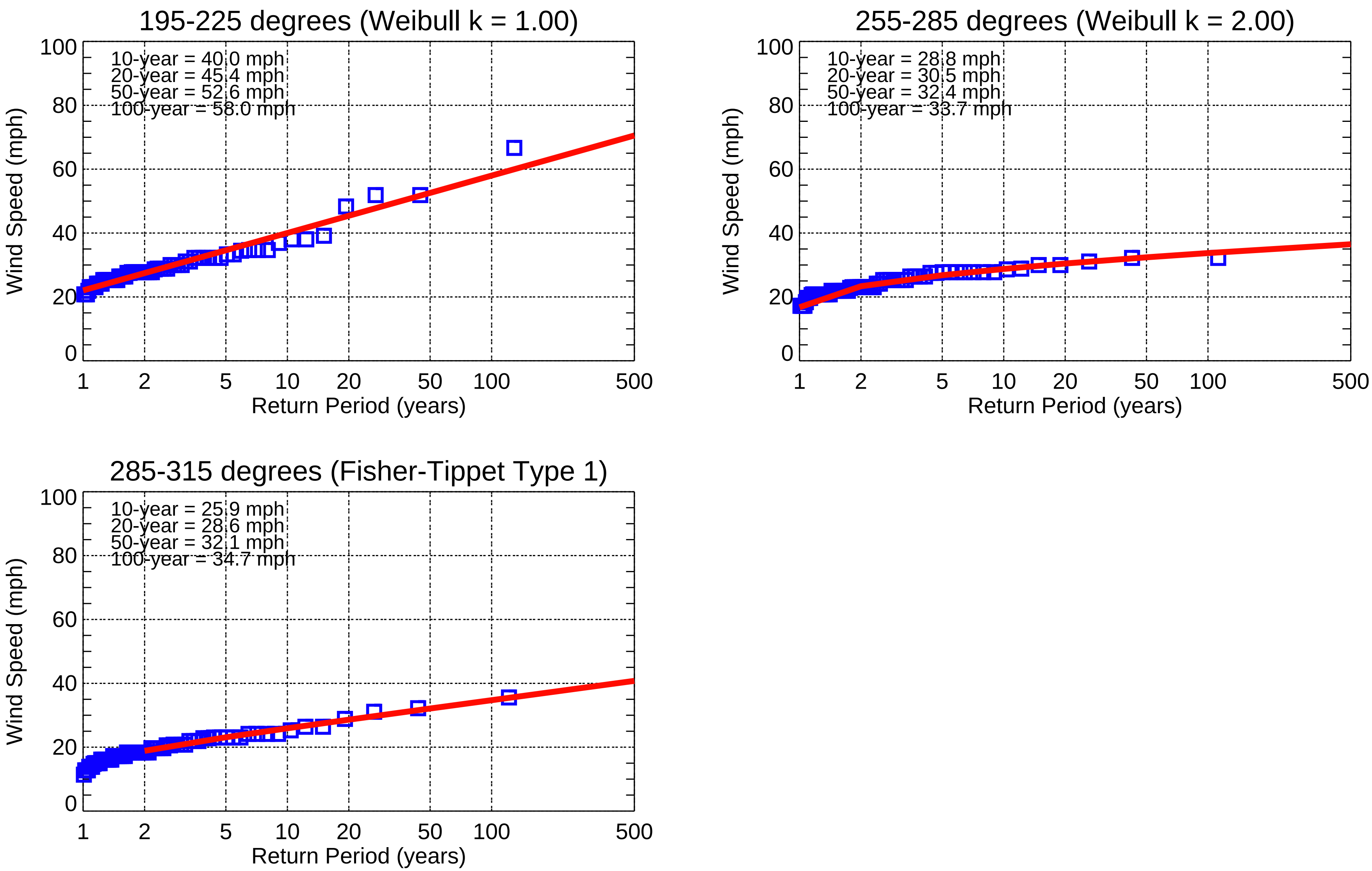
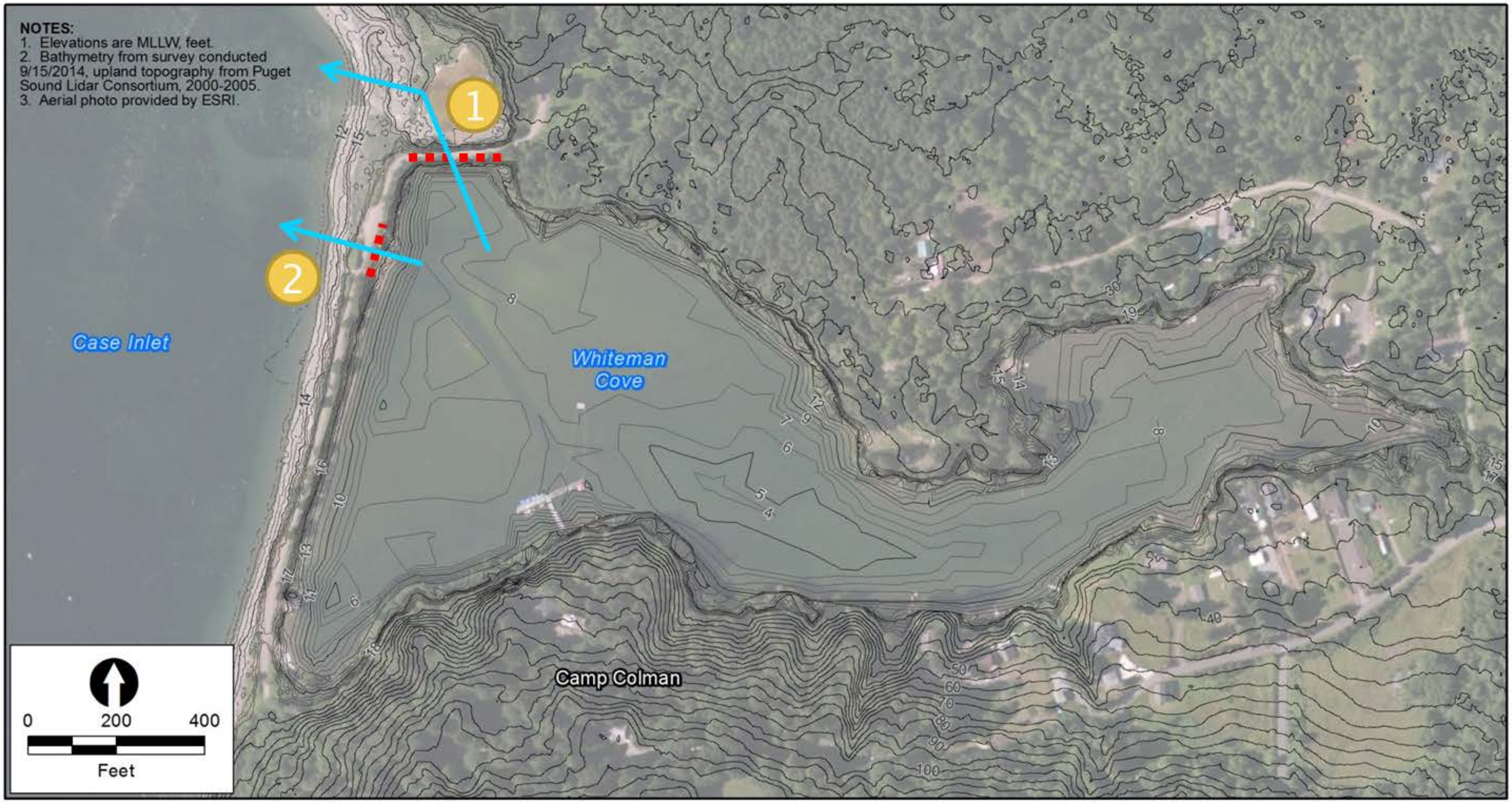


Figure 7
Evaluated Fetch Directions
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



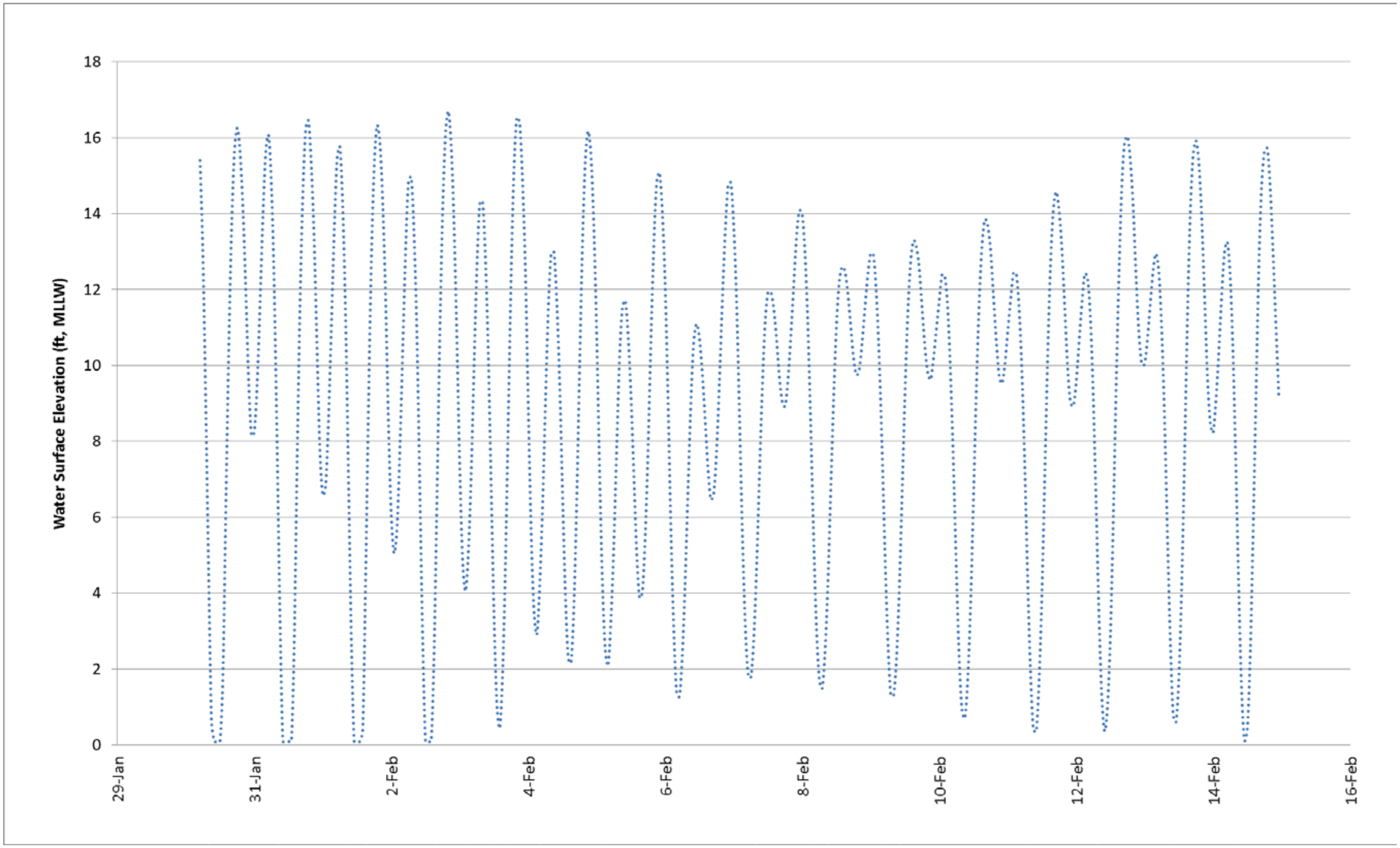
Annual Maximum Winds
Regression

Figure 8
Return Interval Wind Speed Distributions
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



ANCHOR QEA

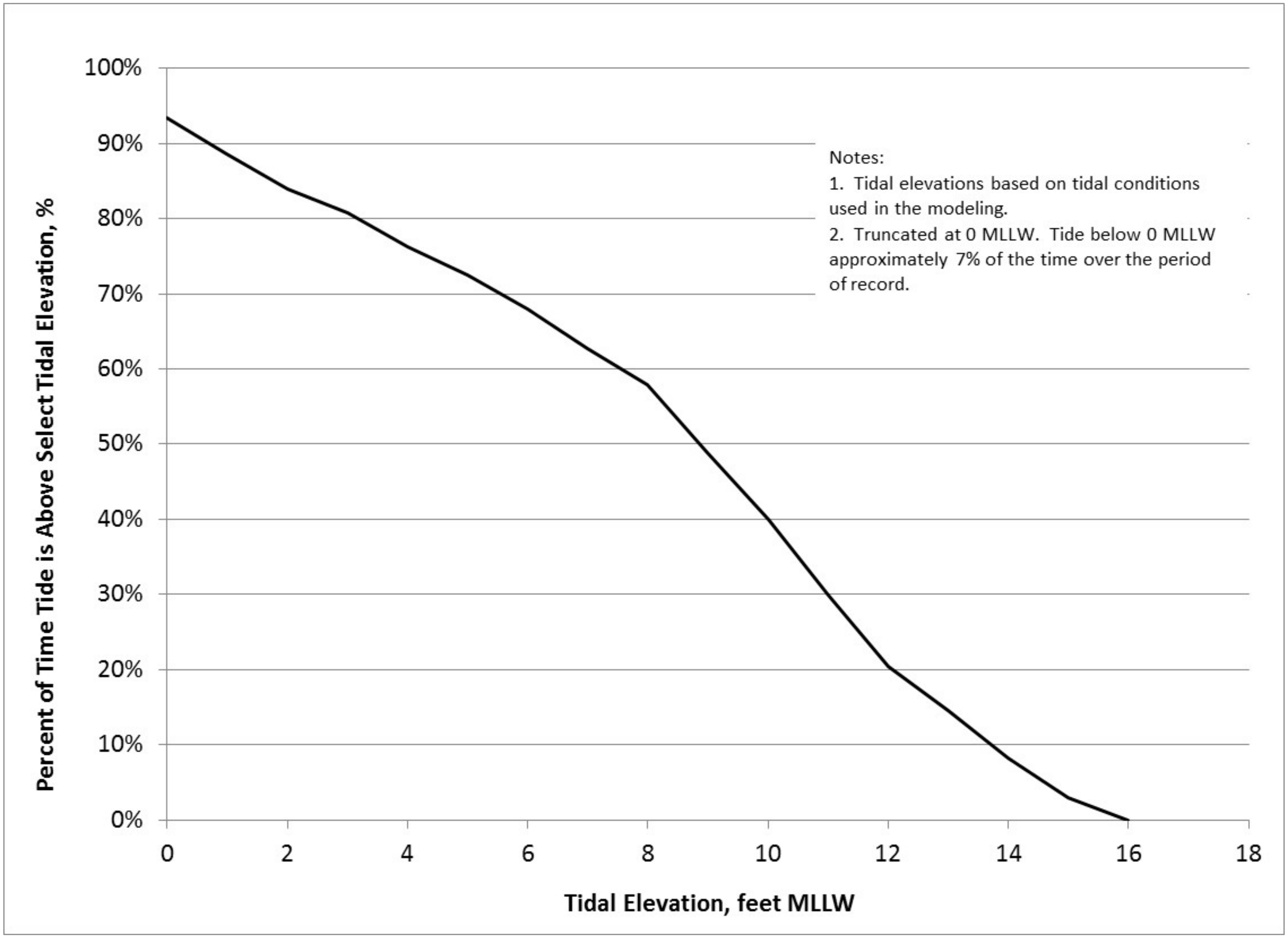
Figure 9
Proposed Opening Locations in Roadway Berm
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



I:\Projects\SPSSEG\Whiteman Cove Restoration\Deliverables\Feasibility Report\Figures\Word Figures\Figure 10 Tidal Boundary Condition.docx

ANCHOR QEA

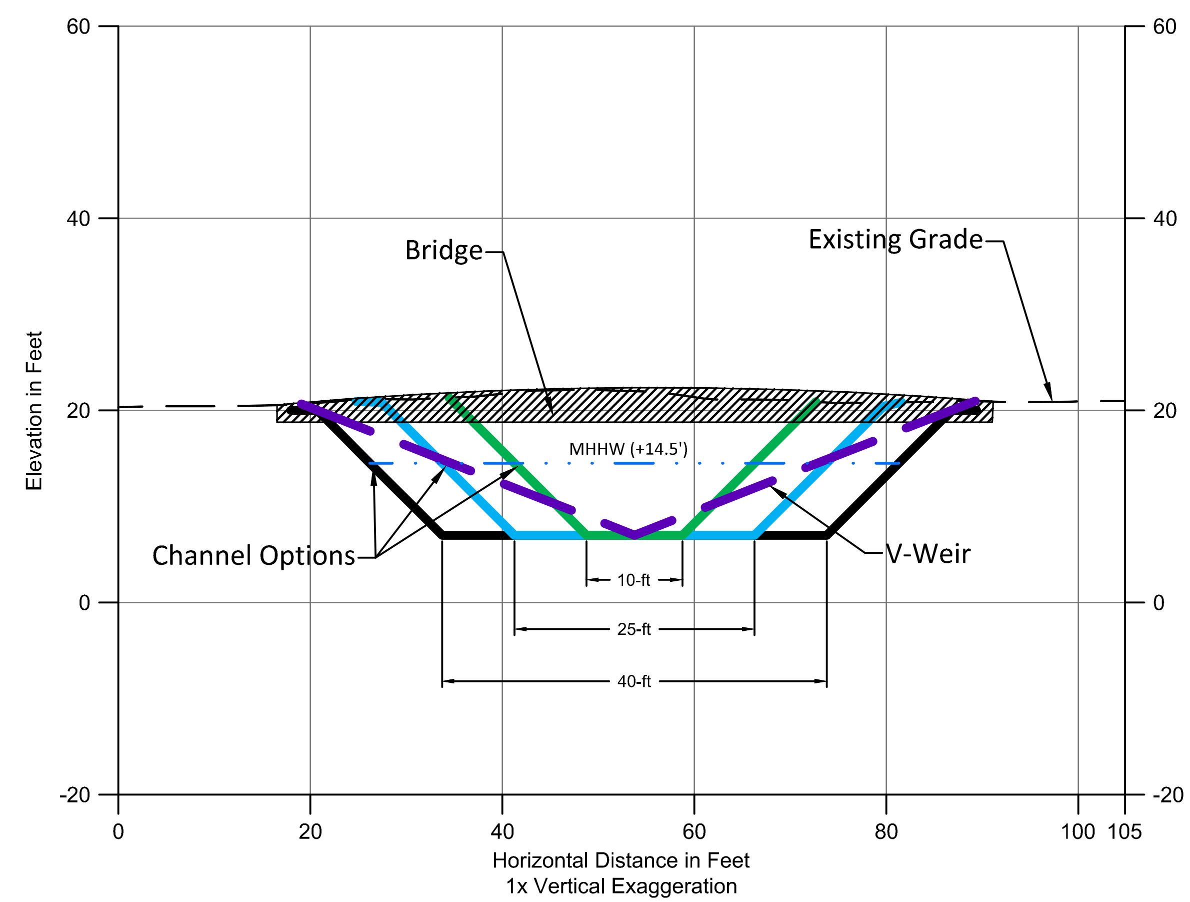
Figure 10
Tidal Boundary Condition for Hydraulic Modeling
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



I:\Projects\SPSSEG\Whiteman Cove Restoration\Deliverables\Feasibility Report\Figures\Word Figures\Figure 11 Frequency of Tidal Heights.docx

ANCHOR QEA

Figure 11
Frequency Distribution of Tidal Heights at Project Site (over period of record)
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



Typical Channel Section

SCALE: 1" = 20'

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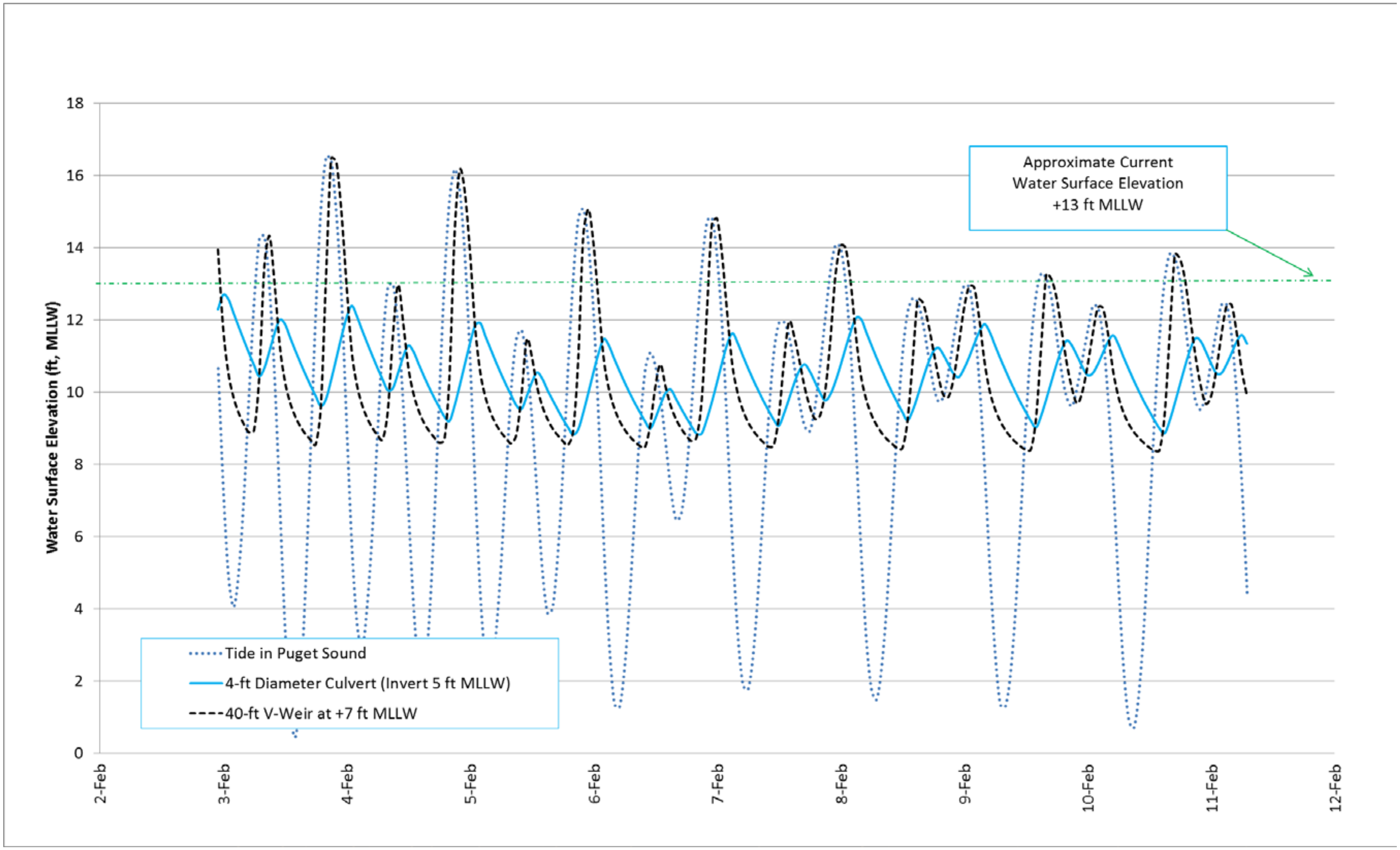
Sep 21, 2015 1:54pm epipkin

SOURCE: Bathymetry from survey conducted 9/15/2014, upland topography from Puget Sound Lidar Consortium 2000-2005
VERTICAL DATUM: Mean Lower Low Water (MLLW).

0 20
Scale in Feet

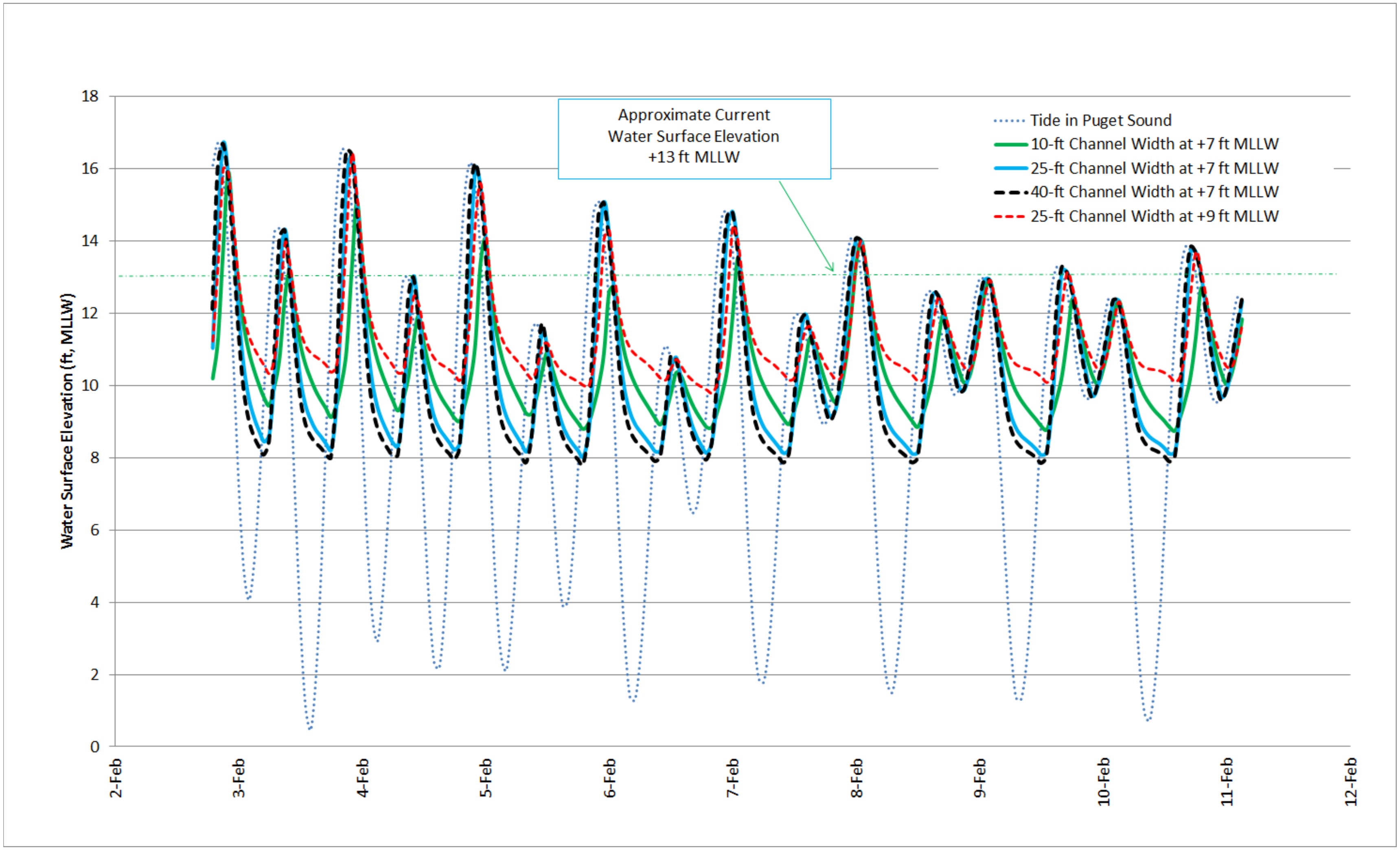
ANCHOR QEA

Figure 12
Channel Options Cross Section
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



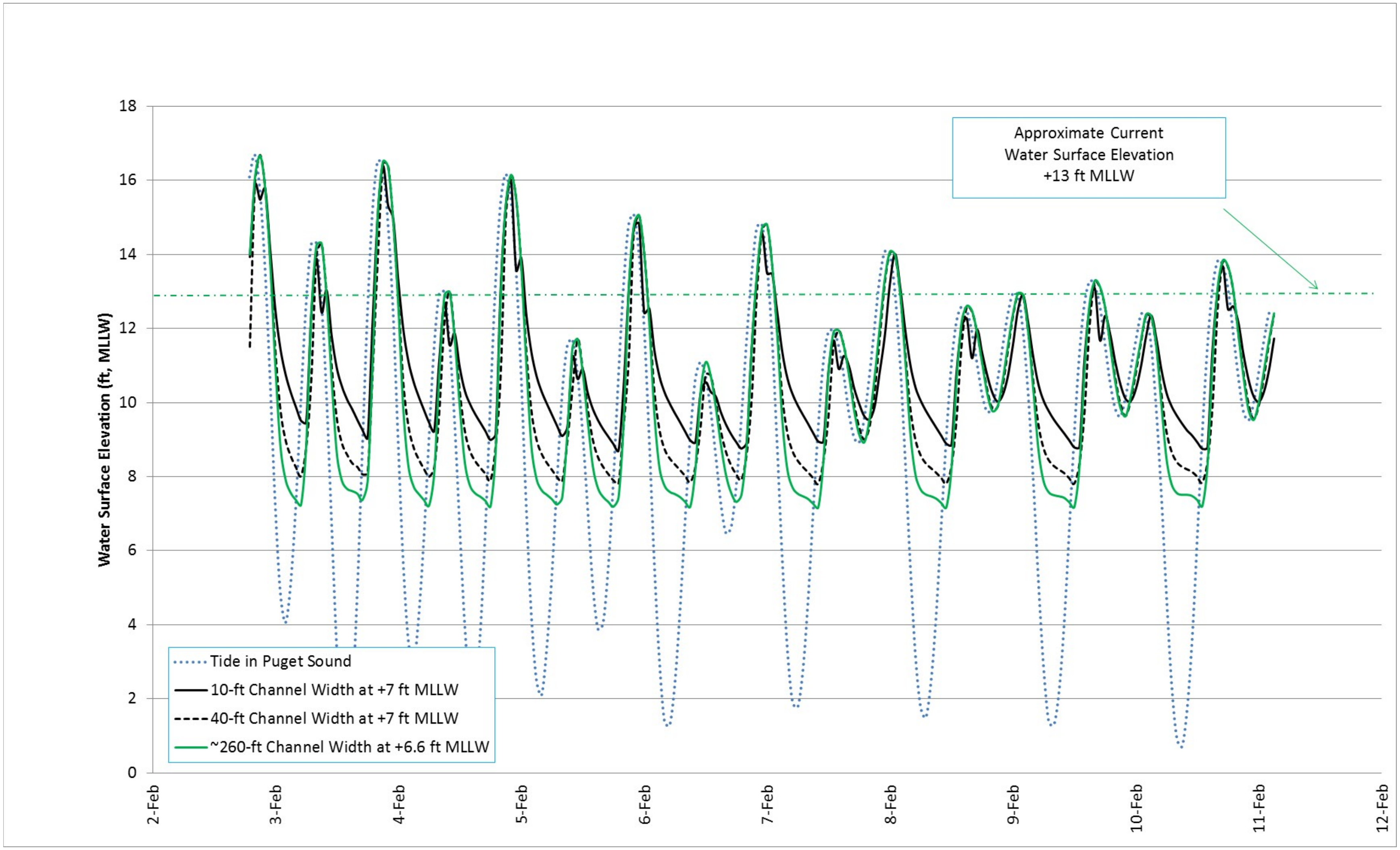
ANCHOR QEA

Figure 13
Predicted Water Surface Elevations for Controlled Openings
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



ANCHOR QEA

Figure 14
Predicted Water Surface Elevations for Confined Open Channels
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG



I:\Projects\SPSSEG\Whiteman Cove Restoration\Deliverables\Feasibility Report\Figures\Word Figures\Figure 15 WSE 260 foot Open Channel_Rev1.docx

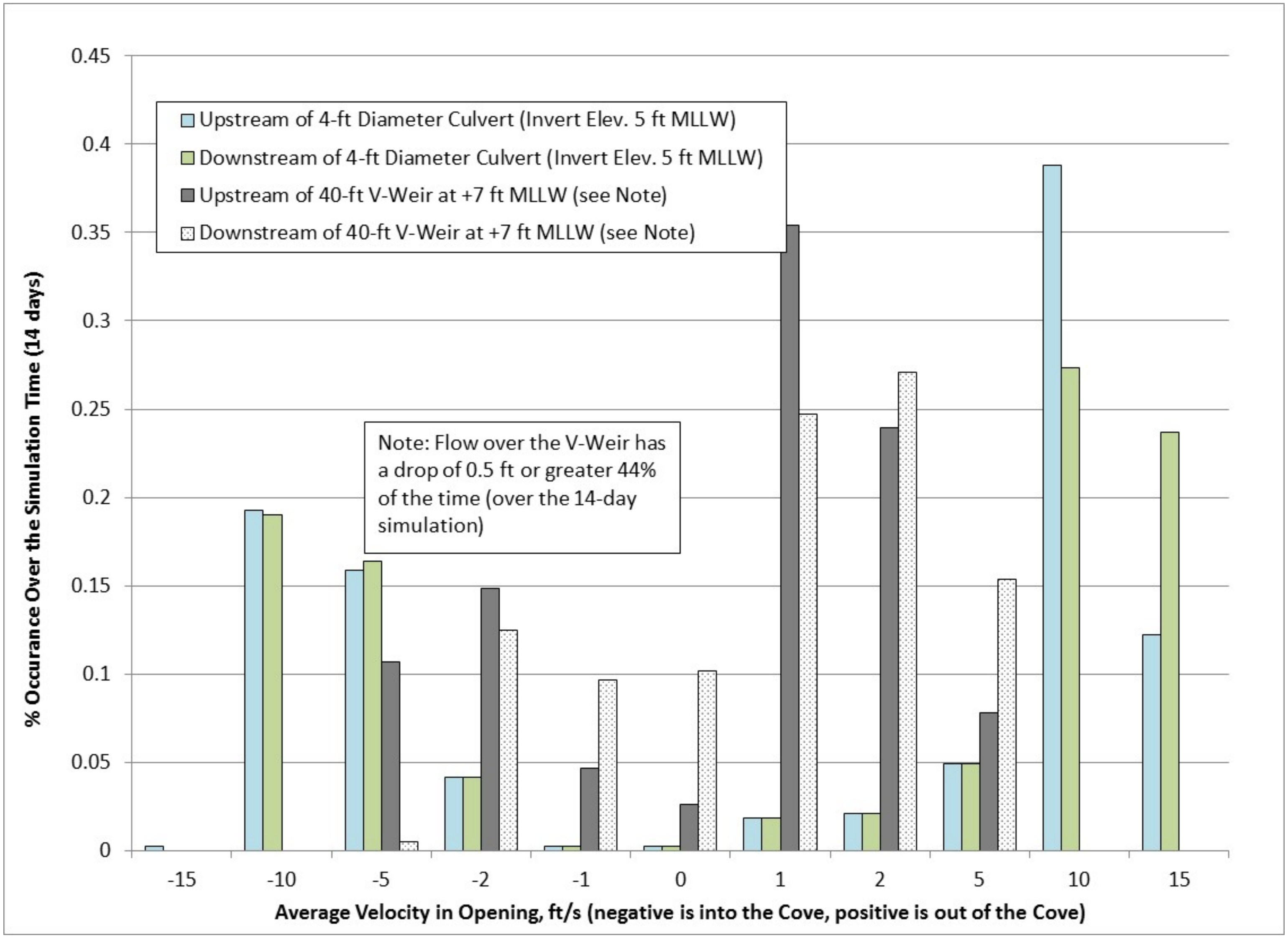
ANCHOR QEA

Figure 15

Predicted Water Surface Elevations for 260-foot Open Channel *(10-foot and 40-foot channels shown for reference)*

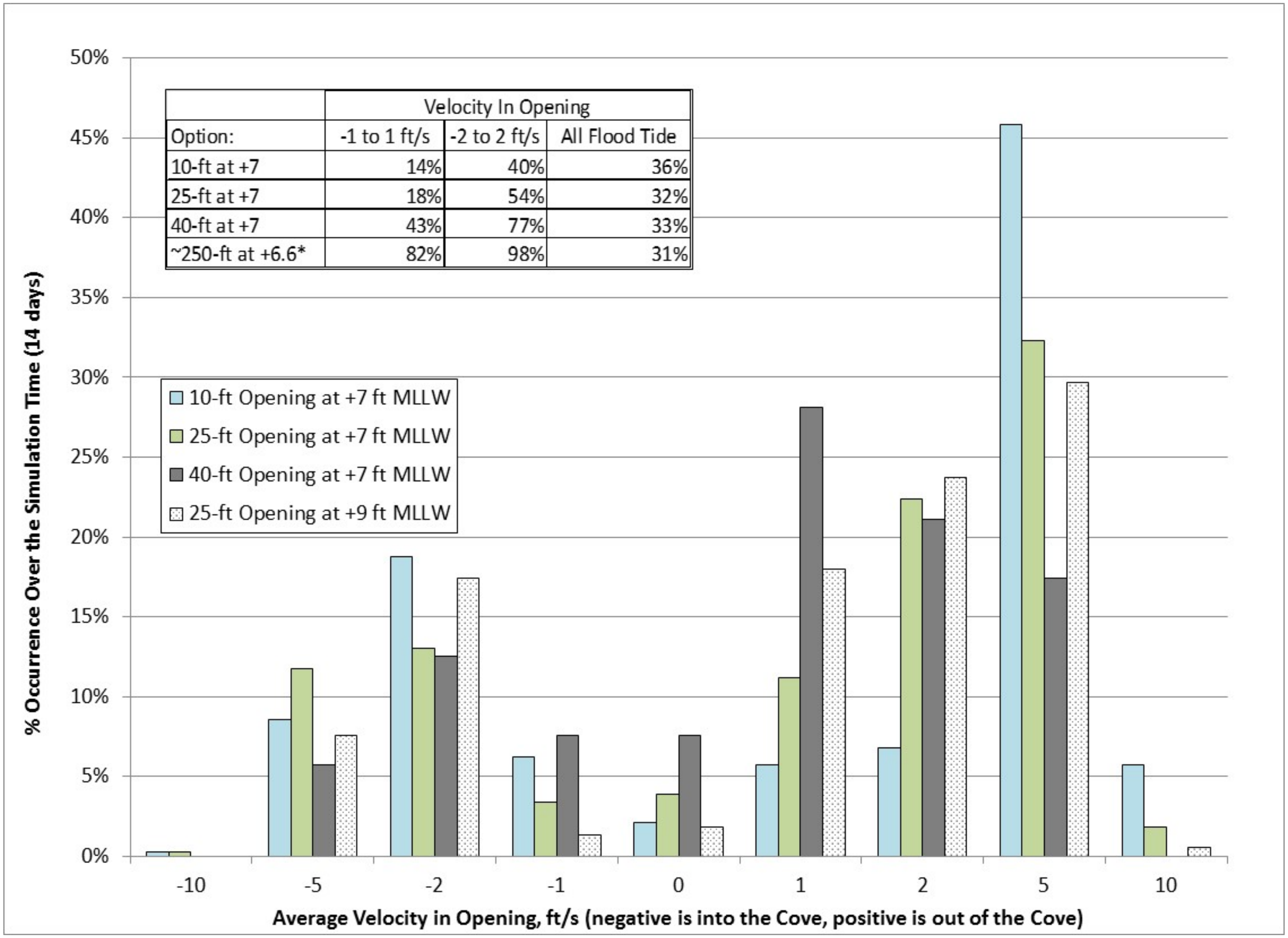
Preliminary Design Report

Whiteman Cove Restoration/SPSSEG



ANCHOR QEA

Figure 16
Predicted Velocities at Controlled Openings
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

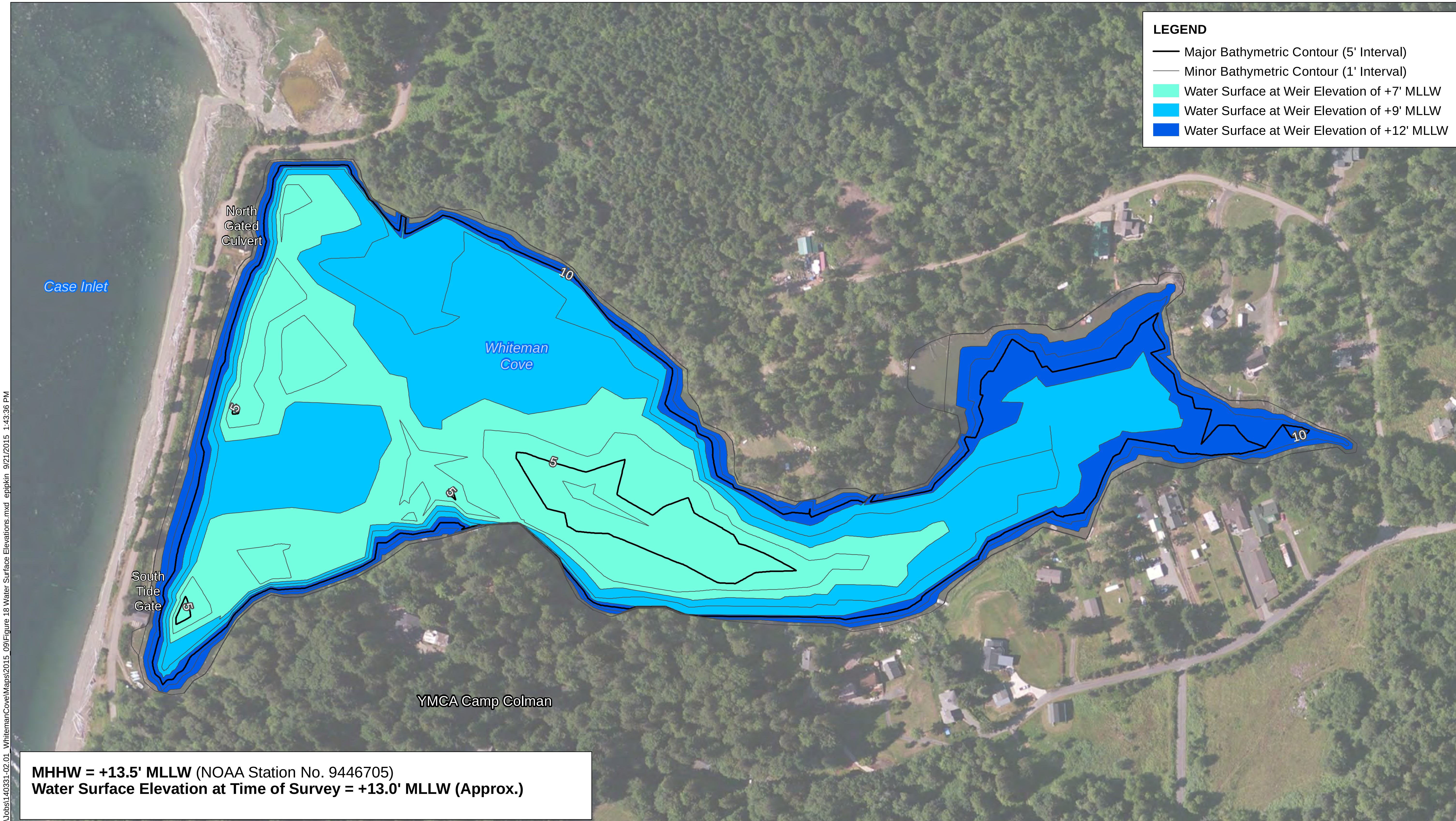


	Velocity In Opening		
Option:	-1 to 1 ft/s	-2 to 2 ft/s	All Flood Tide
10-ft at +7	14%	40%	36%
25-ft at +7	18%	54%	32%
40-ft at +7	43%	77%	33%
~250-ft at +6.6*	82%	98%	31%

Figure 17
Predicted Velocities at Confined Open Channels
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

ANCHOR QEA

I:\Projects\SPSSEG\Whiteman Cove Restoration\Deliverables\Feasibility Report\Figures\Word Figures\Figure 17 Vel Dist Confined OC Openings.docx



R:\Jobs\140331-02.01_WhitemanCove\Maps\2015_09\Figure 18 Water Surface Elevations.mxd epipkin 9/21/2015 1:43:36 PM

ANCHOR QEA

NOTES:
1. Horizontal datum: WA State Plane North, NAD83, Feet.
2. Bathymetry collected on 9/15/2014.
3. Aerial photo provided by ESRI.

Feet
0 100 200

Figure 18
Water Surface Elevations in Whiteman Cove
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

ANCHOR QEA

Figure 19
Reference Site Locations
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

Figure 20
Aerial Photograph of Reference Site No. 1
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

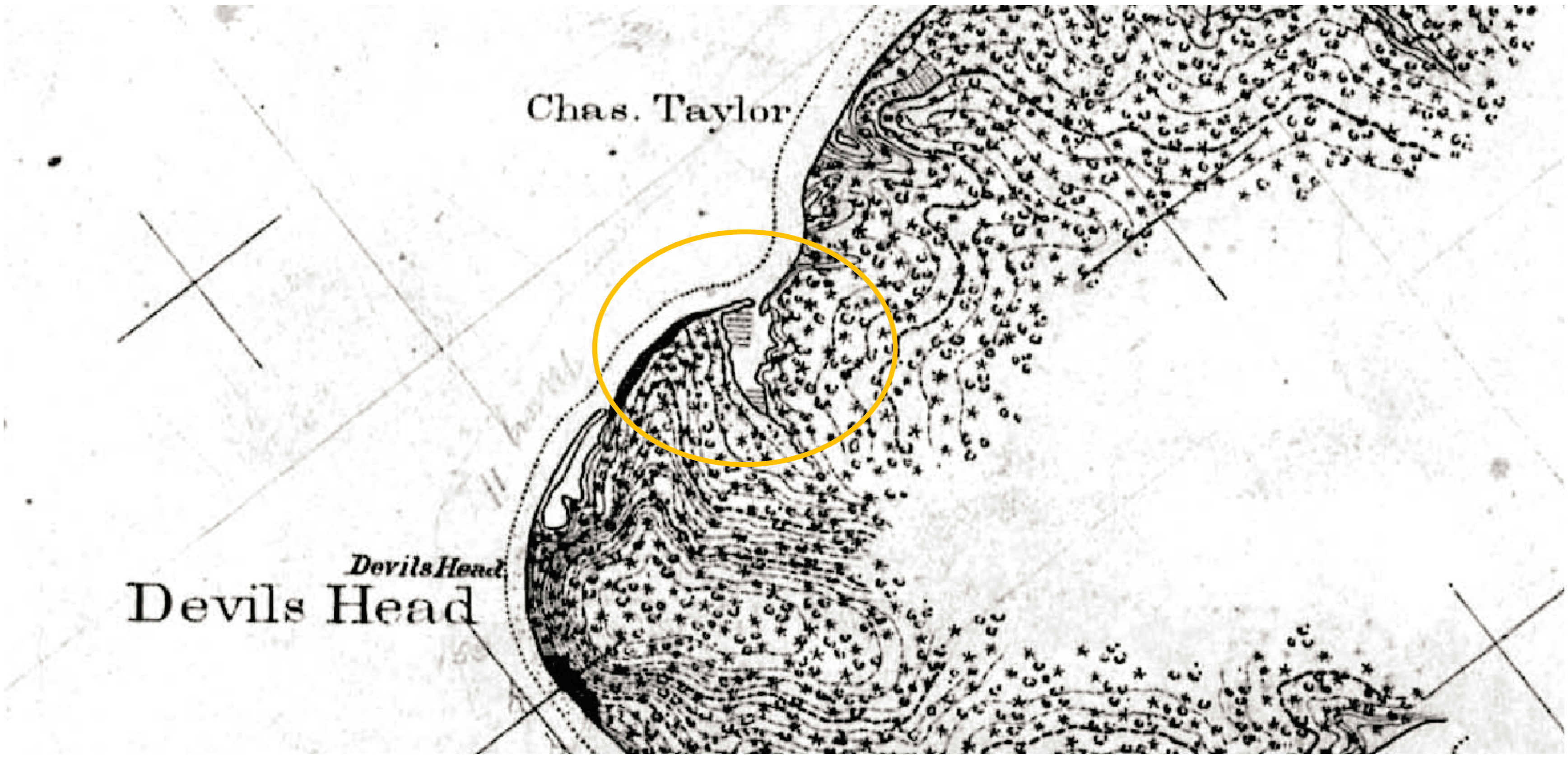


Figure 21
Topography Sheet 1878 (“T-Sheet”), Reference Site No. 1 (circled in yellow)
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

I:\Projects\SPSSEG\Whiteman Cove Restoration\Deliverables\Feasibility Report\Figures\Word Figures\Figure 22 Aerial Reference Site to North.docx

Figure 22
Aerial Photograph of Reference Site 5.5 Miles North of Whiteman Cove (Haley State Park)
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

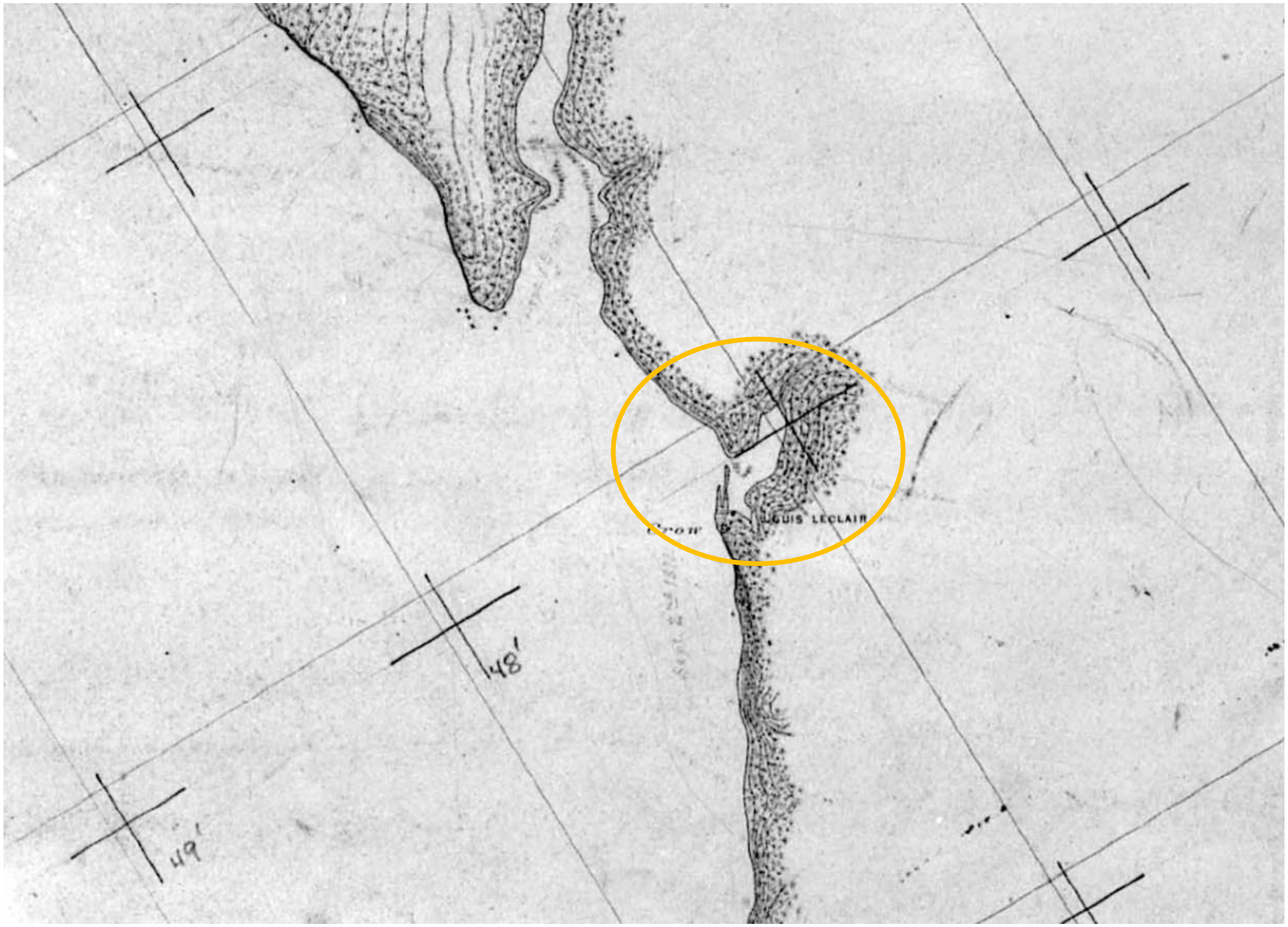


Figure 23
Topography Sheet 1878 (“T-Sheet”), Reference Site No. 2 (Haley State Park) (circled in yellow)
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

1994

2010

2013

I:\Projects\SPSSEG\Whiteman Cove Restoration\Deliverables\Feasibility Report\Figures\Word Figures\Figure 24 Changes to Reference Site #1 over time.docx

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Figure 24
1994, 2010, and 2013 Aerial Photographs of Reference Site No. 1
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

1990

2009

2013

Figure 25
1990, 2009, and 2013 Aerial Photographs of Reference Site No. 2
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

ANCHOR QEA

NOTES:
1. Horizontal datum: WA State Plane North, NAD83, Feet.
2. Bathymetry collected on 9/15/2014.
3. Aerial photo provided by ESRI.

Feet
0 100 200

Figure 26
Water Quality Sampling Locations
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

APPENDIX A
WDFW REFERENCE DOCUMENTS

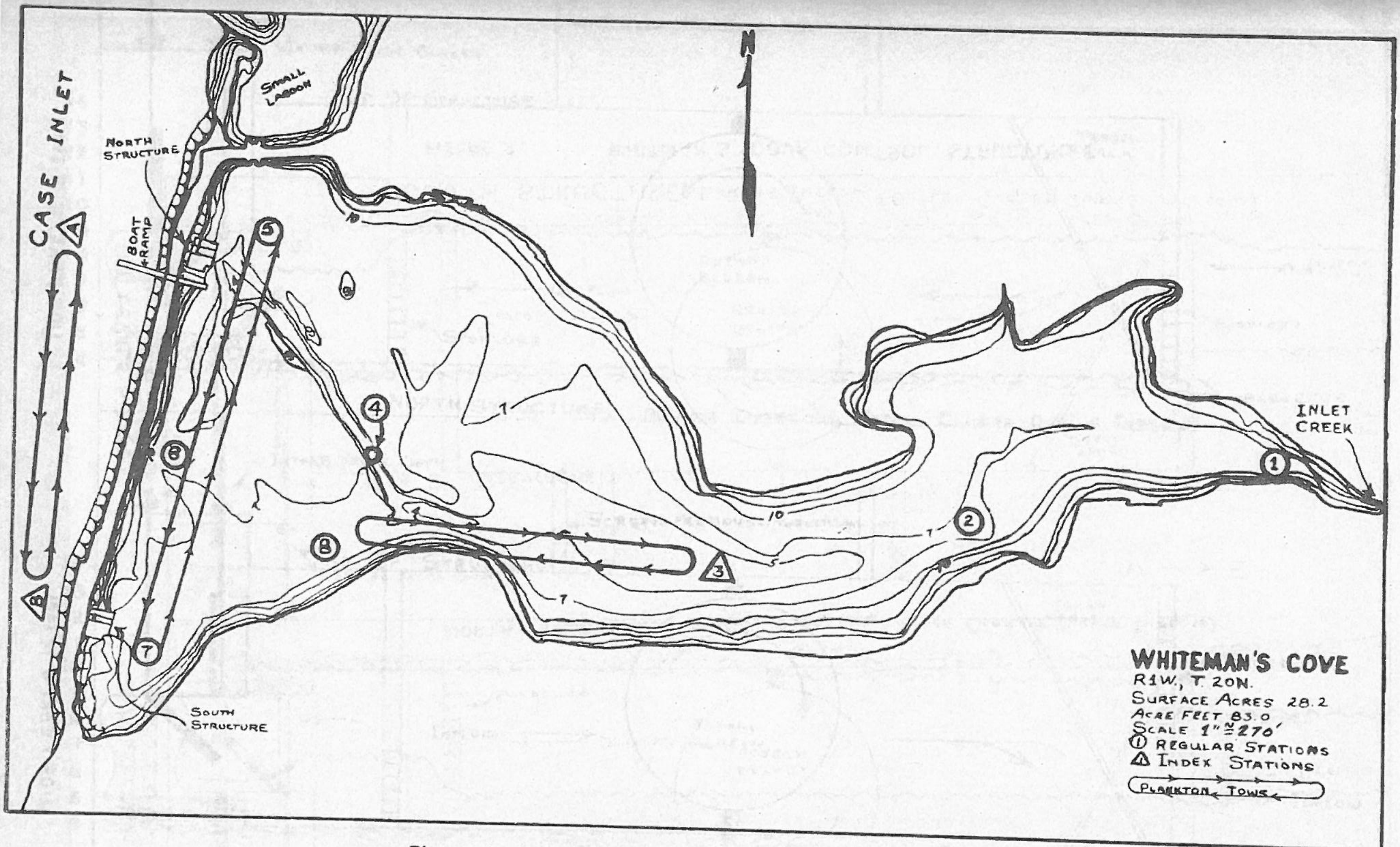

Figure I. Map of Whiteman's Cove

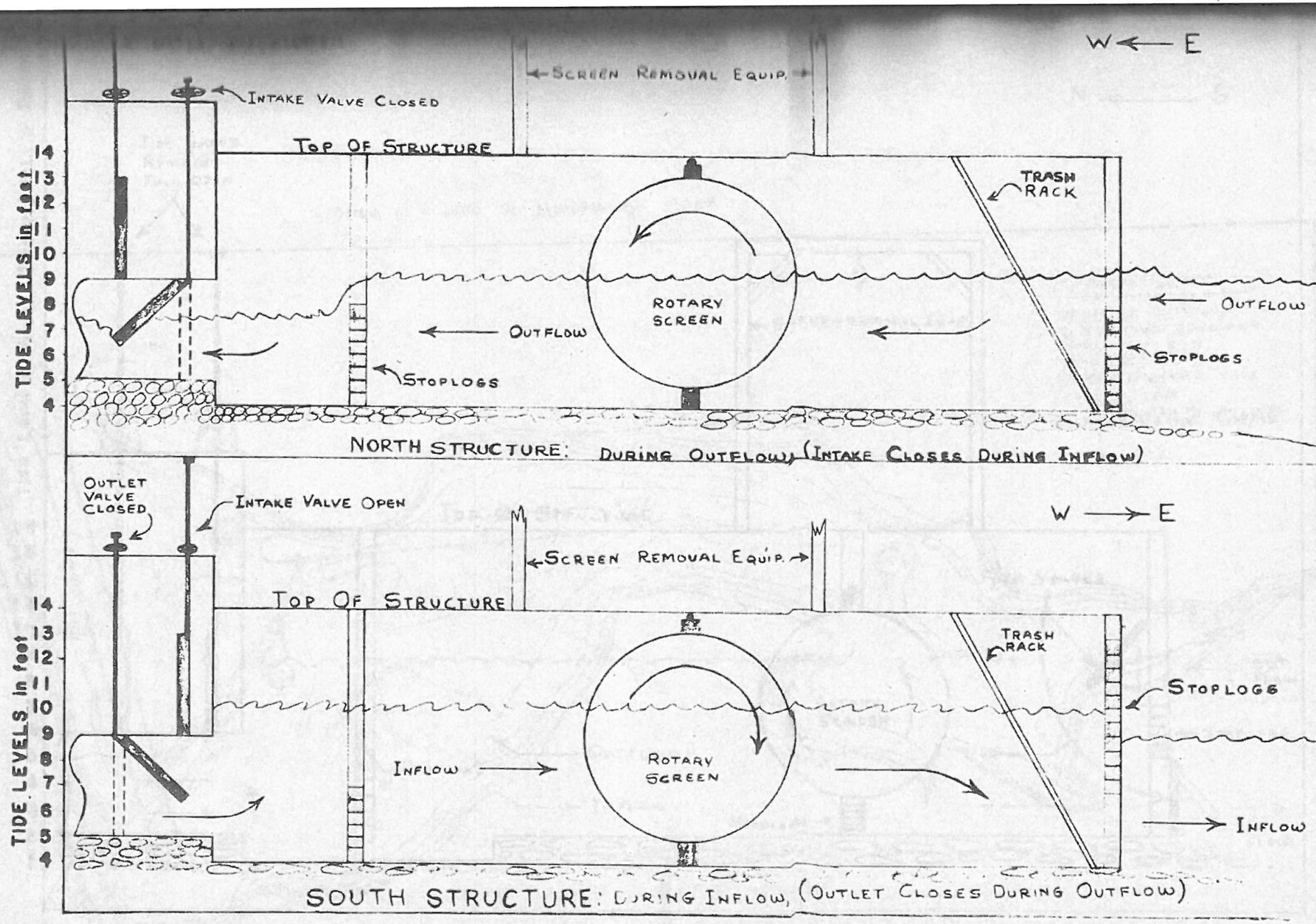

FIGURE 2. WHITMAN'S COVE CONTROL STRUCTURES

APPENDIX B
RENDERINGS

Figure 1
Oblique Photograph of Existing Conditions
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

Figure 2
Rendering of Open Channel Option at Mean Tide Level
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

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022416 I:\Projects\SPSSEG\Whiteman Cove Restoration\Graphics\MLLW\After_MLLW_rev1.indd

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Figure 3
Rendering of Open Channel Option at Mean Lower Low Water
Preliminary Design Report
Whiteman Cove Restoration/SPSSEG

APPENDIX C
WATER QUALITY SAMPLING PLAN

1605 Cornwall Avenue
Bellingham, Washington 98225
Phone 360.733.4311

April 14, 2015

Kristin Williamson
Salmon Restoration Biologist
South Puget Sound Salmon Enhancement Group
6700 Martin Way E#112
Olympia, Washington 98516

Re: Sampling and Analysis Plan for Whiteman Cove Estuary Restoration
Project Number: 140331-02.01

Dear Kristin:

Anchor QEA, LLC, is currently under contract with the South Puget Sound Salmon Enhancement Group to assist them with planning and design work associated with the Whiteman Cove Restoration Project (Project). As part of the Project, Anchor QEA plans to conduct sampling and analysis of water samples from Whiteman Cove to evaluate the potential effect of local septic systems on water quality and resident shellfish beds.

Anchor QEA plans to collect five water quality samples in Whiteman Cove for chemical analysis. Sample collection is proposed at four locations in Whiteman Cove, including one near the northern tide gate, one near the shoreline dock adjacent to YMCA Camp Coleman, and two at the back end of Whiteman Cove (see WQ-01 to WQ-04, Figure 1). To evaluate for potential impacts of local septic systems on surface water quality, water samples will be analyzed for chloride, nitrate, total phosphate, total coliform bacteria, fecal coliform bacteria, *Escherichia coli*, chloride, nitrate, ammonia, and total phosphorous. Water quality parameters will be measured in the field prior to sampling, including salinity, pH, conductivity, temperature, and dissolved oxygen. In addition, salinity profiles will be measured at select locations within Whiteman Cove as shown in Figure 1.

Representative surface water samples will be collected by Anchor QEA personnel using a Kemmerer bottle or another comparable passive sampler. Water quality parameters will be measured using a YSI water quality meter and recorded on the field log. Field personnel will approach each sampling location by row boat. At each station, the total water depth will be measured using a lead line. The Kemmerer bottle will be lowered to midpoint of the water column for water sample collection. Once at the correct depth (midpoint between the water surface and mudline), the sampler will be activated (i.e., opened) using a triggering device at the surface to open the sample chamber. After a sample is collected at the prescribed depth, the Kemmerer bottle will be brought to the surface and the water sample will be transferred directly into laboratory certified, pre-labeled containers. Sample containers will include the sample identification (ID), date and time of collection, requested analyses, and sample custodian. Sampling equipment will be rinsed between locations to prevent potential cross-contamination of water samples.

For quality assurance, one field duplicate sample will be collected. Laboratory analyses will be performed at Spectra Laboratories (Tacoma, Washington). The field duplicate sample will be denoted by the addition of -50 to the parent sample ID.

After collection and during transport to the analytical laboratory, samples will be stored in a cooler with ice. All samples submitted for analysis will be appropriately documented on a sample chain-of-custody log and will be relinquished to the laboratory for analysis within the recommended hold time(s) of all testing parameters.

Field activities are scheduled for April 15, 2015. Site access will be coordinated with YMCA Camp Coleman.

Investigation findings will be incorporated into the Preliminary Design Report for the project. Sampling laboratory data for each sample will be provided upon receipt.

Sincerely,

Kathy Ketteridge, P.E.
Anchor QEA, LLC

Attachments
Figure 1

ANCHOR QEA

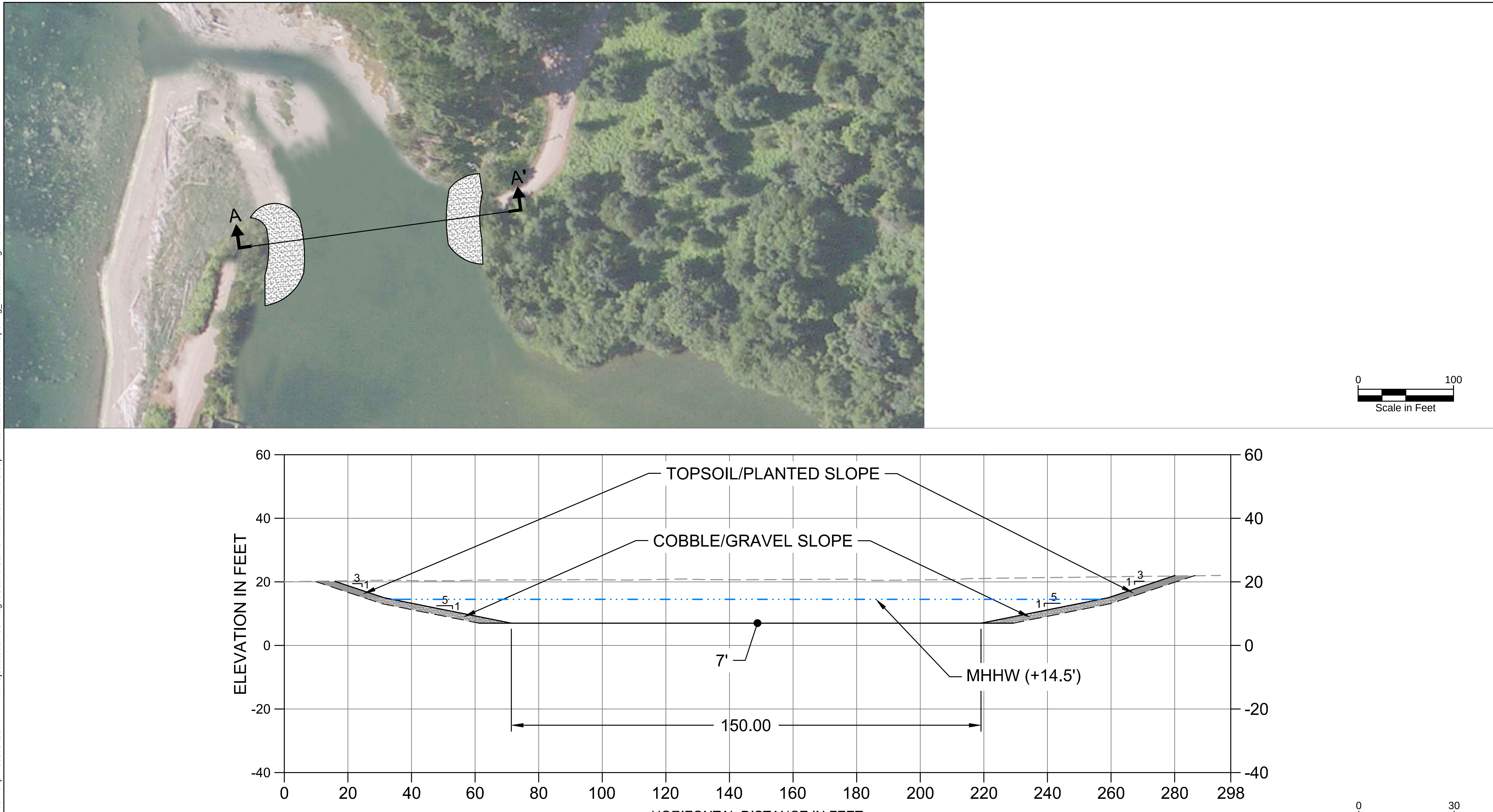
NOTES:
1. Horizontal datum: WA State Plane North, NAD83, Feet.
2. Bathymetry collected on 9/15/2014.
3. Aerial photo provided by ESRI.
4, Fiel duplicate to be collected at WQ-02.

Feet
0 100 200

Figure 1
Proposed Sampling Locations
Whiteman Cove
SPSSEG

APPENDIX D
CONCEPT FIGURES AND PROBABLE OPINIONS OF COST

Feb 29, 2016 4:04pm bsevertsen K:\Projects\0331-So. Puget Sound Salmon Enhancement Group\Whiteman Cove\0331-RP-01-Opening_Historical.dwg FIG 1

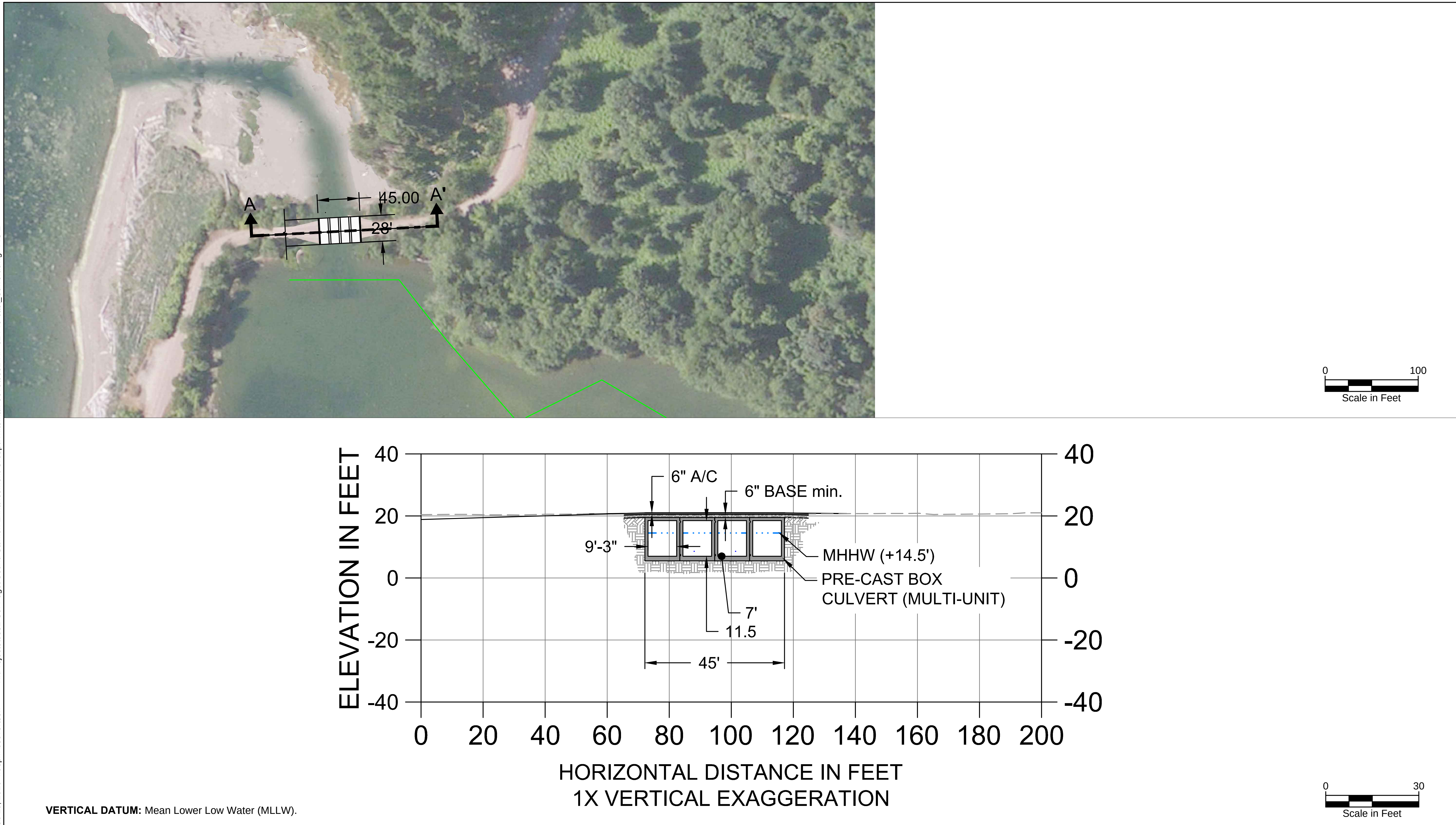


VERTICAL DATUM: Mean Lower Low Water (MLLW).

ANCHOR QEA

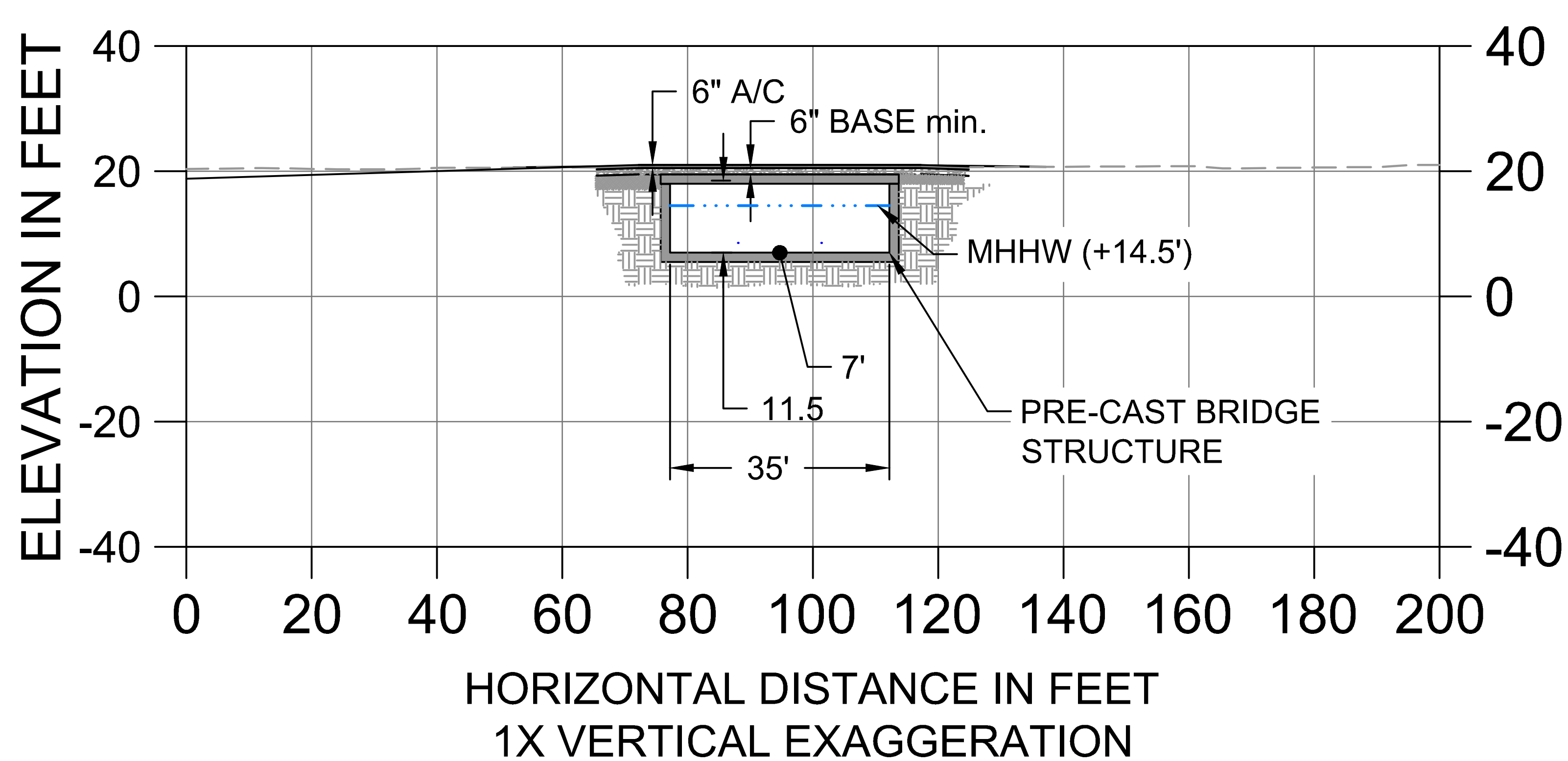
Figure 1
Channel Opening Concept
Whiteman Cove
South Puget Sound Salmon Enhancement Group

Feb 29, 2016 4:08pm bsevertsen K:\Projects\0331-So. Puget Sound Salmon Enhancement Group\Whiteman Cove\0331-RP-01-Pre-cast_Culvert.dwg FIG 2



ANCHOR QEA

Figure 2
Pre-cast Box Culvert Concept
Whiteman Cove
South Puget Sound Salmon Enhancement Group

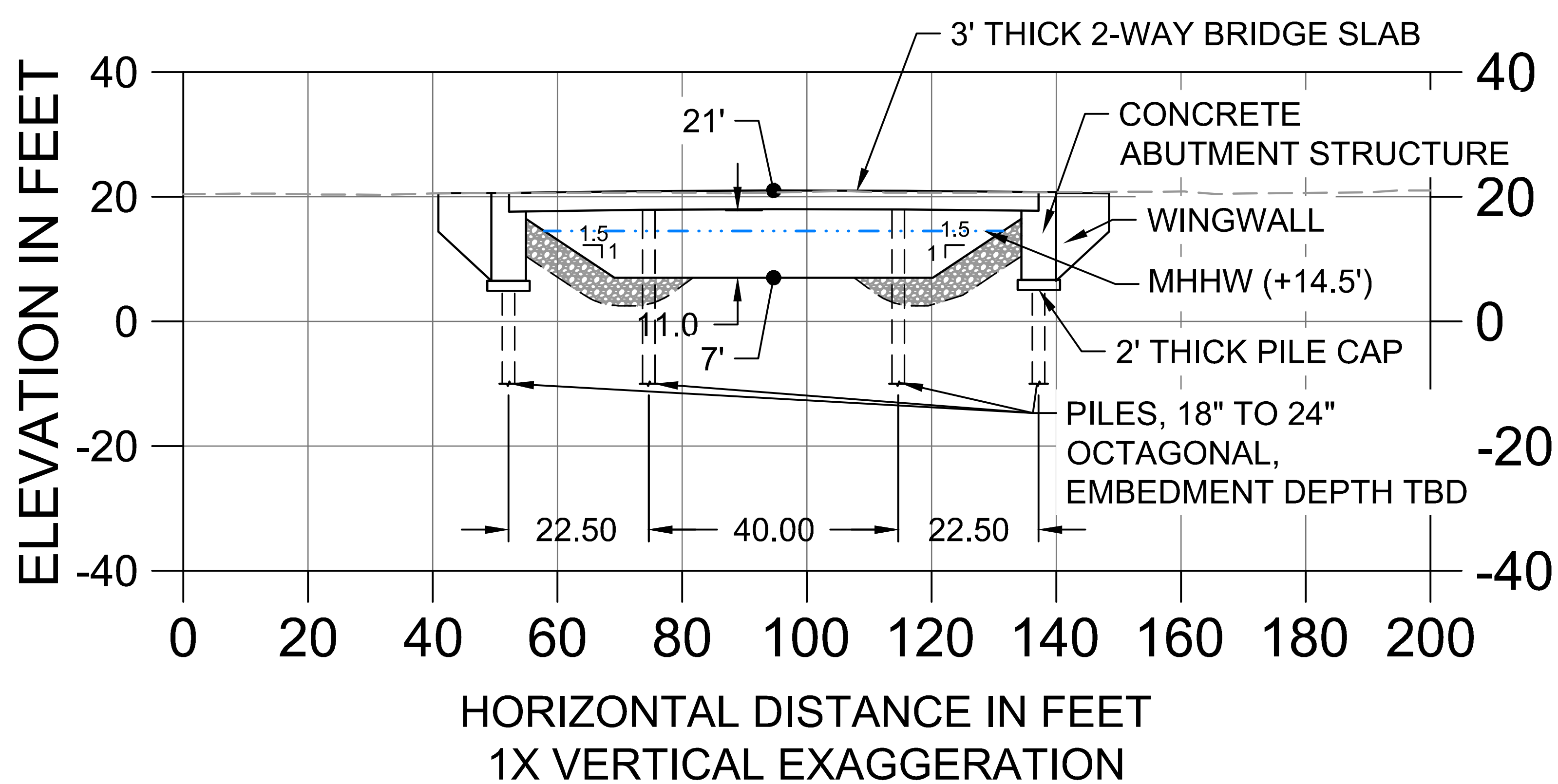


VERTICAL DATUM: Mean Lower Low Water (MLLW).

Feb 29, 2016 4:12pm bsevertsen K:\Projects\0331-So. Puget Sound Salmon Enhancement Group\Whiteman Cove\0331-RP-01-Precast_Bridge.dwg FIG 3

ANCHOR QEA

Figure 3
Pre-cast Short-span Bridge Concept
Whiteman Cove
South Puget Sound Salmon Enhancement Group



VERTICAL DATUM: Mean Lower Low Water (MLLW).

Feb 29, 2016 4:05pm bsevertsen K:\Projects\0331-So. Puget Sound Salmon Enhancement Group\Whiteman Cove\0331-RP-01-Bridge.dwg FIG 4

ANCHOR QEA

Figure 4
Bridge Concept
Whiteman Cove
South Puget Sound Salmon Enhancement Group

Conceptual Opinion of Probable Construction Cost - Whiteman Cove Concepts										
			Option 1 - Open Channel		Option 2 - Pre-cast Box Culvert		Option 3 - Pre-cast Bridge		Option 4 - Bridge	
Item	Unit	Unit Cost	Qty	Subtotal	Qty	Subtotal	Qty	Subtotal	Qty	Subtotal
1. Clearing and Demolition										
a. Clear Vegetation	SF	$0.20	8000	$1,600	2000	$400	2000	$400	8000	$1,600
b. Demolition of structure in berm opening	LS	$25,000.00	1	$25,000	1	$25,000	1	$25,000	1	$25,000
b. Remove culvert structure	LS	$15,000.00	1	$15,000	1	$15,000	1	$15,000	1	$15,000
Subtotal Demolition & Clearing				$41,600		$40,400		$40,400		$41,600
2. Earthwork										
a. Berm and Channel Earthwork (disposal on-site)	CY	$16.00	9000	$144,000	3760	$60,160	3760	$60,160	5460	$87,360
Subtotal Earthwork				$144,000		$60,160		$60,160		$87,360
3. Shoreline Protection										
a. Shoreline Protection	CY	Varies	400	$21,000	0	$0	0	$0	1	$30,000
Subtotal Shoreline Protection				$21,000		$0		$0		$30,000
4. Structural										
a. Structural	LS	Varies		$0	1	$430,000	1	$520,000	1	$853,000
Subtotal Structural				$0		$430,000		$520,000		$853,000
Subtotal Construction				$206,600		$530,560		$620,560		$1,011,960
Mobilization 10%				$20,660		$53,056		$62,056		$101,196
Subtotal Construction + Mob.				$227,260		$583,616		$682,616		$1,113,156
Design & Construction Contingency (30%)				$68,178		$175,085		$204,785		$333,947
Subtotal Const.+ Mob.+ Conting.				$295,438		$758,701		$887,401		$1,447,103
Sales Tax (8.8%)				$25,999		$66,766		$78,091		$127,345
Subtotal Const. + Mob + Conting. + Tax				$321,437		$825,466		$965,492		$1,574,448
Total Opinion of Construction Cost*				$322,000		$826,000		$966,000		$1,575,000

In providing opinions of probable construction cost, the Client (SPSSEG) understands that the Consultant (Anchor QEA) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, expressed or implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

*All costs are in 2016 dollars. Not Included Design/Engineering Fees, Project Management , Planning, & Design Review, Const. Phase Proj. Mngmnt. & Admin., Const. Inspection, Environmental Permitting, and Habitat Monitoring.