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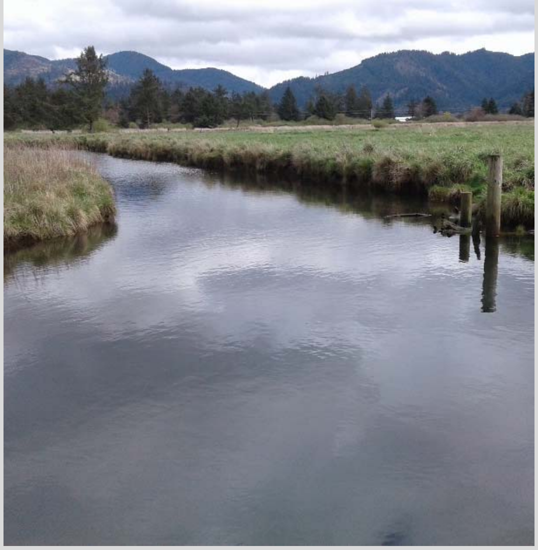
Porter Tract Restoration

Kilchis Estuary Preserve

Feasibility Analysis and Conceptual Restoration Plan

Revised
November 2017



Cover photos:

Level logger installation near Hathaway Slough
Tributary of Hathaway Slough
Nurse log in the mid-marsh habitat within the Porter Tract

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WOLF WATER RESOURCES

PC TRASK AND ASSOCIATES

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1) Introduction

The Nature Conservancy (TNC) seeks to continue restoration of rare tidal wetland habitats along the margins of Tillamook Bay with restoration of the Porter Tract, an approximately 60-acre parcel in Tillamook County, Oregon. The Porter Tract is in the lower Kilchis River watershed, one of the five large river tributaries to Tillamook Bay. The restoration site is situated approximately one mile from the mouth of the Kilchis River, and is influenced by both river flow and ocean tides. The Porter Tract would become part of the recently restored Kilchis Estuary Preserve (former Dooher Property) that was constructed in 2015 by the TNC. The cumulative area of these restoration efforts would result in 127 acres of high functioning estuarine habitat.

The overall goal of the Kilchis Estuary Preserve project is to restore freshwater and tidal hydrologic connections to the Porter Tract wetlands, providing off-channel rearing habitat for salmonids and re-establishing spruce swamp habitat. TNC has retained the Wolf Water Resources (W2r) and Phil Trask and Associates (PCTA) team to assist in developing baseline physical processes data for the site, conduct a feasibility analysis, and develop a restoration plan for the property.

1.1 Background

A significant majority of historic tidal wetlands adjacent to Tillamook Bay have been lost due to agricultural and other developments. Approximately 85 percent of the historic tidal marsh and 91 percent of historic tidal swamp has been lost due to diking or other major tidal restrictions (Ewald and Brophy 2012); most of these wetlands have been converted to agricultural uses (TBNEP 1999). The high losses of tidal swamp (forested and shrub tidal wetland) are typical of the Oregon coast; tidal spruce swamp habitats have suffered over 95 percent loss in Oregon (Christy 2004).

The TNC has prioritized conservation and restoration of tidal wetland habitats that support salmonids and other estuary-dependent species including forage fish, juvenile groundfish species, marine invertebrates, waterfowl, shorebirds and many terrestrial species that spend some portion of their life histories in tidal wetlands. One of the primary limiting factors for salmonids in the Kilchis River system is the lack of off-channel rearing habitat in low-lying areas, especially habitat in the salt-freshwater transition zone of the estuary. Coho salmon populations have been particularly affected by this loss, as access to tidal sloughs are limited by tide gates which also contribute to poor water quality in those sloughs (TBNEP 1999). In addition to habitat loss, tidal wetlands such as these are expected to be affected by sea level rise and other local effects of climate change such as changes in storm frequencies and storm surges, and changes in streamflow.

1.2 Overview of Report Organization

This report presents feasibility analyses relevant to the restoration of the Porter Tract (Figure 1). Feasibility information includes historic and current conditions in Tillamook Bay, recent site topography and bathymetry data in adjacent channels, and site impairments. This report also documents feasibility analyses of concepts for restoration of the site. Feasibility questions focus on site elevations in the wetland, revegetation, tidal channel re-creation, Stasek Slough and Hathaway Slough dike removal, and options for vehicle and pedestrian crossings of Hathaway Slough tributaries. Furthermore, flood risks were evaluated with two-dimensional hydrodynamic modeling intended to identify and/or minimize potential adverse effects on properties upstream and adjacent to the Porter Tract.

Figure 1. Porter Tract and adjacent Kilchis Wetland Preserve.

Our general approach to development of the conceptual restoration plan follows a typical planning framework that has been successfully applied to numerous conceptual restoration design projects. The process begins with a definition of project goals and objectives, opportunities and constraints, a simple conceptual model of expected habitat development, and criteria to be used in alternatives evaluation (feasibility analysis). The next step in the planning process is to characterize existing site conditions. The final steps are alternatives development, evaluation, and selection (selection by TNC based on the alternative evaluation), and documentation of the conceptual plan. The hydrodynamic model developed during the previous Kilchis restoration will be used for evaluating and refining the restoration measures to meet habitat, flood protection, and other objectives.

2) Project Understanding

2.1 Goals and Objectives

Continuing from the Kilchis Estuary Preserve restoration, the overall goal for the Porter Tract restoration is to restore estuarine habitat for listed and other native estuarine-dependent species. Towards this end, the following objectives were identified:

- Restore freshwater and tidal connections.
- Provide off-channel rearing habitat for salmonids.
- Restore spruce swamp habitat.
- Create habitat for estuary-dependent species including forage fish, juvenile groundfish species, marine invertebrates, waterfowl, shorebirds, and many terrestrial species that spend some portion of their life histories in tidal wetlands.
- Contribute to the improved understanding of tidal wetland restoration planning, design, and project construction by using a systematic, science-based adaptive management approach.
- Increase resiliency of restored hydrologic processes and the aquatic habitats they support to climate change.

Restoring freshwater and tidal connections reestablishes the processes that support and sustain natural habitats. One of the primary limiting factors for salmonids in the Kilchis River system is the availability of off-channel rearing habitat in low-lying areas, especially habitat in the salt / freshwater transition zone of the estuary (TBNEP 1999). Tidal wetland losses have been particularly severe for tidal spruce swamp habitats which have suffered over 95% loss in Oregon (Christy 2004).

Other important considerations, or operating principles, include:

- Cost-effectiveness of project implementation will be considered in the planning and design process.

- A focus on the restoration of natural processes rather than a form-based focus, so that the site may evolve under natural perturbations such as erosion, sedimentation, and other natural watershed processes.

- TNC proposes to plan and implement the project so productive relationships are developed and maintained with adjacent landowners and the community at large.

2.2 Constraints

The identification and ranking of constraints early in the design processes assist in framing the restoration feasibility process.

- Adjacent properties must maintain existing use and capacity, despite restored connectivity within the project area. Upslope properties must maintain adequate drainage, matching that of existing conditions or better.
- The project must not significantly increase the risk of offsite flooding in the area.
- Invasive species are present at the site, including nutria (who displace beneficial beaver colonization and whose burrows degrade the dikes) and reed canary grass (RCG), which will require active management to control RCG propagation under restored conditions.
- Access to various regions of the property is desired for maintenance of vegetation, monitoring, and private land access. This will require crossings (bridges or culverts) of multiple tidal channels.

3) Site Conditions

3.1 Site Assessment

Site assessments were conducted on July 27, 2016 and April 7, 2017. The initial site visit observations focused on site hydrology and flooding, geomorphology, vegetation, and identification of site constraints. The latter site visit was focused on gathering bathymetric and channel geometry data of the connector channel. Additional topographic elevation reconnaissance was also conducted to document the dimensions of diked areas along Stasek Slough and Hathaway Slough, as well as the connector channel geometry. The general site assessment and generation of restoration alternatives was also guided by post-construction observations of the Kilchis Estuary Preserve as well as desktop analysis of a nearby reference wetland southwest of the project site. These assessments are described in the following sections.

3.2 Land Use

Portions of the Porter Tract were managed for pastureland in the recent past. These areas were partially-diked and drained. The site is presumed to have subsided due to draining and decomposition of organic soils, though the level of subsidence is expected to be low in general and low relative to the Kilchis Estuary Preserve. The site is bordered by private land to the west, Hathaway Slough to the north, and Stasek Slough to the south. The closest existing infrastructure is a railroad corridor along the northeast boarder. Figure 1 shows the Porter Tract boundary, the adjacent Kilchis Estuary Preserve, and other sloughs and geographic features.

The earliest available aerial photograph from 1939 show numerous tidal channels across much of the site, especially the northwest portion of the tract. This more natural hydrologic condition contrasts with linear ditches and farmed areas in the southwest and east portions of the property. As with much of this region, this property was subject to timber operations and wetland conversion to pasture or other agricultural uses.

3.3 Drainage Infrastructure

3.3.1 Flow Control Structures

There are several flow control structures located within the project area. Two culverts facilitate crossing of ditches / channels along the northern portion of the site near Hathaway Slough. There is also a water control structure (culvert with dilapidated closure gate) in the interior of the site that drains much of the eastern portion of the property into Porter Slough.

A large timber, box culvert along the southern edge of the project area connects Porter Slough and Stasek Slough. Another culvert with tide gate is located between US 101 and the railroad northeast of the main project area. This culvert facilitates drainage of the topographically isolated area to Hathaway Slough.

Removing these structures is fundamental to the restoration of Stasek Slough and the rest of the wetland. Analysis of the impacts of removal of these structures is discussed in Section 5.1, Flood Analysis.

3.3.2 Dikes and Enhancement Natural Levees

The site is partially ringed by dikes and/or enhanced natural levees that were historically constructed to reduce flooding. For the purposes of this report, dikes refer to small and less distinct “improvements” built on top of the natural fluvial levees. Dikes exist in two locations along the boundary of the project area. The first is located along the project’s southern boundary and Stasek Slough. A second string of dikes exist along the northern boundary of the project area along Hathaway Slough. Proposed dike removal areas shown on Figure 8 are represented by a purple cross hatch.

3.4 Topography and Bathymetry

3.4.1 Field Data Collection

Building off data collected from the Kilchis Estuary Preserve restoration project, field visits helped identify site constraints and characterize existing conditions. These features are portrayed in Figure 7 and serve as the basis for alternatives development.

Baseline monitoring continued from the first phase of Kilchis restoration for water surface elevations and temperature. As a result, the period of record now extends over several water years to capture tidal water levels and coastal storms. Topography data collected by Statewide Land Survey (SWLS) were used to capture profiles of important site features including potential restoration areas. This information was also used to improve the LIDAR elevation resolution and the gradient of vegetation communities. Updated water level data are currently in development and will be documented in a revised Conceptual Restoration Plan report or early in the detailed design phase of the project.

3.4.2 LiDAR Verification and Adjustment

Updated LiDAR data (2015) was downloaded from the 2015 U.S. Army Corps of Engineers National Coastal Mapping Program (NCMP) for Tillamook Bay, Oregon. The program Lastools was used to convert the data from ".laz" to ".las" format for compatibility with ESRI ArcMap software. In ArcMap, the .las data were converted to a multipoint dataset, which was used to build the digital elevation model (DEM). A hillshade was produced from the resulting DEM, which is used to help visualize the site topography. The derived LiDAR surface and hillshade are shown in Figure 2.

The LiDAR accuracy was assessed by comparing LiDAR values to ground survey points collected in 2012. The 2012 ground survey was primarily focused on the Kilchis Preserve property to the south; however, two transects on the Porter Tract provide a basis for land elevation comparisons on-site, and channel thalweg measurements with periodic cross sections adjacent to the Porter Tract property in Kilchis River and Hathaway Slough provide a basis for bathymetric comparisons. The comparison was accomplished by extracting the LiDAR value from the cell underneath each SWLS data point and creating a new attribute field populated with the difference between the SWLS and LiDAR elevations (SWLS value minus LiDAR value).

Overall, the LiDAR values appear to exhibit the normal range of offsets between LiDAR and ground surface elevations (+1 to +3 feet). Offsets often correspond to the density of vegetation on the ground surface (i.e. how obscured the ground is from LiDAR access). The two transects on the Porter Tract indicate that the LiDAR is between 1 to 3 feet higher than the SWLS points, whereas LiDAR immediately to the south on the Kilchis site appears to be about 1 foot higher than SWLS points. This discrepancy in offsets is probably due to the difference in vegetation types; the transects in the Porter Tract property are more densely vegetated, whereas the Kilchis property to the south had shorter grasses at the time of the LiDAR flight.

LiDAR accuracy is important to consider because plants are especially sensitive to land elevations in the tidal range. To improve LiDAR accuracy for these purposes, the LiDAR-based topographic surface was adjusted based on the SWLS data comparison. The adjustment was applied only to areas targeted for planting (the southern and eastern portions of the Porter Tract site). Because of the lack of SWLS data in these areas, an average offset could not be calculated and used to apply an adjustment to the LiDAR. Instead, an average offset was derived from areas in the Kilchis Preserve site with similar vegetation. The resulting average offset was 0.8 feet; this value was used to lower (or subtract from) the LiDAR data in the targeted planting areas of the Porter Tract property. Figure 3 and Figure 4 depict the LiDAR data pre- and post-adjustment, highlighting the targeted areas in a black polygon. The SWLS survey data are displayed in Figure 4 with their corresponding elevations; the LiDAR color ramp contrasts the discrepancies between the two datasets. It is important to note that the adjustments applied to the LiDAR surface are based from preliminary analyses and are only suitable for application in planting plan creation.

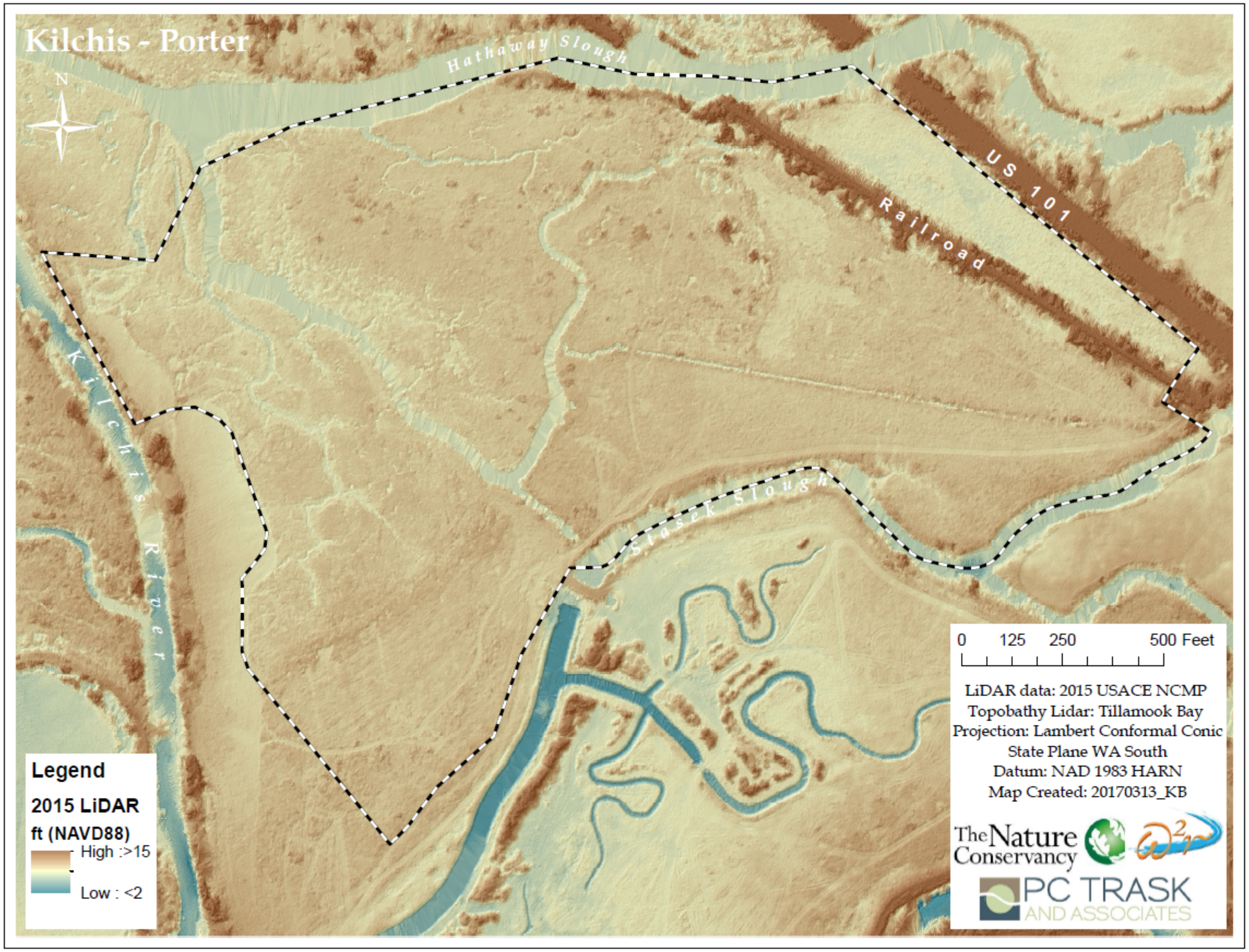

Figure 2. Initial LiDAR derived digital elevation model.

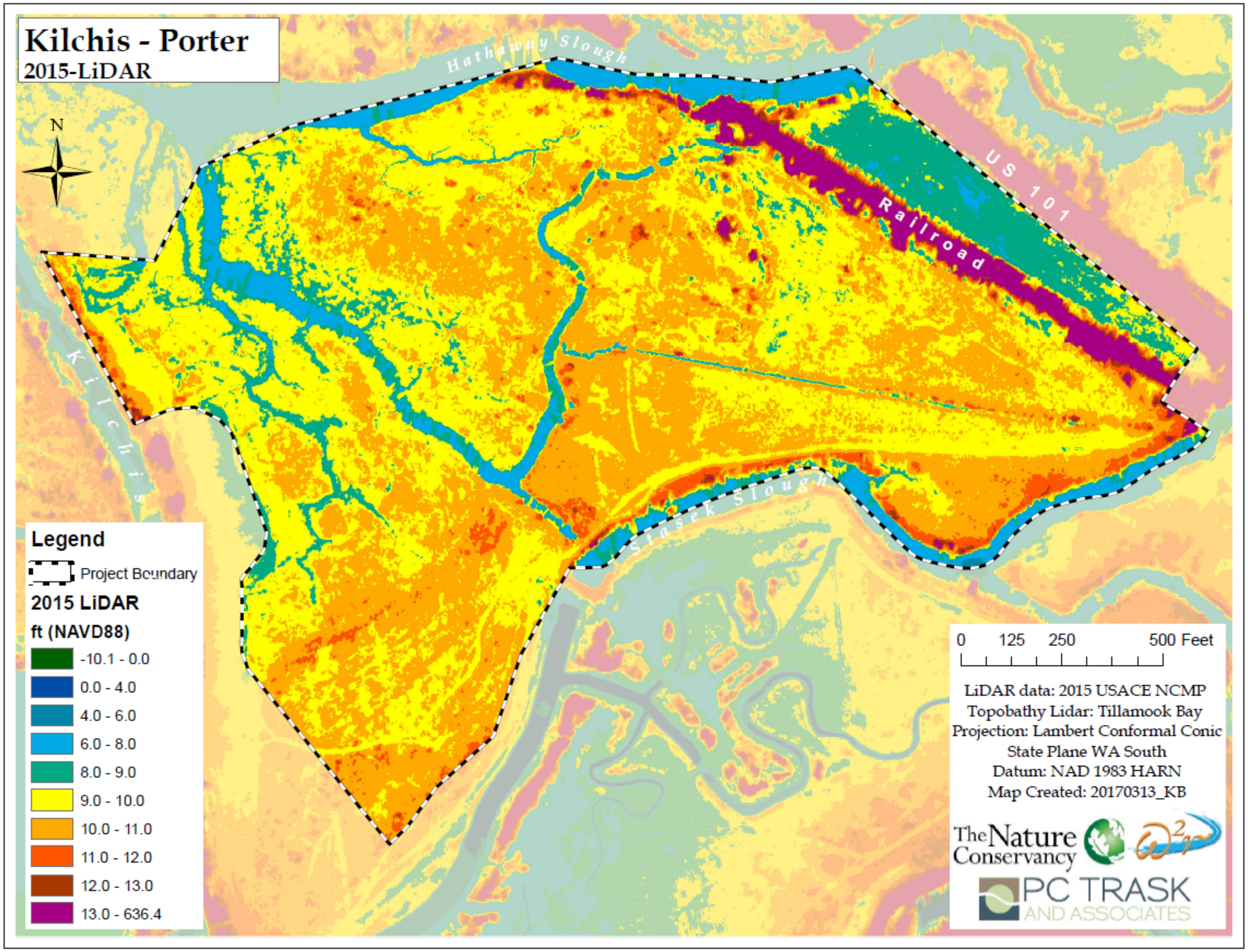

Figure 3. Pre-adjustment LiDAR digital elevation model.

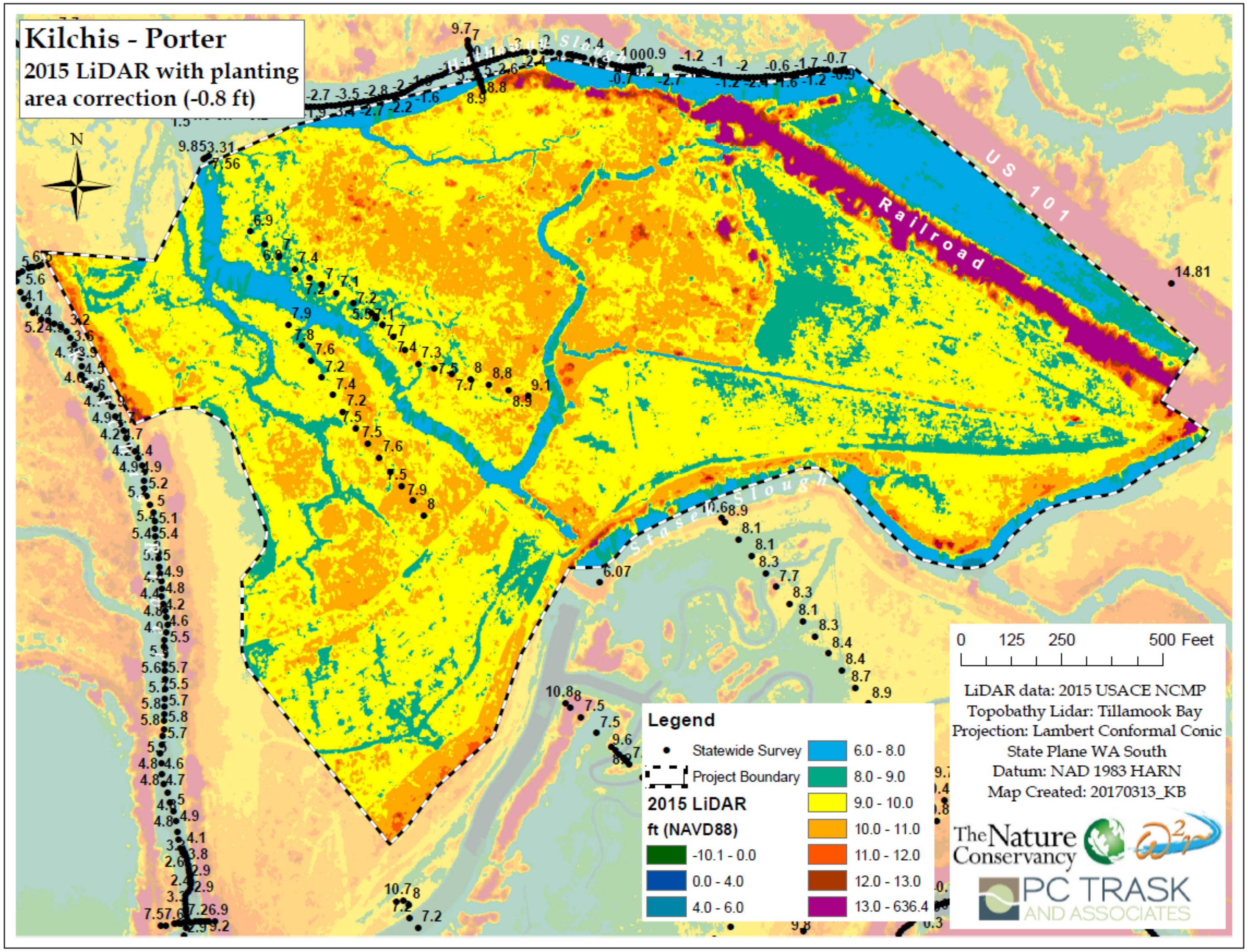

Figure 4. Post-adjustment LiDAR digital elevation model with State Wide Land Survey overlay.

3.5 Hydrology and Flooding

3.5.1 Kilchis River

The Kilchis River flows through an unimpaired watershed that drains approximately 46,920 acres (65 sq. miles). The watershed drains the west slope of the relatively low elevation Coast Range and is generally steep in slope. Because of the steep slope, runoff response during rainfall events is relatively quick, especially under saturated ambient soil conditions. For example, peak flows are high in magnitude and occur with 24 hours of the peak precipitation. In contrast, dry season flows are relatively low due to high permeability of the tertiary volcanic soils and sedimentary rocks that underlie much of the watershed. The results are extreme seasonal flow variability, with high stream flows in the wet season and low flows in the dry season (Follensbee 1998).

3.5.2 Tidal Water Level Data

Tidal datums and extreme tides for the project site are documented below in Table 1.

Table 1. Tidal and extreme water levels.

Datum / Recurrence Interval	NOAA Gage at Garibaldi – For Reference (Feet NAVD88)	Water Level (Feet NAVD88)
FEMA Base Flood	--	11 – 12*
50-Yr	--	11.8
25-Yr	--	11.6
10-Yr	--	11.5
Highest obs. / Ord. high water (OHW)	11.55	11.42
MHHW	7.93	7.80
MHW	7.22	7.01
MTL	4.10	3.89
MLW	0.98	0.98
NAVD88	--	0.00
MLLW	-0.38	-0.33

Source: ESA PWA 2013

Note that ordinary high water at the site was taken to be approximately equivalent to the recent, observed high water level (i.e., still water level) in the period of record. Storm surge and wave runup may result in total water levels above the still water level that is recorded at NOAA and other gaging stations.

4) Formulation of Restoration Alternatives

A summary of restoration concepts and discussed alternatives are depicted in Figure 7. Alternative channels, berm removal areas, alternative planting locations are highlighted in orange. Individual aspects of feasibility and cost/benefit were discussed during the conceptual design phase with TNC staff. In general, preferred design elements represented in the conceptual design (Figure 8) were determined feasible based on cost, site observations, reference material, and overall ecological benefit. The following sections briefly describe the methodology and basis for selecting the preferred design.

4.1 Channel Configuration and Density

The conceptual design of the channel network was based on the historical pattern of channels as well as on a reference site within the tidal tributary drainages of Tillamook Bay. The earliest photographs of the site date from 1939 (Figure 5). Based on the historical records, an initial sketch of the approximate historic channel network was developed. From this sketch and subsequent discussions with the project team, a GIS-based conceptual plan was developed. Channel configuration and density were then further refined by computing the combined density of constructed and tertiary channels present at the Kilchis Estuary Preserve. Channel densities were also calculated for the entirety of Porter Tract and for the channel 2 (CH2) drainage area. A reference site (Figure 6) with a similar drainage area and elevation range located 1.5 miles southwest of the Porter Tract was used to determine the appropriate channel density for the CH2 drainage area. Table 2 summarizes the channel density assessment results. The preferred channel configuration, number, location, and plan form of proposed tidal channels are shown in the Figure 8.

The intent is for the restored channels to be excavated, rather than rely on passive channel formation. Because the wetland surface is relatively high in the tidal range, these channels may not form completely or in a reasonable time frame on their own.

Table 2. Channel density assessment.

Parameter	Constructed Kilchis Channels	Constructed Kilchis Channels incl. Pilot/ Tertiary Channels	Porter Tract (Overall)	Reference Site	Porter Tract Channel 2 Only
Site Area (AC)	70	70	60	16	16.5
Total Channel Length (LF)	6,680	8,684	8,920	3,270	3,730
Total Channel Length per Area (Density) (LF/AC)	***95.4***	***124.1***	***148.7***	***204.4***	***226.1***

4.2 Dike Removal

Two partial tidal dikes would be removed under the preferred restoration plan. These dikes are low and easily accessed, making them cost effective to remove. The dikes are located along Hathaway Slough to the east and west of the railroad, and west of Neilson Slough and east of the connector channel on the north side of Stasek Slough. Removing these barriers would restore complete hydrologic connectivity and sediment and nutrient exchange processes.

Figure 5. Historic 1939 photograph of the Porter Tract and Kilchis Estuary Preserve.

4.2.1 Stasek Slough Dike Removal

Dike removal would involve lowering the dike completely to the wetland surface. Originally, the apparent berm along Stasek Slough (BS-3 in Figure 7) was included as part of the alternatives matrix. Further site assessment revealed that eastern extent of Stasek Slough did not appear to have any man-made dike along it. Thus, the upstream extent the apparent berm was removed from the restoration plan. The lengths, elevations, widths, and other dimensions of the remaining southern portion were calculated in GIS based on the LiDAR data. The total estimated volume of material to be removed 1,390 cubic yards (CY).

4.2.2 Hathaway Slough Dike Removal

Dike removal along Hathaway Slough would involve lowering the dike completely to the wetland surface. This involves removing a small area of diked material east of the railroad. A longer stretch of dike would be removed west of the railroad. Dike lengths, elevations, widths, and other dimensions were calculated in GIS based on the LiDAR data. The total estimated volume of material to be removed 750 CY.

Figure 6. Reference site location and proximity to the Porter Tract.

4.3 Filling Drainage Ditches

Excavation material from channel construction and dike removal would be beneficially reused onsite, reducing the overall costs associated with project materials. For the most part, excavated material would be used to fill agriculture drainage ditches and as backfill at new bridge placements.

Filling the drainage ditches would also assist in natural channel system development, restore wetland topography to a state closer to pre-disturbance conditions, and reduce the risk of stranding of juvenile fishes transported into the wetland during high water events. Specific locations of the existing ditches are shown on conceptual plan (Figure 8). Based on aerial photographs, LiDAR data and field observations, there are an estimated 500 LF of ditches onsite, requiring approximately 140 CY of fill material. These estimates will be refined during the design phase of the project.

4.4 Low Mounds and Fill Areas

The balance of excess excavation material can be used to raise the lowest areas of the site and to create low mounds that can be used for plantings and topographic diversity. Areas that have subsided due to drainage and decomposition of organic soils or areas used as borrow pits for dike repairs would be prioritized. Raising low areas to re-establish intertidal elevations to pre-disturbance conditions would support desired target wetland classes such as Sitka spruce tidal swamp. Reusing excess excavation material to raise low areas or create low mounds would also reduce the cost of excavation by eliminating off-haul and disposal. The restoration plan will not necessarily seek material from channel and dike excavation for raising subsided areas, but it may utilize excess material to help achieve cost savings compared to transporting excavated material offsite.

Placing fill along the tops of the bank of larger channels would simulate a natural wetland surface that slopes gradually downward away from the channel because of higher sedimentation close to the channel. In general, fill would be placed to elevations ranging from approximately one to two feet below MHHW. Final decisions on the final placement of excavated material and specific heights or locations of potential fill placement will be made in discussion with TNC.

For the conceptual design, it was assumed as a conservative estimate that an average of 1.5 feet of fill is placed over 3.5 acres. The volume of this fill is 5,460 CY. Depending on design refinement during the next phase of the project, this quantity may change substantially.

4.5 Conceptual Vegetation Modeling

Post-restoration plant community development at the site would be a function of several factors including groundwater regime, soil conditions, and salinity levels. Successful vegetation establishment also requires an understanding of its relationship to elevation. Estuary wetland vegetation is in part a function of moisture tolerance. Estuary communities colonize along an elevation gradient with respect to tidal inundation patterns. For example, Sitka spruce swamps tend to thrive along the edges of tide where surface water inundation is less frequent. Native emergent communities depend on regular exposure to tides. Invasive species like reed canarygrass to thrive along the high edges of high tide zones, but it germination and colonization capacity is strained in lower marsh zones.

Information collected in areas adjacent to restoration site helps guide potential treatments needed for achieving desired vegetation. In general, the planting zones developed for Phase I are applicable to the Porter Tract (see

Table 3 in the following section). Spot checks of elevation conducted during the reconnaissance phase verified planting zone elevations. This table was also used to query the LIDAR and delineate planting zones described above. This general approach formed the basis for a more precise planting strategy described in Section 5.2. Site elevations and tidal levels are documented in previous sections. For other factors such as salinity and tidal inundation, uncertainties remain due to limited or unreliable monitoring data. Other lessons learned during the Kilchis Preserve restoration including modifying the planting layout given microtopographic variations will also be incorporated into the planting design.

4.6 Connector Channel Crossing Structure

As the most expensive component of the proposed restoration, thorough consideration was made when considering alternatives for structures necessary to cross the connector channel between Porter and Stasek Sloughs. Currently, the crossing on the connector channel is an earthen berm with a dilapidated wooden box culvert. Field observations have determined that this culvert is undersized and restricting tidal flows. Furthermore, a large amount of debris (concrete, wood, and natural material) is exacerbating restriction at the invert on Stasek Slough.

To restore full tidal connectivity and enhance storm drainage for upstream properties, two alternatives to replace the dysfunctional structure were evaluated. The alternatives include a light duty timber bridge (Alternative 1) and a heavy-duty steel bridge (Alternative 2). An elliptical steel plate culvert was also considered as a heavy duty crossing alternative, but it is not described separately in this analysis because its material and installation costs are similar to the steel bridge (Alternative 2).

The purpose of maintaining the connector channel crossing is to allow TNC staff to access and maintain the western portion of the project site and to maintain access to the inholding property adjacent to Stasek Slough. A light duty timber bridge is cost effective and functional for TNC needs; however, additional coordination maybe required with stakeholders before selecting a crossing type.

4.7 Wood Habitat Structures

Woody habitat structures (WHSs) would be placed in newly created and existing tidal channels within the site to provide cover, as well as hydraulic and habitat complexity for estuarine fishes and other wildlife. WHSs cause scour and deposition-induced channel bedforms which result in a greater variability of in-channel habitats. Woody debris is also currently lacking in the Kilchis River estuary, where many log complexes of varying scales were removed during historic agricultural development (Follensbee 1998).

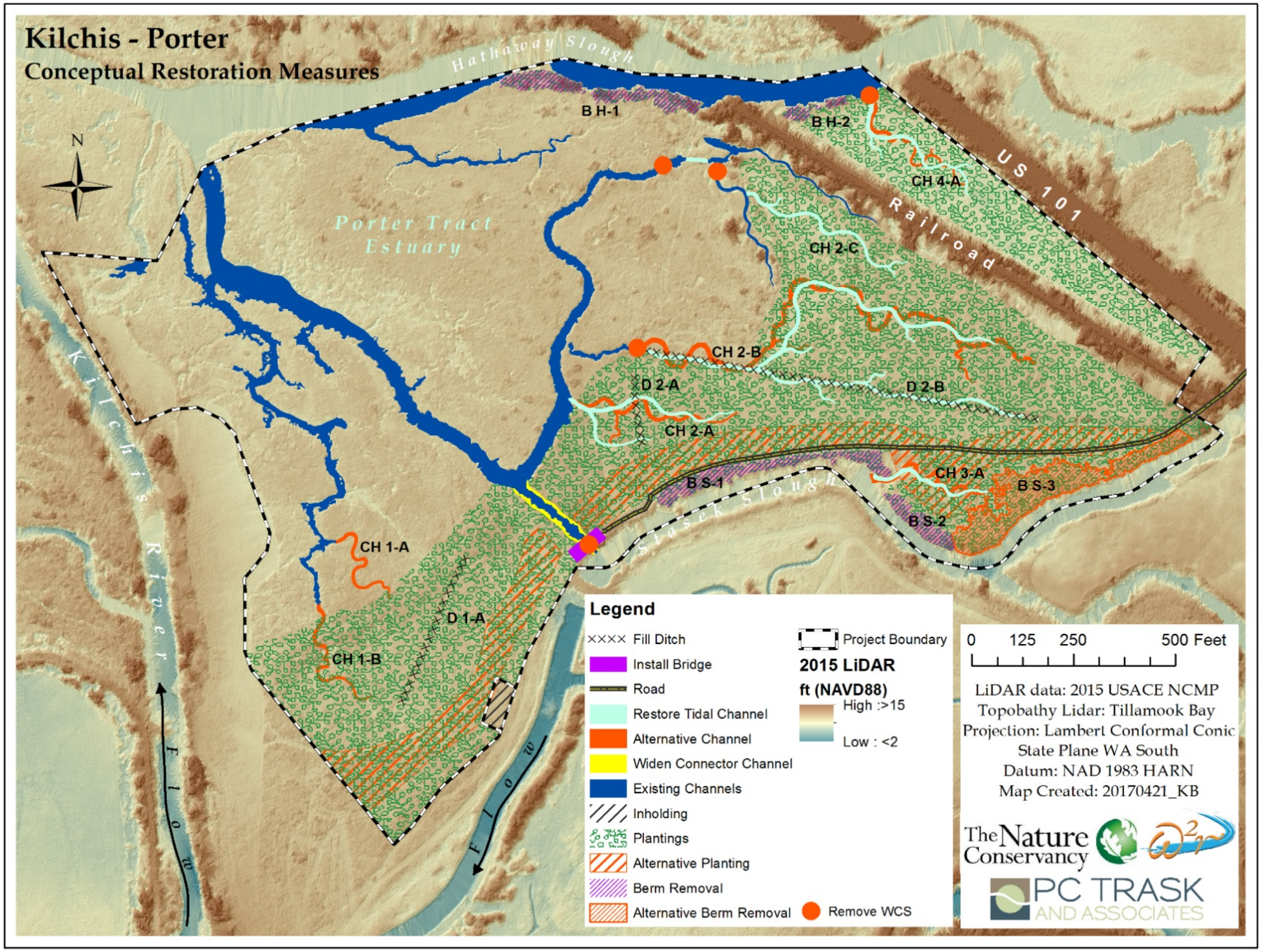

Figure 7. Summary of Restoration Alternatives.

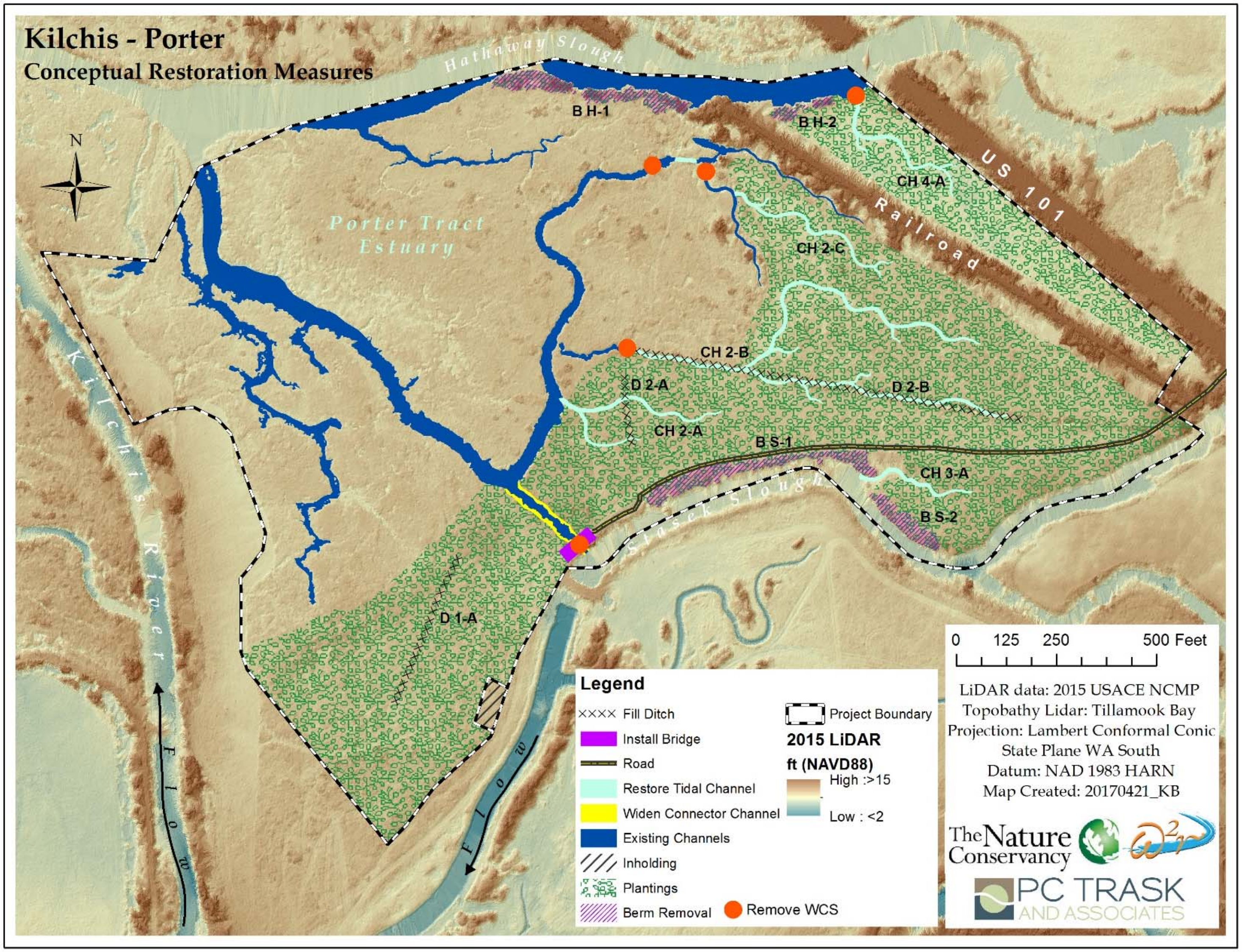

Figure 8. Elements of the preferred conceptual restoration plan.

The intent of wetland restoration is to allow the tidal channels to adjust, migrating laterally and vertically within the wetland, in response to changes in the tidal prism and, also episodic scour and sedimentation. Because WHS logs may be subject to periodic scour and displacement, the restoration design assumes this is an acceptable natural, morphological process. However, we do not expect significant loss of logs, and accumulation of new woody debris would likely be as prevalent as log displacement.

WHSs placed in clusters or groups of 1 to 3 logs are likely appropriate for tidal channels of the sizes within the site. Logs within the clusters would be buried and/or driven into the channel embankment to resist flotation and displacement. The logs will not require rock, anchors, or other ballasting mechanisms due to the relatively low velocities in the tidal channels and sufficient embedment into the wetland soils.

The specific number of logs appropriate for the site is not known. The conceptual design assumes approximately 25 total logs would be required for approximately 12 to 15 individual clusters.

5) Assessment of The Conceptual Plan

5.1 Hydrodynamic Modeling

5.1.1 Post-2015 Storm Geomorphic and Flood Assessment
Hydrodynamic modeling assessment of channel and site changes in response to the 2015 through 2017 storms was recently completed (ESA 2017, see Appendix A). The purpose of this assessment was to survey the geomorphic changes in the channels and wetland, simulate 2015 to 2017 storm conditions to see if site changes might have exacerbated inundation surrounding the Kilchis Estuary Preserve, and make recommendations for the Porter Tract restoration.

Results of the assessment include that significant geomorphic changes in the Kilchis project site (wetlands and channels) as well as the Kilchis River have occurred since the December 2015 storm. Sediment deposition generally on the order to 1 to 2 feet was noted in many channels and wetland areas in the southwest portion of the restored Kilchis Preserve. In the river, bed elevation changes were variable with some erosion and deposition occurring upstream of the restoration (± 2 feet generally), consistent deposition on the order of 2 to 4 feet occurring adjacent to the river dike removal locations, and highly variable bed elevation changes also noted downstream of the dike removal near Squeedunk Slough.

Several significant storms have occurred since restoration of the Kilchis Estuary Preserve. The December 2015 storm was estimated to be between a 10- and 50-year event (over 14,000 cfs), and several other significant storms occurred in 2016 and 2017, the next largest occurring on February 9, 2017 (an approximate 2- to 10-year event of approximately 9,700 cfs). Simulations of the largest flood events since 2015 were conducted using updated topographic and bathymetric data. Model results generally showed fair comparison with observed water levels on the Kilchis River, the interior of the Kilchis Preserve (Channel 2), and Hathaway Slough. The largest uncertainty in the results is likely the estimation of the magnitude and timing of Kilchis River flows which is based on scaling gaged flow records from the Wilson River.

Another finding of the assessment was that water level results in the Kilchis River during extreme events such as the December 2015 storm were not particularly sensitive to bathymetric changes in the river (as-built versus post-2015 storm river bed elevations). It was hypothesized that bed elevations have much less control on water levels than do the increased storage and conveyance capacity associated with the restored Preserve.

The model also showed significant inundation of the properties adjacent to Stasek and Nielsen Sloughs and upstream of US 101 during the peak of the December 2015 and the January and February 2017 storms. It appears that inundation of these regions occurs initially from tidal water levels (from the west, Hathaway Slough, etc.), and during higher Kilchis River flows inundation also occurs from the Kilchis River upstream of US 101 (flowing west into Stasek and Nielsen Sloughs from their upstream ends). However, in each of these simulations including the December 2015 event the Dooher residence located east of the Preserve is surrounded by high water, but it is not inundated - consistent with observations of the landowner during the actual event.

Based on the updated model simulations, several recommendations from the assessment were made. These included to continue to monitor the river and Preserve for sediment accretion and scour, survey the crest elevations of any low berms surrounding properties that might be sensitive to inundation, better determine the effect of the Squeedunk log jam on flow into this slough and in the Kilchis River, and reconsider excavation of the aggraded channels in the Preserve if it can be done in a way to minimize future flows and sedimentation into the channels.

5.1.2 Porter Tract Restoration Assessment

As part of the development of the conceptual restoration plan, the hydrodynamic model described in the previous section was further modified to include the new channels, filled ditches, and other restoration features outlined in Section 4. The primary purpose of these model refinements was to determine if the proposed restoration features on the Porter Tract might have an effect on flood water levels on the properties adjacent to the Preserve. The model was also used to characterize expected benefits in wetland hydrology in the new channel networks.

A comparison of the existing (i.e., current, or post-2015 to 2017 storms) and proposed model geometries is shown in Figure 9. The figure shows existing conditions topography in the top pane and proposed conditions topography in the bottom pane. Elevations bands are color-shaded from +20 feet NAVD88 to -3.0 feet NAVD88. The proposed conditions geometry reflects new channels, filled ditches, removed water control structures, as well as small mounds of fill for topographic relief/diversity located around the channel 2 network (north of Stasek Slough).

Inundation Results

Inundation results between existing and proposed conditions were compared under the December 2015 storm hydrology. Results are shown during two snapshots in time: December 8 at 12:00pm during the approximate peak of tidal water levels (see Figure 10) and December 9 at 1am during the peak of the Kilchis River flows (see Figure 11). The top panels in each figure show color-shaded water surface elevations (WSEs) in feet NAVD88.

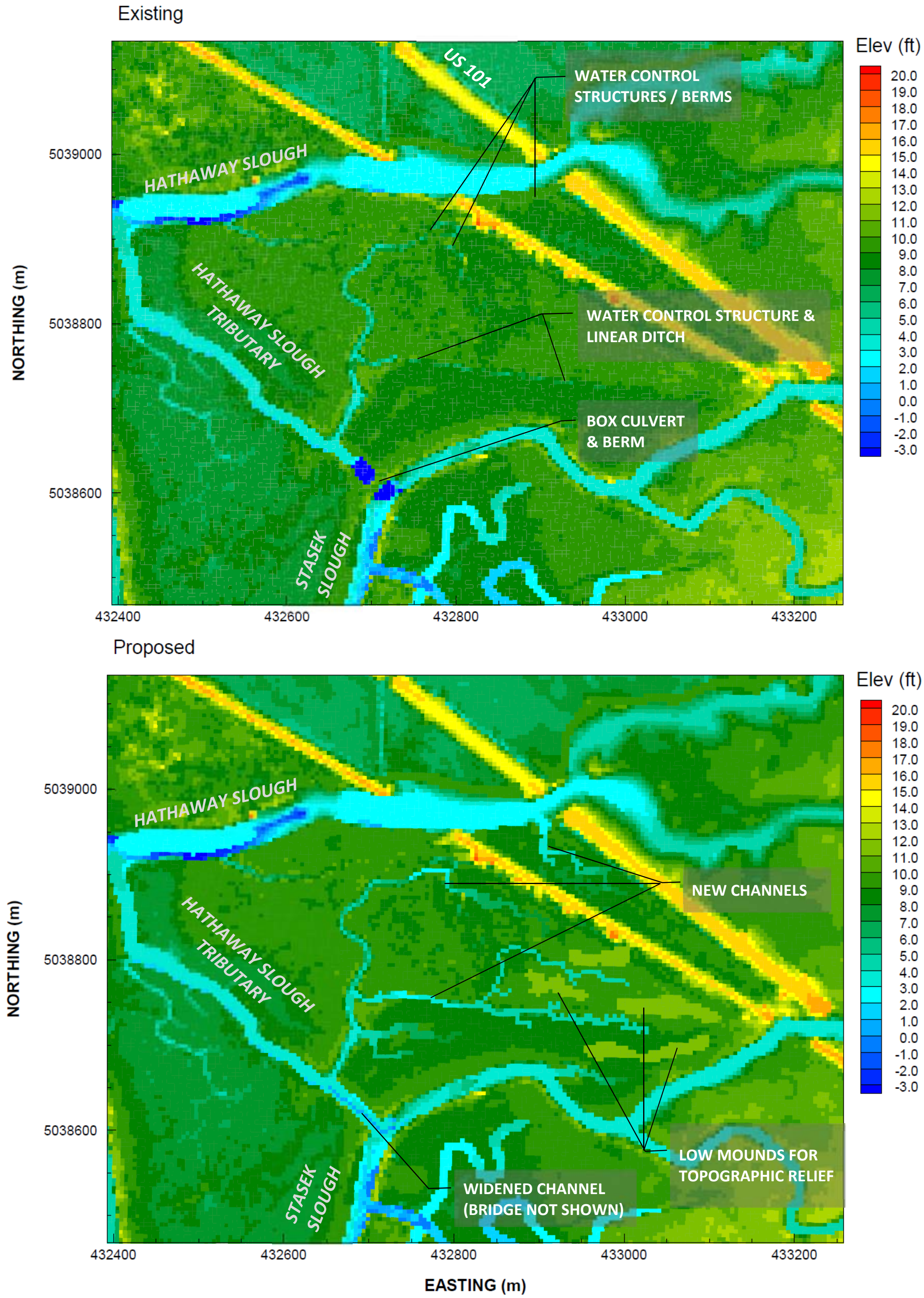

Figure 9 Comparison of Existing (Top) and Proposed (Bottom) Hydrodynamic Model Geometries.

In Figure 10 during peak tidal water levels which occur approximately 12 hours before peak river flows, water levels are very similar between existing and proposed conditions. Peak water levels under both conditions peak between 10.5 and 11.0 feet NAVD88 in the Porter Tract and Kilchis wetlands. The inundation extents around US 101 and Stasek and Nielsen Sloughs are also nearly identical. Very little difference is seen between either water surface elevations or inundation extents.

In Figure 11 during peak river water levels, water levels throughout the model domain are noticeably higher than they were in Figure 10. At this moment in time the river has overtopped its banks and flowing into Stasek and Nielsen Sloughs from their upstream ends, consistent with the prior modeling analysis (ESA 2017). The water surface elevations and inundation extents are also very similar between existing and proposed conditions. This result is as expected, as the relatively minor channel creation and expansion of the connector channel as part of the proposed restoration plan are not anticipated to exacerbate inundation during extreme tidal or fluvial water levels.

Post Storm Drainage Expediency

Results were also evaluated following the flood event when water is receding from the region to determine if proposed restoration actions such as opening the connector channel may aid drainage from key areas such as the properties around Stasek and Nielsen Sloughs. Figure 12 shows the inundation snapshot approximately 14 hours after the peak flows in the Kilchis River. The figure shows small reductions in water surface elevations on the order of 0.5 feet. The callouts in the figure show water surface elevations in Stasek Slough upstream of the connector channel around 11 to 11.5 feet NAVD88, while water surface elevation under proposed conditions vary around 10.5 to 11 feet NAVD88. The small decrease (improvement in drainage) does not appear to persist for more than a few hours.

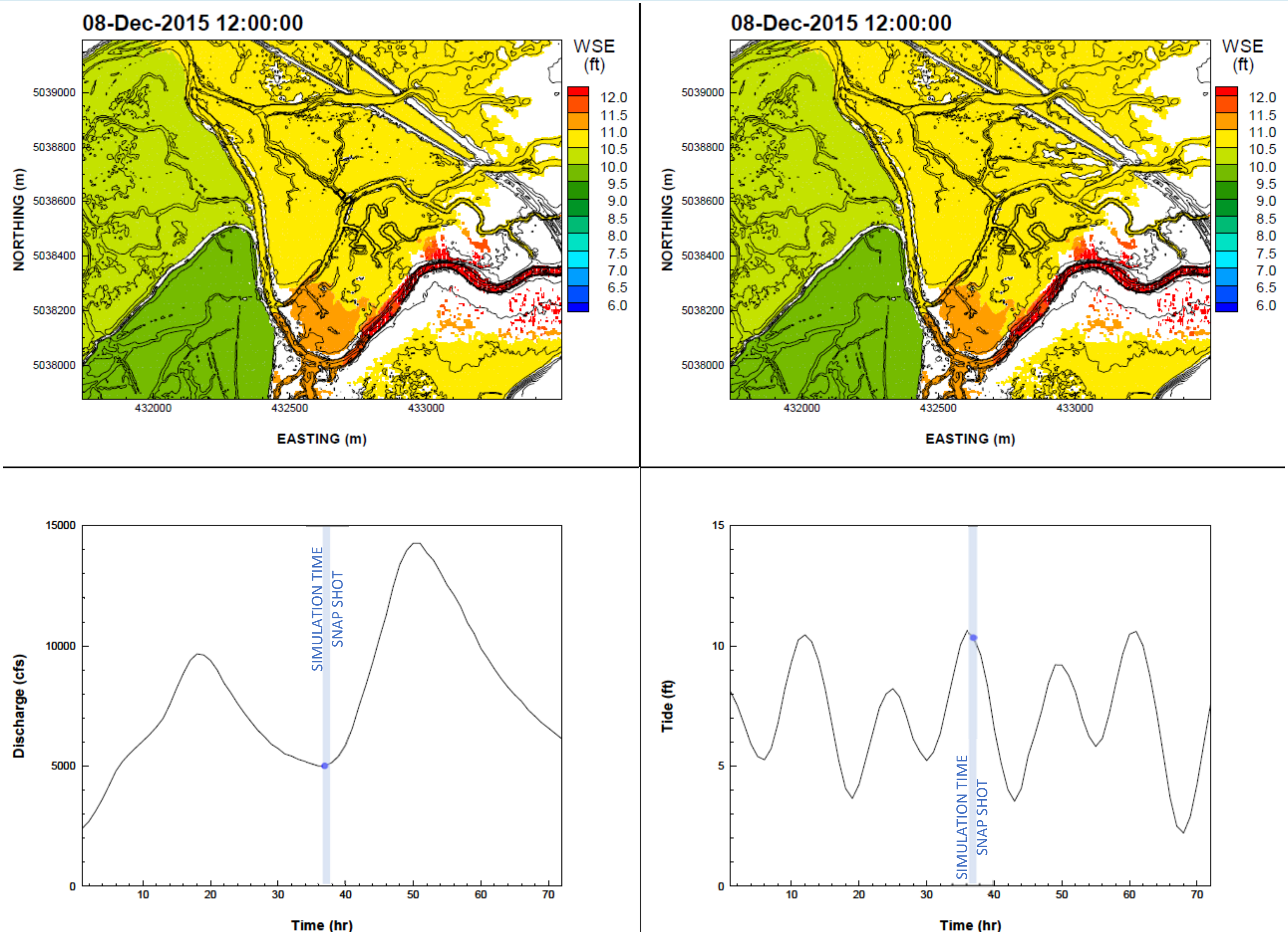

Figure 10 Snapshot of Peak Inundation Extents (12/8/2015) Under Existing (Left) and Proposed (Right) Conditions.

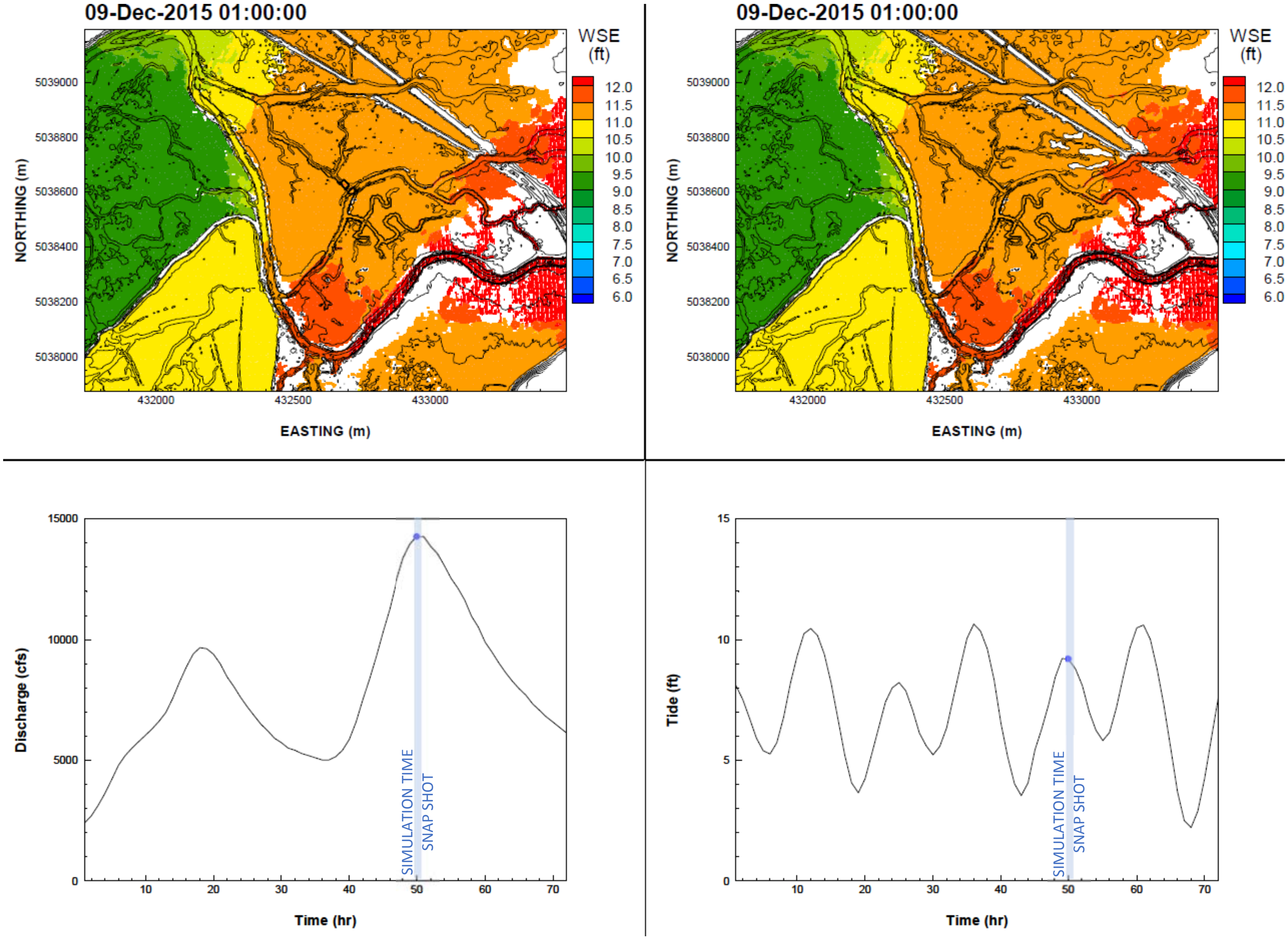

Figure 11 Snapshot of Peak Inundation Extents (12/9/2015) Under Existing (Left) and Proposed (Right) Conditions.

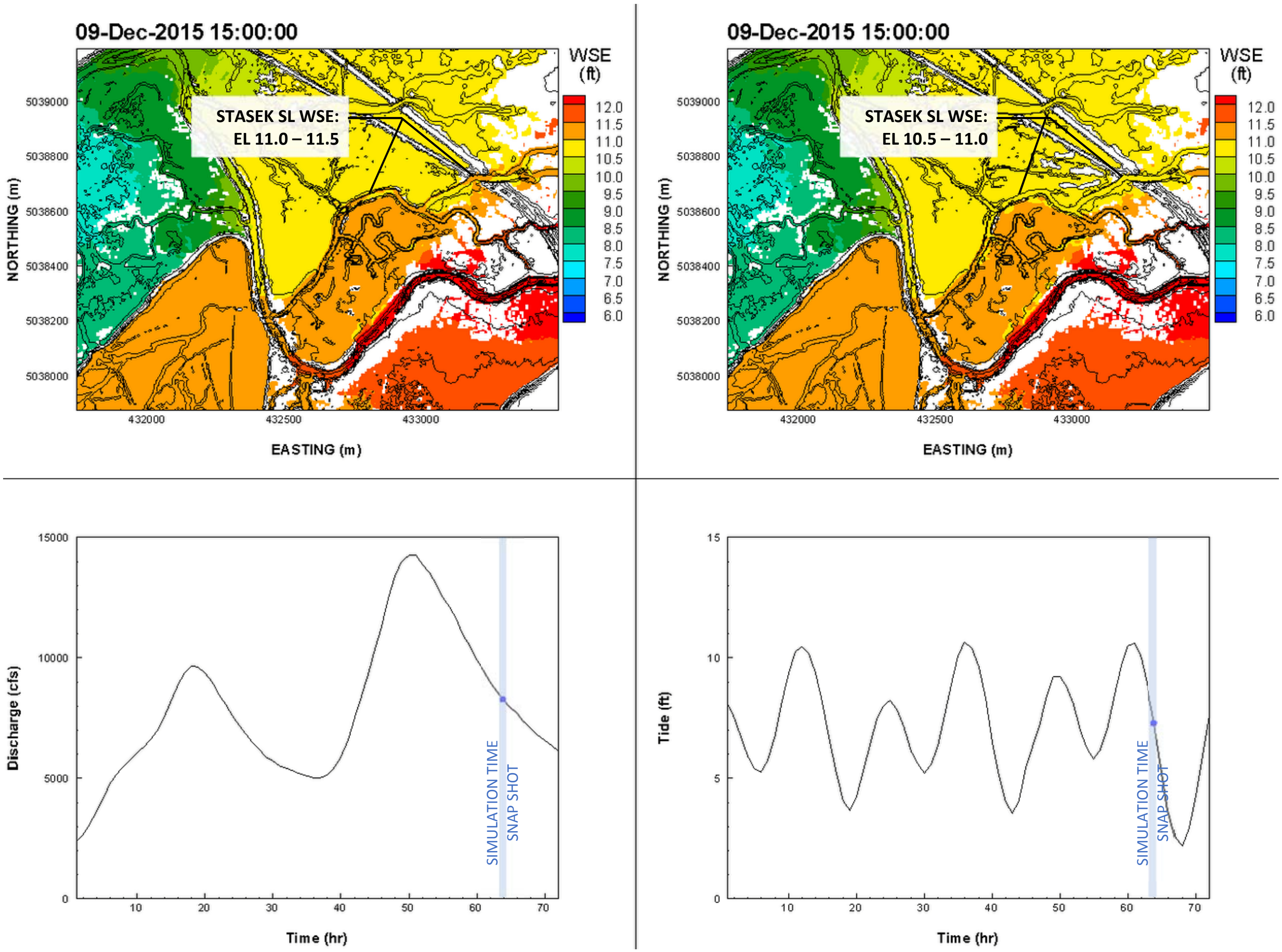

Figure 12 Snapshot of Drainage Patterns (12/9/2015 15:00) Following the Flood Peak Under Existing (Left) and Proposed (Right) Conditions.

5.2 Planting Strategy

The Porter Tract currently includes regions of well-developed, native estuarine marsh on the northern portion of the site adjacent to Hathaway Slough as seen on Figure 13. This native patch transitions to a mix of native estuarine plants and relic pasture grasses to the south and east. We recommend a planting strategy that jump starts the desired estuarine species, supports existing marsh species, and increases wetland species heterogeneity. The planting plan is also informed by the initial response of planting activities from the Kilchis Preserve restoration project. Soil testing information will also be valuable to increase the likelihood of success for certain plants. If possible reference site information should be applied to verify plant list and target proper elevations.

Sitka-spruce swamp development patterns depend on complex successional patterns. These processes can last centuries to achieve climax stage development. Hummock-hollow formation is dependent in part by nurse logs and sediment deposition patterns. Nurse logs add roughness to marsh surface that can facilitate additional debris and sediment deposits. New restoration techniques are being applied to jump-start Sitka spruce development patterns. Examples include the Fort Clatsop and Kandoll restoration projects in the Columbia River Estuary. This includes the disposal of excess fill material to emulate topographic hummocks. Hummocks or low mounds were also created on the adjacent Kilchis Preserve restoration project and have proved successful.

The current planting plan includes hummocks and plantings intended to facilitate spruce colonization over time. The zones depicted in Figure 13 and Table 3 offer enough area to adaptively manage the plantings for sea level rise. Some consideration may be warranted to develop transition zones in anticipation of marsh upward migration patterns from 1 foot of sea level rise within a 50-year planning horizon. Figure 13 below is a conceptual plan developed by TNC staff depicting position and orientation of potential plant communities at the site.

A strong revegetation effort is advisable to minimize reed canarygrass spread and impact on existing native vegetation communities. The initial effort might include both dense herbaceous plantings and well-planned woody plantings to jump-start shading-out of reed canarygrass and development of swamp habitat. In existing dense stands of reed canarygrass, herbicide use, scalping and offsite disposal of the reed canarygrass root mat is advisable, followed by intensive herbaceous and woody species plantings.

Low salinity levels may make it more difficult to control reed canarygrass after restoration. Disturbed sites that are low in salinity (e.g. less than 10 PPT) favor reed canarygrass. If salinity monitoring suggests that internal salinities will be less than 10 parts per thousand (PPT), woody plantings tolerant of very wet conditions (e.g. willow) may be the best approach, even on lower elevation areas. Willow plantings are relatively cheap and can be effective in controlling reed canarygrass. Retaining desirable native vegetation to the extent practicable is also recommended.

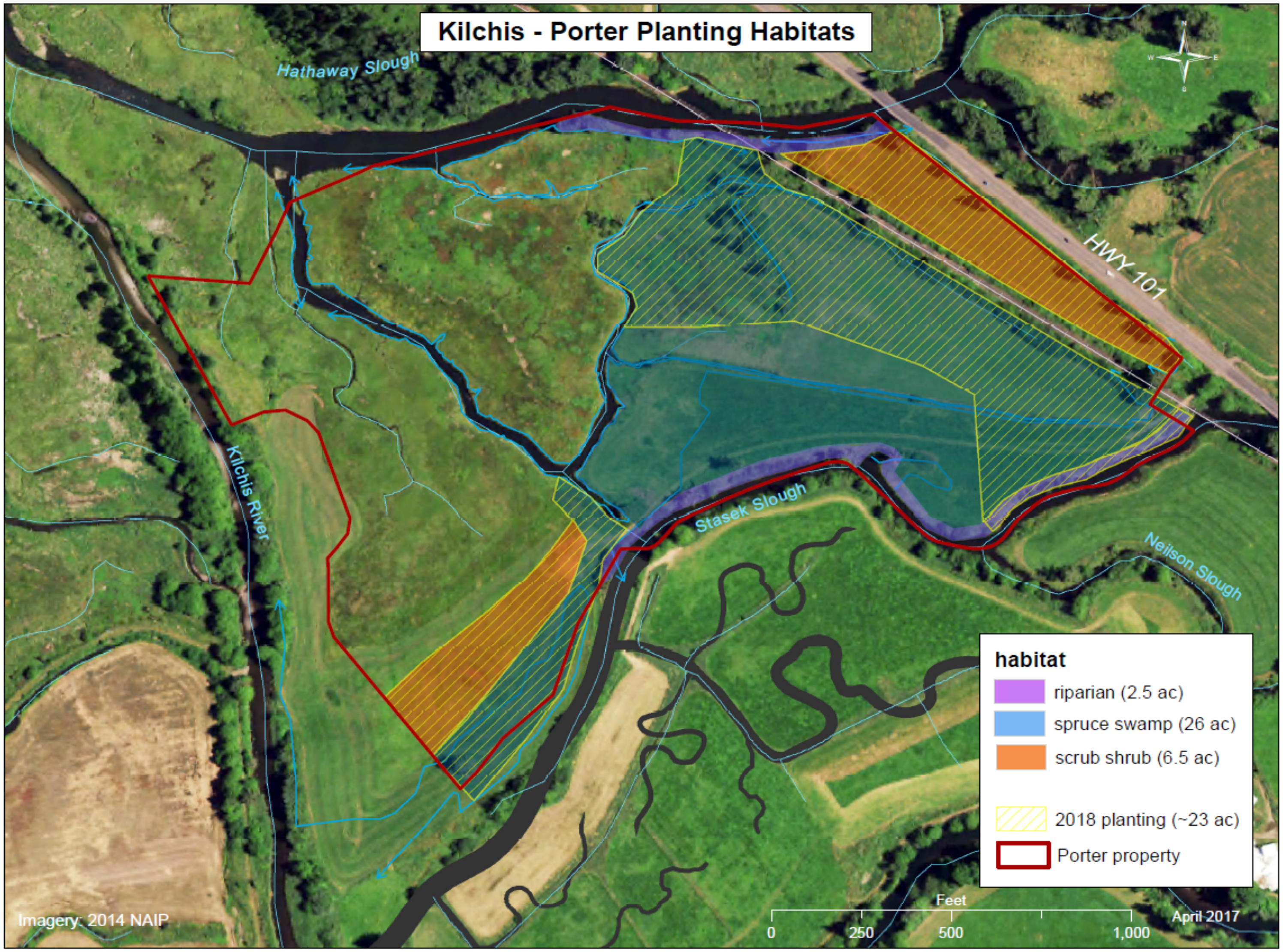

Figure 13. Porter Tract Planting Zones

Table 3. Plant materials for Phase1 and Phase 2 Planting

		Habitats			
Species	Common Name	Spruce Swamp (26 ac)	Riparian Forest (2.5 ac)	Tidal Scrub Shrub (6.5 ac)	Totals
Alnus rubra	Red Alder	800	375	0	**1,175**
Lonicera involucrata	Twinberry	12,300	375	0	**12,675**
Malus fusca	Crabapple	6,100	0	0	**6,100**
Picea sitchensis	Sitka Spruce	4,600	375	0	**4,975**
Populus trichocarpa	Cottonwood	1,500	450	0	**1,950**
Rhamnus purshiana	Cascara	0	375	0	**375**
Rubus parviflorus	Thimbleberry	0	225	0	**225**
Rubus spectabilis	Salmonberry	0	375	0	**375**
Sambucus racemosa	Red Elderberry	7,700	600	0	**8,300**
Spiraea douglasii	Spirea	8,500	375	0	**8,875**
Thuja plicata	Western Red Cedar	0	75	0	**75**
Salix sp.	Hooker's, Sitka Willow	35,500	3,900	18,200	**57,600**
	Plant Totals=	**77,000**	**7,500**	**18,200**	**102,700**
	Overall Plants/AC	3,000	3,000	2,800	--
	Plant Cluster/AC	2,100	2,000	1,100	--

5.3 Cut and Fill Balance

Preliminary cut and fill balances have been calculated based on LiDAR elevations and not on ground survey data; thus, these calculations should be considered preliminary. Modifications to the cut and fill balance will be done in the engineering design phase of the project when supplemental survey data are collected.

Excavation is required for construction of the tidal channels, widening of the connector channel, and lowering the Stasek Slough and Hathaway Slough dikes. The total material generated from berm removal is estimated to be 2,140 CY. Channel construction would require approximately 3,200 CY of excavation. The quantity of material needed to fill ditches is 140 CY. Since the amount of material required for filling ditches is small relative to the berm removal and channel excavation quantities, a large quantity of material, approximately 5,400 CY, would be placed onsite such as subsided areas and mounds.

5.4 Passive Versus Active Channel Creation

Passive tidal channel creation is a restoration approach whereby the channel network is not fully or partially excavated during construction. If a restored tidal wetland is only breached and/or only pilot channels are excavated, future channel development relies on the tidal inundation and drainage to scour channels primarily through head-cutting and incision until the channel size and extent comes into equilibrium with the tidal prism and drainage area. Passive channel creation is best applied to large sites with wetland elevations substantially below MHHW (e.g., Cornu and Sadro 2002).

In the Porter Tract wetland, the lowest elevations are approximately 7 to 8 feet NAVD88, less than 1 feet below MHHW which is 7.8 feet NAVD88. Consequently, incorporating passive channel formation is not recommended. It is not likely that pilot channels would evolve in a reasonable time frame (e.g., 5 to 10 years) or that a complex tributary channels network would form. The relatively well-developed channel network shown in the conceptual plan is intended to be constructed to full width and depth. The geometries of the channels would be determined during the design phase, though for estimates of excavation quantities and costs, depths and widths varied from 2 to 7 feet and 3 to 8 feet, respectively.

5.5 Connector Channel Evaluation

The connector channel is a man-made channel created between 1955 and 1966 based on aerial photographs from these years (ESA PWA 2013). Presumable the channel was constructed when the Lower Stasek Slough was filled/disconnected from the river. The connector was required to drain rainfall-runoff and floodwaters from the Kilchis River into Tillamook Bay via Hathaway Slough (see Figure 8).

During the Kilchis Estuary Preserve project in 2015, the connector channel was kept in place as a secondary drainage pathway as an issue to be re-evaluated during a second phase of restoration (the current Porter Tract restoration). Currently, the preferred restoration plan for the Porter Tract includes slightly widening the channel and providing a crossing structure for maintenance access to the other side. This approach may be justified by the following:

- The secondary drainage pathway facilitates restoration buy-in from the adjacent landowner, who wishes for the channel to remain open.
- The connector channel is practical as a redundant drainage pathway.
- Based on the 1955 aerial photograph, the channel was constructed at the location of an existing natural channel, so the current channel serves as drainage from the adjacent marsh into the south tributary of Hathaway Slough as it did historically.
- The proposed connector channel is not large relative to Stasek Slough.
    - The estimated cross-sectional areas of the widened connector channel and Stasek Slough are approximately 130 SF and 550 SF, respectively. The widened channel is only 20% of the size of the Stasek Slough.
    - It is estimated that the connector channel is not large enough to significantly influence tidal or storm hydraulics or sedimentation in the lower (west) portion of Stasek Slough. The potential negative risks of keeping the secondary connection are not high.

- The size of the tidal channel network as well as the size of the channels themselves that were constructed on the Kilchis Preserve in 2015 are considered conservative (on the high side of what is estimated to be appropriate). The channel network and geometry errored on the high side to provide improved initial tidal aquatic habitat, and to ensure that habitat could evolve appropriately under combined fluvial and tidal processes. Thus, tidal hydraulics are likely sufficient to support a secondary drainage pathway such as the connector channel without a significant detrimental geomorphic response.
- Secondary and distributary tidal channels networks are common in natural or least-disturbed settings. A nearby example is the Squeedunk Slough distributary channel located southwest of the Kilchis Estuary Preserve. Squeedunk Slough apparently began as a small distributary (avulsed) channel based on early site photographs (thought its size is believed to have been enhanced by the landowner).

5.6 Conceptual Cost Estimates

Planning level construction cost estimates were developed to inform project feasibility. The estimates were intended to document general cost ranges of restoration options being considered. This information can be used for project budgeting, and it also informs decision making in case cost/restoration trade-offs will be required.

5.5.1 Cost Basis and Assumptions

General markups and unit costs are based on recent estuary restoration projects in Oregon. Quantities are based on earthwork take-offs and measurements in GIS from the adjusted LiDAR-defined topography. Quantity estimates are generally conservative and rounded up as appropriate to account for the pre-design stage of the project and numerous variables and unknown site conditions.

The following assumptions were made in developing the cost estimate:

- General site preparation markups: total of 10% of other direct costs
- General earthwork: $7 to $10 per cubic yard ($/CY) to reflect relatively dry working conditions
- Revegetation: $7,000 to $8,000 per acre ($/AC) to reflect a high level (density, etc.) of revegetation similar to previous TNC revegetation costs.
- Low berm and dike removal earthwork: $7/CY
- Design contingencies: 25% to account for primarily minor design details not yet included in the estimate

5.5.2 Detailed Cost Estimate

Costs are estimated for two restoration alternatives that contrast the costs of light duty (alternative 1) and heavy duty (alternative 2) connector channel crossing options - see Table 4 below.

Table 4. Construction cost estimates for two restoration alternatives.

Item	Qty	Unit	Unit Cost	Total Cost: Alt. 1 Light Duty Crossing	Total Cost: Alt. 2 Heavy Duty Crossing	Notes
Site Preparation				**$ 64,000**	**$ 68,800**	
Mobilization / Demob.			4%	$ 25,600	$ 27,500	Percent of direct constr. costs
Erosion Control, Clearing/Grubbing			4%	$ 25,600	$ 27,500	Access, erosion, clearing/grubbing
Site & Water Management			2%	$ 12,800	$ 13,800	Dewatering & diversions
Earthwork				**$ 60,180**	**$ 60,180**	
Demo Connector Channel Culvert	1	EA	$ 3,000	$ 3,000	$ 3,000	Approx. 4' timber box culvert
Demo Other Culverts	3	EA	$ 2,000	$ 6,000	$ 6,000	Porter SL and near US 101
Fill Linear Ditches	140	CY	$ 8.00	$ 1,120	$ 1,120	Includes ditches 1-a, 2-a
Excavate / Widen Connector Channel	410	CY	$ 8.00	$ 3,280	$ 3,280	Assume regrade onsite
Excavate Channel 2	2,360	CY	$ 8.00	$ 18,880	$ 18,880	Includes 5 Tributaries
Excavate Channel 3	160	CY	$ 8.00	$ 1,280	$ 1,280	
Excavate Channel 4	230	CY	$ 8.00	$ 1,840	$ 1,840	
Excavate Abandoned/Collapsed Farm Crossings	180	CY	$ 10.00	$ 1,800	$ 1,800	Remove native material, buried water structures
Stasek Dike Removal & Regrade Onsite	1,390	CY	$ 7.00	$ 9,730	$ 9,730	Remove portion of dike
Hathaway Dike Removal & Regrade Onsite	750	CY	$ 7.00	$ 5,250	$ 5,250	Remove portion of dike
Streambed Gravel at Bridge/Culvert Crossings	400	TN	$ 20.00	$ 8,000	$ 8,000	Scour protection at crossings
Structural				**$ 66,000**	**$ 90,000**	
Alt 1.: Light Duty Timber Bridge (ATV, Pedestrians)	**1**	**LS**	**$ 38,000**	**$ 38,000**	--	Across connector channel (light duty), 40' length
Alt 2.: Heavy Duty Steel Bridge/Culvert (Trucks)	**1**	**LS**	**$ 62,000**	**--**	**$ 62,000**	Across connector channel (hvy duty steel bridge or culvert)
Install Timber Pedestrian Bridge - Porter SL North	1	LS	$ 28,000	$ 28,000	$ 28,000	14' long timber bridge
Revegetation				**$ 224,100**	**$ 224,100**	
Riparian Species	3.4	AC	$ 8,000	$ 27,200	$ 27,200	Placed on mounds; incl. prep., 1-yr maintence
Wetland Species	26.7	AC	$ 7,000	$ 186,900	$ 186,900	Scrub / shrub, sedges; incl. prep., 1-yr maintenance
Place Habitat / Nurse Logs	25	EA	$ 400.00	$ 10,000	$ 10,000	Assume imported, small logs
Direct Subtotal				***$ 414,280***	***$ 443,080***	
Design Contingency			25%	$ 103,570	$ 110,770	Considering conceptual phase of project
CONSTRUCTION TOTAL				***$ 518,000***	***$ 554,000***	*(rounded up)*
(Percent Difference Between Alts.)					*6.9%*	

Both alternatives assume Stasek Slough and Hathaway Slough dike removals and regrading onsite, as well as a high-level of site revegetation.

The direct construction subtotal for alternative 1 is approximately $414,000. This includes general site preparation, earthwork, structural (earthen berms), a light duty crossing at the connector channel, and revegetation. When factoring in contingency for design, the total is approximately $520,000. This total is relevant for comparison with construction bids.

Alternative 2 with the heavy-duty steel bridge (or comparable steel plate culvert) has higher costs associated with site preparation (dewatering, temporary shoring, etc.) and structure costs. The direct construction subtotal for alternative 2 is approximately $443,000. The addition of the design contingency totals approximately $550,000. Cost comparison between alternatives shows a 7% cost difference. Note that the construction costs for the two alternatives do not include project management, engineering design, permitting, construction management or other design and construction phase costs.

6) Summary of The Conceptual Plan Development

Based on the above feasibility analysis, the following recommendations for restoration of the Porter Tract Restoration are made. In general, these recommendations are reflected in the Conceptual Plan shown in Figure 8. The preferred approach for these and all other restoration measures are described below.

Channel Configuration
The recommended approach for the tidal channel network within the wetland is to fully construct the channels to the appropriate depth, width, and extent. Passive channel evolution (passive restoration) may not be effective or may require a long period of time due to the relatively high wetland elevations and corresponding limited tidal prism over much of the site, especially the south and east regions where the channels would be constructed.

Connector Channel Crossing
The most cost effective option for the connector channel crossing structure is a light duty bridge. This option could include a glulam-type timber structure designed for ATVs or other lightweight vehicle use.

If a heavy duty crossing structure is necessary for large equipment access, a refurbished railcar bridge is recommended over a steel plate culvert for its structure-based cost efficiency, and to reduce the expected high costs of excavation and dewatering necessary to install a large-span culvert.

Stasek Slough and Hathaway Slough Dike Removals
Full dike removal is the preferred restoration approach. If implemented, post-restoration conditions would more closely mimic pre-development conditions and would enhance connectivity with the adjacent sloughs. Full removal would maximize sediment delivery to the site, improving resilience to sea level rise.

Planting
A preliminary planting strategy has been developed to re-establish native vegetation communities for (from lowest to highest elevation) mid-marsh and willow, high-marsh and willow, Sitka spruce tidal swamp, and Sitka spruce riparian forest. Some species would be planted, while others are expected to colonize from the existing seed bank. Herbaceous species plantings are recommended at all elevation zones. A high level of revegetation effort is recommended for the site. High revegetation effort would increase the likelihood of plant establishment and success and reduce the risk of invasive species recolonization.

Hydrodynamic Assessment of Recent Site Changes and Flood Risks
Updated topographic surveying and two-dimensional hydrodynamic modeling was performed to assess changes to the wetland, river channel, and sloughs surrounding the Preserve following several large storms from 2015 to 2017. Model results show that the river, recently restored tidal channels, and wetland surfaces have changed significantly since the December 2015 storm. Significant accretion has occurred at many locations including several restored channels and the Kilchis River channel adjacent to the river bank where levees were removed. Model results also showed that peak water levels during the simulated storms were not particularly sensitive to bathymetric changes in the Kilchis River, and that river bed elevations have much less control on water levels than do the increased storage and conveyance capacity associated with the restored Preserve.

The hydrodynamic model was further modified to include the new channels, filled ditches, and other restoration features associated with the conceptual restoration plan. Results of simulation of the restored Porter Tract indicate no increase in inundation extents or water surface elevations when compared to existing (i.e., current / post-storm) conditions. This result is as expected, as the relatively localized channel creation and expansion of the connector channel as part of the restoration plan are not anticipated to exacerbate inundation during extreme tidal or fluvial water levels. Further, there appear to be small, short term improvements in drainage following extreme events during which the enlarged connector channel appears to aid drainage especially from Stasek Slough.

Costs of Restoration
The cost scenarios developed for this feasibility analysis incorporate contingencies and will be refined during future design and engineering phases, especially the channel and dike removal earthwork quantity estimates. A light duty crossing over the connector channel has a lower associated cost than the more robust heavy-duty bridge installation.

The construction costs for the project regardless of the channel crossing alternative are likely to be in the range of $500k, without significant changes to the scope of the restoration. This cost range is considered low to moderate given the large area, approximately 60 acres, of wetland and over 4,000 linear feet of channel habitats created and enhanced through the Porter Tract restoration.

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Appendix A
Draft Technical Memorandum
Kilchis River Wetland Restoration Project: Resurvey and Hydrodynamic Modeling Update

September 14, 2017
Environmental Science Associates