The Nature Conservancy
Protecting nature. Preserving life.™

Porter Tract Restoration

Kilchis Estuary Preserve

Basis of Design Report
Final Design

February 2019

Cover photo:

Isometric aerial photograph of the Porter Tract of the Kilchis Estuary Preserve with the Connector Channel and Stasek Slough in the foreground and Hathaway Slough in the background.

Prepared by:

WOLF WATER RESOURCES

Portland, Oregon

Table of Contents

Figures

Tables

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 Wolf Water Resources (W2r) to develop engineering designs and provide permitting support to restore 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 overall 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, especially within 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 increased frequencies of reduced baseflows in streams.

1.2 Scope

This scope of this report includes documenting the basis of the design for the various project elements included in the restoration of the Porter Tract (Figure 1). This engineering design phase follows the recently completed Porter Tract Feasibility Report (Feasibility Analysis and Conceptual Restoration Plan Report; W2r 2017). Restoration elements include removing water control structures, filling linear ditches, removing dikes, excavation of new and tidal channels and enhancement (widening and deepening) of existing channels, beneficial reuse of excavation material placed onsite in low mounds, two new pedestrian bridges across tidal channels for access to maintain vegetation, and plantings throughout the site.

Figure 1. Porter Tract to the north and adjacent Dooher Property which comprise the Kilchis Estuary Preserve.

2 Project Understanding

2.1 Goals and Objectives

As an extension of the Kilchis Estuary Preserve, the overall goal for the Porter Tract restoration is to restore estuarine habitat for listed and other native estuarine-dependent species. Towards this end, restoration objectives include:

- 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.
- Improving hydrologic complexity and redundancy of flow paths to accommodate potential river and tidal channel evolution (sedimentation, erosion, avulsion, reestablishment, etc.).
- 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 of constraints early in the design processes assist in guiding and refining the restoration design process.

- Adjacent properties must maintain existing use and capacity, despite restored connectivity within the project area. Upslope properties must maintain adequate drainage, matching that or improving upon existing drainage conditions.
- 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 tidal channels.

3 Existing Conditions

General site assessment and land uses were characterized in detail the Feasibility Report (W2r 2017). To summarize, much of the Porter Tract was 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 1Figure 3 shows the Porter Tract boundary, the adjacent Kilchis Estuary Preserve, and other sloughs and existing site features.

The earliest available aerial photograph from 1939 (see Figure 2) 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.

3.1 Drainage Infrastructure

There are several flow control structures located within the project area (see Figure 3). 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 along the Connector Channel. 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.

Figure 2. Historic 1939 photograph of the Porter Tract and Kilchis Estuary Preserve.

3.2 Dikes and Enhanced Levees

The site is partially bordered by dikes and/or enhanced natural levees that were historically constructed to reduce flooding. In general, dikes refer to small and less distinct “improvements” built on top of the natural tidal or fluvial levees. Existing dikes are located along the northern boundary of the project area along Hathaway Slough as shown in Figure 3. The dikes are relatively low, with crests that are approximately 3 to 4 feet above the adjacent, natural floodplain surface.

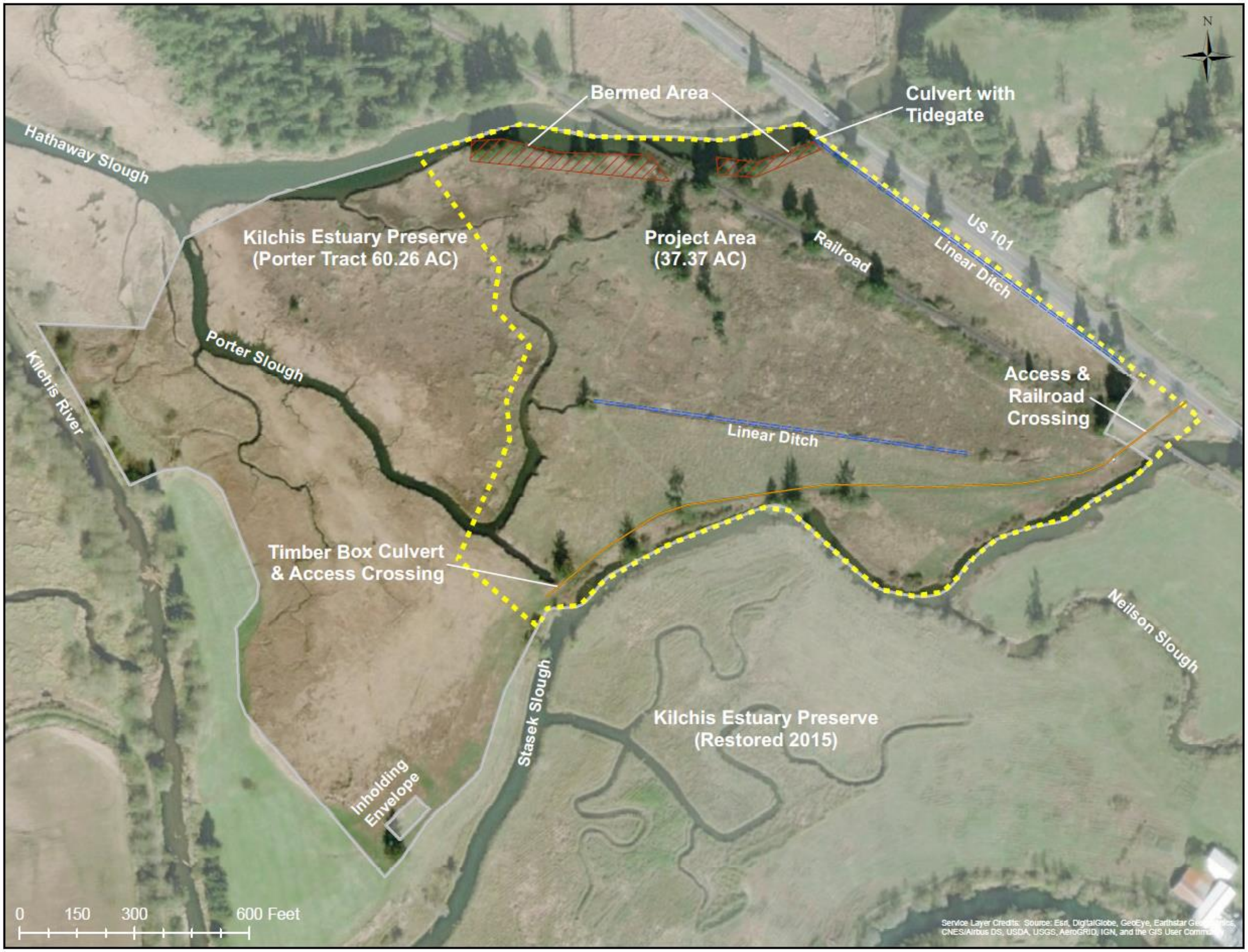

Figure 3 Existing Conditions Map for the Porter Tract.

3.3 Topography, Bathymetry, and Control Survey

Survey data have been collected by Statewide Land Survey (SWLS) at numerous times between 2012 and 2017. The most recent data collection in 2017 focused on resurveys of several sloughs and the Kilchis River and lands upstream of Hwy 101 along Neilson and Stasek Sloughs. These data are shown in Figure 4 and include:

- The linear drainage ditch upstream of the water control structure on the Porter Tract,
- Hathaway Slough and the Connector Channel near the timber culvert that will be removed,
- 10,000 feet of Kilchis River channel (thalweg survey) approximately from Hwy 101 to Hathaway Slough,
- High sediment deposition regions of the former Dooher property that was restored in 2015,
- Restored portions of Stasek Slough,
- Ground elevations along the Dooher home and east of Hwy 101 along Neilson and Stasek Sloughs,
- The high point (ridge) separating Neilson and Hathaway Sloughs,
- Water level logger instrument elevations,
- Control points throughout the surveyed regions.

The surveyed control points used for design and for construction are shown on the Plans on sheet C1.1 in Appendix

Because of the large area of the site, topography is generally defined by LiDAR data flown in 2015 collected under the U.S. Army Corps of Engineers National Coastal Mapping Program (NCMP) for Tillamook Bay, Oregon (NCMP 2015). The LiDAR accuracy was preliminarily assessed in the Feasibility Report. The assessment compared the 2015 LiDAR dataset with ground survey transects along Porter Slough and within the Kilchis site. The primary finding was that in areas of dense native vegetation (not farmed) such as along Porter Slough, LiDAR-based elevations were 1 to 3 feet higher than ground survey points. In areas recently farmed or with a mix of native, non-native, and/or invasive plants, the LiDAR was 0.8 feet higher than ground survey points on average.

These bias magnitudes were not used manipulate the LiDAR-based terrain because there is no simple or automatic way to adjust LiDAR data. Instead, the general bias magnitudes are factored into the channel excavation and grading quantities, and they will also be used to develop the permanent planting plans by TNC.

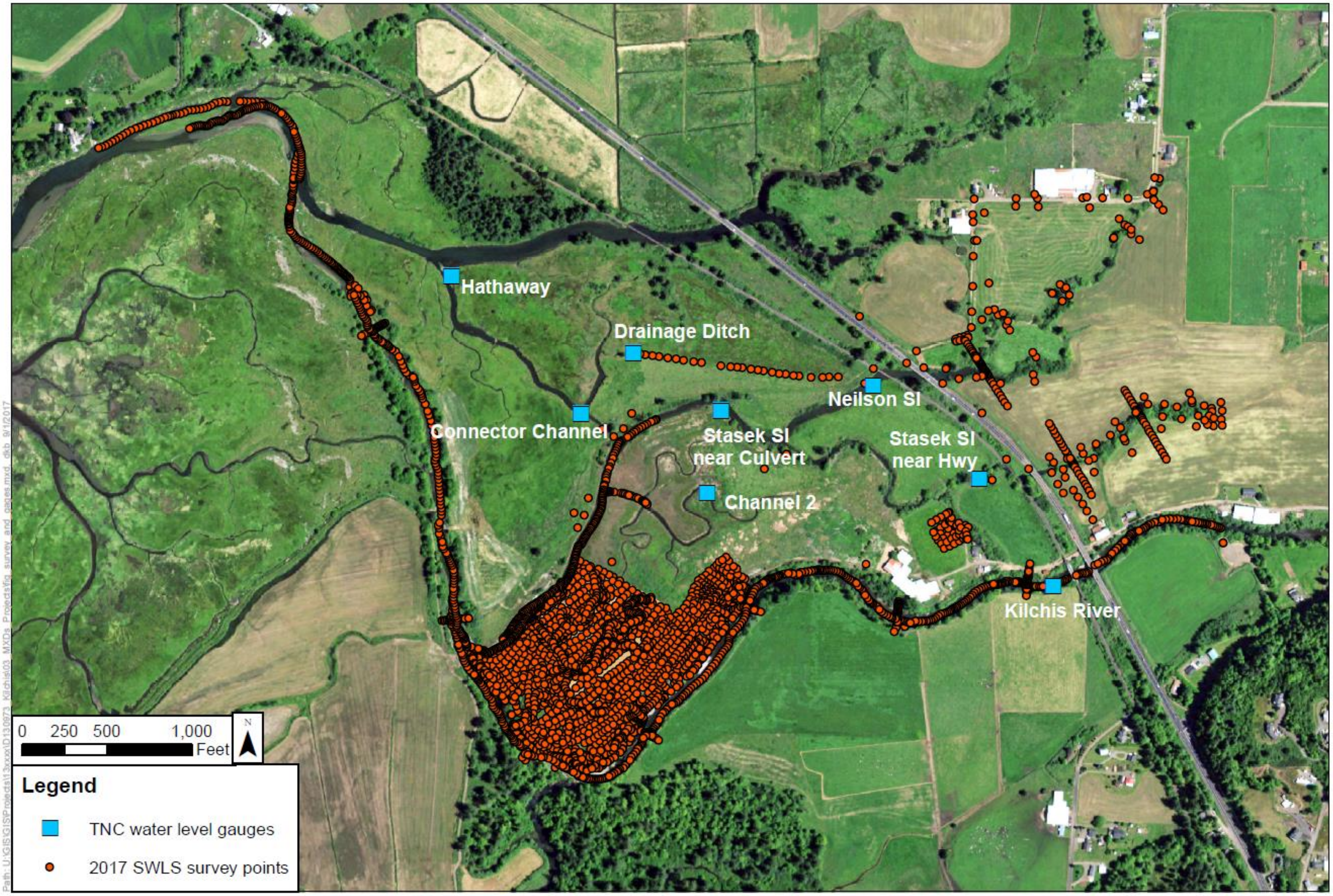

Figure 4. Topographic and Bathymetric Survey Data Collected in 2017.

(source, ESA 2017).

3.4 Hydrology and Flooding

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).

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 (Feet NAVD88)	Water Levels at Project Site (Feet NAVD88)	Notes
FEMA Base Flood	--	11 – 12*	
50-Yr	--	11.8	
25-Yr	--	11.6	
10-Yr	--	11.5	
Highest observed	11.55	11.42	Taken to be OHW at site
5-Yr	--	10.80	
Typical Spring Tide Peak	9.2 - 9.4	9.0 – 9.3	Recent spring tide peaks
MHHW	7.93	7.80	
MHW	7.22	7.01	
MTL	4.10	3.89	
MLW	0.98	0.98	
NAVD88 Datum	--	0.00	
MLLW	-0.38	-0.33	

General 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 Restoration Design

Selection of preferred restoration measures was described in the Feasibility Report (W2r 2017). These measures included channel excavation, dike removal, filling drainage ditches, constructing low mounds (fill areas), construction small wood habitat structures in the channels, tidal channel crossing structures (bridges), and native plantings. A summary of restoration measures is shown in Figure 5.

4.1 Tidal Channels

The channel network design was based on the historical pattern of channels within the Porter Tract, including primarily the lesser-disturbed regions on the west side of Porter Slough. A nearby reference site within the tidal tributary drainages of Tillamook Bay were also examined for channel shape, orientation, density, and other parameters. Initial channel configuration and density were 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 main Porter Slough restored tributary (channel 2 from the Feasibility Report/ Sandpipe and Snipe Channels – see Appendix A) drainage area. The channel density comparison is shown in Table 2.

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***

4.1.1 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).

The design intent for the restored tidal channels is to fully excavate them, rather than rely on passive channel formation. 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 Plans is intended to be constructed to full width and depth. A summary of the channel plan design is shown in Table 3.

Design of the channel widths and geometries is based on a tidal stream simulation design approach and techniques detailed in the *Design Guidelines for the Enhancement and Creation of Estuarine Habitats in the Middle Reaches of the Lower Columbia River* (ESA PWA and PC Trask 2011). Tidal stream simulation is an applied geomorphic approach analogous to the preferred fluvial stream simulation approach for design of stream and river crossing structures (WDFW 2013; ODFW 2004; NMFS 2008), except that it is applicable to tidally-influenced systems.

Table 3. Restored tidal channel design summary.

Tidal channel and tributary channel names	Approx. Length (LF)	Bottom Elev. (FT NAVD)	Top Width (FT)	Approx. Excavation Vol (CY)
Dunlin 1	710	1.0 – 7.0	3 – 16	1,150
Dunlin 2	125	4.0 – 7.0	3 – 11	150
Turnstone	450	3.0 – 7.0	3 – 13	555
Snipe 1	950	3.0 – 8.0	3 – 15	1,300
Snipe 2	250	3.0 – 8.0	3 – 10	195
Snipe 3	125	3.0 – 8.0	3 – 10	150
Snipe 4	110	5.0 – 8.0	3 – 9	150
Sandpiper 1	1305	1.0 – 8.0	3 – 20	2,910
Sandpiper 2	215	5.0 – 8.0	3 – 10	150
Sandpiper 3	85	5.0 – 8.0	3 – 7	150
Plover 1	560	1.0 – 8.0	3 – 20	1,055
Plover 2	210	4.0 – 8.0	3 – 12	180
Heron	490	2.0 – 8.0	3 – 12	605
Porter Connection	250	0.0	30-40	1,430
Total	***5,576***	***NA***	***NA***	***10,130***

4.2 Dike Removal

Two segments of tidal dikes adjacent to Hathaway Slough and one segment along Stasek Slough will be removed. One segment on the Hathaway Dike is west of the railroad embankment, and one segment is between the railroad and Hwy 101 embankments. The segments are bordered by one or more mature Sitka spruce trees that will be preserved and protected during construction. Removal will involve complete excavation of the earthen berms, down to the natural floodplain elevations of approximate 8 to 9 feet NAVD88.

The total dike length and estimated quantity of earth material generated from the Hathaway and Stasek Slough dike removal are 1,080 linear feet and 2,970 CY, respectively.

The excavation material will be beneficially reused to fill the borrow ditch immediately south of Hwy 101 and repurposed to create topographic relief in low mounds.

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 the conceptual plan (Figure 5). Based on aerial photographs, LiDAR data and field observations, there are an estimated 500 LF of ditches onsite, requiring approximately 2,000 CY of fill material.

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 OHW. For the design an average depth of 2.5 feet of fill is placed over 2.8 acres. The volume of this fill is approximately 11,300 CY.

4.5 Pedestrian Bridges

To restore full tidal connectivity and enhance drainage for upstream properties, a light duty timber bridge will span the Porter Connection Channel. A second light duty timber bridge will span the north terminus of the Porter Slough. The purpose of these crossings is to allow TNC staff to access and maintain the west and north regions of the property. The larger bridge across the connection channel is also required to maintain access to the inholding property adjacent to Stasek Slough. Light duty timber bridges were determined during the feasibility phase to be most cost effective and functional for TNC needs.

4.5.1 Tidal Stream Simulation Design Approach

The stream crossing structure design approach for both tidal channels is tidal stream simulation. The stream simulation approach intends to mimic or provide geomorphic, habitat, and hydraulic conditions similar to those upstream and downstream of the crossing structures, such that there are no significant or discernable effects on conditions at each crossing.

Pedestrian Bridge 1 (Porter Connection Channel)

The connection channel is a man-made channel created between 1955 and 1966 based on aerial photographs (ESA PWA 2013). Presumably the channel was constructed when the Lower Stasek Slough was filled/disconnected from the river. The connection was required to drain rainfall-runoff and floodwaters from the Kilchis River into Tillamook Bay via Hathaway Slough (see Figure 5).

During the Kilchis Estuary Preserve project in 2015, the connection 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). The current design approach for the Porter Connection Channel includes slightly widening the channel to a bankfull width of approximately 30 to 35 feet and providing a crossing structure for maintenance access to the other side. This approach is 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 connection 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 connection 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 connection 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 connection 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).

Based on the Porter Connection Channel widened bankfull width of 30 feet at the bridge location, a bridge length of 45 feet (1.5 times greater than the active channel width; NOAA 2001) was selected. Similar to pedestrian bridge 2, this bridge length was determined in part (slightly oversized) to accommodate a relatively low sloped channel (1.5H:1V) and reduce the risk of scour of the high bridge abutments. The bridge abutments were located high relative to the ground surface to avoid excavation and water management during abutment construction in the relatively wet and low-strength soils in this location. The proposed bridge and proposed channel cross section are shown in comparison to the existing connector channel cross section on the bridge plan and elevation on the Plans in Appendix A.

Pedestrian Bridge 2 (Porter Slough)

Pedestrian bridge 2 is located near the north terminus of Porter Slough. The field-measured active width of the channel downstream (west) of the crossing location ranges from 16 to 17 feet. Measurements were taken at three locations, all within 150 feet of the crossing location. The channel size increases significantly beyond 150 feet. As a note, the channel upstream (east) of the crossing has been impacted with two additional culverts and other drainage manipulations such that bankfull measurements upstream were not useful.

Based on the noted active width range, a bridge length of 25 feet (1.5 times greater than the active width) was selected. The bridge length was also determined in part (slightly oversized) to accommodate a relatively low sloped channel (1.5H:1V; other designed tidal channel sideslopes are near vertical, 0.5H:1V) and reduce the risk of scour of the high bridge abutments. The bridge abutments were located high relative to the ground surface to avoid excavation and water management during abutment construction in the relatively wet and low-strength soils in this location. The proposed bridge and proposed cross section are shown relative to the existing channel (and culvert) on the pedestrian bridge 2 plan and elevation in Appendix A.

4.6 Wood Habitat Structures

Wood 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).

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. A total of approximately 70 logs will be constructed throughout the new and enhanced tidal channels.

4.7 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. 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 low mounds and plantings intended to facilitate spruce colonization over time. The zones depicted in Figure 6 and Table 4 offer areas 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 6 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.

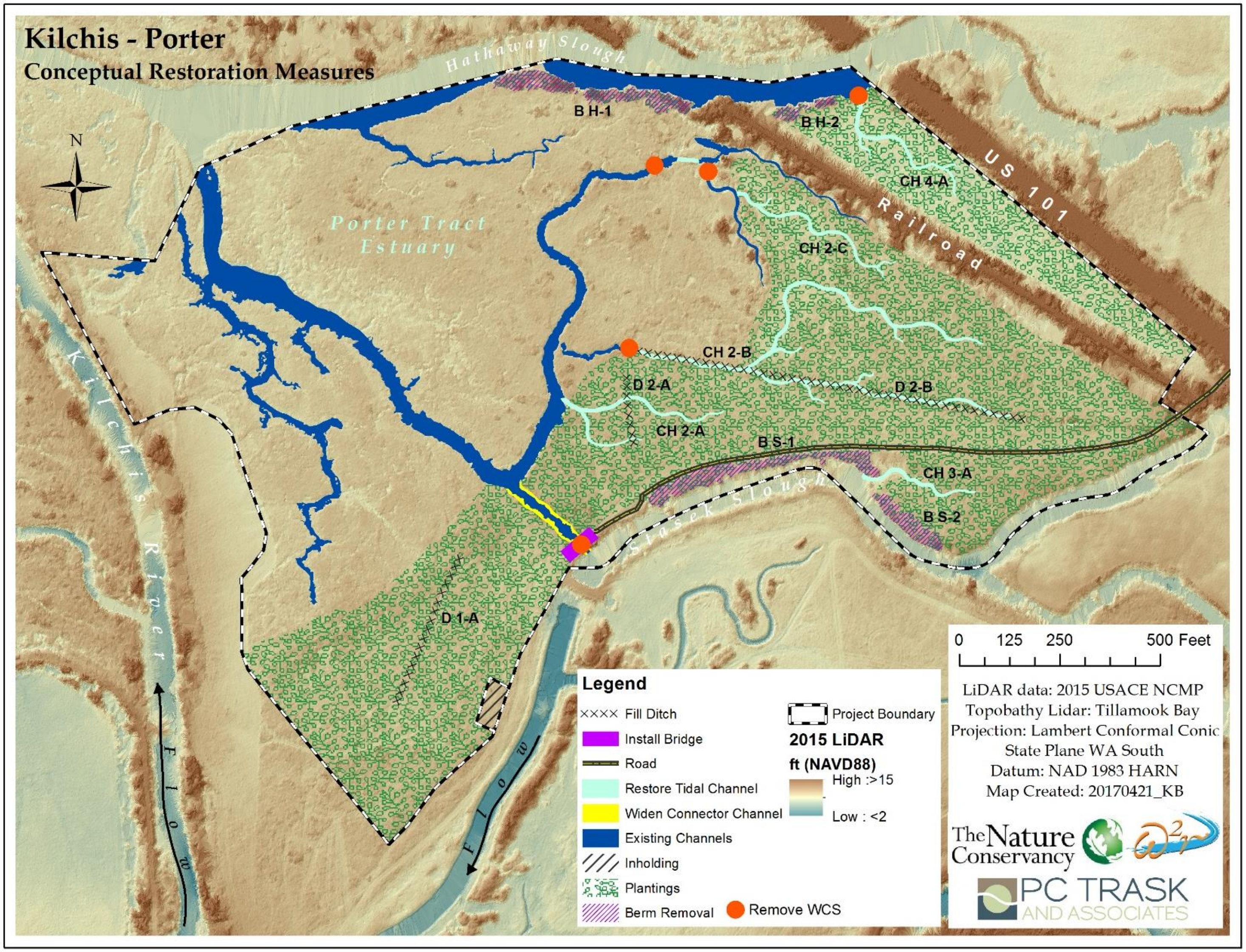

Figure 5. Porter Tract Conceptual Restoration Design.

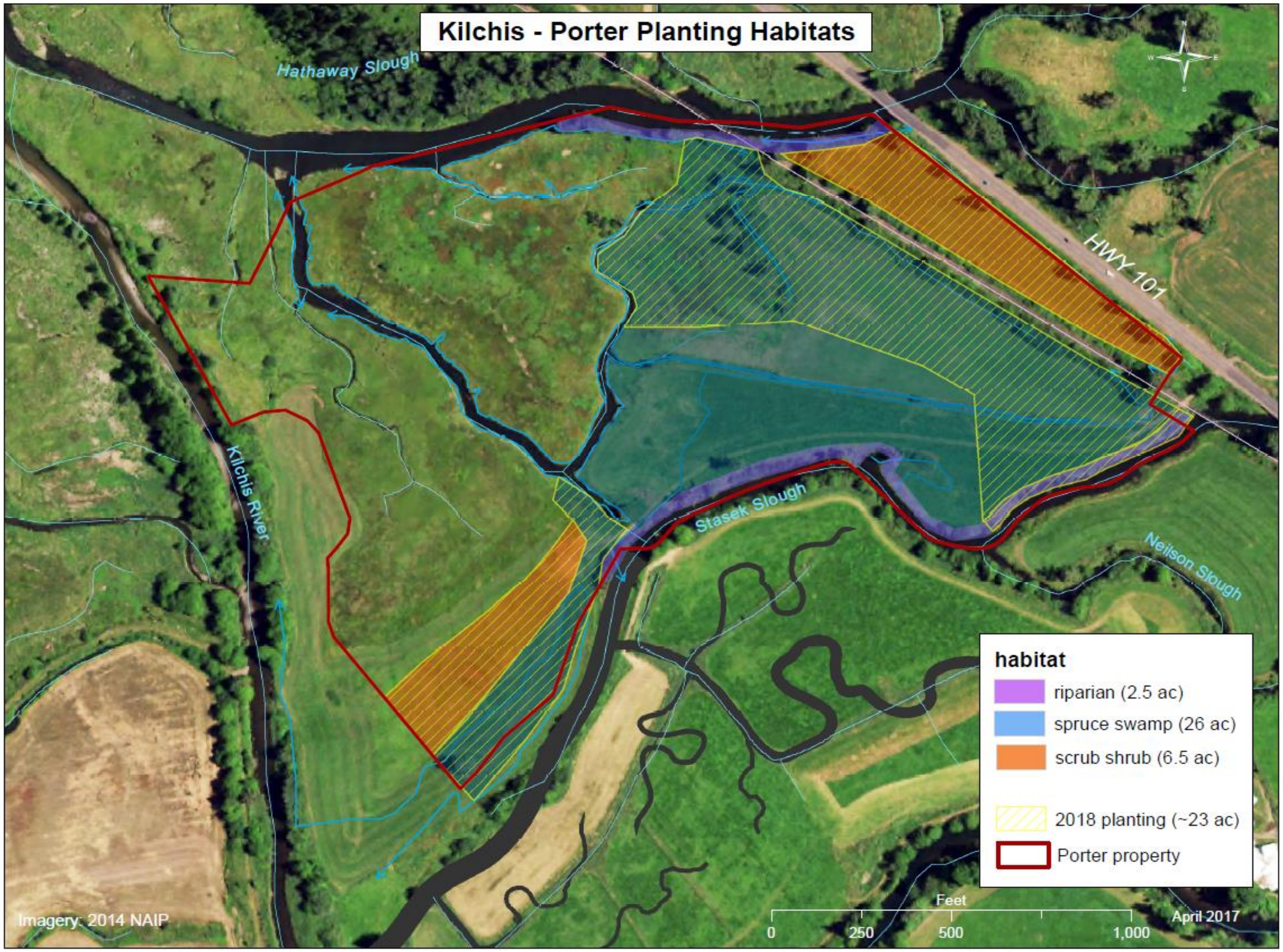

Figure 6. Porter Tract Planting Zones

Table 4. 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	--

4.8 Cut and Fill Balance

Preliminary cut and fill balances have been calculated based on LiDAR elevations supplemented with on the ground survey data collected by W2r. The cut and fill balance of excavated material is derived from the LiDAR surface and should be considered approximate.

Excavation is required for construction of the tidal channels, widening of the Porter connection channel, and lowering the Stasek Slough and Hathaway Slough dikes. The total material generated from dike removal is estimated to be 2,970 CY. Channel construction would require approximately 10,300 CY of excavation. The quantity of material needed to fill ditches is 2,000 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 11,300 CY, would be placed onsite such as subsided areas and mounds.

4.9 Estimate of Probable Construction Costs

Detailed construction cost estimates were developed for comparison to construction contractor bids. The estimates were intended to document cost of restoration measures being considered.

Site preparation and other general markups and unit costs are based on recent estuary restoration projects in Oregon. Quantities are based on earthwork take-offs and measurements in AutoCAD based on the LiDAR-defined topography (and adjusted based on the LiDAR bias and engineering experience). Quantity estimates are conservative and rounded up in some cases as appropriate to account for the numerous variables and unknown site conditions.

The following assumptions were made in developing the cost estimate:

- General site preparation markups: total of 6% of other direct costs.
- Channel excavation earthwork: $8 per cubic yard ($/CY) to reflect relatively good working conditions; this unit cost includes low mound construction because mounds are located close to the channels.
- Native wetland seeding: $3,000 per acre ($/AC), a typical native erosion control seeding cost; this seeding will be completed by the construction contractor.
- Riparian and wetland revegetation: $7,000 to $8,000 per acre ($/AC) to reflect a high level (density, etc.) of revegetation similar to previous TNC revegetation costs. This work is assumed to occur outside the construction contract by TNC staff.
- Low berm and dike removal earthwork: $7/CY.
- Wood habitat structure logs: $400 per log, assuming coniferous species and relative small diameter (12-16") and common lengths (20 to 40 feet; 12-foot pier logs).

A cost detail for the construction work items is summarized in Table 5 below.

Table 5. Construction cost estimate detail.

No.	Spec Section	Item	Qty	Unit	Unit Cost	Total Cost	Notes
		Site Preparation				**$ 52,000**	
1	0210	Mobilization (5%)	1	LS	$ 24,000	$ 24,000	Percent of direct constr. costs
2	0225	Work Zone Traffic Control	1	LS	$ 10,000	$ 10,000	Flaggers, traffic signage, constr. entrance
3	0245	Temp Water Management & Dewatering	1	LS	$ 10,000	$ 10,000	Dewatering & diversions, cofferdams
4	0280	Erosion Control	1	LS	$ 8,000	$ 8,000	Straw wattles, turbidity curtains
		Earthwork				**$ 164,660**	
5	0305	Construction Survey Work	1	LS	$ 10,000	$ 10,000	Constractor responsible for survey
6	0305	Demo Connection Channel Culvert	1	EA	$ 4,000	$ 4,000	Approx. 4' timber box culvert
7	0305	Demo Water Control Structures	4	EA	$ 2,000	$ 8,000	Porter SL, near US 101, WCS, small x-ing
8	0320	Clearing/Grubbing	1	LS	$ 10,000	$ 10,000	Access, channels, clearing/grubbing
9	0330	Fill Ditch along 101	1,070	CY	$ 10.00	$ 10,700	Does not include fill along Sandpiper Ditch
10	0330	Excavate Channels	10,320	CY	$ 9.00	$ 92,880	Includes mound construction - all channel exc.
11	0330	Hathaway & Stasek Slough Dike Removal	2,960	CY	$ 8.00	$ 23,680	Remove portion of dike and regrade onsite
13	0390	Streambed Material	90	TN	$ 60.00	$ 5,400	Scour protection at crossing for bridge 1
		Structural				**$ 89,000**	
14	0575	Pedestrian Bridge 1 & Abutment System	1	LS	$ 55,000	$ 55,000	Across connector channel, 45' long
15	0575	Pedestrian Bridge 2 & Abutment System	1	LS	$ 34,000	$ 34,000	Across small slough to north, 25' long
		Revegetation				**$ 219,850**	
16	1030	Native Erosion Control Seeding	7.5	AC	$ 3,000	$ 22,500	Placed on mounds; incl. prep., 1-yr maintence
17	1040	Riparian Species	3.6	AC	$ 6,000	$ 21,600	Placed on mounds; incl. prep., 1-yr maintence
18	1040	Wetland Species	26.7	AC	$ 5,000	$ 133,500	Scrub / shrub, sedges; incl. prep., 1-yr maintenance
19	1042	Wood Habitat Structures	65	EA	$ 650.00	$ 42,250	Assume imported, small logs
		TOTAL				***$ 525,600***	

References

Brophy, L.S. 2009. Effectiveness Monitoring at Tidal Wetland Restoration and Reference Sites in the Siuslaw River Estuary: A Tidal Swamp Focus. Prepared for Ecotrust, Portland, Oregon. Green Point Consulting, Corvallis, Oregon.

Brophy, L.S., C.E. Cornu, P.R. Adamus, J.A. Christy, A. Gray, M.A. MacClellan, J.A. Doumbia, and R.L. Tully. 2011. New Tools for Tidal Wetland Restoration: Development of a Reference Conditions Database and a Temperature Sensor Method for Detecting Tidal Inundation in Least Disturbed Tidal Wetlands of Oregon, USA. Report to the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), Durham, NH. 199 pp. Accessed October 15, 2011 at http://rfp.ciceet.unh.edu/display/report.php?chosen=1321.

Brophy, L.S., and S. van de Wetering. 2012. Ni-les'tun Tidal Wetland Restoration Effectiveness Monitoring: Baseline: 2010-2011. Corvallis, Oregon: Green Point Consulting, the Institute for Applied Ecology, and the Confederated Tribes of Siletz Indians. Accessed 8/13/12 at http://appliedeco.org/reports/Nilestun_EM_report_June2012.pdf.

Cahoon, D.R., Hensel, P.F., Spencer, T., Reed, D.J., McKee, K.L., Saintlier, N., 2006. Coastal wetland vulnerability to relative sea-level rise: Wetland elevation trends and process controls. In: Verhoeven, J.T.A., Beltman, B., Bobbink, R., Whigham, D. (Eds.), Wetlands and Natural Resource Management. Ecological Studies, vol. 190. Springer-Verlag, Berlin/Heidelberg, pp. 271–292.

Christy, J.A. 2004. Estimated loss of salt marsh and freshwater wetlands within the Oregon coastal coho ESU: Corvallis, Oregon, Oregon Natural Heritage Information Center, Oregon State University, 7 p.

Cornu, C.E., H. Harris, and A. Helms. 2011. NOAA Reference Sites: Measuring Salt Marsh Plant, Soil and Hydrologic Response to Restoration Using Performance Benchmarks from Local Reference Sites. South Slough NERR Report to NOAA. 58 pp.

Cornu, C. E., and S. Sadro. 2002. Physical and Functional Responses to Experimental Marsh Surface Elevation Manipulation in Coos Bay's South Slough. Restoration Ecology 10: 474-486.

Coulton, K., P.B. Williams, and P. A. Benner. 1996. An Environmental History of the Tillamook Bay Estuary and Watershed. Philip Williams and Associates, Ltd. Research Report CE 990292-1, Tillamook Bay National Estuary Project, Garibaldi, OR.

Dicken, S.N. 1961. Some Recent Physical Changes of the Oregon Coast. Department of Geography. Prepared by Samuel N. Dicken, assisted by C.L. Johanessen and B. Hanneson, University of Oregon, Eugene Oregon, November 15, 1961.

ESA 2017. Draft Technical Memorandum, Kilchis River Wetland Restoration Project: Resurvey and Hydrodynamic Modeling Update. Prepared for The Nature Conservancy in Oregon; Prepared by ESA, Portland Oregon, October 31, 2017.

ESA PWA 2013. Kilchis River Tidal Wetlands Restoration Engineering and Design – Conceptual Restoration Plan. Prepared for TNC, Prepared by ESA PWA, December 2013.

ESA PWA and PC Trask, 2011. Design Guidelines for the Enhancement and Creation of Estuarine Habitats in the Middle Reaches of the Lower Columbia River, 58 p.

Ewald, M.J., and Brophy, L.S. 2012. Tidal wetland prioritization for the Tillamook Bay estuary. Prepared for the Tillamook Estuary Partnership, Garibaldi, OR. Estuary Technical Group of the Institute for Applied Ecology and Green Point Consulting, Corvallis, OR. 123 pp.

FEMA 2002. Flood Insurance Study, Tillamook County Unincorporated Areas. Federal Emergency Management Agency (FEMA), Revised August 2002.

Follensbee B., and A. Stark. (Eds). 1998. Kilchis Watershed Analysis. Prepared through the Tillamook Bay National Estuary Program, for US Environmental Protection Agency. Edited by B. Follensbee, A. Stark, October 1998.

Gardner, E. H. and J. Hart. 1995. EC 628: Soil sampling for home gardens and small acreages. Oregon State University Extension Service.

MacClellan, M.A. 2011. Carbon content in Oregon tidal wetland soils. Master's Project Research Report, Marine Resource Management Program, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR. 30pp.

Mattison, L., 2011b, Tide gates in Oregon estuaries: Oregon Coastal Management Program, Portland, Oregon, accessed March 4, 2013, at http://www.coastalatlas.net/downloads/ shapes/TidegatesinOregonEstuariesOCMP2011.zip.

Mitsch, W.J., and J.G. Gosselink, 1993. Wetlands (2nd Ed.). Van Nostrand Reinhold, New York.
NOAA 2013. NOAA Tides and Current, Center for Operational Oceanographic Products and Services (CO-OPS), URL: http://tidesandcurrents.noaa.gov/, 2013.

NCMP 2015. US Army Corps of Engineers National Coastal Mapping Program (NCMP), Joint Airborne Lidary Bathymetry Technical Center of Expertise. Data downloaded via NOAA Coastal Mapping Center, URL: https://www.coast.noaa.gov/dataviewer/#/.

NOAA 2004. Technical Memorandum - Background tides and sea level variations at Seaside, Oregon, PMEL-126. Prepared by Mofjield, H., A. Venturato, F. Gonzalez, V. Titov, Sep. 2004.

NOAA 2001. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service Southwest Region, September 2001.

NRC 2012. Sea Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future. National Research Council, National Academies Press, 2012.

SWLS 2012. Kilchis River Estuary Data Collection Survey Report. SWLS Land Surveying Inc. Job No. 2012-13, July 2012.

TBNEP 1999. Tillamook Bay Comprehensive Conservation and Management Plan. Prepared by the Tillamook Bay National Estuary Project (TBNEP), 1999.

USGS 2013. USGS National Water Information System (NWIS) Web Interface, Wilson River Near Tillamook Station 14301500, URL: http://nwis.waterdata.usgs.gov/nwis/nwisman/?site_no=14301500&agency_cd=USGS, 2013.

W2r 2017. Feasibility Analysis and Conceptual Restoration Plan – Porter Tract Restoration, Kilchis Estuary Preserve. Report prepared by Wolf Water Resources, Portland, OR; prepared for The Nature Conservancy in Oregon, Rev. November 2017.

Appendix A
Engineering Plans – Porter Tract Estuary Restoration