

*Salmon-Snow Estuary
Restoration Project:*

ESTUARY MONITORING PLAN



Prepared by:

North Olympic Salmon Coalition

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Table of Contents

1. Vision, Goals, and Objectives of the Restoration Project.....	5
2. Detailed Monitoring Protocols for the Salmon-Snow Estuary Restoration Project.....	8
2.1 Protocol For Assessing Water Quality and Toxicity	9
2.2 Protocol for Assessing Tidal Channel Development	15
2.3 Protocol for Assessing Terrestrial and Benthic Invertebrates	22
2.4 Protocol for Assessing Marsh Vegetation	28
2.5 Protocol for Assessing Temporal Abundance, Size and Species Composition of Fish Utilizing Salmon Creek Estuary	36
2.6 Protocol for Assessing Sediment Accretion and Changes in Marsh Surface Elevation Over Time	45
2.7 Protocol for Photo Point Monitoring	60
3. Adaptive Management.....	62
4. Monitoring Responsibilities Schedule	64
5. Reporting and Dissemination of Monitoring Results	65
Appendix A.....	
Appendix B.....	

LIST OF FIGURES

Figure 1, Page 5: Project site location

Figure 2, Page 8: 1950 aerial showing project sites overlaying 1950 aerial view prior to fill placement and mill construction.

Figure 3, Page 9: 2004 aerial shows project area prior to fill removal and tidal channel construction.

Figure 4, Page 15: Tidal channels at north site, project nearing completion.

Figure 5, Page 15: Project site following construction phase. Note new estuarine areas following fill removal, and tidal channel creation.

Figure 6, Page 16: Aerial view from the south following construction. Note tidal channels created at south site.

Figure 7, Page 18: Above, the different types of wood waste found: fine wood waste, bark waste, and veneer.

Figure 8, Page 18: Sulfur-loving bacteria growing in leachate-filled tidal channels, prior to restoration and wood waste removal

Figure 9, Page 21: Sites for water quality / toxicity monitoring.

Figure 10, Page 26: South Site, Tidal Channel Construction Specs and cross section locations.

Figure 11, Page 27: North Site, Tidal Channel Construction Specs and cross section locations.

Figure 12, Page 34: Terrestrial and Benthic Invertebrate Sampling Stations.

Figure 13, Page 41: Vegetation Monitoring Locations (North and South Sites)

Figure 14, Page 48: Fyke Net Sampling Stations

Figure 15, Page 51: Example fyke net set up.

Figure 16, Page 52: Sample Fish Monitoring Data Sheet

Figure 17, Page 55: Diagram of a Set Elevation Table

Figure 18, Page 57: North site sediment monitoring array locations. Rectangles indicate sediment arrays.

Figure 19, Page 57: South site sediment monitoring array locations. Rectangles indicate sediment arrays.

Figure 20, Page 58: Typical rSET and Marker Horizon sediment array from above.

Figure 21, Page 59: Sediment array during installation

Figure 22, Page 60: Example of sampling a Marker Horizon plot; note the PVC poles, ¼ meter quadrat and cryo-core funnel

Figure 23, Page 61: Cryo-corer: Note the crimped end of the copper tubing, staggered holes drilled to help freeze the deeper sediments, and the hose clamp attaching the funnel securely to the copper tube.

Figure 24, Page 62: Example of good feldspar layer; note the digital calipers and metal scraper/spatula.

Figure 25, Page 63: Example of cryo-core that needed scraping to expose the feldspar.

Figure 26, Page 65: Photo Point Locations for North Site

Figure 27, Page 66: Photo point locations for south site

1.0 VISION, GOALS AND OBJECTIVES OF THE RESTORATION PROJECT

The goal of ecological restoration is to *emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs* (National Research Council 1992).

The **goal** of the Salmon Creek Estuary Restoration project is to restore estuarine and nearshore conditions and processes in the marine environment to benefit salmonid rearing and habitat for other nearshore and estuarine species.

Objectives:

- Create approximately 11 acres of salt marsh plant communities
- Create 5,200 meters of tidal channels available to salmonids for foraging, rearing, cover, and migration (1,100 meters of constructed tidal channels and 4,100 meters of additional tidal channels developing through natural processes over time)
- Increase presence of benthic and terrestrial insects that are forage for salmonids and shorebirds
- Remove five derelict buildings
- Improve diversity of native wetland vegetation
- Decrease pasture grasses and invasive vegetation
- Remove over 48,000 cubic yards of fill material, including 20,000 cubic yards of wood waste
- Improve water quality

Project Outcomes:

Through the construction process, five derelict buildings and over 60,000 cubic yards of material were removed, resulting in the immediate creation of 11 acres of accessible estuarine habitat and approximately 1,375 meters of newly constructed tidal channels. Additional development of channels over time will likely yield an additional 4200 meters of channel for a total gain of over 5,575 meters of tidal channels spread out over the 11 acres.

As a result of the project, there is increased tidal prism, which will continue to allow natural processes to re-form productive salt marsh and blind tidal channels in areas that were previously cut off from the exchange of tidal and fluvial energy. The increased estuarine habitat will:

- Improve diversity of native salt marsh vegetation
- Decrease pasture grasses and invasive vegetation
- Increase presence of benthic and terrestrial insects, which are forage for salmonids other fishes and shorebirds
- Increase number of rearing channels for juvenile salmonids
- Provide greater area of cover from predators
- Improve water quality of tidal channel adjacent to former wood waste site



Figure 1: Tidal channels at north site, project nearing completion.



Figure 2: Project site following construction phase. Note new estuarine areas following fill removal, and tidal channel creation.



Figure 3: Aerial view from the south following construction. Note tidal channels created at south site.

2.0 DETAILED MONITORING PROTOCOLS FOR THE SALMON-SNOW ESTUARY RESTORATION PROJECT

Below are the six monitoring protocols that have been developed.
These include:

1. **Water quality and sediment toxicity** - in relation to wood waste on the north site (ammonia, sulfide concentrations, wood-waste associated chemicals, sediment toxicity, temperature, conductivity/salinity, pH, dissolved oxygen).
2. **Tidal channel development** (acreage, width, length, location, elevation, depth, sinuosity).
3. **Terrestrial and benthic invertebrates** – using sediment cores and fall-out traps
4. **Marsh vegetation** (salt marsh habitat gains, wetland vegetation species composition and acreage).
5. **Fish utilization** (temporal abundance, size, species composition).
6. **Marsh elevation and sediment accretion.**

For each protocol, information is given in the following format:

Purpose

Goal

Design

Equipment

Site Selection

Sampling

Periodicity

Sampling Protocol

Calculations & Analysis

Additional Information & References

2.1 Protocol For Assessing Water Quality and Toxicity

Water quality and toxicity sampling was contracted with Newfields Northwest, LLC of Port Gamble, WA, who have submitted the following protocol:

Purpose

As outlined above, a portion of the restoration site is located over a former wood waste landfill. Clean woody debris was buried to depths up to 8 ft. below ground surface (bgs).



Figure 4: Above, the different types of wood waste found: fine wood waste, bark waste, and veneer.

Field observations and soil cores collected from the area indicated that leachate from the wood waste was moving into the neighboring tidal channels, resulting in decreased water quality and benthic infaunal abundance.

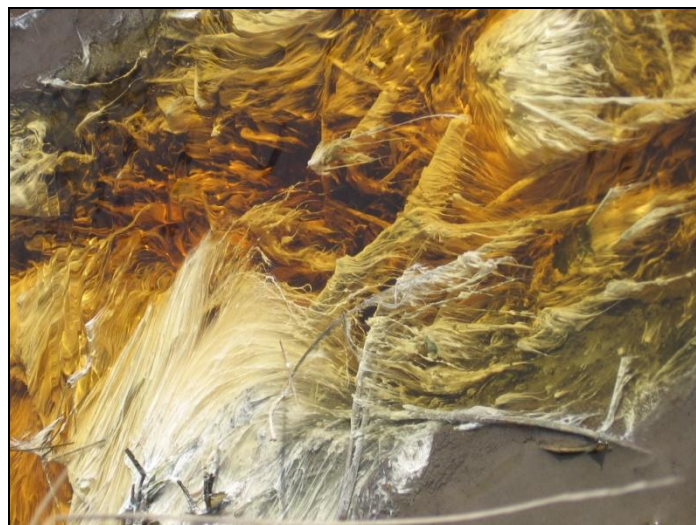


Figure 5: Sulfur-loving bacteria growing in leachate-filled tidal channels, prior to restoration and wood waste removal.

Sulfide and ammonia concentrations at the head of the contaminated tidal channel were elevated in the overlying water but were not found to be elevated in sediments. Ammonia and sulfide concentrations measured at the mouth of the side channel were substantially lower, indicating that the source was most likely localized and probably associated with the wood waste.

NOSC and WDFW removed wood waste fill to restore the functioning estuarine habitat in the nearby channels. It is presumed that channel water and sediment quality will improve following the wood removal. The purpose of this monitoring program is to evaluate changes in water and sediment quality in the leachate channel as indicated by the concentrations of wood-waste related chemicals and toxicity of the incoming water and channel sediments.

Goals

The goals of the water quality and toxicity monitoring program include the following:

1. Establish baseline conditions in the channel and high marsh areas neighboring the wood waste site, including:
 - ammonia and sulfide concentrations in channel water
 - ammonia, sulfide and wood-waste associated chemicals (resin acids, 2- and 4-methylphenol, caprostenol, and guaiacol) in sediment from the channel and neighboring marsh
 - toxicity of incoming water and channel sediments
2. Evaluate changes in water quality (ammonia, total sulfides, dissolved oxygen, pH, conductivity/salinity, and temperature) and sediment quality following wood-waste removal. This data will be paired with monitoring data for the benthic community to determine whether the benthic community is responding to changes in water and sediment quality.

Design

Toxicity will be evaluated prior to wood-waste removal, two months following removal, and if needed approximately one year following removal. Water quality will be evaluated prior to and following wood-waste removal. Wood waste related chemicals will be evaluated in sediments prior to wood waste removal.

Sediments in the tidal channel draining the North Site high marsh will be sampled at three locations: at the head of the channel, approximately 1/3 channel length from the head and at the mouth of the channel (see Figure 9). One channel reference station will also be sampled from the reference area east of the main channel of Salmon Creek. These stations correspond with sampling locations for benthic community analysis.

Toxicity will be evaluated for each of the potentially affected environmental compartments (sediment, sediment-water interface, and leachate water). Toxicity to benthic infauna will be evaluated using the 10-day amphipod test with the amphipod, *Eohaustorius estuarius*. Toxicity of the water immediately overlying the test sediment will be evaluated using the sediment-water interface test with larval echinoderms. Acute toxicity of the water entering the channel

(leachate) will be evaluated using the 48-h daphnid test. Toxicity tests will be conducted at the NewFields laboratory in Port Gamble following standardized protocols.

Water quality measurements will be conducted by NewFields and will include ammonia, sulfides, temperature, conductivity/salinity, and pH.

Equipment

Channel sediments will be collected to a depth 6 cm using either a 3" diameter Lexan® corer (benthic community) and a stainless steel scoop designed to sample to 6 cm (chemistry and toxicity testing).

Resin acids, methylphenols, and guiacols will be analyzed using gas chromatography/mass spectrometry (GC/MS). Ammonia will be measured with an Orion 5-Star Meter fitted with an ammonia-ion specific probe. Sulfides will be measured using a DR/4000U Spectrophotometer. Temperature, salinity, and pH will be measured using an Orion 5-Star water quality meter.

Site Selection

Sampling locations are based on a down-channel gradient away from the potential source of the wood waste. Station CH-1 was located near the head of the channel, approximately one meter from the location where water first daylights in the channel and was approximately 20 cm in width. Station CH-2 was located approximately 1/3 the channel length from the head and was just above the confluence with a small side channel that flows from a nearby culvert. The channel width was approximately one meter at this location. Station CH-3 was located at the mouth of the study channel, just above the confluence with Salmon Creek. CH-3 is located in a small pool with fine sediment and gravel. The reference station was located in a large high marsh system east of Salmon Creek. The reference channel was relatively small (approximately 50 cm width) and the reference station was located at the middle of the channel. Sediment was fine grained with organic matter and water quality was typical of Puget Sound.

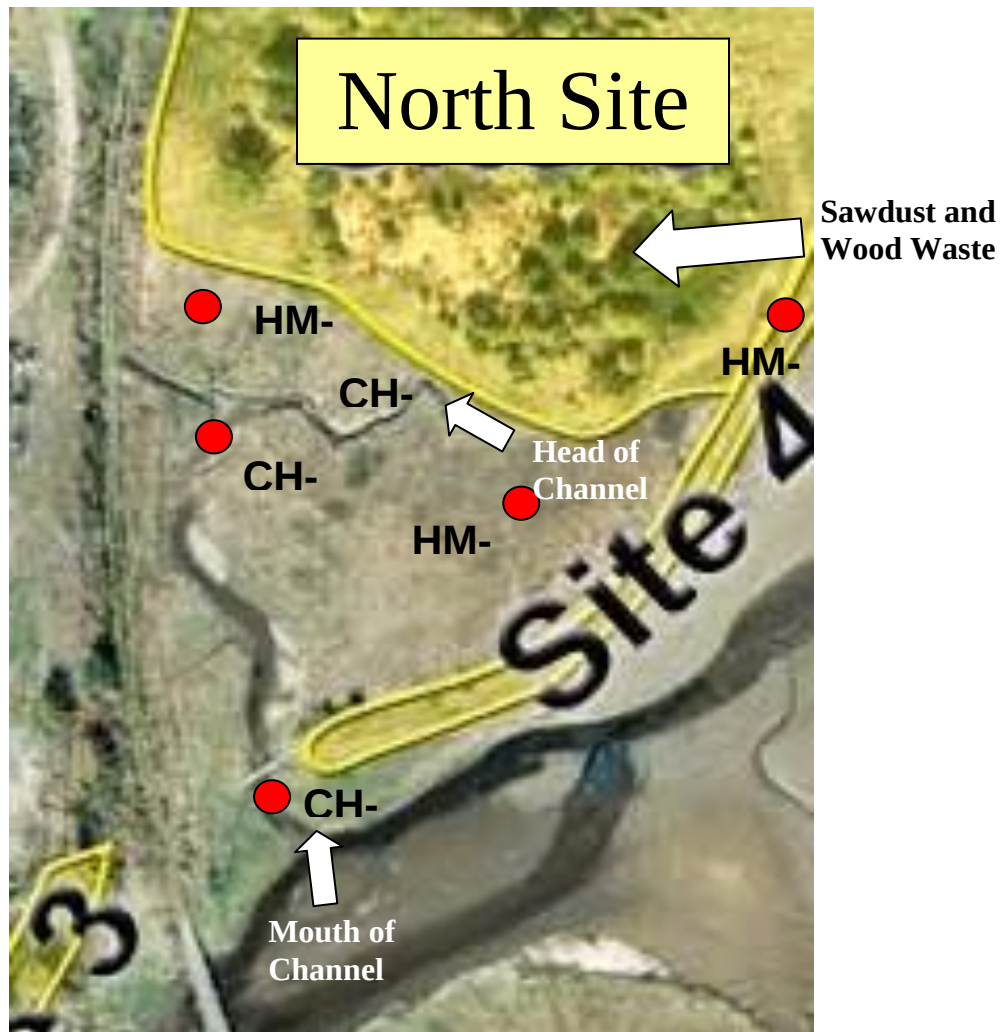


Figure 6: Sites for water quality / toxicity monitoring.

Sampling Periodicity

Sampling and analysis under this monitoring element will occur prior to wood-waste removal and approximately two months following removal. Additional sampling and analysis may occur one year following removal if needed.

Sampling Protocol

Sampling and analysis will follow standardized protocols including the following:

Sediment sampling methods were consistent with methods outlined in Washington's Sediment Management Standards evaluations [Puget Sound Estuary Program (PSEP) 1995; Sediment Sampling and Analysis Plan Appendix (Ecology 2003)].

The 10-day acute toxicity test was conducted with the estuarine amphipod, *Eohaustorius estuarius* in accordance with procedures described in Standard Methods (ASTM 2003c) and methods developed to support Washington's Sediment Management Standards evaluations [Puget Sound Estuary Program (PSEP) 1995; Sediment Sampling and Analysis Plan Appendix (Ecology 2003)].

The larval sediment-water interface test with larval echinoderms (*Strongylocentrotus purpuratus*) followed methods cited in Anderson et al. 1996.

The toxicity of water entering the leachate channel was evaluated using the 48-h daphnid test with *Ceriodaphnia dubia*. Test methods for the *C. dubia* bioassay followed guidelines presented in *Methods for Measuring Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms* EPA-821-R-02-012 (EPA 2002).

Calculations & Analysis

Toxicity evaluations include calculations of percentage survival, and in the case of the larval echinoderm test, normal development. Results of the exposures with each of the test treatments (CH-1, CH-2, and CH-3) are compared to the reference using a one-tailed t-test ($\alpha = 0.05$). Concentrations of wood-waste chemicals will be directly compared to reference.

Additional Information & References

Anderson BS, Hunt JW, Hester M, Phillips BM. 1996. *Assessment of sediment toxicity at the sediment-water interface*. In: G.K. Ostrander (ed.) *Techniques in Aquatic Toxicology*. Lewis Publishers, Ann Arbor, MI.

ASTM. 2003c. E1367-99 Standard Guide for Conducting 20-Day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods. In *Annual Book of Standards*, Vol. 11-05. West Conshohocken, Penn.

Ecology 2003. Sediment Sampling and Analysis Plan Appendix: Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173-204 WAC), Sediment Management Unit, Department of Ecology, Bellevue, Washington.

PSEP. 1995. Puget Sound Protocols and Guidelines. Puget Sound Estuary Program. Puget Sound Water Quality Action Team, Olympia, Washington.

USEPA. 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms—Fifth Edition. EPA 821/R-02/012. USEPA Office of Water.

2.2 Protocol for Assessing Tidal Channel Development

Purpose

The response of the artificially created tidal channels to the forces of the natural environment will be one of the most important factors to monitor. With the engineered creation of 1,375 meters of new tidal channels, it will be vital to monitor the time-dependent process of new channel development – as plans predict that 4,375 meters of additional channels will develop by natural processes over time. Monitoring and documenting the channel changes over time also ensures they are functioning well and are not creating an impediment to fish survival.

Goals

1. Document and attempt to understand the evolution of a set of artificial tidal channels based on natural analogs. To this end we will measure:
 - a. The profile of excavated primary tidal channels and the changes in that profile annually
 - b. Cross-sections of the primary tidal channels at monumental locations
 - c. The initiation and development of lower order channels
2. Document the temporal changes in overall tidal channel habitat. Stratification will be possible on the basis of channel order and depth.
3. Document baseline sinuosity of excavated tidal channels. Document changes in sinuosity of excavated and newly forming channels annually.
4. Train volunteers to assist in the monitoring and data collection.

Design

The planform of tidal channels has a number of characteristics that have a bearing on their performance, evolution and habitat benefits. These are channel order, bifurcation, length, density and sinuosity. An accurate map displays these characteristics. Due to the small scale of the project and budget limitations remote sensing imagery will not be used. Alternatively, a ground surveyed profile along the tidal channels will establish the thalweg and bank elevation and location as x-y-z data referenced to permanent monuments.

The cross sectional shape of tidal channels is determined, primarily, by sediment characteristics, plant roots and tidal hydraulics (Coats 1995). The initial shape and elevation of the constructed channels was crudely taken from existing channels in the Salmon Creek marsh. The development of the channels over time is likely to be influenced by

1. Unvegetated soil characteristics
2. The evolution of marsh hydraulics through deposition
3. Colonization and serial progression of marsh vegetation

The Salmon Creek restoration project provides a unique opportunity to measure the interplay of these factors. The correlation of these variables with cross sectional and profile properties is not elucidated here. Three permanently monumented cross sections in each of the estuaries will be surveyed to document the lateral location, depth and cross sectional area of the main channels.

Equipment

The Jefferson County Conservation District assisted NOSC by using a total station to gather all x,y,z coordinate data. Using total station software, data was tied to WDFW benchmarks and layered onto as-built drawings. The following equipment can be use in the future to gather data if total station is unavailable.

1. Measure Master by Roll Tape measuring wheel – used to measure channel lengths.
2. Stanley fiberglass measuring tapes - used to measure distance form head to mouth of channels.
3. A Topcon AT-F4 Auto Level and stadia rod (in feet) used to record elevations for profiles and cross sections.
4. Short standard measuring tape – used to record and document newly forming channels that have reached a depth of 4 inches and a length of 6 inches.
5. Rite in the Rain – data sheet and field book.
6. Digital camera – for photo documentation.
7. Metal detector for locating monuments.
8. GPS unit.

Site Selection

All excavated primary channels will be monitored at the North and South sites at the Salmon Snow Estuary Restoration Project site. Formation of new channels will be recorded and monitored as well when they reach a four-inch depth and six-foot length.

Lateral location and depth of channels relative to the surrounding marsh surface and established benchmarks will be established. Cross sections at the mouth of the main, highest order, channel in each estuary will track their development over time.

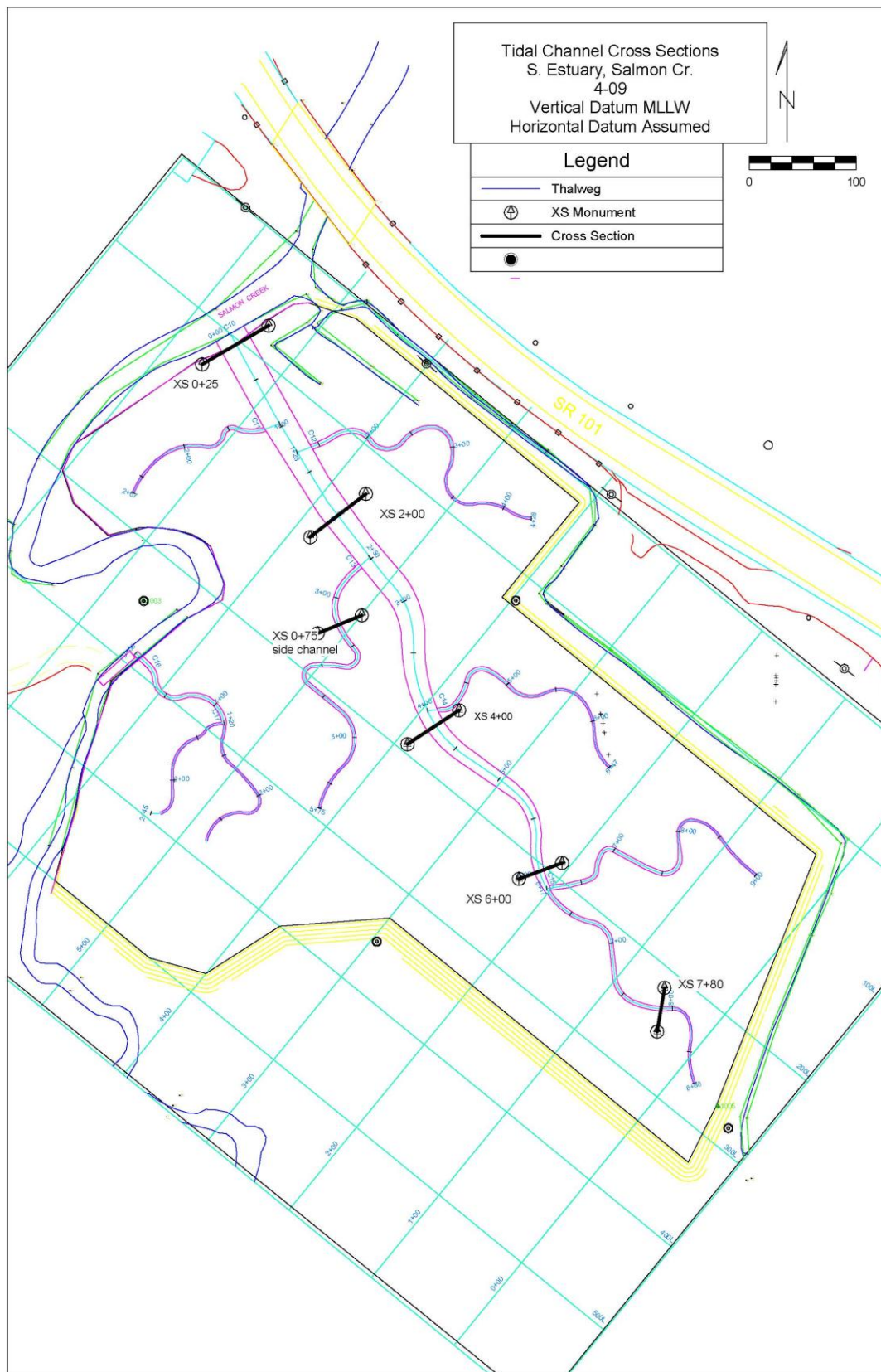


Figure 7: South Site, Tidal Channel Construction Specs and cross section locations.

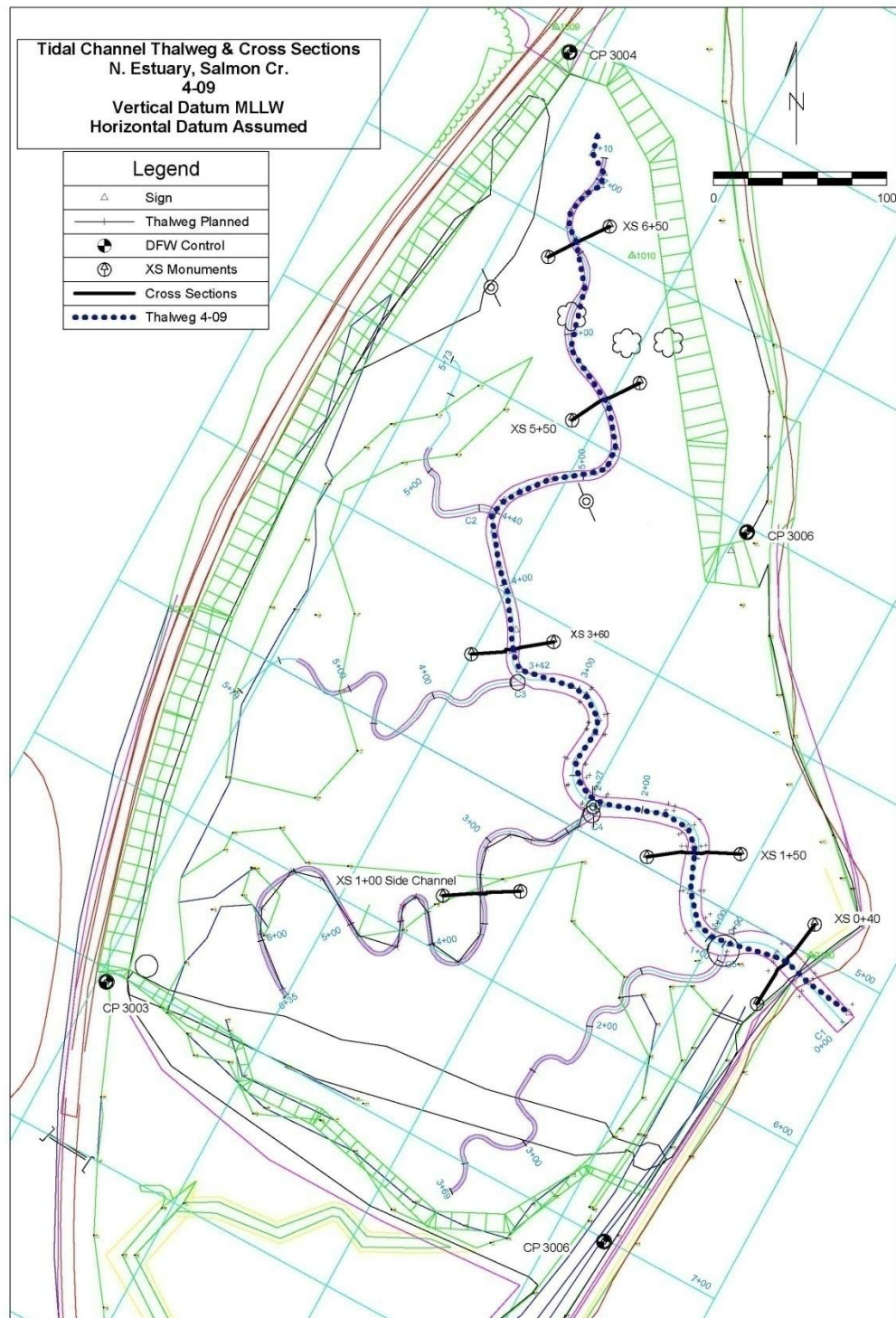


Figure 8: North Site, Tidal Channel Construction Specs and cross section locations.

Sampling Protocol

- 1) Channel Cross Sections - Established using total station in cooperation with Jefferson County Conservation District and tied to WDFW bench marks.
- 2) Select cross section locations starting at 200' intervals from channel mouth on primary channel, and one cross section on one major tributary.
- 3) At each cross section location set "monuments" on each side of tidal channel, 20' back from the top of bank. "Monuments" will consist of 1/2" galvanized pipe floor flange, 24" schedule 80 pvc pipe, and 3/8"x4' fiberglass rod.
- 4) Location and elevations of "monuments" established using total station and WDFW survey control points.
- 5) Using a total station, survey tidal channel thalweg profile and cross sections. Future cross section measurements could be taken with total station or level and tape.
- 6) Channel Cross Sections
 - a. Locate cross section locations at the mouth and two points equidistant between head and mouth
 - b. Establish two monumental benchmarks (rebar and concrete) for each cross section located on the upland adjacent to the site. Survey tidal channel profiles and selected cross sections. Channel cross section survey locations will be marked with rebar and GPS points taken at both ends of the transect to ensure that the same location is sampled from year to year.

Depending on the consistency of the mud, part of this work may need to be done from a boat or with plywood soles.

7) Tidal Channel Length (procedure to be used if no total station available)

Using measuring wheel, walk from head to mouth of channel with the wheel set to feet. Keep the wheel on the ground surface as close to the edge of the channel as possible. Record the distance from the wheel at mouth. The channels will also be mapped while measuring the channel length. At three to four feet intervals GPS points will be taken in order to graphically map out the channel. GPS points will also be taken where naturally forming tributaries (minimum 4 inches deep and 6 feet long) have formed and are connecting to the primary or secondary channels.

8) Distance from head to mouth (procedure to be used if no total station available)

Establish center point at the head and mouth of tidal channel. The line that connects these two points is the tidal channel distance. Using an eyed survey pin, stake the tag of fiberglass measuring tape to the center point at the head of the tidal channel. Extend the tape directly towards the center point of the mouth. If necessary, attach a second tape measure to reach the mouth. Record the distance from point to point. Repeat for all excavated channels. GPS points

will be taken at these sample locations to determine if the location of the head or mouth of the marsh is changing over time.

Calculations & Analysis

1. Sinuosity

Sinuosity = total length / distance from head to mouth

Example: Total length of channel is 36 feet

Distance from head to mouth is 27 feet

$$36/27=1.333 \quad \text{Sinuosity Ratio} = 1.333$$

Sinuosity Ratio Scale:

Straight (SR = 1)

Sinuuous (SR = 1-1.5)

Meandering (SR > 1.5)

2. Width to Depth Ratio

Convert field elevations to actual elevations by subtracting the Forward Sight from the Height of Instrument.

HI-FS= Elevation above sea level NADD

HI=height of instrument (laser level)

FS= forward sight to measured elevation (thalwegs, and top of Bank)

Example: With a Height of instrument of 14 and a recorded elevation of 6 the actual elevation would equal 8: $14-6=8$

Convert all recorded elevations to actual elevations. When top of bank and thalweg have been converted to actual elevation the depth can be calculated by subtracting the thalweg from the top of bank. Example: Top of Bank (7) - Thalweg (3) = Depth (4)

At this point it is possible to calculate the Width/ Depth ratio.

$$\text{Width (10) / Depth (4) = Width Depth Ratio 2.5}$$

3. Graph all profiles and cross sections.

4. Number of channels and channel complexity

--Number of channels is the number of 1st, 2nd, 3rd, and 4th order channels.

--Channel complexity is the number of tributaries that have formed off of the main (primary or 1st order) channel.

Additional Information & References

Coats, R.N, et. al. 1995. Design Guidelines for Tidal Channels in Coastal Wetlands. Phillip Williams and Associates. Pp 46+App & figures.

Cornu, Craig E., Steven Sadro. September 2002. Physical and Functional Responses to

Experimental Marsh Surface Elevation Manipulation in Coos Bay's South Slough. *Restoration Ecology* Vol. 10 No. 3, pp. 474-486.

Roegner, G.C., et al. 2008. Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary. Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, under related Service Agreement with the U.S. Department of Energy Contract DE-AC05-76RL01830.

2.3 Protocol for Assessing Terrestrial and Benthic Invertebrates

Benthic and terrestrial invertebrate monitoring was to be completed by a partnership between NOAA, NOSC, and community partners. The reassignment of key NOAA staff will not allow this work to occur. The proposed monitoring protocol is included.

Purpose

To develop an inexpensive monitoring tool that is scientifically defensible, quantifiable, replicable, and transferable to restoration practitioners and community members engaged in monitoring restoration projects in estuarine environments.

Consistent, cost-effective, and widely distributed tools for evaluating the success of restoration of estuarine wetland habitats in the Pacific Northwest are not currently available. Pilot programs have incorporated plants and amphibians to some success, but aquatic invertebrates have received little attention despite their wide use as a monitoring tool for streams and rivers. Interest in developing assessment tools for Pacific Northwest wetlands has been growing in recent years, in particular due to the increasing number of threatened and endangered species dependent on these habitats for critical life stages.

Aquatic invertebrates are prevalent, abundant and taxonomically rich in wetlands, they are highly sensitive to pesticides, metals and other contaminants, and they have a relatively short lifecycle, which allows invertebrate populations to show a quick response to environmental stressors. In addition, epibenthic-benthic organisms in tidal channels are prominent in the diet of juvenile Pacific salmon feeding in estuarine habitats.

Goals

1. Document invertebrate baseline conditions in the area containing wood waste before and directly after construction, and compare those to invertebrates collected from reference areas.
2. Document changes, if any, in invertebrate assemblages by sampling monthly before and directly after construction activities. Resample at established stations at the same time of year and in the years 1, 3, 5 and 10 after removal and construction activities.
3. Document potential prey resources for Pacific juvenile salmonids in the area containing wood waste before and directly after construction activities.
4. Train volunteers to collect, process, identify, and analyze invertebrate assemblages using established methods that are scientifically defensible and quantifiable.

Design

Benthic invertebrates and marsh surface invertebrates were chosen for analysis in the tidal channels for two reasons: their prominence in the diet of juvenile salmon feeding in other estuarine habitats (Simenstad and Salo 1980; Healey 1982a, b; Levy and Northcote 1982; Wolf et al. 1983; Macdonald et al. 1987; Shreffler et al. 1992), and aquatic insects have specific

ecological requirements for food, substrate, pH, temperature, dissolved oxygen concentrations and water velocity, and occupy several trophic levels. Because these organisms are highly dependent upon environmental conditions, they are useful bio-indicators of the health of the aquatic ecosystem.

Benthic macroinvertebrates and marsh surface fauna were collected from a tidal channel immediately south of the area containing wood waste, and from a tidal channel in a nearby reference area. Benthic macroinvertebrate samples were collected from the channel sediment. Marsh surface invertebrate samples were collected from the riparian vegetation and stations were co-located with the benthic sampling stations.

Equipment

Benthic invertebrate Sampling Equipment

PVC pipe for sediment cores

Jars

10% Buffered Formaldehyde (Formalin)

Sieves (a 250- μ m sieve and a 106- μ m sieve)

70% isopropanol

Rose Bengal stain

Illuminating dissecting microscope

Fallout invertebrate Sampling Equipment

Marsh surface invertebrates were collected in traps (55-cm $\times$ 38-cm rectangular plastic storage bins), which have been successfully deployed in other estuarine emergent vegetation habitats in the Pacific Northwest. Fallout traps are designed to catch invertebrates that fall from the air, from riparian vegetation, or that settle onto the surface of the water, providing a direct measure of input from the marsh to the aquatic system. This method can assess other available prey resources for juvenile salmon.

Other equipment:

Biodegradable dish soap

Sieve (0.106 mm)

Jars

50% isopropyl alcohol

Site Selection

Benthic invertebrates

Epibenthic and benthic macroinvertebrates were collected from the channel sediment at three stations in each of the channels: 1) head of channel, 2) mid-channel, and 3) mouth of channel for a total of six sampling stations.

Fallout invertebrates

Marsh surface invertebrates were collected from the riparian vegetation at three stations along the channels: 1) head of channel, 2) mid-channel, and 3) mouth of channel for a total of six sampling stations.



Terrestrial and Benthic Invertebrate Sampling Stations

- ▲ Reference Site Sampling Stations
- ▲ Prior Wood Waste Channel Stations

Figure 9: Terrestrial and Benthic Invertebrate Sampling Stations.

Sampling Periodicity

Benthic invertebrates

Epibenthic and benthic organisms are sampled one time, each month prior to, and directly following construction.

Fallout invertebrates

Marsh surface invertebrates were sampled one time, each month prior to, and directly following construction.

Sampling Protocol

Benthic invertebrates

At each station, three replicate sediment cores are taken in the tidal channel. A core is made of PVC pipe and used to sample an area of 0.0024 m². Sediment cores are sampled to a depth of 10 cm and taken from the exposed channel bottom. The benthic cores are transferred to jars in the field and fixed with 10% buffered formaldehyde (formalin). Cordell et al. (1994) found that sediment cores sampled epibenthic taxa as well as, or better than, epibenthic suction pumps and also incorporated benthic infaunal taxa.

After a minimum of one week of fixation in the buffered formalin, benthic core samples are washed through two sieves: 250-µm and 106-µm mesh size. Benthic macrofauna are retained on the 250-µm screen and meiofauna that pass through are caught in the 106-µm sieve. Samples are then transferred to 70% isopropanol and stained with Rose Bengal. After a minimum of seven days in Rose Bengal, samples are sieved and all organisms are identified using an illuminated dissecting microscope. Individuals are identified to the lowest reasonable taxonomic level.

Fallout invertebrates

Fallout traps are placed in the riparian vegetation, one trap at each of the co-located benthic sampling stations. The traps are tethered to PVC poles driven into the sediment at each corner of the basin, which keep the traps in place but allow vertical movement with the tidal cycles. The traps are filled to a depth of 10 cm with water containing a small amount of biodegradable dish soap, which breaks the surface tension, trapping and preserving the invertebrates. The traps are left for three consecutive days. If a fallout trap capsizes or is flooded the sample is discarded. At the end of the sampling period, the soapy water in each trap is drained through a 0.106 mm sieve. The samples were then transferred to jars in the field containing 50% isopropyl alcohol.

Calculations & Analysis

Using an illuminated dissecting microscope, prey organisms will be identified to the lowest reasonable taxonomic level, sorted by life history stage, and counted.

Benthic invertebrates

Representative samples of the smaller fractions will be initially scanned under a dissecting microscope to determine whether any juvenile salmon prey are present. If no obvious prey taxa are found in the scans, the smaller fractions will not be processed further. Due to the high number of individual animals observed in some of the sediment cores, for example > 2000 of the dominant organism in the larger fraction, subsampling of the larger fractions is sometimes necessary. These larger fractions are systematically subsampled using a Folsom plankton splitter (Wickstead 1976) until a fraction containing a minimum of 100 of the dominant organism is obtained (Simenstad et al. 1991). All organisms in those fractions will be sorted and counted.

Taxa totals, life history stage, mean, standard deviation, and the percentage of the total sample will be reported for benthic and surface samples.

Fallout invertebrates

All organisms from the fallout samples will be identified using an illuminated dissecting microscope and, when necessary, a compound microscope. All individuals will be identified to the lowest reasonable taxonomic level and life history stage, and counted.

Taxa totals, life history stage, mean, standard deviation, and the percentage of the total sample will be reported for benthic and surface samples.

Additional Information & References

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2.4 Protocol for Assessing Marsh Vegetation

Purpose

The purpose of the vegetation monitoring plan is to describe recommended tasks for monitoring the progress of the estuary vegetation restoration elements of the Salmon Creek Estuary Restoration Project. This monitoring plan is intended to encompass only the estuary portion of the project area, and does not include monitoring of the riparian plantings that preceded the plans for estuary restoration. Although this plan is focused on the estuary, it does recognize the connectivity of the estuary with freshwater, terrestrial, nearshore, and marine ecosystems.

Goal

To examine and monitor changes over time two critical components of the estuarine habitat, which are:

- 1) Salt marsh habitat gains.
- 2) Wetland vegetation species composition and acreage.

Design

Salt Marsh Habitat Gains

Changes in the overall acreage of salt marsh habitat from prior to post construction, are to be monitored and compared over time with the historic salt marsh habitat depicted on the 1870 “T sheet.” This is in accord with the project restoration goal to create approximately 11 acres of new salt marsh habitat.

Wetland Vegetation Transects

The historic species composition and acreage of wetland vegetation in the Salmon Creek estuary is unknown. In September 2006, Dave Shreffler of Shreffler Environmental and Ralph Thomas Rogers of EPA conducted preliminary vegetation characterizations in the estuary portion of the north and south sites of the project area. The dominant wetland plant species within areas that could serve as potential reference sites (because they won’t be altered by any proposed grading) were as follows:

Reference for South Site (existing high salt marsh in Site 1 along Salmon Creek): *Carex lyngbyei*, *Aster subspicatus*, *Juncus effusus*, and *Potentilla pacifica*.

Reference for North Site (existing “triangle” area of high salt marsh): *Distichlis spicata*, *Salicornia virginica*, and *Juncus gerardii*.

The historic species composition and extent of invasive plants in the project area is also unknown. In 2003, Fred Weinmann, a retired wetland ecologist, did a plant inventory of the Salmon Creek area that included native, invasive, and noxious species (see Appendix A).

Invasive and noxious plant species of particular concern at the restoration site are reed canary grass (*Phalaris arundinacea*), Canada thistle (*Cirsium arvense*), Scot's broom (*Cytisus scoparius*), Queen Ann's lace (*Daucus carota*), St. John's wart (*Hypericum perforatum*), Hairy cat's ear (*Hypochaeris radicata*), Tansy ragwort (*Senecio jacobaea*), Himalayan blackberry (*Rubus discolor*), Japanese knotweed (*Polygonum cuspidatum*), and many species of non-native, invasive grasses.

Wetland vegetation provides habitat structure, facilitates sediment trapping, and serves as a critical source of organic matter to support detritus-based food webs for juvenile salmonids, shorebirds, and waterfowl.

The project partners believe that the existing seedbed will be sufficient to allow natural recolonization of the estuary, and no planting of wetland species is currently planned. Non-native, invasive plant species disrupt native plant community structure that provides higher quality habitat and food for a variety of wildlife species, which, in turn, have evolved in conjunction with native plant communities. Removal of invasive plants is essential for the restoration project to succeed.

Vegetation monitoring consists of establishing reference sites on the North and South Sites in areas that were not to be excavated as part of the proposed estuary restoration. Gathering baseline data on wetland plant cover and species composition at these reference sites was critical for two reasons: 1) the vegetation communities at these sites provides information on the target plant communities and desired elevations for the estuary restoration; and 2) the baseline conditions will serve as a future reference for determining how comparable the post-restoration plant communities are to the target plant communities the project partners are hoping to achieve. Shreffler Environmental will provide NOSC with two sets of reference plant specimens collected from the North and South Sites prior to the start of baseline monitoring. These reference sites will be analyzed and compared with permanent transects to be established on the North and South Sites but located in the recently excavated areas.

Equipment

Salt Marsh Habitat Gains

Tools used to identify current salt marsh habitat vegetation perimeters are aerial photographs, GPS, or traditional survey techniques. An as-built drawing can be used to verify that the target elevations and the total acreage of new salt marsh habitat were achieved.

Wetland Vegetation Transects

Measuring Tape
Compass
Wooden Stakes (transect markers)
0.25m x 0.25m Quadrats
GPS

Digital Camera
Flagging
Data sheets
Pencils
Clip Boards
Sample Specimens
ID Books

Site Selection

Salt Marsh Habitat Gains

All predicted 11 acres of salt marsh were created at an elevation consistent with expected recruitment of low salt marsh vegetation as indicated by as built drawings.

Wetland Vegetation Transects

Reference Site Transects: Permanent transects were established (approximately 200 meters in length) adjacent to the North and South Sites in existing wetland vegetation that was not to be excavated as part of the proposed estuary restoration.

Restored Site Transects: Permanent transects have been established (approximately 200 meters in length) in the recently excavated areas of the North and South Sites.



Figure 10: Vegetation Monitoring Locations (North and South Sites)

Sampling Periodicity

Salt Marsh Habitat Gains

Monitoring will be essential at three stages of the restoration process: pre-project (baseline) monitoring, during construction (implementation) monitoring, and post-project (effectiveness) monitoring.

Monitoring, as outlined in this plan, is intended to proceed for a minimum of 5 years (baseline monitoring in 2007 plus 4 years post-construction). As with all monitoring programs, the actual length of monitoring will depend on the availability of grant funding.

Wetland Vegetation Transects

With both Reference Site transects and Restoration Site transects, surveys took place in June and September 2007 and once during July 2008. Surveys will continue once per year in July.

Monitoring, as outlined in this plan, is intended to proceed for a minimum of 5 years (baseline monitoring in 2007 plus 4 years post-construction).

Sampling Protocol

Salt Marsh Habitat Gains

Accurate evaluation of total salt marsh acreage will be obtained through aerial photographs, GPS or traditional survey techniques in all three phases of the project. Conditions will be compared to historic 1870 "T sheets," as well as with contractor provided as-builts of the project site.

Wetland Vegetation Transects

Reference Site Transects:

1) Establish permanent transects (approximately 200 meters in length) in or adjacent to the North and South Sites in existing wetland vegetation that will not be excavated as part of the proposed estuary restoration. Mark the start and end of each transect with wooden stakes, GPS their locations, and survey each transect once per year in July to determine *percent cover* and *species composition* within a 1-m² quadrat placed at 10-foot intervals along the right side of each transect line. The survey team should walk on the left side of each transect line and record data from the right side of each transect line. On standardized data forms, record all plant species observed (including invasives, not just wetland species) within the quadrat at each sampling location (i.e., each 10-foot interval), and visually estimate percent cover of each species within each quadrat.

2) At each transect location, take photographs from each transect start stake looking toward the end stake and from each end stake looking toward the start stake. Photos should be taken at the

same time the transect sampling is done in #1 above and logged on the standardized fixed point photo data form.

3) Prior to estuary excavation and grading, flag patches of invasive species for excavation and removal.

Restoration Site Transects:

1) Sites will be selected to intercept various substrates as well as reflect varying distances from the mouth of the main tidal channel. Mark the start and end of each transect with wooden stakes, GPS their locations, and survey each transect two times per year (in June and September) to determine *percent cover* and *species composition* within two 0.25m x 0.25m quadrats placed at 10-meter intervals along opposite sides of each transect line. On standardized data forms, record all plant species observed (including invasives, not just wetland species) within the two quadrats at each sampling location, and visually estimate percent cover of each species within each quadrat.

2) At each transect location, take photographs from each transect start stake looking toward the end stake and from each end stake looking toward the start stake. Photos should be taken at the same time the transect sampling is done in #1 above and logged on the standardized fixed point photo data form.

Calculations & Analysis

Salt Marsh Habitat Gains

Following five years post construction, 11 acres of **new** salt marsh habitat should exist at the restored site.

Wetland Vegetation Transects

Reference Site Transects:

Transfer the field data from the standardized forms onto Excel spreadsheets.

Restoration Site Transects:

Transfer the field data from the standardized forms onto Excel spreadsheets. Track changes through time in the percent cover and species composition relative to baseline conditions and evaluate whether the performance criteria listed below are being met after five years.

Compare pre-project and post-project photos to track changes in vegetation.

1) Percent cover of native wetland plant species should be on a trajectory toward percent cover comparable to the baseline reference sites after 5 years.

2) Species composition of native wetland plant species should be on a trajectory toward species composition comparable to the baseline reference sites after 5 years.

3) Fixed photos: there are no stated performance criteria associated with the fixed photos, as this is primarily a qualitative monitoring technique. However, these photos are very important as a way for people to visualize the changes in plant community species and percent cover. There is probably no better, more cost-effective way to convince the public of the benefits of wetland restoration than to show them “before” (pre-project) and “after” (post-project) photos.

4) Invasives: after 5 years, $\leq 5\%$ of the excavated project area will contain invasive plant species.

Excessive failure rates for plant establishment will be addressed with contingency measures. Potential causes could include inadequate natural seed base, inappropriate elevations, poor soil structure and/or organic content, herbivory, or competition. Contingency measures could include plantings, soil amendments, watering, weeding, fencing, excavating to proper elevations, management of non-native invasive plant species, and/or improved stewardship.

More than 5% cover by area of invasive plant species in any given monitoring year would trigger the need for contingency measures. Contingency measures could include some combination of additional mechanical treatments (e.g. hand clearing, burning, weed whacking, mowing, shading).

Additional Information & References

Shreffler Environmental developed the above protocol at the request of the North Olympic Salmon Coalition (NOSC). The technical aspects of this monitoring plan are consistent with “Guidance for Protection and Restoration of the Nearshore Ecosystems of Puget Sound” (NST 2003) prepared by the Nearshore Science Team (NST) for the Puget Sound Nearshore Ecosystem Restoration Program (PSNERP). Because the proposed monitoring will be accomplished by NOSC staff working with volunteers, this plan also draws from “Broadening Participation in Biological Monitoring: Handbook for Scientists and Managers” (Pilz et al. 2006).

For entire monitoring protocol, see “Salmon Creek Estuary Restoration Project: Vegetation Monitoring Plan” prepared by Dave Shreffler of Shreffler Environmental, Sequim, WA.

[illegible]

Figure : Sample Vegetation Monitoring Data Sheet

3.5 Protocol for Assessing Temporal Abundance, Size and Species Composition of Fish Utilizing Salmon Creek Estuary

Purpose

The incentive for restoration activity in Salmon Creek Estuary involves increasing habitat for rearing and migrating juvenile salmonids and other nearshore estuarine species. Evaluating community structure of existing rehabilitated and created tidal channels will be important for understanding the relationships between fish habitat use and physical conditions such as water quality, tidal conditions, hour of day, and diurnal period. In addition, ocular surveys will monitor for fish stranding within newly created tidal channel areas in regards to tidal influence.

Goals

- 1) Evaluate species composition (lowest practical taxon), fish size (fork length), and abundance in each habitat type. Habitat types include: a) leachate channel after rehabilitation, b) reference channel, and c) excavated channels.
- 2) Monitor and document any episodes of fish stranding following project site construction, and take appropriate actions to alleviate stranding if necessary.

Design

Fish Sampling

Fish utilization will be determined by sampling fish use at the two pre-project sites, as well as up to two additional post project sites. The metrics for fish sampled post project can be correlated with other biological and physical features of each habitat to determine features that provide the best enhancement of habitat for fish use.

Ocular Surveys

Ocular surveys will consist of walking all tidal channels near the waters edge, on a 6-9 foot tide that is slowly outgoing. Survey will be done walking at a slow pace, and in a direction that minimizes water glare. Polarized sunglasses and a hat will be worn to help in minimizing glare as well, and winds need to be 10 knots or less in order for optimal viewing conditions.

Equipment

Fish Sampling

Fyke nets will be used to sample fish usage in estuary tidal channels. Fyke nets depend on volitional fish entry and water current for entrapment. The fyke net is appropriate for this type of sampling because the tidal channels being sampled at Salmon Estuary are low velocity channels that completely dewater. Dimensions of the fyke net to be used in sampling protocol are (height

x width): 10' x 6' mouth, 10' x 15' wings, and a 2' x 3' floating box (It may be possible to borrow another fyke net from WDFW to ease sampling process).

Annual Permits

- Endangered Species Act permit from NOAA Fisheries must be obtained an available onsite. Currently arranged through Doris Small, WDFW. Applications due in October.
- Washington State Scientific Collection Permit must be obtained by NOSC and available onsite. Applications due with previous year catch report by January 31.
www.wdfw.wa.gov/scp/
- The permit holder or one of the sub-permit holders must be present during sampling.

Ancillary Hardware and Materials-

- Fyke net trapping station installation
 - Six 7 ft. T-posts
 - T-post driver
 - Four 1.5 inch diameter, 5ft. long PVC sections
- Chest waders
- Dip net
- Measuring boards
- Small measuring tray for juvenile salmonids
- Shovel
- Water-proof data forms and pencil
- Field ID books
- Camera and photographing jar
- 5 gallon bucket to use as post capture counting bucket

Ocular Surveys

Equipment will consist of:

- Polarized glasses
- Brimmed hat
- Field notebook and tide tables

Site Selection

Fish Sampling

Two Fyke net sampling sites were established pre-project; both have necessary posts and piping installed. Channel #2 is located at the North Project Site, on the northwest side of Salmon Estuary. This channel was subject to leachate from wood waste prior to project improvement. Channel #3 is located on the east side of the Salmon Estuary off of the project site but within Salmon Estuary. This channel is not subject to wood waste leachate. These two channels currently begin to fill and are empty at a six-foot tide.

Two additional Fyke net sampling sites were established post project. Channel #1 is an excavated channel created at the North Project Site. It is possible that future channels will form and may be monitored for fish utilization depending on priorities, personnel and funding availability. Channel #4 is an excavated tidal channel created during the rehabilitation project at the South Project Site.

Ocular Surveys

Ocular surveys will be conducted as walking surveys along all newly created tidal channels within the entire project area.



Figure 11: Fyke Net Sampling Stations

Sampling Periodicity

Fish Sampling

The minimum frequency will be one day a month February through May for each Channel Site. Although increased sampling frequency is desirable it may not be realistic due to limited resources. Because fyke net trapping is passive and dependant on tidal currents it is necessary to standardize the tide cycles used during sampling. Opportunities for sample days are limited by three factors: tidal elevation, elevation of tidal channel thalweg, and length of day. For example: Channel #1 both begins to fill, and completely dewater, at a tidal elevation of 6 feet. Consequently a tidal elevation of eight feet is needed to get 2 feet of water in this tidal channel. Therefore to sample in at least 2 ft. of water the tide must rise to 8ft. and then recede to 6ft during daylight hours. Periodicity is further limited early on in monitoring season due to shorter day length.

Ocular Surveys

Ocular surveys will be conducted at the same time as fyke net sampling, during the first week of each month from the months of February through May. Additionally, sampling may be conducted again in June.

Sampling Protocol

Fish Sampling

Step 1

Initial Installation- Initial installation is complete on channels 1-4(March 2009). When future channels are selected for monitoring, initial installation will need to occur prior to sampling time. Once a site is selected, drive four t-posts in the substrate at least one foot deep. These four T-posts should be spaced according to the sleeves and tie lines on the fyke net. Place a six-foot length of appropriate diameter PVC piping over each inland T-post to protect the net from excessive wear. These four T-posts will support the web tunnel and net box of the fyke net. Drive a T-post snug against the inside of each of the PVC covered T-posts. Slide a six-foot PVC pipe over each of these as well. These two posts will be used to attach upstream facing wings of the fyke net. An additional T-post may be required at the end of each wing depending on channel width.

Step 2

Sampling Day Installation- Transport all the necessary equipment to the site. At high tide slack, slide associated sleeves on fyke net over PVC piping, tie net box to T-post, and install wings. It is necessary to ensure that the lead line has created a seal that does not allow fish to pass under. Ensure that there is no route between tidal channel banks and wings for fish to escape. Prepare photographic, measuring, and recording gear. Record air temperature, water temperature, time and date.

**** NOTE:** Incoming tides have been observed to exhibit a pulsing nature. At least four separate pulses have been observed in the hour or so approaching high tide. The tide will come in and then flow out for 15 to 20 minutes before turning and flowing in again. This pattern repeats several times. These pulses have been known to turn the set fyke net inside out if the net is placed in the channel too soon before the final pulse. It is important to know when the high tide is expected, and not to set the fyke nets too early just because the tide seems to be receding.

Step 3

*Count and Measure-*As the tidal channel drains, use the dip net to move trapped fish from the net box on the fyke net to a five gallon bucket. Remove fish from the five-gallon bucket one at a time, measure each fish, and then release fish downstream of net. Measure the fork length of the first 30 of each species of fish; after first 30 are measured, individuals only need to be counted. Keep a total count for each species. Photograph any fish of interest and one of each species to verify proper ID. When the tidal channel has completely drained, check the net thoroughly for remaining fish. Sample any remaining pools between the fyke net and channel head with a dip net. Remove the net and record the end time.

Step 4

Clean and Dry Net- Spray down the entire net with a high water pressure nozzle, removing all plant debris and sediment. Hang the net allowing sufficient drying time. Store the net for future use in a dry, rodent free location.

Ocular Surveys

Survey protocol is to walk the tidal channels near the water's edge, on a six to nine foot tide that is slowly outgoing, at a slow pace, and in a direction which minimizes glare while observing fish within the channel area. Polarized glasses and a hat are to be worn to minimize glare and enhance viewing conditions. All salmonids spotted along the shore will be enumerated, their species noted, and any strandings will be documented.

Calculations & Analysis

Fish Sampling

1. Catch: Absence/presence.
2. Size frequency: Compute mean and standard deviations by species for each date sampled.
3. Measures of fish community (diversity, evenness, dominance).

Ocular Surveys

Stranding of fish needs to be immediately addressed, especially if large numbers are involved. Appropriate actions will be determined once the particular situation and cause is identified.

Additional Information



Figure 12: Example fyke net set up.

Salmon Snow Estuary Tidal Channel - Fyke Net Sampling Form 2009

North Olympic Salmon Coalition, phone 360.379.8051

Location # 1 Name Owen French, Betsy Kain Date 2/11 -09

Location Description Station 1, North Site 1st order channel at mouth

Wind no, Air °C 10°, Rain no, %Cloud 50, Sea Surface temp 3.8°C

Tidal elevation: Start 9.5 End 6.5

Time Set 3:30 PM Time pulled 7:30 PM

Notes: Net was set at mouth of 1st order channel on North site (1)
at slack tide. Photos were taken of each species.

A school of perch happened to be in channel? (Bring bigger dipnet.)

Photo Y, N, & #	Species	Tally	Fork length mm											
Y, 1-4	Chum	(17)	III III III III	50	38	48	45	37	40	43	48	51	55	
				39	39	43	47	51	52	50				
Y, 4, 5	Coho	(12)	III III II	36	39	40	41	63	50	55	40	43	47	
				48	47									
Y, 5-8	Sculpin	(38)	III III III III III III	24	32	21	70	60	60	25	60	80	62	
				50	40	20	50	25	20	35	40	61	40	
Y, 10	3 spine Stickback	(5)	II	42	30	25	44	40						
Y, 11a	Shiner Perch	(68)	III III III III III III III III III III	90	120	70	75	60	75	72	120	110	92	
				120	60	75	70	76	80	91	112	130	180	

Figure13: Sample Fish Monitoring Data Sheet

References

Roegner, G.C., et al. 2008. Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary. Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, under related Service Agreement with the U.S. Department of Energy Contract DE-AC05-76RL01830.

2.6 Protocol for assessing sediment accretion and changes in marsh surface elevation over time

Purpose

The soils and their relative surface elevation are of vital importance in a tidal marsh. The Salmon Ck estuary restoration design intentionally established the constructed marsh surface 1.0 foot lower than the adjacent marsh elevation, expecting it to rise as particulate matter is deposited on the surface, plants colonize it and invertebrates occupy it. A number of interesting questions arise:

1. What is the rate of change in surface elevation and sediment accretion?
2. What is the role of subsurface processes in marsh elevation?
3. What role do invertebrates and vegetation have in the relationship between elevation and accretion?
4. What is the texture of the accreted material and how does this change across the various sections of the marsh?
5. How is the texture related to invertebrate and plant communities?
6. And, will the restored marsh surface keep pace with sea level rise?

This monitoring program can begin to answer some of these questions and correlate these with the disparate study areas.

Goals

- 1) Establish the rate of accretion in various parts of the restored estuary.
- 2) Monitor the change in marsh surface elevation over time.
- 3) Determine the recovery trajectory toward high salt marsh, and the future of the marsh with predicted sea level rise.
- 4) Analyze the texture of deposited materials in various locations in the restored estuary.

Design

The final elevation of the marsh surface will be determined by the sediment it accretes and by any subsurface forces at work raising or lowering surface elevation. To measure changes in surface elevation and determine which of these forces is effecting the elevation change, two techniques must be used in conjunction. These devices are set in conjunction with one another and are referred to as sediment monitoring arrays.

Marker Horizons

In order to measure surface sediment accretion without interference from subsurface processes, a marker horizon is placed near the surface as a reference to measure the change in depth of sediment. From the marker horizon one can determine the accretion rate, which is defined as the

change in the vertical distance between the horizon and the sediment surface. For this study, marker horizons are placed around SET tables (see next section) and are .25m x .25m areas of the substrate that have been covered in a thin layer (1-2mm) of G200 feldspar clay. The white powdered clay is layered onto the existing marsh surface inside .25m x .25m quadrats, as sediment accretes it covers the clay. This accretion can be measured by sediment coring marker horizon installations and measuring the accreted sediment atop the white layer of clay.

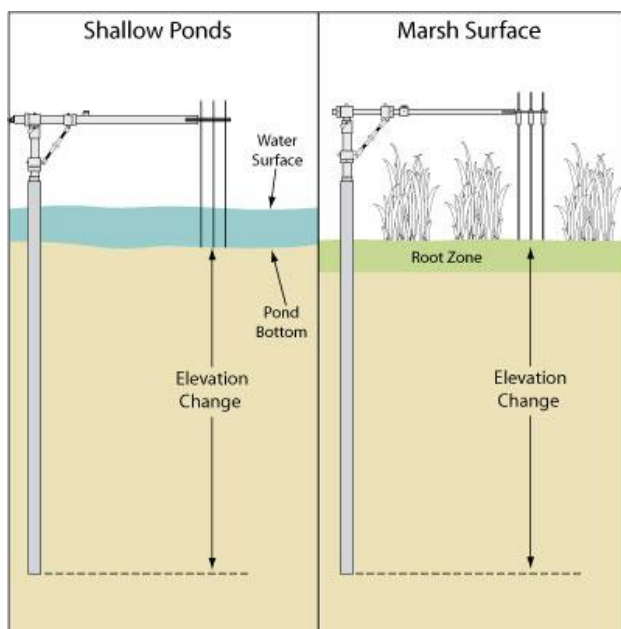
rSET Device

The rSET device, or Rod Set Elevation Table can measure differences in surface elevation as they relate to sub surface processes with a high degree of accuracy. Used in combination with marker horizons, the rSet not only documents surface elevation change, but allows one to determine if the elevation change is the result of subsurface or surface processes.

Elevation is defined as the average surface level relative to an established benchmark. Since a natural soil surface can vary many millimeters over very short distances, a large number of measurements must be made. In addition, the soil surface is soft and the measuring device must apply a minimum amount of force on the surface. The Sediment Elevation Table (SET) is designed to determine the marsh surface elevation with a high degree of accuracy. The design and operation of the SET table is extensively covered in this web page:

<http://www.pwrc.usgs.gov/set/> .

Four SET sites, two at the N Site and 2 at the south site, have been established.



SET sketch (USGS SET concepts and theory <http://www.pwrc.usgs.gov/set/theory.html>)

Figure 14: Diagram of a Set Elevation Table

Equipment

Marker Horizons

1. Installation

- Camera
- *Data Sheets
- *Clipboard
- *Pencils
- G-200 feldspar clay
- Plastic Cup
- Bucket
- ½" PVC Pipe
- *¼ meter Quadrat

2. Measurement (ALWAYS BRING ABOVE INSTALLATION SUPPLIES)

- Large (25 L) Liquid Nitrogen Dewar
- Small (1 L) Liquid Nitrogen Dewar/Thermos
- Gloves
- Digital Calipers
- 2x Metal Funnel
- 2x Cryo Core Copper Tubing
- Knife
- Metal Spatula/Scraper
- Soft cloth
- *Camera
- *Data Sheets
- *Clipboard
- *Pencils
- *¼ meter Quadrat, split into quarters by string

Rod Set Elevation Table (rSET)

1. Installation

- rSet benchmark installation materials and protocol are extensively covered at <http://www.pwrc.usgs.gov/set/>, Cahoon (2002)
- Survey equipment to determine elevations of rSET benchmarks

2. Measurement

- rSET, fabricated per Cahoon (2002)
- Field notebook
- Platforms to keep observers from trampling rSET sites
- Steel ruler(metric), must start at zero,

Site Selection



Figure 15: North site sediment monitoring array locations. Rectangles indicate sediment arrays.



Figure 16: South site sediment monitoring array locations. Rectangles indicate sediment arrays.

The proximity of Salmon Creek hypothetically influences sediment accretion. The sediment arrays sites were selected to show the role of position in the overall estuary in the amount of accretion that occurs. Two arrays at the north site and two arrays at the south site will help to measure differences in sediment accretion between the restoration sites. Given that river sediments account for the majority of sediment reaching the estuary, the south site should show more deposition than the north, which is further out into the bay and would be exposed to lower densities of suspended materials as well as larger particles that would accompany peak flood events.

The location of sediment monitoring arrays at each restoration site were located so that one array is close to the influence of Salmon Creek and tidal flooding and one array is more removed from the influences of Salmon Creek and tidal flooding to measure accretion differences.

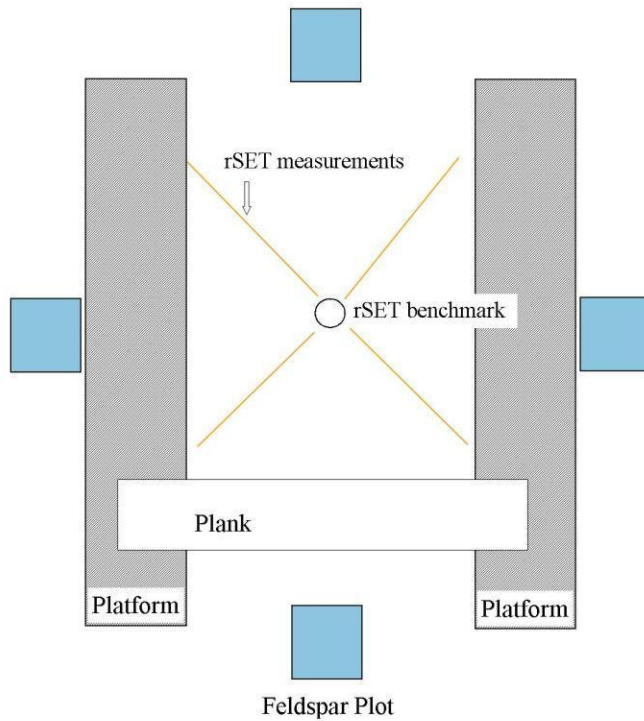


Figure 17: Typical rSET and Marker Horizon sediment array from above.



Figure 18: Sediment array during installation

Marker horizons

Marker horizons are placed adjacent to the rSET benchmarks so that they can be read from the platforms used to run the rSET. Their location is set in positions that do not interfere with locations read by the rSET.

rSET

The SET benchmark posts are located along the transects in association with the artificial horizon plate locations outlined above. The posts must be placed in a way to minimize vandalism as shown on the SET website.

Sampling / Sampling Periodicity

Marker horizons

Marker horizon measurement will be measured annually.

rSET

The SET measurements should occur annually. The tolerance of the measurement is approximately 1mm and elevation changes in marshes is on the order of 1-4 mm per year.

Sampling Protocol

Sampling protocol adapted from Cahoon, 2006.

Reading Marker Horizons

At the field site, be very cautious of how you walk in the marsh. Use the boardwalks and try to minimize disturbance as much as possible. Wear gloves and eye protection and be very careful with the liquid nitrogen. It can easily burn your skin. Use caution when pouring it and carrying it in the thermos. Be mindful of your feet because it can spill on your feet, become trapped in your shoe and burn you.

Fill the large dewar with liquid nitrogen. When you arrive at site, fill the small dewar/thermos from the large dewar. You will be using the thermos to take the cryo-cores. Use the Marker Horizon datasheet to locate the PVC poles that frame the marker horizon. Lay the $\frac{1}{2}$ meter quadrat around the PVC poles in the correct orientation as dictated by the datasheet. You will be sampling from one quarter of this plot, be sure to sample from one that has not been previously sampled from, also dictated by the data sheet. Be sure to record on the datasheet which quarter you took the cryo-cores from so as to not sample from the same quarter during the next field outing.



Figure 19: Example of sampling a Marker Horizon plot; note the PVC poles, $\frac{1}{4}$ meter quadrat and cryo-core funnel



Figure 20: Cryo-corer: Note the crimped end of the copper tubing, staggered holes drilled to help freeze the deeper sediments, and the hose clamp attaching the funnel securely to the copper tube.

Push the copper tubing with the attached funnel several inches into the sediment. Push from the copper tubing, NOT the funnel. Pushing from the funnel will dislodge it from the copper tubing hampering your ability to take cores. If you have an idea how deep the feldspar layer is (consult data sheet for info on last reading), it is helpful to wrap electrical tape around the copper tubing to serve as a marker of when to stop. This can also help to determine the surface of the core when estimating the depth of the feldspar layer on hot summer days when the mud begins to melt at the very surface of the core (*NOTE: this only works if you have the edge of the tape exactly at the sediment surface when you take your cryo-core*). Pour a small amount of liquid nitrogen in the funnel. Allow the liquid nitrogen to bubble and freeze the sediment to the copper tube. It is best to pour in smaller amounts, several times using a total ~200ml, than to fill the funnel to the brim once. A good connection between the funnel and copper tubing is necessary, however, a small amount of liquid nitrogen spilling out from where the two meet is a good thing as it helps to freeze the surface layer. It is also helpful to have good contact between the core tube and the surrounding sediment; this can be achieved by pushing the core down in a straight line and not moving it from side to side. The amount of liquid N₂ added will depend on desired depth of core, outside temperature, sediment organic matter and water content.

Once all the liquid nitrogen has evaporated, test the sediment surface directly surrounding the copper tubing with the metal scraper/spatula. Frozen sediment on the surface within a $\frac{3}{4}$ " radius extending from the tubing is a good indicator of a readable cryo-core. Use the knife, or scraper/spatula, to carve a circle in the mud around the sediment using the color of the frozen sediment as a guide. Cut conically with the point of the cone/your knife connecting beneath the lowest end of copper tubing. Remove the cryo-core by pulling on the copper tubing and NOT the funnel; the scraper/spatula can be used to gently pry up the bottom. A slight rocking or circular motion will help dislodge the core. If the core is in a site with high plant densities the knife will need to be used to cut the plant roots.

Inspect the cryo-core. Normally you will not see a good feldspar layer on the outside of the core this is because you were disrupting the layer while cutting around the core. Use the scraper/spatula to scrape away the sediment and locate the undisturbed, frozen layer. It seems to work best when you scrape the core parallel to the tube (i.e. Not up or down to the sediment surface). Do not give up, keep scraping until you find the layer or you are sure there is no layer

(i.e. you remove all the sediment and only copper tubing is left). They can be difficult to spot, varying from a straight line to a splotchy inconsistent layer, especially when there is a lot of root matter.

When a layer is found, use the digital calipers to measure from the sediment surface to the TOP of the feldspar layer. Take 3 measurements at 3 different spots along each cryo-core. The goal is to take three cryo-cores from a single quarter and to take three readings per core for a total of 9 measurements. In cases where repeated sampling, upwards of 5 cores, shows no feldspar layer attempt another quarter of the plot. If no feldspar layer is found in this new quarter after repeated samplings create a new marker horizon. Describe and note it on the data sheet assigning the next sequential number for the plot at that site. Make a note that no feldspar was found including the number of cryo-cores attempted, draw the new plot on the map and mark its location on a map and/or GPS points any new plots at a site follow the aforementioned convention for subsequent plots.

When feldspar is on the surface, the depth of feldspar measurement will be zero. In the case where feldspar is seen on the surface take pictures and record the percent coverage of feldspar over the $.25\text{m}^2$ plot. The percent coverage will denote the number of cores to take and the number of zero measurements (feldspar on surface) to enter into the datasheet to account for no accretion in some areas (see table below). The balance between the number of at-depth measurements vs. zero measurements is created to reflect the percent coverage of feldspar seen over the entire $.25\text{m}^2$. Remember that individual cryo-cores are measured three times; the zero measurements entered into the datasheet must balance this accordingly.



Figure 21: Example of good feldspar layer; note the digital calipers and metal scraper/spatula.



Figure 22: Example of cryo-core that needed scraping to expose the feldspar

SET

The sampling protocol is well established on the SET website <http://www.pwrc.usgs.gov/set/>. Various options are possible for the arrangement of the SET site and these should be decided based on the personnel, available funds and equipment. Piling and staging planks are first installed at each SET location and the base rod installed. At a stable, convenient location, the elevation of the base rod should be measured using survey equipment and recorded. The offset between the location of this elevation location and the top of the SET arm should be measured and recorded (this gives the elevation of the arm). The SET device is installed on the base rod. The arm quadrants should be established and recorded for each location according to the arrangement of the staging planks. In all four quadrants, the arm should be leveled and the nine pins lowered gently to the marsh surface. The protruding length of each pin is then measured with a ruler and the value recorded with the quadrant and site ID.

Calculations & Analysis

Marker horizons

Ten to 14 individual measurements are made at each artificial horizon. These are recorded in a field book or monitoring form with the unique site identifier. Each measurement should be entered in a data base so that the mean can be calculated as well as error statistics associated with sampling. Assuming these measurements to be normally distributed, the arithmetic mean and standard deviation should be calculated. Rates of sediment accretion should be calculated using simple linear regression over the sampling time period (Cahoon, 2000).

rSET

Similar to the artificial horizon calculations, the 36 pin measurements are recorded in a field book or monitoring form with the unique site identifier. Each measurement should be entered in a data base so that the mean can be calculated as well as error statistics associated with sampling. The elevation of the marsh surface at each pin location is equal to the elevation of the arm, minus the difference between the pin measurement and pin total length. Assuming these measurements to be normally distributed, the arithmetic mean and standard deviation should be calculated.

Rates of change in marsh elevation should be calculated using simple linear regression over the sampling time period (Cahoon, 2000).

Salmon Estuary Sediment Monitoring

Location N1--North Site, Northern Most SET

Date

Observers

	Position 4, SW	Position 2, NW	Position 8, NE	Position 6, SE
1				
2				
3				
4				
5				
6				
7				
8				
9				

Average rod above bar

Average rod below bar

Average Surface Elevation Equals Top of bar elevation minus B17

Figure : Sample Sediment Monitoring Data Sheet

References

Cahoon, DR, JC Lynch, BC Perez, B Segura, R Holland, C Stelly, G Stephenson, and PF Hensel 2002. High precision measurement of wetland sediment elevation: II. the rod surface elevation table. *Journal of Sedimentary Research* 72:734-739 (Bob B. has a copy and will oversee the fabrication, if desired).

Cahoon, D. R., J. R. French, T. Spencer, D. Reed, I. Moller (2000). Vertical accretion versus elevation adjustment in UK saltmarshes: an evaluation of alternative methodologies. Coastal and estuarine environments: sedimentology, geomorphology, and geoarchaeology. London, Geological Society of London: 223-238.

Cahoon, D. R., J. C. Lynch, and R. M. Knaus. 1996. Improved cryogenic coring device for sampling wetland soils. *Journal of Sedimentary Research* 66:1025-1027

2.7 Protocol for Photopoint Monitoring

Purpose

A picture is worth a thousand words. Photopoint monitoring will track the progression of the restoration visually.

Goals

1) Capture visually the initial conditions in restored estuary sections and track their progression through time.

Design

Photopoints will be established around survey markers at the N and S sites. The combination of multiple photos from each location and multiple locations around each restoration site will provide excellent visual coverage of the restoration areas.

Equipment

As built drawings for survey marker locations.

GPS unit

Digital Camera

Compass

Field Note Book

Site Selection

Photopoints were located at WDFW monuments for ease of relocation and to provide good visual cover of the restoration sites.

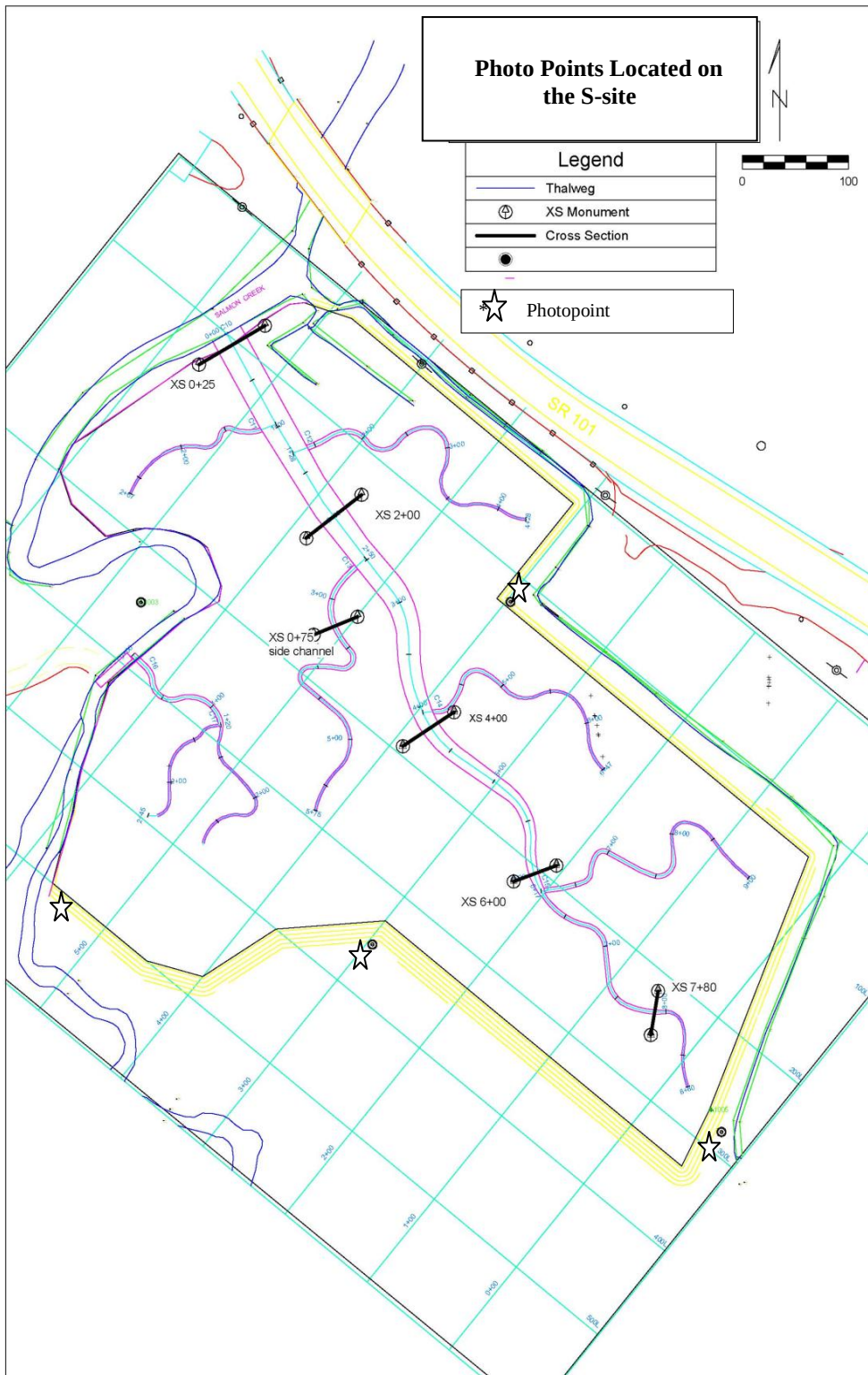


Figure 23: Photo point locations for south site

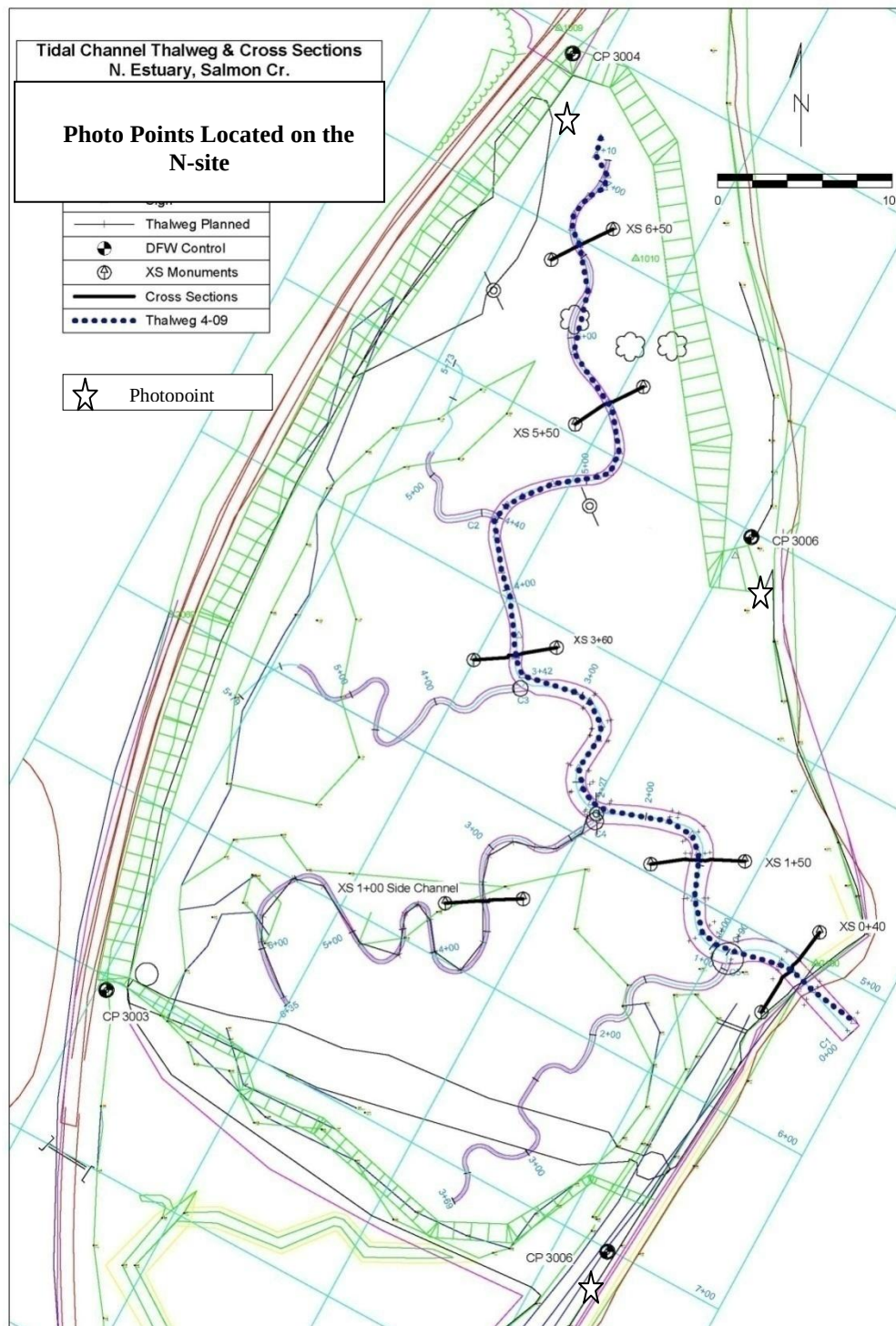


Figure 27: Photo point locations for north site

Sampling / Sampling Periodicity

Photos will be taken twice a year. Once in mid to late October and once in early May.

Sampling Protocol

- 1) Stand at locations indicated on above drawings.
- 2) Using previous seasons photos and a compass, replicate angle and scope of photos at each location
- 3) Record photos into logbook.

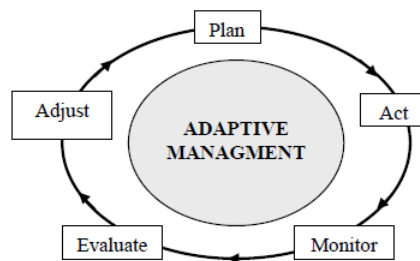
Calculations & Analysis

Download photos and log into excel spreadsheet. Produce document highlighting a set of sequential photographs.

3.0 ADAPTIVE MANAGEMENT

Adaptive management section taken from Shreffler, 2007

There are, perhaps, as many definitions of “adaptive management” as there are restoration projects currently underway in the United States. In general, adaptive management focuses on reducing uncertainty by treating human intervention into natural systems as experiments (Independent Science Panel 2000). In the context of this document, **adaptive management** is defined as the process of: stating restoration goals (plan), implementing restoration actions (act), collecting credible data (monitor), determining if performance criteria are met (evaluate), and deciding what actions to take (adjust). A flow diagram depicting this process is presented below (modified from Thom and Wellman 1996).



Adaptive management relies on an accumulation of credible evidence to support a decision that demands action (Walters and Holling 1990). As outlined by Thom (2000), an adaptive management program associated with a restoration project requires:

- Measuring the existing condition of the ecosystem using selected indicators;
- Assessing progress toward stated restoration goals using performance criteria (i.e., asking questions of the data); and
- Making decisions on actions to take.

Within an adaptive management framework, the three main actions one can take are: 1) do nothing (i.e., wait for conditions to improve); 2) do something (i.e., implement corrective actions based upon the data); and 3) change the goal (i.e., admit that the project will never likely reach the original stated goal, and that an alternative ecosystem state is acceptable).

NOSC has identified restoration goals and objectives, specific measurable performance criteria to evaluate whether those objectives are being met, and potential contingency measures if the objectives are not being met. Adaptive management is the process by which NOSC will collectively analyze all the monitoring data and available information, determine the implications, and institute actions or policies to make mid-course corrections. In other words, adaptive management is the feedback loop from the assessment step (i.e., monitor) to the decision step (i.e., adjust).

Given the five-year timeframe of this monitoring plan, it is important to recognize the potential need to modify the plan. The following possible changes to the monitoring plan can be envisioned at this point:

1. Changes in monitoring tasks: The science of ecosystem restoration is rapidly evolving and it is likely that opportunities to improve the estuary monitoring program will be identified (e.g., new or better equipment becomes available, standard monitoring protocols are developed for this region, monitoring protocols can be improved based on each previous year’s field experience).

2. Elimination of monitoring tasks: If consensus is reached among the technical advisory group that specific performance criteria have been met, then associated monitoring tasks could cease. Alternatively, the group could determine that a particular monitoring task is not returning useful information, and therefore that task is not worth the expense of continuation. It's also conceivable that monitoring funds might no longer be available, and thus monitoring priorities would have to be reconsidered.
3. Addition of new monitoring tasks: Monitoring in the first several years may show that the technical group is not monitoring the appropriate parameters or species.
4. Changes in lead responsibilities for monitoring tasks: Over a 5-year period, NOSC staff and volunteer turnover could result in the lead for particular monitoring tasks switching between individuals. Changes in funding availability could also result in a different entity taking the lead on a particular monitoring task(s).
5. Modification of project goals: As suggested by Thom (2000), one of the cornerstones of applying adaptive management principles to coastal restoration projects is the ability to modify project goals during the monitoring period.

By using adaptive management, this monitoring plan attempts to balance the need for long-term consistency and comparability in data collection with real-world practicality. As noted by Thom and Wellman (1996), adaptive management recognizes the imperfect knowledge of interdependencies within and among natural and social systems. Hence, monitoring plans must be modified as technical knowledge improves and social preferences change.

References

Independent Science Panel. 2000. Recommendations for Monitoring Salmonid Recovery in Washington State. Report 2000-2. Governor's Salmon Recovery Office, Olympia, Washington.

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Simenstad, C.A., and R.M. Thom. 1996. Functional equivalency trajectories of the restored Gog-Le-Hi-Te estuarine wetland. *Ecological Applications* 6:38-56.

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Walters, C.J., and C.S. Holling. 1990. Large-scale management experiments and learning by doing. *Ecology* 71:2060-2068.

Zedler, J.B., and J.C. Callaway. 1999. Tracking Wetland Restoration: Do Mitigation Sites Follow Desired Trajectories? *Restoration Ecology* 7(1):69-73.

4.0 MONITORING RESPONSIBILITIES, SCHEDULE

Salmon Estuary Monitoring Schedule – Year Calendar

	Water Quality & Sediment Toxicity	Tidal Channel Development	Sediment Accretion Study	Marsh Vegetation / Salt Marsh Habitat	Photo Points	Fish Utilization	Benthic Invertebrates
January						<i>Submit Scientific Collection Permit (SCP) and SCP Renewal</i>	
February						<i>Fyke Net Sampling/Ocular survey</i>	
March						<i>Fyke Net Sampling/Ocular survey</i>	
April						<i>Fyke Net Sampling/Ocular survey</i>	
May						<i>Fyke Net Sampling/Ocular survey</i>	
June							
July			<i>Marker Horizons and rSet Measurement</i>	<i>Reference & Restoration site vegetation transects</i>	<i>Photo Points</i>		
August		<i>Tidal Channel monitoring 1 x yearly</i>					
September							
October	<i>Sed. & Tox. Sampling October 2009</i>					<i>Federal Take Permits Renewal-WDFW</i>	
November							
December	<i>Sed & Tox. Sampling Dec. 2008</i>				<i>Photo Points</i>		

5.0 REPORTING AND DISSEMINATION OF MONITORING RESULTS, DATA

All data gathered by the above monitoring tasks will be made available to all project funders and partners involved in the Salmon Estuary Restoration Project. Information and results will also be made accessible on the web, and data gathered will be reported to NOAA and ESRP.

Documents are likely to be posted in PRISM, a Washington State database program for grant funds which is available for download, and the Washington *Habitat Work Schedule* which is online at <http://hws.ekosystem.us>.

Appendix A
Restoration Project Background

1. Introduction.....	3
1.1 Purpose of Monitoring Plan	3
1.2 Project Site Location	4
1.3 Description of Salmon Creek Watershed and Proposed Salmon Creek Estuary Restoration Project	6
1.4 Project Phases, Partners, and Funding	10
1.5 Project Need	11
1.6 Technical Advisory Group	11
1.7 Project Description and Timeline	12

1.0 INTRODUCTION

An 11acre restoration project was completed at the mouth of Salmon Creek in Jefferson County, WA in 2008. Two sites were excavated to an elevation that will replicate emergent salt marsh providing vegetation and tidal channels in areas that were impacted by log milling operations and agriculture. The Salmon Creek watershed and associated nearshore habitat are critical areas for ESA listed summer chum salmon and this estuary restoration project is part of a larger, ongoing effort to recover these salmon to self-sustaining levels.

Historic log milling operations lead to the deposition of thousands of cubic yards of sawdust and other wood waste in the estuarine environment, thereby creating uplands. Ground water moving through the wood waste created aquatic conditions toxic to some forms of aquatic life and portions of this monitoring plan are tailored to look at these leachates and their effects over time. Other portions of the protocol are designed to track critical decision points in the design (to excavate tidal channels or not, to plant salt marsh vegetation or not, what elevation to construct to) to assess success of the project, and inform future restoration efforts grappling with similar decisions.

This monitoring plan is tailored to this project; however, we believe that many of the protocol are adaptable to other sites and in fact, many of the protocol have been used on other sites and were adapted to this projects needs.

1.1 Purpose of the Monitoring Plan

The purpose of this monitoring plan is to describe recommended tasks for monitoring the overall health of the Salmon-Snow Estuary, particularly in regards to work completed with the Salmon-Snow Estuary Restoration Project. This monitoring plan is intended to include only the estuary portion of the project area, and does not include monitoring of the riparian plantings preceding estuary restoration, or monitoring of restoration areas upstream of the estuary on Salmon and Snow Creeks.

This monitoring plan encompasses all phases of the restoration project, both in establishing pre-project baseline values and examining post – construction ‘results,’ as well as implementation monitoring during construction (if applicable to the measurement criteria.)

Monitoring will be accomplished by a variety of partners:

- * Water quality and toxicity monitoring will be completed by NewFields Northwest, LLC
- * Sediment accretion monitoring will be accomplished by WDFW Habitat Engineering staff and the North Olympic Salmon Coalition (NOSC)
- * Vegetation monitoring protocol has been developed by Dave Shreffler of Shreffler Environmental, and monitoring will be completed by NOSC staff and trained volunteers
- * Tidal channel development and fish monitoring will be completed by NOSC staff working with trained volunteers

- * Benthic and terrestrial invertebrate monitoring was to be completed by a partnership between NOAA, NOSC, and community partners. The reassignment of key NOAA staff will not allow this work to occur. The proposed monitoring protocol is included

1.2 Project Site Location

The estuary restoration and monitoring project occurs solely on properties owned by the Washington Department of Fish and Wildlife. The Salmon-Snow Estuary is located in Washington State in the northeastern corner of the Olympic Peninsula at the head of Discovery Bay near the eastern end of the Strait of Juan de Fuca. The location of the estuary restoration project is in Jefferson County Township 29N, Range 2W, within Sections 23, 25 and 26. The restoration project is within the Quilcene-Snow Watershed, located in WRIA 17. (Refer to map depicting monitoring site areas.)

Vicinity Map for Salmon/Snow Lower Watershed Restoration

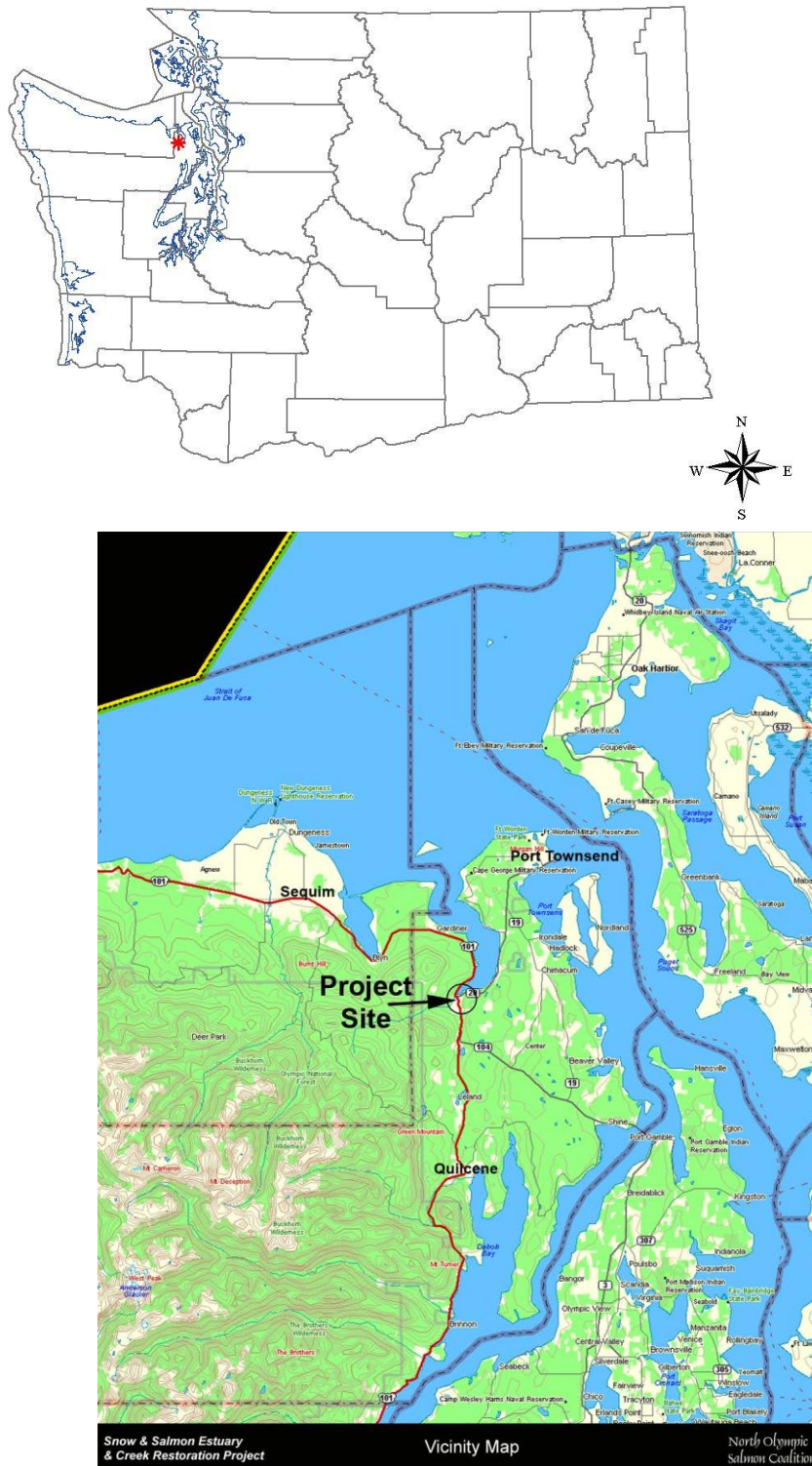


Figure: Project site location

1.3 Description of Salmon Creek Watershed and Proposed Salmon Creek Estuary Restoration Project

Description of the Salmon Creek Watershed

The Salmon Creek watershed is 18.9 square miles, with 8.7 miles of mainstem and 21.8 miles of tributary stream channels. A total of 5.7 miles of main stem and 6.5 miles of tributaries, or 40 percent of the total stream length, is accessible to anadromous fish. The headwaters are on the north slope of Mount Zion at an elevation of 3,400 feet within the Olympic National Forest. A waterfall in the upper watershed at river mile 2.7 and a culvert under U.S. Forest Service Road 2850 are migration barriers. The middle section is a single-thread channel with lower gradients, which flows into a wide floodplain and then drains into Discovery Bay.

The geology of the watershed is composed of predominately basalt and glacial outwash in the upper basin, changing to sand, gravel, and clay deposited during glaciation in the lower valley, and a broad alluvial fan at the mouth. A large marsh at RM 7.36 supplies additional water to the creek system. Salmon Creek and nearby Snow Creek share a substantial and ecologically significant estuary.

Known fish species in the watershed include summer chum salmon, coho salmon, steelhead, resident and anadromous cutthroat trout, sculpins, sticklebacks, pacific lamprey, and brook lamprey. In addition, white sturgeon inhabit the intertidal area. Sand lance, surf smelt, and pacific herring hold and spawn in Discovery Bay. The Discovery Bay herring stock is the major stock in the Strait of Juan de Fuca. Historically, it was one of the largest stocks in Washington State, but in 2008 it is at a critically low level of abundance. More than 20 rockfish and bottom fish species are present in Discovery Bay. In 2003-2004 a major summer chum supplementation program was completed in Salmon Creek. This Endangered Species Act (ESA)-listed species is an important sport and commercial fishing resource and this watershed is the highest priority for restoration in the Hood Canal/Strait of Juan de Fuca evolutionarily significant unit. The coho stock in the creek is currently listed as critical in the Salmonid Stock Inventory (SASI) and restoration efforts are expected to support higher out-migration survival for summer chum, coho, and other anadromous fish in the system.

General Description of the Estuary Restoration Project Area

The Salmon Creek Estuary Restoration Project is located at the head of Discovery Bay in Jefferson County, Washington. Salmon Creek, and neighboring Snow Creek, enter Discovery Bay within a half-mile of one another and form the estuary complex where the project is located. ESA-listed summer chum, coho and steelhead (listed in 2008), as well as cutthroat trout, utilize the estuary during out-migration from the streams and for rearing. ESA-listed Puget Sound Chinook salmon also likely use the estuary for rearing.

The streams and their estuaries were significantly impacted by human activities over the past 130 years. The streams, which historically shared a mouth into the estuary, were separated and

moved to the valley walls for improved agricultural land access. The salt marsh and tidal channels available to salmonids were greatly reduced by filling and bulkheading for a railroad line and construction of mill buildings on top of the historic salt marsh. A highway bisects the historic location of the estuary, and tidal flow to a portion of the estuary is restricted underneath the highway bridge. Cumulatively, these activities reduce both quantity of, and access to, salt marsh habitat critical to out-migrating juvenile salmonids.

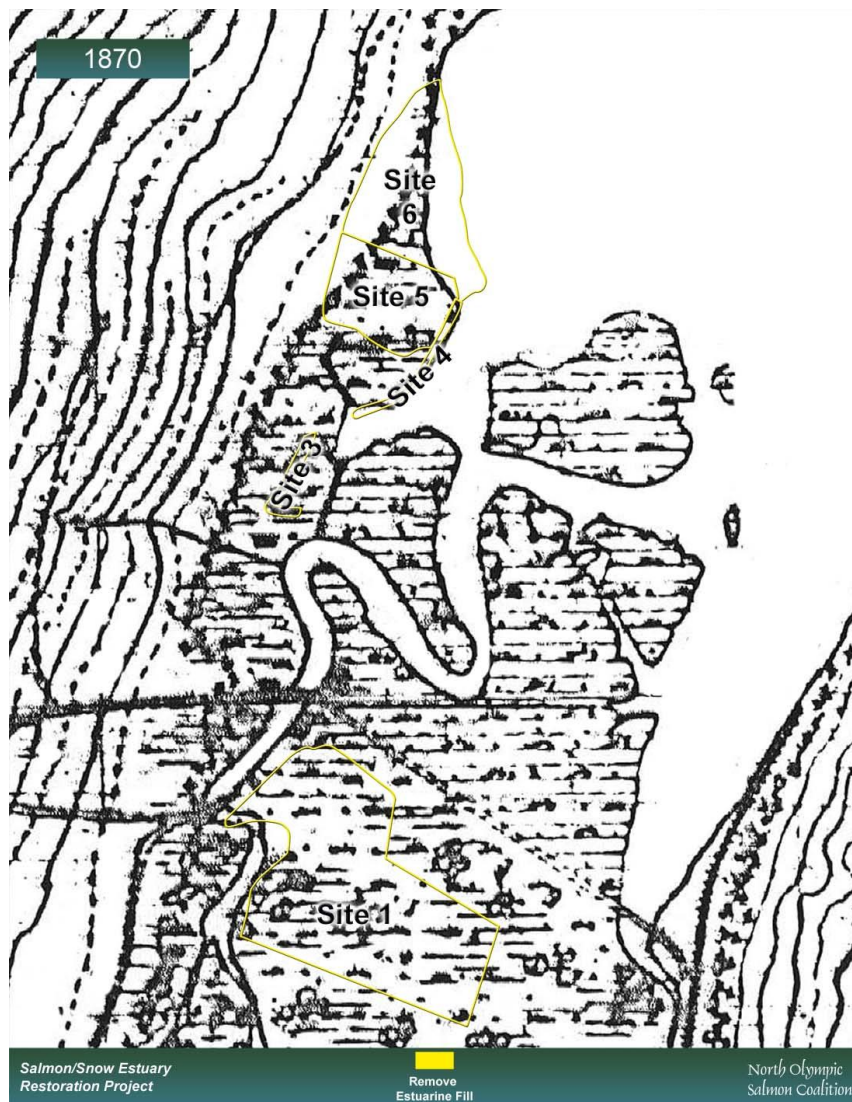


Figure : 1870 drawing showing project sites. Sites 4,5 &6 are now called North Site and Sites 1 is called South Site. Site 3 was not excavated.



Figure: 1950 aerial showing project sites overlaying 1950 aerial view prior to fill placement and mill construction.



Figure: 2004 aerial shows project area prior to fill removal and tidal channel construction.

1.4 Project Phases, Partners, and Funding

The Salmon Creek Estuary Restoration Project is part of a multi-phase, ongoing watershed restoration effort that began in the early 1990's with a partnership between Washington Department of Fish and Wildlife, Hood Canal Coordinating Council, Jefferson County, Jefferson County Conservation District, North Olympic Salmon Coalition, Jefferson Land Trust, Jamestown S'Klallam Tribe, Point no Point Treaty Council, Washington State University's Cooperative Extension, Port Townsend Marine Science Center and Jefferson County Marine Resource Committee; all members of a larger watershed council called the Chumsortium.

In 1992 when the declines of summer chum in Salmon Creek and other watersheds reached a critical point, Wild Olympic Salmon (now NOSC) and WDFW began a volunteer-based, broodstock program that has been a remarkable success. The broodstock program was already producing a turnaround in the adult returns when Hood Canal/Strait of Juan de Fuca summer chum were listed as threatened under the ESA in 2000. Due in large measure to the broodstock program, the returns of adult summer chum into Discovery Bay tributaries have increased from a low of 194 to over 7,000 in 2005. Now the Chumsortium partners have turned their efforts to restoring and protecting Discovery Bay estuarine and nearshore habitats critical to summer chum and Puget Sound Chinook, another ESA-listed species.

Restoration efforts have resulted in the following lower watershed milestones (2008):

- Reconstruction of a half mile of summer chum spawning habitat on Salmon Creek (completed in 2004, JCCD).
- 29 acres of riparian plantings on Salmon Creek (completed in 2006, JCCD).
- 7 acres of riparian plantings on Snow Creek (completed in 2006, JCCD).
- Acquisition and conservation of over 150 acres of estuarine, riparian, and upland habitat (JLT and WDFW).
- NOSC volunteers have donated over 22,800 hours of service working on habitat restoration and salmon stock recovery projects in the past five years (2002-2006).

The Hood Canal Coordinating Council (HCCC) is the lead entity for prioritization of Salmon Recovery Funding Board grant awards in the local Water Resources Inventory Area (WRIA) #17, which encompasses the project area. The HCCC's "Salmon Habitat Recovery Strategy for the Hood Canal & Eastern Strait of Juan de Fuca Version 09-2005" identifies the Salmon Creek Estuary as the highest priority habitat type in Water Resource Inventory Area (WRIA) #17, critical to the recovery of Hood Canal/Strait of Juan de Fuca summer chum salmon. Given the importance of the area to federal and state-listed species, the estuary project has been awarded six different grants that include both state and federal sources.

1.5 Project Need

Ecological Need

The estuarine restoration was made possible because of a recent acquisition of land for the purposes of restoration and conservation. This land acquisition and restoration is timely, given

the recent ESA-listing of two estuarine-obligate salmonids (Hood Canal/Strait of Juan de Fuca summer chum and Puget Sound chinook), the concurrent development of a Land Management Plan for the Salmon-Snow Watershed, the continued poor returns of Snow Creek (non-supplemented) summer chum salmon, and the sunset of the Salmon Creek summer chum broodstock program initiated in 1992. Finally, the Salmon Creek estuary is the highest priority for restoration in the entire summer chum salmon ESU (HCCC Strategy, 2004). The following documents cite the Salmon Creek estuary as a priority for restoration:

- *Hood Canal Eastern Strait of Juan de Fuca Summer Chum Conservation Initiative*; Co-Managers 2000.
- *WRIA 17 Salmon and Steelhead Habitat Limiting Factors Analysis*; Washington Conservation Commission 2002.
- *The Status of Anadromous Fish Stocks in the Streams of Eastern Jefferson County*; Jim Lichatowich 1993.
- *Salmonid Stock Inventory*; WDFW, Tribes 2002.
- *Snow Creek and Salmon Creek Watershed Analysis*; US Forest Service, 1996.
- *Hood Canal Coordinating Council Salmon Habitat Recovery Strategy*; Hood Canal and the Eastern Strait of Juan de Fuca; Rot and Bernthal 2001.
- *Hood Canal Coordinating Council Summer Chum Salmon Recovery Plan*; Hood Canal Coordinating Council 2005.

1.6 Technical Advisory Group

A technical advisory group, known as Salmon/Snow Technical Advisory Group (SSTAG) and comprised of the following individuals, met approximately monthly since 2005 to develop the Estuary Restoration Plan: Bob Barnard – WDFW Habitat Engineering, John Hansen– WDFW Engineering, Randy Johnson – WDFW Habitat Program, Byron Rot – Jamestown S’Klallam Tribe, Sarah Spaeth – Jefferson Land Trust, Al Latham – Jefferson County Conservation District, Paula Mackrow – NOSC, Rebecca Benjamin – NOSC, Richard Brocksmith – Lead Entity Coordinator for WRIA 17, Richard Wojt – NOSC Board and Peninsula Trails Coalition, Steve Todd – Point No Point Treaty Council, John Cambalik – Puget Sound Action Team, and Pat Pearson – Washington State University. In addition, various individuals representing Jefferson County have participated in the SSTAG at various times.

1.7 Project Description and Timeline

The Project

The large scale of this project required preliminary work by surveyors, soil scientists, wetland specialists, archaeologists and a special team of project planners who developed the restoration plan. The restoration plan has guided the development of the following construction and re-vegetation plans.

The project sites north of US Highway 101 began with the removal of five derelict buildings. The fill underneath the building and an adjacent sawdust pile were removed to salt marsh

elevation. The berm protecting the sawdust pile and other fill material was partially removed, leaving a portion to protect the resulting marsh from undue erosion. A short railroad spur was removed as well. First and second order tidal channels were constructed in the new marsh. South of US Highway 101 material was removed to salt marsh elevation and tidal channels were created. A portion of the fill from this site was removed to an onsite upland area for disposal and some fill was hauled to the north site to back fill areas of deep wood. A temporary culvert was installed and temporary haul road were constructed to gain access across Salmon Creek to the upland site.

The disposal site is now seeded and riparian restoration will take place on the site. Areas adjacent to upland will be planted with a 25' buffer of native vegetation. Areas with existing riparian vegetation will be underplanted with conifers to augment the development of overhanging vegetation along the marsh edges. Tidal channels will be left to colonize naturally. Using an as-built map of the project as our baseline, vegetation monitoring will begin to track success of planted marsh vegetation. Monitoring of vegetation, fish, birds and macro-invertebrates will take place as funding allows.

It should be noted that this project was initially envisioned as a straightforward excavation of fill material to restore nearshore habitat; however, soils investigations and project excavation revealed significant and unexpected amounts of wood waste on site. Toxic leachates emerged from the buried woodwaste and exited in adjacent tidal channels presenting themselves as hydrocarbon-like smell, black liquid, foamy water and an oily sheen on standing water that breaks into angled fragments when touched. Sulfur-loving bacteria inhabited the tidal channel adjacent to the wood waste pile, and other signs of life in the channel were scarce. Testing at the project site revealed extremely high levels of sulfides and toxic levels of ammonia. The Salmon Snow Technical Advisory Group (SSTAG) decided that ALL of the wood waste would be removed to improve these toxic conditions.

Project Timeline

The preliminary restoration plan was completed in November 2006. The timeline below summarizes accomplishments to date, as well as anticipated schedule for 2008-2010.

Project Activity	Anticipated Dates of Implementation	Actual Dates of Implementation
Restoration Plan Creation	Completed November 2006	October 2006
Surveying	Completed November 2006	October 2006
Permit Drawings	Completed January 2006	August 2007
Final Engineering	Completed	March 2008
Permitting	Jan. 15 th through August 30 th 2007	October 2007
Removal of Buildings	May 2008	July 2008
Fill Removal	Complete by September 2008	Completed by October 2008
Cover Crop fill disposal area	Upon completion of material placement, no later than October 2008	Completed by October 2008
Plant along riparian areas	Various volunteer events fall 2008 through 2010	Began November 2008
Pre-Project Monitoring	Vegetation monitoring April 2007	Summer 2007 and 2008
	Water quality and sediment toxicity monitoring	June 2008
	Fish utilization monitoring	Baseline: Winter/Spring 2009
	Benthic and terrestrial invertebrate monitoring	Baseline: April-October 2008
Post-Project Monitoring	10 years beginning fall 2008	Began February 2009

Appendix B
Plant Species List for Salmon Creek vicinity
Fred Weinmann, 9/23/04

Salmon Creek Plant Species List	by Fred Weinmann 9/23/04			sm=salt marsh
			N=natural	hsm=high salt marsh
			I=invasive	lsm=low salt marsh
			nox=noxious	rr=railroad grade
				rip=riparian
Scientific Name	Common name	Family	Origin	Location
<i>Abies grandis</i>	Grand fir	Pinaceae	N	rr
<i>Acer macrophyllum</i>	Bigleaf maple	Aceraceae	N	
<i>Achillea millefolium</i>	Yarrow	Asteraceae	N	rr
<i>Agrostis capillaris</i>	Colonial bentgrass	Poaceae	I	rr,pasture
<i>Agrostis stolonifera</i>	Creeping bentgrass	Poaceae	I	hsm,rr
<i>Aira praecox</i>	Elegant hairgrass	Poaceae	I	rr
<i>Alnus rubra</i>	Red Alder	Betulaceae	N	rip
<i>Alopecurus pratensis</i>	Meadow foxtail	Poaceae	I	pasture
<i>Ambrosia chamissonis</i>	Silver burweed	Asteraceae	N	sandy shores
<i>Amelanchier alnifolia</i>	Serviceberry	Rosaceae	N	rr
<i>Anaphalis margaritacea</i>	Pearly everlasting	Asteraceae	N	rr,rip
<i>Angelica lucida</i>	Sea watch	Apiaceae	N	hsm
<i>Arbutus menziesii</i>	Pacific madrone	Ericaceae	N	rr
<i>Asparagus officinalis</i>	Asparagus	Liliaceae	I	hsm
<i>Aster subspicatus</i>	Saltmarsh aster	Asteraceae	N	hsm
<i>Athyrium filix-femina</i>	Lady fern	Dryopteridaceae	N	rr,rip,fw
<i>Atriplex prostrata</i>	Fat hen	Chenopodiaceae	I	hsm
<i>Brassica nigra</i>	Black mustard	Brassicaceae	I	pasture
<i>Buddleja davidii</i>	Butterfly bush	Buddlejaceae	I	rr
<i>Calystegia silvatica</i>	Giant bindweed	Convolvulaceae	I	rr,rip
<i>Carex deweyana</i>	Dewey's sedge	Cyperaceae	N	pasture
<i>Carex lyngbyei</i>	Lyngbey's sedge	Cyperaceae	N	hsm,lsm
<i>Carex obnupta</i>	Slough sedge	Cyperaceae	N	fw
<i>Centaurea biebersteinii</i>	Spotted knapweed	Asteraceae	I	rr
<i>Chenopodium album</i>	Lambsquarters	Chenopodiaceae	I	rr,hsm
<i>Cichorium intybus</i>	Chicory	Asteraceae	I	rr
<i>Cirsium arvense</i>	Creeping thistle	Asteraceae	nox	rr,rip,pasture, filled sm
<i>Cornus sericea</i>	Red-stem dogwood	Cornaceae	N	rip
<i>Crepis capillaris</i>	Smooth hawk's-beard	Asteraceae	I	rr
<i>Cytisus scoparius</i>	Scot's broom	Fabaceae	nox	rr
<i>Dactylus glomerata</i>	Orchard grass	Poaceae	I	rr,pasture
<i>Daucus carota</i>	Queen Ann's lace	Apiaceae	nox	rr
<i>Deschampsia cespitosa</i>	Tufted hairgrass	Poaceae	N	hsm
<i>Dipsacus fullonum</i>	Wild teasel	Dipsacaceae	I	rr,rip
<i>Distichlis spicata</i>	Saltgrass	Poaceae	N	hsm,lsm
<i>Elytrigia repens</i>	Quackgrass	Poaceae	I	rr,pasture

Scientific Name	Common name	Family	Origin	Location
<i>Epilobium ciliatum</i>	Watson's willowherb	Onagraceae	N	rip
<i>Equisetum arvense</i>	Field horsetail	Equisetaceae	N	pasture
<i>Equisetum hyemale</i>	Scouring rush	Equisetaceae	N	rip
<i>Equisetum telmateia</i>	Giant horsetail	Equisetaceae	N	rr,rip
<i>Festuca arundinaceae</i>	Tall fescue	Poaceae	I	rr,pasture
<i>Festuca rubra</i> var. <i>littoralis</i>	Salt marsh fescue	Poaceae	N	hsm
<i>Festuca rubra</i> var. <i>rubra</i>	European red fescue	Poaceae	I	pasture
<i>Fragaria virginiana</i>	Wild strawberry	Rosaceae	N	rr
<i>Gaultheria shallon</i>	Salal	Ericaceae	N	rr
<i>Geum macrophyllum</i>	Big-leaved avens	Rosaceae	N	rr,rip
<i>Glaux maritima</i>	Sea milkwort	Primulaceae	N	hsm
<i>Glechoma hederacea</i>	Creeping charlie	Lamiaceae	I	rr,rip
<i>Grindelia integrifolia</i>	Beach gumweed	Asteraceae	N	rr,hsm
<i>Holcus lanatus</i>	Velvet grass	Poaceae	I	rr,pasture
<i>Holodiscus discolor</i>	Ocean spray	Rosaceae	N	rr,rip
<i>Hordeum brachyantherum</i>	Meadow barley	Poaceae	N	hsm
<i>Hypericum perforatum</i>	St. John's wort	Celastraceae	nox	rr
<i>Hypochaeris radicata</i>	Hairy catsear	Asteraceae	nox	rr
<i>Ilex aquifolium</i>	English holly	Aquifoliaceae	I	rr
<i>Impatiens capensis</i>	Jewelweed	Balsaminaceae	I	rip
<i>Juncus balticus</i>	Baltic rush	Juncaceae	N	hsm
<i>Juncus effusus</i> var. <i>pacificus</i>	Soft rush	Juncaceae	N	hsm
<i>Juncus effusus</i> var. <i>effusus</i>	Wire rush	Juncaceae	I	rr,pasture
<i>Juncus gerardii</i>	Mud rush	Juncaceae	I	hsm
<i>Lactuca muralis</i>	Wall lettuce	Asteraceae	I	rr
<i>Lapsana communis</i>	Nipplewort	Asteraceae	I	rr
<i>Lathyrus littoralis</i>	Gray beach pea	Fabaceae	N	rr
<i>Lolium perenne</i>	Perennial ryegrass	Poaceae	I	pasture
<i>Lonicera involucrata</i>	Black twinberry	Caprifoliaceae	N	rip
<i>Lotus corniculatus</i>	Bird's foot trefoil	Fabaceae	I	pasture
<i>Lupinus arboreus</i>	Tree lupine	Fabaceae	I	rr
<i>Malus fusca</i>	Pacific crabapple	Rosaceae	N	rr,rip
<i>Oemlaria cerasiformis</i>	Indian plum	Rosaceae	N	rr
<i>Phalaris arundinacea</i>	Reed canary grass	Poaceae	nox	pasture,rip,filled sm,fw
<i>Phleum pratense</i>	Timothy	Poaceae	I	pasture
<i>Picea sitchensis</i>	Sitka spruce	Pinaceae	N	rr
<i>Plantago lanceolata</i>	English plantain	Plantaginaceae	I	rr
<i>Plantago maritima</i>	Salt marsh plantain	Plantaginaceae	N	hsm,ism
<i>Polystichum munitum</i>	Sword fern	Polypodiaceae	N	rr,rip
<i>Potentilla anserina</i>	Pacific silverweed	Rosaceae	N	hsm,rip,fw
<i>Prunus avium</i>	Mazzard	Rosaceae	I	rr

Scientific Name	Common name	Family	Origin	Location
<i>Pseudotsuga menziesii</i>	Douglas fir	Pinaceae	N	rr
<i>Pteridium aquilinum</i>	Bracken	Polypodiaceae	N	rr
<i>Ranunculus acris</i>	Meadow buttercup	Ranunculaceae	I	rr,pasture
<i>Ranunculus repens</i>	Creeping buttercup	Ranunculaceae	I	rr,rip,pasture, filled sm, fw
<i>Rhamnus purshiana</i>	Cascara	Rhamnaceae	N	rr,rip
<i>Rhododendron macrophyllum</i>	Pacific rhododendron	Ericaceae	N	rr
<i>Rosa nutkana</i>	Nootka rose	Rosaceae	N	rr,rip
<i>Rubus armeniacus</i>	Himalaya blackberry	Rosaceae	I	rr,rip,pasture
<i>Rubus laciniatus</i>	Evergreen blackberry	Rosaceae	I	rr,pasture
<i>Rubus parviflorus</i>	Thimbleberry	Rosaceae	N	rr,rip
<i>Rubus spectabilis</i>	Salmon berry	Rosaceae	N	rr,rip
<i>Rubus ursinus</i>	Dewberry	Rosaceae	N	rr,rip,
<i>Rumex crispus</i>	Sour dock	Polygonaceae	I	rr,pasture
<i>Salicornia virginica</i>	American glasswort	Chenopodiaceae	N	hsm, lsm
<i>Salix lasiandra</i>	Pacific willow	Salicaceae	N	rip
<i>Salix scouleriana</i>	Scouler's willow	Salicaceae	N	rr,rip
<i>Sambucus racemosa</i>	Red elderberry	Caprifoliaceae	N	rr
<i>Scirpus acutus</i>	Hard-stem bulrush	Cyperaceae	N	salt water shoreline
<i>Scirpus maritimus</i>	Salt marsh bulrush	Cyperaceae	N	salt water shoreline
<i>Scirpus microcarpus</i>	Small-fruited bulrush	Cyperaceae	N	pasture, fw
<i>Senecio jacobaea</i>	Tansy ragwort	Asteraceae	nox	rr
<i>Solanum dulcamara</i>	Bittersweet nightshade	Solanaceae	I	rr,rip
<i>Sorbus aucuparia</i>	Rowan tree	Rosaceae	I	rr
<i>Spiraea douglasii</i>	Hardhack	Rosaceae	N	rr,rip, fw
<i>Stellaria humifusa</i>	Salt marsh starwort	Caryophyllaceae	N	lsm
<i>Taraxacum officinale</i>	Dandelion	Asteraceae	I	rr,pasture
<i>Thuja plicata</i>	Western redcedar	Cupressaceae	N	rr,rip
<i>Trifolium arvensis</i>	Rabbit's foot clover	Fabaceae	I	rr
<i>Trifolium pratense</i>	Red clover	Fabaceae	I	rr,pasture
<i>Trifolium repens</i>	White clover	Brassicaceae	I	rr
<i>Triglochin maritima</i>	Seaside arrowgrass	Juncaginaceae	N	hsm, lsm
<i>Tsuga heterophylla</i>	Western hemlock	Pinaceae	N	rr,rip
<i>Typha latifolia</i>	Common cattail	Typhaceae	N	fresh water
<i>Urtica dioica var. lyallii</i>	Stinging nettle	Urticaceae	N	rr,rip
<i>Vaccinium ovatum</i>	Evergreen huckleberry	Ericaceae	N	rr
<i>Vaccinium parvifolium</i>	Red huckleberry	Ericaceae	N	rr
<i>Verbascum thapsus</i>	Common mullein	Scrophulariaceae	I	rr
<i>Vicia sativa</i>	Common vetch	Fabaceae	I	rr