

Fisher Slough Tidal Marsh Restoration Monitoring and Adaptive Management Plan



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ACRONYMS AND ABBREVIATIONS

BA	before-after
BACI	before-after/control-impact
DO	dissolved oxygen
Fisher Slough Project	Fisher Slough Marsh Restoration Project
GIS	geographic information system
GLO	General Land Office
GPS	geographic positioning system
LEAP	low elevation aerial photography
LiDAR	light detection and ranging
mg/L	milligrams per liter
MHHW	mean higher high water
MLLW	mean lower low water
NA	not applicable
NAVD88	North American Vertical Datum 1988
NOAA	National Oceanic and Atmospheric Administration
RTK	real time kinematic
SRSC	Skagit River System Cooperative
QA/QC	quality assurance/quality control
TBD	to be determined
TMDL	total maximum daily load
TNC	The Nature Conservancy
WSRN	Washington State Reference Network

1. INTRODUCTION

This monitoring and adaptive management plan provides guidance for implementing effectiveness monitoring and adaptive management for The Nature Conservancy's (TNC) Fisher Slough Tidal Marsh Restoration project (Fisher Slough Project) in Skagit County, Washington. The monitoring and adaptive management plan includes:

- A description of the restoration site and design;
- Monitoring approach which includes project objectives and hypotheses to be evaluated through monitoring;
- Metrics used to test the hypotheses;
- Values or performance criteria for defining success;
- Protocols for data collection, analysis, and reporting; and
- Performance criteria and contingency actions to guide adaptive management.

The monitoring approach described is designed to assist with evaluating the effectiveness of the restoration actions relative to the stated objectives of the restoration project. This monitoring plan does not address the compliance of monitoring (i.e., was the project constructed as designed or specified in permit conditions).

This monitoring plan was developed through discussions with TNC, which included a review and incorporation of previous reports prepared for the conceptual and final design stages of the restoration project, and review of standard references for restoration monitoring in the Pacific Northwest tidally influenced systems:

- Tetra Tech 2007. Fisher Slough – Preferred Restoration Plan. Final Report. February 2007.
- SRSC (Skagit River System Cooperative) 2007. Draft Monitoring Plan for the Fisher Slough Restoration Project.
- Tetra Tech 2009. Fisher Slough Final Design and Permitting FINAL Tidal Marsh Restoration Design Recommendations Report. May 2009.
- Rice et al. 2005. Monitoring Rehabilitation in Temperate North American Estuaries.
- Roegner et al. 2008. Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary.
- Elzinga et al. 1998. Measuring and Monitoring Plant Populations
- NOAA 2004. Monitoring Requirements under the Estuary Restoration Act.

The adaptive management component of the plan is designed to address the inherent uncertainty in ecological restoration projects, and seeks to minimize this uncertainty by learning about the system being managed (Thom and Wellman 1996; Thom 2000; Linkov et al. 2006). The basic process for adaptive management followed here includes five components:

1. A conceptual model of existing conditions and ecological processes affecting the restoration site that is used to predict the likely outcomes of individual restoration actions;
2. Clear statement of the goals and objectives for the restoration project;

3. Development of performance targets or criteria for evaluating outcomes relative to the objectives;
4. Monitoring the effects of the restoration actions relative to performance criteria; and
5. Adjusting restoration actions as needed—if performance criteria are not met, develop contingency plans or measures (decision framework) for adapting designs or implementing new actions.

This monitoring and adaptive management plan is organized in the following sections: (1) a description of the restoration site and project; (2) overall monitoring approach; (3) discussion of the restoration objectives, and development of hypotheses and parameters for monitoring, and performance criteria; (4) detailed monitoring methods for data collection and analysis; (5) monitoring schedule and reporting; and (6) a description of the adaptive management decision framework.

2. RESTORATION PROJECT

The Fisher Slough Project seeks to restore landscape processes and salmonid habitat functions within Fisher Slough, while providing additional benefits to adjacent landowners and farmers, which includes improved flood protection and drainage (Tetra Tech 2007). The project is a collaborative effort between TNC, Skagit County Public Works, Diking District #3, Drainage and Irrigation District #17, and local landowners (Tetra Tech 2007). The Fisher Slough project site is located south of the town of Conway, at the downstream end of the Carpenter Creek watershed and the confluence with Tom Moore Slough on the South Fork of the Skagit River, in Skagit County, Washington (Figure 2-1). Fisher Slough, like much of the Skagit Delta, has been subjected to channelization, confinement within levees, restriction of tidal exchange, irrigation and drainage, and agricultural development over the past 150 years. To restore tidal wetlands and improve habitat and access for salmon, the overall goal of the project is guided by the following mission statement (Tetra Tech 2007):

“Maximize the area influenced by natural stream and tidal processes, allow for a broad range of ecosystem variability, restore estuarine rearing habitat for juvenile salmon to the maximum extent possible, and improve flood protection and storage capacity for Carpenter Creek and Fisher Slough.”

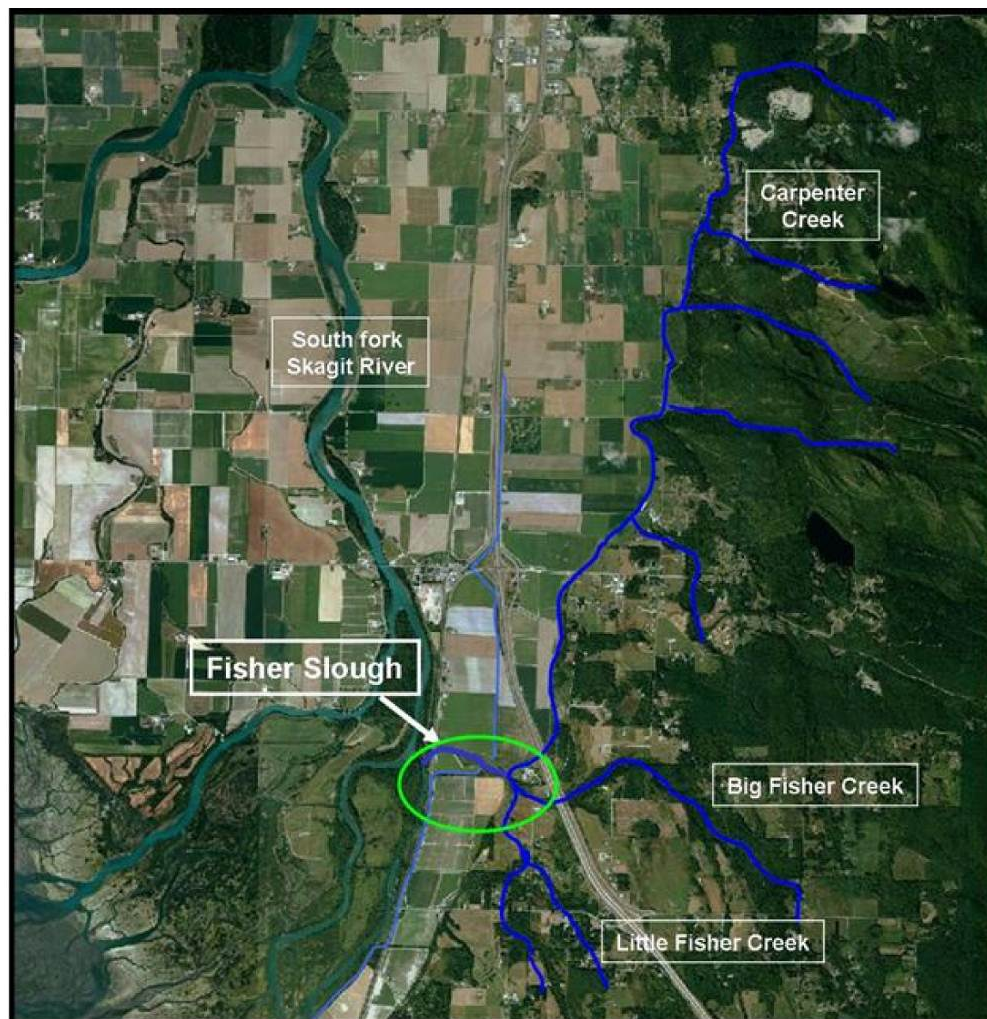


Figure 2-1. Fisher Slough Watershed Map

2.1 SITE DESCRIPTION

The Fisher Slough project site is located at the downstream end of the Carpenter Creek, Little Fisher and Big Fisher Creek watersheds (see Figure 2-1). Prior to construction of the levee system, most of the project area (e.g., Smith parcels A and B) was within the floodplain of these streams and within the Skagit tidal delta (Figure 2-2). Fisher Slough is a tidally influenced, but freshwater system (Tetra Tech 2007; SRSC 2010). Water levels within Fisher Slough rise and fall with the tides, but salinity levels on the site are extremely low and/or negligible and existing vegetation is characteristic of freshwater wetlands in the Puget Sound region. The water in Fisher Slough is derived from the Skagit River during flood tides and is fed from three upstream tributaries: Carpenter Creek (Hill Ditch), Little Fisher, and Big Fisher Creeks (see Figure 2-1).

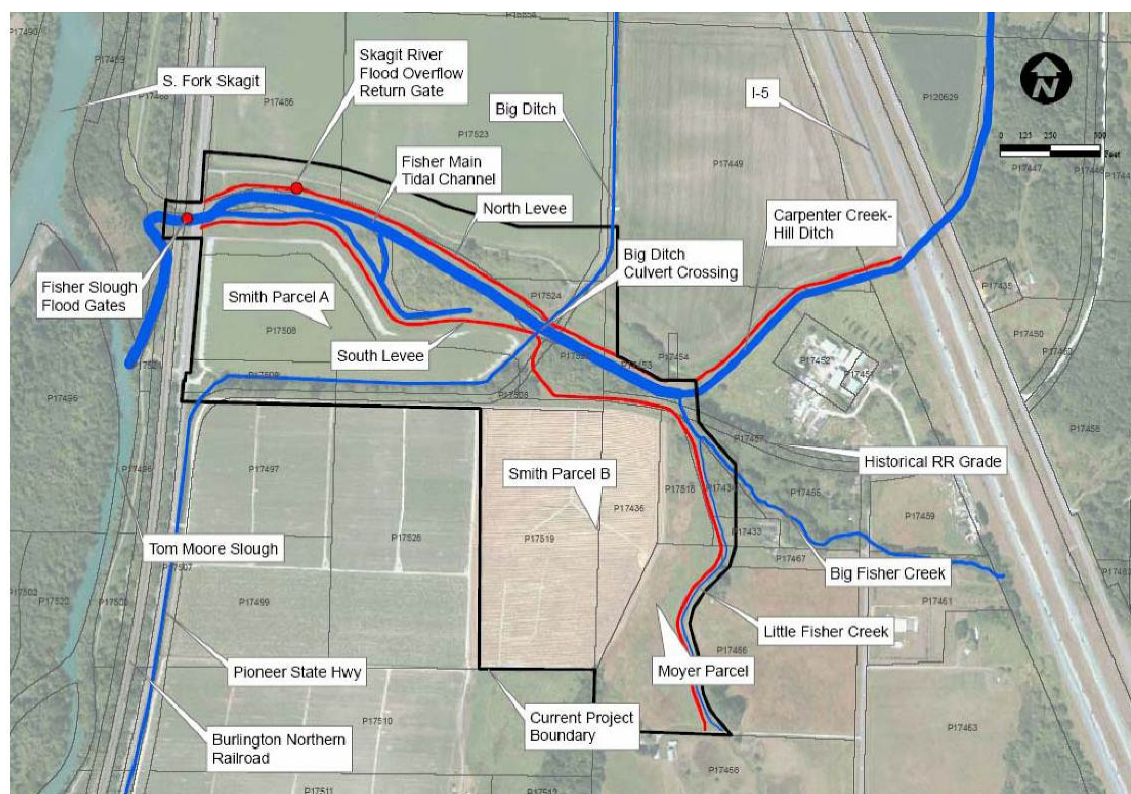


Figure 2-2. Fisher Slough Project Area and Site Features

Pre-project conditions on the site include a number of features that will be affected by the restoration project, including tidegates/floodgates (hereafter floodgates), levees, and the Big Ditch culvert (siphon) (Figure 2-2). Prior to implementation of Project Element 1 (see Section 2.2 below) a series of floodgate or floodgate structures were present immediately downstream of the Pioneer Highway Bridge. These floodgates consisted of six, 5-foot by 9-foot barn-style doors that were operated during the flood season, approximately October through May. During the summer months the doors were lashed open for the irrigation season, approximately June through September. The floodgates were operated to keep rising Skagit River floodwaters from Tom Moore Slough from entering Fisher Slough, and prevent flooding upstream in the Carpenter Creek system and adjacent agricultural fields (Tetra Tech 2008). The floodgates create a fish passage barrier when closed, and the sill of the structure also acts as a passage barrier during summer low flow or low tide conditions (Tetra Tech 2007).

Upstream of the floodgates, Fisher Slough is confined on both the north and south sides within two earthen levees (Figure 2-2). These levees are part of the Skagit River flood protection system and are owned and maintained by Dike District #3. The levee system along Fisher Slough is quite old, pre-dating the earliest aerial photographs of the site, and an original levee system is shown along the slough in the 1870's General Land Office (GLO) survey maps (Puget Sound River History Project; <http://riverhistory.ess.washington.edu/>). The Fisher Slough levees are tied to a larger network of levees on the Skagit delta that protect adjacent farmland from flooding, along with the system of drainage ditches that extend through the site and adjacent fields (Tetra Tech 2007).

There is a small riparian/floodplain area immediately adjacent to Fisher Slough that fills the area between the two levees (Figure 2-2). This area is referred to as the marsh plain or marsh floodplain in the design development documents (Tetra Tech 2007). Within this floodplain area the main channel and secondary channels of the slough flow through emergent, scrub-shrub, and forested wetland vegetation. Emergent vegetation is predominantly reed canarygrass (*Phalaris arundinacea*), with some native sedges and rushes (Tetra Tech 2007). The most common shrubs and trees include red alder (*Alnus rubra*), Pacific willow (*Salix lasiandra*), Indian plum (*Oemleria cerasiformis*), salmonberry (*Rubus spectabilis*), Nootka rose (*Rosa nutkana*), twinberry (*Lonicera involucrata*), and red elderberry (*Sambucus racemosa*) (Tetra Tech 2007; data collected by Parametrix 2010¹). The levees and surrounding agricultural fields are dominated by non-native grasses and forbs, such as red top (*Agrostis alba*), timothy (*Phleum pratense*), annual ryegrass (*Lolium multiflorum*), dandelion (*Taraxacum officinale*), and narrow-leaved plantain (*Plantago lanceolata*). Due to settling and compaction of the former Skagit wetland areas that are now agricultural fields, the agricultural areas to the north and south of the levees are currently about 3 to 4 feet lower than the riparian/floodplain area within Fisher Slough. According to the pre-design site assessments, these fields are not lower than the invert of the existing Fisher Slough channel (Tetra Tech 2007).

Two other structures related to the flood control system within the Skagit Delta are the flood return gates on the north levee and the Big Ditch crossing and culvert (Figure 2-2). The flood return gates are designed to open in the event of a flood in the Skagit River. If the flood is large enough the return flow from the fields to the north needs to flow through Fisher Slough and into the Skagit for relief, although there is no record of this event occurring (Tetra Tech 2007). The flood return gates will not be affected by the project. The Big Ditch is the primary drainage canal owned and operated by Drainage and Irrigation District #17; it collects water from the fields to the east and north of the project site, passes under Fisher Slough and continues to the south. Big Ditch crosses under Fisher Slough through a series of box culverts (sometimes called the "siphon") that are about 4-foot by 4.5-foot concrete box culverts. The top of the box culvert is exposed along the bed of Fisher Slough and creates a fish passage barrier at low flows. This structure acts as a hydraulic control and can create upstream backwater conditions, flooding, and sedimentation issues (Tetra Tech 2007).

Upstream of the Big Ditch crossing is the confluence of Carpenter, Little Fisher, and Big Fisher Creeks (Figure 2-2). The confluence acts as a hydraulic control or choke point where sediment is deposited, forming a large gravel bar. There is some localized scour and erosion of the north and south levees associated with the confluence area (Tetra Tech 2007).

Fisher Creek is listed as impaired for dissolved oxygen (DO) and of concern for fecal coliform on the Washington Clean Water Action Section 303(d) list for 2008

¹ Data to be included in the Fisher Slough 2010 Monitoring Report.

(<http://www.ecy.wa.gov/programs/wq/303d/index.html>). Fisher and Carpenter Creeks have been listed as impaired for stream temperature and are currently under a total maximum daily load (TMDL) for the lower Skagit River. Portions of Carpenter Creek have been listed as concern and/or impaired for fecal coliform and is under the lower Skagit River TMDL for fecal coliform. Pre-design site assessments conducted by Tetra Tech (2007) indicated that levels of DO and temperature may be of concern in Fisher Slough as reaching harmful levels for cold water fish such as salmon (Tetra Tech 2007).

2.2 PROJECT DESCRIPTION

Outlined in the final report on the preferred restoration plan (Tetra Tech 2007), the project includes a proposal to re-establish greater tidal action in Fisher Slough by replacing the existing floodgates, remove a fish passage barrier and allow for levee setbacks by relocating Big Ditch, increase the tidally influenced wetland and riparian habitat area by setting back the existing south levee, facilitate the establishment of new tidal channel area and native emergent, scrub-shrub, and forested vegetation, improve fish access, and increase the flood storage capacity of the site (Tetra Tech 2007; TNC Project Construction Drawings 2010).

The Fisher Slough Project is comprised of three Project Elements:

Project Element 1 – Involves replacing the existing floodgate at the Pioneer Highway crossing with new self-regulating floodgates that will allow greater tidal exchange and fish access upstream of the floodgate; while still providing flood protection to adjacent farmland (see Figure 2-2). The new floodgate will be operated in a manner designed to maximize tidal exchange (i.e., gates will be open for a longer timeframe during the year) and in particular improve fish access during the Chinook salmon (*Oncorhynchus tshawytscha*) spring migration period (Tetra Tech 2008). In addition, a small flapgate located below the floodgates was installed so it can be propped open and allow fish passage when water levels drop below the floodgate sill. Project Element 1 was completed in Fall 2009.

Project Element 2 – Involves re-aligning Big Ditch from its current configuration where it crosses under Fisher Slough. Big Ditch is currently within the proposed levee setback area, so moving Big Ditch out of this area is necessary so the ditch can continue to function as part of the drainage system for the adjacent and upstream landowners. Project Element 2 includes excavation of borrow pits; pre-excavation of pilot channels (Smith A and B pilot channels), the main tidal channel and tributaries (Big and Little Fisher Creeks); and levee setback pre-loading.

Project Element 3 – Includes final loading of the new levee setback structure; removal of the existing south levee; removal of the Big Ditch culvert; connecting pilot, main tidal and tributary channels; filling and plugging the abandoned channels and drainage ditches; and planting in some marsh and riparian areas (Tetra Tech 2007, Fisher Slough Construction Plans, March 2010).

3. MONITORING APPROACH

The purpose of restoration monitoring at Fisher Slough is to evaluate the effectiveness and success of the restoration actions relative to the project goal and objectives. Evaluating effectiveness requires a clear statement of restoration objectives and a set of hypotheses that allow testing of restoration outcomes relative to the objectives. During design development TNC identified four primary objectives for the Fisher Slough restoration:

1. Restore the ecological processes and structure to support and maintain a functional freshwater tidal wetland that supports target species, such as Chinook salmon.²
2. Restore and improve freshwater tidal rearing habitat for Chinook salmon;
3. Restore fish passage for coho (*Oncorhynchus kisutch*) and chum salmon (*Oncorhynchus keta*) spawning access; and
4. Improve flood storage to protect agricultural uses of adjacent properties.

The first three objectives are related primarily to biological response goals and include: supporting target species, emphasizing juvenile Chinook salmon, including coho and chum salmon. The fourth objective is related to maintaining and improving ecosystem services (flood management) provided by the site.

Development of these objectives was guided by a conceptual model that describes linkages among controlling factors, processes, structures, and functions in tidal freshwater wetlands in Puget Sound (Rice et al. 2005; Clancy et al. 2009). This conceptual model describes how the restoration actions at Fisher Slough are predicted to affect ecosystem processes, structures, and functions (Figure 3-1). The conceptual model can be used to link the project objectives to the hypotheses, which can be tested or evaluated during monitoring. Monitoring hypotheses were developed for each of the four primary objectives and are described in Section 4. The hypotheses provide the rationale for the selection of parameters or attributes for monitoring and performance criteria or targets that indicate the project objectives are being met. As recommended for monitoring ecological restoration projects, hypotheses have been developed to include processes (e.g., sedimentation rates), structure (e.g., channel form, vegetation structure), and functional responses (e.g., fish populations, plant communities) (Thom and Wellman 1996; Zedler 2001; Rice et al. 2005; Roegner et al. 2008).

In this monitoring plan, objectives, hypotheses, parameters, and targets determine which monitoring methods and protocols are appropriate, and are defined as follows:

Objectives: Are what the project seeks to achieve— restore tidal wetland processes and habitat quality and improve salmon access and habitat quality.

Hypotheses: Are the key monitoring questions or predictions about what is expected to happen on the restoration site as a result of the restoration actions. Hypotheses are based on logic about why or how the restoration actions are thought to achieve the restoration objectives using the conceptual model that guides the restoration project. Hypotheses are the explicit link between objective and what will be measured during monitoring; if our hypotheses are confirmed, the project is meeting the stated objectives. Hypotheses as described above begin as questions about the performance of the project relative to project objectives. Questions can then be developed into testable hypotheses in the

² Objective 1 is defined to be consistent with the previously stated objective “Restore a diverse array of native vegetative communities,” which was articulated in earlier stages of project evaluation and design (Tetra Tech 2007).

monitoring design (i.e., explicitly defined to falsify the hypothesis statement). In this monitoring plan, hypotheses will typically be stated as predictions about the effect of restoration actions. Monitoring results will be used to determine whether the site conditions are consistent with hypotheses or not. Hypotheses have the following general form:

- Specific actions will restore processes
- Specific actions or restored processes will restore structure
- New structure and processes will result in changed functions and biological responses

Parameters/attributes: Are the things that can be measured to evaluate or test the hypotheses.

Targets: Are the values of the parameters that show that the hypotheses have not been rejected and are supported— these are the performance criteria that indicate success.

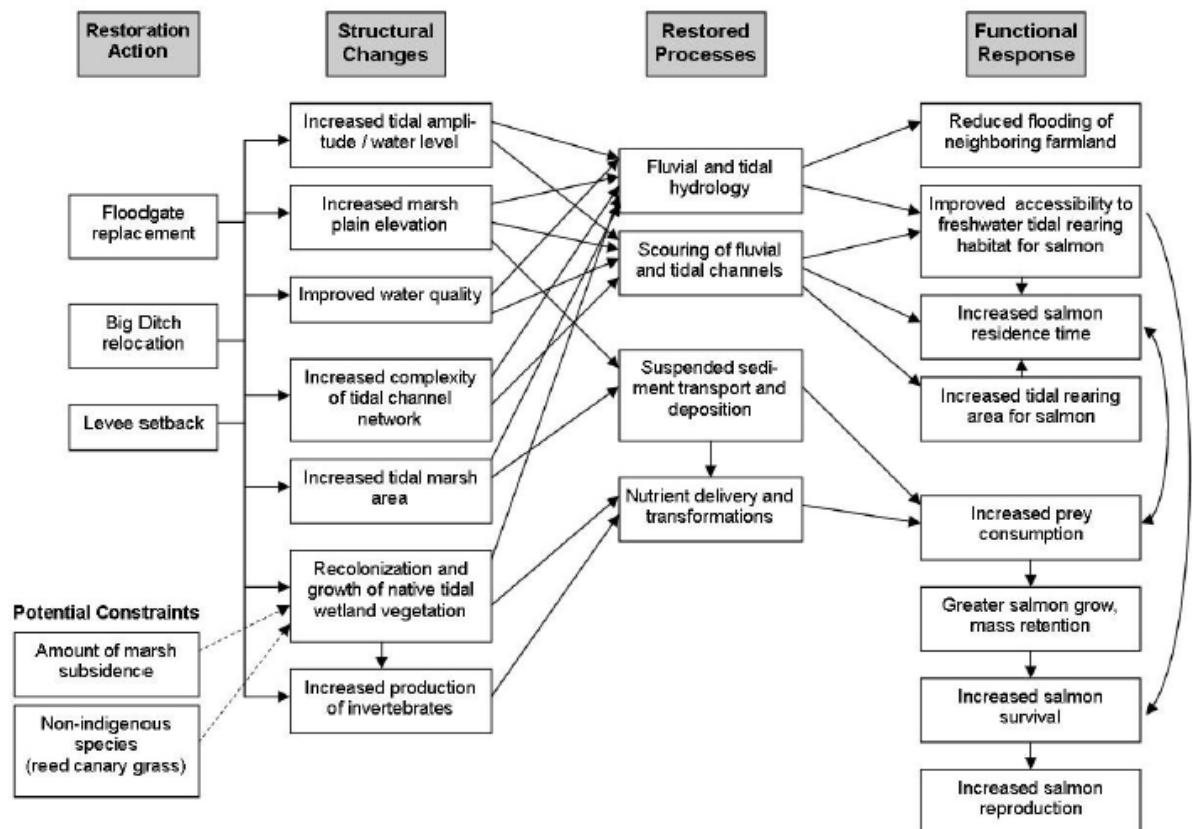


Figure 3-1. Conceptual Model Linking Restoration Actions with Processes, Structures and Functions

3.1 STUDY DESIGN

The monitoring approach for Fisher Slough is a simple before-after (BA) comparison, in which pre-project site conditions, prior to Project Element 1 are compared to post-project site conditions, after Project Element 3 is completed (Smith et al. 1993; Roni et al. 2005). This approach can be used to detect differences in site conditions after the project is constructed (i.e., a treatment effect). However, this design makes it difficult to separate effects of the restoration action from natural variability or changes over time that may be affecting other sites in the Skagit Delta including Fisher Slough (Smith et al. 1993). Monitoring other control sites in the watershed at the same time (BA/control-impact [BACI]) would allow restoration project effects to be distinguished from other factors (e.g., natural variability) because such a design requires more resources than are available to this project.

BA designs allow for basic statistical inference because these designs do not include replication (single site), or are affected by issues of pseudoreplication (Hurlbert 1984; Conquest 2000). With an un-replicated BA design, this monitoring plan will rely heavily on graphical and visual summaries of data, and describe results in terms of the conceptual model of ecosystem processes rather than focusing on statistical tests alone. Monitoring of effectiveness will include documenting changes between existing (pre-project) and restored (post-project) habitats on the project site following reintroduction of tidal hydrology and reconnection of stream floodplains. Results of monitoring using the BA design need to be interpreted carefully in the context of these limitations.

The scale for monitoring Fisher Slough will be the area within the project footprint, or immediately adjacent farm fields. The Skagit River System Cooperative (SRSC) will include a landscape component in the fish monitoring, by incorporating information from the larger Skagit delta in evaluating fish response at Fisher Slough (SRSC 2003).

Pre-project data collection occurred as part of project feasibility and design stages from 2006 to 2008. Baseline data collection occurred in 2009, prior to Project Element 1 (floodgate replacement) and occurred in fall of 2009. Project Element 2 (re-aligning Big Ditch) will be implemented in 2010, and Project Element 3 (levee setback and channel connections) will be implemented in 2011. The monitoring plan currently calls for monitoring the site for seven years with some monitoring actions only occurring in some years (see Section 6). The following summarizes the overall monitoring schedule:

- Pre-project, 2006 to 2008 (feasibility and site assessment studies)
- Year 1, 2009 (Project Element 1, self-regulated floodgates installed)
- Year 2, 2010 (Project Element 2, re-aligning Big Ditch)
- Year 3, 2011 (Project Element 3, levee setback and channel connections)
- Year 4, 2012 (monitoring)
- Year 5, 2013 (monitoring)
- Year 6, 2014 (monitoring)
- Year 7, 2015 (final year of proposed monitoring)

3.2 ADAPTIVE MANAGEMENT PLAN

The adaptive management plan (see Section 7) describes how the performance criteria developed for monitoring can be used to identify contingencies or corrective measures if the site is not performing as anticipated.

3.3 DATA STORAGE AND MANAGEMENT

For 2010, data management and storage will follow standard protocols, using readily retrievable data formats. Raw data from automatic data loggers and site surveys will be stored on DVDs following downloads of field surveys. Post-processing data will be in standard file formats (e.g., excel, shape files, jpegs), maintained on the Parametrix network (backed up regularly) during 2010, and stored on DVDs. Hard copies will be made of all field notes and data sheets each day.

All electronic data files will be provided to TNC with the final report in January 2011. Hard copies of data sheets and field notes will also be provided to TNC. Monitoring reports will be provided to TNC in electronic (pdf) format.

TNC has indicated that during 2010, the state-wide Conservation Information Manager will assist in developing a data storage and management plan for long-term data storage and access. This monitoring plan is expected to be updated by TNC with the data storage and data management protocols that are pending.

4. MONITORING HYPOTHESES, PARAMETERS, AND TARGETS

For each project objective, hypotheses were developed by using the conceptual model of linkages between restoration actions and changes in processes, structures, and functions at Fisher Slough. For each objective, the hypotheses will be evaluated by measuring a combination of environmental attributes or parameters. During the feasibility and design stages of the project, some performance criteria or targets were developed to allow progress towards the project objectives to be tracked. Additional targets or performance criteria are developed in this section to provide benchmarks for evaluating the hypotheses. The hypotheses, parameters, and targets in turn determine which monitoring methods and protocols are suitable for monitoring restoration effectiveness.

The relationship between objectives, hypotheses, parameters, targets, and protocols is as follows:

Objective

Key Questions/Hypotheses

Parameters/Attributes to Measure

Targets or Performance Criteria

Protocols for Data Collection and Analysis

Monitoring objectives and hypotheses were originally developed by TNC during development of the final restoration design (Tetra Tech 2009) and this monitoring plan. These hypotheses were then refined in discussions between TNC, Parametrix, and outside reviewers to develop a final list of hypotheses and parameters to be used in monitoring. These are summarized in Table 4-1, and in the following sections. The rationale for each of the four objectives, hypotheses, and parameters are summarized, and the performance criteria or restoration targets for each hypothesis are identified.

Table 4-1. Summary of Targets Associated with Objectives, Hypotheses, and Parameters for Fisher Slough

Objective	Hypothesis	Parameters	Pre-project Condition	Restoration Target
1: Restore the ecological processes and structure to support and maintain a functional freshwater tidal wetland that supports target species, such as Chinook salmon.	H1: Replacement/revised operation of the floodgate (post-project condition) will result in increased tidal amplitude and water elevations upstream of the new floodgate, compared to pre-project conditions.	Water levels below and above the new floodgates will determine whether gate operations result in higher water levels and greater tidal amplitude upstream of the floodgates.	6 to 7 feet NAVD88 (Tetra Tech 2008). Gates closed October through May (Tetra Tech 2008).	By 2010: Tidal amplitude upstream of floodgates will increase. Tidal amplitude immediately upstream of floodgates will match amplitude downstream of floodgates (gates open). Mean high tide water elevations (MHHW) will be 8.8 ^a NAVD88 upstream of floodgates. Mean high tide water elevations (MHHW) just upstream of the floodgates will be 9.5 NAVD88 during spring migration (as of 2010). Floodgate position will be open 90% of time during spring migration.
	H2: Restoration of tidal exchange will increase twice daily mixing of waters in Fisher Slough on the project site, increasing oxygen levels and reducing temperatures compared to pre-project conditions, particularly during the summer months.	DO levels in Fisher Slough. Temperature levels in Fisher Slough.	<7 mg/L during some days in summer (Beamer et al 2010). 18.4 to 19.4 degrees centigrade (7-day maximum in summer) (Tetra Tech 2007).	Increased DO during summer; daily minimum >8.0 mg/L upstream floodgates by 2015. Decreased temperatures during summer; 7-day maximum temperature within 12 to 14 degrees centigrade (WDOE 2004).
	H3: Relocation of the confining levees will restore 50 acres of tidal marsh which will result in a total of 60 acres of freshwater tidal marsh area—the area of tidally inundated freshwater wetland will increase.	Water level elevations relative to site elevations—calculated total area of the project site that is inundated at 9.5 feet NAVD88 (as measured upstream of the floodgates), compare pre-project area to post-project area. Time series of water level elevations (for % inundation curves). Site elevation. Number of days or percent of period. Percent of the project area inundated by twice daily tides (at MHHW, 9.5 feet NAVD88 as measured upstream of the floodgate).	Elevations at 6 to 7 feet NAVD88 (Tetra Tech 2008). TBD during 2010 monitoring. 10 acres freshwater tidal marsh.	Increase in area inundated at MHHW upstream of floodgates by 2015. Greater by 2015 than in period before 2010. Increase in area of freshwater wetland vegetation. 60 acres of freshwater tidal wetland by 2015. Photo-documentation shows significant change by 2015.

Table 4-1. Summary of Targets Associated with Objectives, Hypotheses, and Parameters for Fisher Slough (continued)

Objective	Hypothesis	Parameters	Pre-project Condition	Restoration Target
	H4: Restored tidal exchange/levee setback and greater inundation will result in accretion and aggradation of the ground surface in tidal marsh areas.	Sedimentation rates across the newly exposed marsh/floodplain area. Elevation of the newly exposed marsh/floodplain area.	NA TBD during 2010 monitoring.	Mean sedimentation rates are positive. More pins with positive (accretion) opposed to negative (erosion) sedimentation.
	H5: Restoration of tidal, fluvial, and sediment processes (and limited planting) will result in recolonization of the site by native freshwater wetland emergent, scrub-shrub, and forested wetland, and riparian plants as predicted by Hood (Tetra Tech 2007) and TNC (Tetra Tech 2009).	Total area of the site with native and non-native vegetation communities, determined from vegetation mapping in aerial photographs. Cover of vegetation species—aquatic, herbaceous, scrub-shrub, forest. Species richness—total number of species observed on the site from species lists compiled during vegetation sampling. Elevation ranges and inundation times of vegetation species.	TBD during 2010 monitoring.	Photo-documentation shows significant change in plant community species composition and type by 2015. By 2015, >30% cover of freshwater tidal wetland plant species. Total area mapped with tidal freshwater wetland plant communities increases (60 acres by 2015). Increased native species richness compared to 2010 conditions. Elevation ranges (NAVD88) for major vegetation types will be similar to: ^b Aquatic/channel: 0 to 4.5 feet Low marsh: 4.5 to 6 feet High marsh: 6 to 7.5 feet Riparian: 7.5 to 10.5 feet Upland: >10.5 to 11 feet
	H6: Restoring a natural and more variable tidal regime will reduce the cover of reed canarygrass in areas where it occurs pre-project.	Total area of the site with reed canarygrass, determined from vegetation mapping in aerial photographs. Average cover of reed canarygrass in vegetation plots. Average elevation and elevation range of reed canarygrass on the site.	TBD during 2010 monitoring.	Area mapped with reed canarygrass is the same or less by 2015 (TBD—areas derived from 2010 monitoring). Percent cover of reed canarygrass in plots is same or less (TBD—percent cover derived from 2010 monitoring).
	H7: Restored tidal exchange will re-introduce sediment transport and scouring of tidal channels on the project site, resulting in the creation of greater overall channel area and a more complex channel network compared to pre-project conditions.	Channel area (total channel area estimated from aerial photographs and elevations using GIS). Channel cross sections and longitudinal profiles (estimate area). Total length of channel network (estimated from aerial	TBD during 2010 and 2011 monitoring.	TBD—actual values to be derived from 2010 monitoring report from mapping of existing channels. TBD—measures of pilot channels from as-built drawings in 2011.

Table 4-1. Summary of Targets Associated with Objectives, Hypotheses, and Parameters for Fisher Slough (continued)

Objective	Hypothesis	Parameters	Pre-project Condition	Restoration Target
		photographs using GIS). Total edge area of channel network (estimated from aerial photographs using GIS). Channel density (total length divided by project area). Distance upstream to head of blind.		
2: Restore and improve freshwater tidal rearing habitat for Chinook salmon (<i>Oncorhynchus tshawytscha</i>).	H8: Chinook salmon abundances (0+ year class) will be similar above and below the floodgates (post replacement) during peak migration periods. H9: Juvenile Chinook salmon will utilize restored channels and marshes at densities similar to other Skagit freshwater tidal marshes, adjusted for landscape connectivity.	Chinook salmon: Presence/absence Density/abundance Location Timing	There is no significant difference in log transformed mean juvenile Chinook density between sites up and downstream of the tidegate from February to August 2009 (Beamer et al 2010).	By 2015, trends suggest higher relative density year-0 Chinook above floodgates compared to pre-2010 conditions.
3: Restore passage for coho and chum salmon spawning access.	H10: Floodgate operation will improve fish passage opportunity for coho and chum compared to pre-project conditions. H11: Removal of the passage barrier at Big Ditch will result in more natural channel profile through this area.	Number of days floodgates are open from October 1 to February 28 or 29. Longitudinal channel profile at Big Ditch crossing.	Gates were open for 34% of the time during the fall of 2006 (Tetra Tech 2008). TBD during 2010.	Gates open at least once per day October to February 28 or 29. By 2015, passage barrier at Big Ditch can no longer be seen in channel profile. Mean water depth at crossing increases.
4: Improve flood storage and protect adjacent farm uses.	H12: Levee setback and restoration of tidal exchange will result in 310 acre-feet available for flood water storage (i.e., greater floodplain and channel area) during high flows.	Ground elevations relative to Fisher Slough flood stages Change in channel area and volume.	64 acre-feet of storage (Tetra Tech 2009).	At least 247 acre-feet of new flood storage (about 310 acre-feet total).

^a Due to tidal muting expected on the site from the design and operation of floodgates, MHHW upstream of the floodgates (near Big Ditch crossing) is expected to be about 8.8 NAVD88 (TNC 2009).

^b Elevation ranges from Draft Technical Memorandum #1.7 – Vegetation Survey (Appendix A.2, Final Design Report, Tetra Tech 2009).

TBD = to be determined, mg/L = milligrams per liter, NA = not applicable, GIS = geographic information system, NAVD88 = North American Vertical Datum 1988

4.1 OBJECTIVE 1: RESTORE ECOLOGICAL PROCESSES AND STRUCTURES THAT MAINTAIN A FUNCTIONAL TIDAL FRESHWATER WETLAND THAT SUPPORTS TARGET SPECIES

This objective contains a number of sub-objectives or component parts:

- Restore ecological processes and structures to support and maintain tidal freshwater wetlands
 - Restore tidal exchange/amplitude
 - Restore site inundation with tidal exchange
 - Restore processes of sedimentation and marsh accretion or aggradation
 - Restore tidal, fluvial, and sedimentation processes that result in channel formation
 - Restore channel structure and form
 - Restore tidal wetland habitat area
 - Restore native vegetation community structure and composition
- Maintain tidal freshwater ecological functions, such as Chinook salmon support
 - Rearing habitat capacity and opportunity (quality of habitat and access)

The key question related to the first objective is: Does the restoration project affect habitat conditions (tidal freshwater wetland, stream channels, stream riparian area) and/or presence/abundance of biota (e.g., Chinook salmon, native wetland plants) on the Fisher Slough project site?

Rationale for the basic hypotheses for Objective 1 is as follows:

Compared to historical conditions on the site, the levees and the pre-project floodgate operation have prevented significant tidal exchange in Fisher Slough; reducing tidal amplitudes and water elevations; reducing fish passage; reducing mixing of water in Fisher Slough associated with tidal currents; reducing inundation of the site, altering hydrologic and sediment processes that form complex channel structure and contribute to sediment deposition and marsh accretion; and reducing the amount and quality of habitat suitable for native wetland vegetation and juvenile Chinook salmon.

The planned restoration actions (levee setback, minimal floodgate closure, pre-excavation of some channels, and limited planting) are predicted to affect these conditions in the following ways:

Tidal exchange can be expected to influence mixing further upstream in Fisher Slough than currently occurs (pre-project), and a relatively greater contribution of Skagit River water entering Fisher Slough. With restoration, oxygen levels should increase and temperatures decrease in the portion of Fisher Slough upstream of the floodgates. Oxygen levels and water temperatures should be more similar at the floodgates and upstream at the limit of tidal influence, than are under existing, pre-project conditions.

The area of the site that is inundated by twice daily tides will be affected by both the increase in tidal amplitude upstream of the floodgates, and the levee setback, which will expose more area to tidal action. Sediment transport and deposition, including the accumulation of organic matter produced by marsh vegetation, is a characteristic

of tidally influenced freshwater wetlands. Because much of the project site is currently lower than the existing riparian/floodplain area, sediment deposition is expected to occur in areas of the site that are subject to tidal inundation following restoration. Accretion and aggradation rates are unknown and may vary widely across the site, and measurable changes may occur slowly (i.e., longer time frames than the current monitoring period). Therefore, this will be evaluated by looking at actual sedimentation rates and overall changes in elevation to look for trends in elevation over time compared to pre-project conditions.

Restoration of native plant communities is a key factor in maintaining and supporting wetland function, creating habitat structure, shading stream and tidal channels, stabilizing sediments and contributing to marsh accretion, contributing detritus and insects to aquatic food webs, and increasing salmon prey production. It is anticipated that despite restoration activities, reed canarygrass will continue to be on the site. A reed canarygrass management strategy has been developed (Fisher Slough Final Design and Permitting Final Tidal Marsh Restoration Design Recommendation Report, Appendix C.3 [Tetra Tech 2009]) and a plan to monitor reed canarygrass expansion is included in this management plan.

The re-introduction of tidal action will increase sediment transport and scouring of tidal channels on the project site, resulting in the creation of greater overall channel area and a more complex channel network compared to pre-project conditions (affecting opportunity and capacity for salmon). Greater channel area and complexity will increase the amount and quality of rearing habitat for Chinook by creating predator, flow and temperature refugia (channel complexity), and increasing availability and access to prey items from overhanging vegetation, detritus, and terrestrial insects/invertebrates contributed to channels from wetland and riparian vegetation.

4.2 OBJECTIVE 2: RESTORE AND IMPROVE FRESHWATER TIDAL REARING HABITAT FOR CHINOOK SALMON

Objective 2 is closely related to Objective 1, in terms of improving freshwater tidal rearing habitat for juvenile Chinook. Improving rearing habitat can be addressed through two main components of opportunity and capacity (Simenstad and Cordell 2000). Predictions about fish abundance or distribution are not addressed in this monitoring plan; these predictions are evaluated through the SRSC fish monitoring (see Appendix A). This monitoring plan, however, addresses habitat quality for fish only as it is related to parameters being evaluated for other hypotheses—e.g., channel area, water elevations, and native vegetation.

Increased tidal exchange and a greater proportion of the year with floodgates held open will facilitate access of juveniles to the site during flood tides, especially during the spring migration period. Greater channel area and complexity will increase the amount and quality of rearing habitat for Chinook by creating predator, flow and temperature refugia (channel complexity), and increasing availability and access to prey items from overhanging vegetation, detritus, and terrestrial insects/invertebrates contributed to channels from wetland and riparian vegetation.

4.3 OBJECTIVE 3: RESTORE PASSAGE FOR COHO AND CHUM

The original floodgate configuration and operation is thought to create a passage barrier to salmonids other than Chinook. In addition, the Big Ditch ‘siphon’ or culvert structure may also be a passage barrier during some flow conditions (Tetra Tech 2007). Removal or replacement of these structures and revised operation of the floodgates should increase access for both coho and chum salmon that use the Carpenter Creek/Fisher Slough system³.

4.4 OBJECTIVE 4: IMPROVE FLOOD STORAGE TO PROTECT ADJACENT AGRICULTURAL USES

Objective 4 is related to the effects that the restoration project may have on adjacent properties through changes in the capacity of the Fisher Slough site to perform valued ecosystem services—in this case primarily flood mitigation. Restoration actions that change hydrology on the site could potentially affect adjacent properties and land uses. During the design phase, several restoration alternatives were investigated for effects on flood storage on the project site and the preferred alternative is designed to result in an increase in flood storage (Tetra Tech 2007). The levee setback will significantly increase the area over which flood flows can spread and be stored during high flow events—for both high tides and high flows in the Carpenter/Fisher Creek system.

4.5 GROUNDWATER ELEVATIONS

Groundwater elevations are not related to project objectives and hypotheses but there is an interest in tracking groundwater elevations at several locations during and after the restoration project. Groundwater elevations will be plotted over time and used as a descriptive indicator to identify whether there is a need in the future for additional groundwater monitoring. Due to the difficulties of positioning groundwater wells in actively farmed fields, the established wells have been positioned immediately adjacent to Fisher Slough dikes and drainage ditches. The wells will not reflect groundwater dynamics in the farm fields. Groundwater levels can drop rapidly as distance from a channel increases and there are too few wells to yield statistically relevant data. There are many factors other than restoration actions that are affecting, and will affect, groundwater elevations on both the project site and adjacent properties (e.g., effects of the regional drainage system, variation in precipitation from year to year). Determining what factors groundwater elevations are responding to would require more extensive sampling than currently planned. However, by tracking groundwater elevations at a few locations, any significant anomalies can be evaluated and used to determine whether there is a need for further investigation.

The protocols for monitoring groundwater at Fisher Slough are described in Appendix C. Groundwater elevation data will be reported in a yearly technical memorandum to TNC.

³ Details on monitoring for coho and chum salmon are included in the SRSC monitoring methods.

4.6 PERFORMANCE TARGETS

The performance targets are the parameter values that can be used to evaluate whether or not the restoration site is meeting the stated objectives of the project. For each of the hypotheses and parameters, a value, or range of values, indicates that the site is performing as desired or predicted by the conceptual models that guided the restoration design (Tetra Tech 2007). Parameter values falling outside those ranges may indicate that the restoration actions have not had the predicted effect on processes, structures, or functions, and contingency measures may need to be implemented. Because the monitoring is limited to a BA design, parameter values falling outside of predicted ranges should be interpreted with care, as factors other than the restoration actions may be affecting conditions and parameter values on the site (Roegner et al. 2008).

Pre-project values and targeted performance criteria associated with project objectives, hypotheses, and parameters are summarized in Table 4-1.

5. METHODS

This section describes the monitoring methods used to evaluate the restoration objectives and hypotheses. Monitoring approach and detailed methods are described for each of the parameters identified above. For each of the monitoring methods, this section includes an introduction and discussion of the purpose and rationale for the method, which objectives and hypotheses the method addresses, the general monitoring approach and study design, data collection protocols (may include equipment installation/operation, field data collection protocols), and data analysis and reporting. A quality assurance/quality control (QA/QC) plan for data collection, analysis, and management will be used.

Monitoring parameters, methods and protocols, and monitoring frequency for all monitoring data are summarized in Section 6.3.

5.1 HYDROLOGY

Hydrology is the primary controlling factor for wetlands and influences wetland processes, habitat structure, and ecological functions (Zedler 2001; Rice et al. 2005). In tidally influenced wetlands, tidal forcing or tidal exchange affects variation in water levels, which determine habitat suitability for wetland plants and animals. Tidal exchange determines numerous processes that are important for wetland structure and function, including sediment transport, erosion, and deposition; tidal channel development and complexity, vegetation distribution and composition; inundation periods, and salinity intrusion (Mitsch and Gosselink 2000). Because of the importance of water elevation to key processes, measuring the pattern of water level variation over time provides information to address a number of the project hypotheses. Water levels or elevation measured at frequent intervals (hourly or 15-minute) provides information on the daily tidal fluctuations, extreme events, and seasonal variation in water levels. By examining water level fluctuation over time, pre-project and post-project patterns can be compared, including differences in water elevation patterns at different locations on the project site.

Because the operation of the floodgates at Fisher Slough determines tidal forcing upstream of the gates, operation of the gates is an important parameter in evaluating hydrology on the restoration site. Although surface water elevations and variations associated with tidal forcing are a primary controlling factor in tidal wetlands, methods for monitoring water elevations, and floodgate operation, are discussed below.

5.1.1 Goals and Hypotheses

The goal of hydrology monitoring is to determine how restoration actions influence both surface and groundwater elevations within the project site. Surface water elevations are related to tidal inundation, sedimentation, channel formation, and vegetation processes and can affect fish passage and access to habitat. The following hypotheses are addressed by hydrology monitoring (see Table 4-1):

- H1:** *Replacement/revised operation of the floodgate (post-project condition) will result in increased tidal amplitude and water elevations upstream of the new floodgate, compared to pre-project conditions, particularly during the spring Chinook migration period.*
- H3:** *Relocation of the confining levees will restore 50 acres of tidal marsh which will result in a total of 60 acres of freshwater tidal marsh area—the area of tidally inundated freshwater wetland will increase.*

H12: *Levee setback and restoration of tidal exchange will result in 310 acre-feet available for flood water storage (i.e., greater floodplain and channel area) during high flows.*

5.1.2 Hydrology Study Design and Protocols

Changes in surface water hydrology and effects on tidal inundation, channel geomorphology, and vegetation will be evaluated by tracking surface water elevations over time at several locations on the project site, and relating those to channel morphology and vegetation. Information on water elevations will be used with information on floodgate operations to verify that the timing of floodgate opening and closing are correlated with migration periods for salmonids and with increased tidal amplitude and water elevations.

5.1.2.1 Tidal Amplitude/Surface Water Levels

Changes in surface water hydrology (tidal amplitude and flood water elevations) will be measured at the site by continuously documenting water levels at three locations using submersible water level loggers tied to a known vertical elevation datum. Data loggers were established by TNC between 2006 and 2009 at three locations—level logger locations include:

- Logger 1 – downstream of the floodgates (as a reference condition),
- Logger 2 – upstream of the floodgates, and
- Logger 3 – upstream of the current (2009) Big Ditch Crossing (Figure 5-1).

Model 3001 Levellogger Gold® data loggers (Solinst Canada Ltd.) will be used to measure total pressure (the combined values of water pressure and air pressure) above the logger. A separate barometric data logger (Solinst Barologger Gold) will measure air pressure in the near vicinity. Water elevation values are corrected for barometric pressure by subtracting the air pressure from the level logger value and elevation. The level loggers will be set to record water level in 15-minute intervals.

The data loggers are placed in standpipes at the three sites. The loggers are suspended so that they remain submerged during low water periods (suspended in subtidal or below the lowest low water levels), and are not covered by more water than the stated range for the logger (overpressure). Sensors are positioned slightly above the substrate (6 to 12 inches) to prevent sedimentation or abrasion at high flows. The barologger that records barometric pressure is suspended so that it remains above water level at all times.

The location of the loggers was surveyed and the height of the sensors relative to a known elevation was recorded so that water-level data is properly geo-referenced to local topographic data. All topographic data are tied to an established vertical elevation datum (e.g., North American Vertical Datum 1988 [NAVD88] and mean lower low water [MLLW]) so that water elevations can be related to ground surface and tidal ranges (Roegner et al. 2008).

The level loggers were programmed and started using the appropriate software (Solinst software version 3.2.3 or higher). Loggers have been installed using a suspension cord connected to the installation cap of the logger to the underside of a well cap. The data are retrieved manually by withdrawing the logger, removing the installation cap and attaching an Optical Reader directly to the logger. The Optical Reader is downloaded directly to a laptop at the site. Loggers are downloaded quarterly (January, April, July, and October) for the duration of the monitoring period.

Water level information will be used with topographic elevation information (see Section 5.3) to calculate inundation timing, extent, and duration.



Figure 5-1. Surface Water and Groundwater Sampling Locations

5.1.2.2 Floodgate Operation

Floodgate operations have significantly restricted fish passage and tidal exchange in the past because they were closed a large proportion of the time during periods of increased flood risk (Tetra Tech 2008). This included complete closure during fall, winter, and early spring periods. The new floodgates are capable of providing increased tidal exchange and fish passage while still providing flood protection by closing only once prescribed water elevations in the Skagit River (Tom Moore Slough) are reached. Floodgate operations will influence whether or not the project meets the objectives of maintaining tidal exchange and allowing fish passage during critical migration times for Chinook and other salmonids.

The floodgate Operations and Maintenance Manual describes the operation of the floodgates that has been agreed to by the project partners and procedures for data collection related to operation of the floodgates in relation to water elevations and fish abundance and utilization. Potentiometers installed on each of the three floodgates continuously record gate position (percent open) at 15-minute intervals on a year-around basis. Potentiometer readings will be used to determine the amount of time gates are open (and to what degree) during various operational periods/seasons. Loggers will be downloaded on a quarterly basis (January, April, July, and October) for the duration of the project. Detailed notes for floodgate operations monitoring are included in Appendix B.

5.1.3 Hydrology Data Analysis and Reporting

Surface Water Elevations

The data output of the water level loggers is a time series of water levels. Post-processing of the data includes correcting the relative water level heights for atmospheric pressure, following the guidelines in the Solinst operations manual. Corrected water levels are then converted into elevation relative to the standard vertical datum (NAVD88).

The following parameters are calculated or data visually displayed to address the hydrology related hypotheses:

Plot time series of water elevations downstream and upstream of the floodgates for each month; tidal amplitudes and elevations of Loggers 1 and 2 should match during periods when the floodgates are open. Tidal amplitudes and elevations of Loggers 1 and 3 may diverge somewhat when gates are open, depending on muting of tidal flows following restoration.

Using the time series of water elevations and site topography, inundation period (percent inundation) for different locations within the project site is calculated by season (winter, spring, summer, and fall). Inundation period can be plotted as an exposure-height curve which shows the percent of the period that a given elevation is inundated. (Either display curves or use geographic information system [GIS] to prepare maps that show percent inundation across the site using site topographic data).

Floodgate Operations

Output is a time series of floodgate positions that can be used to calculate percent of time that gates are open, and percent openness for any given time period. Gate position can then be matched to water elevations upstream and downstream of the gates, water quality parameters, and fish abundance or utilization measures.

5.2 WATER QUALITY

Water quality parameters such as DO levels, temperatures, salinity, turbidity or suspended solids, and pH are important determinants of habitat quality for aquatic organisms. Many aquatic organisms have specific tolerances for water quality parameters. In tidally influenced wetlands, salinity levels are important in controlling the distribution of wetland plants (Thom et al. 2002). Because salinity levels are extremely low in Fisher Slough and waters entering the slough on high tides are freshwater from the Skagit, salinity is not an important parameter for any of the monitoring hypotheses. Water temperature and DO levels affect juvenile salmon and determine abundance and condition (Fresh et al. 2006; Rice et al. 2005). The feasibility site assessment identified warm temperatures and low DO as potential factors affecting habitat conditions for salmon in Fisher Slough, especially when the floodgates were closed (Tetra Tech 2007). Warmer temperatures may be due to prolonged ponding of water at the gates when they are closed, water being backed up behind the existing Big Ditch culvert, and a lack of mixing between waters upstream and downstream of the gates. The introduction of greater tidal forcing and mixing with twice daily tidal cycles is expected to increase oxygen levels and lower temperatures upstream of the floodgates.

5.2.1 Water Quality Goals and Hypotheses

The purpose of water quality monitoring is to measure time series temperature and DO parameters under pre-project and post-project conditions to evaluate whether changes in water quality accompany the restoration actions at Fisher Slough.

The following water quality related hypotheses will be addressed (see Table 4-1):

H2: *Restoration of tidal exchange will increase twice daily mixing of waters in Fisher Slough on the project site, increasing oxygen levels and reducing temperatures compared to pre-project conditions, particularly during the summer months.*

5.2.2 Water Quality Study Design and Protocols

To determine whether increased tidal forcing affects water quality upstream of the floodgates, water temperature and DO will be measured at three locations within Fisher Slough. Continuous, automated data logging instruments, (equivalent to Aquistar® DO sensor, Instruments Northwest) will be placed at the three locations where the water level loggers are installed (1) downstream and upstream of the floodgates, (2) just upstream of Big Ditch Crossing, and (3) beyond the likely limit of tidal influence⁴ (see Figure 5-2). Water temperature and DO will be measured at hourly intervals. Locating one instrument upstream of expected tidal influence will allow evaluation of the relative influence of water quality associated with flows from the Carpenter Creek system, the Skagit, and tidal mixing within Fisher Slough. Locations of the instruments will be surveyed relative to known benchmarks. Automated data loggers will provide a time series of temperature and DO measurements that can be related to tidal cycles and floodgate operation to test the water quality hypothesis.

During the pre-project data collection, DO was collected with a hand held DO meter. To account for changes in data collection technique, data will be collected using both methods during 2011 to better understand variation in data collection techniques. Manual collection of DO and temperature should occur two times per month from July to September. Downloading of the data loggers will occur at the same time as data from the water level loggers are downloaded (see Section 5.1.1).



Figure 5-2. Fisher Slough Dissolved Oxygen and Temperature Sampling Locations

⁴ Per discussion with TNC staff, July 2010.

5.2.3 Water Quality Data Analysis and Reporting

The data output from the water quality data loggers is a time series of DO and temperature values. To evaluate the effects of restoration at Fisher Slough on water quality, the period of interest is during the summer months, when increased tidal circulation may result in greater mixing and reduced temperatures and increased DO compared to pre-project conditions. BA designs make it difficult to attribute changes in water quality pre- and post-project due to natural annual variability, especially in temperature. For example, post-project annual variation in temperatures could lead to either an increase or decrease in summer temperatures at the site, making it difficult to attribute changes in temperature to the restoration. However, trends in temperature and DO can be evaluated following restoration to determine if there is a general upward or downward trend, or not change, in temperature or DO levels.

The following calculations and visual data displays will be used to evaluate restoration effects on water quality:

- Time series of DO for each logger, pre- and post-project (i.e., 2010, 2011, 2012, 2013, etc.) to evaluate trends in DO over time following restoration.
- Time series of temperature for each logger, pre- and post-project (i.e., 2010, 2011, 2012, 2013, etc.) to evaluate trends in DO over time following restoration.
- For each season (spring, summer, fall, and winter), plot temperature and DO levels during periods when floodgates are open against closed to evaluate whether floodgate operation has an effect on temperature or DO.
- Mean (and standard deviation) daily maximum values before and after project (temperature); compared to optimal and stress values for salmon.
- Mean (and standard deviation) daily minimum values before and after project (DO); compare to optimal and stress values for salmon.
- Mean monthly values pre-project opposed to post-project (DO and temperature).

5.3 ELEVATION

In tidal wetlands, elevation relative to tidal amplitude is a major factor in the evolution of channel geomorphology, marsh development, fish habitat and vegetation establishment, and succession (Rice et al. 2005). Rapid changes in channel morphology and vegetation following tidal reconnection and levee setbacks frequently occur as a result of tidal restoration projects (Zedler 2001). Therefore, establishing the rate and extent of change in elevation on the Fisher Slough site will be important for evaluating the progress and success of the restoration effort.

Relative elevations are also important for understanding how processes are changing on the site over time following restoration. Channel formation and sedimentation processes can be measured by proxy indicators such as changes in channel cross sections or accumulation (or removal) of sediment at fixed locations.

5.3.1 Goals and Hypotheses

The goal for elevation monitoring is to quantify changes in elevation after restoration on those portions of the site affected by tidal inundation, and to relate those changes to changes in vegetation and/or hydrology. The following hypotheses are addressed by measuring changes in elevation on the project site (see Table 4-1):

- H3:** *Relocation of the confining levees will restore 50 acres of tidal marsh which will result in a total of 60 acres of freshwater tidal marsh area—the area of tidally inundated freshwater wetland will increase.*
- H4:** *Restored tidal exchange/levee setback and greater inundation will result in accretion and aggradation of the ground surface in tidal marsh areas.*
- H12:** *Levee setback and restoration of tidal exchange will result in 310 acre-feet available for flood water storage (i.e., greater floodplain and channel area) during high flows.*

5.3.2 Elevation Study Design and Protocols

To evaluate how changes in site elevation are associated with restoration actions and related to changes in vegetation and geomorphology, requires precise elevation surveys of the site tied to known benchmarks and linked to an established vertical datum. For the Fisher Slough site, the vertical datum used is NAVD88. Mean higher high water (MHHW) at Pioneer Highway is at 9.5 feet NAVD88. Surveys are needed for locations and elevations of data loggers for surface and ground water elevations, water quality instruments, vegetation transects and plots, channel cross sections, boundaries between vegetation communities, natural features such as channels and berms, and sedimentation stakes (see below).

To evaluate changes in tidal inundation, channel geomorphology, vegetation succession, and sedimentation, elevation data for Fisher Slough will be collected for the area within the project limits, instrumentation (water level loggers and water quality instruments), channel cross sections and longitudinal profiles, and locations of the sedimentation stakes.

5.3.2.1 General Elevation Surveys

During the site assessment and design stages of the project, topographic data for the area within the project footprint were developed from a light detection and ranging (LiDAR) survey (see Figure 4; Tetra Tech 2007). Overall changes in project site elevations associated with the restoration will be evaluated by comparing this pre-project LiDAR data with LiDAR data collected again in 2015. In early 2015, during a winter low water event, LiDAR data will be collected over the project area, and used to compare project site elevations between pre- and post-restoration.

Project site elevations will be computed in GIS using existing LiDAR data, ground survey, and orthorectified color aerial imagery. Extent of inundation will be calculated from water level data and project site elevations. Vegetation correlations with elevation will be evaluated by examining the relationship between elevations and major vegetation communities as developed in the vegetation mapping, as well as quantitative data on vegetation abundance and plot elevations (see Section 5.5).

In 2010, 27 vegetation plots were established across the site for quantitative vegetation sampling (see Section 5.5). The elevation of the center of each plot was surveyed to allow vegetation data to be correlated with elevation. The elevation of plot center points will be

surveyed again in 2015. These elevation data can be used with the LiDAR and sediment stake elevation data to describe changes in elevation across the site.

In 2010 or 2011, elevation data will be confirmed for key locations on the site. To obtain elevation data for relevant features within the project site, elevation data will be collected in the following locations:

- All instrumentation and data points for monitoring—water level loggers (surface and groundwater), water quality data loggers, vegetation transects and plots, and sedimentation stakes (in 2011);
- Selected boundaries between vegetation communities (locations to be identified prior to field survey work);
- Channel cross sections and the uppermost limit of blind tidal channels; and
- Longitudinal channel profiles at the Big Ditch crossing.

Survey Approach and Equipment. A Real Time Kinematic (RTK) receiver combined with a data link to the Washington State Reference Network (WSRN) provides survey grade geographic positioning system (GPS) accuracy, and will be used to gather data for ground elevations, sediment pin locations, vegetation transects and boundaries, channel areas, and cross sections. This system should be suitable for survey work on the Fisher Slough site because the site is open and generally lacks dense vegetation. The WSRN includes a network of continuously operating base stations, which gather satellite GPS data and then solve the correction formula for the signals. The need for a correction formula is derived from the distortion created by the atmosphere on the signals sent from the satellites towards the earth, and clock misalignment between the satellites and the ground. By sitting atop a monument with a known coordinate position, the WSRN network stations are able to establish the formula to remove the distortion and clock misalignment and are able to broadcast this correction to the roving RTK receiver. This allows the receiver to collect corrected, survey grade, GPS data instantly, without the need for lengthy post-processing procedures.

In areas of very dense vegetation where satellite signals may be compromised, conventional survey equipment may be used instead of the RTK receivers. If this is necessary, a Total Station, combined with prisms and a prism pole, would be used to measure angles and distances from a known baseline established by RTK or conventional equipment. Simple coordinate geometry is used to establish the position of the prism pole in relationship to the Total Station. A series of recorded positions can be combined to create a survey grade digital terrain model of the ground surface. In portions of the slough where water may be too deep to wade across, use of boats (consistent with the monitoring safety plan) may be required to gain access to establish accurate bathymetric data.

5.3.2.2 Sediment Accretion

Re-introduction of tidal sediment transport and deposition within the site is predicted to result in accretion and aggradation of the ground surface in the areas currently behind levees. Patterns of erosion and deposition/accretion will likely be dynamic on the site for some time following restoration, so that sedimentation rates (positive or negative) should be measured at a number of locations that will be subject to inundation following tidal reconnection and levee setback. Areas subject to inundation will likely be near the new pilot channels, existing channels, and newly exposed tidal marsh areas on Smith Parcels A and B (see Figure 2-2).

Sedimentation rates will be evaluated using a series of sediment stakes or pins that will be established on the site in the summer of 2011, following construction of Project Element 3. To cover a representative area of the site, 16 sediment stakes will be placed adjacent to

vegetation plots in Smith Parcels A and B. Sediment stakes will be located adjacent to the area where new tidal channels are predicted to form and where inundation is expected to occur. At each quantitative vegetation sampling plot, a sediment stake will be established about 10 feet due north of the vegetation plot. This will allow sedimentation rates (erosion or accretion) to be correlated to vegetation. Vegetation plots occur in low marsh, high marsh, and channel locations so that a range of inundation and sedimentation conditions will be captured. Locations for the sediment stakes will be determined in the field during the 2011 monitoring effort and approximate locations are shown in Section 5.2.3 (Figure 5-7).

Sedimentation stakes will be 1- to 2-inch schedule 40 PVC conduit or rebar. Stakes will be driven into the ground at least 1-meter deep (if possible) to ensure that they remain stable and should extend about 1-meter above the ground surface (Takekawa et al. 2002). Locations of the stakes will be surveyed and the elevation of the top of the stake and the ground surface surveyed relative to a known benchmark. For baseline or pre-project conditions (2011 monitoring year), the distance from the tip of the stake to the ground surface will be recorded to establish the initial ground surface elevation. Measurements should be taken from the top of the stake to the sediment surface, 10 centimeters from the base at zero compass degrees (due north) from the stake. The vertical distance from stake top to sediment surface will then be calculated after data collection with a handheld field data recorder or using Excel in the office. Caution should be used by field personnel to avoid disturbance of sediments near the base of the stakes by minimizing activities in the vicinity of the stakes, especially upgradient of the stakes.

Sedimentation rates will be measured at least twice yearly in the spring and fall; sedimentation rates can be measured at the same time that the water loggers are downloaded in the spring and fall. The distance from the tip of the stake to the ground surface is recorded. The sedimentation rate will be calculated as the baseline distance minus the new distance (positive value represents sedimentation, negative value represents erosion).

5.3.2.3 Channel Cross Sections

Tidal re-introduction and re-connection can strongly influence channel geomorphology through effects on hydrology and sediment erosion, transport, and deposition (Hood 2002, 2004). Channel cross sections in existing and new channels will likely change following restoration at Fisher Slough as channels evolve in response to changed hydrology and sediment processes. Channel form as reflected in cross sections is also related to habitat and water storage functions through effects on total channel area.

Cross sections of the Fisher Slough primary tidal channel were surveyed along five permanent transects established in 2006, as part of the feasibility study for the preferred restoration plan (see Figure 4; Tetra Tech 2007). These five cross sections will be surveyed again in 2010 for the main and secondary Fisher Slough channels. In 2011, additional channel cross sections will be established in the new pilot channels. A total of two to three new permanent transects will be established along the alignment of each pilot channel, for a total of six to nine new cross sections.

The transects end points will be permanently marked with rebar (endpoints far enough away from the channel banks that they are not likely to be affected by erosion), surveyed for location and elevation relative to NAVD88, and the cross section surveyed to establish baseline cross section elevations along the transect. Elevations will be recorded at 10-foot intervals along each transect outside of the channel area and 5-foot intervals within channels, and/or at any clear break in topography—including at a minimum, left bank, right bank, and channel thalweg. In each monitoring year following construction, cross sections will be surveyed again and channel cross sections plotted to evaluate changes. Cross section surveys

will be completed using the methods described above for general elevation surveys. Channel cross sections will be measured once per year during the summer.

Calculations:

- Change in channel cross sectional area
- Visual display of changes in cross sections over time
- Wetted width of channels (from water elevation and cross section elevations)

5.3.2.4 Channel Longitudinal Profiles

The concrete infrastructure associated with the existing Big Ditch crossing (Figure 5-3) will be removed in 2011 during Project Element 3. Because the culvert acts as a hydraulic barrier and likely fish passage barrier, the removal of this infrastructure itself will allow/increase fish passage and restore natural channel morphology. Effects of culvert removal will be evaluated by measuring the longitudinal profile through this reach before and after culvert removal and comparing the profiles.

The longitudinal channel profile through the Big Ditch reach will be measured by establishing a point 50 feet upstream and a point 50 feet downstream from the Big Ditch crossing. Between these two points, the elevation of the channel thalweg will be recorded at 1-foot intervals. If the channel substrate on either side of the crossing is too fine/soft for accurate determination of the thalweg location, the longitudinal transect will be adjusted to capture a smaller area to either side of the crossing. The profile will be long enough to include the entire area of the crossing and several feet on the upstream and downstream side in the profile.



Figure 5-3. Big Ditch Structural Crown Fish Passage Barrier in Fisher Slough

5.3.3 Elevation Data Analysis and Reporting

General site elevation data from ground survey and LiDAR will be combined with orthorectified aerial photographs of the site, and elevation ranges on the site will be visually displayed using color gradations.

Elevation profiles along the vegetation transects will be graphically displayed with vegetation data to show species distributions relative to elevation.

Sedimentation rates will be reported by plotting the time series of sedimentation rates for each stake, calculating average sedimentation rates for the entire site, and sedimentation rates by elevation.

Channel cross section calculations and reporting will include:

- Change in channel cross sectional area
- Visual display of changes in cross sections over time
- Change in channel gradient
- Wetted width of channels (from water elevation and cross section elevations)

Before (2010 Baseline) and after (2011) longitudinal channel profiles through the Big Ditch crossing area will be plotted on the same graph to visually display changes in profiles.

5.4 LANDSCAPE FEATURES

Larger landscape features that change on a site following restoration are best evaluated at a landscape scale, so the larger-scale changes in features such as vegetation or channel geomorphology can be detected. To detect these larger-scale changes with statistical sampling would require a very extensive sampling effort that is typically not possible on any but the smallest restoration sites (Roni 2005). Landscape features can be evaluated using aerial imagery (photography or satellite imaging) or photographic documentation that shows change over time from a given point on the site (Roegner et al. 2008).

5.4.1 Goals and Hypotheses

The goals of these methods are to describe and/or quantify project-wide changes in geomorphology and broad vegetation patterns associated with restoration actions—levee setback, floodgate replacement, channel initiation, and planting—on the Fisher Slough site.

The following hypotheses will be addressed through evaluation of landscape features (see Table 4-1):

- H3:** *Relocation of the confining levees will restore 50 acres of tidal marsh which will result in a total of 60 acres of freshwater tidal marsh area—the area of tidally inundated freshwater wetland will increase.*
- H5:** *Restoration of tidal, fluvial, and sediment processes (and limited planting) will result in recolonization of the site by native freshwater wetland emergent, scrub-shrub, and forested wetland, and riparian plants as predicted by Hood (Tetra Tech 2007) and TNC (Tetra Tech 2009).*
- H6:** *Restoring a natural and more variable tidal regime will reduce the cover of reed canarygrass in areas where it occurs pre-project.*

H7: *Restored tidal exchange will re-introduce sediment transport and scouring of tidal channels on the project site, resulting in the creation of greater overall channel area and a more complex channel network compared to pre-project conditions.*

In addition, the photo-documentation from permanent photographic points will provide a qualitative picture of changes in site condition over time following the restoration.

5.4.2 Landscape Features Study Design and Protocols

Landscape features will be evaluated through two methods (1) aerial imagery for mapping geomorphic and vegetation changes, and (2) photo-documentation to illustrate trends in site condition over time.

5.4.2.1 Aerial Imagery Analysis

Major site features will be mapped on existing aerial photographs, which were used by TNC and Tetra Tech in the initial restoration planning and design stages (Tetra Tech 2007; see Figure 2-2). Features to be mapped on baseline aerial imagery include primary and secondary channel features (Fisher Slough, Little and Big Fisher Creeks, and Carpenter Creek), major infrastructure (levees, highways, floodgates, Big Ditch culvert, etc.), project footprint, and existing vegetation communities. Baseline mapping will be accomplished through a combination of existing data provided by TNC, digitizing from existing data sources, and field verification of features during the 2010 monitoring effort. The study design for vegetation mapping is discussed in Section 5.5.

For channel area and complexity measures, a baseline map will be created in 2010, using existing aerial photographs to map the boundaries of the existing channel network—including Fisher Slough primary and secondary channels, Little and Big Fisher Creeks, and Carpenter Creek. Boundaries will be verified and adjusted in the field during the 2010 sampling effort and site surveys. Channel features will then be digitized using GIS. The channel features map will be georeferenced to the existing site elevation data so the location of channel features can be integrated with ground surface and tidal elevations.

In 2011, 2013, and 2015, channel morphology and extent will again be mapped and digitized onto aerial imagery using GIS. Elevation data collected during the quantitative sampling intervals will be used to verify and adjust the channel mapping.

The following parameters will be calculated from the channel feature maps using GIS, and used to compare channel conditions over time with the baseline condition and predicted channel morphology and development (Tetra Tech 2009; Table 5-1, Table 5-2):

- Channel wetted area (total channel area estimated from aerial photographs and elevations using GIS)
- Total length of channel network (estimated from aerial photographs using GIS)
- Total edge area of channel network (estimated from aerial photographs using GIS)
- Channel density (total channel length divided by project area)
- Distance upstream to head of blind channel (from the junction with Fisher Slough to end of channel); head of channels recorded with GPS, length estimated using GIS
- Bifurcation measure/number of nodes in channel network, estimated with GIS

Table 5-1. Predicted Geomorphic Response, Channel Development, and Sedimentation Periods for Fisher Slough Channels (Tetra Tech 2009, Table 16)

Erosion and Sedimentation Criterion	Baseline Conditions	Smith A	Smith B
Length of channels (ft)		3915	5180
1-ft deep by 1-ft wide average formation period (yrs)	n/a	<1 mo	<1 mo
2-ft deep by 2-ft wide formation period	n/a	<1 mo	<1 mo
3-ft deep by 6-ft wide formation period	n/a	<6 mo	<1 yr
3-ft deep by 20-ft wide formation period	n/a	<2 yr	< 5 yr
Fan sedimentation filling period	0 yr	<160+ yr	
Floodplain sedimentation filling period to MHHW	0 yr	<500 yr	

ft = feet, yr = year, mo = month

Table 5-2. Predicted Potential Channel Planform Metrics (Tetra Tech 2007, Table 25)

Area Location	Restored Marsh Area	Predicted Total	Predicted Max.	Predicted Total	Predicted Max.	Predicted Max.	Predicted Channel	Predicted Max. Trunk
		Ch. L (m)	Ch. L (m)	Ch. A (ha)	Ch. A (ha)	Ch. W (m)	Count	Branches
Smith A	10.3	1,379	661	0.18	0.1	6	8	5
	upper 90% CL	4,321	2,106	0.58	0.39	17	19	16
	lower 90% CL	440	207	0.06	0.02	2	3	2
Smith B	12.4	1,742	809	0.24	0.13	7	9	6
	upper 90% CL	5,467	2,582	0.77	0.51	19	22	18
	lower 90% CL	555	253	0.08	0.03	2	3	2

5.4.2.2 Photographic Documentation

Two types of photographic documentation will be used to document the restoration project—tracking progress with permanent photo points following restoration and during project construction. During project construction (2010 to 2011), the TNC project manager will make regular site visits to inspect and photograph project progress. Visits will be made no less than weekly when construction is underway (anticipated during June through October in 2010 and 2011). This photographic documentation will be maintained by TNC as a separate effort, and is not part of this restoration monitoring and adaptive management plan.

Longer-term changes to the restoration site such as changes in vegetation and channel development will be captured with quarterly photo point monitoring each year, from 2009 through 2015. Permanent photo points were established at eleven locations on the project site in 2009 (Figure 5-4). Locations of the permanent photo points were recorded with GPS, and compass headings for the photographs were recorded (see Appendix D). Points were located in areas that provide views of portions of the site that are expected to undergo significant change following restoration.



Figure 5-4. Permanent Photo Point Locations and Photo Bearings for Photo Points Established by TNC

Photographs will be taken at the permanent photo point locations during the following time periods each year; January, April, July, and October. Photo point monitoring protocols, locations of photo points, and data storage and management protocols are provided in Appendix D. To meet grant requirements and project needs, all images will meet the criteria outlined in Appendix D and be stored consistent with the data storage and management plan, and may be shared on a Conserve-On-Line site that is being developed by TNC Staff.

During the 2010 additional photo points were established with selected vegetation sampling plots to provide additional images of vegetation in new channel, low marsh, and high marsh areas.

5.4.3 Data Analysis and Reporting

Data analysis and reporting for the vegetation mapping is described below in Section 5.5.

For channel area and extent, for 2010, 2011, 2013, and 2015 monitoring, channel areas will be digitized on the aerial photographic base, and verified with field sampling data. Channel area and complexity will be analyzed using GIS⁵. Measures of channel geomorphology will include:

- Channel wetted area (total channel area estimated from aerial photographs and elevations using GIS)
- Total length of channel network (estimated from aerial photographs using GIS)
- Total edge area of channel network (estimated from aerial photographs using GIS)
- Channel density (channel network length divided by project area)
- Distance upstream to head of blind channel (from Pioneer Highway to end of channel); head of channels recorded with GPS, length estimated using GIS
- Bifurcation measure/number of nodes in channel network, estimated with GIS

Changes in channel geomorphology will be displayed visually with the aerial images, using GIS, as well as by comparing the parameter values in each monitoring year to the baseline (2010) values.

For the permanent photo points, the photographs will be inspected each monitoring year for changes in the site conditions compared to pre-project conditions. The time series of photographs will be included as an Appendix in the annual reports and changes will be qualitatively described in annual monitoring reports.

5.5 VEGETATION

Native wetland vegetation is an important structural element, and contributes to functional performance in tidal wetlands (Zedler 2001), and changes in vegetation are important indicators of ecological condition in restored wetlands (Rice et al. 2005). Ecological functions of native vegetation include primary productivity, habitat structure, shade, and temperature mitigation in nearby surface waters, sediment stabilization, sediment accretion, and marsh aggradation, contributing detritus and insects to aquatic food webs and increasing salmon prey production.

Existing vegetation on the project site has been dramatically altered from historical conditions by diking, draining, and conversion to agriculture of the tidal wetlands that historically occurred here (Collins and Sheikh 2003). Much of the narrow riparian area between the dikes is dominated by reed canarygrass, and most of the site is currently dominated by non-native grasses and forbs (Tetra Tech 2007). Restoration of tidal inundation is expected to result in changes in species abundance, composition, and distribution within the project site and a shift to native plant communities established at elevations relative to tidal inundation similar to those occurring in Fisher Slough and predicted by the restoration design models (see Table 5-2) (Tetra Tech 2009). Based on investigations in the Skagit system and vegetation surveys at Fisher Slough, design studies concluded that restoring tidal dynamics could be an effective way of controlling reed canarygrass and could reduce reed canarygrass abundance (SRSC 2007, Tetra Tech 2009). However, reed canarygrass will be monitored and managed to account for potential expansion. Table 5-3 shows the predicted

⁵ In addition, cross sections from selected locations will be used to evaluate changes in channel morphology over time (see Section 5.3)

vegetation zones by elevation and inundation period during the growing season, as developed by TNC during project design.

Table 5-3. TNC Final Design Report Predicted Vegetation Zones, Elevation Ranges, and Duration of Inundation in the Growing Season (Tetra Tech 2009, Table 3)

Vegetation/ Habitat Zone (Treatment Area)	Inundation Duration (Growing Season) ⁶	Elevation Range (feet relative to NAVD88)	Common Name	Scientific Name
Mud – Channels/Ponds	90% – 100%	0 – 4.5	Northern milfoil	<i>Myriophyllum sibiricum</i>
			Giant bur-reed	<i>Sparganium eurycarpum</i>
			Slender-leaved pondweed	<i>Potamogeton filiformis</i>
			Cattail	<i>Typha angustifolia</i>
Low Marsh	50% – 90%	4.5 – 6	Bulrush	<i>Scirpus americanus</i>
			Lyngbye's sedge	<i>Carex Lyngbyei</i>
			Spikerush	<i>Eleocharis palustris</i>
High Marsh	20% – 50%	6 – 7.5	Lyngbye's sedge	<i>Carex Lyngbyei</i>
			Sweetgale	<i>Myrica gale</i>
			Reed canarygrass	<i>Phalaris arundinacea</i>
			Willow	<i>Salix</i> spp.
Riparian	5% – 20%	7.5 – 10.5	Spirea	<i>Spiraea douglasii</i>
			Red osier dogwood	<i>Cornus sericea</i>
			Reed canarygrass	<i>Phalaris arundinacea</i>
			Rye grass	<i>Lolium multiflorum</i>
Upland	0% – 5%	> 10.5 – 11	Dandelion	<i>Taraxacum officinale</i>
			Narrow-leaved plantain	<i>Plantago lanceolata</i>

5.5.1 Goal and Hypotheses

The goal of vegetation monitoring is to measure changes in vegetation distribution, species composition, and abundance following levee setback and revised floodgate operation (tidal reconnection), relative to the following hypotheses:

H5: *Restoration of tidal, fluvial, and sediment processes (and limited planting) will result in recolonization of the site by native freshwater wetland emergent, scrub-shrub, and forested wetland and riparian plants as predicted by Hood (Tetra Tech 2007) and Tetra Tech (2009). (see Table 5-3)⁷.*

⁶ Percent of time during the growing season that this elevation range is inundated by tidal flows.

⁷ Establishment of native vegetation on the site will also be affected by the surrounding agricultural landscape with sources of non-native seeds and the existence of reed canarygrass in the system—the potential for non-native plant establishment also exists. Additionally, significant areas within the restoration project area where construction actions leave bare soil will be actively seeded/planted, potentially contributing to establishment of native species within and beyond revegetation areas.

H6: *Restoring a natural and more variable tidal regime will reduce the cover of reed canarygrass in areas where it occurs pre-project.*⁸

5.5.2 Vegetation Study Design and Protocols

Changes in vegetation will be evaluated by a combination of assessing landscape features, quantifying changes in species presence and percent cover, and documenting elevation ranges of selected species. This will allow vegetation changes to be evaluated using three complementary approaches as recommended by Roegner et al. (2008) (1) quantitative measures from aerial photography (vegetation mapping), (2) qualitative photographic documentation, and (3) quantitative sampling in plots.

Assessing landscape features will include mapping major plant community (or treatment areas, see below) boundaries on aerial photographs, and using GIS to evaluate changes in distribution and abundance over time, as well as plotting the location of major plant communities relative to ground surface and tidal elevations. Changes in overall site conditions, including general vegetation conditions, will be obtained through photographic documentation from permanent photographic points (see Section 5.4). Qualitative assessment of vegetation condition or changes in vegetation will include photographic documentation of the vegetation sampling plots (see Figure 5-5). Pre-project conditions are shown in Figure 5-6.

⁸ Reed canarygrass occurs primarily in the existing Fisher Slough floodplain (or marsh plain) between the levees, in ditches adjacent to levees, along the levees, and in the central and southeastern portion of Smith B.

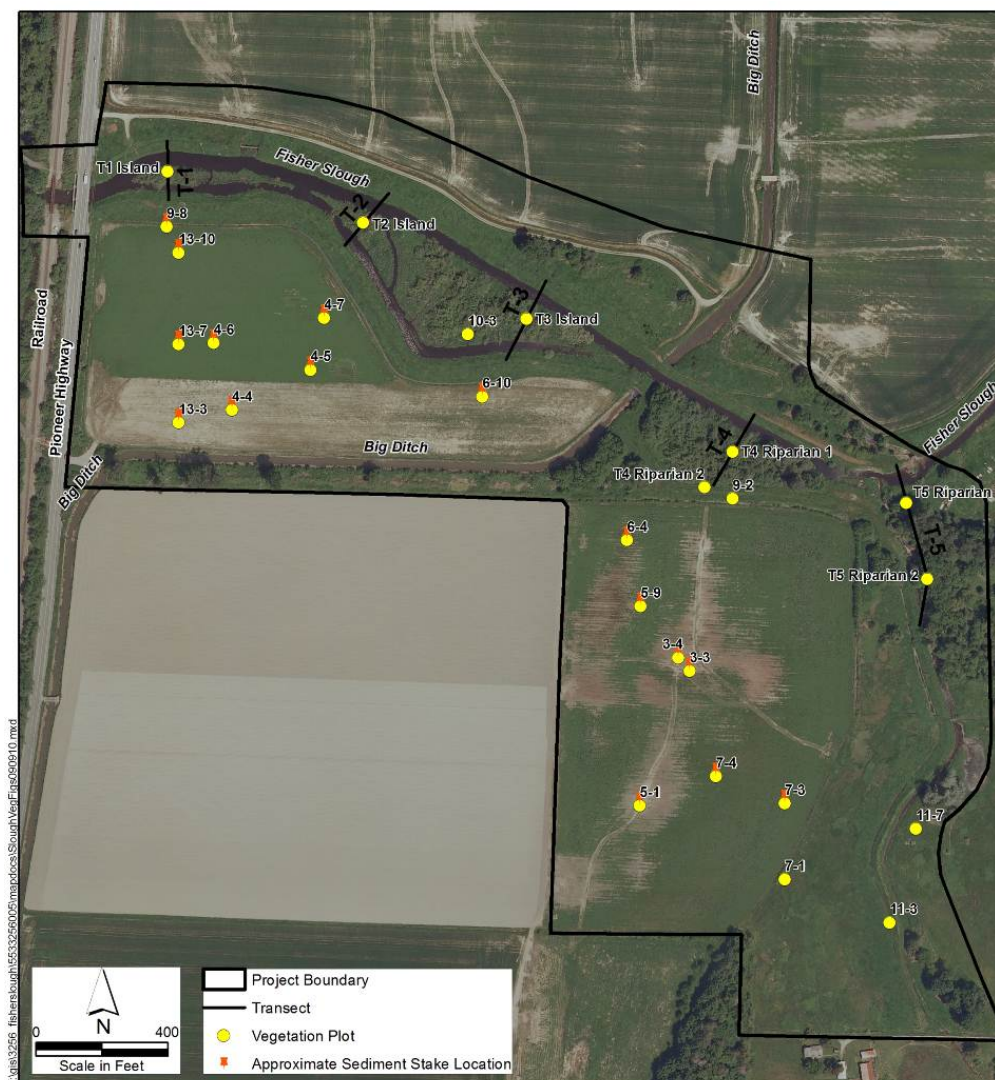


Figure 5-5. Vegetation Sampling Plots and Approximate Sediment Stake Locations

Changes in species richness, percent cover, and correlation of vegetation with elevation/inundation, will be measured in plots using a stratified random sampling design to monitor changes in vegetation in five broad vegetation types or ‘treatment’ areas (1) areas to be hydroseeded with herbaceous marsh vegetation (existing south levee area after levee removal and the new pilot channels); (2) low marsh; (3) high marsh; (4) existing riparian; and (5) new hydroseeding in riparian areas. This will allow vegetation changes to be measured in the areas that are expected to show the greatest effects of levee setback and tidal reconnection – i.e., the areas within parcels Smith A and B that are currently behind the levees and disconnected from Fisher Slough; general areas predicted to contain low marsh, high marsh, and riparian vegetation are shown in (Figure 5-7). Coordinates (latitude, longitude, and elevation) of plot center points within each treatment will be surveyed to allow vegetation data to be geo-referenced and integrated with hydrology and elevation data (Roegner et al. 2008).

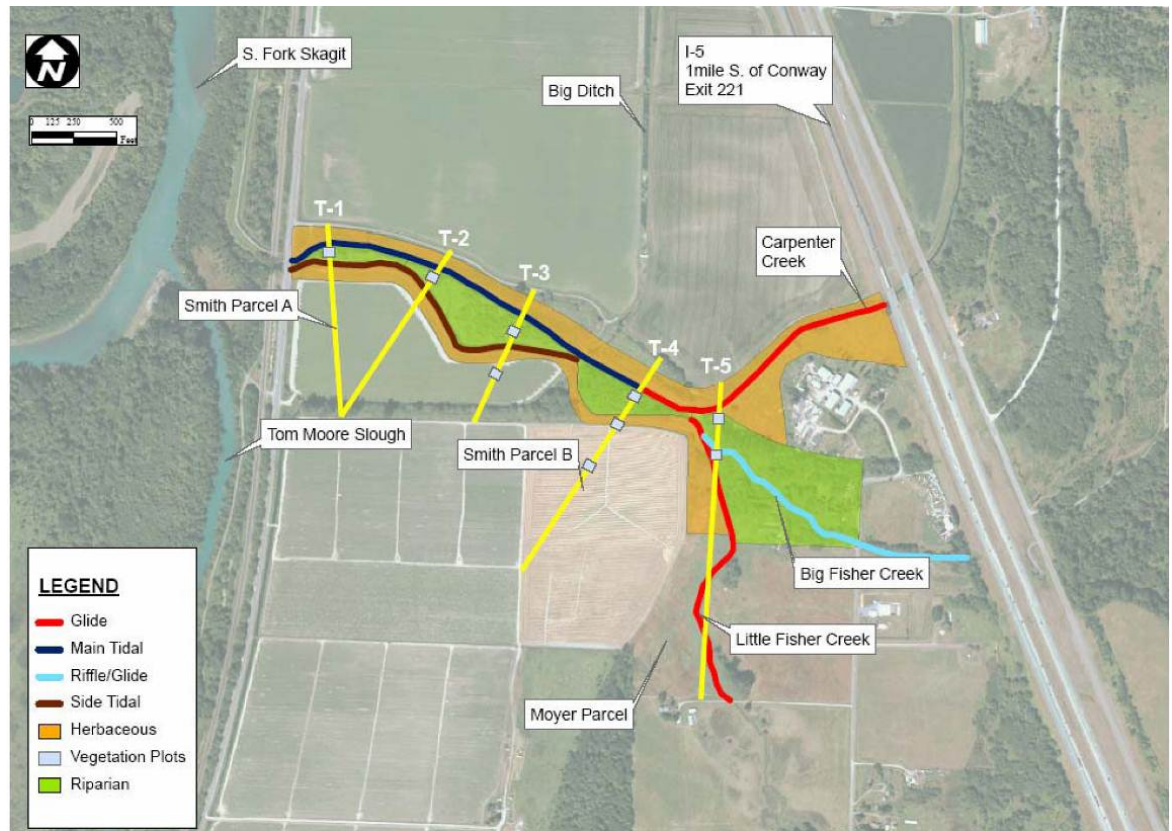


Figure 5-6. Pre-project Habitat and Vegetation Conditions and Monitoring Transects for Fisher Slough

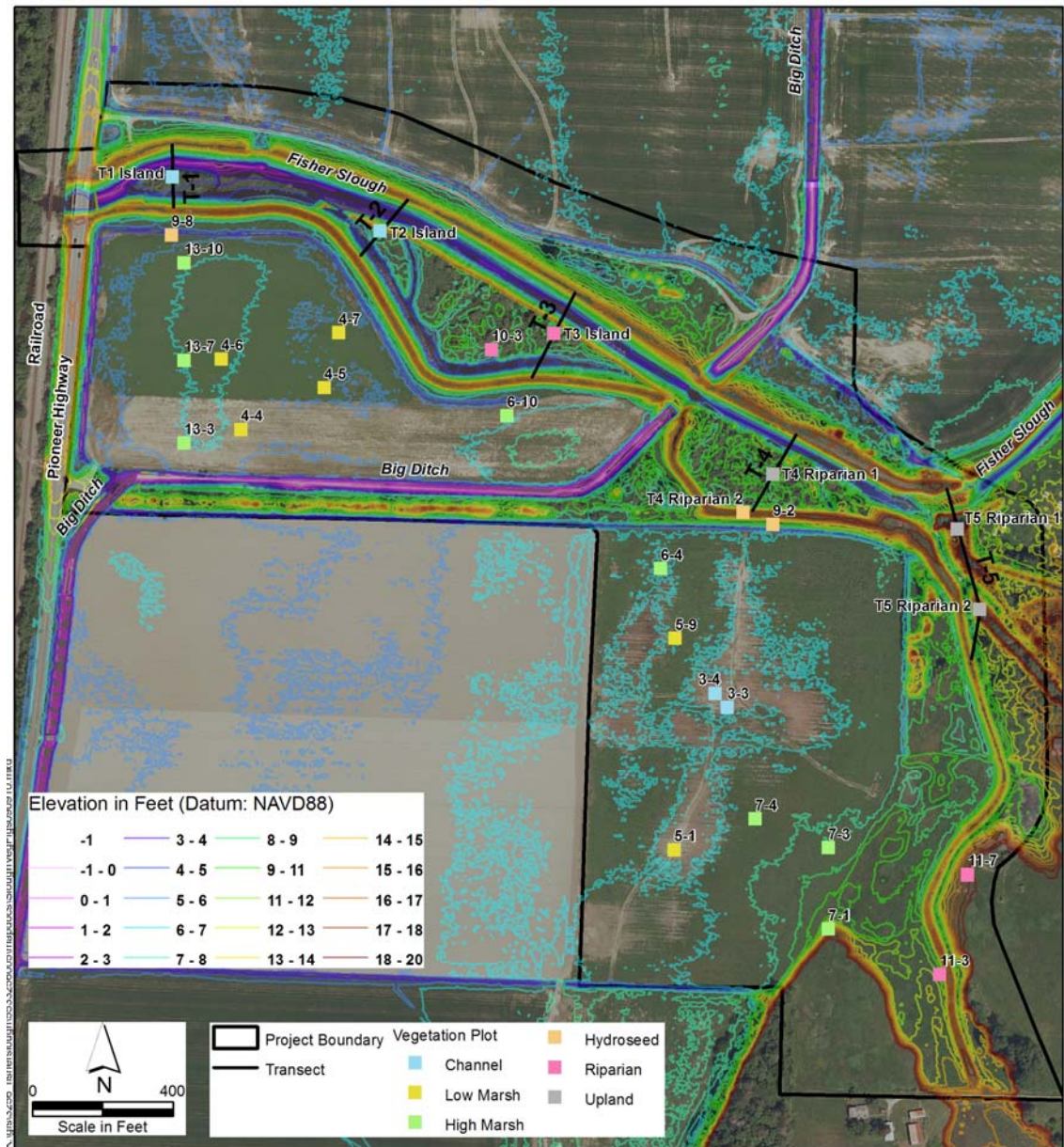


Figure 5-7. Quantitative Vegetation Sampling Plots, Stratified by Treatment Area and Predicted Elevation/Inundation Range

Treatment areas, as defined here include the major vegetation types identified in the Fisher Slough design technical studies (see Table 5-3), plus the marsh (channels), riparian, and upland hydroseed treatments, which were developed to be similar to the existing riparian, upland areas and native low marsh vegetation (Tetra Tech 2009, Appendix A.2; TNC Construction Specifications July 2010). The seven treatment areas used to stratify the sampling are:

1. Marsh hydroseed area; primarily new pilot channels, levee removal area, and borrow pits/topsoil staging areas. Hydroseed mix to include Lyngbye's sedge, slough sedge (*Carex obnupta*), small-fruited bulrush (*Scirpus microcarpus*), and tufted hairgrass (*Deschampsia cespitosa*) (TNC Construction Specifications – Seeding, June 2010).
2. Low marsh vegetation in areas that are frequently inundated, typical species include Lyngbye's sedge (*Carex Lyngbyei*), Slough sedge (*Carex obnupta*), and spikerush (*Eleocharis palustris*).
3. High marsh vegetation at higher elevations in areas that are inundated less frequently; typical species include Lyngbye's sedge, sweetgale (*Myrica gale*), and reed canarygrass (*Phalaris arundinacea*).
4. Existing riparian areas along Fisher Slough, Carpenter, and Fisher Creeks that are inundated infrequently and dominated by shrubs and trees, including various species of willow (*Salix* spp.), spirea (*Spiraea douglasii*), and red osier dogwood (*Cornus sericea*). Reed canarygrass also occurs in this zone.
5. Riparian hydroseed in new riparian areas along new channel alignments (red fescue, perennial ryegrass).

5.5.2.1 Vegetation Mapping

A baseline map of vegetation will be created in the late summer of 2010, using existing orthorectified, true color aerial photographs to map vegetation. The treatment areas (defined above) will be used to determine major vegetation types to be mapped. In 2010, the vegetation types that currently exist on the site—aquatic bed/channel, low marsh, high marsh, riparian, and upland, will be mapped. Areas dominated by reed canarygrass will also be mapped. In 2011, as-built information will be used to add the specific treatment areas to the vegetation map—new channels/low marsh, levee removal area/low marsh, new riparian hydroseed, and upland hydroseed.

Prior to field work in 2010, boundaries of treatment areas (channel, low marsh, high marsh, riparian, and upland)⁹ and known areas of reed canarygrass (based on previous vegetation surveys – Tetra Tech 2009), will be delineated on a base map. Treatment areas will be initially identified based on vegetation strata—i.e., areas where the dominant strata (>50 percent cover) are trees, shrubs, or herbaceous vegetation will be delineated. Additionally, areas that can be categorized from the aerial photographs—upland vegetation on the levees, riparian vegetation adjacent to channels, reed canarygrass documented previously along Fisher Slough will be delineated. Boundaries and categories will be verified and adjusted in the field by walking across the site from north to south at roughly 100 foot intervals and recording where breaks between treatment areas occur, using survey grade GPS. Biologists will determine, while on-site, the vegetation types that clearly transitions to another. For reed canarygrass, all patches greater than 5 feet by 5 feet will be mapped. For all

⁹ Hydroseed areas will not be mapped in 2010; areas hydroseeded will be shown with an overlay on the 2015 maps.

other vegetation types, patches or areas greater than 50 feet by 50 feet will be mapped. In addition, information from the qualitative and quantitative sampling (see below) will be used to verify vegetation types and locations. Following field verification and adjustment, boundaries will be digitized, and GIS maps will be produced showing treatment areas and reed canarygrass patches.

Reed canarygrass rapid assessment surveys will be conducted each year. The locations of the boundaries of mapped reed canarygrass patches will be re-surveyed using survey-grade GPS to determine if patches have expanded or contracted. In addition, the entire site will be rapidly surveyed to identify and map any new isolated patches of reed canarygrass that occur. Areas of reed canarygrass will be plotted as a hatched overlay on the overall vegetation map to show areas and distribution of patches, and the reed canarygrass information will be updated annually between 2010 and 2015.

Vegetation will be mapped again in late summer of 2015. An orthorectified true color aerial photograph of the site taken in 2015 will be used as the base. Changes in vegetation will be evaluated by comparing the 2010 vegetation map with the 2015 vegetation map, including changes in:

- Areal extent of treatment areas (major vegetation types); and
- Areal extent of reed canarygrass.

Based on design studies (Tetra Tech 2009), the area of major vegetation types (treatment areas) predicted to establish on the site based on elevation and tidal inundation are summarized in Table 5-4.

Table 5-4. Area (acres) of Each Vegetation Type (treatment areas) Predicted to Establish in the Smith A and B Parcels (from Tetra Tech 2009, Appendix C.2)

Vegetation/ Habitat Type	New Area (Smith A)	New Area (Smith B)	New Area (Tributary)	EXISTING Area Before Restoration	Total Area After Restoration	% of Restored Area
Channel (or pond)	0.1	0.1	0.0	1.4	1.6	2.7%
Low Marsh	12.0	8.5	0.6	1.7	22.7	37.3%
High Marsh	6.4	7.2	1.2	1.0	15.8	25.9%
Riparian	0.7	2.1	8.8	4.1	15.7	25.9%
Upland	0	0	3.5	1.6	5.1	8.4%
Total	19.2	17.8	14.1	9.8	60.8	100%

5.5.2.2 Qualitative Vegetation Sampling

Qualitative vegetation sampling will be used to provide visual assessments of changes in vegetation on the site following restoration. Two types of qualitative sampling will occur (1) photo-documentation at permanent photo points and in vegetation plots, and (2) annual reed canarygrass rapid assessment surveys.

Photographic Documentation

Photographs taken quarterly (described above in Section 5.4.2.2) at the permanent photo points will allow tracking of changes in overall site conditions as the site develops. As described above (Section 5.4.2.2), additional photo points will be established in 2010 at the vegetation plots. A small set of these will be selected to allow areas to be hydroseeded, low

marsh, high marsh, and riparian vegetation to be qualitatively tracked during years when quantitative sampling does not occur. Changes in vegetation between 2010 and 2015 will also be documented with photographs of the quantitative sampling plots (see below). Photographs will be examined for vegetation conditions that are consistent (or not) with restoration predictions. For example, evidence of development of low or high marsh vegetation or establishment and growth of native shrubs or trees in new riparian areas are consistent with restoration expectations. Evidence of dead or stressed plants, or non-native invasive plants in new areas may indicate the need for additional monitoring and/or management actions. Vegetation changes documented in the photographs will be described in each annual monitoring report.

Reed Canarygrass Rapid Assessment

Beginning in 2010 and continuing each year during the monitoring period, the site will be surveyed for occurrences of invasive reed canarygrass. Reed canarygrass patches will first be identified and mapped during the summer 2010 monitoring effort (see Section 5.5.2.1, Vegetation Mapping). Most of the reed canarygrass occurs along the edges of the slough between the levees, although patches also occur on levees and in adjacent agricultural fields. Boundaries of the patches will be drawn on the aerial photograph base and GPS positions recorded. Each subsequent monitoring year during the summer data collection effort (e.g., downloading level loggers), reed canarygrass patches will be re-mapped and GPS positions of the boundaries recorded to determine if patches are expanding or contracting.

In addition, during annual data collection efforts, biologists will look for new patches of reed canarygrass in two ways. First, during all routine data collection such as downloading level loggers or collecting sedimentation data, field crews will look for occurrences of reed canarygrass. Second, during the annual summer data collection period, biologists will conduct a rapid assessment survey of the site to look for occurrences of reed canarygrass. Biologists will use a random meander method (Elzinga et al. 1998, Huebner 2007), by walking through portions of the site that were not covered by the routine data collection effort. In these areas of the site, surveyors will walk in a meandering or zig-zag pattern to cover the entire area, looking for occurrences of reed canarygrass. Any occurrences of reed canarygrass will be marked on a field map, and the location recorded with GPS and marked with flagging. The vegetation map will be updated annual with the results of the reed canarygrass surveys.

Information on reed canarygrass collected by these two methods will be communicated to TNC immediately following the field visit, and will be included in the annual monitoring reports. These qualitative surveys will allow for any newly establishing reed canarygrass to be identified, and for implementation of management measures as necessary.

5.5.2.3 Quantitative Vegetation Sampling

Limited quantitative vegetation monitoring was conducted during the summer of 2006, during the project assessment and design stage. To evaluate changes in vegetation following restoration, and in particular to evaluate the relationship between vegetation and elevation or tidal inundation, additional plots were established in 2010 for quantitative sampling. Vegetation abundance and composition was measured as percent canopy cover (for herbaceous and shrub vegetation) and presence (for trees) by species, using random sampling stratified by the treatment areas defined above (Elzinga et al. 1998, Tetra Tech 2009).

Results of the quantitative sampling will be used to compare actual distribution with predicted distributions (see Table 5-2).

Vegetation Sampling Design

Stratified random sampling will allow vegetation to be sampled from the range of elevations and tidal inundation conditions expected on the site, including, riparian zones, channel edges, low marsh, and high marsh treatment areas (Roegner et al. 2008). Once treatment areas have been identified and delineated on a base map, an approximately 50 foot by 50 foot grid will be overlain on the treatment areas using GIS. Points on the grid will be assigned a number and latitude/longitude coordinates will be recorded. Using a random number generator, a number of points will be selected in each treatment area to be used to establish plot locations. There were 2 to 4 plots established per treatment area. Existing plots for 2006 sampling were assigned to one of the six treatment areas, depending on their location. Locations of vegetation plots and stratification by treatment area and predicted elevation/inundation ranges are shown in Figure 5-7. After analysis of the data gathered in 2010 and completion of the project as-built it will be determined if any additional plots are needed and where they should be located.

Due to the limited amount of pre-project vegetation sampling, there was not enough information to base sample size calculations. Therefore, data collected in the summer of 2010 will be used to calculate adequate sample sizes for estimating percent cover with an 80 percent confidence level and confidence interval no greater than 20 percent (Elzinga et al. 1998) and will be documented in subsequent monitoring reports.

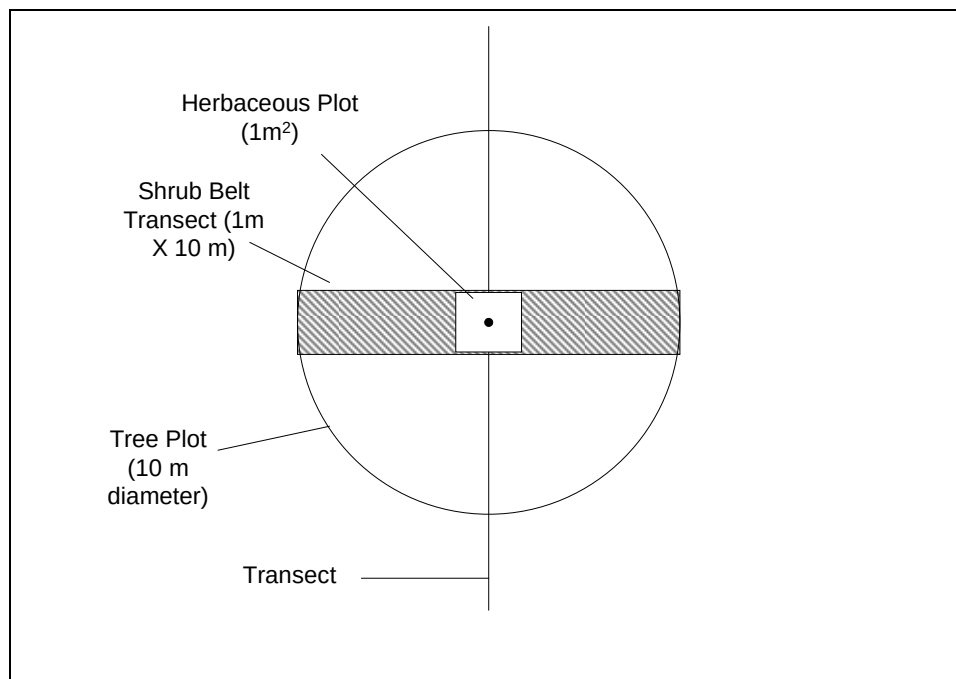


Figure 5-8. Plot Design for Sampling Herbaceous, Shrub, and Forested Vegetation

Sampling plot size and shape will differ depending on the vegetation layer to be sampled for herbaceous/emergent vegetation, 1 meter square plots; for scrub-shrub vegetation, belt transects (10 meters by 1 meter); and for forested vegetation, circular plots of 33 feet, or 10 meters, in diameter (Thom et al. 2002; Havens et al. 2003; Elzinga et al. 1998; Rice et al. 2005) (Figure 5-8).

Plot centers will be marked temporarily with stakes to facilitate elevation surveys, and the center location will be recorded with survey grade GPS (to verify coordinates from GIS). The ground surface elevation of each plot center point will be surveyed, to tie sampling locations to elevation and site benchmarks. Quantitative sampling will occur in 2010, in 2013, and again in 2015.

Vegetation Sampling Protocols

Stratifying the site by predicted elevation zones and vegetation types, and determining plot size and shape will follow methods described in Elzinga et al. (1998).

Selecting Blocks for Stratifying the Site and Randomizing Plots

The methods described above were used to stratify the site by vegetation types/treatment areas and randomly generate the sample plot locations. In the field, using GPS, locate each point and establish a plot at that location, until there are 2 to 4 plots per treatment area, depending on the size of the area to ensure representative coverage of each treatment area. Additional plots can be assigned as needed in 2013 to ensure coverage of seeded areas (these may be difficult to locate accurately on the ground in 2010). Assign the six plots sampled in 2006 (Tetra Tech 2007) to one of the treatment areas.

Plots will be temporarily marked with wooden stakes to facilitate survey, but permanent staking (e.g., rebar) of the plots will not be used to mark permanent plot locations. Because construction activities between in 2010 will disturb much of the site and quantitative sampling will only occur again in 2013 and 2015, permanent plot markers (e.g., rebar) will likely interfere with construction or not be easily re-located. Plot coordinates recorded in 2010 will be used to relocate plots in 2013 and 2015.

Table 5-5 shows the treatment areas, general location, and assigned treatment area label.

Table 5-5. Sampling Design for Vegetation

Site Stratification	Sampling Blocks/Location	Treatment Area (Block) Label	Estimated Number Plots
Marsh Hydroseed	Pilot Channels Smith A	C2	2-3
	Pilot Channels Smith B	C3	2-3
	Old south levee and borrow pit/storage areas on both Smith A and B	H2	2-3
Low Marsh	Smith A	LM1	2-3
	Smith B	LM2	2-3
High Marsh	Smith A	HM1	2-3
	Smith B	HM2	2-3
Riparian – intact	Existing Fisher Slough Islands	R1	2-3
Riparian – new hydroseed	New Tributary (SE corner of site)	R2	2-3

Establishing Plots and Sampling Vegetation

Mark the center of each plot with a temporary wooden stake. Survey the location and elevation of each plot center; assign each plot a number ID (treatment area label plus plot number; e.g., for the low marsh area in Smith A, LM1-1). Take two photographs of the plot center from a point due south of the plot and about 20 feet outside of the plot, looking

towards the center to the north. One photograph looks down at the plot center, the second photograph looks towards the perimeter of the plot to show a slightly larger area.

Visual estimates of plant cover are recommended as an estimate of biomass and abundance; plant cover measures are relatively rapid and are not biased by size and distribution of individuals (Mueller-Dombois and Ellenberg 1974; Floyd and Anderson 1987). Plant cover is defined as the vertical projection of all living aerial parts of plants as percentage of the total plot area (Westhoff and van der Maarel 1973).

At each plot location, sample herbaceous, shrub, and tree layers separately (sampling each depending on which vegetation layers are present). For herbaceous vegetation, establish the 1 square meter plot and record all species observed in the plot. Visually estimate the percent of the 1 square meter plot that is covered by the canopy of each species (even if a plant is rooted outside the plot). Canopy cover will be recorded in 5 percent increments, using “trace” for species present at less than 5 percent cover. Percent cover is estimated as “canopy cover” or “aerial cover”—the area covered by the outline of the total area occupied by the plant’s stems and foliage, extended from the top of the plant to the ground surface (see Figure 5-9) (Elzinga et al. 1998). Total cover within the plot can therefore exceed 100 percent.

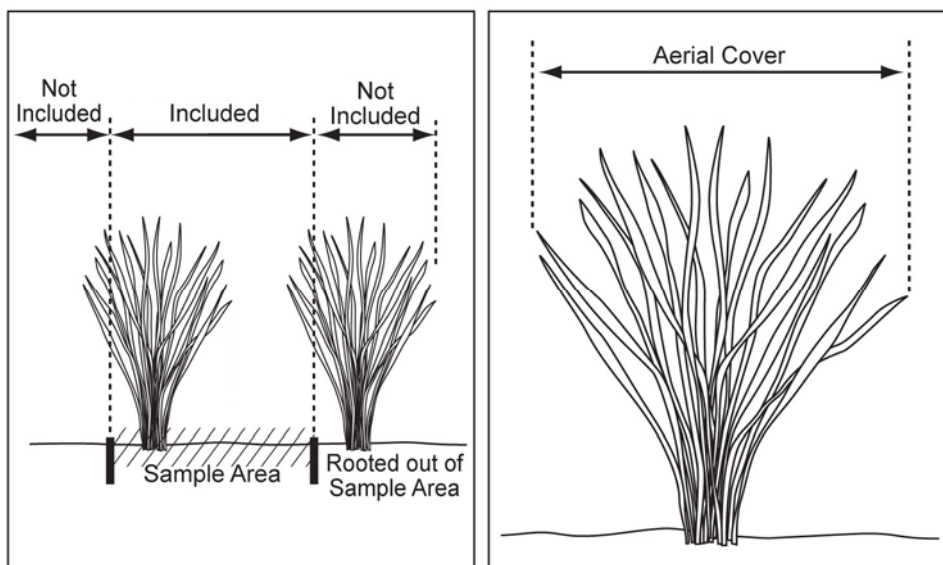


Figure 5-9. Vegetation Sampling Methods

For shrubs, establish the belt transect as in Figure 5-8. Identify and record all species of shrubs that are within the belt transect. Visually estimate the percent of the belt transect that is covered by the canopy of each species. Record percent canopy cover for each species that is in the belt transect (even if the plant is rooted outside of the belt transect). Record percent canopy cover in 5 percent increments, using “trace” for species present at less than 5 percent cover. Percent cover is estimated as “canopy cover” or the area covered by the outline of the total area occupied by the plant’s stems and foliage, extended from the top of the plant to the ground surface (Elzinga et al. 1998). Total cover within the belt transect can therefore exceed 100 percent.

For trees, establish the circular plot by laying the tape perpendicular to the shrub belt transect, measuring to 10 meters, and marking the edges of a 10 meter diameter circle at 4 to 5 points with pin flags. Identify all trees in the plot to species and record the number of trees for each species. Visually estimate the percent of the circular plot that is covered by the canopy of

each species. Record percent canopy cover for each species that is in the plot (even if the plant is rooted outside of the plot). Record percent canopy cover in 5 percent increments, using “trace” for species present at less than 5 percent cover. Percent cover is estimated as “canopy cover” or the area covered by the outline of the total area occupied by the plant’s stems and foliage, extended from the top of the plant to the ground surface (Elzinga et al. 1998). Total cover within the plot can therefore exceed 100 percent.

5.5.3 Vegetation Sampling Data Analysis and Reporting

To evaluate vegetation hypotheses, the results of vegetation sampling in any given year will be compared to the results from 2010. The following data will be presented:

Vegetation Distribution and Abundance from Maps. The following parameters will be calculated from the vegetation maps using GIS, and used to compare vegetation conditions in 2010 with conditions in 2015:

- Total area and percent total area, of marsh hydroseed, upland hydroseed, aquatic/channel, low marsh, high marsh, riparian, and upland;
- Total area and percent total area, of reed canarygrass; and
- Elevation ranges of low marsh, high marsh, riparian areas derived from mapped vegetation distributions, and elevations from project LiDAR.

Species Abundance, Distribution, and Composition from Quantitative Sampling.

Species abundance, distribution, and composition measures will be reported by treatment area as means, standard deviation, and ranges. To evaluate changes in vegetation, results in each year of quantitative sampling (2010, 2013, and 2015) will be compared to 2010 results.

Species Abundance:

- Percent cover by species and treatment area.

Species Distribution (elevation):

- Elevation frequency distribution curves for all species recorded in plots¹⁰ (relative to NAVD88) (Leary et al. 2006). Elevation ranges will be compared to predicted values (see Table 5-3).

Species Composition:

- Complete list of species recorded in each treatment area.
- Native species richness by treatment area and site.

¹⁰ Focus will be on evaluated distributions of selected channel, low marsh, high marsh, and riparian species, as well as reed canarygrass.

5.6 FISH COMMUNITY

Fish sampling will be conducted by the SRSC, using the methodology developed for estuarine fish sampling (SRSC 2003, www.skagitcoop.org/, attached as Appendix A). Fish monitoring will occur twice per month from February through August on an annual basis (except for years two and four) in coordination with the Skagit River System Cooperative's (SRSC) juvenile Chinook monitoring program.

The goal of the fish sampling is to evaluate hypotheses associated with Objectives 2 and 3, as described in Appendix A. Annual reports documenting the results of fish sampling will be prepared by the SRSC and included in each Fisher Slough Annual Monitoring Report as an Appendix.

5.7 SUMMARY OF MONITORING METHODS

Section 6.3 summarizes the environmental parameters to be measured, monitoring methods, and data collection frequency for Fisher Slough monitoring.

6. MONITORING SCHEDULE

Monitoring of the Fisher Slough Project includes several periods of pre-project data collection, as well as the proposed 2010 baseline and five years of post-project monitoring (Table 6-1).

6.1 PRE-PROJECT MONITORING

Baseline monitoring, or pre-project data collection, occurred as part of project feasibility and design stages in 2006 to 2009 (Tetra Tech 2007, SRSC 2007). A baseline monitoring report that presents the results of the monitoring efforts between 2006 and 2009 was prepared in the summer of 2010.

Baseline data will continue to be collected in 2010, after the completion of Project Element 1, but before Project Elements 2 and 3. The 2010 baseline monitoring will be conducted according to this Monitoring and Adaptive Management Plan.

6.2 POST-PROJECT MONITORING

This monitoring plan calls for the site to be monitored for a total of seven years, with five years of monitoring following completion of Project Element 3. Not all monitoring tasks will occur in each year. The following summarizes the overall data collection and monitoring schedule:

- 2006 to 2009 – Pre-project design studies
- 2009 – Construction Project Element 1
- 2010 – Construction Project Element 2
- 2011 – Construction Project Element 3; as-builts
- 2012 – Monitoring
- 2013 – Monitoring
- 2014 – Monitoring
- 2015 – Final year of proposed monitoring

The summary of monitoring report deliverables, and parameters and hypotheses evaluated for each monitoring year is provided in Table 6-1.

Annual monitoring reports that contain the results of all data collected from January 1 through December 31 of each year will be completed for each year that funding is available. Floodgate reports each year will summarize the results of operations from October 1 through September 30.

Future monitoring and reporting will only be completed if funding can be secured to complete identified tasks (Table 6-2). As of February 2010, funding has been secured for monitoring activities through December of 2011.

6.3 MONITORING PRODUCTS

Annual monitoring products are listed with Table 6-2, report due dates and funding status.

Table 6-1. Annual Monitoring Reports, Parameters and Hypotheses Evaluated for Fisher Slough ^a

Year	Deliverable	Parameters/Environmental Attributes	Hypotheses to be Evaluated
1 - 2009	Baseline Monitoring Report 2009 Fish Utilization Report	Surface water elevation DO and temperature Marsh elevations and LiDAR ^b Channel area and extent Photo-point documentation Vegetation abundance ^c Stream macroinvertebrate data ^d Groundwater elevations (partial year data) Fish abundance ^e	No hypotheses; baseline data only
2 - 2010	2010 Monitoring Report Floodgate Report (October 1, 2009 through September 30, 2010)	Surface water elevations Marsh elevations DO and temperature in Fisher Slough Channel area and extent Channel profile through Big Ditch reach Photo-point documentation Qualitative vegetation data – maps and photo documentation Vegetation abundance Groundwater elevations Fish abundance ^f Floodgate operation/gate position	H1: Replacement/revised operation of the floodgate (post-project condition) will result in increased tidal amplitude and water elevations upstream of the new floodgate, compared to pre-project conditions. ☑ H2: Restoration of tidal exchange will increase twice daily mixing of waters in Fisher Slough on the project site, increasing oxygen levels and reducing temperatures compared to pre-project conditions, particularly during the summer months. ☑ H8: Chinook salmon abundances (0+ year class) will be similar above and below the floodgates (post replacement) during peak migration periods. ☑ H9: Juvenile Chinook salmon will utilize restored channels and marshes at densities similar to other Skagit freshwater tidal marshes, adjusted for landscape connectivity. ☑ H10: Floodgate operation will improve fish passage opportunity for coho and chum compared to pre-project conditions.
3 - 2011	2011 Monitoring Report As-Built Report	Surface water elevations Channel area and extent (as-builts) Channel profile through Big Ditch reach Marsh elevations (as-builts) Sedimentation rates DO in Fisher Slough Temperature in Fisher Slough Qualitative vegetation survey – RCG survey and photo documentation Plantings (as-builts) Photo-documentation Floodgate operation/gate position Groundwater elevations	H1: Replacement/revised operation of the floodgate (post-project condition) will result in increased tidal amplitude and water elevations upstream of the new floodgate, compared to pre-project conditions, particularly during spring Chinook migration periods. ☑ H2: Restoration of tidal exchange will increase twice daily mixing of waters in Fisher Slough on the project site, increasing oxygen levels and reducing temperatures compared to pre-project conditions, particularly during the summer months. ☑ H7: Restored tidal exchange will re-introduce sediment transport and scouring of tidal channels on the project site, resulting in the creation of greater overall channel area and a more complex channel network compared to pre-project conditions. ☑ H11: Removal of the passage barrier at Big Ditch will result in more natural channel profile through this area. ☑ H12: Levee setback and restoration of tidal exchange will result in 310 acre feet available for flood water storage (i.e., greater floodplain and channel area) during high flows.

Table 6-1. Annual Monitoring Reports, Parameters and Hypotheses Evaluated for Fisher Slough (continued)

Year	Deliverable	Parameters/Environmental Attributes	Hypotheses to be Evaluated
4 - 2012	2012 Monitoring Report	Surface water elevations Water quality – DO and temperature Sedimentation rates Qualitative vegetation – RCG survey and photo documentation Photo monitoring – overall site Floodgate operation/gate position Fish abundance Groundwater elevations	H8: Chinook salmon abundances (0+ year class) will be similar above and below the floodgates (post replacement) during peak migration periods. ☑ H9: Juvenile Chinook salmon will utilize restored channels and marshes at densities similar to other Skagit freshwater tidal marshes, adjusted for landscape connectivity. ☑
5 - 2013	2013 Monitoring Report Mid-Project Report	Surface water elevations Marsh elevations Sedimentation rates DO and temperature in Fisher Slough Channel area and extent Channel profile through Big Ditch reach Photo-point documentation Aerial photos Qualitative vegetation data – RCG survey, maps and photo documentation Vegetation abundance/quantitative sampling ^g Groundwater elevations Fish abundance ^h Floodgate operation/gate position	H1: Replacement/revised operation of the floodgate (post-project condition) will result in increased tidal amplitude and water elevations upstream of the new floodgate, compared to pre-project conditions. ☑ H2: Restoration of tidal exchange will increase twice daily mixing of waters in Fisher Slough on the project site, increasing oxygen levels and reducing temperatures compared to pre-project conditions, particularly during the summer months. ☑ H3: Relocation of the confining levees will restore 50 acres of tidal marsh which will result in a total of 60 acres of freshwater tidal marsh area - the area of tidally inundated freshwater wetland will increase. ☑ H4: Restored tidal exchange/levee setback and greater inundation will result in accretion and aggradation of the ground surface in tidal marsh areas. ☺ H5: Restoration of tidal, fluvial, and sediment processes (and limited planting) will result in recolonization of the site by native freshwater wetland emergent, scrub-shrub, and forested wetland and riparian plants as predicted by Hood (TT 2007) and (TT 2009). ☺ H6: Restoring a natural and more variable tidal regime will reduce the cover of reed canarygrass in areas where it occurs pre-project. ☺ H7: Restored tidal exchange will re-introduce sediment transport and scouring of tidal channels on the project site, resulting in the creation of greater overall channel area and a more complex channel network compared to pre-project conditions. ☺ H8: Chinook salmon abundances (0+ year class) will be similar above and below the floodgates (post replacement) during peak migration periods. ☑ H9: Juvenile Chinook salmon will utilize restored channels and marshes at densities similar to other Skagit freshwater tidal marshes, adjusted for landscape connectivity. ☑ H10: Floodgate operation will improve fish passage opportunity for coho and chum compared to pre-project conditions. H11: Removal of the passage barrier at Big Ditch will result in more natural channel profile through this area. ☑ H12: Levee setback and restoration of tidal exchange will result in 310 acre feet available for flood water storage (i.e., greater floodplain and channel area) during high flows. ☑

Table 6-1. Annual Monitoring Reports, Parameters and Hypotheses Evaluated for Fisher Slough (continued)

Year	Deliverable	Parameters/Environmental Attributes	Hypotheses to be Evaluated
6 - 2014	2014 Monitoring Report	Surface water elevations Water quality – DO and temperature Sedimentation rates Qualitative vegetation – RCG survey and photo documentation Photo monitoring – overall site Floodgate operation/gate position Groundwater elevations	Qualitative update on site conditions.
7 - 2015	2015 Monitoring Report – Final Report	Surface water elevations Marsh elevations Sedimentation rates DO and temperature in Fisher Slough Channel area and extent Channel profile through Big Ditch reach Photo-point documentation – overall site Aerial photos Qualitative vegetation data – RCG survey, maps and photo documentation Vegetation abundance/quantitative sampling ⁱ Groundwater elevations Fish abundance ^j Floodgate operation/gate position	All hypotheses (H1 – H12) evaluated.

^a Hypotheses that have a ☑ (check box) following the item indicates that data analysis will yield a “yes/no” answer regarding expected project outcomes. Hypotheses marked with a ☺ indicate priority questions where analysis will examine trends over time.

^b LiDAR data collected in 2006.

^c Vegetation sampling conducted in 2006 and results reported here.

^d Invertebrate sampling conducted in 2006 and results reported here.

^e See SRSC fish monitoring reports for fish sampling details.

^f See SRSC fish monitoring reports for fish sampling details.

^g Invertebrate sampling conducted in 2006 and results reported here.

^h See SRSC fish monitoring reports for fish sampling details.

ⁱ Invertebrate sampling conducted in 2006 and results reported here.

^j See SRSC fish monitoring reports for fish sampling details.

Table 6-2. Reporting Schedule, Reporting Dates, and Funding

Deliverable ^a	Completion Date	Funding
2009 Baseline Monitoring Report	October 15, 2010	Yes
2009 Fish Monitoring Report	February 28, 2010	Yes
2010 Monitoring Report and 2010 Floodgate Report	January 31, 2011 November 1, 2010	Yes
2010 Fish Monitoring Report	January 31, 2011	Yes
2011 Monitoring Report – As-built Report	January 31, 2012	
2012 Monitoring Report	January 31, 2013	
2012 Fish Monitoring Report		
2013 Monitoring Report – Mid-project Report	January 31, 2014	
2013 Fish Monitoring Report		
2014 Monitoring Report	January 31, 2015	
2015 Monitoring Report	January 31, 2016	
2015 Fish Monitoring Report		
Fisher Slough FINAL MONITORING REPORT	May 30, 2016	

^a Note: Monitoring deliverables will be generated from project monitoring and their proposed completion date, funding dependent.

7. ADAPTIVE MANAGEMENT PLAN

The adaptive management component of the plan is designed to address the inherent uncertainty in ecological restoration projects, and seeks to minimize this uncertainty by learning about the system being managed (Thom and Wellman 1996, Thom 2000, Linkov et al. 2006). The basic process for adaptive management followed here includes five components:

1. A conceptual model of existing conditions and ecological processes affecting the restoration site that is used to predict the likely outcomes of individual restoration actions;
2. Clear statement of the goals and objectives for the restoration project;
3. Development of performance targets or criteria for evaluating outcomes relative to the goals and objectives;
4. Monitoring the effects of the restoration actions relative to performance criteria; and
5. Adjusting restoration actions as needed – if performance criteria are not met, develop contingency plans or measures (decision framework) for adapting designs or implementing new actions.

7.1 PERFORMANCE CRITERIA/TARGETS

Performance criteria are summarized in Table 4-1 for each hypothesis.

7.2 POTENTIAL CONTINGENCY MEASURES

Natural systems are highly variable and there is significant uncertainty surrounding predictions about how the project site will respond to restoration actions. Restoration actions may have unexpected or unanticipated effects and/or conditions and factors external to the restoration may cause the site to respond in an unexpected way. Due to this uncertainty, when the project targets and objectives are not met, there are three basic alternatives (Thom and Wellman 1996; Rice et al. 2005):

- No action
- Maintenance
- Modification of goals or performance criteria

No action means that no corrective action will be taken and no change in goals or targets is needed. For example, elevation ranges of native vegetation at Fisher Slough may not match those found elsewhere in Skagit delta marshes. However, as long as native vegetation is establishing successfully and contributing to habitat function, differences in elevation between the project site and other sites in the Skagit may result in new hypotheses, but do not require any action.

Maintenance is the most common response to project targets not being met and includes any physical actions that are taken to maintain the progress or course of changes desired on the restoration site. Examples include invasive species management and re-planting with native species if the abundance of non-native invasive is greater than specified in project targets.

A simple decision framework should be used to determine appropriate contingency actions if project targets are not met. The framework includes the following steps and questions:

- Performance criteria is not met during a given monitoring year;
- Is the trend in the right direction, but the target has not been met? – No action; continue to monitor;
- Is the trend in the wrong direction and the target has not been met? – determine the likely cause and select among possible contingency actions;
 - Have controlling factors or influences external to the project site changed and may be contributing to site performance?
 - Are other site conditions not performing as expected and may be contributing factors?
 - What contributing factors can be affected on the project site to correct the problem?

At Fisher Slough, based on the site conditions, landscape setting, uncertainty surrounding the hypotheses, and the combination of active and passive restoration being proposed, the following targets have the most likelihood of not being met in the early stages of monitoring:

- Establishment of native freshwater marsh vegetation.
- Presence and abundance of reed canarygrass or other invasive plants.
- Elevation/vegetation correlations.
- Rate of channel formation and channel geomorphology.
- Changes in surface elevation or sedimentation rates.

Potential contingency measures most likely to be available for maintenance at Fisher Slough:

- Modify operation of the floodgates per negotiations with Dike District 3 and Washington Department of Fish and Wildlife
- Reed canarygrass management measures, to include manual controls and/or herbicide treatment to eradicate small patches and control the spread of larger areas.
- Re-planting of areas with native shrubs and/or trees if reed canarygrass begins establishing in high marsh or riparian areas.
- Re-grading/re-contouring of site to establish desired elevations and inundation conditions.
- Adding channel habitat features and/or riparian plantings to influence habitat conditions for salmon and/or water quality parameters.

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APPENDIX A

Fish Sampling Methods from Skagit River System Cooperative

Skagit System Cooperative
Research Department
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La Conner, WA 98257-0368

ESTUARINE FISH SAMPLING METHODS

March 2003

We sample estuarine habitat using three different methods (small net beach seine, large net beach seine, and fyke trap) depending on the habitat types.

Small net beach seine methods are used for sampling shallow intertidal shoreline areas of Skagit and Padilla Bays or distributary channel habitat in the Skagit tidal delta and Swinomish Channel. The areas seined are typically less than 4ft deep (1.2m) and have relatively homogeneous habitat features such as: water depth and velocity, substrate, and vegetation. Small net beach seine methodology uses an 80' (24.4m) by 6' (1.8m) by 1/8" (0.3cm) mesh knotless nylon net (Figure 1). The net is set in "round haul" fashion by fixing one end of the net on the beach while the other end is deployed by wading the net "upstream" against the water current using a floating tote, and then returning to the shoreline in a ½ circle. Both ends of the net are then retrieved yielding a catch. We typically conduct three sets per site.

Large net beach seine methods are used for sampling the intertidal-subtidal fringe of the Skagit and Padilla Bays. These areas are typically deeper than the areas seined by small net beach seine, ranging from 6-15ft (1.8-4.6m) requiring a longer and deeper net. Large net beach seine methodology uses a 120' (36.6m) by 12' (3.7m) by 1/8" (0.3cm) mesh knotless nylon net where one end of the net is fixed on the beach while the other end is set by boat across the current at an approximate distance of 60 percent of the net's length (Figure 2). After the set has been held open against the tidal current for a period of about 4 minutes, the boat end is brought to the shoreline edge and both ends are retrieved yielding a catch in the net's bunt section. We typically conduct three sets per site.

Fyke trap methods are used for sampling blind tidal channel habitat in the Skagit tidal delta, Swinomish Channel corridor, and southern Padilla Bay. Fyke trap methodology uses nets constructed of 1/8" (0.3cm) mesh knotless nylon with a 2' (0.6m) by 9' (2.7m) diameter cone sewn into the net to collect fish draining out of the blind channel site (Figure 3). Overall net dimensions (length and depth) are variable depending on the site's cross-sectional channel dimensions. All nets are sized to completely block fish access at high tide. The net is set across the blind channel site at high tide and "fished" through the ebb tide yielding a catch. The juvenile chinook catch is adjusted by a trap recovery efficiency (RE) estimate that is derived from mark-recapture experiments using a known number of marked fish released upstream of the trap at high tide. RE is usually related to hydraulic characteristics unique to the site (e.g., change in water surface elevation during trapping, or water surface elevation at the end of trapping). Multiple RE tests (several times per season) at each site are used to develop a regression model to convert the "raw" juvenile chinook catch to an estimated population within the habitat upstream of the fyke trap on any sampling day.

Data collected for each beach seine set include:

- Time and date of set
- Tidal stage (ebb, flood, high tide slack, low tide slack)
- Water surface area seined
- Length of time the set is held open (large net only)
- Surface and bottom water temperature of area seined using YSI meter
- Surface and bottom salinity of area seined using YSI meter
- Maximum depth of area seined
- Average surface water velocity (small net only) using a flow meter
- Substrate of area seined following the definitions shown in Table 1 (small net only, unless substrate type is uniform for large net area)
- Vegetation of area seined following the definitions shown in Table 2 (small net only, unless vegetation type is uniform for large net area)
- Complete fish catch records by species following the coding shown in Table 3
- Sub-sample of individual juvenile chinook lengths and weights (following mark coding shown in Table 4)
- Sub-sample of individual lengths on all other fish species (following mark coding shown in Table 4)

Data collected for each fyke trap set include:

- Time at start and end of trapping
- Water surface elevation at start and end of trapping
- Surface and bottom water temperature at start and end of trapping
- Surface and bottom salinity at start and end of trapping
- Complete fish catch records by species following the coding shown in Table 3
- Sub-sample of individual juvenile chinook lengths and weights (following mark coding shown in Table 4)
- Sub-sample of individual lengths on all other fish species (following mark coding shown in Table 4)

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Table 1. Definitions of Substrate Types Modified from Dethier (1990)

Substrate Type	Definition
Bedrock	75% of the surface is covered by bedrock, commonly forming bluffs and headlands.
Boulder	75% of the surface is covered by boulders (>256mm).
Cobble	75% of the surface is covered by clasts 64 to 256mm in diameter.
Gravel	75% of the surface is covered by clasts 4 to 64mm in diameter.
Mixed Coarse	No one size comprises > 75% of surface area. Cobbles and boulders are > 6%.
Fines With Gravel	No one clast size comprises more than 75% of the surface area. Cobbles and boulders make up > 6% of the surface area; Coarse sediments combined make up < 55%. Rich with epibenthic fauna.
Sand	More than 75% of the surface area consists of sand 0.06 to 4 mm in diameter.
Mixed Fines	Fine sand, silt, and clay comprise 75% of the surface area, with no one size class being dominant. May contain gravel (<15%). Cobbles and boulders make up < 6%. Walkable.
Mud	Silt and clay comprise 75% of the surface area. Often anaerobic, with high organics content. Tends to pool water on the surface and be un-walkable.
Artificial	Anthropogenic structures replacing natural substrate within the intertidal zone, including boat ramps, jetties, fill, and pilings.

APPENDIX B

Floodgate Operations Monitoring Methods – TNC

Fisher Slough Monitoring Notes

The Nature Conservancy

February 10, 2010

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Preface

Data viewing and collection was chosen to be done with a free program called PC200W, available by download from www.campbellsci.com. Assistance with operation can be found in the programs Help Menu.

Station Options with Maintenance, Data Collection and Software

Due to a limited initial budget, the following items were not installed initially. But, can be added in the future to reduce long-term data collection and maintenance costs.

1. A solar panel/lead acid battery would eliminate the need for replacing batteries/resetting calibrations.
2. A cell phone interface would allow data collection, maintenance and monitoring remotely, via an Internet IP Address.
3. Currently, you're using free software to download data with few options. More advanced software allows graphical displays of conditions, automatic data retrieval, and easy resetting of calibrations.

Connecting to the Datalogger

To communicate with the datalogger, connect a serial cable from a laptop's serial port to the datalogger's RS-232 9pin terminal. If your computer does not have a serial port, obtain a USB to serial converter.

Start PC200W, select the FisherSlough Datalogger icon on the left panel, and push the "Connect" button at the upper left. Or, simply double-click the 'FisherSlough Datalogger' icon. The "Connect" button should revert to a "Disconnect" button.

Viewing Current Data

This is a description of monitoring current measured data. Data are measured once every minute, and this data can be displayed on the 'Monitor Data' tab. This is not viewing stored data, stored data are viewed by collecting the data from the datalogger, and opening as a data file.

- To View Current Data:
- Connect to the datalogger, as described above.
- Select the 'Monitor Data' Tab.
- The data elements are described below.
- Press the 'Disconnect' button, in the upper left corner to Exit. 3

The data elements available for viewing are listed below, and can be re-arranged on your screen in any order simply by dragging and dropping with the mouse. The data values not used can also be deleted from your screen without causing any problem.

Data Abbreviation	Description
RecNum	Record Number of data point
TimeStamp	TimeStamp
BattV	Battery Voltage (volt)
Elev_Up_ft	Water Elevation , Upstream (ft)
Elev_Down_ft	Water Elevation , Downstream (ft)

Data Abbreviation	Description
WatTemp_Up_F	Water Temperature, Upstream (F)
WatTemp_Down_F	Water Temperature, Downstream (F)
PercentOpen_North	Percent Gate is Open (North Gate)
PercentOpen_Middle	Percent Gate is Open (Middle Gate)
PercentOpen_South	Percent Gate is Open (South Gate)
NewDepth_Up_ft	For calibration, enter new upstream gage height
NewDepth_Down_ft	For calibration, enter new downstream gage height
Head_Up_ft	Not needed, amount of water above sensor (ft)
Head_Down_ft	Not needed, amount of water above sensor (ft)
Offset_Up_ft	The difference between Head and Elev, ft
Offset_Down_ft	The difference between Head and Elev, ft
V1(1)	Ignore, used for calculations
V1(2)	Ignore, used for calculations
V2(1)	Ignore, used for calculations
V2(2)	Ignore, used for calculations
ReturnV(1)	Ignore, used for calculations
ReturnV(2)	Ignore, used for calculations
ReturnV(3)	Ignore, used for calculations
Res(1)	Ignore, used for calculations
Res(2)	Ignore, used for calculations
Res(3)	Ignore, used for calculations

Collecting Stored Data

Data are measured every minute, summaries are stored at the following intervals: 15 minutes, hourly, and daily. By collecting data, you will create, or append, to four separate data files. The data files are a 1 Minute data file, a 15 Minute data file, an hourly data file, and a daily data file. Stored data are viewed by collecting the data from the datalogger, and opening as a data file.

To collect the data:

- Connect to the datalogger as described above
- Select the ‘Collect Data’ Tab
- Press the ‘Collect’ button, to collect the newest data file.
- The data will then be retrieved, and stored on the computer’s hard drive, by default it goes to the folder ‘C:/Campbellsci/PC200W’.
- Press the ‘Disconnect’ button, in the upper left corner to Exit.

Not all files need to be viewed or accessed, if you only need the daily data, then just use the daily data file.

The data are not erased when a computer collects the data. Data continues to be collected, and when the memory fills up, it simply writes over the oldest data; therefore, the memory is always full of the latest data. The datalogger can store 5 months (150 days) of data, before beginning to overwrite the oldest data.

Following are descriptions of the data stored.

1 Minute Data File	15 Minute Data File	Hourly Data File	Daily Data File
Date/Time	Date/Time	Date/Time	Date/Time
Record Number	Record Number	Record Number	Record Number
WaterElev, Upstream (ft)	WaterElev, Upstream - Avg (ft)	WaterElev, Upstream - Avg (ft)	WaterElev, Upstream - Avg (ft)
WaterElev, DownSt - (ft)	WaterElev, Upstream - Max (ft)	WaterElev, Upstream - Max (ft)	WaterElev, Upstream - Max (ft)
WaterTemp, Upstream - (F)	WaterElev, Upstream - Min (ft)	WaterElev, Upstream - Min (ft)	WaterElev, Upstream - Min (ft)
WaterTemp, DownSt - (F)	WaterElev, DownSt - Avg (ft)	WaterElev, DownSt - Avg (ft)	WaterElev, DownSt - Avg (ft)
PercentGateOpen, North (%)	WaterElev, DownSt - Max (ft)	WaterElev, DownSt - Max (ft)	WaterElev, DownSt - Max (ft)
PercentGateOpen, Middle (%)	WaterElev, DownSt - Min (ft)	WaterElev, DownSt - Min (ft)	WaterElev, DownSt - Min (ft)
PercentGateOpen, South (%)	WaterTemp, Upstream - Avg (F)	WaterTemp, Upstream - Avg (F)	WaterTemp, Upstream - Avg (F)
WaterTemp, Upstream - Max (F)	WaterTemp, Upstream - Max (F)	WaterTemp, Upstream - Max (F)	
WaterTemp, Upstream - Min (F)	WaterTemp, Upstream - Min (F)	WaterTemp, Upstream - Min (F)	
WaterTemp, DownSt - Avg (F)	WaterTemp, DownSt - Avg (F)	WaterTemp, DownSt - Avg (F)	
WaterTemp, DownSt - Max (F)	WaterTemp, DownSt - Max (F)	WaterTemp, DownSt - Max (F)	
WaterTemp, DownSt - Min (F)	WaterTemp, DownSt - Min (F)	WaterTemp, DownSt - Min (F)	
PercentGateOpen, North – Avg (%)	PercentGateOpen, North – Avg (%)	PercentGateOpen, North – Avg (%)	
PercentGateOpen, North – Max (%)	PercentGateOpen, North – Max (%)	PercentGateOpen, North – Max (%)	
PercentGateOpen, North – Min (%)	PercentGateOpen, North – Min (%)	PercentGateOpen, North – Min (%)	
PercentGateOpen, Middle – Avg (%)	PercentGateOpen, Middle – Avg (%)	PercentGateOpen, Middle – Avg (%)	
PercentGateOpen, Middle – Max (%)	PercentGateOpen, Middle – Max (%)	PercentGateOpen, Middle – Max (%)	
PercentGateOpen, Middle – Min (%)	PercentGateOpen, Middle – Min (%)	PercentGateOpen, Middle – Min (%)	
PercentGateOpen, South – Avg (%)	PercentGateOpen, South – Avg (%)	PercentGateOpen, South – Avg (%)	
PercentGateOpen, South – Max (%)	PercentGateOpen, South – Max (%)	PercentGateOpen, South – Max (%)	
PercentGateOpen, South – Min (%)	PercentGateOpen, South – Min (%)	PercentGateOpen, South – Min (%)	
Elevation Offset Upstream (ft)			
Elevation Offset DownSt (ft)			
GateN,HoursFrom0<25%			
GateN,HoursFrom26<50%			
GateN,HoursFrom51<75%			
GateN,HoursFrom76<100%			
GateMid,HoursFrom0<25%			
GateMid,HoursFrom26<50%			
GateMid,HoursFrom51<75%			
GateMid,HoursFrom76<100%			
GateS,HoursFrom0<25%			
GateS,HoursFrom26<50%			
GateS,HoursFrom51<75%			
GateS,HoursFrom76<100%			

The percentage that the gate is open, is referenced to 0 percent = gate closed, 100 percent = gate fully open, which is about a 130 degree angle. A 50 percent gate opening would be a 65 degree opening. The daily output contains the number of hours each gate is within the following ranges:

- Time (hours) the gate is open 0 to 25 percent
- Time (hours) the gate is open from 26 to 50 percent
- Time (hours) the gate is open from 51 to 75 percent
- Time (hours) the gate is open from 76 to 100 percent

Setting/Calibrating Water Level

Setting/calibrating the water level should be done whenever the datalogger's recorded water elevation does not match the corresponding staff gage. When changing batteries, this will also need to be done.

There are two water levels to check, the upstream gage and the downstream gage.

To Set/Calibrate Water Level:

- Read the Water Level Staff Gage in feet (Upper or Lower)
- Connect to the datalogger, as described above.
- Select the 'Monitor Data' Tab.
- Check to see if the Elev_Up_ft or Elev_Down_ft, is within acceptable range of the corresponding Water Level Staff Gage.
- If it does match, you are done and can disconnect.
- If it does not match, change "NewDepth_Up_ft", or "NewDepth_Down_ft", to that of the Water Level Staff Gage. This is done by double-clicking on the value and entering the value.
- Within about 1 minute, the "NewDepth" value will revert back to 0, and the "Elev" will indicate the proper water level. (The datalogger has automatically created an offset, which is also recorded in your data file.)
- Press the 'Disconnect' button, in the upper left corner to Exit.

Setting/Calibrating Gate Percent Open

Setting/calibrating the water level should be done whenever the datalogger's recorded gate opening percentage does not match actual conditions. When changing batteries, this will also need to be done.

There are three gate open percentages to check.

To Set/Calibrate Gate Percent Opening:

- Determine the gate opening percentage with an angle measurement. 100 percent open is fully open, 0 percent is fully closed.
- Connect to the datalogger, as described above.
- Select the 'Monitor Data' Tab.

- Check to see if the PercentOpen_North, PercentOpen_Middle, or PercentOpen_South, is within acceptable range.
- If they do match, you are done and can disconnect.
- If they do not match, change “NewPercentOpen_N”, or “_M”, or “_S”, to that of the measured percentage open. This is done by double-clicking on the value and entering the value.
- Within about 1 minute, the “NewPercentOpen” value will revert back to 0, and the “PercentOpen” will indicate the proper gate opening.
- Press the ‘Disconnect’ button, in the upper left corner to Exit.

Changing the Batteries

The batteries should be changed when they get down below 11 Volts DC. This value can be seen by monitoring the current data.

The batteries used in this station are eight (8) Standard D-Cell batteries. These are accessed under the BP-ALK lid. The lid is removed with a simple thumbscrew.

When placing new batteries in the battery pack, be very careful that both sides of the battery are touching the metal positive and negative terminals. You will need to push the batteries up against the positive side, as the small springs are not strong enough to push them into place, only to hold them in place.

It is a good idea to take a voltmeter, and measure the voltage on the red and black wires coming out of the battery pack. With new batteries, this voltage should be about 12.5 Volts DC. If not, one or more of the batteries are probably not making contact.

When finished, connect to the datalogger and check water level calibrations.

APPENDIX C

Groundwater Monitoring

Groundwater Elevation

Groundwater elevations will be monitored at three locations, to track groundwater elevations following project construction (see Figure 5-1). Groundwater elevations will be monitored using Solinst LT F30 Gold loggers. Wells were installed in 2009 and groundwater elevation data were downloaded on a quarterly basis from January 2009 through September 2009.

Detailed installation guidelines for the Solinst LT F30 Gold loggers are found in the Solinst Levellogger User Guide (August 11, 2009). The three groundwater loggers were installed using the free suspended method. This method utilizes a suspension wire or line to position the logger at the appropriate depth in the piezometer. Using Solinst software version 3.2.3 the logger was pre-programmed with user selected settings such as; Project ID, Location, Altitude, Sample Mode, Sample Rate, units for water level/temperature and a delayed start time. The data is retrieved manually, by withdrawing the Levellogger, removing the installation cap and attaching to a laptop with an RS232 Serial Port or a USB connection. After a successful download the cap is replaced on the logger and it is returned to its previous position by the suspending line. Water elevation will be corrected for barometric pressure and tied to the site vertical datum to related groundwater elevations to surface water elevations and marsh elevations. Loggers from all three wells will be downloaded on a quarterly basis (March, June, September, and December).

Monthly time series of groundwater elevations for all three wells will be plotted each year and submitted to TNC in a technical memorandum as an appendix to the annual monitoring reports. Trends in groundwater elevations will be evaluated annually to determine if there is a need for additional monitoring of groundwater levels.

APPENDIX D

Photo Documentation Methods

Fisher Slough Photo Point Descriptions

Danelle Heatwole

September 2009

Compass declination was set to 17 deg E for Conway (48.33785 N, 122.34123 W) per NOAA's National Geophysical Data Center website (<http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp>). Camera is positioned horizontally at 5 ft height unless stated otherwise. Photos are named by the photo point and direction (e.g., FS04-143). A direction was not recorded for photos of the floodgates – these are named by the photo point and “FG” for “floodgate.” Filenames should include the photo point and direction, the date (yyyymmdd), and the image number from the camera (e.g., FS04-143_20090921_IMG3524.JPG).

FS01

Location: On the south bank of Fisher Slough at the railroad bridge (48.32368 N, 122.34409 W).

Approaching the railroad from the south end of the highway bridge, turn right and descend the slope toward Fisher Slough. The photo point is on a flat spot near the channel bank, right next to the second set of pilings for the railroad bridge.

Photo 1

Direction: The center floodgate should be in the center of the photo.

Description: Downstream side of floodgates.

FS02

Location: On the north bank of Fisher Slough at the highway bridge (48.32375 N, 122.34365 W). From the northeast corner of the highway bridge, walk 20 ft down the dike slope toward Fisher Slough. A large bolt and nut is on the side of the bridge at eye level to your right. The rebar marker for the photo point is approximately 1 ft beyond this bolt and 1 ft underneath the bridge.

Photo 1

Direction: The center floodgate should be in the center of the photo.

Description: Upstream side of floodgates.

Camera Height: 2 ft

Note: The south gate is between the 4th and 5th columns from the left, the middle between the 5th and 7th columns, and the north gate behind the three concrete and wooden pilings on the right. To make sure the floodgates are in focus rather than the pilings, you may need to focus on the south gate and then center the camera.

Photo 2

Direction: 214 deg

Description: The new crossing for Big Ditch at water level.

Photo 3

Location: Above the FS02 marker on the highway bridge. From the northeast corner of the highway bridge, walk 20 ft south along the bridge. The photo point is at the joint between the 2nd and 3rd sections of the concrete guard rail. The bolt and nut are visible below when looking over the guard rail.

Direction: 214 deg

Description: The new crossing for Big Ditch, the new south levee, and Smith A.

FS03

Location: On the south levee of Fisher Slough, about 150 ft east of the highway (48. N, 122. W). From the southeast corner of the highway bridge, walk 47 large steps along center of the south levee. This is the approximate location of the south levee setback. A rebar marker for the photo point is centered on the levee top.

Photo 1

Direction: The center floodgate should be in the center of the photo.

Description: Upstream side of floodgates.

Photo 2

Direction: 356 deg

Description:

Photo 3

Direction: 70 deg

Description:

Photo 4

Direction: 138 deg

Description:

Photo 5

Direction: 206 deg

Description:

FS04

Location: On the north levee of Fisher Slough at the second marsh island (48.32378 N, 122.33999 W). Walk or drive east along the north levee, passing the flood return structure and arriving at the second vegetated island in Fisher Slough. A cluster of shrubs is in front of you, and a small tidal channel enters Fisher Slough to their left. The rebar marker is aligned with a scraggly dead tree in the marsh island and the left most tall tree on the old railroad grade at the far side of Smith A (see figure), about 42 inches south of the centerline of the levee path.

Photo 1

Direction: 143 deg

Description: The marsh island and Fisher Slough upstream of this point.

Photo 2

Direction: 175 deg

Description: The marsh islands and channel, with Smith A in the background.

Photo 3

Direction: 224 deg

Description: The middle marsh island and Smith A.

Photo 4

Direction: 262 deg

Description: The marsh islands and Fisher Slough downstream of this point.

FS05

Location: On the north levee of Fisher Slough at the current Big Ditch Crossing (48.32243 N, 122.33662 W). Continue east along the north levee, passing a grassy and shrubby area on the north side of the dike and arriving at Big Ditch. The rebar marker is about 10 ft down the south slope of the levee, approximately centered between the shrubby area and Big Ditch.

Photo 1

Direction: 148 deg

Description: Fisher Slough upstream of this point.

Photo 2

Direction: 168 deg

Description: Downstream end of future main tidal channel realignment and existing south levee.

Photo 3

Direction: 188 deg

Description: Existing crossing structure for Big Ditch.

Photo 4

Direction: 249 deg

Description: Fisher Slough and Smith A.

Photo 5

Direction: 276 deg

Description: Smith A and Fisher Slough downstream of this point.

Photo 6

Direction: 62 deg

Description: Existing location of Big Ditch, upstream of Fisher Slough crossing.

FS06

Location: At the eastern end of the north levee, near an old shed and gate structure (48.32154 N, 122.33369 W). Continue east along the north levee, which becomes very wide and then narrows before turning north. Riprap and blackberries cover the south side of the levee, and straight across the slough is Fisher Creek. The rebar marker is 6 ft west from the eastern end of the riprap, near the upper edge of the levee slope. Photos are taken 2-2.5 ft down-slope of the marker for better visibility.

Photo 1

Direction: 128 deg

Description: Carpenter Creek/Fisher Slough upstream of this point. Upstream end of future main tidal channel realignment.

Photo 2

Direction: 191 deg

Description: Fisher Creek mouth and existing south levee.

Photo 3

Direction: 212 deg

Description: Fisher Slough (future plug location) and Smith B.

Photo 4

Direction: 254 deg

Description: Existing south levee and Fisher Slough downstream of this point.

FS07

Location: Near the southern edge of the Moyer property, east of Little Fisher Creek (48. N, 122. W). A 4 ft fence post marks the photo point, located at the northwest end of the riparian vegetation and blackberries.

Photo 1

Direction: 284 deg

Description:

Photo 2

Direction: 330 deg

Description:

FS08

Location: At the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property (48. N, 122. W). A 5 ft fence post marks the photo point, located between a lone scrubby tree on the hillside and a large blackberry patch at the fenceline.

Photo 1

Direction: 252 deg

Description:

Photo 2

Direction: 317 deg

Description:

Photo 3

Direction: 27 deg

Description:

Photo 4

Direction: 112 deg

Description:

FS09

Location: At the northwest corner of Smith B, in the footprint of the new levee (48.32107 N, 122.33741 W). The point is located 50 ft south of the centerline of the drainage ditch at the north end of Smith B, and about 50 ft east from the edge of the dirt access road (this is about 6 ft east of the levee centerline that was marked by TetraTech). Photos were taken from a stepladder to simulate the new levee elevation; camera was thus 8 ¾ ft above the ground surface. *Camera Height:* 8 ¾ ft above the ground surface

Photo 1

Direction: 83 deg

Description:

Photo 2

Direction: 134 deg

Description:

Photo 3

Direction: 174 deg

Description:

Photo 4

Direction: 294 deg

Description:

FS10

Location: Off Pioneer Hwy, south of the old railroad grade (48. N, 122. W). The pull off is crosses Big Ditch. Follow the northernmost support beam to the 23rd plank of the bridge to take the photos.

Photo 1

Direction: Big Ditch should be centered in the photo.

Description: Camera is vertical

Photo 2

Direction: 35 deg

Description:

Photo 3

Direction: 66 deg

Description:

Photo 4

Direction: 92 deg

Description:

FS11

Location: At the south access point from the highway to Smith A (48. N, 122. W). Photos are taken about 40 ft into the pull-off from the road's edge, at the approximate centerline of the pulloff. This is about 2 ft north of a long crack in the pavement.

Photo 1

Direction: 10 deg

Description:

Photo 2

Direction: 48 deg

Description:

Photo 3

Direction: 96 deg

Description:

Photo 4

Direction: 180 deg

Description:

Digital Image Format

To meet grant requirements, digital photographs will meet the following requirements:

- Images shall be accompanied by a site plan that indicates the location and bearing of each photo points. The notated site plan shall be in PDF format. Photo points will be selected to provide an overview of the impact, and shall include landscape features that indicate the scale of the activity.
- Each images photo point series shall include a minimum of one shot for each of the before, during, and after construction time periods. Where possible, before during and after images will occur within a single season.
- Image file name shall include project site code name, photo-point code as displayed on the map, and date (i.e. _PROJECTNAME_P1_05-1014.jpg).

- All images shall be released to the public domain, and will be reproducible by WDFW or its associates for any and all purposes.
- Images shall be delivered as un-embedded minimally compressed JPG files at a minimum of 4 million-pixel resolution.