

Fisher Slough Tidal Marsh Restoration Baseline Monitoring Report



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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
DO	dissolved oxygen
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ft	Feet
Fisher Slough Project	Fisher Slough Tidal Marsh Restoration Project
GIS	geographic information system
GPS	global positioning system
HBI	Hilsenhoff Biotic Index
LiDAR	light detection and ranging
mg/L	milligrams per liter
MHHW	mean higher high water
NAVD88	North American Vertical Datum of 1988
RTK	Real Time Kinematic
TNC	The Nature Conservancy
WDOE	Washington Department of Ecology
WSRN	Washington State Reference Network
µS/cm	micro Siemens per centimeter

1. INTRODUCTION

The Nature Conservancy's (TNC) Fisher Slough Tidal Marsh Restoration project (Fisher Slough Project) is being monitored to document changes between existing and restored freshwater tidal habitats following reintroduction of tidal hydrology and reconnection of stream floodplains on the site to evaluate success of restoration efforts. This monitoring report establishes baseline (pre-project) conditions for which post-project conditions shall be compared against to test hypotheses derived from the objectives. The Fisher Slough Project site is located in Skagit County, Washington, just 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 (Figure 1-1). Fisher Slough has been subjected to channelization and levee construction as part of flood control, irrigation and drainage, and agricultural development on the Skagit River delta for the past 150 years.



Figure 1-1 Fisher Slough Watershed Map

1.1 PROJECT PURPOSE

The purpose of the Fisher Slough Project is to restore landscape processes and salmonid habitat functions within Fisher Slough, while also providing additional benefits to local landowners and farmers, including improved flood protection and drainage. Specifically, the project will reestablish riparian floodplain and tidal processes within Fisher Slough and its tributaries, on 60 acres of land controlled in fee by TNC. TNC is working collaboratively with Skagit County Public Works, Diking District 3, Drainage and Irrigation District 17, and local landowners to implement this project (Figure 1-2). The Fisher Slough Project consists of three elements:

Project Element 1 – Completed in the fall of 2009, this element consisted of the replacement of 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. The new floodgate is designed and operated to maximize tidal exchange (i.e., the gates will be open for a longer timeframe during the year) and, in particular, to improve fish access during the spring migration period for Chinook salmon (*Oncorhynchus tshawytscha*) (Tetra Tech 2008). A small flapgate located below the middle and south floodgates was also installed to allow fish passage when water levels drop below the floodgate sill.

Project Element 2 – This element involves the realignment of Big Ditch from its current configuration where it crosses under Fisher Slough. Big Ditch is currently within the proposed levee setback area. For the ditch to continue functioning as part of the drainage system for the adjacent and upstream landowners, it must be moved. 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 Fisher Creek and Little Fisher Creeks); and levee setback preloading.

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

This report documents baseline data collected between 2006 and 2009. The purpose of baseline data collection is to establish the pre-project site conditions for comparison to post-project site conditions in terms of ecological indicators that are expected to increase in function as a result of the project actions. Goals and objectives related to fish habitat are reported separately in Juvenile Salmon, Estuarine, and Freshwater Fish Utilization of Habitat Associated with the Fisher Slough Restoration Project, Washington 2009 (Beamer et al 2010). The methods for the data collection beginning in 2010 are described in the Fisher Slough Tidal Marsh Restoration Monitoring and Adaptive Management Plan (Parametrix 2010).

Sources of data used in the preparation of this report include the Fisher Slough Preferred Restoration Plan (Tetra Tech 2007), data collected by TNC (2009), Juvenile Salmon, Estuarine, and Freshwater Fish Utilization of Habitat Associated with the Fisher Slough Restoration Project, Washington 2009 (Beamer et al. 2010), and the Fisher Slough Final Design and Permitting Final Tidal Marsh Restoration Design Recommendations Report (Tetra Tech 2009a).

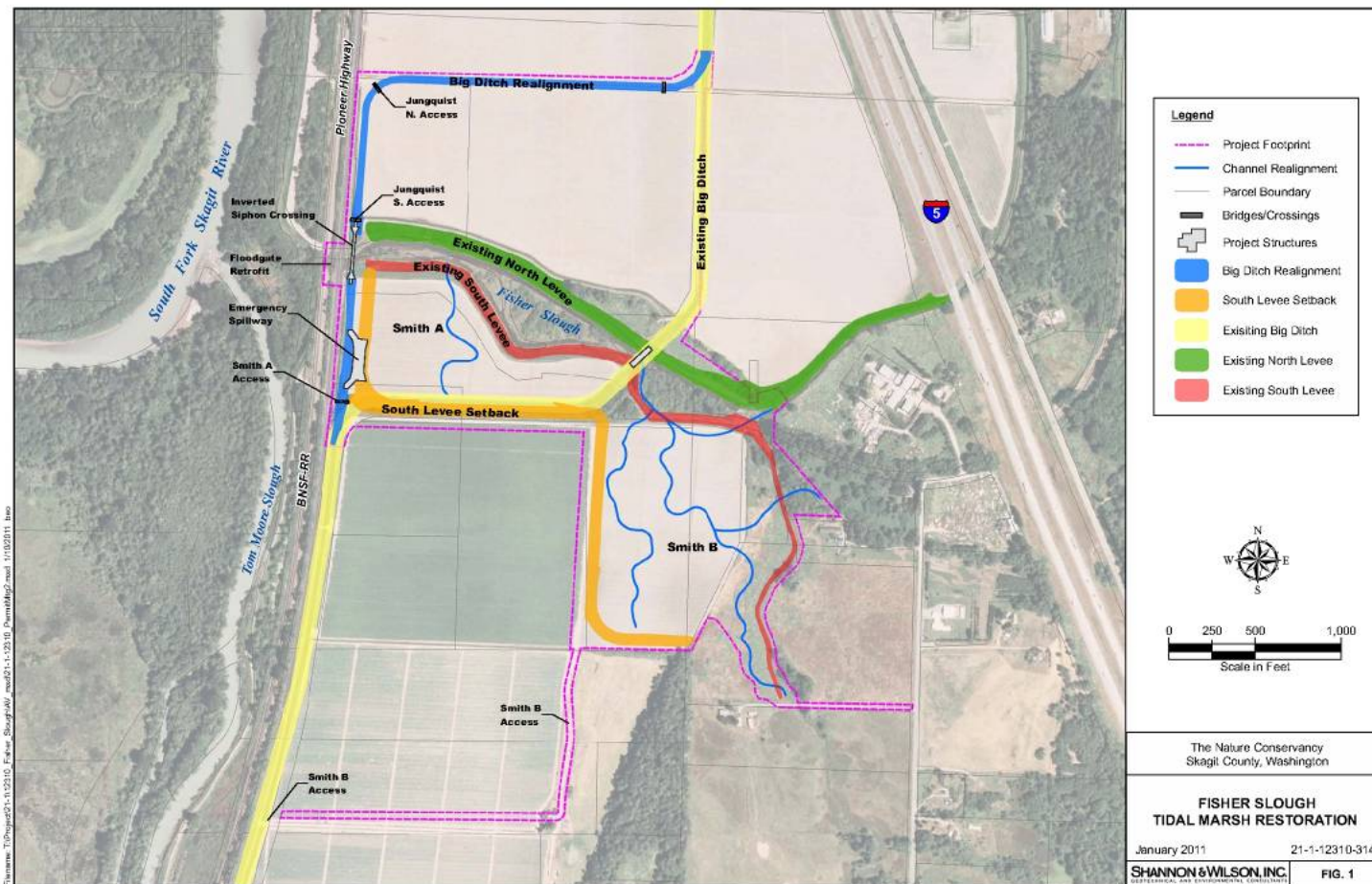


Figure 1-2 Fisher Slough Tidal Marsh Restoration Project Site Map

1.2 PROJECT OBJECTIVES

The goal of restoration monitoring at Fisher Slough is to evaluate the success of restoration efforts by documenting changes between existing and restored habitats after the reintroduction of tidal hydrology and reconnection of stream floodplains on the site. Specifically, the monitoring program is designed to track progress toward the primary project objectives (Tetra Tech 2007; Parametrix 2010):

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. Restore and improve freshwater tidal rearing habitat for Chinook salmon;
3. Restore fish passage for access by spawning coho (*Oncorhynchus kisutch*) and chum salmon (*Oncorhynchus keta*); and
4. Improve flood storage to protect agricultural uses of adjacent properties.

Restoration of Fisher Slough is expected to reestablish landscape processes and habitats within the project site and improve hydrologic function upstream in the Carpenter Creek watershed. Monitoring efforts for biotic response variables and landscape changes include the collection of data associated with surface water levels, groundwater levels, water quality (dissolved oxygen [DO], conductivity, temperature, and pH), vegetation, marsh elevations, and channel cross sections. Pre-2009 data also include macroinvertebrate data collected in 2006.

2. BASELINE MONITORING METHODS

Methods used for monitoring the Fisher Slough Project are detailed in the Fisher Slough Tidal Marsh Restoration Monitoring and Adaptive Management Plan (Parametrix 2010). However, some methods used for baseline (2006-2009) monitoring are inconsistent because data collection occurred prior to finalization of the monitoring and adaptive management plan. The following is a description of the baseline methods used that deviate from those described in the monitoring and adaptive management plan. Site photos are located in Appendix D.

2.1 WATER QUALITY

The interaction of freshwater stream and tidal hydrology at the site, as well as surrounding and upstream land uses, influences local water quality parameters, particularly those important for salmonids. Water temperature, pH, conductivity, and DO concentrations were measured with a HACH, LDO101 IntelliCAL Rugged Dissolved Oxygen Probe at three locations within Fisher Slough: upstream and downstream of the floodgates and upstream of the Big Ditch crossing (Figure 2-1). The water quality data were collected 14 times between May 7, 2009, and October 2, 2009, at least twice a month (except for October) during high and low tide events. Measurements for Temperature, pH, conductivity and DO were taken both at the surface and the bottom of the water column.

2.2 ELEVATION

2.2.1 Cross Sections

Five transects were established in 2006 as part of the feasibility study for the preferred restoration plan (Tetra Tech 2007) (see Section 3.1.4, Figure 2-2). Cross-sections of the Fisher Slough channel were created along these transects using the light detection and ranging (LiDAR) data and geographic information system (GIS).

Contours were generated by an aerial-based LiDAR system, which combines a fixed-wing airplane, scanning laser, Inertial Measurement Unit, global positioning system (GPS) receiver, computers, and sophisticated software to measure the earth's surface. A laser beam is directed from the plane to the earth's surface and is reflected off the earth or vegetation and received back at the plane. The GPS unit and Inertial Measurement Unit keep track of the position of the plane. After receiving the return laser signals, the computer and software measure the time it took to get the return signal and combine that with the position of the plane to create an accurate representation of the ground. The field data collection for the LiDAR took place from March 3 to 5, 2005. The control network and check point surveys were performed on March 4, 2005 by Terrapoint.

LiDAR accuracy is as follows, quoted at the 95 percent confidence level (2 sigma):

Absolute Vertical Accuracy:

- +/- 15-20 centimeters on hard surfaces (roads and buildings)
- +/- 15-25 centimeters on soft/vegetated surfaces (flat to rolling terrain)
- +/- 25-40 centimeters on soft /vegetated surfaces (hilly terrain)

Absolute Horizontal Accuracy:

- +/- 20-60 centimeters on all but extremely hilly terrain.



Figure 2-1 Water Quality Sampling Locations

June 2011

2.3 VEGETATION

Vegetation abundance and composition (percent species cover) were sampled at vegetation plots randomly established along five permanent transects (Figure 2-2). The transects and plots were established by Tetra Tech staff to assess existing vegetation in June 2006 (Tetra Tech 2007). Tetra Tech used a modified transect-quadrat methodology that generally conforms to the comprehensive vegetation sampling protocol in the U.S. Army Corps of Engineers 1987 Wetland Delineation Manual (Environmental Laboratory 1987).

2.4 MACROINVERTEBRATES

Benthic macroinvertebrate samples were taken at three locations. One downstream of the floodgates and railroad bridge, one at Transect 1, and one at the edge of tidal influence at Transect 4 (Figure 2-2). At each site, 3 composite samples were collected that consisted of three randomly collected samples. A PVC plastic core that samples an area of 0.0024 square meter as recommended by Cordell *et al.* (1998) was used to collect the sample. Cores were taken to a depth of 10 centimeters and were fixed in the field in a 5 percent buffered formaldehyde solution. The samples were sent to Aquatic Biology Associates, Inc. laboratory (Corvallis, Oregon) for identification and analysis.

Metrics calculated from the macroinvertebrate samples included total abundance (number of individuals), number of taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT) abundance, and two diversity indices (Hilsenhoff Biotic Index [HBI] and the Shannon Diversity Index). A complete list of all taxa observed was also compiled.

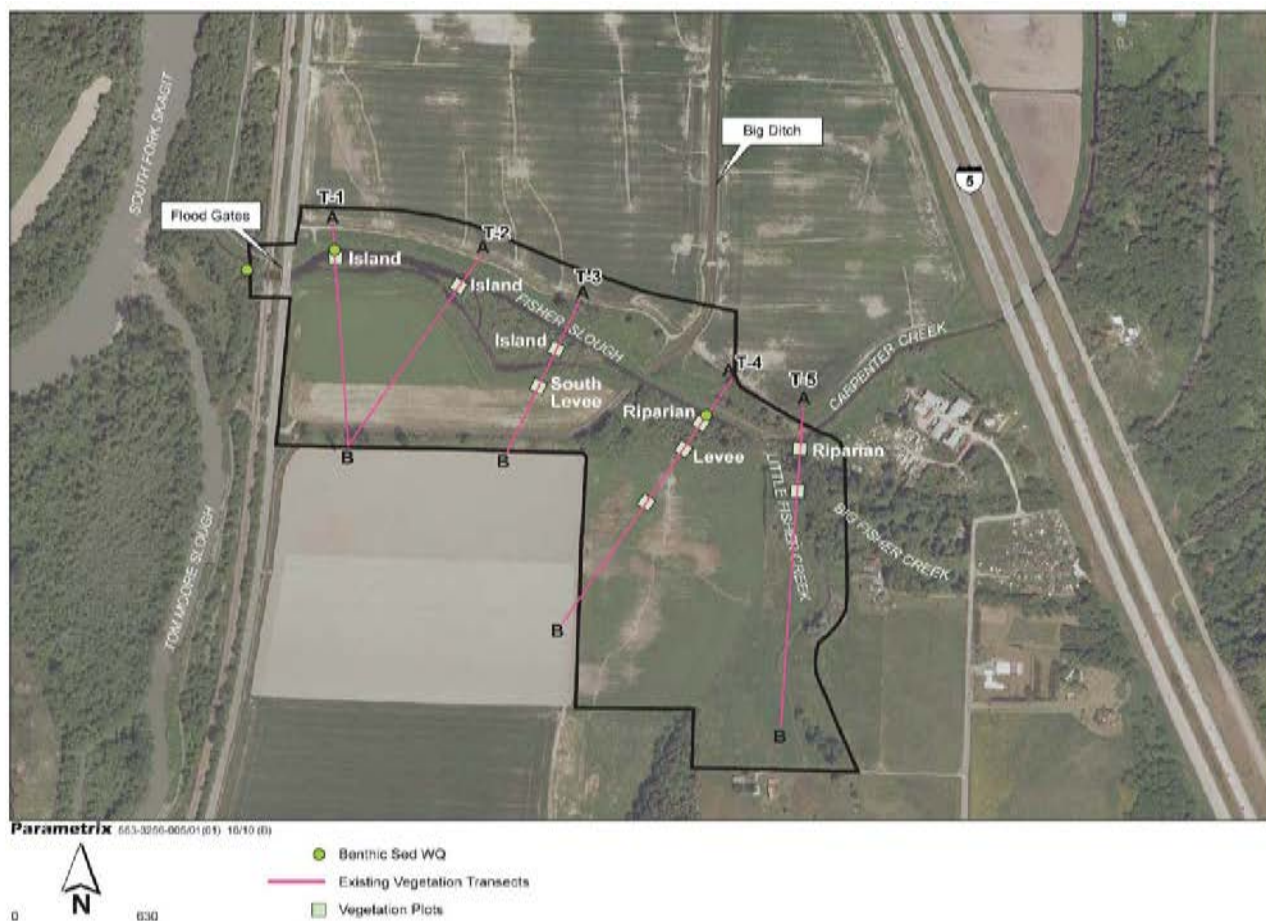


Figure 2-2 Sampling Transect Locations

Channel cross-sections of Fisher Slough were measured along the five transects, T-1 - T-5. **Vegetation** abundance and composition was sampled at vegetation plots along the five transects (identified by grey squares). **Macroinvertebrate** samples were collected at three locations along transects T-1 and T-4 and at one site downstream of the floodgates.

3. RESULTS AND DISCUSSION

This section describes the pre-project conditions as established by the baseline monitoring and discusses how these conditions relate to the project hypotheses (Table 3-1). Table 3-1 includes columns for subsequent reporting of annual conditions starting in 2010. Pre-project data were collected to determine if they will substantiate assumptions regarding existing conditions and provide data with which to compare post-project data.

This report addresses nine of the twelve hypotheses associated with the Fisher Slough Project. The remaining three hypotheses (below) are addressed in “Juvenile Salmon, Estuarine, and Freshwater Fish Utilization of Habitat Associated with the Fisher Slough Restoration Project, Washington 2009” (Beamer 2010).

- 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.*

Groundwater elevations are not specifically related to project objectives and hypotheses but there is an interest in tracking groundwater elevations at several locations during and after the restoration project. 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. Groundwater results and data are included Appendix A.

Table 3-1. Summary of Conditions and Restoration Targets Associated with Objectives, Hypotheses, and Parameters for Fisher Slough

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	2009 Condition	2010 Condition	2011 Condition	2012 Condition	2013 Condition	2014 Condition	2015 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.	Tidal amplitude upstream of floodgates is 6 to 7 ft NAVD88 (Tetra Tech 2008).	6.84 ft NAVD88 (June 09–Sept 09) ^a to 7.19 ft NAVD88 (Oct 08 – May 09). Big Ditch Crossing 6.96 ft NAVD88 (June 09 – Sept 09) to 7.30 ft NAVD88 (Oct 08 – May 09). Measurements taken above the floodgates.							By 2010: Tidal amplitude upstream of floodgates will increase.
		Compare tidal amplitude immediately upstream of floodgate to downstream of floodgate when floodgates open.	Surface Data collected but not converted to tidal amplitude	Not measured, upstream floodgate data logger malfunctioned.							Tidal amplitude immediately upstream of floodgates will match amplitude downstream of floodgates (gates open).
		MHHW upstream of floodgates.	Surface Data collected but not converted to MHHW	MHHW at Big Ditch crossing is 8.72 ft NAVD88.							Mean higher high water elevations (MHHW) will be 8.8 ^b NAVD88 upstream of floodgates.
		MHHW immediately upstream of floodgate during spring migration.	Surface Data collected but not converted to MHHW	Surface Data collected but not converted to MHHW							Mean higher high water elevations (MHHW) immediately upstream of the floodgates will be 9.5 NAVD88 during spring migration (as of 2010).
		Floodgate openness during spring migration.	Not Measured	Not measured. New Floodgates installed in Fall 2009. Beamer et al, 2010 estimated upstream passage as 49% during spring migration.							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.	Not measured.	<8 mg/L upstream of the floodgates during 5 of the days sampled (June –Sept,).							Increased DO during summer; daily minimum >8.0 mg/L upstream floodgates by 2015.
		Temperature levels in Fisher Slough.	18.4 to 19.4 °C (7-day maximum in summer) (Tetra Tech 2007).	The summer 7-day maximum temperature occurred during July 25 – July 31 2009 and ranged from 22.5 to 24.2 °C, averaging 23.3°C at Big Ditch crossing.							Decreased temperatures during summer; highest 7-day maximum temperature average within 12 to14 °C (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 ft NAVD88 (as measured upstream of the floodgates).	9.8acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).	9.8acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).							Increase in area inundated at MHHW upstream of floodgates by 2015. Increase in area of freshwater wetland vegetation. 60 acres of freshwater tidal wetland by 2015.
		Time series of water level elevations (for % inundation curves).	Not calculated	Not calculated							Photo-documentation shows significant increase in total area that is inundated by 2015.
		Site elevation.	Calculated by LiDAR	Calculated by LiDAR							The percent of the project area inundated

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	2009 Condition	2010 Condition	2011 Condition	2012 Condition	2013 Condition	2014 Condition	2015 Condition	Restoration Target
			ranging from 1.5 ft to almost 16 ft NAVD88	ranging from 1.5 ft to almost 16 ft NAVD88							at MHHW of 9.5ft NAVD88 increases by 2015.
		Number of days or percent of period site inundated.	Not calculated	Not calculated							
		Percent of the project site that is inundated at MHHW (9.5 ft NAVD88 at the floodgates).	The project area that is inundated when the surface(?) water level is 9.5ft NAVD88 is16.3% which is based on 9.8 acres of the 60 acres of freshwater tidal marsh area.	The project area that is inundated when the surface(?) water level is 9.5ft NAVD88 is16.3% which is based on 9.8 acres of the 60 acres of freshwater tidal marsh area.							
	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.	Not measured.	Not measured.							Mean sedimentation rates are positive by 2015.
		Elevation of the newly exposed marsh/floodplain area.	Not measured.	Not measured.							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 2009a).	Total area of the site with native and non-native vegetation communities, determined from vegetation mapping in aerial photographs (in acres).	Not calculated.	Not measured.							Photo-documentation shows significant change in plant community species composition and type by 2015. Total area mapped with tidal freshwater wetland plant communities increases (60 acres by 2015).
		Cover of vegetation species—aquatic, herbaceous, scrub-shrub, forest.	Not calculated.	Not measured.							By 2015, >30% cover of freshwater tidal wetland plant species.
		Species richness—total number of species observed on the site from species lists compiled during vegetation sampling.	Only calculated at the transect level. 21 native species present on transects during 2006 survey.	Not measured.							Increased native plant species richness compared to 2010 conditions.
		Elevation ranges and inundation times of vegetation species.	Elevation ranges (NAVD88), % inundation Mud-channel: 0 to 5.5 feet, 100% Low marsh: 6.0 to 6.5 feet, 46.9-65.5% High marsh: 7.0 to 7.5 feet, 20.5–32.9% Riparian: 8.0 to 10.0 feet, 4.7-11.9% Upland: 10.5 to 14 feet, 0-2.6% (Tetra Tech 2009)	Not measured.							Elevation ranges (NAVD88) and % inundation for major vegetation types will be similar to: ^d Mud-channel: 0 to 4.5 feet, 95-100% Low marsh: 4.5 to 7.0 feet, 50-95% High marsh: 7.0 to 8.5 feet, 15-50% Riparian: 8.5 to 10.0 feet, 5-15% Upland: >10 feet, 0-5%
	H6: Restoring a natural and more variable tidal regime will reduce the cover of Reed canary grass in areas where it	Total area of the site with Reed canary grass, determined from vegetation mapping in aerial photographs.	Not measured.	Not measured.							Area mapped with Reed canary grass is the same or less by 2015 (TBD—areas derived from 2010 monitoring).

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	2009 Condition	2010 Condition	2011 Condition	2012 Condition	2013 Condition	2014 Condition	2015 Condition	Restoration Target
	occurs pre-project.	Average elevation and elevation range of Reed canary grass on the site.	Not measured.	Not measured.							
		Average cover of Reed canary grass in vegetation plots.	Reed Canary Grass cover in the seven vegetation transects ranged from 10-70% cover in 2006.	Not analyzed.							Percent cover of Reed canary grass 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).	6.0 acres of channel area (TNC 2010).	1.7 acres of channel area.							Total Channel Area and Length will increase by 2015
		Channel cross sections and longitudinal profiles (estimate area).	Not measured.	Not measured.							
		Total length of channel network (estimated from aerial photographs using GIS).	Not calculated.	Not measured.							TBD—measures of pilot channels from as-built drawings in 2011.
		Channel density (total length divided by project area).	Not calculated.	Not measured.							
		Distance upstream to head of blind tidal channel.	Not calculated.	Not measured.							
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.	Chinook salmon: Presence/absence Density/abundance Location Timing	Not measured.	There is no significant difference in log transformed mean juvenile Chinook density between sites up and downstream of the floodgates 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.
	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	Not measured.	(Beamer et al 2010) shows no reduction in landscape connectivity due to the presence of tidegates							
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.	Number of days floodgates are open from October 1 to February 28 or 29.	Gates were open for 34% of the time during the fall of 2006 (Tetra Tech 2008).	Not measured.							Gates open at least once per day October to February 28 or 29
	H11: Removal of the passage barrier at Big Ditch will result in more natural channel profile through this area.	Longitudinal channel profile at Big Ditch crossing.	Not measured.	Not measured.							By 2015, passage barrier at Big Ditch can no longer be seen in channel profile
		Mean water depth at crossing.	Not calculated.	Not measured.							Mean water depth at crossing increases.

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	2009 Condition	2010 Condition	2011 Condition	2012 Condition	2013 Condition	2014 Condition	2015 Condition	Restoration Target
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.	Change in flood storage capacity	64 acre-feet of storage (Tetra Tech 2009a).	Not measured.							At least 247 acre-feet of new flood storage (about 310 acre-feet total).

^a Floodgate positions are generalized based on seasonal operations of the floodgates. The floodgates were operated on a "neutral velocity" system, opening when the water pressure was higher upstream than downstream of the floodgate between October 1, 2008 and May 31, 2009. Under normal river flow conditions, the floodgates opened just after high tide and remained open throughout the ebbing tide. The floodgates closed again when flood tidal flow pushed back upstream into the Skagit tidal delta and made the water level higher than Fisher Slough freshwater inflow, coming from the watersheds upstream of the floodgates. During the summer months (June 1 through September 30, 2009) the doors were lashed open for the irrigation season, unless there was a high water event.

^b 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).

^c Original vegetation communities delineated in 2006 differ from 2009-2015.

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

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

3.1 OBJECTIVE 1

Restore the ecological processes and structure to support and maintain a functional freshwater tidal wetland that supports target species, such as Chinook salmon.

3.1.1 Hypothesis 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.

Table 3-2 Fisher Slough Water Surface Elevations, Tidal Amplitude and MHHW

Parameter	Before 2009	2009 Condition	2010 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
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.	Tidal amplitude upstream of floodgates is 6 to 7 ft NAVD88 (Tetra Tech 2008).	6.84 ft NAVD88 (June 09–Sept 09) ^a to 7.19 ft NAVD88 (Oct 08 – May 09). Big Ditch Crossing 6.96 ft NAVD88 (June 09 – Sept 09) to 7.30 ft NAVD88 (Oct 08 – May 09). Measurements taken above the floodgates.					By 2010: Tidal amplitude upstream of floodgates will increase.
Compare tidal amplitude immediately upstream of floodgate to downstream of floodgate when floodgates open.	Surface Data collected but not converted to tidal amplitude	Not measured, upstream floodgate data logger malfunctioned.					Tidal amplitude immediately upstream of floodgates will match amplitude downstream of floodgates (gates open).
MHHW upstream of floodgates.	Surface Data collected but not converted	MHHW at Big Ditch crossing is 8.72 ft NAVD88.					Mean higher high water elevations (MHHW) will be 8.8 ^b NAVD88 upstream of floodgates.

Parameter	Before 2009	2009 Condition	2010 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
	to MHHW						
MHHW immediately upstream of floodgate during spring migration.	Surface Data collected but not converted to MHHW	Surface Data collected but not converted to MHHW					Mean higher high water elevations (MHHW) immediately upstream of the floodgates will be 9.5 NAVD88 during spring migration (as of 2010).
Floodgate openness during spring migration.	Not Measured	Not measured. New Floodgates installed in Fall 2009. Beamer et al, 2010 estimated upstream passage as 49% during spring migration.					Floodgate position will be open 90% of time during spring migration.

3.1.1.1 Surface Water Levels below and above the new floodgates

Before Project Element 1 was implemented, a series of floodgate structures was present immediately downstream of the Pioneer Highway Bridge. These floodgates consisted of six 5-by-9-foot barn-style doors that were operated on a “neutral velocity” system, opening when the water pressure was higher upstream than downstream of the floodgate during the flood season, approximately October 2008 through May 2009. During the summer months, the doors were lashed open for the irrigation season, approximately June through September. The floodgates were managed on this schedule to prevent rising Skagit River floodwaters from Tom Moore Slough from entering Fisher Slough to prevent flooding upstream in the Carpenter Creek system and adjacent agricultural fields (Tetra Tech 2008).

Surface water level data will be used to test Hypothesis H1 by determining the effects of floodgate replacement on the tidal amplitude and water levels throughout the site. Surface water data were collected at two locations from September to December 2008 (Fisher Slough downstream and Big Ditch crossing) and three locations from January 2009 to September 2009 (Fisher Slough downstream, Fisher Slough upstream, and Big Ditch crossing). However, the data logger located immediately upstream of the floodgates appears to have malfunctioned during the summer of 2009 and recorded water levels far lower than what would be expected. Therefore, data from this logger are excluded from this report.

Three notable spikes in surface water elevations occurred during the 2008-2009 sampling period (Appendix B). Surface water elevations peaked at approximately 12 and 14 ft at two separate events in November and at approximately 15 ft in January of 2009, at the locations

downstream of the floodgates and at the Big Ditch crossing. All three of these spikes coincided with rain events, with the event in January producing approximately 1 inch of precipitation in the area during a two-day period. The tidal amplitude immediately upstream of the floodgates compared to the amplitude downstream of the floodgates was not compared due to the malfunctioning of the upstream data logger. The Fisher Slough downstream location appears to have generally greater amplitude of water levels than Big Ditch crossing while floodgates were operating on a “neutral velocity” system (October 2008 – May 2009), as would be anticipated because downstream is influenced by the tide. This is readily apparent in Appendix B.

3.1.1.2 Difference in Tidal Amplitude above and below the floodgates

Gates were installed in 2009 and tidal amplitude will be calculated and reported in the 2011 monitoring report.

Restoration Target: The target specifies equal amplitude upstream and downstream of the projects site when the new gates are in operation.

Target met?: Will be calculated and reported in the 2011 monitoring report

3.1.1.3 MHHW upstream of floodgates

MHHW was 8.72ft NAVD88 at the Big Ditch Crossing in 2009.

Restoration Target: MHHW immediately upstream is targeted at 9.5ft NAVD88.

Target met?: No at the Big Ditch Crossing. Will likely be met after construction.

3.1.1.4 MHHW immediately upstream of floodgate during spring migration

MHHW will be calculated from data generated at the upstream water level logger site and reported in the 2010 monitoring report.

Restoration Target: MHHW immediately upstream is targeted at 9.5ft NAVD88.

Target met?: Will be calculated and reported in the 2011 monitoring report

3.1.1.5 Floodgate openness during spring migration (March 1-May 31)

Floodgate position is also associated with Hypothesis H1 (see Section 3.3.1). Floodgate openness during spring migration (March 1 – May 31) was not measured in 2009. As previously described the floodgates were opening and closing based on “neutral velocity” of the water flows during this time period. (Beamer et al 2010) shows no reduction in landscape connectivity due to the presence of tidegates and juvenile densities are similar to other Skagit marshes if juveniles are using the downstream end of Tom Moore slough.

Restoration Target: Floodgate position will be open 90% of the time during spring migration

Target met?: Will be calculated after construction in 2011 and reported in the 2011 monitoring report

3.1.2 Hypothesis 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.

The water quality data will be used to determine whether the expected increase in tidal influence creates a decrease in water temperatures and an increase in DO concentrations during the summer months. Key components (DO, temperature, pH, and conductivity) of water quality data collected for the Fisher Slough Project are summarized below and in Appendix C. Data were collected from May 7, 2009 to October 2, 2009.

Table 3-3 Water Quality Parameters

Parameter	Before 2009	2009 Condition	2010 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
DO levels in Fisher Slough.	Not measured.	<8 mg/L upstream of the floodgates during 5 of the days sampled (June – Sept,).					Increased DO during summer; daily minimum >8.0 mg/L upstream floodgates by 2015.
Temperature levels in Fisher Slough.	18.4 to 19.4 °C (7-day maximum in summer) (Tetra Tech 2007).	The summer 7-day maximum temperature occurred during July 25 – July 31 2009 and ranged from 22.5 to 24.2 °C, averaging 23.3°C at Big Ditch crossing.					Decreased temperatures during summer; highest 7-day maximum temperature average within 12 to 14 °C (WDOE 2004).

3.1.2.1 Dissolved Oxygen

Concentrations of DO ranged from 5.9 milligrams per liter (mg/L) to 10.8 mg/L at the surface and from 7.0 to 10.8 mg/L at the bottom (Appendix C). The DO concentration of 5.9 mg/L occurred at the Big Ditch crossing in June 2009, while the surface 10.8 mg/L reading occurred at the Fisher Slough upstream location in September 2009. The 7.0 mg/L reading occurred at the Fisher Slough downstream location in June 2009 and the bottom DO concentration of 10.8 mg/L occurred at the Fisher Slough upstream location twice (August

and September 2009). The Washington State water quality minimum standard for DO is 8.0 mg/L in fresh water and 6.0 mg/L in marine water (Washington Department of Ecology [WDOE] 2004). These values are minimum thresholds. Average DO levels from the three locations taken from Fisher Slough for June 1st to Sept 30th, 2009 were higher than the target level of 8.0 mg/L at all locations during both high and low tide (Table 3-2). There were 5 days (June 17, June 18, July 13, July 14, and September 1, 2009) where sampling occurred and DO levels were below 8.0 mg/L upstream of the floodgates (Table 3-3).

Table 3-4 Average DO for June 1 – Sept. 30, 2009 (mg/L)

Location	Tide	Water Depth	Average DO ^a (June 1-Sept. 30)	Number of Days DO below 8.0 mg/L
Downstream (DS)				
	High	Surface	8.88	2
		Bottom	8.83	2
	Low	Surface	8.74	1
		Bottom	8.50	2
Upstream (US)				
	High	Surface	8.82	2
		Bottom	8.85	2
	Low	Surface	9.22	2
		Bottom	8.96	2
Big Ditch Crossing (BDC)				
	High	Surface	8.77	2
		Bottom	9.71	0 (n=3)
	Low	Surface	8.95	1
		Bottom	DNS	DNS

^a Floodgates were tied open for all sampling dates during summer. N=9 sample days unless specified. DNS = did not sample

Table 3-5 Dissolved oxygen levels below daily minimum of 8.0 mg/L

Date (2009)	Sample Location	DO ^a level (mg/L)
June 17 (High Tide)	DS, US , BDC	7.26/7.00, 7.36/7.08 ,6.21/NM
June 18 (Low Tide)	DS, US , BDC	7.38/7.76, 7.84/7.65 ,5.86/NM
July 13 (Low Tide)	DS	7.60 bottom
July 14 (High Tide)	DS, US , BDC	7.75/7.60, 7.80/7.51 ,7.44/NM
September 1 (Low Tide)	US	7.90/7.19

^a DO reported is in the format surface/bottom in order of sampling locations DS, US, BDC, etc

Average DO levels sampled from June 1st to Sept 30th, 2009 were higher when floodgates were closed during high tides at all locations. However, they were lower when the floodgates

were closed during low tides at the upstream of floodgates and downstream of floodgates sampling locations. This indicates that the high tide waters from downstream of the floodgates likely have a lower DO than those of the streams upgradient of the floodgates.

Restoration Target: Increased DO during summer; daily minimum >8.0 mg/L upstream of the floodgates by 2015.

Target met?: No. Target not met for 4 days at the upstream DO logger.

3.1.2.2 Temperature

Preferred temperatures for Chinook, coho, sockeye, and chum salmon range from 12°C to 14°C, while the preferred temperature for steelhead trout range from 10°C to 13°C (WDOE 2004). Temperatures in the target range of 12°C to 14°C only occurred in samples collected while the floodgates were closed. Average temperatures observed while the floodgates were open were all above this target range.

To determine the average daily maximum temperatures it was necessary to use data from the level loggers at the Big Ditch crossing and Fisher Slough downstream locations. These data were collected from September 29, 2008 to September 17, 2009. The 7-day average daily maximum water temperature target condition is within the range of 12 to 14 °C during the summer months. In 2009, the highest 7-day average of daily maximum temperatures occurred at the Big Ditch crossing location from July 25 to July 31. The maximum temperatures during these dates ranged from 22.5°C to 24.2°C and averaged 23.3°C. The highest 7-day average maximum temperature at the Fisher Slough downstream location was 22.9°C between July 24, 2009 and July 30, 2009 (Table 3-4).

Table 3-6 Fisher Slough 7-day Average Maximum Temperatures (°C)

Location	7-day Average Max (°C)	Date Range of recorded Max
Big Ditch	23.3	July 25-July 31, 2009
Fisher Slough Downstream	22.9	July 24-July 30, 2009

Restoration Target: Decreased Temperatures during summer; highest 7-day maximum temperature average within 12 to 14°C

Target met?: No

3.1.2.3 pH

The surface water pH measurements are not associated with any of the hypotheses, but measurements were taken for the purpose of gathering additional background information for potential future use. The pH measurements of surface water were near (slightly above) neutral, fluctuating from 7.09 to 7.91 at the surface and from 7.21 to 7.97 at the bottom (Appendix C). The surface pH of 7.09 was measured at the Fisher Slough downstream location in May 2009 and the surface pH of 7.91 was measured at the Fisher Slough upstream location in August 2009. The low and high bottom pH readings were observed at the Fisher Slough upstream location in July 2009 and at the same location in August 2009 respectively.

(Table 3.5 No pH samples were taken during sampling dates when the floodgates were closed.

Table 3.7 pH Ranges for Summer of 2009

Location	Tide	Water Depth	Summer ^a (June 1-Sept. 30)
Downstream			
	High	Surface	7.09-7.80
		Bottom	7.28-7.57
	Low	Surface	7.42-7.81
		Bottom	7.42-7.78
Upstream			
	High	Surface	7.25-7.51
		Bottom	7.21-7.49
	Low	Surface	7.25-7.91
		Bottom	7.24-7.97
Big Ditch Crossing			
	High	Surface	7.34-7.62
		Bottom	DNS
	Low	Surface	7.39-7.82
		Bottom	DNS

^a Floodgates open for all sampling dates during summer

DNS = did not sample

3.1.2.4 Conductivity

The surface water conductivity measurements are not associated with any of the hypotheses, but measurements were taken for the purpose of gathering additional background information for potential future use. Conductivity at the surface ranged from 47.4 micro Siemens per centimeter ($\mu\text{S}/\text{cm}$) at the Fisher Slough downstream location in August 2009 to 269.0 $\mu\text{S}/\text{cm}$ at the Big Ditch location in October 2009 (Appendix C). Similarly, conductivity measured at the bottom of the water column ranged from 47.0 $\mu\text{S}/\text{cm}$ at the Fisher Slough downstream location in August 2009 to 266.0 $\mu\text{S}/\text{cm}$ at the Fisher Slough downstream location in October 2009. The average conductivity at all locations when the floodgates were open ranged from 63.90 $\mu\text{S}/\text{cm}$ to 183.53 $\mu\text{S}/\text{cm}$ (Table 3.6). The conductivity readings were higher during samplings that occurred while the floodgates were closed. The differences may be based on seasonal changes in water conditions. However, data collection while the floodgates were closed was limited and do not provide a sufficient sample size to make reliable determinations.

Table 3.8 Conductivity Range for Summer of 2009 ($\mu\text{S}/\text{cm}$)

Location	Tide	Water Depth	Summer ^a (June 1-Sept. 30)
Downstream			

High	Surface	47.4-230
	Bottom	47-147.7
Low	Surface	100-266
	Bottom	96.4-266
Upstream		
High	Surface	47.5-211
	Bottom	47.5-198
Low	Surface	105.4-265
	Bottom	102.1-265
Big Ditch Crossing		
High	Surface	52-269
	Bottom	50-74.8
Low	Surface	67-264
	Bottom	DNS

^a Floodgates open for all sampling dates during summer

DNS = did not sample

3.1.3 Hypothesis 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.

Table 3-9 Area of Tidally Inundated Freshwater Wetlands

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
Water level elevations relative to site elevations—calculated total area of the project site that is inundated at 9.5 ft NAVD88 (as measured upstream of the floodgates).	9.8 acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).	9.8 acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).			Increase in area inundated at MHHW upstream of floodgates by 2015.
Time series	Not	Not			Increase in area of

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
of water level elevations (for % inundation curves).	calculated	calculated			freshwater wetland vegetation
Site elevation.	Calculated by LiDAR ranging from 1.5 ft to almost 16 ft NAVD88	Calculated by LiDAR ranging from 1.5 ft to almost 16 ft NAVD88			60 acres of freshwater tidal wetland by 2015.
Number of days or percent of period site inundated.	Not calculated	Not calculated			Photo-documentation shows significant increase in total area that is inundated by 2015.
Percent of the project site that is inundated at MHHW (9.5 ft NAVD88 at the floodgates).	The project area that is inundated when the surface(?) water level is 9.5ft NAVD88 is 16.3% which is based on 9.8 acres of the 60 acres of freshwater tidal marsh area.	The project area that is inundated when the surface(?) water level is 9.5ft NAVD88 is 16.3% which is based on 9.8 acres of the 60 acres of freshwater tidal marsh area.			The percent of the project area inundated at MHHW of 9.5ft NAVD88 increases by 2015.

3.1.3.1 Water Levels and Total Site Area

The baseline condition for the total area of the project site that is inundated at MHHW is 9.8 acres (9.5ft NAVD88 at the floodgates) (Tetra Tech 2007).

Restoration Target: Increase in area inundated at MHHW upstream of floodgates

Target met?: Not calculated. Will be reported in 2013 monitoring report.

3.1.3.2 Water Level Time Series

Water Level Logger data has been collected at three locations: The Big Ditch crossing, upstream and downstream of the floodgates. Water level logger data will be analyzed and time series will be generated for these three locations.

Restoration Target: Time series greater by 2015 than in period before 2010

Target met?: Not calculated. Will be reported in 2013 monitoring report.

3.1.3.3 Site Elevations

Initial site elevations have been generated from LiDAR and a detailed ground survey (1-foot contouring intervals per professional survey standards). Subsequent elevations will be generated using RTK-GPS. These data will support a Digital Elevation Model (DEM). The DEM will be used to demonstrate an increase in the area of freshwater wetland vegetation.

Restoration Target: Increase in area of freshwater wetland vegetation

Target met?: Not calculated. Will be reported in 2013 monitoring report.

3.1.3.4 Number of days or period of project inundated

Water level logger data will be used to calculate the period of time in days that the project is tidally inundated.

Restoration Target: 60 acres of freshwater tidal wetland by 2015

Target met?: Not calculated. Will be reported in 2013 monitoring report.

3.1.3.5 Percent of project inundated at MHHW/9.5ft NAVD88

Water level logger data will be used to calculate the maximum percentage of the project area that is inundated at MHHW when the water level at the floodgates is 9.5ft NAVD88. The project area that is inundated when the surface(?) water level is 9.5ft NAVD88 is 16.3% which is based on 9.8 acres of the 60 acres of freshwater tidal marsh area.

Restoration Target: The percent of the project area inundated at MHHW of 9.5ft NAVD88 increases by 2015.

Target met?: Not calculated. Will be reported in 2013 monitoring report.

3.1.4 Hypothesis H4

Restored tidal exchange/levee setback and greater inundation will result in accretion and aggradation of the ground surface in tidal marsh areas.

Table 3-10 Sedimentation and Elevation Rates

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
Sedimentation rates across the newly exposed marsh/floodplain	Not measured.	Not measured.			Mean sedimentation rates are positive by 2015.

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
area.					
Elevation of the newly exposed marsh/floodplain area.	Not measured.	Not measured.			More pins with positive (accretion) opposed to negative (erosion) sedimentation.

3.1.4.1 Sedimentation Rates

A previous study (Tetra Tech 2007) hypothesized that levee removal may result in the establishment of a wider variety of native freshwater marsh communities.

Existing marsh elevation data from LiDAR and a detailed ground survey (1-foot contouring intervals per professional survey standards) will be used for a comparison to the proposed marsh areas to determine whether the elevation of the proposed marsh areas increases over time as a result of sediment deposition. LiDAR results indicate that the elevations of the existing freshwater marsh range from 4 to 11 ft NAVD88 (Figure 3-1), while elevations within the proposed marsh areas range from 5 to 8 ft NAVD88. Sedimentation rates will be evaluated using a series of sediment stakes or pins that will be established on site in the summer of 2011, after construction of Project Element 3. The target elevation, due to natural accretion and aggradation, for the proposed marsh plain is near 9 ft NAVD88 (Tetra Tech 2007).

Restoration Target: Mean Sedimentation Rates are positive by 2015

Target met?: Not measured. Will be reported in 2013 monitoring report.

3.1.4.2 Elevation of the newly exposed marsh/floodplain area

General elevation surveys were conducted with LiDAR data to provide baseline conditions prior to project construction. LiDAR data are typically used before construction to help determine the existing topographic conditions and general project features. Often, the use of LiDAR data assists in locating geomorphic features that are indistinguishable from the ground, such as relic stream channels and other geomorphologic features. Although this information is useful for characterizing site conditions, it is expected to be supplemented by site-specific topographic information after construction.

LiDAR data were collected before construction began. The features of the Fisher Slough Project area range from approximately 1 to 18 ft NAVD88 elevation (Figure 3-1). The LiDAR data were used to create contours and determine elevations throughout the site.

LiDAR data were used in conjunction with GIS to provide an estimate of existing marsh elevations (see Section 3.1.4.1). LiDAR imagery indicates higher elevations in areas where taller vegetation (willows) is located. A final LiDAR image of the site, documenting changes in elevation and site topography since project implementation, will be taken in 2015. This will assist in evaluating Hypothesis H4, as well as, H3, H11, and H12.

Restoration Target: More pins with positive (accretion) opposed to negative (erosion) sedimentation

Target met?: Not measured. Will be reported in 2013 monitoring report.

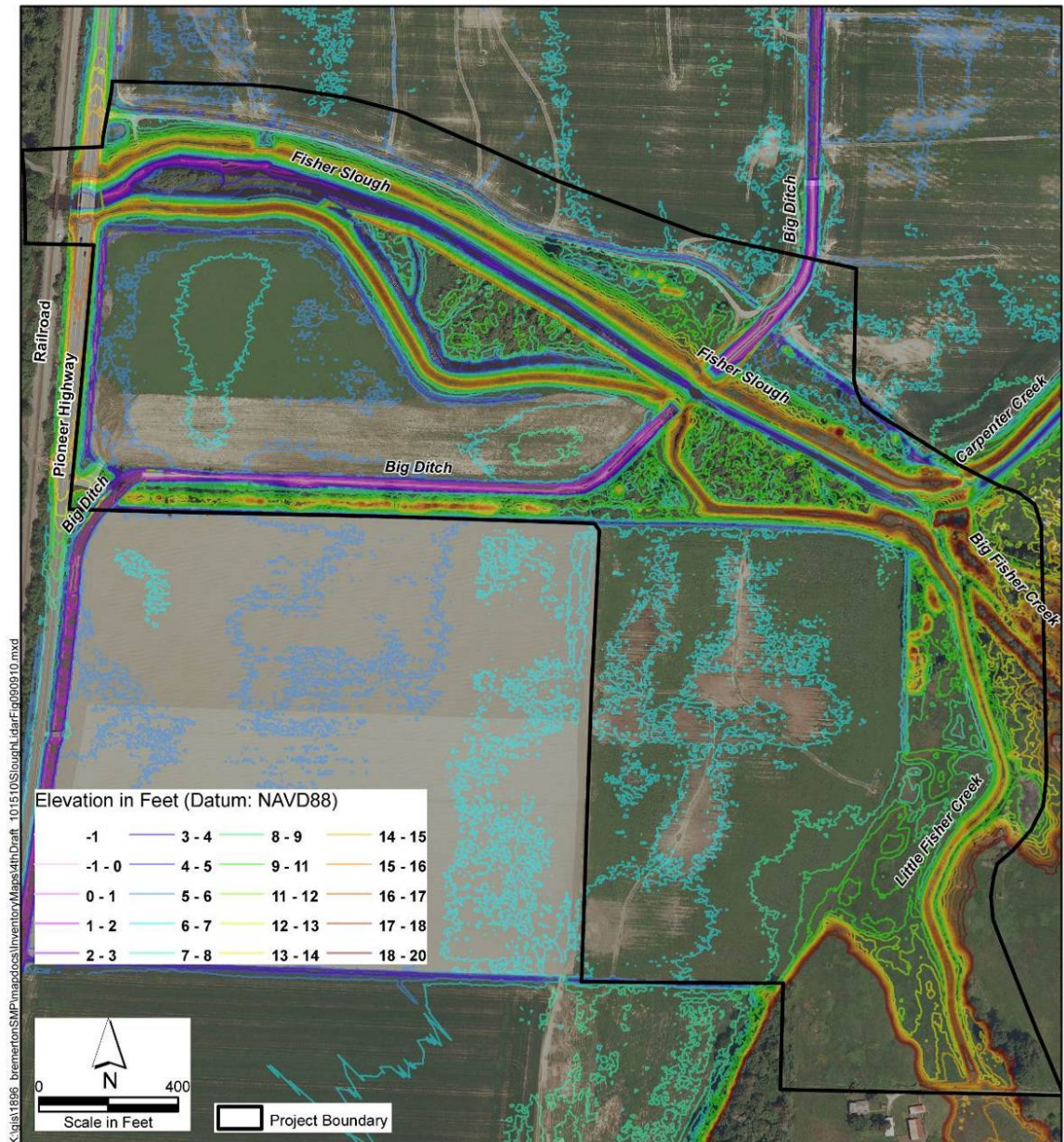


Figure 3-1 LiDAR Imagery of Project Site

3.1.5 Hypothesis 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 2009a).

Table 3-11 Vegetation Parameters

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
Total area of the site with native and non-native vegetation communities, determined from vegetation mapping in aerial photographs (in acres).	Not calculated.	Not measured.			Photo-documentation shows significant change in plant community species composition and type by 2015. Total area mapped with tidal freshwater wetland plant communities increases (60 acres by 2015).
Cover of vegetation species— aquatic, herbaceous, scrub-shrub, forest.	Not calculated.	Not measured.			By 2015, >30% cover of freshwater tidal wetland plant species.
Species richness— total number of species observed on the site from species lists compiled during vegetation sampling.	Only calculated at the transect level. 21 native species present on transects during 2006 survey.	Not measured.			Increased native plant species richness compared to 2010 conditions.
Elevation ranges and inundation times of vegetation species.	Elevation ranges (NAVD88), % inundation Mud-channel: 0 to 5.5 feet, 100% Low marsh: 6.0 to 6.5 feet, 46.9-65.5% High marsh: 7.0 to 7.5 feet, 20.5-32.9% Riparian:	Not measured.			Elevation ranges (NAVD88) and % inundation for major vegetation types will be similar to: ^d Mud-channel: 0 to 4.5 feet, 95-100% Low marsh: 4.5 to 7.0 feet, 50-95% High marsh: 7.0 to 8.5 feet, 15-50% Riparian: 8.5 to 10.0 feet, 5-15% Upland: >10 feet, 0-5%

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
	8.0 to 10.0 feet, 4.7-11.9% Upland: 10.5 to 14 feet, 0-2.6% (Tetra Tech 2009)				

Four vegetation communities were identified and sampled at the project site in 2006 (Table 3-7; Figure 3-2).

- Riparian
- Non-native riparian herbaceous
- Non-native upland herbaceous
- Cultivated fields (plowed and primarily bare ground or agriculture related vegetation)

These four vegetation communities were based on pre-project conditions while the five vegetation communities associated with Hypothesis H5 are referring to target wetland and riparian communities after restoration of the site has occurred. The five communities associated with Hypothesis H5 are (1) mud – channels/ponds, (2) low marsh, (3) high marsh, (4) riparian, and (5) upland. These communities are defined in the Fisher Slough Tidal Marsh Restoration Monitoring and Adaptive Management Plan (Parametrix 2010) (Table 3-7). There are currently approximately 1.4 acres of mud – channels/ponds, 1.7 acres of low marsh, 1.0 acre of high marsh, 4.1 acres of riparian, and 1.6 acres of upland (Tetra Tech 2009a). Generally, areas designated as cultivated fields in 2006 are expected to become high or low marsh, with some riparian communities. Some areas designated as non-native upland herbaceous and non-native riparian in 2006 (i.e. south levee) are expected to become riparian. Much of the riparian community designated in 2006 is expected to continue to be riparian community.

Table 3-12 Vegetation Communities (2006)

Vegetation Community	Dominant Vegetation
Riparian	<i>Salix lasiandra</i> , <i>Cornus sericea</i> , and <i>Phalaris arundinacea</i> .
Non-native riparian herbaceous	<i>Phalaris arundinacea</i>
Non-native upland herbaceous	<i>Agrostis gigantea</i> , <i>Lolium multiflorum</i> , <i>Phleum pratense</i> , and <i>Phalaris arundinacea</i>
Cultivated fields	DNS

DNS=did not sample

The baseline riparian communities are located between the levees associated with Fisher Slough, along the corridor of Big Fisher Creek, and at the lower end of Little Fisher Creek (see Figure 3-2). The riparian zones are narrow strips along the edges of the slough and creeks and although they do provide wildlife migratory corridors, to some extent they are highly constrained by the surrounding cultivated and fallow agricultural fields.

The north and south levees are composed of two non-native herbaceous vegetation communities, the non-native upland herbaceous community and the non-native riparian herbaceous community. In the south ditch that runs parallel to the south levee the vegetation community is dominated by Reed canary grass (*Phalaris arundinacea*), common bedstraw (*Galium aparine*), vetch (*Vicia* sp.), and a cultivated brassica (*Raphanus* sp.).

Two large areas of cultivated fields are located in the Fisher Slough Project area. These areas dominate the southwestern portion of the project area.

This list of vegetation includes species observed during the original data collection in 2006 (Table 3.7)

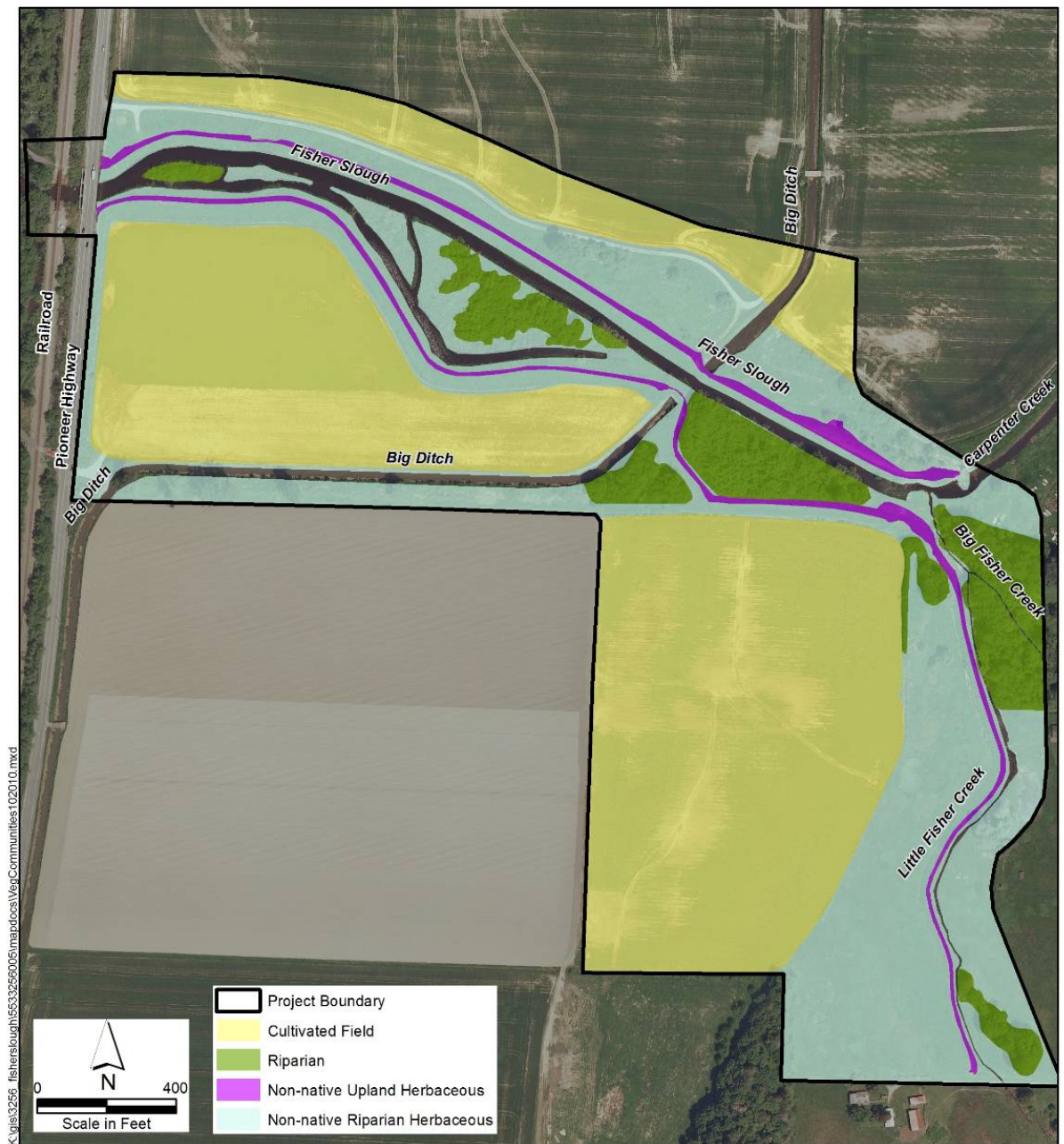


Figure 3-2 2006 Vegetation Communities

Vegetation community delineation is based on descriptions in The Fisher Slough Final Preferred Restoration Plan (Tetra Tech 2007).

Table 3-13 Vegetation Communities (2009-2015)

Vegetation Community	Vegetation (Tetra Tech 2009b)	2009 Existing Area ^a (acres)	2010	2011	2013	2015	Anticipated Vegetation	Target area (acres)
Mud-Channels/ Ponds	<i>Potamogeton filiformis</i> , <i>Sparganium eurycarpum</i> , <i>Potamogeton richardsonii</i> , <i>Myriophyllum sibiricum</i> , and <i>Elodea canadensis</i> .	1.4					<i>Myriophyllum sibiricum</i> , <i>Sparganium eurycarpum</i> , <i>Potamogeton filiformis</i> , <i>Typha angustifolia</i> , <i>Scirpus americanus</i> , and <i>Scirpus validus</i> .	1.6-4.8
Low Marsh	DNS	1.7					<i>Carex lyngbyei</i> and <i>Eleocharis palustris</i>	22.7- 24.2
High Marsh	<i>Phalaris arundinacea</i> , <i>Persicaria hydropiper</i> , <i>Alisma plantago-aquatica</i> , and <i>Sparganium eurycarpum</i>	1.0					<i>Myrica gale</i> , <i>Phalaris arundinacea</i> , <i>Salix spp.</i> , and <i>Spiraea douglasii</i> .	14.1- 15.8
Riparian	<i>Phalaris arundinacea</i> , <i>Spiraea douglasii</i> , <i>Cornus sericea</i> , <i>Rosa nutkana</i> , <i>Salix sitchensis</i> ^b , and <i>Salix lasiandra</i>	4.1					<i>Cornus sericea</i> , <i>Phalaris arundinacea</i> , and <i>Lolium multiflorum</i>	12.9- 15.7
Upland	DNS	1.6					<i>Plantago lanceolata</i> and <i>Taraxacum officinale</i>	4.9-5.1
Total Acres		9.8						

^a Area for 2006 data is not included in this table because it was based on different vegetation communities.

^b *Salix sitchensis* was originally identified as *Salix geyeriana* in 2006.

DNS = did not sample

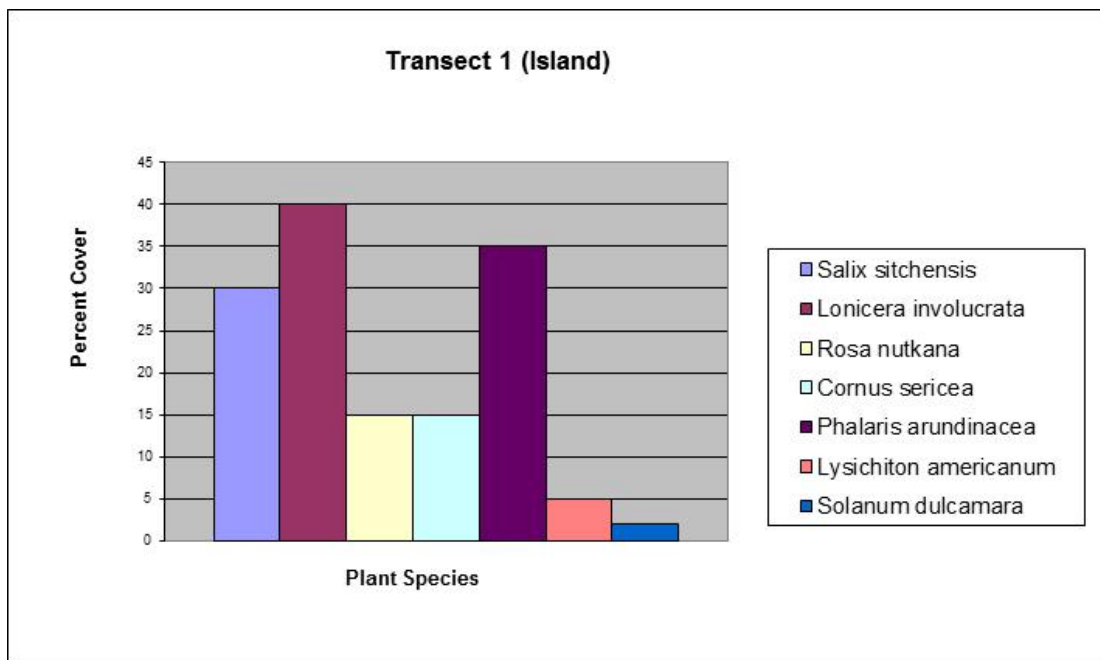


Figure 3-3 Transect 1 (Island) Percent Vegetation Cover

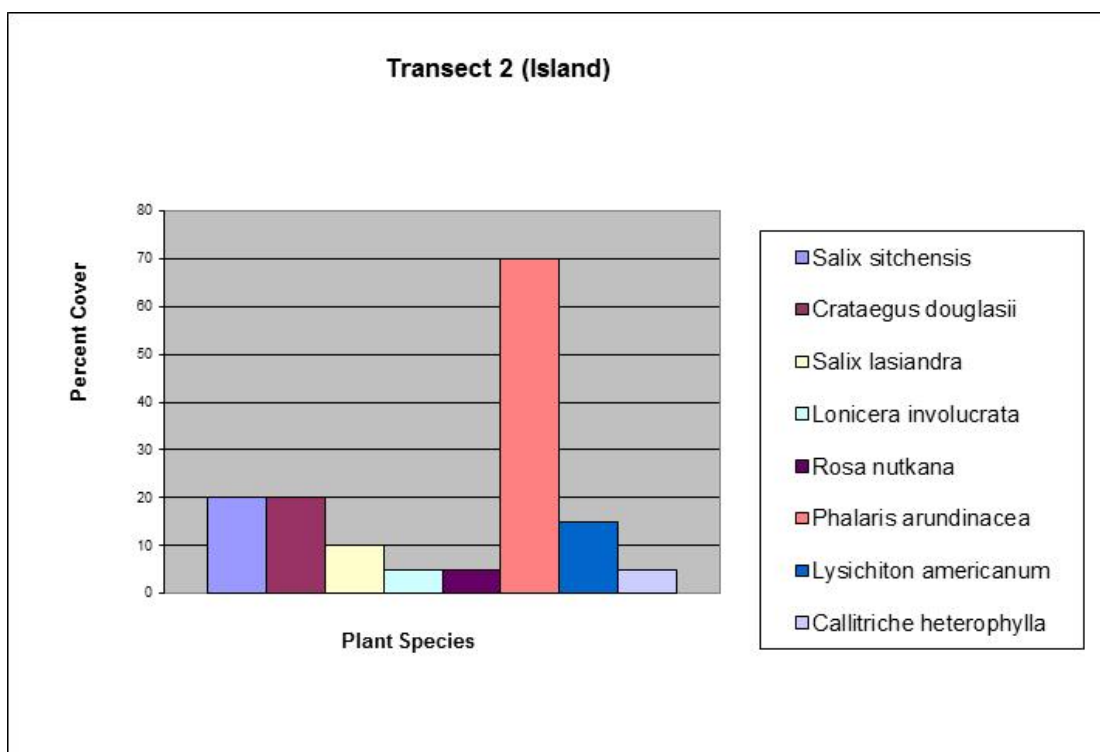


Figure 3-4 Transect 2 (Island) Percent Vegetation Cover

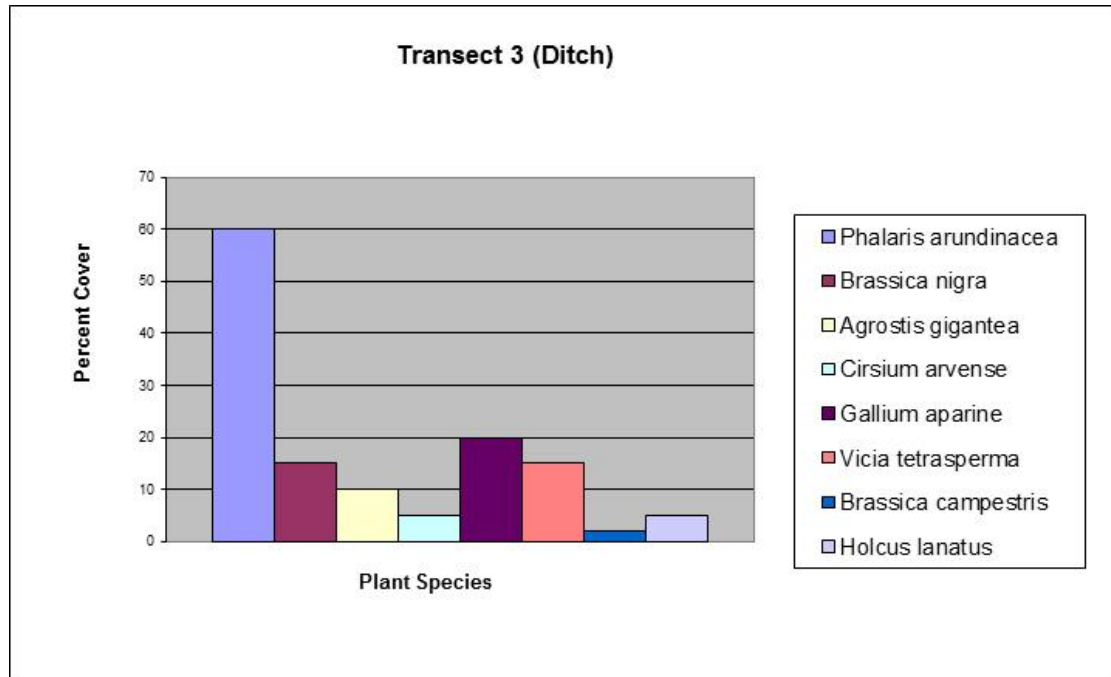


Figure 3-5 Transect 3 (Ditch) Percent Vegetation Cover

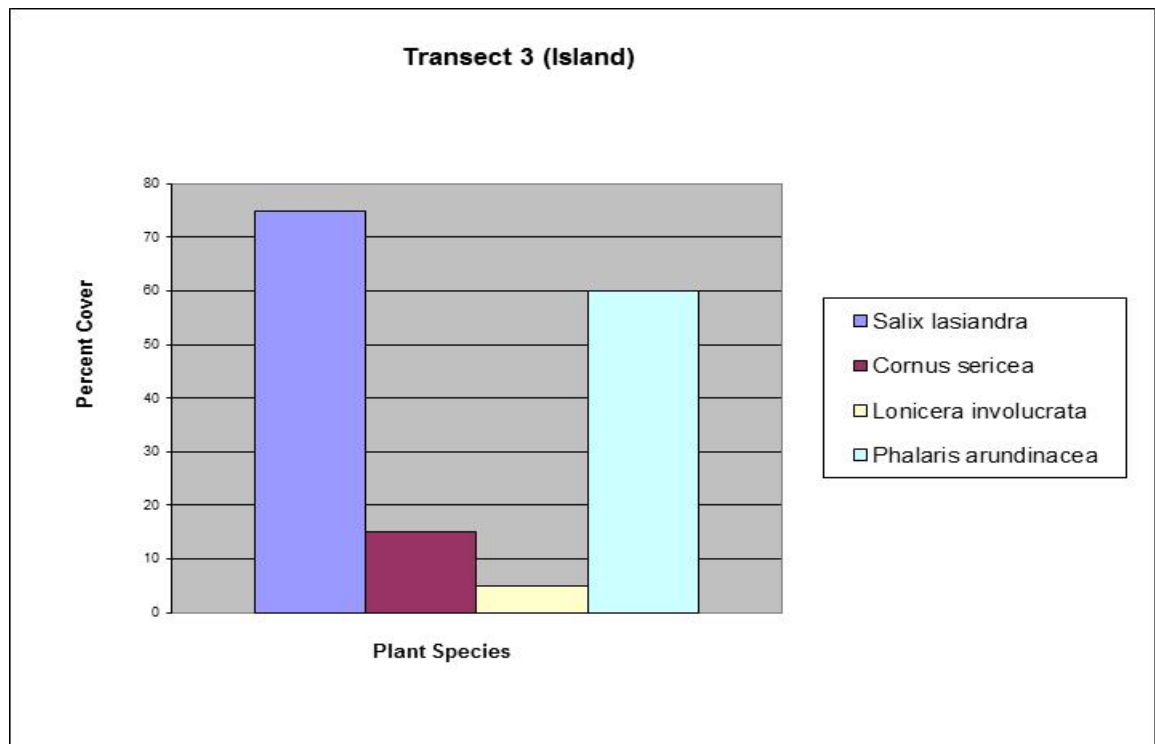


Figure 3-6 Transect 3 (Island) Percent Vegetation Cover

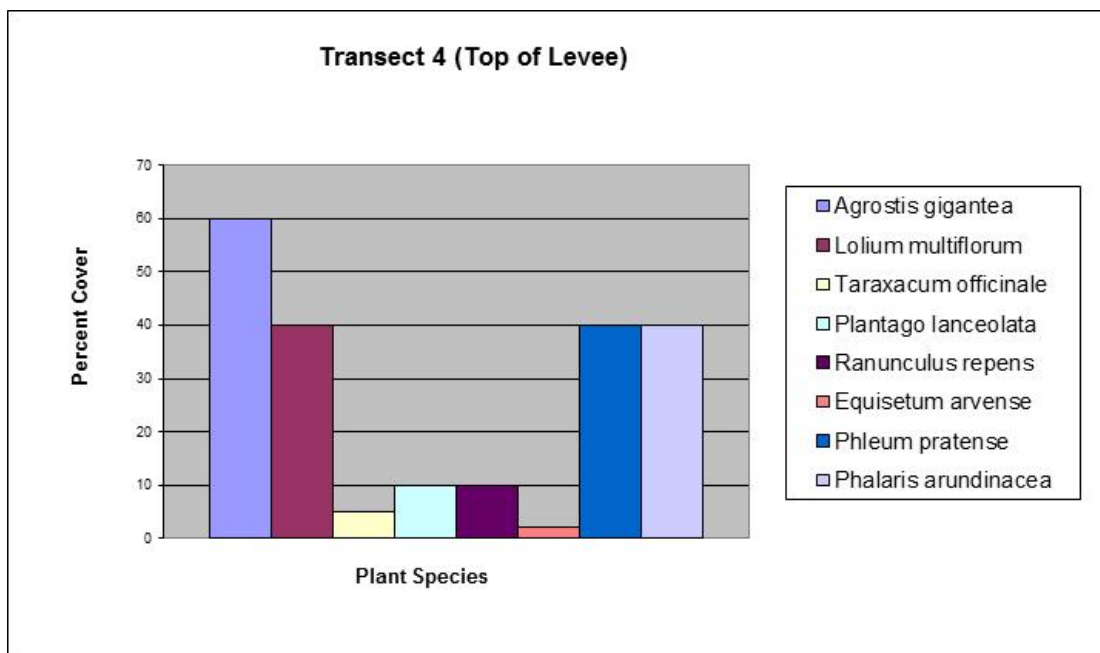


Figure 3-7 Transect 4 (Top of Levee) Percent Vegetation Cover

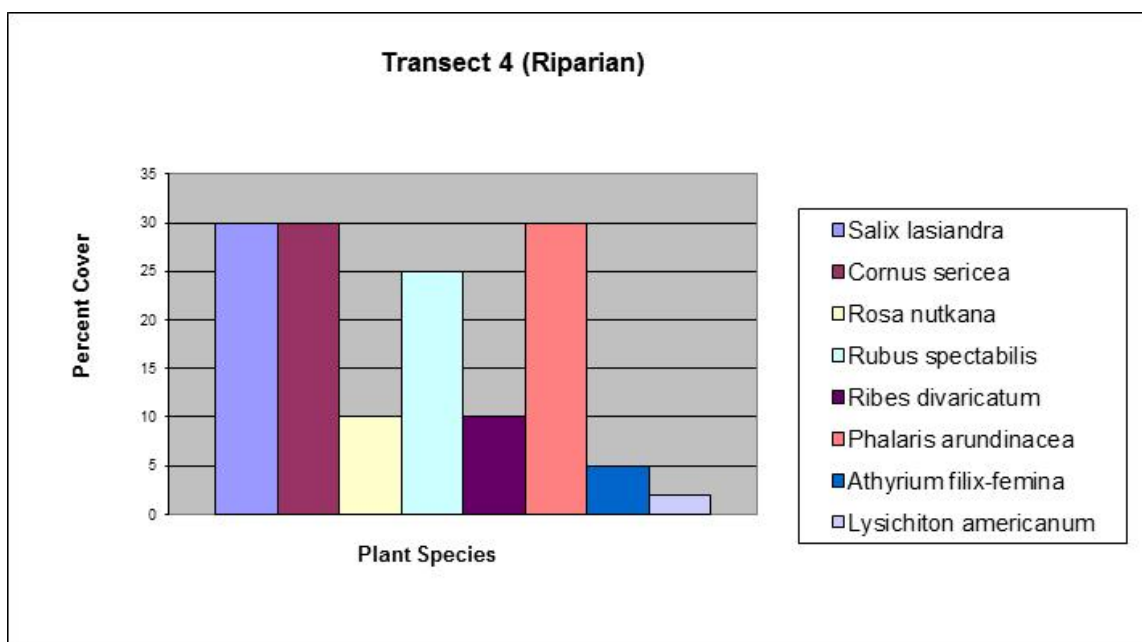


Figure 3-8 Transect 4 (Riparian) Percent Vegetation Cover

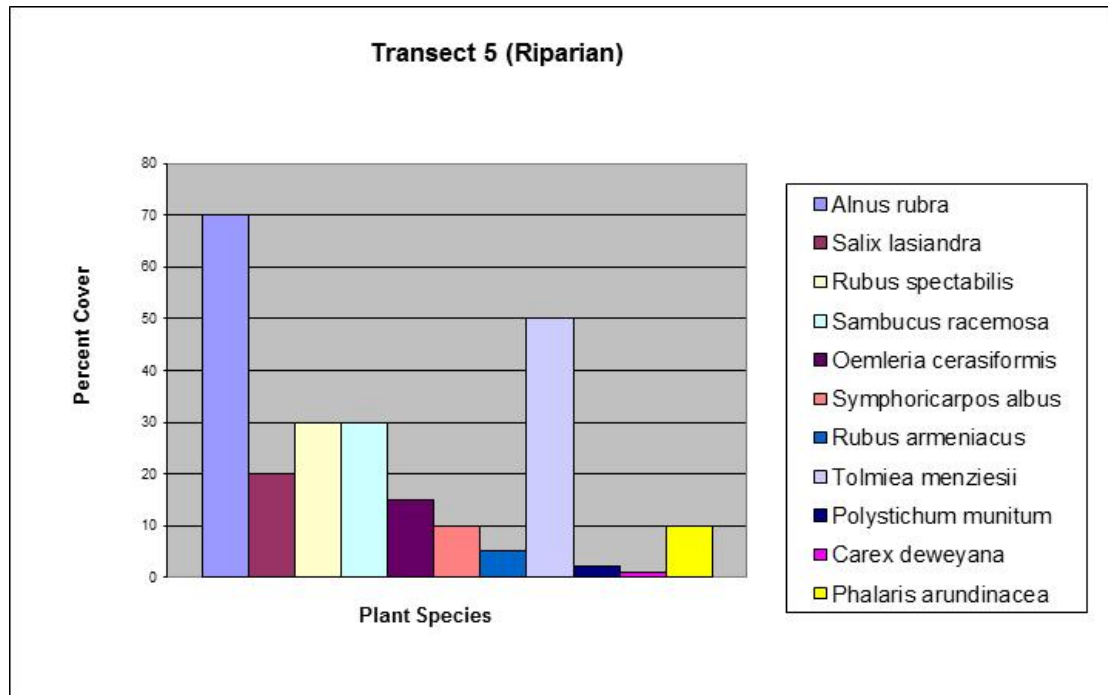


Figure 3-9 Transect 5 (Riparian) Percent Vegetation Cover

3.1.5.1 Total Area of the site with native and non-native species

Vegetation transects show species presence and percent cover was measured at points on these transects. Table 3-9 shows the species found on the fisher slough project site.

Restoration Target: Photo-documentation shows significant change in plant community species composition and type by 2015. Total area mapped with tidal freshwater wetland plant communities increases (60 acres by 2015)

Target met?: Total area of the site with native and non-native species will be calculated in hydroseed treatment areas from 2013 on.

3.1.5.2 Cover of Vegetation Species

Transect data showing percent cover of plant species is in figures 3-3 to 3-9.

Restoration Target: By 2015, >30% cover of freshwater tidal wetland plant species.

Target met?: Not calculated. Percent cover of vegetation species was not recorded in transect data calculated in 2006. Vegetation cover of species and treatment areas will occur from 2013 on.

3.1.5.3 Species Richness

Subsequent transects and vegetation cover measurements will show changes in species richness over time.

Restoration Target: Increased native species richness compared to 2010 conditions

Target met?: Not calculated. Transects during 2006 found 21 native species in the project area (Table 3-7). Native species richness will be determined by hydroseeding treatment areas in 2013 and beyond.

Table 3-9 2006 Fisher Slough Project Plant Species List

Scientific Name	Common Name	Plant Wetland Indicator Status ^a	Vegetation Community Occurrence (based on 2006 Data)			
			Riparian	Cultivated Fields	Non-native Riparian Herbaceous	Non-native Upland Herbaceous
<i>Agrostis gigantea</i>	redtop	FAC			X	X
<i>Alnus rubra</i>	red alder	FAC	X			
<i>Athyrium filix-femina</i>	lady fern	FAC	X			
<i>Brassica campestris</i>	field mustard	NL			X	
<i>Brassica nigra</i>	black mustard	NL			X	
<i>Callitriche heterophylla</i>	water-starwort	OBL	X			
<i>Carex deweyana</i>	Dewey's sedge	FACU	X			
<i>Cirsium arvense</i>	Canada thistle	FACU			X	
<i>Cornus sericea</i>	red osier dogwood	FACW	X			
<i>Crataegus douglasii</i>	black hawthorn	FAC	X			
<i>Equisetum arvense</i>	field horsetail	FAC				X
<i>Gallium aparine</i>	common bedstraw	FACU			X	
<i>Holcus lanatus</i>	velvet grass	FAC			X	
<i>Lolium multiflorum</i>	annual ryegrass	FACU				X
<i>Lonicera involucrata</i>	black twinberry	FAC	X			
<i>Lysichiton americanum</i>	skunk cabbage	OBL	X			
<i>Oemleria cerasiformis</i>	Indian plum	FACU	X			
<i>Phalaris arundinacea</i>	Reed canary grass	FACW	X		X	X
<i>Phleum pratense</i>	timothy grass	FAC				X
<i>Plantago lanceolata</i>	narrow leaf plantain	FAC				X
<i>Polystichum munitum</i>	sword fern	FACU	X			
<i>Ranunculus repens</i>	creeping buttercup	FACW				X
<i>Ribes divaricatum</i>	coast black currant	FAC	X			
<i>Rosa nutkana</i>	Nootka rose	FAC	X			
<i>Rubus armeniacus</i>	Himalayan blackberry	FACU	X			
<i>Rubus spectabilis</i>	salmonberry	FAC	X			
<i>Salix sitchensis</i> ^b	Sitka willow	FACW	X			
<i>Salix lasiandra</i>	Pacific willow	FACW	X			
<i>Sambucus racemosa</i>	Red elderberry	FACU	X			
<i>Solanum dulcamara</i>	climbing nightshade	FAC	X			
<i>Symphoricarpos albus</i>	snowberry	FACU	X			
<i>Taraxacum officinale</i>	dandelion	FACU				X
<i>Tolmiea menziesii</i>	youth-on-age	FAC	X			
<i>Vicia tetrasperma</i>	lentil vetch	NL			X	

Scientific Name	Common Name	Plant Wetland Indicator Status ^a	Riparian	Cultivated Fields	Non-native Riparian Herbaceous	Non-native Upland Herbaceous
			Vegetation Community Occurrence (based on 2006 Data)			
^a FAC= Plants with a similar likelihood (33% to 66% of the time) of occurring in both wetlands and non-wetlands NL= Not listed OBL= Plants that almost always (> 99% of the time) occur in wetlands, but which may rarely (< 1% of the time) occur in non-wetlands FACU= Plants that sometimes (1% to 33% of the time) occur in wetlands, but occur more often (67% to 99% of the time) in non-wetlands FACW= Plants that often (67% to 99% of the time) occur in wetlands, but sometimes (1% to 33% of the time) occur in non-wetlands						
^b Sitka willow (<i>Salix sitchensis</i>) was originally identified as Geyer's willow (<i>Salix geyeriana</i>) in 2006.						

3.1.5.4 Elevation Ranges and Inundation times of vegetation communities

Elevation ranges are strongly correlated with inundation times and vegetation community extent and composition (Table 3-8).

Restoration Target: Elevation ranges (NAVD88) and % inundation for major vegetation types will be similar to: Mud-channel, 0-4.5 feet, 95-100%; Low marsh, 4.5-7.0 feet, 50-95%; High marsh, 7.0-8.5 feet, 15-50%; Riparian, 8.5-10.0 feet, 5-15% and Upland, > 10 feet, 0-5%

Target met?: Not calculated. This parameter is a new addition to the monitoring plan and was not measured or calculated prior to 2010. Using a combination of LiDAR and RKS-GPS, elevation ranges will be determined for tidal marsh vegetation communities (High Marsh, Low Marsh and Mudflat) and inundation times will be calculated and reported in the 2013 monitoring report.

3.1.6 Hypothesis H6

Restoring a natural and more variable tidal regime will reduce the cover of Reed canary grass in areas where it occurs pre-project.

Table 3-15 Reed canary grass Parameters

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
Total area of the site with Reed canary grass, determined from vegetation mapping in aerial photographs.	Not measured.	Not measured.			Area mapped with Reed canary grass is the same or less by 2015 (TBD—areas derived from 2010 monitoring).

Parameter	Before 2009	2009 Condition	2013 Condition	2015 Condition	Restoration Target
Average elevation and elevation range of Reed canary grass on the site.	Not measured.	Not measured.			
Average cover of Reed canary grass in vegetation plots.	Reed Canary Grass cover in the seven vegetation transects ranged from 10-70% cover in 2006.	Not analyzed.			Percent cover of Reed canary grass in plots is same or less (TBD—percent cover derived from 2010 monitoring).

The presence of Reed canary grass throughout the project site reduces habitat values and is a limitation to the natural colonization of native vegetative communities at the site. Additionally, the presence of Reed canary grass along the channel of Fisher Slough increases the risk of the grass dominating the restored floodplain. The levees are also mowed periodically for inspections and to prevent the growth of woody species. The existing marsh plain is dominated by Reed canary grass with patches of shrubs and small trees. Reed canary grass 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.

Data associated with Hypothesis H6 will be included in the 2010 Monitoring Report – 2010 will serve as baseline condition for evaluating change over time and testing Hypothesis H6. Testing of hypothesis H6 is also dependent upon photographic documentation described under Hypothesis H3 (see Section 3.1.3), and will be used to verify presence and extent of Reed canary grass.

3.1.6.1 Total area of the site with Reed Canary Grass

Reed Canary Grass occurs in the riparian zone which is 4.1 acres or 41.8 percent of the 9.8 acres of baseline habitat present at the project site. The total acreage of Reed Canary Grass in the project area was not measured in 2009 or prior.

Restoration Target: Area mapped with Reed canary grass is the same or less (TBD-percent cover derived from 2010 monitoring)

Target met?: Not calculated. Will be reported from 2013 on.

3.1.6.2 Average Elevation and Elevation range of Reed Canary Grass on the site

The elevation range that Reed Canary Grass or riparian vegetation exists is 7.5-10.5 ft NAVD88. The average elevation that Reed Canary grass currently occupies was not calculated.

Restoration Target: To be developed

Target met?: Not calculated. Restoration target will be developed and data will be reported from 2013 on.

3.1.6.3 Average cover of Reed Canary Grass in Vegetation plots

Reed Canary Grass cover in the five vegetation transects (Fig 2-2) ranged from 10-70% cover in 2006 (Fig 3-3 to 3-9).

Restoration Target: Percent cover of Reed canary grass in plots is the same or less (TBD-percent cover derived from 2010 monitoring)

Target met?: Average cover of Reed Canary Grass in Vegetation plots will be measured from 2013 on at the same vegetation transect locations.

3.1.7 Hypothesis H7

Restored tidal exchange will reintroduce 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.

The replacement of the existing floodgate at the Pioneer Highway crossing with new self-regulating floodgates will allow greater tidal exchange and fish access upstream of the floodgate. This combined with the levee setbacks will allow for the processes that support a complex channel network.

Table 3-16 Fisher Slough Channel Metrics

Parameter	Before 2009	2009 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
Channel area (total channel area estimated from aerial photographs and elevations using GIS).	1.7 acres of channel area (TNC 2010).	1.7 acres of channel area.				Total Channel Area and Length will increase by 2015
Channel cross sections and longitudinal profiles	Not measured.	Not measured.				

Parameter	Before 2009	2009 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
(estimate area).						
Total length of channel network (estimated from aerial photographs using GIS).	Not calculated.	Not measured.				TBD—measures of pilot channels from as-built drawings in 2011.
Channel density (total length divided by project area).	Not calculated.	Not measured.				
Distance upstream to head of blind tidal channel.	Not calculated.	Not measured.				

Channel area is the total channel area estimated from aerial photographs and elevations using GIS.

Channel cross sections and **channel longitudinal profiles** are shown graphically.

Total length of channel network is estimated from measuring the channel length along the middle of the channel using aerial photographs using GIS.

Channel density is the total length of channels divided by the project area.

Distance upstream to the head of blind tidal channel, measured as both average and maximum of distance from the floodgates to the farther upstream extent of blind channels.

3.1.7.1 Channel Area

Channel area, derived from aerial imagery, will be used to compare pre-project conditions to post-project conditions, as well as during the progression (in 2011, 2013, and 2015). The aerial imagery used was shot in May and June 2009 with 1 foot pixels from Aerials Express. Aerial imagery analysis will assist in testing Hypothesis H7 by determining changes in channel area and complexity.

After construction and the reintroduction of increased tidal influence, the channel area is expected to increase significantly (with the associated increase in habitat available to salmonids) throughout the project site. The pre-restoration estimated total channel area of the project site is approximately 1.7 acres (Figure 3-3). Carpenter Creek is approximately 0.1 acre, Big Fisher Creek is approximately 0.1 acre and Little Fisher Creek is approximately 0.3 acre within the project area.

Tidal channels are scheduled to be measured every other year once construction of the project site is complete in 2011 (Parametrix 2010).

Restoration Target: Total Channel Area and Length will increase by 2015.

Target met?: Current channel area is 1.7 acres. Restoration target will be developed and data will be reported from 2011 on.

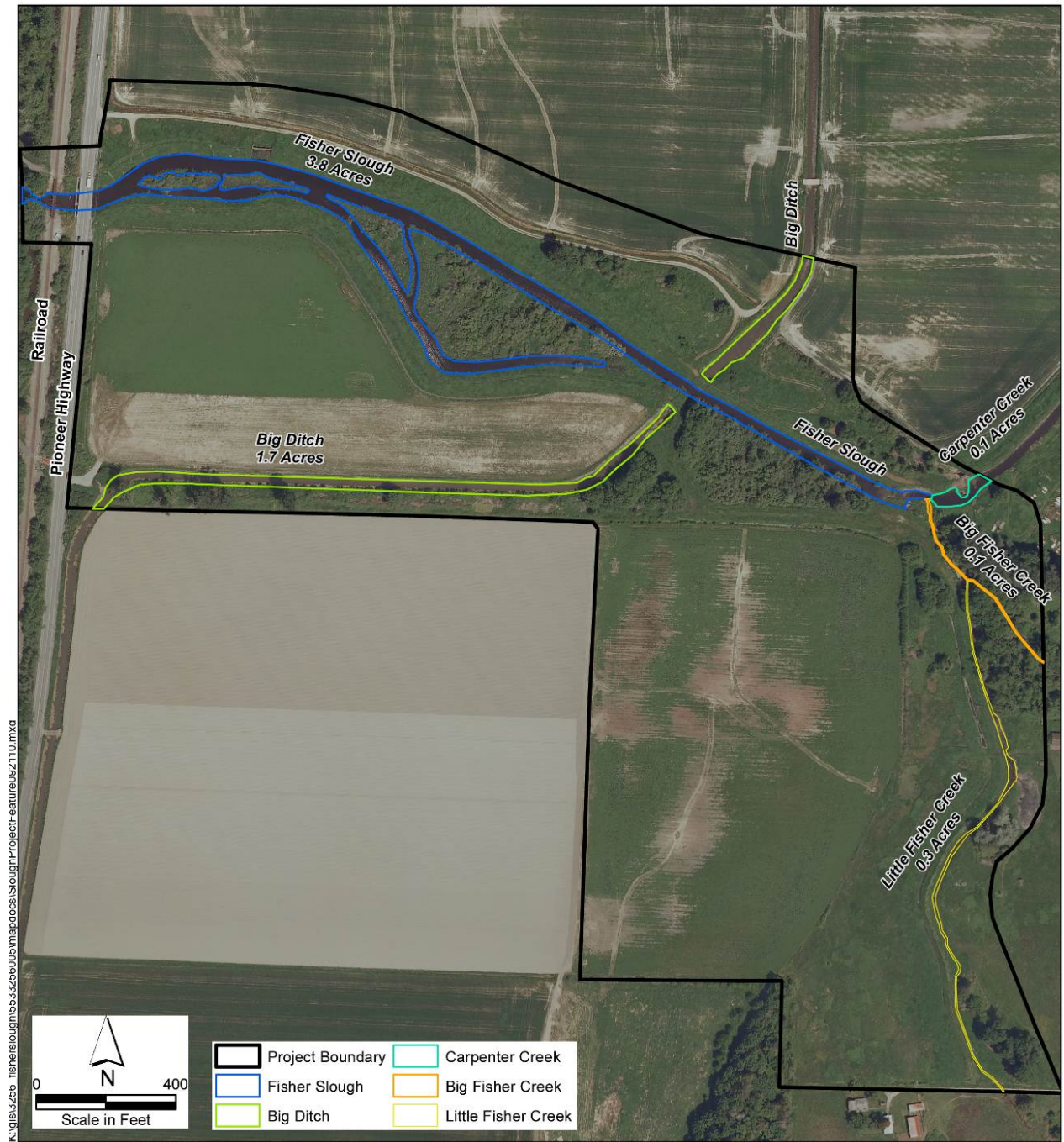


Figure 3-10 Channel area in the Project Site*

*Big Ditch is not included in channel length or area estimates of the project site.

3.1.7.2 Cross Sections

Channel cross sections of Fisher Slough were created along the five sampling transects (Fig 2-2) using the LiDAR data (Figures 3-4). Pre-project conditions of these cross sections will be compared to future conditions to determine if existing and new channels have changed over the project period. Pre-project elevations along the five transects range from 1.5 to nearly 16 ft NAVD88. LiDAR is most effective in areas of exposed earth and other hard surfaces. Areas of dense vegetation are more difficult to measure due to the laser signals reflecting off of the vegetation instead of the ground creating false ground surface contours. Therefore, it is likely that the high elevations noted in the marsh portions of the transects are likely false elevation readings due to vegetation (trees and shrubs) in those areas. Future cross sections will be created using survey results along permanently established transects to track changes in topography and elevation which will provide more detail and accuracy.

Restoration Target: To be developed

Target met?: Not calculated. Restoration target will be developed and data will be reported from 2011.

on.

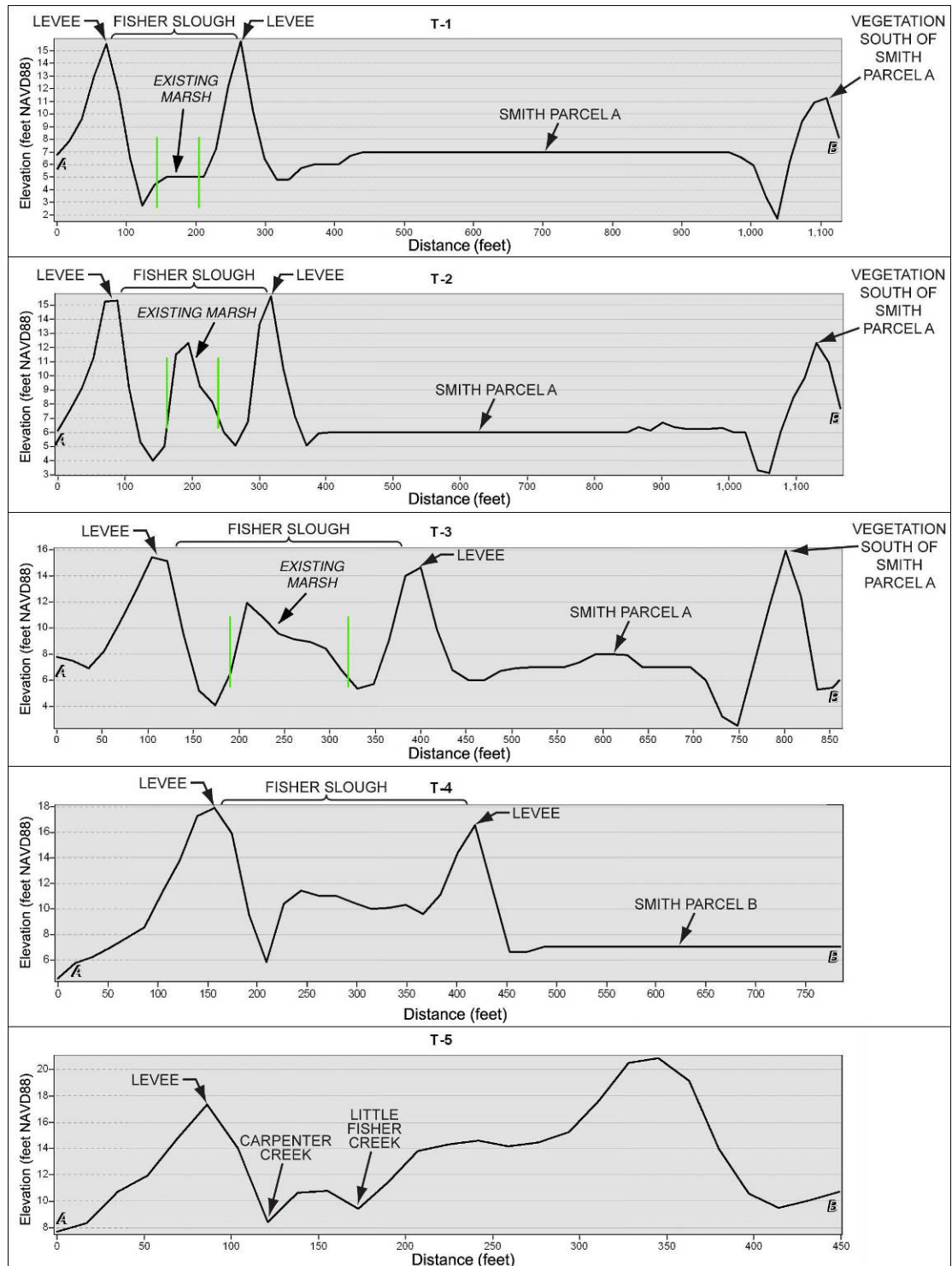


Figure 3-3 Channel Cross Sections of Fisher Slough along Transects

3.1.7.3 Total Length of Channel Network

The total length of the existing channel network has not been calculated. There are four existing channel networks; Fisher Slough, Carpenter Creek, Big Fisher Creek and Little Fisher Creek. Existing aerial photos and GIS will be used to determine total channel length.

Restoration Target: To be developed-measures of pilot channels from as-built drawing in 2011.

Target met?: Not calculated. Restoration target will be developed and data will be reported after as-built drawings document baseline condition.

3.1.7.4 Total Edge Length of Channel Network

The total edge length of the existing channel network has not been calculated. There are four existing channel networks; Fisher Slough, Carpenter Creek, Big Fisher Creek and Little Fisher Creek. Existing aerial photos and GIS will be used to determine total channel edge length.

Restoration Target: To be developed

Target met?: Not calculated. Restoration target will be developed and data will be reported from 2011 on.

3.1.7.5 Channel Density

The current project channel area is 9.8 acres. The total channel network length has not been measured for each of the four channel networks.

Restoration Target: To be developed

Target met?: Not calculated. Restoration target will be developed and data will be reported beginning in 2011.

3.1.7.6 Distance Upstream to head of blind tidal channel

This is the distance from the junction with Fisher Slough to the end of the channel. This will be calculated using existing aerial photos and GIS. **Restoration Target:** To be developed
Target met?: Not calculated. Restoration target will be developed and data will be reported beginning in 2011.

3.2 OBJECTIVE 2

Restore and improve freshwater tidal rearing habitat for Chinook salmon (*Oncorhynchus tshawytscha*).

Fish data were gathered separately from vegetation, site condition, and macroinvertebrate data. Hypotheses under Objective 2 are reported in a separate document titled Juvenile Salmon, Estuarine, and Freshwater Fish Utilization of Habitat Associated with the Fisher Slough Restoration Project, Washington 2009 (Beamer 2010). In future years when fish monitoring occurs the results and analysis will also be provided in a separate report.

3.2.1 Hypothesis H8

Chinook salmon abundances (0+ year class) will be similar above and below the floodgates (post replacement) during peak migration periods.

Table 3-17 Chinook Salmon Abundance

Parameter	Before 2009	2009 Condition	2010 Condition	2012 Condition	2013 Condition	2015 Condition	Restoration Target
Chinook salmon: Presence/absence Density/abundance Location Timing	Not measured.	There is no significant difference in log transformed mean juvenile Chinook density between sites up and downstream of the floodgates 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.

Data associated with Hypothesis H8 are addressed in Juvenile Salmon, Estuarine, and Freshwater Fish Utilization of Habitat Associated with the Fisher Slough Restoration Project, Washington 2009 (Beamer 2010).

3.2.2 Hypothesis H9

Juvenile Chinook salmon will utilize restored channels and marshes at densities similar to other Skagit freshwater tidal marshes, adjusted for landscape connectivity.

Table 3-18 Juvenile Chinook Abundance

Parameter	Before 2009	2009 Condition	2010 Condition	2012 Condition	2013 Condition	2015 Condition	Restoration Target
Chinook salmon: Presence/absence Density/abundance Location Timing	Not measured.	(Beamer et al 2010) shows no reduction in landscape connectivity due to the presence of tidegates					

Data associated with Hypothesis H9 are addressed in Juvenile Salmon, Estuarine, and Freshwater Fish Utilization of Habitat Associated with the Fisher Slough Restoration Project, Washington 2009 (Beamer 2010) Macroinvertebrates

3.2.3 Macroinvertebrates

Macroinvertebrates are not included as parameters to test hypotheses but were originally sampled with the intention of providing data associated with Objective 2. Macroinvertebrate sampling was conducted in 2006. The macroinvertebrates collected in 2006 were almost all freshwater taxa (Table 3-12). The one exception was the one amphipod, *Ramellogammarus* (formerly *Anisogammarus*). This amphipod is a brackish water taxon, and is common in estuaries, bays, and in the lower reaches of streams and rivers draining into Puget Sound. The rest of the taxa are commonly encountered in soft substrates of lakes and rivers in the Pacific Northwest.

There were several species of Chironomidae (midges), which is normal for mucky, sandy and organic depositional areas of rivers and streams. The one species of caddisfly (*Psychoglypha bella*) indicates that palatable (e.g., conditioned by bacteria for easy consumption) depositional material (e.g., leaves, sticks, and twigs) are present. In addition, there must be inorganic structure on the bottom of the channel for this genus of caddisfly to inhabit. The genus, *Psychoglypha* sp., is also found in low elevation mountain streams of Oregon and Washington. *Pisidium*, fingernail clams, are common in sandy-bottom streams and rivers throughout the region. Turbellaria (flatworms) can be found where there is cold spring-water entering the channel. They also thrive in portions of streams that have a high density of prey items like nematodes and oligochaetes. The Western Floater freshwater mussel (*Anodonta kennerlyi*) was present which has a more northerly distribution and is generally indicative of the absence of introduced pollutants. The western floater is able to inhabit lake-like conditions and withstand some of the chemical stressors like low dissolved oxygen concentrations or moderately high temperature conditions. This location is near the southerly

range for distribution and is apparently less polluted than most drainages where the western floater has disappeared. This species of bivalve is usually located at the base of extensive drainages and is adapted to the more naturally stressful chemical characteristics.

Transect 1 had a score of 5.29 on the Hilsenhoff Biotic Index which indicated good water quality with some organic pollution. Transect 4 (5.63) has fair water quality with fairly significant organic pollution. The Shannon diversity index (H) is an index that is commonly used to characterize species diversity in a community. Transect 4 displays a higher diversity with a score of 1.52 over Transect 1 with a score of 0.63. The macroinvertebrate data suggest some degradation of the habitat, but overall water quality and habitat conditions in Fisher Slough are fair to good. This is similar to what DO levels in Fisher Slough indicate, which are generally higher than the WDOE minimum standards (WDOE 2004), but occasionally drop below. However, the temperatures of Fisher Slough are more frequently above the WDOE standards (WDOE 2004).

Table 3-19 Macroinvertebrate Species List

Taxon	Taxonomic Hierarchy	Common Name	Habitat	Tolerant	Feeding
<i>Turbellaria</i>	Turbellaria	flatworms	freshwater		predator
<i>Nematoda</i>	Nematoda	roundworms	freshwater		parasite/ collector gatherer
<i>Oligochaeta</i>	Annelida, Oligochaeta	segmented worms	freshwater		collector gatherer
<i>Pisidium</i>	Mollusca, Pelecypoda, Sphaeriidae	finger nail clams	freshwater		collector filterer
<i>Anodonta kennerlyi</i>	Mollusca, Pelecypoda, Unionidae	freshwater mussels	freshwater		collector filterer
<i>Ramellogammarus</i>	Arthropoda, Crustacea, Amphipoda, Anisogammaridae	scuds	estuarine, bays		collector gatherer
<i>Ramellogammarus</i>	Arthropoda, Crustacea, Amphipoda, Anisogammaridae	scuds	estuarine, bays		parasite
<i>Psychoglypha bella</i>	Arthropoda, Insecta, Trichoptera, Limnephilidae	caddisflies	freshwater		omnivore
<i>Chironomidae-pupae</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater		collector gatherer
<i>Chironomus</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater	tolerant	collector
<i>Cricotopus</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater		collector gatherer
<i>Cryptochironomus</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater	tolerant	collector
<i>Microtendipes</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater	tolerant	collector gatherer
<i>Parakiefferiella</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater		collector gatherer
<i>Paralauterborniella</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater	tolerant	collector gatherer
<i>Phaenopsectra</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater		scraper/ collector gatherer
<i>Polypedilum</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater		omnivore
<i>Procladius</i>	Arthropoda, Insecta, Diptera, Chironomidae	midges	freshwater	tolerant	predator
<i>Tanytarsus</i>	Arthropoda, Insecta, Diptera,	midges	freshwater	tolerant	collector

Taxon	Taxonomic Hierarchy	Common Name	Habitat	Tolerant	Feeding
	Chironomidae				

Mean abundance of macroinvertebrates, number of taxa, EPT abundance, and two biodiversity indices are shown in Table 3-13. The mean abundance scores have been converted to a square meter basis. The densities of 9,722 and 18,195 organisms per square meter for Transect 1 and 4, respectively, are moderate to high for fine sediment substrates. *Ephemeroptera* (Mayflies), *Plecoptera* (Stoneflies), and *Trichoptera* (Caddisflies) are all species that are considered to be very sensitive to poor water quality conditions, therefore the presence of these organisms are indicators of good water quality sites. The higher the populations of these organisms and the higher the EPT Metric score, the more stable the site. The EPT abundance is low for both sites with Transect 1 having no EPT taxa collected. The HBI (Hilsenhoff 1982) score provides a measure of water quality health. HBI values range from zero to ten, zero having excellent water quality (no apparent organic pollution) and ten having very poor water quality (severe organic pollution) (Table 3-14).

Table 3-20 Macroinvertebrate Metric Scores

Metric	Transect 1	Transect 4
Abundance	9,722.4	18,194.7
Number of Taxa	8	15
EPT Abundance	0	277.8
Hilsenhoff Biotic Index	5.29	5.63
Shannon Diversity Index	0.63	1.52

Table 3-21 Hilsenhoff Biotic Index¹

Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very good	Possible slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very poor	Severe organic pollution

¹ (Hilsenhoff 1982)

3.3 OBJECTIVE 3

Restore passage for coho and chum salmon spawning access.

3.3.1 Hypothesis H10

Floodgate operation will improve fish passage opportunity for coho and chum compared to pre-project conditions.

Table 3-22 Floodgate Operation Metrics

Parameter	Before 2009	2009 Condition	2010 Condition	2013 Condition	2015 Condition	Restoration Target
Number of days floodgates are open from October 1 to February 28 or 29.	Gates were open for 34% of the time during the fall of 2006 (Tetra Tech 2008).	Not measured.				Gates open at least once per day October to February 28 or 29

The barn door style floodgates were not replaced with the self regulating floodgates until fall of 2009, after the data collection period for this report. Hypothesis H10 will be evaluated beginning in 2010 in the separate Fish Monitoring Report.

3.3.2 Hypothesis H11

Removal of the passage barrier at Big Ditch will result in more natural channel profile through this area.

Table 3-23 Big Ditch Channel Metrics

Parameter	Before 2009	2009 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
Longitudinal channel profile at	Not measured.	Not measured.				By 2015, passage barrier at

Parameter	Before 2009	2009 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
Big Ditch crossing.						Big Ditch can no longer be seen in channel profile
Mean water depth at crossing.	Not calculated.	Not measured.				Mean water depth at crossing increases.

3.3.2.1 Longitudinal channel profile at Big Ditch Crossing

Restoration Target: By 2015, passage barrier at Big Ditch can no longer be seen in channel profile

Target met?: Not calculated. Data will be reported in 2011.

3.3.2.2 Mean water depth at crossing

Restoration Target: Mean water depth at crossing increases

Target met?: Not calculated. Restoration target will be developed and data will be reported in 2011

3.4 OBJECTIVE 4

Improve flood storage and protect adjacent farm uses.

3.4.1 Hypothesis 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 3-24 Flood Storage Metrics

Parameter	Before 2009	2009 Condition	2011 Condition	2013 Condition	2015 Condition	Restoration Target
Change in flood storage capacity	64 acre-feet of storage (Tetra Tech 2009a).	Not measured.				At least 247 acre-feet of new flood storage (about 310 acre-feet total).

3.4.1.1 Change in Flood Storage Capacity

The existing total flood storage volume for the project area is 64 acre-ft (Tetra Tech 2009a). The target flood storage condition is 310 acre-ft of total flood storage (volume). For data associated with H12 see Hypotheses H1 and H4 (see Sections 3.1.1 and 3.1.4).

Restoration Target: At least 247 acre-ft of new flood storage (about 310 acre-ft total)

Target met?: Not calculated. Restoration target will be developed and data will be reported in 2011.

4. RECOMMENDATIONS

The level logger located upstream of the floodgates appears to have malfunctioned during the summer of 2009 and recorded negative pressures, indicating water levels lower than what is possible. It is recommended that repairs or replacement occur to the upstream data logger. This would allow for more reliable data for comparison of conditions upstream and downstream of the floodgates.

It is anticipated that despite restoration activities, Reed canary grass will continue to be on the site. It is recommended that close attention is paid to Reed canary grass expansion and the Reed canary grass management strategy be closely followed.

5. REFERENCES

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APPENDIX A - GROUNDWATER DATA



Figure A-1. Surface Water and Groundwater Sampling

Appendix A presents groundwater data collected from January 2, 2009 to September 30, 2009 at three locations (GW-Smith, GW-Jungquist East, and GW-Jungquist West). The following charts display groundwater elevations collected at 15-minute intervals during this data collections period by month. Tables A-2 through A-4 show monthly averages, maximums, and minimums at each well location.

Groundwater Levels

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. 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.

Water levels at GW-Smith were generally higher than those at the other two wells until the middle of July 2009. By late July, the water levels at GW-Smith were lower than those at GW-Jungquist East and GW-Jungquist West and remained lower through the end of August. The groundwater levels at GW-Jungquist West were consistently higher than those at GW-Jungquist East until June 2009. GW-Smith is located farther away from Fisher Slough and other potential hydrologic sources. Therefore it is anticipated that water levels would be lower and that they would drop more quickly during the summer at GW-Smith when compared to the other two groundwater wells. It is possible that water levels are higher at the GW-Smith well during the winter and spring months because groundwater may drain toward

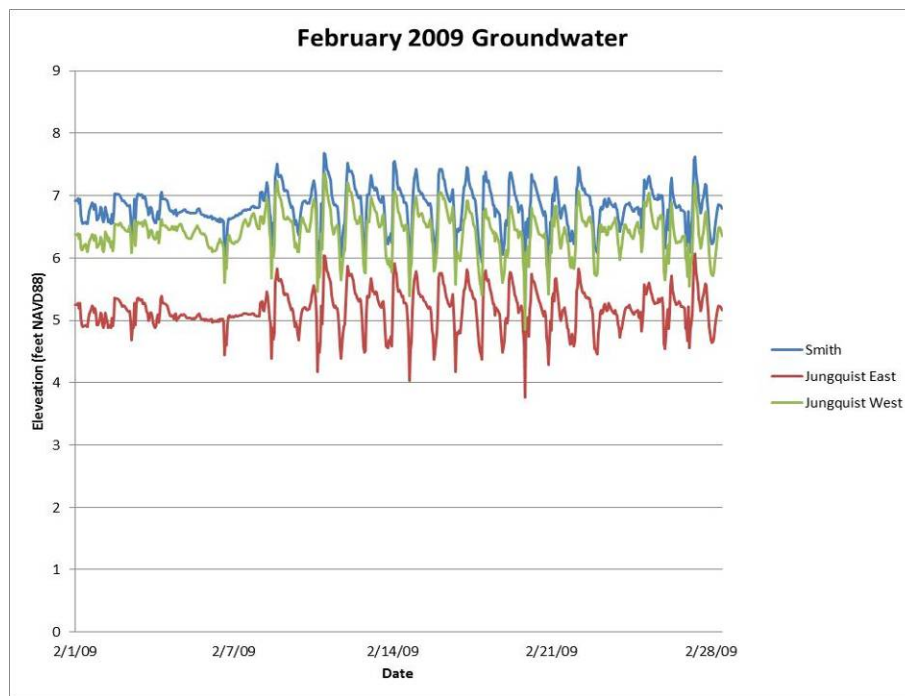
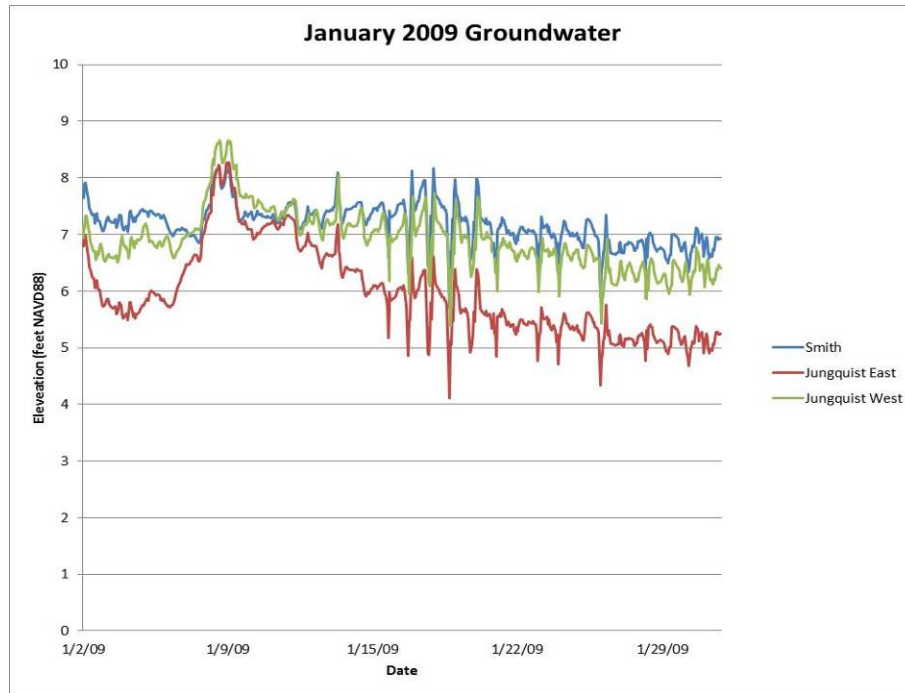
Fisher Slough more readily after rain events, compared to the GW-Smith area which is in the center of a field.

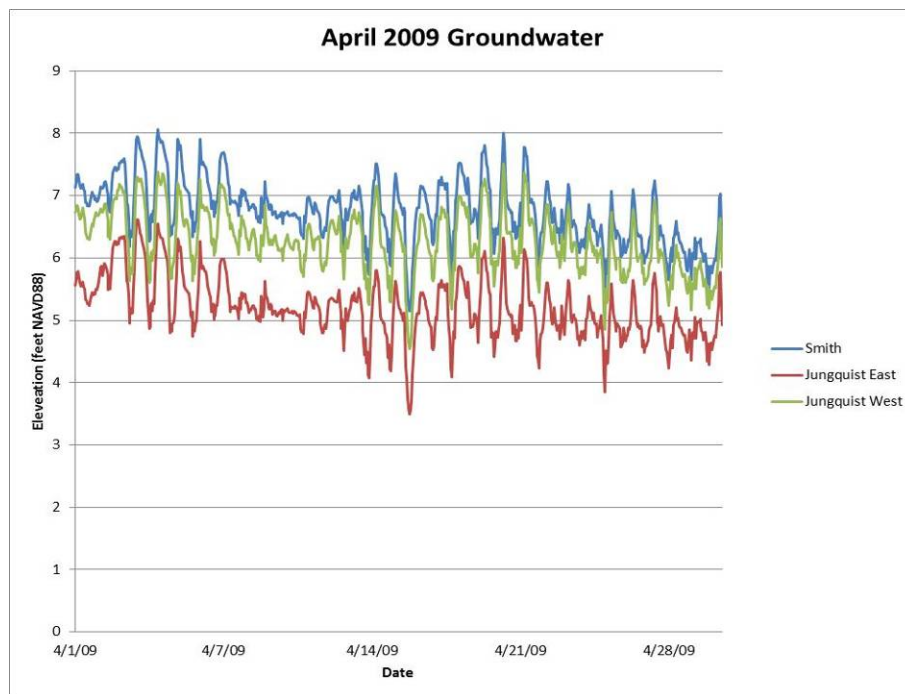
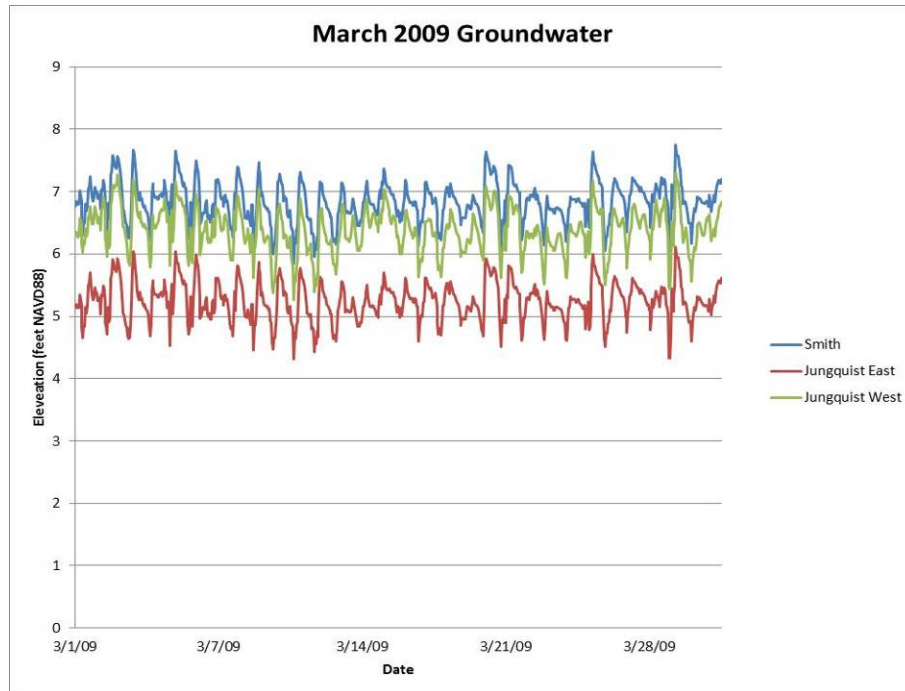
Anomalies in the data occurred on January 2, 2009, and May 14, 2009. These anomalies were associated with the removal and adjustments to the data loggers on those dates and were removed from the charts.

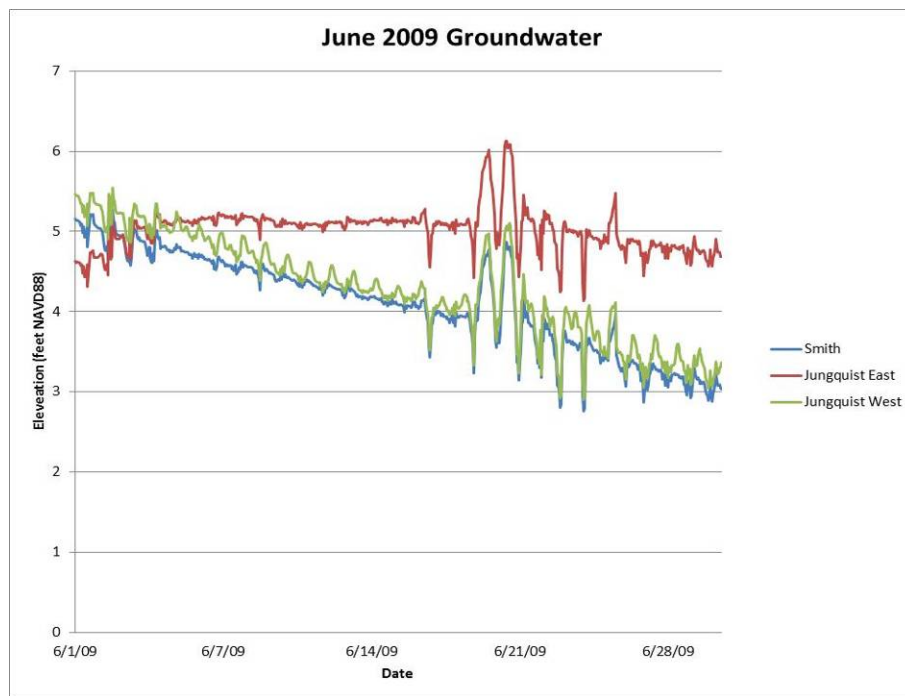
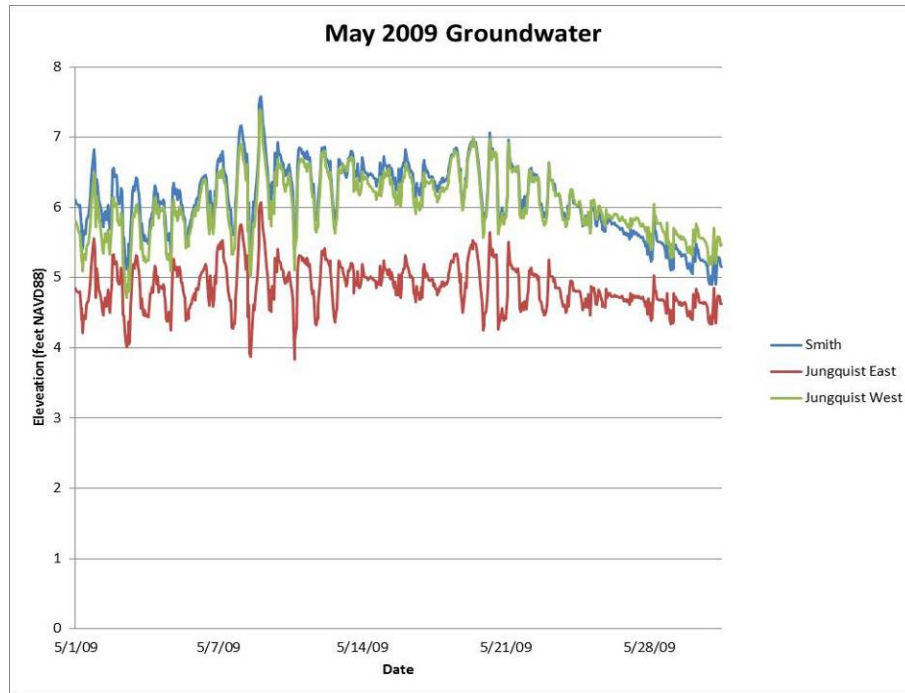
Table A-1. 2009 Groundwater Elevation Summary (ft-NAVD88)

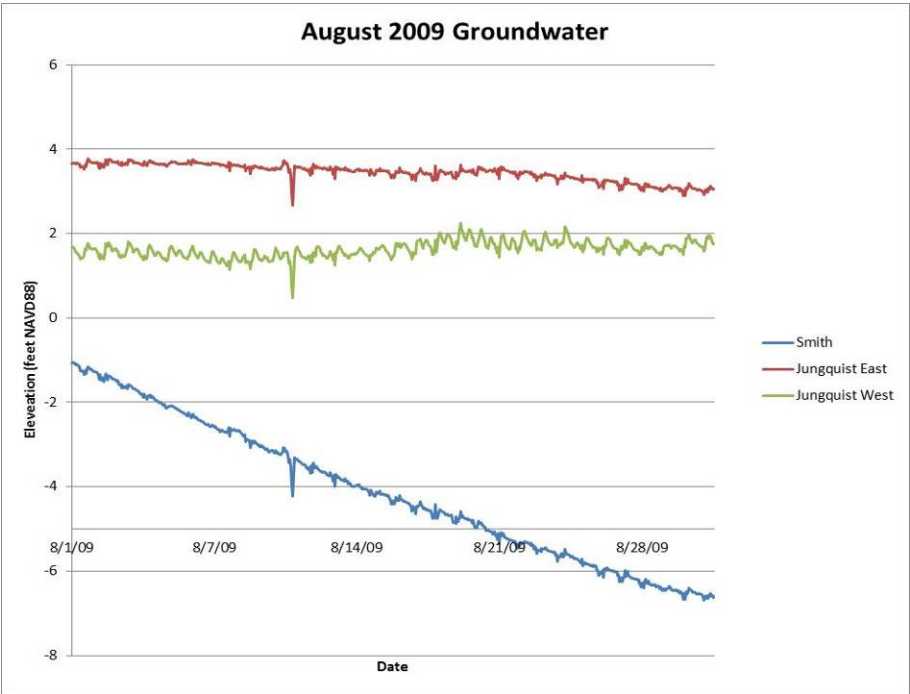
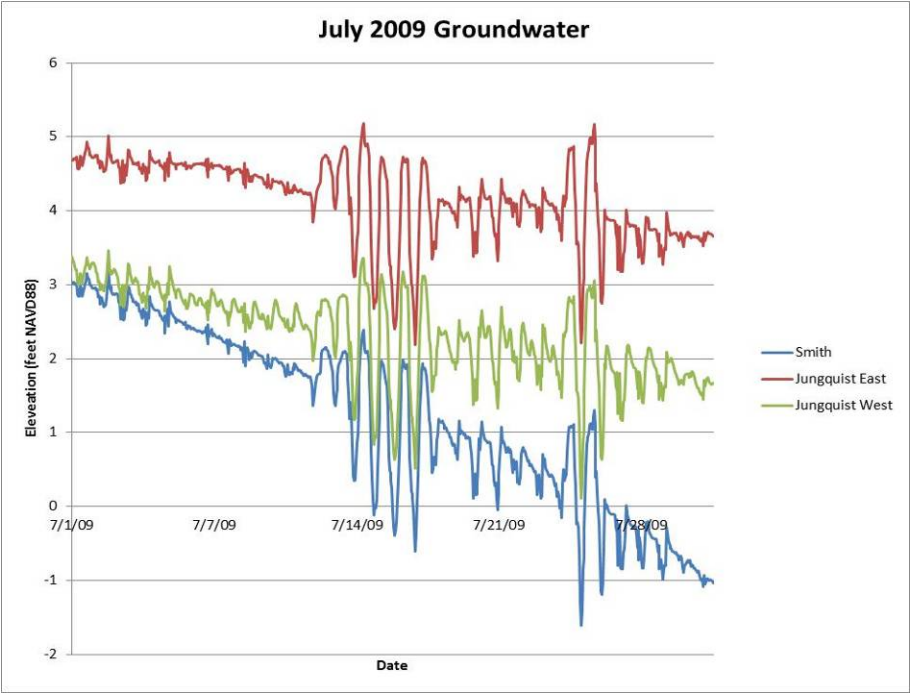
Location	Jan 2-Feb 28			Mar 1-May 31			Jun 1-Sep 30*		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
GW-Smith	7.00	8.21	5.35	6.56	8.06	4.90	0.31	5.27	-6.85
GW-Jungquist East	5.57	8.28	3.76	5.10	6.63	3.50	4.20	6.13	2.19
GW-Jungquist West	6.67	8.67	4.85	6.23	7.52	4.54	2.73	5.55	0.11

*Tidegates cabled open during this period. Tidegates operating normally from Jan2 to May 31









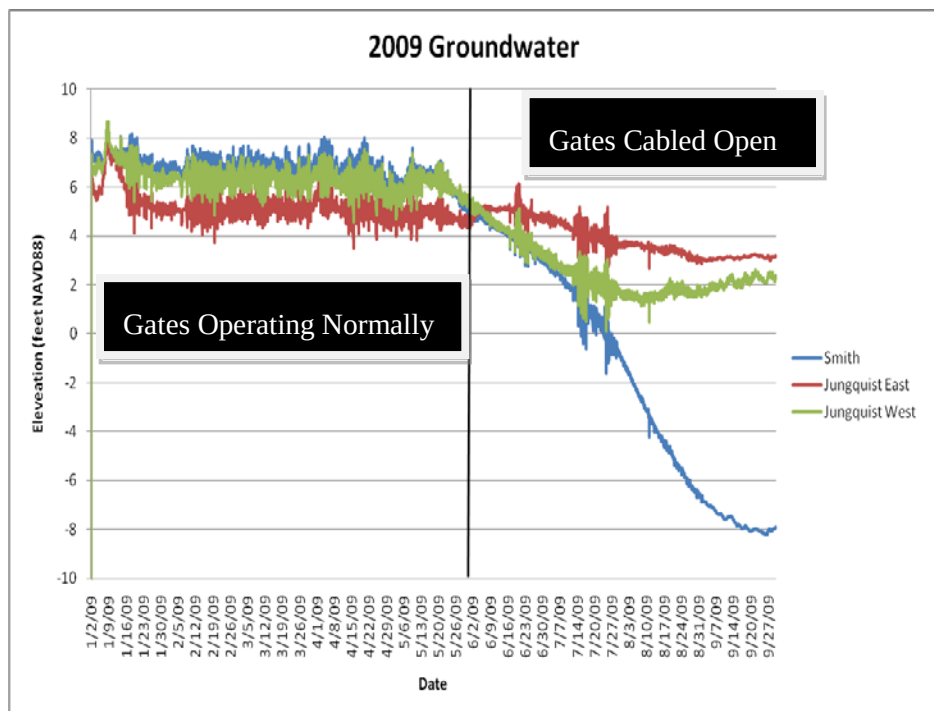
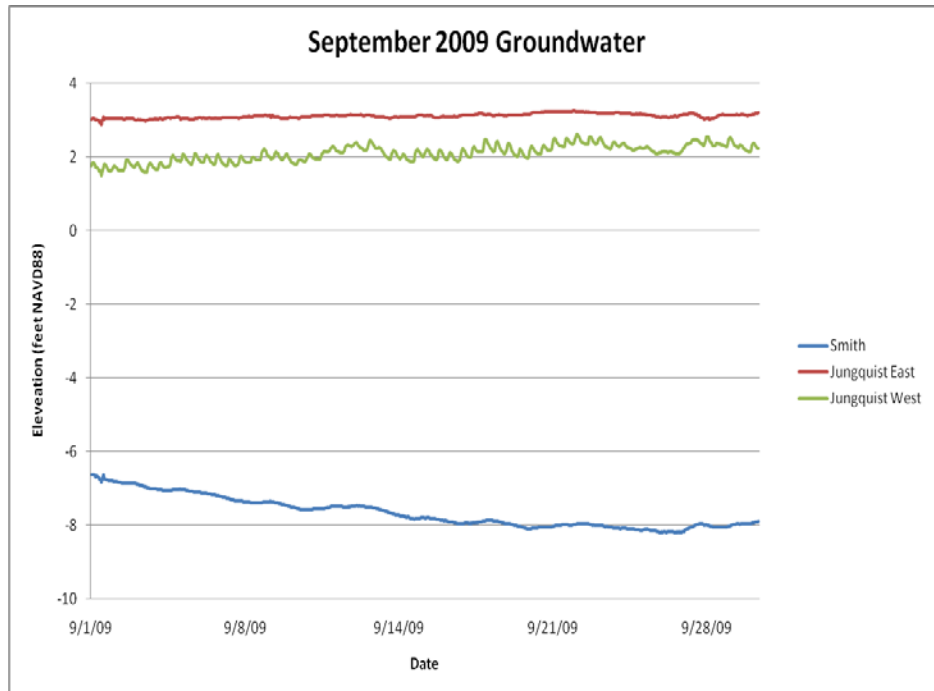


Table A-2. 2009 Monthly Groundwater Elevation Data for GW-Smith (ft-NAVD88)

	January	February	March	April	May	June	July	August	September
Avg	7.19	6.81	6.83	6.75	6.12	4.10	1.20	-4.13	-7.66
Max	8.21	7.68	7.75	8.06	7.58	5.27	3.20	-1.05	-6.63
Min	5.70	5.35	5.84	5.15	4.90	2.76	-1.61	-6.69	-8.19

Table A-3. 2009 Monthly Groundwater Elevation Data for GW-Jungquist East (ft-NAVD88)

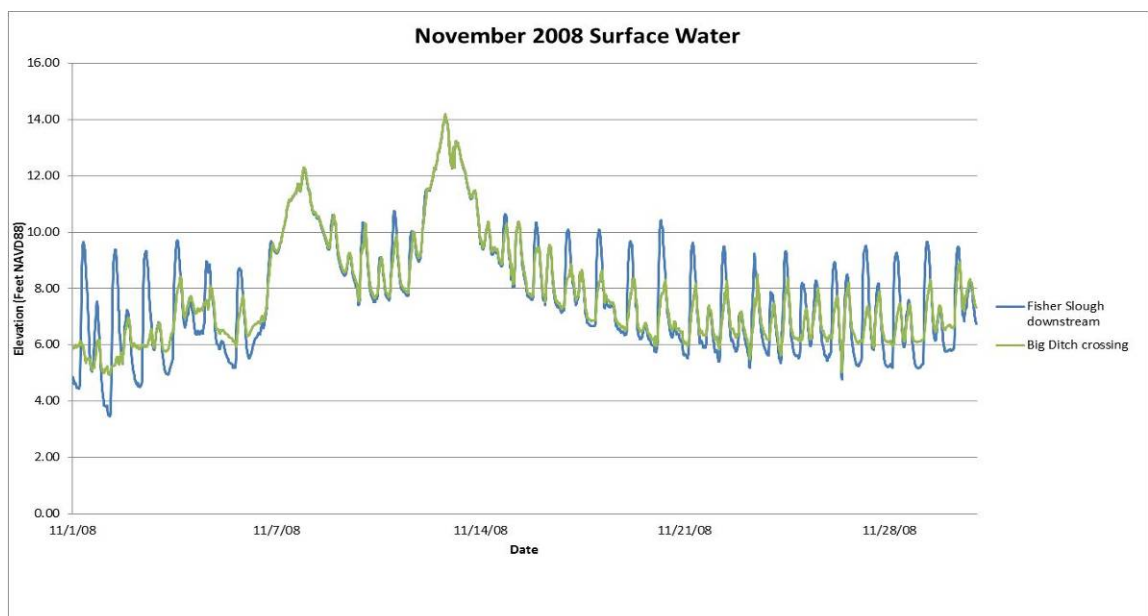
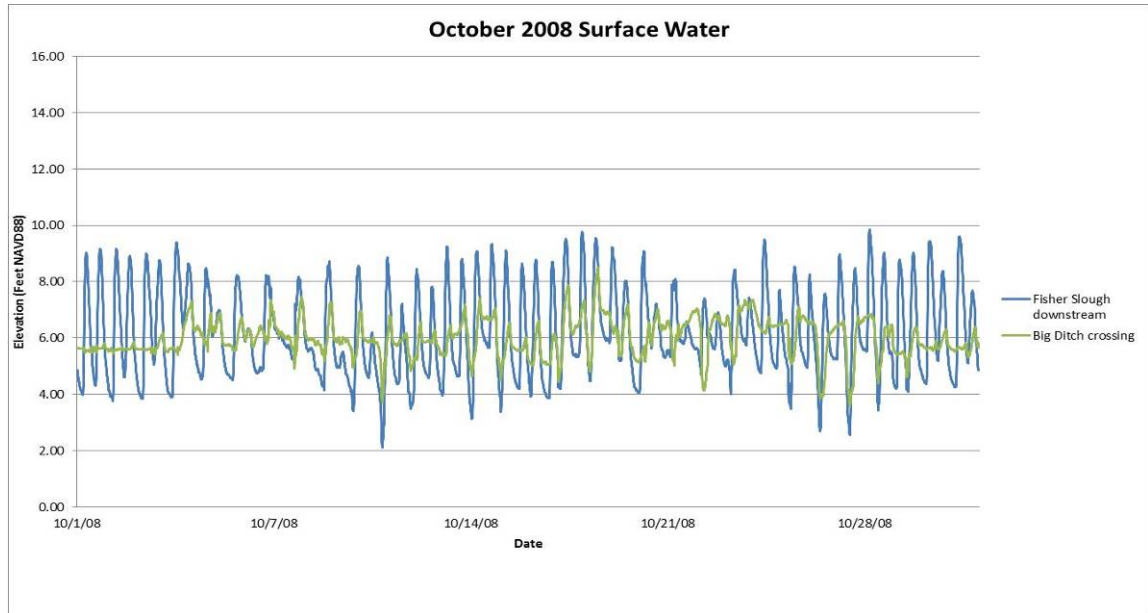
	January	February	March	April	May	June	July	August	September
Avg	5.96	5.16	5.24	5.20	4.86	5.03	4.17	3.45	3.11
Max	8.28	6.06	6.11	6.63	6.07	6.13	5.18	3.77	3.25
Min	4.12	3.76	4.32	3.50	3.83	4.14	2.19	2.67	2.87

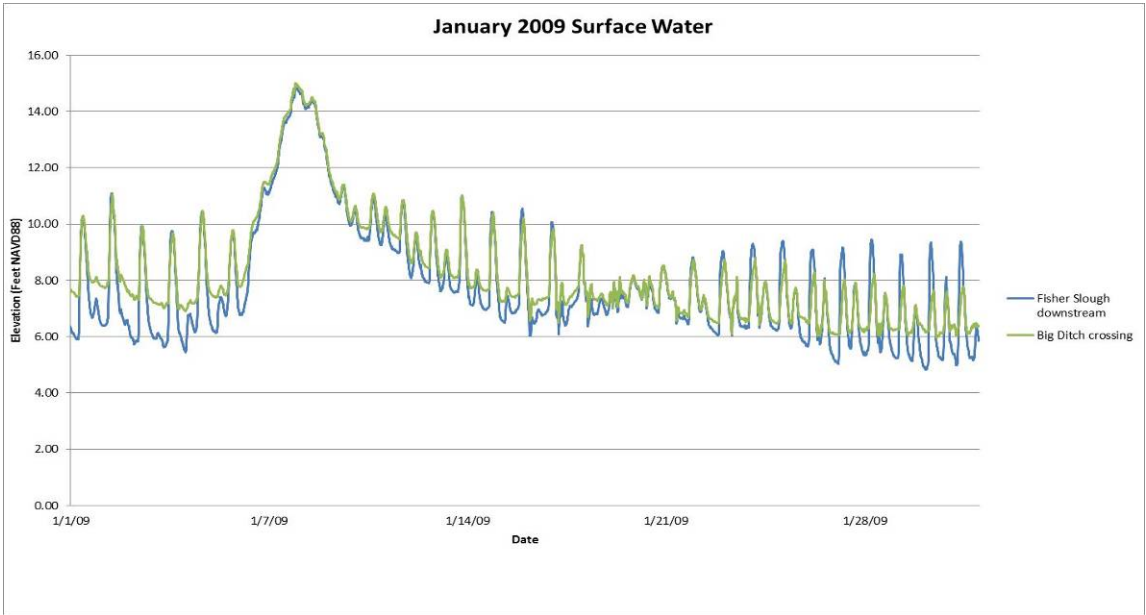
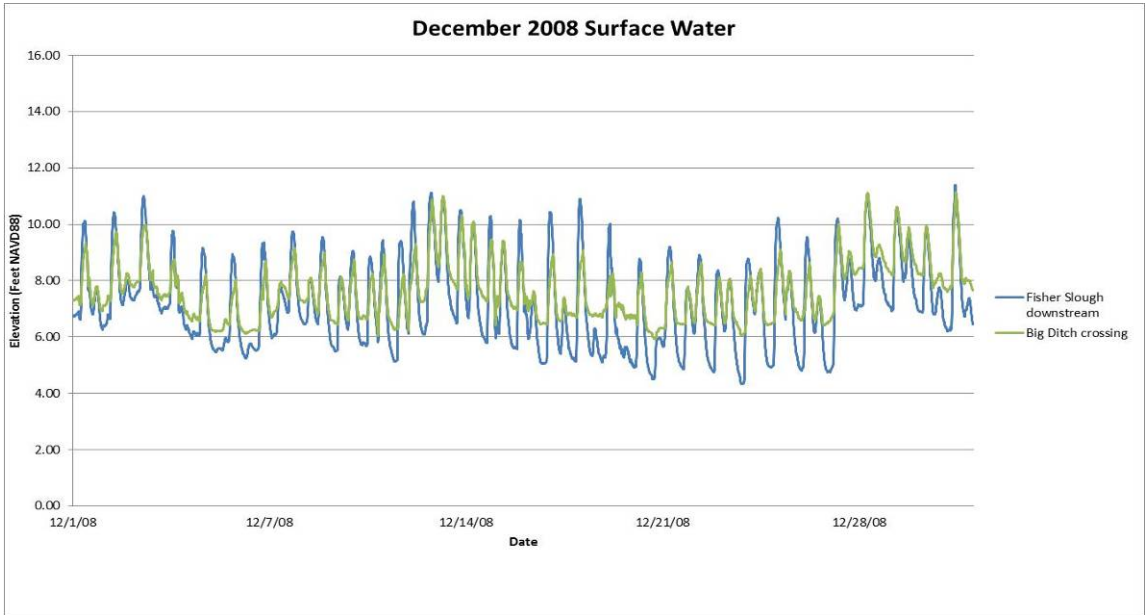
Table A-4. 2009 Monthly Groundwater Elevation Data for GW-Jungquist West(ft-NAVD88)

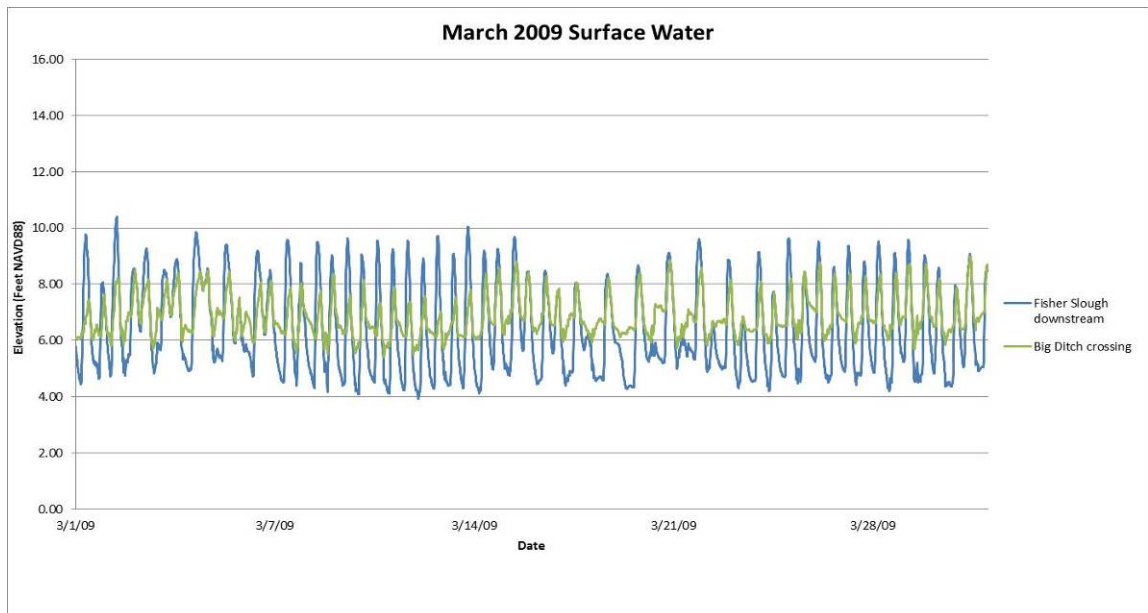
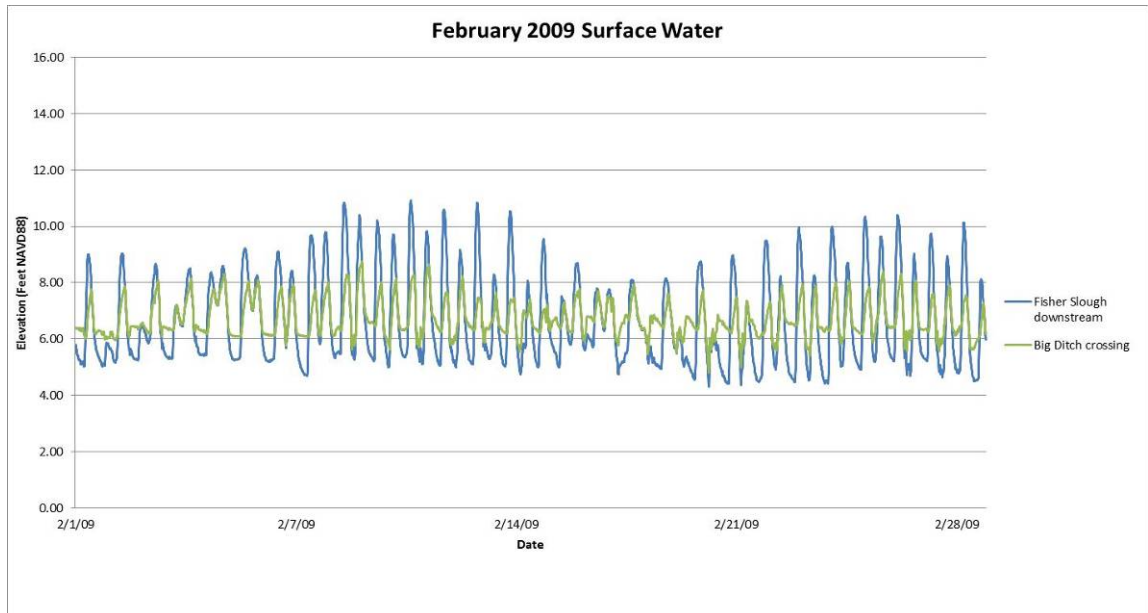
	January	February	March	April	May	June	July	August	September
Avg	6.91	6.42	6.39	6.27	6.03	4.29	2.34	1.62	2.10
Max	8.67	7.35	7.29	7.52	7.39	5.55	3.46	2.25	2.62
Min	5.38	4.85	5.26	4.54	4.71	2.91	0.11	0.48	1.50

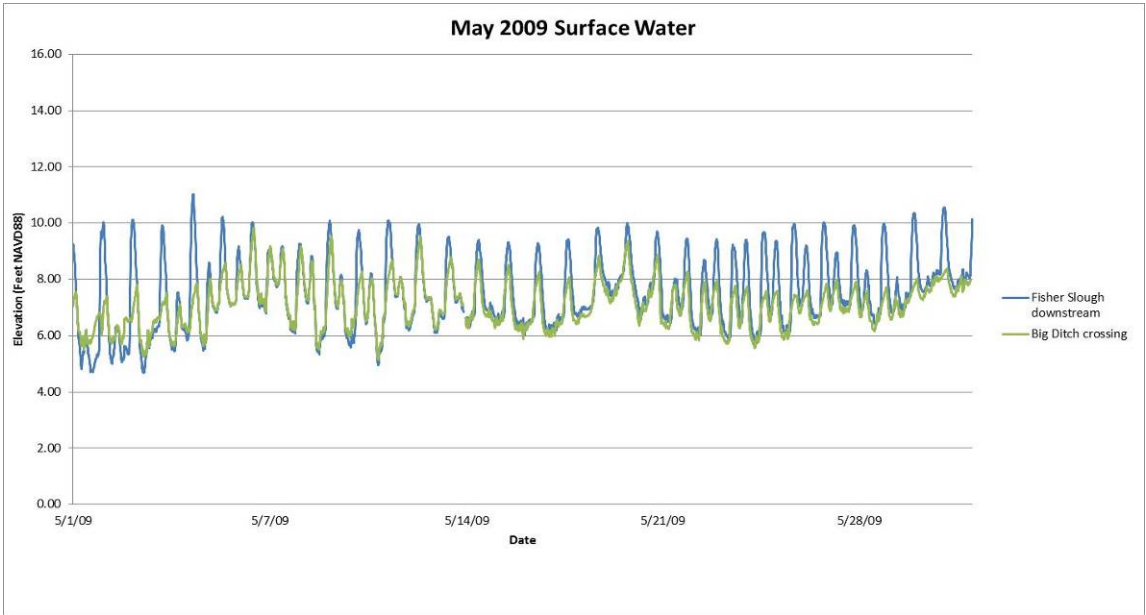
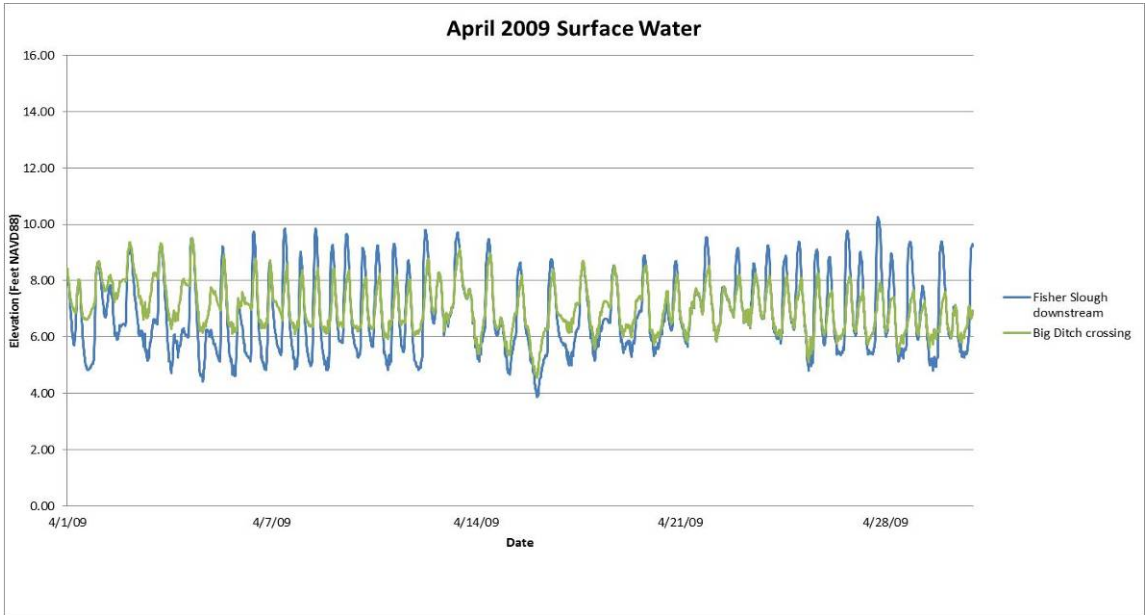
APPENDIX B - SURFACE WATER DATA

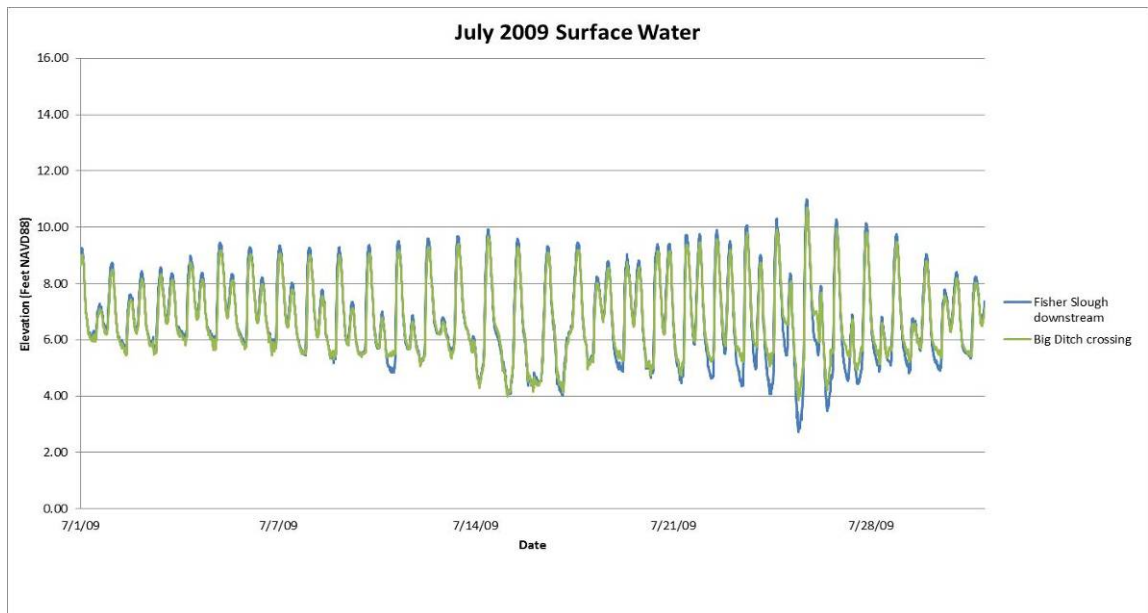
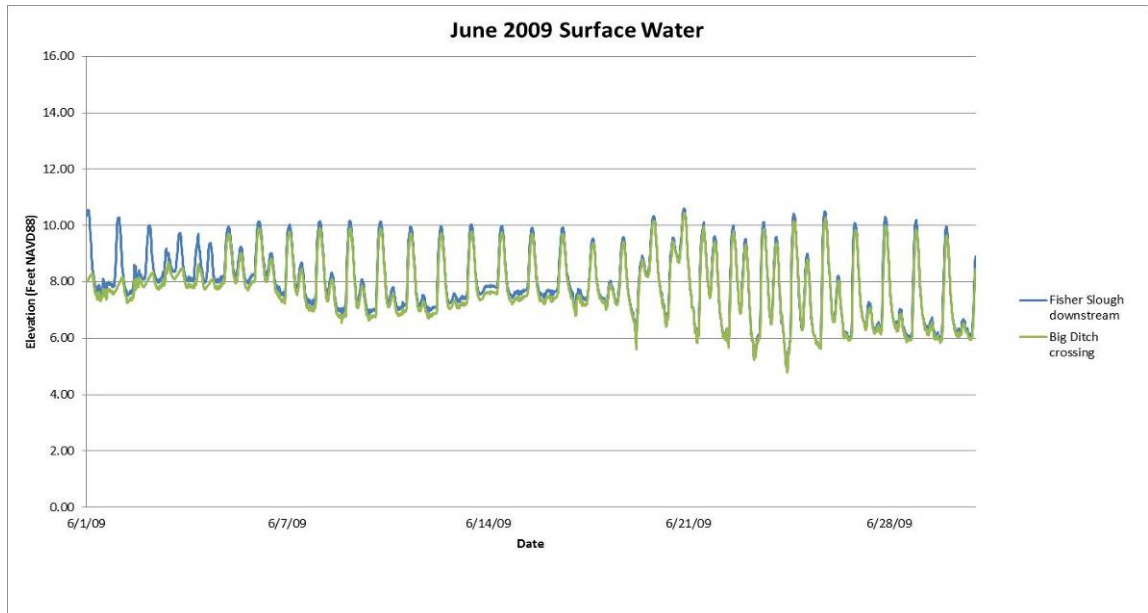
See Figure A-1 for Surface Water Sampling locations. Appendix B presents surface water data collected from September 29, 2008 to September 30, 2009 at two locations (Fisher Slough Downstream and Big Ditch Crossing). The following charts display surface water elevations collected at 15-minute intervals, October of 2008 through August 2009 by month. The data from September of 2008 are not included because of limited sampling. Tables B-1 through B-2 show monthly averages, maximums, and minimums at both sampling locations.

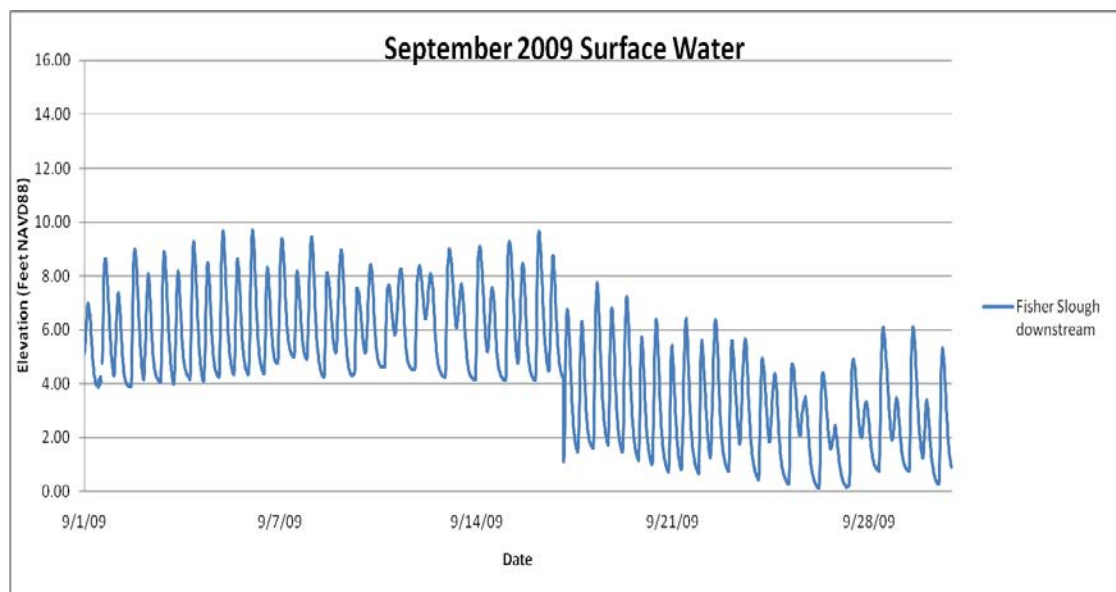
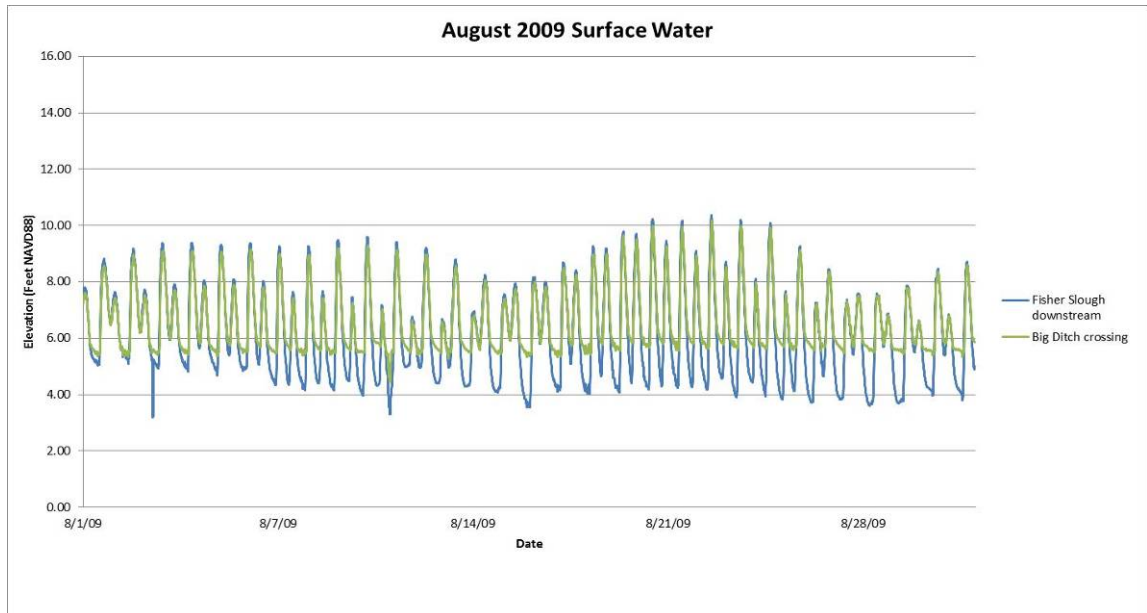




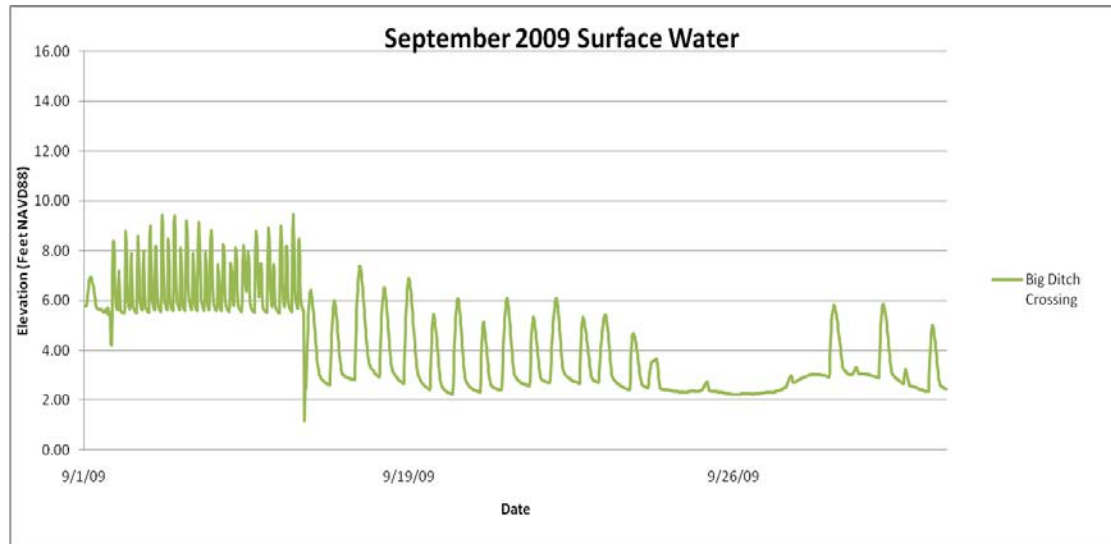




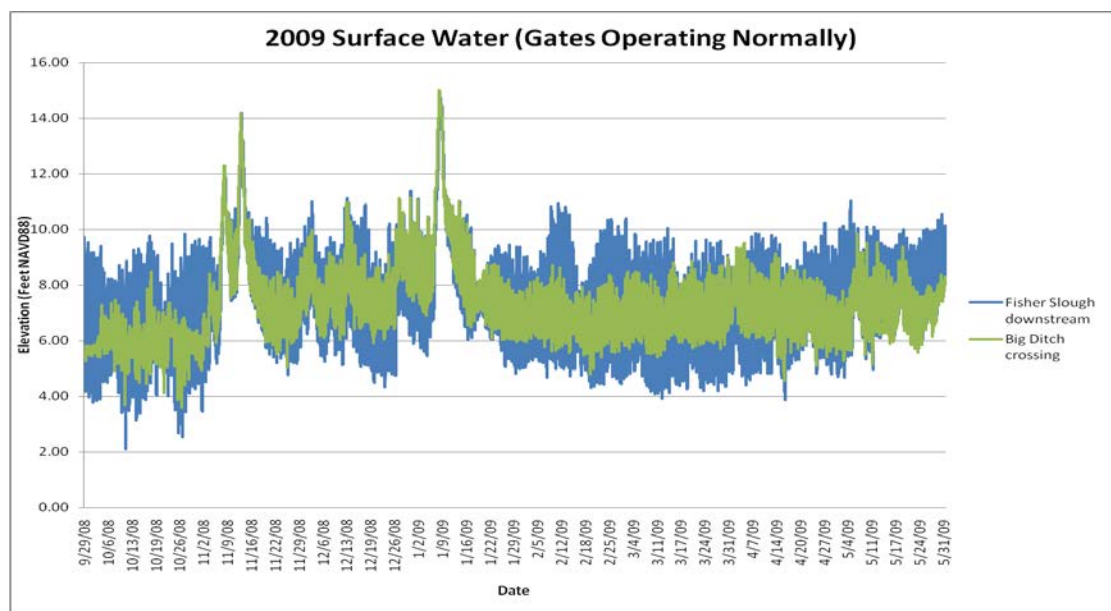




*September 2009 data for Surface water taken at different time intervals. Fisher Slough is every 15 minutes and Big Ditch is every hour so this month was graphed separately



*September 2009 data for Surface water taken at different time intervals. Fisher Slough is every 15 minutes and Big Ditch is every hour so this month was graphed separately



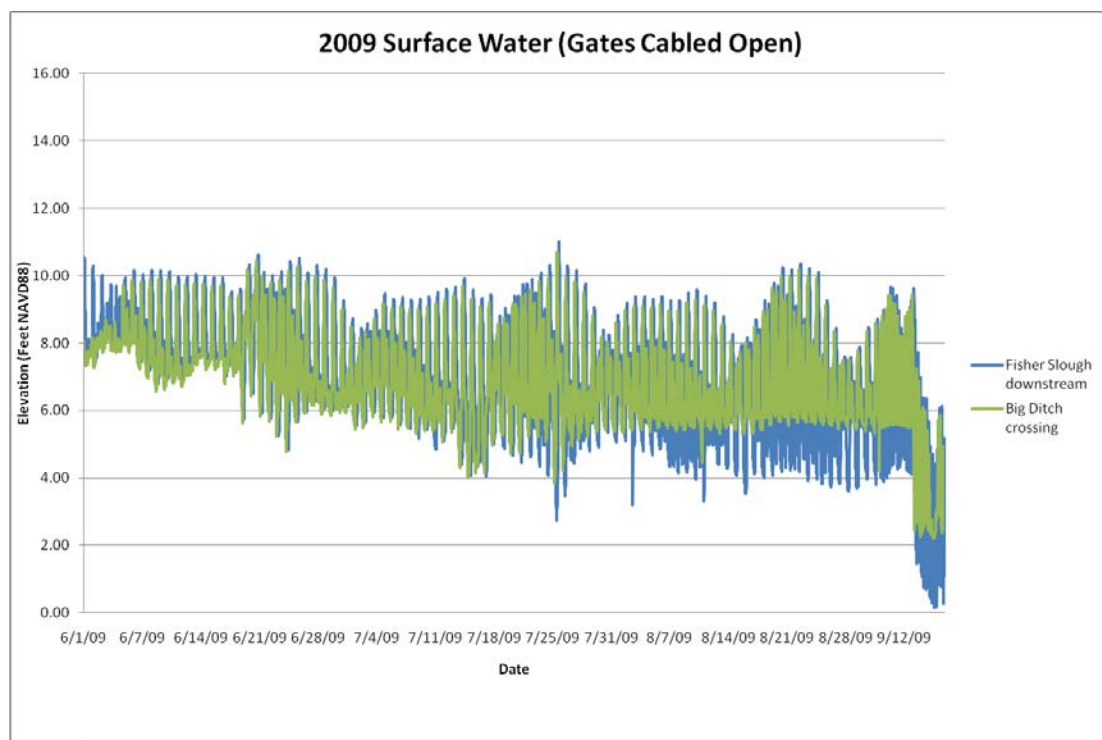


Table B-1. 2008-2009 Monthly Surface Water Data for Fisher Slough Downstream (ft-NAVD88)

	September (08)*	October (08)	November (08)	December (08)	January	February	March	April	May	June	July	August	September
Avg	6.54	6.18	7.85	7.25	7.96	6.66	6.42	6.80	7.50	7.97	6.76	6.19	4.68
Max	9.72	9.84	14.19	11.39	14.85	10.93	10.41	10.25	11.03	10.60	11.00	10.36	9.71
Min	4.17	2.10	3.45	4.33	4.82	4.31	3.92	3.87	4.68	4.83	2.73	3.19	0.13

*incomplete data for this month (September 29-September 30, 2008)

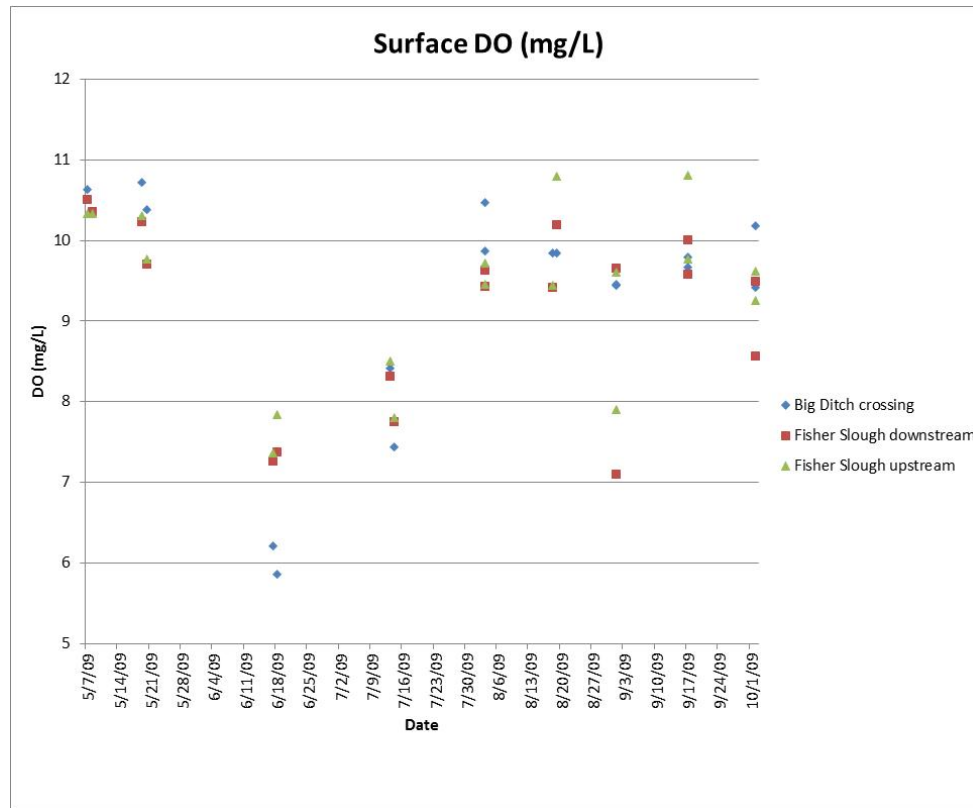
Table B-2. 2008-2009 Monthly Surface Water Data for Big Ditch Crossing (ft-NAVD88)

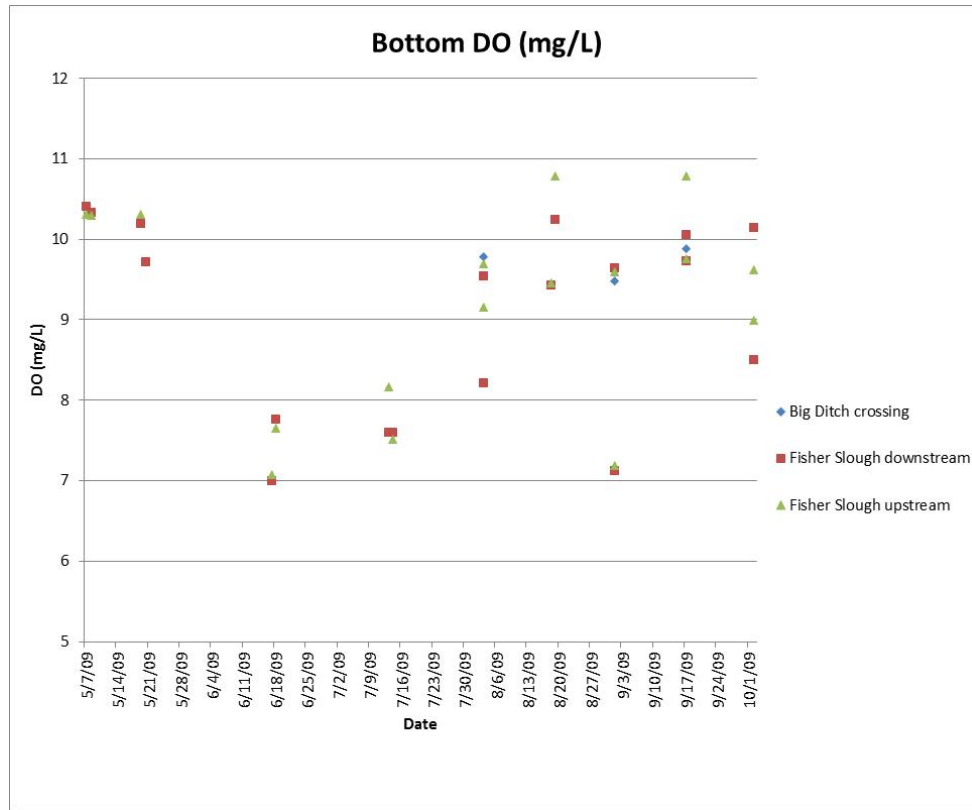
	September (08)*	October (08)	November (08)	December (08)	January	February	March	April	May	June	July	August	September
Avg	5.64	6.00	7.79	7.65	8.28	6.72	6.87	7.03	7.12	7.74	6.73	6.56	4.10
Max	5.82	8.49	14.19	11.15	15.00	8.74	9.00	9.52	9.84	10.44	10.69	10.17	9.45
Min	5.25	3.58	4.93	5.91	5.96	4.81	5.41	4.55	5.15	4.78	3.85	4.45	1.18

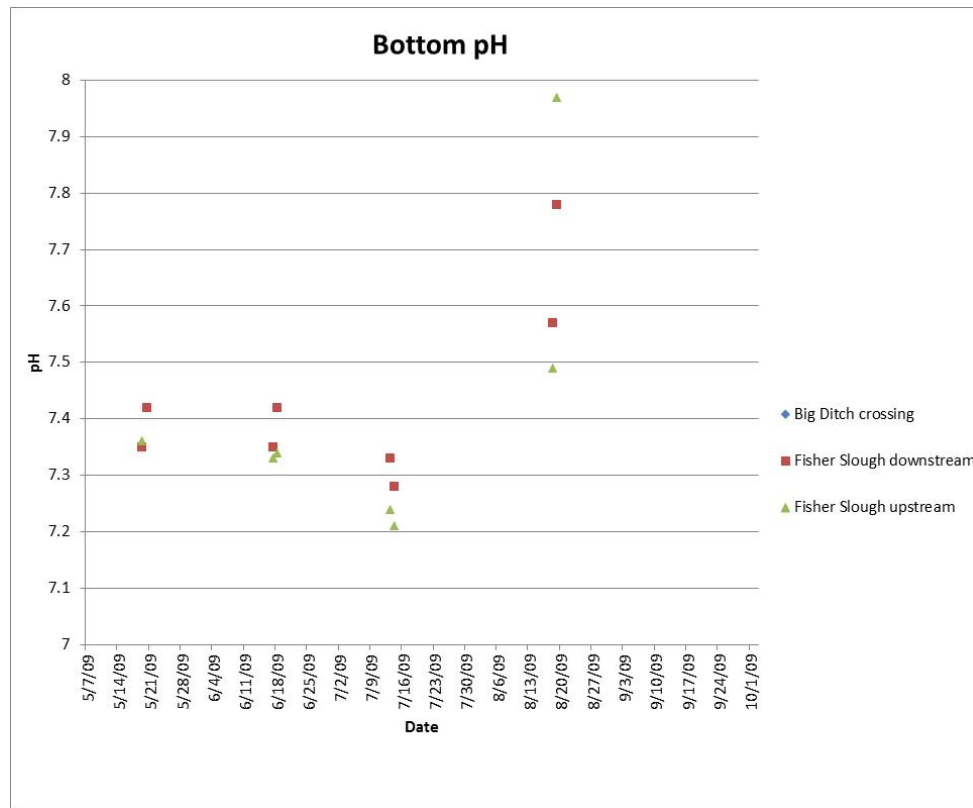
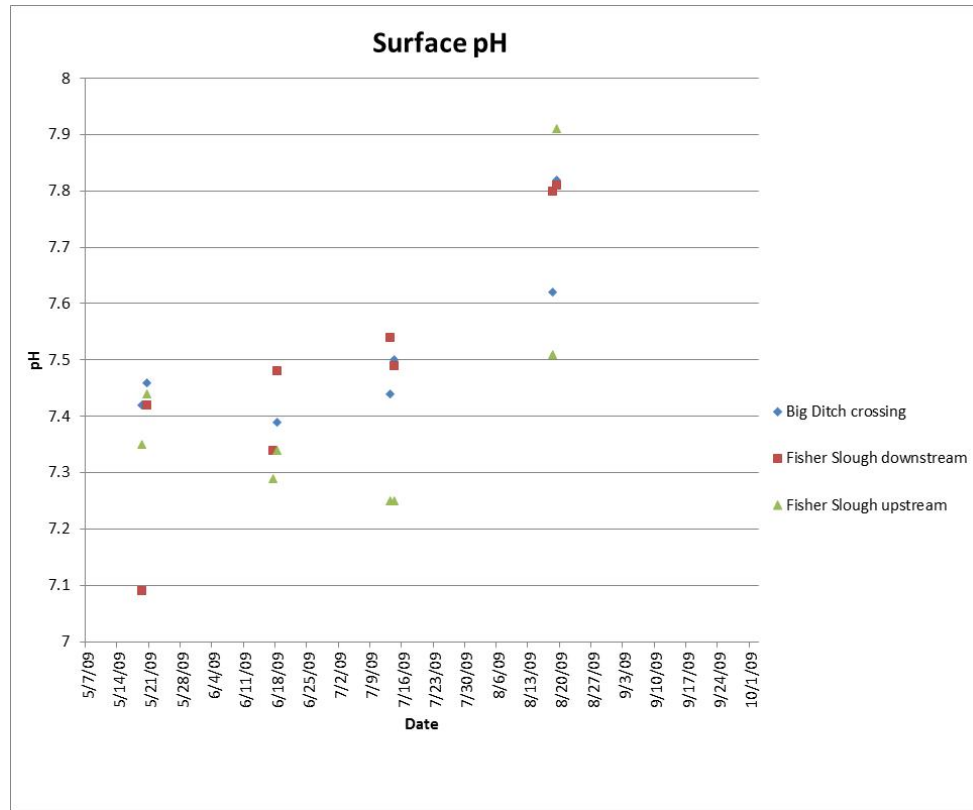
*incomplete data for this month (September 29-September 30, 2008)

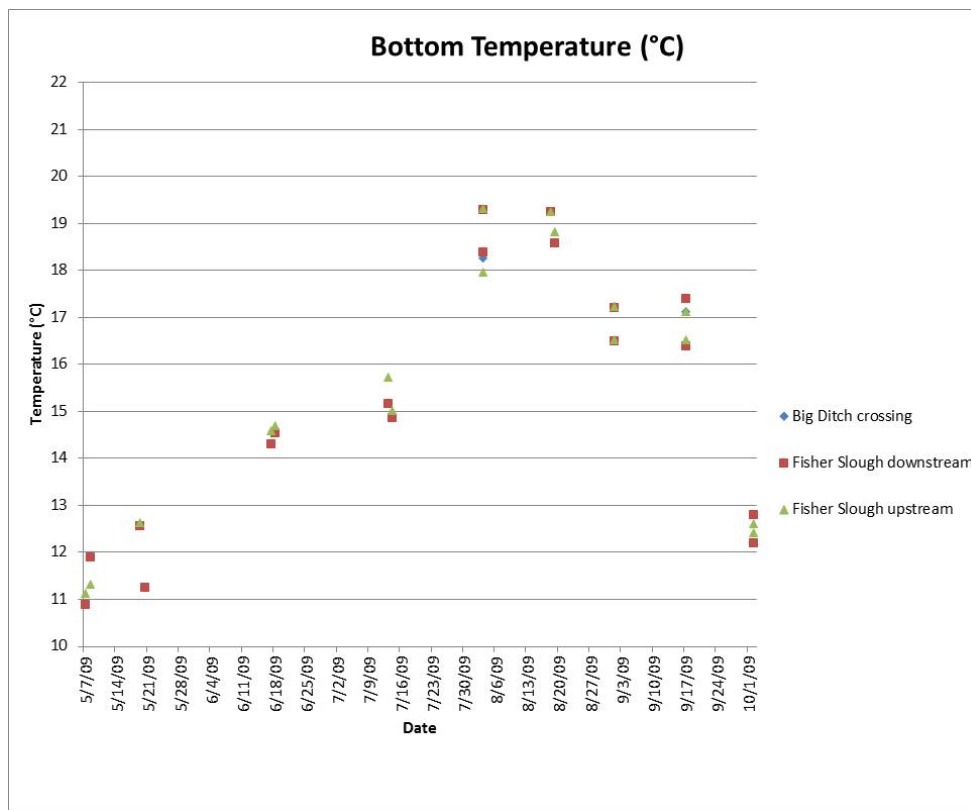
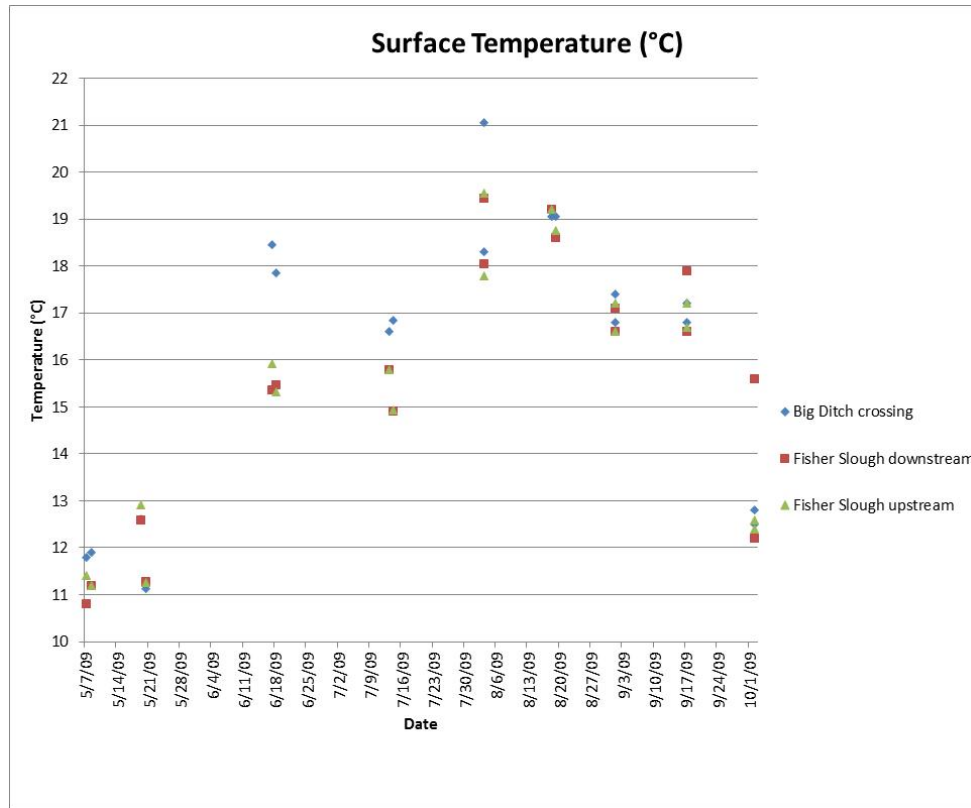
APPENDIX C - WATER QUALITY DATA

Appendix C presents water quality data collected from May 7, 2009 to October 2, 2009 at three locations (Fisher Slough Downstream, Fisher Slough Upstream, and Big Ditch Crossing). The following charts display water quality conditions for the sampling period, shown by water quality parameter and water depth. Tables C-1 through C-9 show monthly averages, maximums, and minimums, for each water quality parameter and sampling depth at each sampling location.









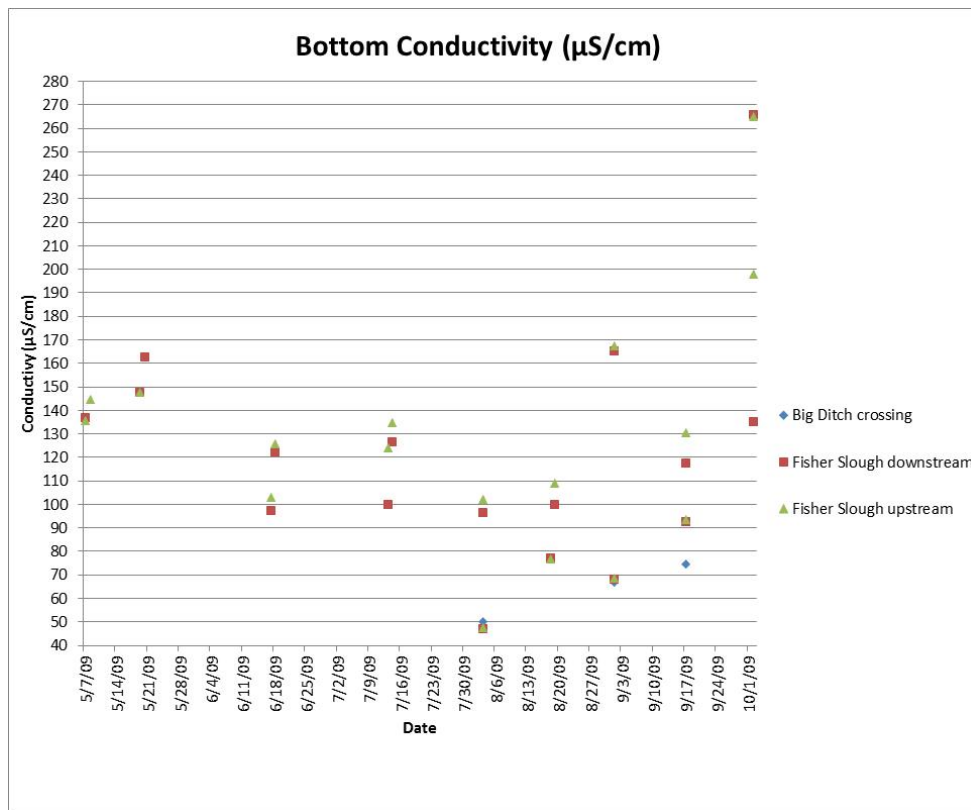
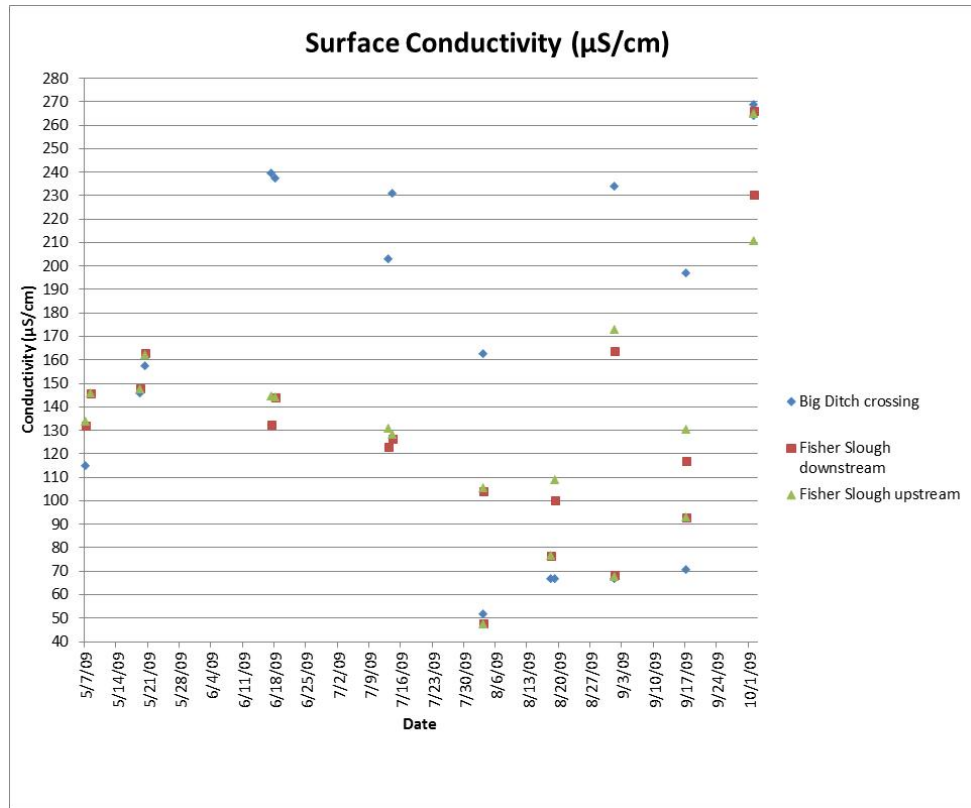


Table C-1. 2009 Monthly Water Quality Averages for Upstream

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	10.19	11.69	147.43	7.40	10.31	11.67	142.70	7.36
June	7.60	15.62	144.35	7.32	7.37	14.63	114.20	7.34
July	8.16	15.37	129.45	7.25	7.84	15.35	129.45	7.23
August	9.86	18.83	84.70	7.71	9.78	18.82	83.88	7.73
September	9.49	16.93	116.13	DNS	9.33	16.83	114.88	DNS
October ^a	9.44	12.50	238.00	DNS	9.31	12.50	231.50	DNS

^a One sampling day this month (October 2)

DNS=did not sample

Table C-2. 2009 Monthly Water Quality Maximums for Upstream

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	10.34	12.91	162.30	7.44	10.31	12.61	147.60	7.36
June	7.84	15.92	144.50	7.34	7.65	14.68	125.60	7.34
July	8.51	15.79	130.70	7.25	8.17	15.70	134.90	7.24
August	10.80	19.55	109.20	7.91	10.79	19.30	109.10	7.97
September	10.81	17.20	172.90	DNS	10.79	17.20	167.40	DNS
October ^a	9.62	12.60	265.00	DNS	9.62	12.60	265.00	DNS

^a One sampling day this month (October 2)

DNS=did not sample

Table C-3. Monthly Water Quality Minimums for Upstream

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	9.77	11.20	133.90	7.35	10.30	11.10	135.80	7.36
June	7.36	15.31	144.20	7.29	7.08	14.57	102.80	7.33
July	7.80	14.94	128.20	7.25	7.51	14.99	124.00	7.21
August	9.45	17.80	47.50	7.51	9.16	17.95	47.50	7.49
September	7.90	16.60	67.90	DNS	7.19	16.50	68.40	DNS
October ^a	9.26	12.40	211.00	DNS	8.99	12.40	198.00	DNS

^a One sampling day this month (October 2)

*incomplete data for this month

DNS=did not sample

Table C-4. 2009 Monthly Water Quality Averages for Big Ditch

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	10.52	11.86	139.53	7.44	DNS	DNS	DNS	DNS
June	6.04	18.16	238.55	7.37	DNS	DNS	DNS	DNS
July	7.93	16.72	217.05	7.47	DNS	DNS	DNS	DNS
August	10.01	19.37	87.18	7.72	9.78	18.25	50.00	DNS
September	9.60	17.05	142.13	DNS	9.68	17.15	70.85	DNS
October ^a	9.80	12.65	266.50	DNS	DNS	DNS	DNS	DNS

^a One sampling day this month (October 2)

DNS=did not sample

Table C-5. 2009 Monthly Water Quality Maximums for Big Ditch

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	10.72	12.62	157.7	7.46	DNS	DNS	DNS	DNS
June	6.21	18.46	239.7	7.39	DNS	DNS	DNS	DNS
July	8.42	16.84	230.9	7.5	DNS	DNS	DNS	DNS
August	10.47	21.05	162.7	7.82	9.78	18.25	50	DNS
September	9.8	17.4	234	DNS	9.88	17.2	74.8	DNS
October ^a	10.18	12.8	269	DNS	DNS	DNS	DNS	DNS

^a One sampling day this month (October 2)

DNS=did not sample

Table C-6. 2009 Monthly Water Quality Minimums for Big Ditch

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	10.33	11.13	115	7.42	DNS	DNS	DNS	DNS
June	5.86	17.86	237.4	7.34	DNS	DNS	DNS	DNS
July	7.44	16.6	203.2	7.44	DNS	DNS	DNS	DNS
August	9.84	18.3	52	7.62	9.78	18.25	50	DNS
September	9.45	16.8	66.8	DNS	9.48	17.1	66.9	DNS
October ^a	9.42	12.5	264	DNS	DNS	DNS	DNS	DNS

^a One sampling day this month (October 2)

DNS=did not sample

Table C-7. 2009 Monthly Water Quality Averages for Downstream

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	10.20	11.47	146.95	7.26	10.17	11.66	149.17	7.39
June	7.32	15.42	137.80	7.41	7.38	14.43	109.90	7.39
July	8.03	15.35	124.60	7.52	7.60	15.02	113.25	7.31
August	9.67	18.83	81.98	7.81	9.36	18.89	80.15	7.68
September	9.09	17.05	110.23	DNS	9.14	16.88	110.95	DNS
October ^a	9.03	13.90	248.00	DNS	9.33	12.50	200.60	DNS

^a One sampling day this month (October 2)

DNS=did not sample

Table C-8. 2009 Monthly Water Quality Maximums for Downstream

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	10.51	12.58	162.60	7.42	10.41	12.57	162.80	7.42
June	7.38	15.47	143.60	7.48	7.76	14.55	122.40	7.42
July	8.31	15.80	126.30	7.54	7.60	15.16	126.60	7.33
August	10.20	19.45	104.00	7.81	10.24	19.30	100.00	7.78
September	10.01	17.90	163.70	DNS	10.06	17.40	165.40	DNS
October ^a	9.49	15.60	266.00	DNS	10.14	12.80	266.00	DNS

^a One sampling day this month (October 2)

DNS=did not sample

Table C-9. Monthly Water Quality Minimums for Downstream

	Surface				Bottom			
	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH	DO (mg/L)	Temp (°C)	Cond (µS/cm)	pH
May	9.71	10.80	131.90	7.09	9.72	10.90	137.00	7.35
June	7.26	15.36	132.00	7.34	7.00	14.30	97.40	7.35
July	7.75	14.90	122.90	7.49	7.60	14.87	99.90	7.28
August	9.42	18.05	47.40	7.80	8.21	18.40	47.00	7.57
September	7.10	16.60	68.00	DNS	7.13	16.40	68.10	DNS
October ^a	8.57	12.20	230.00	DNS	8.51	12.20	135.20	DNS

^a One sampling day this month (October 2)

DNS=did not sample

APPENDIX D - SITE PHOTOGRAPHS

Appendix D presents the photograph locations and as well as photographs taken in September and October of 2009.





FS01-Photograph 1: Taken from the south bank of Fisher Slough at the railroad bridge looking at the downstream side of floodgates. (Photo taken September 21, 2009)



FS02-Photograph 1: Taken from the north bank of Fisher Slough at the highway bridge looking at the upstream side of floodgates. (Photo taken September 21, 2009)



FS02-Photograph 2: Taken from the north bank of Fisher Slough at the highway bridge looking at the new crossing for Big Ditch at water level. (Photo taken September 21, 2009)



FS02-Photograph 3: Taken from the highway bridge looking at the new crossing for Big Ditch, the new south levee, and Smith A. (Photo taken September 21, 2009)



FS03-Photograph 1: Taken from the south levee of Fisher Slough looking at the upstream side of floodgates. (Photo taken September 21, 2009)



FS03-Photograph 2: Taken from the south levee of Fisher Slough looking at north levee. (Photo taken September 21, 2009)



FS03-Photograph 3: Taken from the south levee of Fisher Slough looking at Fisher Slough. (Photo taken September 21, 2009)



FS03-Photograph 4: Taken from the south levee of Fisher Slough looking southeast at Smith A. (Photo taken September 21, 2009)



FS03-Photograph 5: Taken from the south levee of Fisher Slough looking south at Smith A. (Photo taken September 21, 2009)



FS04-Photograph 1: Taken from the north levee of Fisher Slough looking at the second marsh island and Fisher Slough. (Photo taken September 21, 2009)



FS04-Photograph 2: Taken from the north levee of Fisher Slough looking upstream at the marsh islands and channel, with Smith A in the background. (Photo taken September 21, 2009)



FS04-Photograph 3: Taken from the north levee of Fisher Slough looking at the middle marsh island and Smith A. (Photo taken September 21, 2009)



FS04-Photograph 4: Taken from the north levee of Fisher Slough looking downstream at the marsh islands and Fisher Slough. (Photo taken September 21, 2009)



FS05-Photograph 1: Taken from the north levee of Fisher Slough at the current Big Ditch Crossing looking upstream at Fisher Slough. (Photo taken September 21, 2009)



FS05-Photograph 2: Taken from the north levee of Fisher Slough at the current Big Ditch Crossing looking at the downstream end of future main tidal channel realignment and existing south levee. (Photo taken September 21, 2009)



FS05-Photograph 3: Taken from the north levee of Fisher Slough at the current Big Ditch Crossing looking at the existing crossing structure. (Photo taken September 21, 2009)



FS05-Photograph 4: Taken from the north levee of Fisher Slough at the current Big Ditch Crossing looking at Fisher Slough and Smith A. (Photo taken September 21, 2009)



FS05-Photograph 5: Taken from the north levee of Fisher Slough at the current Big Ditch Crossing looking downstream at Fisher Slough and Smith A. (Photo taken September 21, 2009)



FS05-Photograph 6: Taken from the north levee of Fisher Slough at the current Big Ditch Crossing looking at the existing location of Big Ditch, upstream of Fisher Slough crossing. (Photo taken September 21, 2009)



FS06-Photograph 1: Taken from the eastern end of the north levee, near an old shed and gate structure looking upstream at Carpenter Creek/Fisher Slough and the upstream end of future main tidal channel realignment. (Photo taken October 2, 2009)



FS06-Photograph 2: Taken from the eastern end of the north levee, near an old shed and gate structure looking at Fisher Creek mouth and existing south levee. (Photo taken October 2, 2009)



FS06-Photograph 3: Taken from the eastern end of the north levee, near an old shed and gate structure looking at Fisher Slough (future plug location) and Smith B. (Photo taken October 2, 2009)



FS06-Photograph 4: Taken from the eastern end of the north levee, near an old shed and gate structure looking downstream at the existing south levee and Fisher Slough. (Photo taken October 2, 2009)



FS07-Photograph 1: Taken from near the southern edge of the Moyer property, east of Little Fisher Creek looking west. (Photo taken October 2, 2009)



FS07-Photograph 2: Taken from near the southern edge of the Moyer property, east of Little Fisher Creek looking northwest with Smith B in background. (Photo taken October 2, 2009)



FS08-Photograph 1: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking west-southwest at Smith B. (Photo taken October 2, 2009)



FS08-Photograph 2: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking northwest at Smith B. (Photo taken October 2, 2009)



FS08-Photograph 3: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking north-northeast. (Photo taken October 2, 2009)



FS08-Photograph 4: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking east-southeast. (Photo taken October 2, 2009)



FS09-Photograph 1: Taken from the northwest corner of Smith B, in the footprint of the new levee looking east. (Photo taken October 2, 2009)



FS09-Photograph 2: Taken from the northwest corner of Smith B, in the footprint of the new levee looking southeast. (Photo taken October 2, 2009)



FS09-Photograph 3: Taken from the northwest corner of Smith B, in the footprint of the new levee looking south. (Photo taken October 2, 2009)



FS09-Photograph 4: Taken from the northwest corner of Smith B, in the footprint of the new levee looking west-northwest. (Photo taken October 2, 2009)



FS10-Photograph 1: Taken off of Pioneer Highway, south of the old railroad grade looking at Big Ditch. (Photo taken October 2, 2009)



FS10-Photograph 2: Taken off of Pioneer Highway, south of the old railroad grade looking northeast. (Photo taken October 2, 2009)



FS10-Photograph 3: Taken off of Pioneer Highway, south of the old railroad grade looking east-northeast. (Photo taken October 2, 2009)



FS10-Photograph 4: Taken off of Pioneer Highway, south of the old railroad grade looking east. (Photo taken October 2, 2009)



FS11-Photograph 1: Taken at the south access point from Pioneer Highway to Smith A looking north. (Photo taken October 2, 2009)



FS11-Photograph 2: Taken at the south access point from Pioneer Highway to Smith A looking northeast. (Photo taken October 2, 2009)



FS11-Photograph 3: Taken at the south access point from Pioneer Highway to Smith A looking east. (Photo taken October 2, 2009)



FS11-Photograph 4: Taken at the south access point from Pioneer Highway to Smith A looking south. (Photo taken October 2, 2009)

APPENDIX E - CHANNEL CROSS SECTIONS BETWEEN FLOODGATES AND TOM MOORE SLOUGH



MEMORANDUM

TNC – Fisher Slough Final Design and Permitting
Subject: Fisher Slough Downstream Hydraulic Conditions

To: Jenny Baker, The Nature Conservancy
Dave Olson, Dike District No. 3
Vaughn Collins, NHC

From: Patty Robinson and David Cline, PE (Tetra Tech)

Date: Mar. 1, 2010

Introduction

This hydraulic design technical memorandum is in response to 3rd party review comments regarding the flow conditions downstream from the Fisher Slough, Pioneer Highway and BNSF railroad bridge. Several comments were made regarding the potential for erosion and channel expansion in the downstream reach of Fisher Slough near the outlet into Tom Moore Slough. The following items are discussed in this memo:

- Cross section surveys
- Channel bank conditions
- Channel hydraulics, peak flow rates, velocities and erosion potential
- Discussion of empirical geomorphologic relationship application to the site
- Comments on erosion protection needs for each specific location cited in 3rd party comments

Cross section surveys

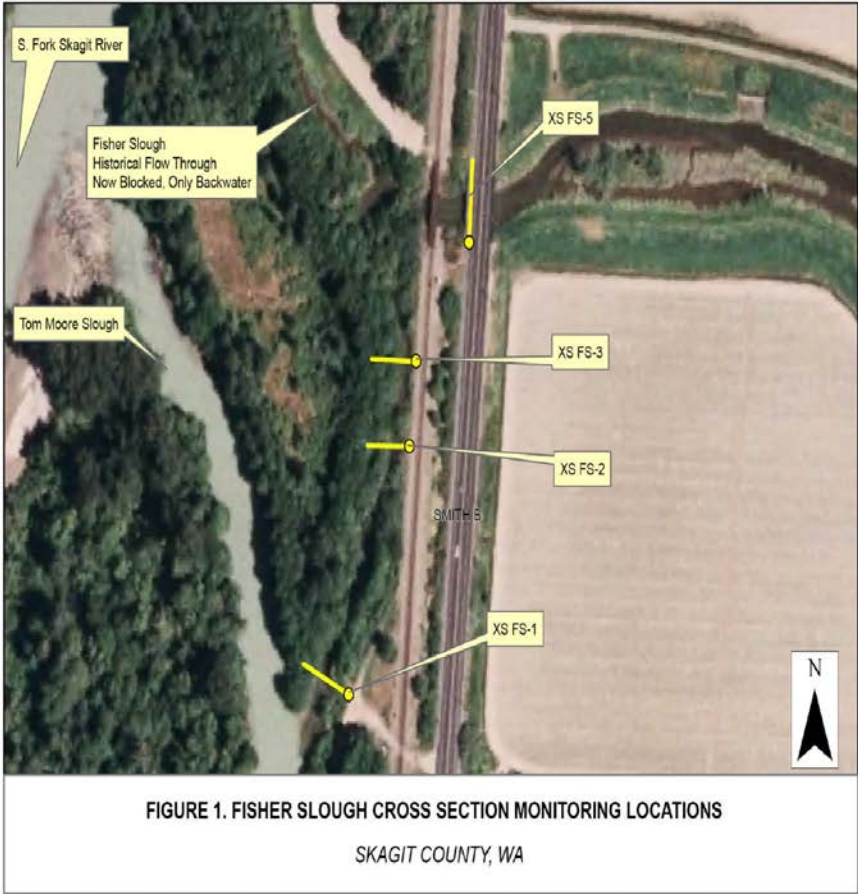
Three cross sections were surveyed downstream from the BNSF railroad bridge. The location of these sections is shown in **Figure 1**. The cross sections were surveyed using a survey level and tag line. The endpoints were located using resource grade GPS and accurate to within 1-meter. The left endpoint rebar elevations were determined by a level loop run from SC-10 survey control point from Skagit County on the Pioneer Highway bridge.

The reduced cross section data are shown in **Figures 2 through 4** (sections FS-1, FS-2 and FS-3). In general the cross sections are 40 to 50ft wide with depths (measured from the top of bank at elevation 10.0ft) on the order of 10 to 12ft deep. A previous survey of FS-5 is also provided to show the comparison of channel cross sections upstream and downstream of the floodgate (**Figure 5**, Section FS-5). For reference in following discussions, the cross section areas for each survey section, as measured from an approximate top of bank elevation at 10ft NAVD88 are:

FS-1 = 407sf
FS-2 = 267sf
FS-3 = 301sf
FS-5 = 578sf



MEMORANDUM



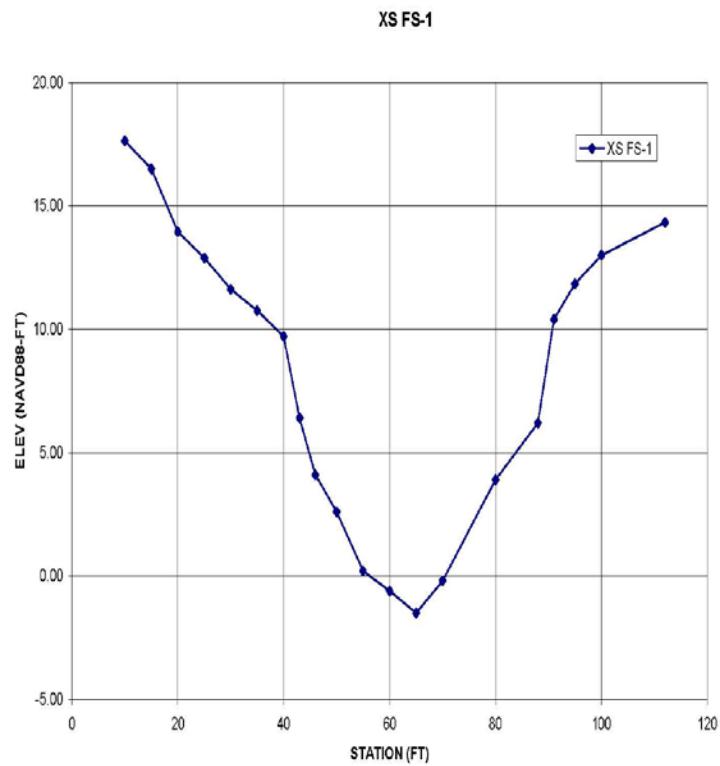


Figure 2. Cross Section FS-1

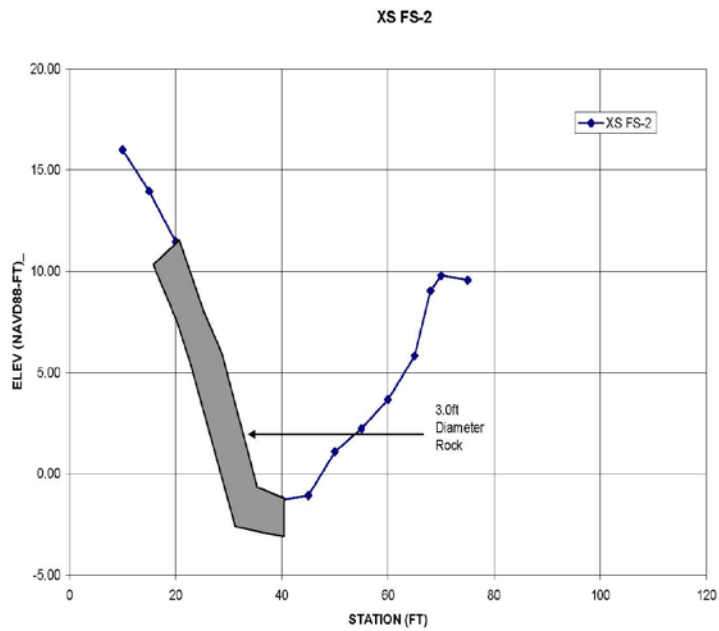


Figure 3. Cross Section FS-1

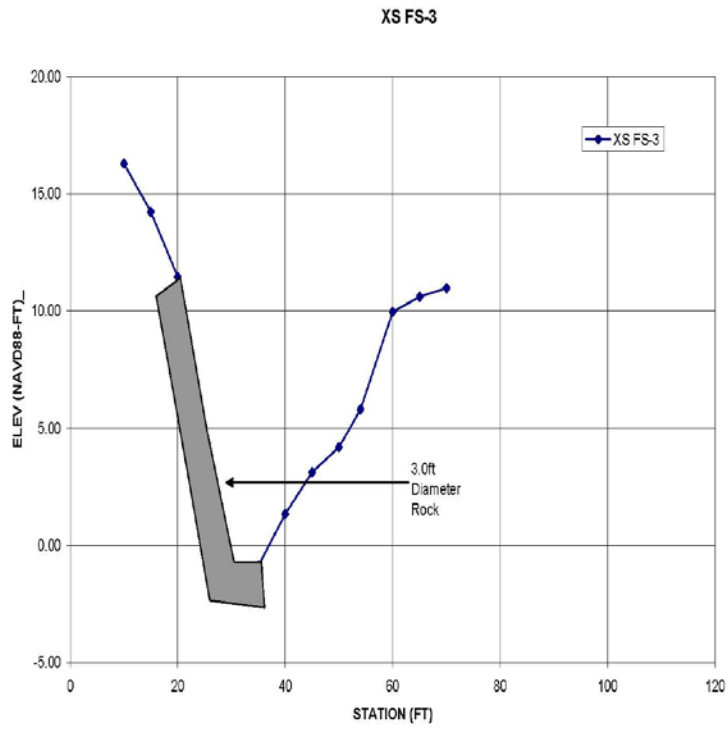


Figure 4. Cross Section 3

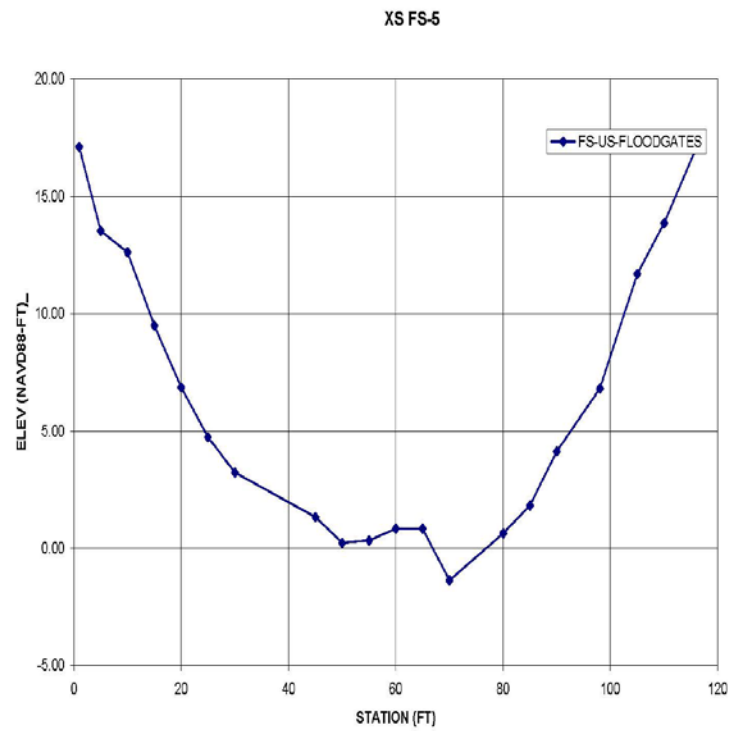


Figure 5. Cross Section 5



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Bank Condition Observations

During the cross section surveys, observations were made regarding the bank conditions of the Fisher Slough channel downstream from the BNSF railroad bridge. The following is a synopsis of bank conditions by section along the downstream reach.

The FS-1 cross section is fairly broad with heavy willow vegetation (**Figures 6-9**). In fact, the willows are dense enough that even in low leaf conditions, it was difficult to gain access or see the channel in this location. The willows are dense and have robust root systems. On the left (east) side of the channel, there is a 20 to 30ft bench that extends out from the levee and railroad embankment. This bank is covered with fairly dense willow and tree vegetation, although the willow buffer width is only ~10ft wide right at the FS-1 cross section. Upstream from the abandoned railroad, the buffer extends nearly the entire 20 to 30ft of the bench.

The FS-2 cross section is narrower with a steep bank along the railroad embankment (**Figures 10-13**). At this location, there is no bench at the toe of the left bank along the railroad embankment. There is large rock (2 to 3ft in diameter) on the railroad embankment that extends out beyond the toe of the embankment into the channel (**Figure 3**). The right bank has the same configuration as FS-1 and FS-3 with heavy and dense vegetation. The left bank has the large diameter protective rock overlain with sedimentary deposits and grassy vegetation. A series of photographs were taken to document the rock placement condition along the embankment (**Figure 14**). More details regarding rock protection are included following the FS-3 description.

The FS-3 cross section is similar to the FS-2 section with a steep bank along the railroad embankment (**Figures 15-18**). The right bank is covered with dense vegetation and the left bank has the large diameter protective rock overlain with fine sediment deposits and grasses (**Figures 19-21**).

The rock protection observed along the reach extends approximately 50ft upstream of FS-3 and 50ft downstream of FS-2 and is roughly in the locations without willows or tree vegetation along the railroad embankment. The rock size appears to be a D50 of 3ft. During the surveys it was noted that the rock extends out towards the center of the channel, beyond the toe. It is not apparent if this is by design, a relic of construction placement, or from previous loss and launching of material. Overall the embankment is heavily protected by large rock.

One item of note is that we understand that some of this rock may have been placed during different flow conditions. At some point in the past, Fisher Slough was a flow through side channel, and not a backwater. It was likely during the period when the channel was a flow through side channel off the Skagit River that the rock placed. The current conditions are that the side channel is blocked at the upstream end, and Fisher Slough is now a backwater channel to the Skagit River.



Figure 6. Looking towards right bank (west) FS-1



Figure 7. Looking downstream from abandoned bridge towards Tom Moore Slough FS-1



Figure 8. Looking upstream towards from abandoned bridge at FS-1



Figure 9. Looking toward left (east) bank FS-1



Figure 10. Looking toward right (west) bank FS-2



Figure 11. Looking toward left (east) bank FS-2



Figure 12. Looking downstream, FS-2

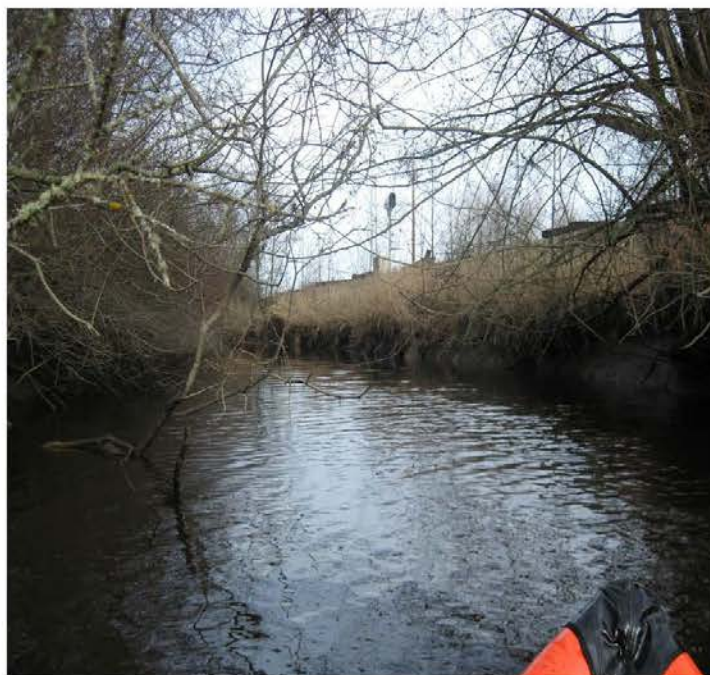


Figure 13. Looking upstream, FS-2



Figure 14. Looking upstream, bank protection



Figure 15. Looking toward right (west) bank FS-3



Figure 16. Looking toward left (east) bank FS-3



Figure 17. Looking downstream, FS-3



Figure 18. Looking upstream, FS-3



Figure 19. Rock at FS-3 left bank



Figure 20. Rock at FS-3 left bank



Figure 21. Rock upstream from FS-3 left bank

Channel Hydraulics – Peak flow rates, velocities and erosion potential

A brief review of channel flow and hydraulics conditions is presented to provide additional clarification on the expected flow conditions in the downstream channel as a result of the levee setback.

Figures 22 and 23 show the relationship of tidal stage to discharge and velocity. Typically for the tidal exchange, peak flows (flood and ebb) occur just before and just after the flood peak. Velocity peaks typically occur somewhere near the mid-point of the flood and ebb periods, and are related to the gradient and “steepness” of the tidal stage curve.

In order to evaluate if there is potential for downstream erosion and expansion of the channel due to changes in tidal exchange conditions, the following summary **Table 1** for the downstream Fisher Slough sections is provided for reference. These conditions occurred at FS-2 with the smallest cross section area.

Table 1. FS-2 Maximum Tidal Hydraulic Conditions for Future Marsh Conditions

Peak Flow (Ebb) (cfs)	614.0
Max. Ebb Velocity (fps)	2.3
Peak Flow (Flood) (cfs)	-1,003.0
Max. Flood Velocity (fps)	-3.8

The maximum tidal peaks are commensurate with the increase in marsh areas, on the order of 3 to 5 times the existing peak flows. However, even with these increases, the velocities and shear stress are relatively low through the narrower downstream Fisher Slough channel. The predicted velocity conditions as a result of increasing the marsh tidal prism volume are within published guidelines for permissible channel velocities. In reviewing studies and publications on permissible velocities based on stream channel soil type, without vegetation, the threshold for alluvial silt permissible velocity is 3.5fps (Fortier, 1926). Cohesive alluvial silts with colloids can be as much as 5.0fps. Also, these permissible velocity estimates do not account for additional stability provided by dense riparian and willow vegetation as well as the protective rock on the railroad embankment. Well established vegetation can significantly increase the erosion resistance of a channel.

Overall, the predicted velocities in the channel are within permissible velocity ranges, and do not exceed the erosion threshold. Therefore, it is not anticipated that the downstream Fisher Slough channel will experience significant erosion or changes in channel geometry as a result of the levee setback and increase in tidal marsh area.



TETRA TECH

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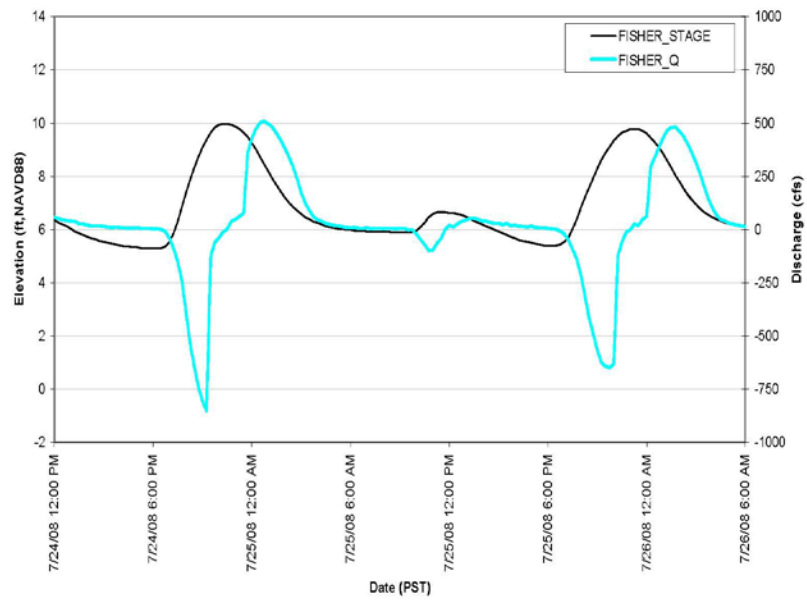


Figure 22. Fisher Slough Downstream Typical Future Tidal Flow Conditions

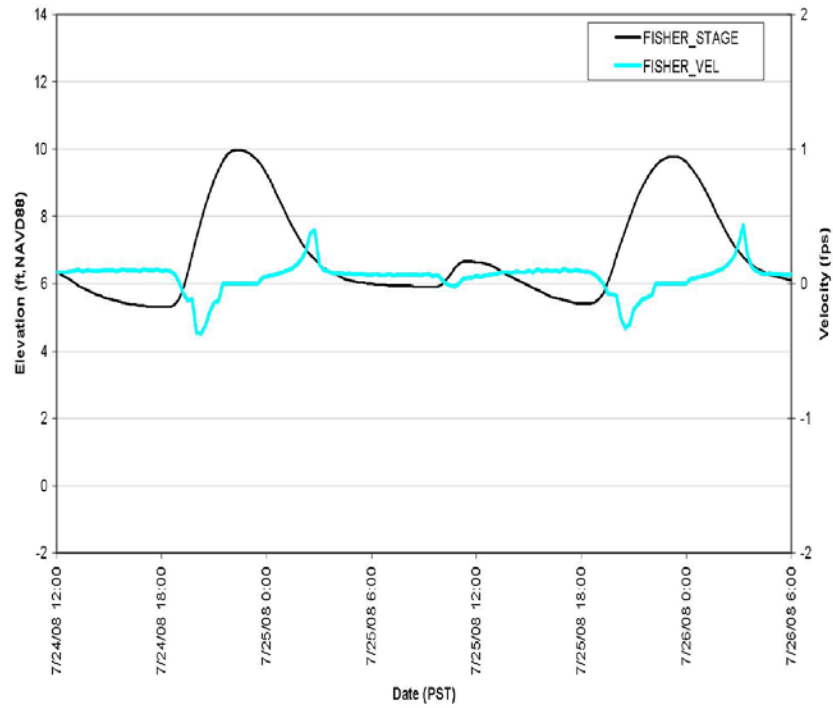


Figure 23. Fisher Slough Downstream Typical Future Tidal Flow and Velocity Conditions



MEMORANDUM

Empirical Geomorphologic Relationships for Channel Size

NHC provided review comments regarding the potential effects of the tidal marsh restoration project on the downstream channel. The following section of this memo discusses the comments provided by NHC, with selected points and figures from their memorandum that are the focus of the discussion. Their points included the following comments:

Given that the channel upstream of Pioneer Highway will be armored, we are concerned that there is no discussion of erosion risk to the channel which is of equal or smaller size downstream, even though it will convey the same flows. Areas of higher concern are shown in black lines on the figures. Note this includes a reach of the railroad embankment well downstream of the bridge.

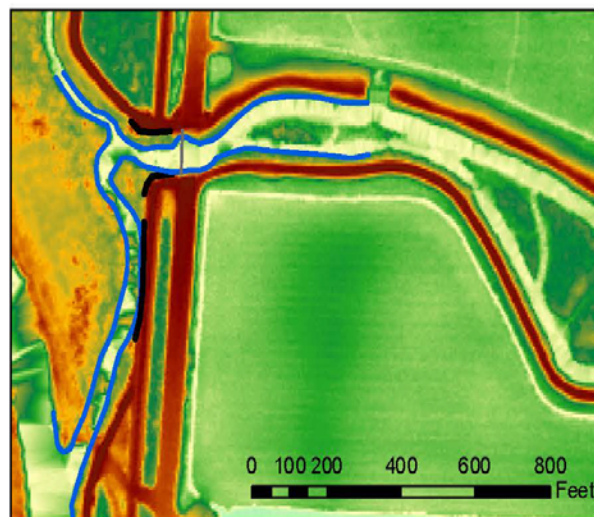


Figure 23. NHC Comments regarding potential erosion areas highlighted in black

AND

The Coats relationship predicts between a two to three fold expansion in channel area as a result of the project.

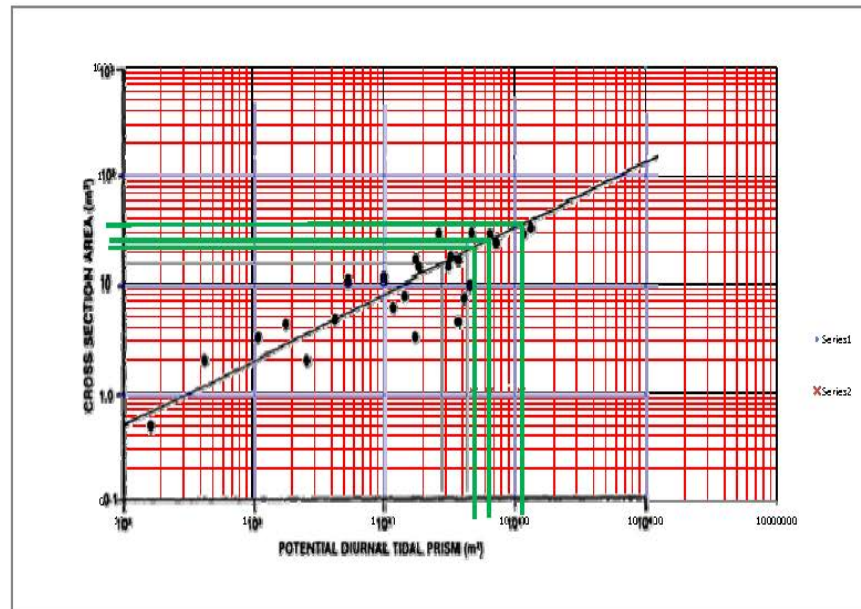


Figure 24. NHC Comments Regarding Potential for Geomorphologic Changes

The first response is in regards to the comment referring to use of channel protection in Fisher Slough just upstream from the Pioneer Bridge, and that there may be higher velocities and areas needing protection downstream from the bridge. The use and application of erosion protection material was a judgment call by the engineer. The hydraulic analysis, velocities and shear stress analysis did not necessarily indicate that erosion protection material was needed in this area. However, three additional design conditions did play into the decision to include erosion protection.

The first of these was the fact that the area will be freshly reconstructed, bare soils from the inverted siphon installation and reconstruction of the north and south levees at this location. The concern that prompted use of the protection was for the immediate post-construction condition that the bare and exposed soils were on the threshold of design velocities and shear stresses, the decision was to be conservative and provide secondary protection underlying the topsoil and seeding areas.

The second was the fact that recent changes to the floodgate operations and replacement of the submerged flapgates may allow more transport of sediment through the gates. This could lower the bed of the channel, albeit on the order of 2-3ft. If the bed does experience lowering, then the toes of the levees could erode, and having the underlying armor layer would prevent excessive widening.

Finally, the third consideration was the flow convergence that will occur right at the corner-end of the south levee setback. The narrowing of the floodplain at this point may have secondary

flow conditions whereby increased velocities could occur along the edge of the south levee in particular. The underlying armoring will again provide protection if localized erosion were to occur.

It is noted that the downstream areas identified by NHC in Figure 23, have none of these conditions that were key design considerations in the decision to place rock at the upstream side of Pioneer Highway.

The next area of discussion addresses the concerns regarding potential channel adjustments and expansion per Coats empirical regression equation for tidal channel area as a function of tidal prism.

The Coats relationship as well as the Skagit River System Cooperative empirical geomorphologic response equations were reviewed and analyzed for the project as part of the marsh restoration alternatives analysis (Tetra Tech, 2009 – Passive Restoration Alternatives Analysis). The study compared these two methods to estimate the channel size as a function of drainage area and tidal prism. The estimated tidal channel area as a function of tidal prism and drainage area was $23m^2$. This corresponds to an estimate of 250sf, which is on the same order of size of the downstream Fisher Slough channel as referenced at the start of this memo. The predicted top width from the SRSC geomorphologic equations was for 13m (42ft) topwidth which also is very similar in size to the current downstream Fisher Slough channel. Therefore, the results indicate that the current channel is within the expected size for tidal prism volumes planned for the project, and major changes in size and composition as a result of opening up the marsh are not expected.

There are a number of considerations in regards to appropriateness, application and predictions of the Coats (2005) regression equation may or may not be applicable directly to the Fisher Slough project site. The first point in this discussion is to note that Fisher Slough is a freshwater, riverine, tidal marsh. This type of marsh is unique in its hydrologic, geomorphic, and vegetation conditions. The hydrology and geomorphology are a result of both riverine and tidal conditions. The key is to determine the primary drivers (is it Skagit River or tributary flood conditions, or the daily tidal fluctuations) that will effect the site over the long term. In observing the system over the past 5 years, it appears that the major driving factor in channel size and formation are the 5 to 10 year recurrence interval tributary flood events that occur in the late fall, when the Skagit River remains low. Another influencing factor is that the downstream Fisher Slough channel is also subject to Skagit River flood flows, inside the levees, which can have higher velocities in the confined channel area. The project will ultimately reduce the peak tributary flow conditions and velocities as a result of more flood storage, thereby reducing erosion potential. In contrast, the peak tidal exchange will occur more frequently, which likely offsets the reductions in channel erosion potential reductions from reducing tributary flood flows.

The second point is that the Coats relationship was developed from studies and projects located in low lying, salt water marshes in the San Francisco Bay area. These marshes are very different from Fisher Slough in that the projects typically involved breaching of sea dikes, to marshes with subsided marsh plains (very low topography). The tidal marsh drainage hydrology is a function of the tidal prism and interior drainage confined to a dike or geologic impoundment. These

channels are blind channels and developed their morphologies and channel geometries as a result of interior drainage area and tidal prism within the impoundment. This is very different from the Fisher Slough, riverine-tidal, Skagit River and tributary flood hydrologic conditions and inputs.

Third, when using the Coats equation, it is noted that there is quite a bit of variability within the estimates of the regression equation. **Figure 24** shows as much as an order of magnitude difference in cross section area for the same tidal prism volume. The prediction for increased area is much smaller than the error or variation within the data used to develop the relationship, and therefore we are relying more on the hydraulic analyses of channel flow, velocity and shear stress conditions to assess mobility and potential for channel expansion versus the empirical regression analysis. The variability in the regression equation also leads into the next discussion point regarding the predictions of the equation.

There are several other studies that have noted the inaccuracies in predicting channel marsh channel geometry and geomorphology. Notably the SRSC studies tend to indicate that there may be differences in tidal marsh morphology as a function of hydrologic and geologic processes. For Fisher Slough and the Skagit Delta, this finding tends to indicate that the Skagit Delta and riverine-tidal processes are different than a strictly tidal process.

Also of note are studies being performed by Kirwan, 2006 and Fagherazzi 2006 that indicate that the elevation of the marsh plain and vegetation composition play a major factor in predicting tidal marsh channel geometry and geomorphology. These studies indicate that in elevated marsh plains and those areas having substantial vegetation on the marsh plain and channel banks, that the Coats model tends to over-predict channel dimensions and widths as these other factors provide stability and resistance to erosion.

Comments on the need for additional bank protection in downstream Fisher Slough

Overall, it is the opinion of the designer that the predicted hydraulic and geomorphologic conditions of the Fisher Slough channel will not erode significantly. The predicted flow rates, velocities and shear stresses are similar to or lower than the permissible velocities for alluvial silts, without compensation for additional erosion resistance from vegetation. The size, cross section and area of the downstream channel are commensurate in size with the predictions from Coats and the SRSC geomorphologic predictive regression equations. Also, other studies tend to indicate that these regression equations may over-predict tidal channel dimensions if there are elevated marsh plains and resistance to erosion from vegetation, which is considered to be the case for the downstream section of Fisher Slough. The two final points of this discussion are that the channel size and shape appears to be more a function of tributary flood flows, for which the tidal exchange falls within those channel forming processes and is not the key driver. Finally, the one key area of concern in the downstream area, immediately along the railroad embankment, has significant protection in the form of 3.0ft diameter rock. The other areas identified in **Figure 23** have topographic benches that extend away from the railroad embankment and have significant amounts of vegetation, which will protect and reduce the potential for erosion.

In summary, it is the opinion of the designer that no additional rock protection measures are necessary for the downstream Fisher Slough channel as a result of changes in tidal prism exchange for the restoration project.

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Coats, R. et al. 2005. Hydrologic Analysis for Coastal Wetland Restoration. Environmental Management, Vol. 13, No. 6, pp. 715-727.

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Kirwan, M, et al. 2006. A coupled geomorphic and ecological model of tidal marsh evolution.

Skagit River System Cooperative, 2007. Channel pattern predictions based on Skagit River delta historical conditions.