U.S. Fish & Wildlife Service

Ni-les'tun Tidal Wetlands Restoration Project: Planning, Implementation, and Lessons Learned

Biological Technical Publication
BTP-R1015-2017

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Acknowledgments

The tidal wetlands restoration project at the Ni-les'tun Unit of the Bandon Marsh National Wildlife Refuge was the result of more than a decade of planning, partnerships, land acquisition, scientific study, and engineering. Funding sources included the U.S. Fish and Wildlife Service (USFWS or Service), Federal Highway Administration, M/V *New Carissa* oil spill natural resource trustees, Oregon Watershed Enhancement Board, Ducks Unlimited, National Oceanic and Atmospheric Administration, National Fish and Wildlife Foundation, and Cape Arago Audubon Society.

Early in the design and planning process, the Service contracted or partnered with other critical personnel including: a Ducks Unlimited wetlands engineer and surveyor, a fisheries biologist with the Confederated Tribes of the Siletz Indians, a wetlands scientist with Green Point Consulting, a consultant (PBS&J) to prepare permits and National Environmental Policy Act documents, an archaeological consulting firm (Byram Archaeological Consulting, LLC) to oversee and conduct cultural resource preservation and monitoring, and the Coquille Watershed Association to provide labor for removal of agricultural infrastructure (e.g., fencing).

Other major partners who had input to the restoration planning and design process included the Coquille Indian Tribe, Oregon Department of Fish and Wildlife, U.S. Army Corps of Engineers, the State Historic Preservation Office, and National Marine Fisheries Service. Due to the projects associated with the marsh restoration (road improvement, utilities relocation), planning and restoration construction work was closely coordinated with the Federal Highway Administration, Oregon Department of Transportation, Coos County Roads Department, Coos-Curry Electric Cooperative, Pacific Power, Oregon Department of State Lands, Oregon Department of Environmental Quality, and U.S. Forest Service. Major stakeholders who were kept informed about the project included the Coos County Commissioners, City of Bandon, Port of Bandon, Coquille Watershed Association, and The Nature Conservancy. In addition, a number of highly dedicated local, regional and nationally recruited volunteers assisted with pre-, during, and post-restoration efforts.

Funding for the lead author's time spent on writing this report was provided by the M/V *New Carissa* oil spill settlement, USFWS Region 1 Refuge System Chief's Office, and USFWS Region 1 Inventory and Monitoring Program. Additional support from Oregon Coast National Wildlife Refuge Complex Project Leader Kelly Moroney and the South Coast Refuge Manager Eric Mruz was critical for completing this report. Many discussions with Christopher Claire, fish habitat biologist with Oregon Department of Fish and Wildlife and integral partner throughout the Ni-les'tun restoration project, contributed greatly to understanding the effects of the restoration on aquatic resources. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

Executive Summary

Bandon Marsh National Wildlife Refuge (NWR or Refuge) was established in 1983 through Congressional legislation and is managed by the U.S. Fish and Wildlife Service (USFWS or Service). The 582-acre Ni-les'tun Unit of the Refuge was acquired by the Service between 2000 and 2004 and is located upstream (northeast) of the older 307-acre Bandon Marsh Unit of the Refuge. Much of the floodplain portion of the Ni-les'tun Unit, totaling over 400 acres (hereafter restoration site, or site), was historically a tidal wetland, but was diked, ditched, fenced, and tide gated during conversion for agricultural purposes in the late 19th and early 20th century. The Ni-les'tun Unit was acquired with the intent of tidal wetland restoration for the purposes of increasing depleted estuarine fish and wildlife habitat and creating opportunities for compatible wildlife-dependent recreation. The purpose of this report is to document (1) the process of accomplishing this large and complex restoration project, and (2) the results of efficacy monitoring and consequences of design decisions four years after the tides returned.

The restoration site consisted of three sub-basins, each with separate freshwater inflow leading to the three respective tide gates. Only a remnant of the former tidal channel network existed on the site. The goal of the restoration project was to recreate the conditions that would ultimately restore tidal wetland habitat values and functions lost when the site was converted to pasture. The restored wetlands would provide:

- Foraging, roosting, and breeding habitat for migratory and resident birds;
- Foraging and nursery habitat for anadromous and estuarine fish and aquatic organisms;
- Pass-through habitat for anadromous fish breeding upstream of the restoration site;
- Fewer restrictions or mortality factors impacting wildlife, fish and other species;
- Increased native vegetation, including regionally depleted tidal woodland;
- Compatible wildlife-dependent public recreation opportunities; and
- Improved estuarine health and overall biological productivity.

Planning for the restoration involved assembling a design team; procuring funding; preparing National Environmental Policy Act (NEPA) documents and permit applications; consultation with stakeholders; gathering baseline data on many physical, biological, and cultural parameters; and making numerous design and implementation decisions. Complicating the entire process was the necessity of elevating portions of the Coos County road that would be flooded by restored tides, and burial of a 25 kilovolt (kV) electrical line that passed through the site. There was also an eleven-acre non-tidal riparian parcel that had been converted to a commercial cranberry bog, abandoned, and eventually donated to the Refuge (Anaflor Q. Smith Tract) to be restored as part of the larger project. These ancillary projects are only described briefly in this report, which focuses on the tidal wetland restoration.

Integral to this project was the design of the efficacy monitoring program. This project offered an outstanding opportunity to track the effectiveness of restoration actions, quantify ecosystem responses to restoration, guide adaptive management, and contribute to ongoing efforts to develop improved guidance for other tidal wetland restoration projects in the Pacific Northwest. The monitoring that began two years prior to tidal restoration and continued for four years post-restoration accomplished those goals and provided accountability for the project's substantial restoration investment. All of the ecological parameters measured on the site before and after the restoration were also measured on comparable areas of the Bandon Marsh Unit, which provided a reference crucial for evaluating how different the site was before the restoration, and the degree to which the restored site functioned as a natural tidal marsh.

Before the restoration work could proceed, a series of engineering and design decisions needed to be taken, including: how to replace agricultural ditches with a more natural tidal channel system, how much river dike to remove, how to install large woody debris (LWD) in channels to improve fish habitat, determining whether to remove existing pilings, how to repair machine damage to wetland soils, how to mitigate sedimentation and infusion of warm water into fish-bearing (particularly coho salmon) waters during excavation, how to conserve important cultural resources known to be present on the site, and where could costs be saved without compromising the goals of the project, among many others. This report documents the factors considered for each of these decisions, and the consequences of those decisions that have been evaluated four years after they were implemented.

In August 2011 during a week of the lowest high tides of the season, the last layer of dike and three tide gates were removed, the heavy earth-moving equipment retreated to high ground, and the tides returned to the site unfettered for the first time in over one hundred years. The result was the largest tidal wetland restoration in Oregon to date starting on a trajectory toward full ecological function. Formal and informal monitoring witnessed an immediate response by fish and wildlife as many species began using the site for the first time in anyone's memory.

A decision had been taken to treat the many shallow drainage ditches that had been constructed by the previous landowners by discing them and adjacent areas to attempt to fill them or obliterate their function. This did break up the linear drainage function, but resulted in a broken chain of small depressions along the ditch lines that would be filled by high tides, and retain that water after the tide receded. Where this occurred at elevations between the lower high tides of the month and the higher high tides, the resulting pools became suitable breeding sites for the salt marsh mosquito (*Aedes dorsalis*). By the summer of 2013 the numbers of these mosquitoes produced on the site reached levels well above any precedent, and they became a serious nuisance to the Refuge staff and the surrounding community triggering a health advisory by the Coos County Public Health director. After confirmation that these mosquitoes were breeding in huge numbers in pools inadvertently created by the restoration construction, and that these breeding pools were not features of naturally developed tidal marshes in the region, the Service developed and implemented an Integrated Marsh Management Plan to resolve the problem. The permanent solution was to connect the vast majority of the breeding pools to the tidal exchange, rendering them unsuitable mosquito breeding habitat. In summer 2014, this plan was implemented by constructing almost 23 miles of new first and second order channels that functioned to drain the pools on the ebbing tide. Continued mosquito monitoring has shown that this solution is working, and mosquito production on the site is now negligible relative to levels that result in any concern by the staff and local community.

The term "restoration" as used in this report refers both to the physical changes made on site to alter the hydrology and improve fish and wildlife habitat (i.e., tide gate and dike removal, construction of the tidal distribution system, LWD placement, woody plantings); and the ongoing process of development toward full ecological function of the tidal marsh initiated by these changes. By all metrics employed to monitor the restoration, it is a success in both meanings of the term. The primary ecological driver of the return of the daily tidal flows had the immediate effect of initiating the biological responses to the new conditions. Those responses were accelerated by the later construction of the smaller channels that greatly increased the extent of the tidal exchange. The inherent mobility of animals permitted their rapid response to the new conditions: birds, fish, mammals, and invertebrates that had been absent, or nearly so, on site before started using the site almost immediately after the tides returned. Plants intolerant of the new salinity and inundation regimes began to die shortly after exposure, and the slower process of colonization by tidal marsh species began. Plant and microbial responses to gradual biophysical changes in the marsh soils will continue for many years, but those processes are underway. No one knows how long it will take for the marsh to achieve its full potential for productivity and high quality habitat for species of conservation concern, but there is clear evidence that it is already well on its way to that goal, and is already providing important benefits.

This success notwithstanding, we report on the positive and negative consequences of eight major design decisions for the edification of any restorationists confronted with similar decisions. The mosquito problem resulting from a decision about how to treat the small ditches on the site was the most consequential, but the negative experience and additional resources required to solve it did result in a much more developed tidal channel system that advanced the restoration process by an unknown amount, but likely by several decades. Other consequences discussed include the loss of a significant fraction of the LWD installation, impediments to tidal exchange resulting from lack of grade control, settling of major ditch fill, and the fate of woody plantings intended to jump start the tidal woodland restoration.

The total cost of the restoration, including the ancillary infrastructure projects, efficacy monitoring, and mosquito management was $11,794,158 procured from a variety of sources. Of this, the restoration construction and monitoring cost $3,467,155 and developing and implementing the mosquito plan cost $1,035,456.

Four major conclusions and recommendations arising from this experience are discussed: (1) Prepare for unexpected contingencies; (2) If the historic tidal channel system is not intact, place a high priority on creating as nearly a natural configuration of all channel orders as possible; (3) Develop and maintain strong local community support for the project with a systematic public education plan implemented early in the project planning process; and, (4) Efficacy monitoring is extremely important, especially for large or otherwise highly visible projects.

Finally, supporting documents detailing construction specifications, procedures, and schedules are included in Appendices, and internet links to major monitoring reports are given in the References Cited section.

1. Introduction

1.1 Historic and landscape context of site (adapted from USFWS 2013)

The lower portion of the Coquille River and adjacent bottomlands were historically tidal for approximately 40 river miles, from the city of Bandon on the Pacific coast to immediately upstream of the town of Myrtle Point. At the time of Euro-American settlement (mid-1800s), an estimated 14,440 acres of vegetated tidal wetland was associated with this reach of the Coquille River (Benner 1991). The lower Coquille River was deep channeled with shallow floodplains covered by a mosaic of fresh and brackish wetlands including spruce swamp forest, dense willow and alder scrub-shrub, emergent marsh, and tidal mudflats (Benner 1991). This riverine and estuarine system was also hydraulically and biologically influenced by many freshwater tributaries and extensive beaver activity.

Beginning in the late 1800s and continuing well into the twentieth century, up to 95 percent of all the Coquille River tidal wetlands was disconnected to some degree from the river and its daily tidal exchange by the installation of dikes and tide gates. The purpose of these structures was to convert the historical wetlands and floodplain to agricultural use, largely pastures, by confining the tides to the main river channel. Most of these converted bottomlands still flooded during the rainy winters, but they remained dry enough to support livestock forage plants and permit grazing during part of the year. Conversion included removing woody vegetation and beavers, which were incompatible with ranching and farming. By 1983, the 289-acre parcel (now part of the Bandon Marsh Unit) acquired by the U.S. Fish and Wildlife Service (Service or USFWS) to establish Bandon Marsh National Wildlife Refuge (Refuge or NWR) was the largest fully functioning tidal marsh remaining in the Coquille Basin.

Much of the converted acreage functioned as degraded fresh water wetlands, with severely muted tidal influence, if any. Ditches constructed to improve drainage inside the dikes provided some native fish habitat, but the limited hydraulic connection to the river and lack of shading resulted in poor habitat for anadromous salmonids and other estuarine-dependent species. Non-native forage plants were introduced to improve grazing, and soils were compacted by trampling and decomposition of organic matter. Nutrient and sediment exchange between the river and the floodplain was disrupted. Combined with forestry and timber harvest practices, commercial fish harvest, and other development throughout the watershed, the loss of off-channel habitat for salmon resulted in a 90 percent reduction of salmon production in the Coquille River, with coho suffering the most loss (ODFW 2007). By 2007, it was determined that lack of off-channel wintering habitat was the limiting factor for recovery of the Coquille River coho population (ODFW 2007).

1.2 Planning for restoration (adapted from USFWS and FHA 2009)

Bandon Marsh National Wildlife Refuge was established in 1983 through Congressional legislation and is managed by the Service. The 582-acre Ni-les'tun Unit was acquired by the Service between 2000 and 2004 and is located upstream (northeast) of the 307-acre Bandon Marsh Unit of the Refuge (Figure 1). The land comprising the Ni-les'tun Unit includes parcels from several previous private owners who sold their land to the Service, plus one parcel donated by Anaflor Q. Smith (the Smith Tract).

The floodplain portion of the Ni-les'tun Unit (Unit), totaling over 400 acres (hereafter restoration site, or site), was historically a tidal wetland, but was diked, ditched, fenced, and tide gated drained for agricultural purposes in the late 19th and early 20th century (Figures 2–4). Upon acquisition the floodplain was dominated by ditched, seasonally wet pasture, and miles of fencing; the Service's intent was to restore it to tidal marsh for the purposes of increasing estuarine fish and wildlife habitat and opportunities for compatible wildlife-dependent recreation. The remaining 30 percent of the Unit was tidal marsh, shrub swamp, forested wetlands, upland forest, upland pasture, and abandoned cranberry bogs. The restoration site consisted of three sub-basins, each with separate freshwater inflow leading to the three respective tide gates. Only a remnant of the former tidal channel network existed on the site (Figure 5). In 2003, the tide gate on Fahys Creek failed and was replaced with a fish-friendly tide gate, which allowed for muted tidal flows in lower Fahys Creek from 2003–2011. The goal of the restoration project was to recreate the conditions that would ultimately restore tidal marsh habitat values and functions lost when the site was converted to pasture. The restored marsh would provide:

- Foraging, roosting, and breeding habitat for migratory and resident birds;
- Foraging and nursery habitat for anadromous and estuarine fish and aquatic organisms;
- Pass-through habitat for anadromous fish

breeding upstream of the restoration site;
- Fewer restrictions or mortality factors impacting wildlife, fish and other species (e.g, inverts);
- Increased native vegetation, including regionally depleted tidal woodland;
- Compatible wildlife-dependent public recreation opportunities; and
- Improved estuarine health and overall biological productivity.

1.3 Funding

Major funding for the restoration project was secured from several sources before plans were finalized and construction was scheduled, however additional funding became necessary as the project developed. Sources included USFWS ($516,400), Oregon Watershed Enhancement Board ($1,098,754), M/V *New Carissa* oil spill settlement funds ($1,625,000), Ducks Unlimited ($142,000), and Cape Arago Audubon Society ($10,000). In addition to the restoration project there were two ancillary projects including roadway improvements to North Bank Lane and burial of an electrical transmission line across the river and floodplain. Funding sources for the roadway improvements included Federal Highway Administration ($4,200,000) and USFWS-Refuge Roads ($372,107). The $2,719,440 in funding for transmission line burial was provided by the USFWS with American Recovery and Reinvestment Act funds. Actual total expenditures for the project to date and the funding sources are shown in Section 9. Not included in this report are the costs of acquiring and managing the Ni-les'tun Unit land, nor salaries of permanent USFWS staff who worked on the project.

Figure 1. Bandon Marsh NWR and vicinity

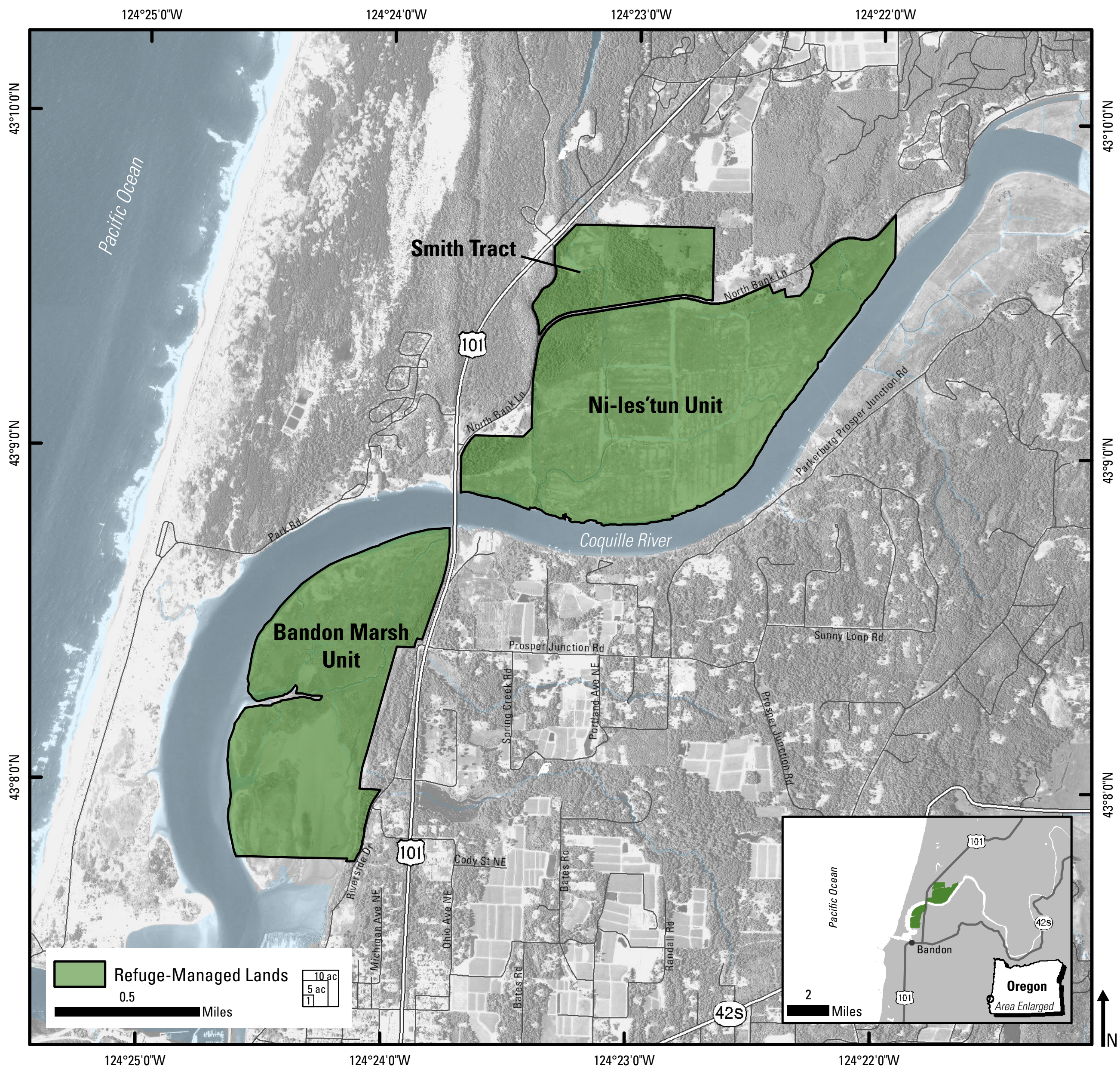


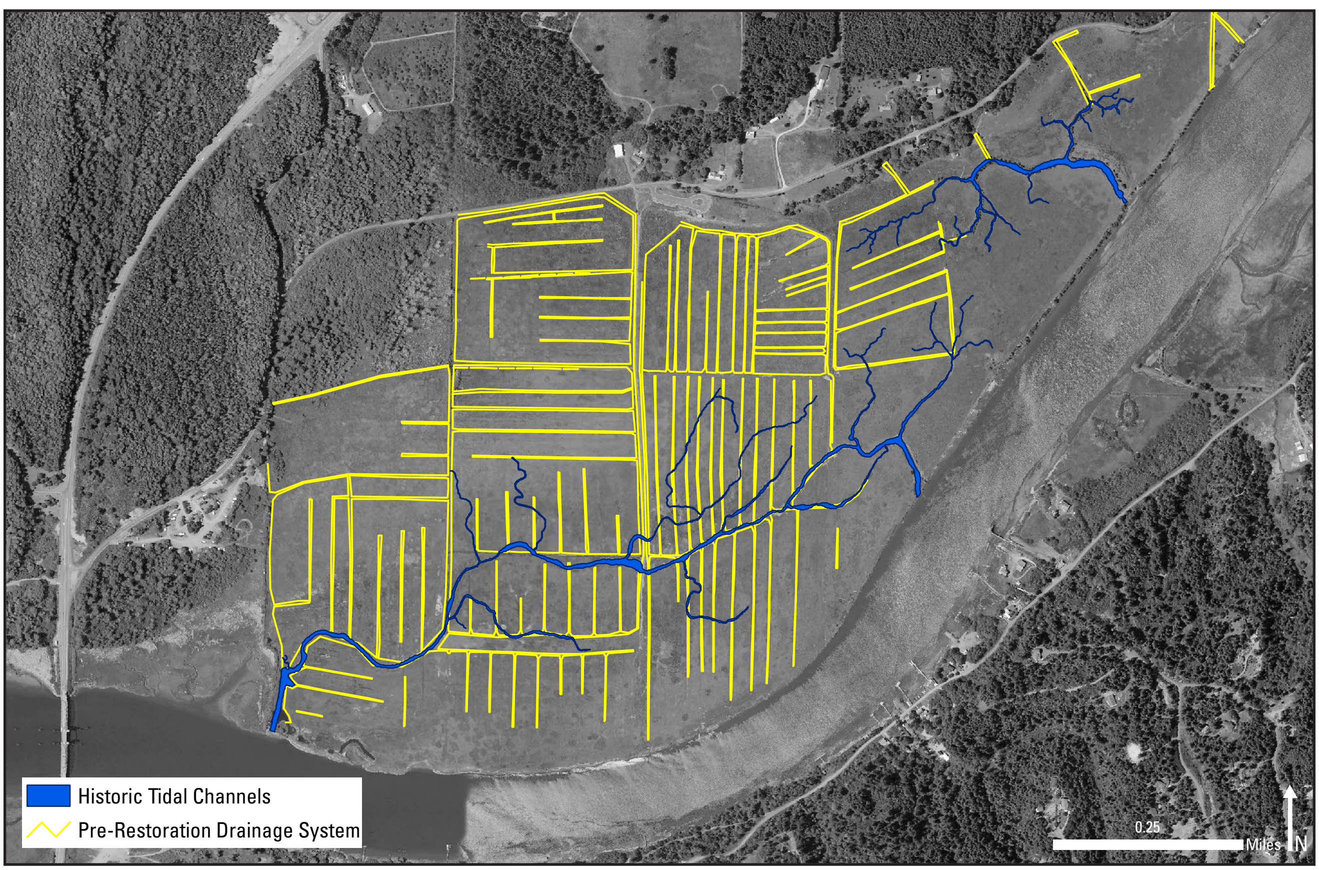
Figure 2. Detail of 1857 General Land Office map showing pre-agricultural conversion features

General Land Office (1857)

Figure 3. Mosaic of geo-referenced 1939 OCSW aerial photography

Figure 4. Mosaic of geo-referenced 1954 COB 1N aerial photography

Figure 5. Historic tidal channels digitized from 1939 and 1954 aerial photography and pre-restoration drainage ditch system



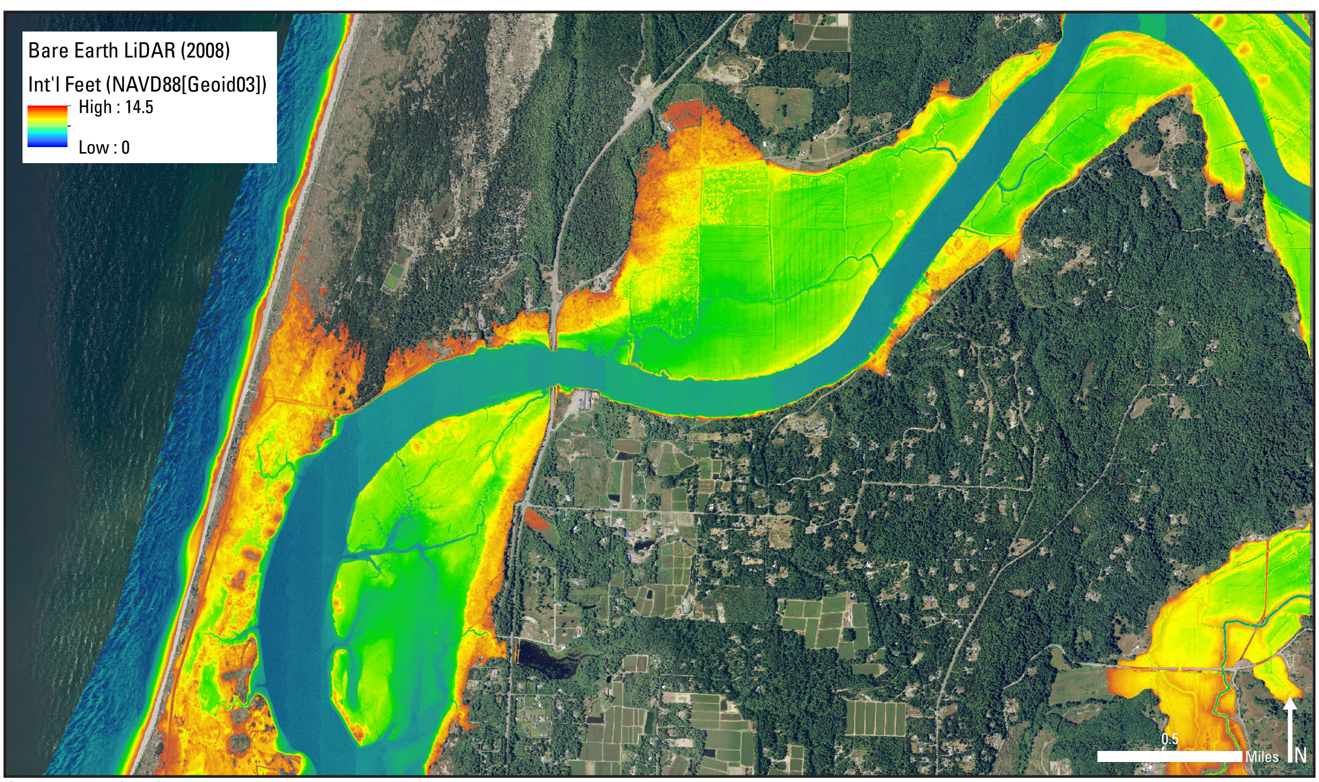
2. Pre-restoration Site Description

2.1 Topography and drainage (adapted from USFWS 2014a)

The site is bounded by a marine-deposited terrace and county road bed on the north, and generally slopes down to the river bank to the south and southwest. Normal ground elevation (North American Vertical Datum of 1988 [NAVD 88]) of the site ranges from 8 feet at the northeastern end, to 5 feet at the southwestern end (Figure 6). Eighty percent of the site is below 7.0 feet (mean higher high water [MHHW]). Soil analyses revealed that there was a natural levee along the north bank of the river ranging from elevation 8 to 9 feet that was augmented by previous owners to a range of elevation 9 to 12.5 feet (Ducks Unlimited 2009). The entire restoration site lies within the boundary of the 100-year floodplain (FEMA 2009a, FEMA 2009b).

Superimposed on the floodplain table was an extensive network of artificial drainage ditches (Figure 5) designed to hasten drying of the site to promote conditions for forage plant growth and grazing. These included large ditches holding permanent water connected directly to the main channels leading to the tide gates, and many shallow ditches that were usually dry feeding into the large ditches. The largest and westernmost of the three streams flowing through the site (Figure 1) is Fahys Creek, which had been relocated into a straightened channel much of its length, but also flowed through one remnant historical channel for 1,000 feet before it was diverted again into a ditch leading to the tide gate. The central portion of the site was drained by No Name Creek, which also flowed through a remnant tidal channel for about 800 feet before entering a tide gated culvert. No Name Creek was fed by several ditches that drained a perennial spring and seepages out of the marine terrace that forms the northern central boundary of the floodplain. In the northeast portion of the site, Redd Creek and its tributary, Blue Barn Creek, flowed through the site to the third tide gate, and although parts of it had been channelized, most of it remained in natural channels. Nonetheless, many ditches had been built that drain into it. Apart from the remnant tidal channels mentioned above, all traces of the original channel system had been totally obliterated by the artificial ditch system and grading of the land.

Figure 6. LiDAR image of Bandon Marsh NWR showing elevations below 14.5 feet (NAVD 88)



Oregon LiDAR Consortium (2009)

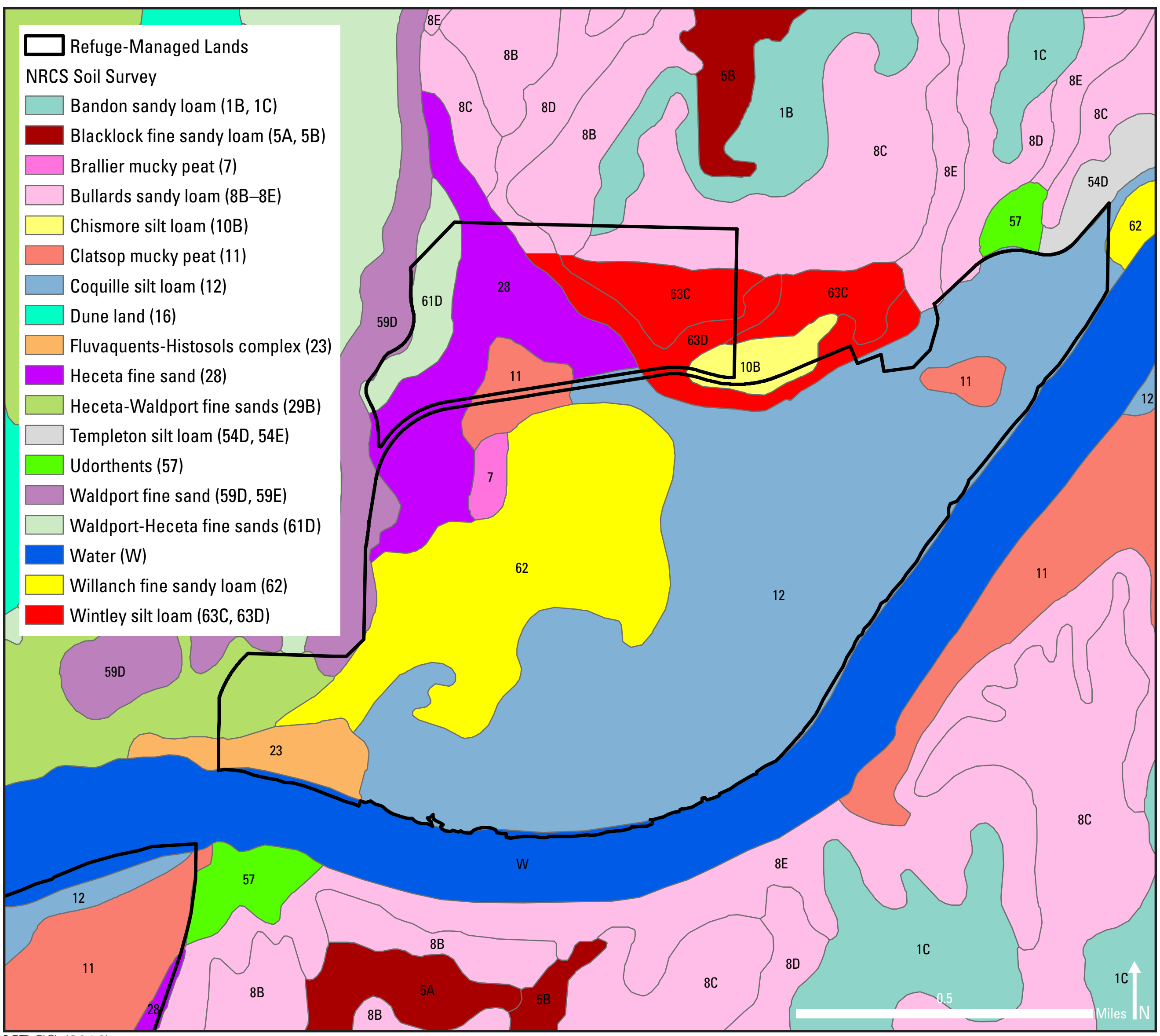
2.2 Soils (adapted from USFWS 2014a)

Soil characteristics are typical of pasture and degraded wetlands that have not experienced daily tidal flood events for approximately 100 years. Before its agricultural conversion, the project area was shaped by periodic earthquakes and tsunamis within the Cascadian subduction zone and the daily tidal processes associated with the Coquille River and the Pacific Ocean. Twelve subduction earthquakes have occurred in the last 6,700 years, the last in 1700, and each of these events reduced local elevations and resulted in more flooding of the site. Over time, accretion of fine sediments and organic materials resulted in the formation of a classic tidal mudflat and marsh system (Byram and Witter 2000).

The soils of the Ni-les'tun Unit vary between the diked pasture environment; palustrine emergent, persistent, seasonally flooded wetland; and the palustrine forest/scrub, seasonally flooded wetlands (Cowardin et al. 1979) located on the northwest portion of the Unit (Brophy 2005). The Natural Resources Conservation Service (NRCS) mapped soils on the pasture and wet prairie in the project area (Figure 7) that include Clatsop mucky peat, Coquille silt loam, and Willanch fine sandy loam. Soils within forested wetlands include Wintley silt loam, Brallier mucky peat, Clatsop mucky peat, and Haceta fine sand (Brophy 2005). None of these soil types are designated as prime, unique, or important farmland soils.

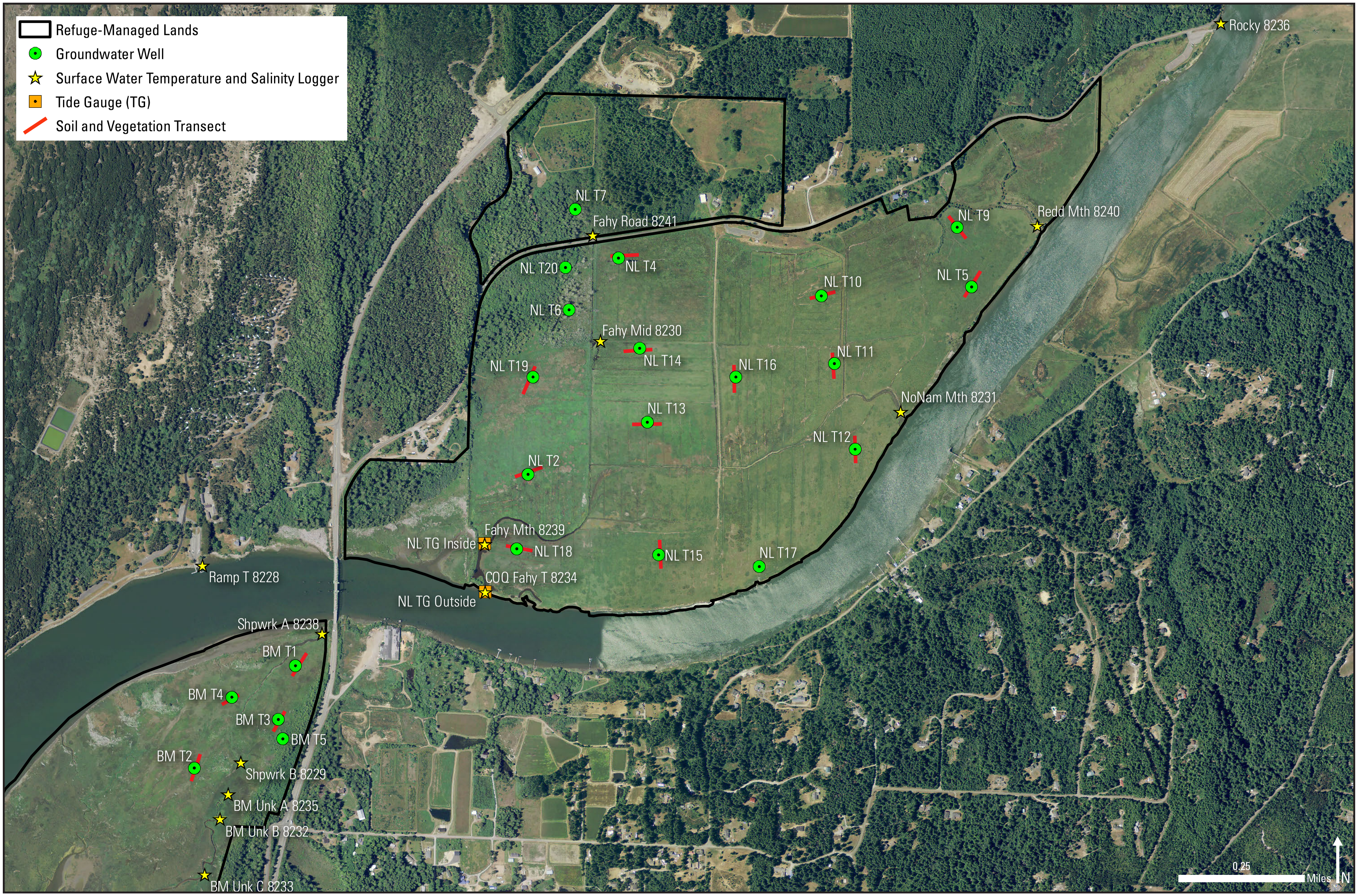
According to a hydrogeologic characterization of the Ni-les'tun Unit performed in 2005, the shallow groundwater on the site fluctuated between approximately 4 feet below the ground surface during late summer and early fall to 0.5 feet above the ground surface during wet winter months. The average depth to groundwater was between 1 and 2 feet below the ground surface (Kocourek 2006). Groundwater sampling locations are shown in Figure 8.

Figure 7. NRCS soil survey data for the Ni-les'tun restoration site



NRCS (2016)

Figure 8. 2010–2011 sample locations for groundwater, tidal hydrology, surface water temperature and salinity, soils, and vegetation



2.3 Hydrology (adapted from USFWS and FHA 2009)

The artificial dikes and tide gates excluded the tides from the site, except for some periods of muted tidal influence in the lowest portions of Fahys Creek. During high water periods on the Coquille River, portions of the artificial levees were overtopped and the entire site flooded, at times including portions of North Bank Lane. Heavy rains could overwhelm the capacity of the tide gates to drain the site and also resulted in extensive flooding during the winter. U.S. Geological Survey tidal data for Bandon, Oregon, on the Coquille River for 1983–2001 epoch (NOAA 2017) are shown in Table 1, and indicates what the tidal regime would be at the site without the dikes and tide gates. Figures 9 and 10 compare representative tide levels and salinity levels in the river and just inside the tide gate on Fahys Creek, and show that there was still some tidal effect despite the control structures (Brophy and van de Wetering 2012). Sampling locations are shown in Figure 8. Much of this muted tide signal is due to the backup of freshwater flows during closure of the tide gates during high tides, but the slight salinity signal (Figure 9) indicates some entry of brackish water during flood tides. Freshwater backup and slight salinity intrusion are typical of most tide gate systems (Giannico and Souder 2005).

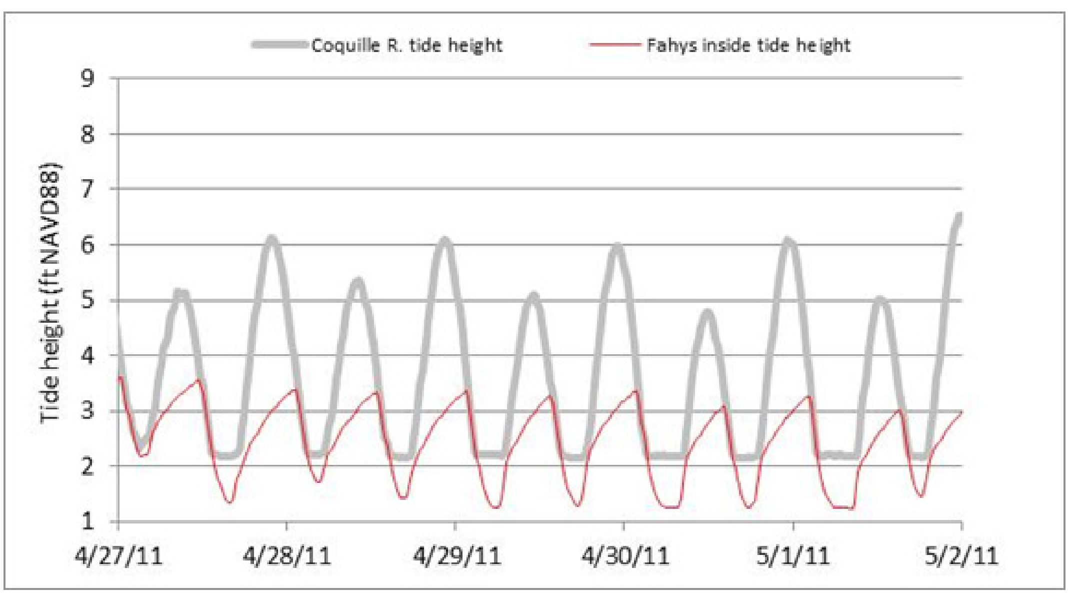
Table 1. Tidal benchmark summary for Bandon, Oregon, at the Coquille River

Station Information	Bandon, Coquille River Sta. ID 9432373
Mean Higher High Water (MHHW) (feet)	7.09
Mean High Water (MHW) (feet)	6.37
Mean Tide Level (MTL) (feet)	3.78
Mean Sea Level (MSL) (feet)	3.75
Mean Low Water (MLW) (feet)	1.19
North American Vertical Datum 1988 (NAVD 88)	0.1
Mean Lower Low Water (MLLW)	0

NOAA (2017)

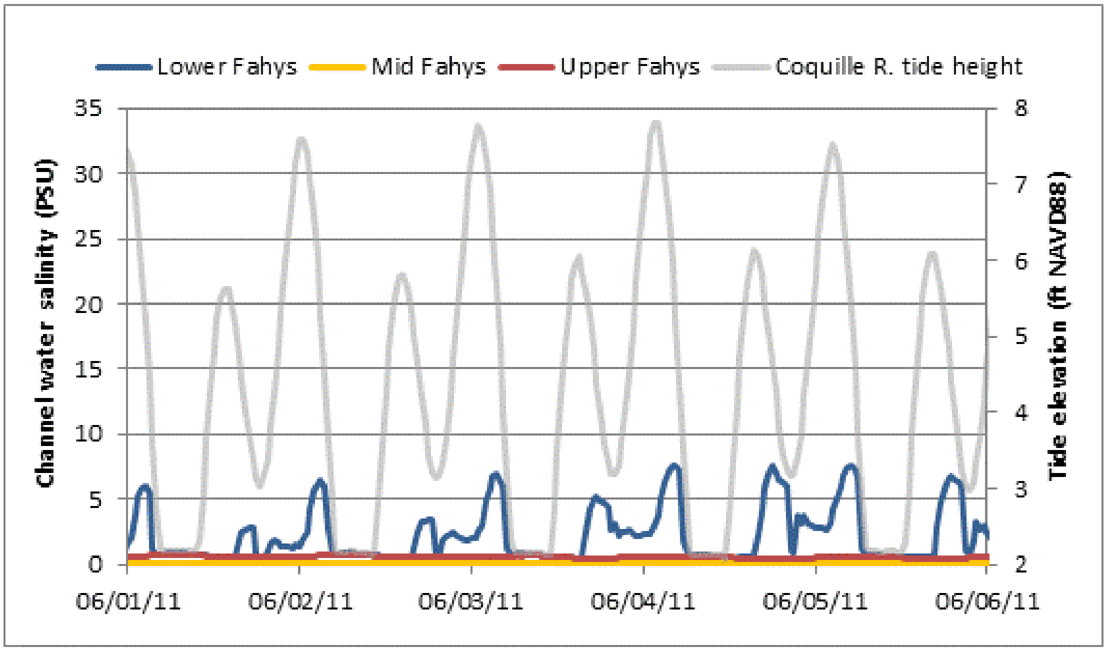
Figure 9. Pre-restoration tide heights in lower Fahys Creek (behind tide gates) and in the adjacent Coquille River, April 27–May 1, 2011

The Coquille River tide gauge was position above most low tide levels, which accounts for the truncated troughs in the chart.



Brophy and van de Wetering (2012)

Figure 10. Pre-restoration salinities in lower, middle, and upper Fahys Creek, May 2011
Middle and upper Fahys Creek showed no salinity, and lower Fahys Creek showed low-brackish salinities (0–6).



Brophy and van de Wetering (2012)

2.4 Vegetation

Vegetative cover was characterized on the restoration site and the Bandon Marsh Unit as a reference site in 2003 and 2010 using permanent transects and standard sampling methods by a contractor (Green Point Consulting). The following excerpt is from a report of their findings (Brophy and van de Wetering 2012). Figure 8 shows the locations of transects referred to in the excerpt, tables of species found by transect are below, and more details about sampling methods and results can be found in the report. Note that "Ni-les'tun" refers to the restoration site portion of the Unit.

> ***Plant community composition***
> During baseline monitoring, strong contrasts were apparent between emergent wetland plant communities at the Ni-les'tun pasture and the Bandon Marsh Unit reference site. Vegetation cover at Ni-les'tun consisted of about half non-native pasture grasses and half native species, while the reference site had much higher cover of native species [see Table 2].... Communities with a higher proportion of native species were concentrated on the west end of the site.... The transects near the mouth of Fahys Creek (NL T2, NL T18) had higher soil salinities and more native species – including several of the same species that are dominant at the reference site, such as seashore saltgrass (*Distichlis spicata*) and Pacific silverweed (*Potentilla anserina*).... Native species are more competitive in these areas because of the brackish conditions, which negatively affect non-native pasture grasses. Other strongly native-dominated communities occurred in the wettest parts of the pasture, which were less heavily grazed (transects NL T4, NL T19). Although invasive reed canarygrass (*Phalaris arundinacea*) is present in these wettest areas, it is not dominant, and may actually have decreased since 2003. NL T19, located within a large area mapped as a slough sedge (*Carex obnupta*)-reed canarygrass community in 2003, had less than 5% cover of reed canarygrass in 2010.
>
> The forested wetlands at the Ni-les'tun Unit were dominated by native species – in fact, non-native species were almost completely absent [see Tables 3–5].... This contrasts with the Ni-les'tun pasture, where non-native species dominated, as described above. Land use history explains this difference: on the pasture, grazing and intensive hydrologic alteration (dikes, tide gates, ditching) discouraged native species and favored non-natives, and non-native grasses were deliberately planted. By contrast, in the forest, little direct manipulation of vegetation appears to have occurred, although timber harvest probably occurred in the past. The primary human influence on the forested wetlands of the Ni-les'tun Unit and north of North Bank Road has been through hydrologic manipulation: Ni-les'tun's dikes and tide gates blocked tidal flow, North Bank Road altered freshwater flows, and the channelization of Fahys Creek reduced floodplain connectivity. These hydrologic manipulations, as well as beaver activity, have led to dynamic conditions in the forests for many years. For example, our team's 2003 monitoring showed many dead and dying Sitka spruce in the area near NL T6 (Brophy 2005a) [likely caused by recent flooding by beaver impoundments]; this trend continued through 2011 (Brophy, personal observation).

Table 2. Emergent wetlands, Ni-les'tun restoration site: plant community composition by transect, July 2010

Non-native species are highlighted in gray.

		Average Percent Cover*													
Common Name	Scientific Name	NL T2	NL T4	NL T5	NL T9	NL T10	NL T11	NL T12	NL T13	NL T14	NL T15	NL T16	NL T17	NL T18	NL T19
creeping bentgrass	*Agrostis stolonifera*	13.1					13.8		29.6	26.4	7.4	31.8	5.2	20.9	
water foxtail	*Alopecurus geniculatus*								13.4						
slough sedge	*Carex obnupta*		60.6	6.9											83.5
seashore saltgrass	*Distichlis spicata*													79	
creeping spikerush	*Eleocharis palustris*	46.7							8.4						
common velvetgrass	*Holcus lanatus*								6.7	8.7					5.3
hairy cat's-ear	*Hypochaeris radicata*												8.8		
Baltic rush	*Juncus balticus*		9.2	55.5	30.3	66.7	16.5				30.1	18.7	5.1		
common rush	*Juncus effusus***	5.7	7.2							6.1					
birdsfoot trefoil	*Lotus corniculatus*			29.2	47.5		5.1	12.5	23.5	12.4	20.7				
pacific water-parsley	*Oenanthe sarmentosa*		28.4												
Pacific silverweed	*Potentilla anserina*	59		6.5	24				14.2	49.5					13.8
tall fescue	*Schedonorus arundinaceus*			34.4	15.4	22.4	70.4	96.9			59.5	48.9	85.7		
white clover	*Trifolium repens*								6.8						
springbank clover	*Trifolium wormskjoldii*					5.6									

* Table includes only species with more than 5% cover in any single transect.

** There are native and non-native varieties of *Juncus effusus*, but these were not distinguished during 2010 field work.

Brophy and van de Wetering (2012)

Table 3. Forested wetlands, Ni-les'tun restoration site (NL T6, NL T7, NL T20) and Bandon Marsh Unit (BM T5): tree density by transect, July 2011

All trees in plots were native species.

		Tree Density (Trees/Acre)			
Common Name	Scientific Name	BM T5	NL T6	NL T7	NL T20
Oregon alder	*Alnus rubra*	774		110	317
Pacific wax myrtle	*Myrica californica*	702			
Sitka spruce	*Picea sitchensis*	605	17	129	63
cascara	*Rhamnus purshiana*	944		32	24
western hemlock	*Tsuga heterophylla*	24			
Total		3049	17	271	404

Brophy and van de Wetering (2012)

Table 4. Forested wetlands, Ni-les'tun restoration site (NL T6, NL T7, NL T20) and Bandon Marsh Unit (BM T5): stem density by transect, July 2011

All shrubs in plots were native species.

		Shrub/sapling Density (Stems/Acre)			
Common Name	Scientific Name	BM T5	NL T6	NL T7	NL T20
salal*	*Gaultheria shallon**			2759	
black twinberry	*Lonicera involucrata*	194		242	
Oregon crabapple	*Malus fusca*		194		
salmonberry	*Rubus spectabilis*		1162	2275	1646
Pacific blackberry	*Rubus ursinus*	145			
red elderberry	*Sambucus racemosa*		194		
evergreen blueberry*	*Vaccinium ovatum**	726		2662	1549
red huckleberry	*Vaccinium parvifolium*	97		2614	
huckleberry	*Vaccinium sp.*			1791	
Total		1162	1549	12342	3194

* Evergreen blueberry and salal were generally growing on fallen logs, not in the soil.
Brophy and van de Wetering (2012)

Table 5. Forested wetlands, Ni-les'tun restoration site (NL T6, NL T7, NL T20) and Bandon Marsh Unit (BM T5): percent cover of herbaceous (understory) species, July 2011

All herbaceous species with >5% cover were native.

		Average Percent Cover			
Common Name	Scientific Name	BM T5	NL T6	NL T7	NL T20
slough sedge	*Carex obnupta*		71.9	20.5	75.4
skunk cabbage	*Lysichiton americanus*	6.3	27.9	59.5	11.6
Pacific water parsley	*Oenanthe sarmentosa*	10.1			
Pacific blackberry	*Rubus ursinus*	8.3		8.4	

* Table includes only species with more than 5% cover in any single transect.
Brophy and van de Wetering (2012)

2.5 Fish and wildlife use

Fish use

Fish use of the site was monitored by Green Point Consulting and the USFWS Columbia River Fisheries Program Office (CRFPO) between 2007 and 2014 using various sampling methods, including seine nets, hoop nets, and underwater video. Pre-restoration results are reported in Brophy and van de Wetering (2012) and Hudson et al. (2010). The approach was to compare the fish presence in the river mainstem, Bandon Marsh reference site, and the restoration site as a way to evaluate the potential for fish use of the site over multiple seasons, tidal ranges, and years. Both studies also included sampling of aquatic invertebrates to characterize the prey base for fish. While there was fish habitat within the site, the tide gates functioned to limit fish passage, reduce salinity and raise water temperatures inside the gates, and severely reduce fish access to the ditch system; all of which limited native fish use. Coho salmon was the only listed (federally threatened under the Endangered Species Act, NOAA 2008) fish species using the site, and was a focus of the surveys. Detailed methods and results may be found in the respective reports cited above. The following is an excerpt from Brophy and van de Wetering (2012) summarizing the results.

> [Ni-les'tun] fish use during the early spring through late summer pre-restoration period reflected tide gate presence [Figure 11] and its effect on migration,…[and water] temperatures and salinities.... Young of the year salmonids emerge from … upstream … tributaries [of the Coquille River]. These age 0+ salmonids migrate downstream throughout the spring and early summer. These age 0+ salmonids and other species (staghorn sculpin, shiner perch and stickleback) enter marsh habitats during windows of limited opportunity (tide gate openings) and during high flow events that overtop dikes. At past study sites we have observed that age 0+ coho will utilize marsh habitats without carrying out daily migrations as long as water depths are great enough and temperatures and salinities are low enough. These circumstances are usually found in marsh channel habitats that are associated with a perennial stream where beaver activity is present at the tidal boundary. Under these circumstances, coho can rear continuously throughout the summer and following winter if the habitat quality remains high. Fahys and Redd Creeks both offered these conditions during the pre-restoration period – Fahys in the upper reach and immediately inside the tide gate (Figure 12). The age 0+ chinook and staghorn sculpin were able to use the lower and middle Fahys reaches until water quality became too poor or habitat too limited. These same species were able to use Redd Creek until water volumes became too limited in late summer. Sticklebacks were able to make use of nearly all degraded habitats in Fahys, No Name and Redd Creeks. Shiner perch depend on broader daily tidal migration opportunities to make use of marsh habitats and we suggest they were therefore significantly limited in their ability to use Fahys, No Name and Redd marshes for nursery habitat during pre-restoration. No Name Creek offered adequate salmonid habitat, yet poor access, into the late spring at which time flows dropped, aquatic macrophyte and periphyton growth increased and temperatures began to rise. Limited tide gate access most likely resulted in No Name having the lowest salmonid and staghorn sculpin use rates.

Terrestrial vertebrate use

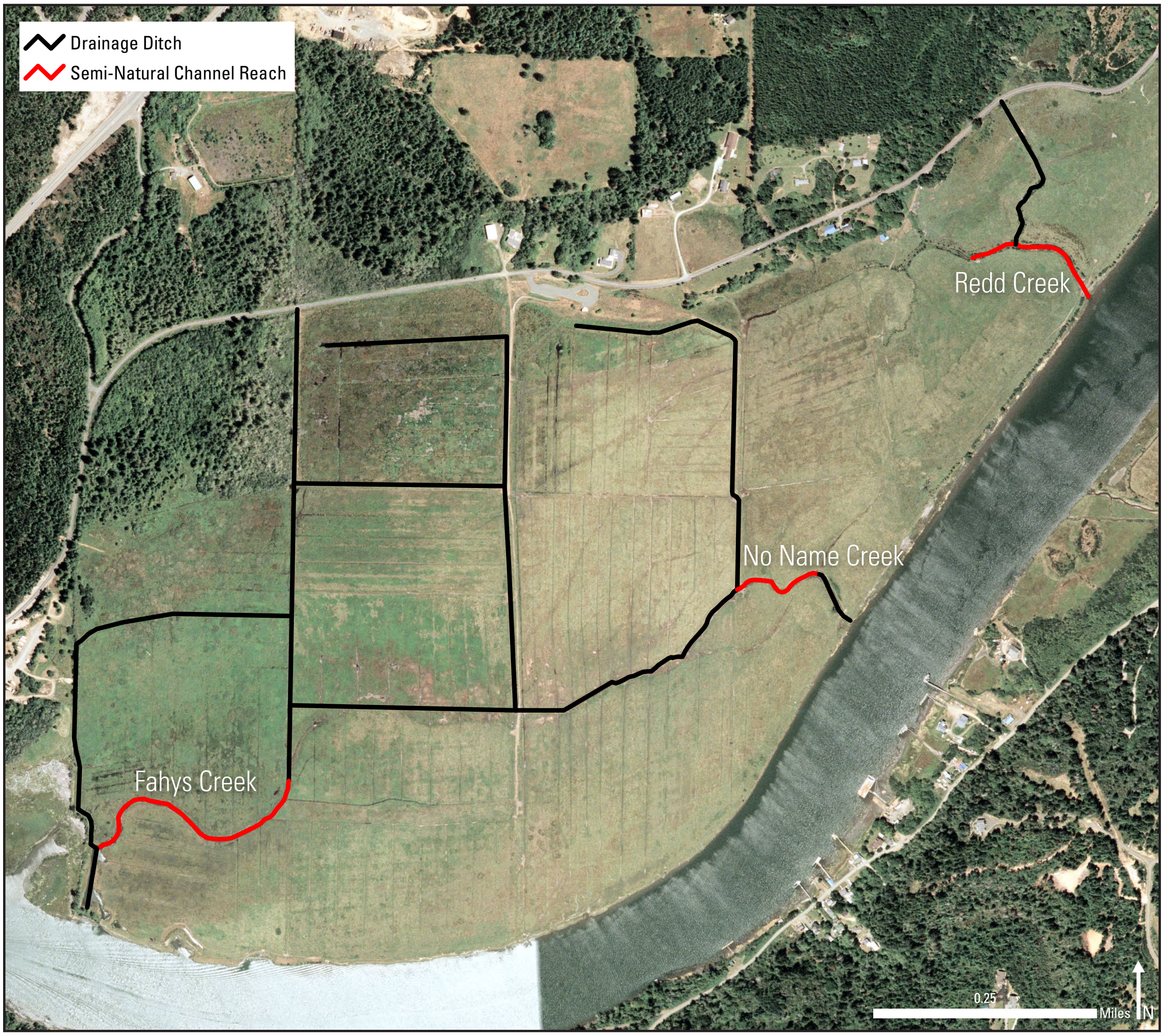
The only terrestrial vertebrates monitored systematically on the restoration site were birds. Mammal, reptile, and amphibian use is only known from anecdotal observations. The first assessment of bird use that compared the restoration site and the reference (Bandon Marsh) site occurred from October 2004 through November 2006 (Castelein and Lauten 2008). That study documented more species using the restoration site because of more forest and forest edge was included harboring species not using marsh habitat. There were fewer species and lower numbers of waterfowl and shorebirds using the restoration site than the reference marsh, as expected. Similar observations were made during systematic surveys conducted by Refuge staff during the two years before the tides were restored (Wishnek 2014).

No State or Federal threatened or endangered terrestrial species are known to use the Refuge. Mammals, reptiles, and amphibians that have been observed are all common and widespread species typical of the habitat types present. However, there were remarkable numbers of rough-skinned newts (*Taricha granulosa*) using the fresh water habitat of the drainage ditches (Figure 12) the summer of 2010, when well over 5000 were captured and relocated during salvage operations as the ditches were being filled. A complete discussion of the wildlife species occurring on the Refuge is in the Bandon Marsh NWR Comprehensive Conservation Plan (USFWS 2013).

Figure 11. Fahys Creek tide gate during mid-ebb tide in late spring, 2010

Brophy and van de Wetering (2012)

Figure 12. Waters available for fish use in early and late spring during the pre-restoration period



2.6 Cultural resources (adapted from USFWS and FHA 2009)

The restoration site is an important cultural resource area for the Coquille Indian Tribe and the Confederated Tribes of the Siletz Indians because it contains several recorded archaeological sites (Tveskov and Cohen 2007). Two of the sites are documented long-term occupation locations. Three sites have major midden components that may indicate occupation or food processing locations. The rest are single fish weirs or a complex of weirs in discrete locations. It is these weirs that are referred to in the Coquille name of the Refuge Unit: Ni-les'tun means "small dam in the river". This pattern and density of sites extends both up and down river from the Refuge (Byram and Shindruk 2010). Decades-long archaeological research performed by the Tribes, numerous educational institutions, the Service, the Bureau of Land Management, and others have documented the Tribes' occupation of this area and made it one of the most researched areas of pre-European history on the Oregon coast. Since the 1990s, the Service has been consulting with the Coquille Indian Tribe and the Confederated Tribe of the Siletz Indians to investigate, protect, and restore the cultural values and natural ecological processes along the shores of the lower Coquille River in the vicinity of the Refuge. Of these cultural resource sites, some are listed on the National Register of Historic Places.

The development of artificial dikes and water control structures over a century ago in the Ni-les'tun Unit to convert the tidal marsh to pasture has negatively impacted the site's archaeological resources. Dikes confine the river, resulting in increased water velocities that undercut and erode the adjacent river banks, slowly destroying the cultural sites. Also, by creating unnaturally dry conditions inside the dikes, the cultural artifacts decomposed more quickly due to increased exposure to oxygen.

3. Restoration Conceptual Approach

The goal of the restoration project was to recreate the conditions that would ultimately restore intertidal marsh habitat values and functions lost when the site was converted to pasture. Reintroduction of unrestricted tidal influence to the restoration site was the most important condition to restore, and the lack of a natural dendritic system of distributional tidal channels on the site presented formidable engineering challenges to the design team. Added to this were the other major changes that had occurred on site over the many decades of tidal muting, including soil compaction and subsidence, vegetation composition, and the infrastructure of ditches, utilities, irrigation systems, and roads. Some of these habitat conditions could be directly mitigated during the restoration construction process, some would repair themselves in a few years or decades after the tides returned, and others would be essentially permanent changes, perhaps taking many decades to mitigate, if ever. Added to the site conditions are the highly modified conditions of the watershed and region beyond the site boundaries that determine the ultimate potential for restored function, and are outside of the control of the Refuge or Service. Accepting these limitations, and the limits to resources available to implement the project, the restoration design team had to make a series of decisions about what was necessary to accomplish the goals, what could be done beyond what was necessary, and what could be reasonably foregone. The major design decisions and how they were decided are discussed in Section 5.3, and the consequences of those decisions are discussed in Section 8.

Integral to this project was the design of the efficacy monitoring program (see Section 7). This project offered an outstanding opportunity to track the effectiveness or failure of restoration actions, quantify ecosystem responses to restoration, guide adaptive management (if needed), and contribute to ongoing efforts to develop improved guidance for other tidal wetland restoration projects in the Pacific Northwest. The monitoring accomplished those goals and provided accountability for the project's substantial restoration investment.

4. Ancillary Projects

Local transportation and utility infrastructure would be directly affected by tidal restoration to the site, and had to be addressed before the tides returned. Simultaneous with the marsh restoration work, two related infrastructure projects facilitating the restoration were planned and implemented. A separate non-tidal stream relocation and riparian forest restoration was also part of the overall project. These are described briefly here, and the remainder of this report focuses on the tidal marsh restoration only.

4.1 North Bank Road improvements (adapted from USFWS and FHA 2009)

North Bank Lane is a two-lane county-owned road that bisects the Ni-les'tun Unit. The road is classified as a rural collector and provides access to local residences, businesses, Refuge headquarters, a Refuge scenic overlook, Coos County boat ramp, and other local roads. The road through the Refuge is a portion of the designated Bandon-Charleston State Scenic Tour Route. The need for improvements to North Bank Lane arose because the road flooded regularly and became impassable at Fahys and Redd creeks when high tides and river flood levels coincided, which would happen much more frequently post-restoration. The purpose of the improvements was to increase public safety by eliminating road flooding from high tide events, upgrade stream culverts to allow fish passage and meet current regulations and requirements, improve the pavement surface, and better accommodate the mixed (bicycle and vehicle) use of the roadway. In total, 3,550 feet of road were elevated from one to six feet, two large culverts were installed (for Fahys and Redd creeks), one pedestrian undercrossing was installed, a new entrance road to the Refuge Headquarters was constructed, two intersections were redesigned for greater safety, and 2.5 miles of road were repaved. Detailed plans for this project are in USFWS and FHA 2009.

4.2 Utility transmission line burial (adapted from USFWS and FHA 2009)

Two aerial electrical utility lines and associated series of poles crossed the Ni-les'tun Unit. One was a 25 kV transmission line owned by Coos-Curry Electric Cooperative (CCEC) that spanned the Coquille River and the eastern portion of the Refuge running generally north-south. The other was a set of smaller local transmission utility lines that paralleled North Bank Lane owned by Pacific Power. The stability of the utility poles, and maintenance access for the CCEC line would be compromised by the renewed tidal flooding of the utility right of way. CCEC required the Service to bury the lines and place a redundant series of lines underground to meet their infrastructure maintenance requirements. Burial of utility lines is desirable to eliminate collision risk for migrating and resident birds, because birds often fly into utility lines during periods of low visibility causing injury or death (NWCC 2001). In light of the goal of restoration to increase the number of migratory birds expected to use the Refuge, the most hazardous portions of the roadside lines were also buried.

4.3 Non-tidal riparian restoration

Complimentary to the restoration of the tidal portion of Fahys Creek was reparation of an upstream portion of that creek that had been diverted into a ditch during the construction of eleven acres of commercial cranberry bog. That property was donated to the Refuge in 2003 and was designated by the Service as the Anaflor Q. Smith tract of Bandon Marsh NWR. The project involved salvaging and stockpiling native wetland plants and topsoil, re-grading the cranberry bogs and excavation of a new channel for Fahys Creek through the site, installation of 20 large logs with root wads, placement of salmonid spawning gravel in the channel, redistributing the salvaged plants and soils, and redirecting the creek flow into the new channel. Well over 20,000 trees and shrubs were planted onsite over the following two winters to hasten the development of a native riparian habitat. An aerial electrical transmission line running through the middle of the project area was relocated to the edge of the floodplain.

5. Restoration Planning Process

5.1 The project team

The Service immediately recognized the need for a wide array of expertise to plan and execute a project of this size and complexity. In 2003, a refuge manager position for Bandon Marsh NWR and the southern coast portion of Oregon Islands NWR was first established, and tasked with organizing the restoration project planning, along with the Refuge biologist and project leader. Additional Service personnel with major roles included a GIS specialist who gathered and organized spatial data, an Ecological Services biologist who facilitated environmental permits, and a restoration biologist hired in 2009 and based in Bandon who facilitated planning meetings and coordinated and conducted field work.

The Service contracted or partnered with other critical personnel to join the design and planning team early in the process including: a Ducks Unlimited (DU) wetlands engineer and surveyor, a fisheries biologist with the Confederated Tribes of the Siletz, a consultant (PBS&J) to prepare permits and NEPA documents, an archaeological consulting firm (Byram Archaeological Consulting, LLC) to oversee and conduct cultural resource preservation and monitoring, and the Coquille Watershed Association to provide labor for removal of agricultural infrastructure (e.g., fencing).

Other major partners who had input to the restoration planning and design process included the Confederated Tribes of the Siletz Indians, Coquille Indian Tribe, Oregon Department of Fish and Wildlife (ODFW), U.S. Army Corps of Engineers (ACOE), the State Historic Preservation Office (SHPO), and National Marine Fisheries Service (NMFS). Due to the projects associated with the marsh restoration (road improvement, utilities relocation), planning and restoration construction work was closely coordinated with the Federal Highway Administration, Oregon Department of Transportation, Coos County Roads Department, Coos-Curry Electric Cooperative, Pacific Power, Oregon Department of State Lands (DSL), Oregon Department of Environmental Quality (DEQ), and U.S. Forest Service. Major stakeholders who were kept informed about the project included the Coos County Commissioners, City of Bandon, Port of Bandon, Coquille Watershed Association, and The Nature Conservancy. In addition, a number of highly dedicated local, regional and nationally recruited volunteers assisted with pre-, during, and post-restoration efforts. A complete list of organizations and agencies with permitting or consultation requirements for all aspects of the project is in Table 6.

Table 6. Organizations with permitting or consultation requirements

Organization	Permit or Required Consultation
Confederated Tribes of the Siletz Indians	Consultation on impacts to cultural resources
Coos County Commissioners	Project Consultation
Coos County Planning Department	Land Use Consistency Determination
Coos-Curry Electric Cooperative	Approval of powerline burial
Coquille Indian Tribe	Consultation on impacts to cultural resources
Coquille Watershed Association	Project Consultation
National Marine Fisheries Service	Endangered Species Act Section 7 Consultation
OR Dept. of Land Conservation and Development	Coastal Zone Certification and Utility Easement
OR State Historic Preservation Office	Consultation on potential impacts to historic features
OR Dept. of Environmental Quality	Clean Water Act: Section 401 Certification and Section 402 National Polution Discharge Elimination System Permit
OR Dept. of State Lands	Removal-Fill Permit
U.S. Army Corps of Engineers	Clean Water Act Section 404 Permit Rivers and Harbors Act Section 10 Permit
USFWS Ecological Services Division	Endangered Species Act Section 7 Consultation
USFWS Refuges Division	Road ROW Issuance
Verizon Telephone/ Pacific Power and Electric	Utilities relocation

5.2 Planning and preparation

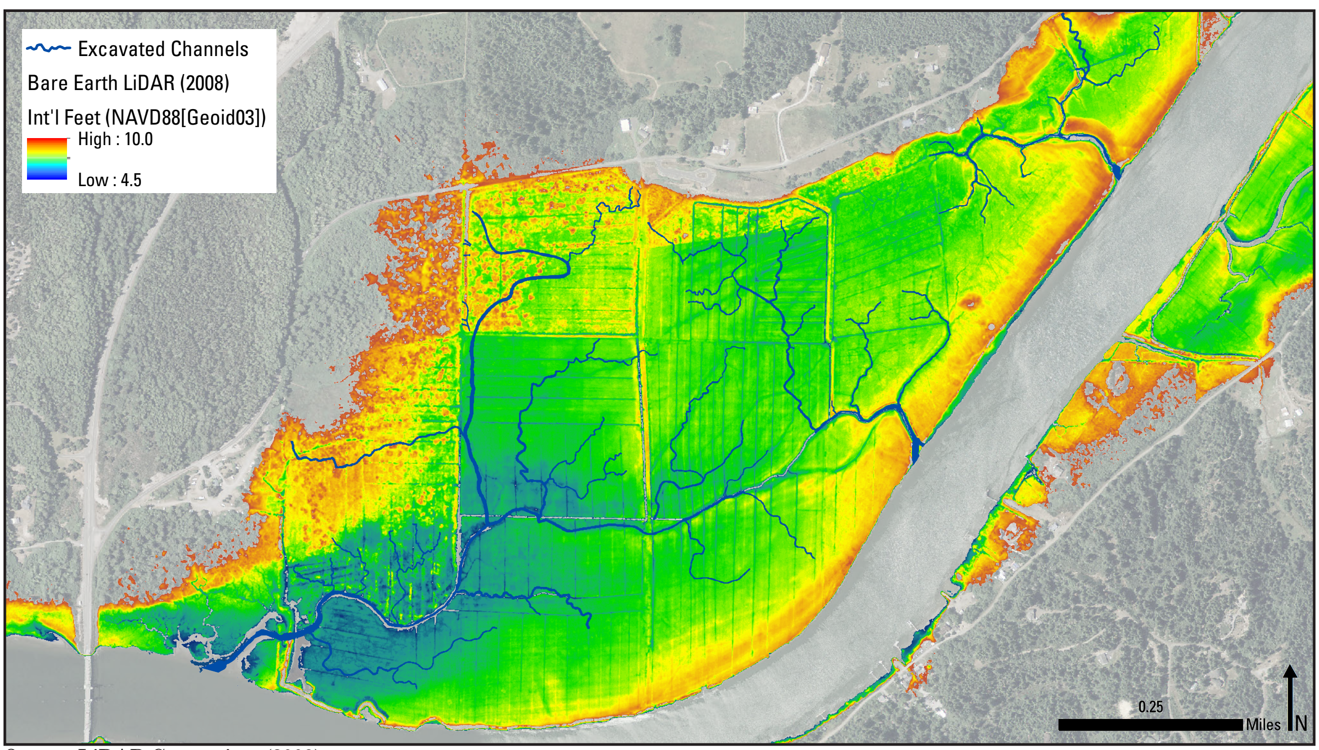
In the years leading up to the restoration construction, efforts were focused on gathering baseline data and information needed for the design and engineering of the project by DU, and preparing the site for the ground work. Table 7 lists the major preparatory events and when they occurred prior to the 2010 construction season. Information needed for designing the new channel system included tide level data from the adjacent river to compare to predicted tides, a detailed topographic map of the site, and locations of known archaeological and historical sites. The DU engineer installed water level loggers inside and outside of the dike to collect the tidal data, and a Light Detection and Ranging (LiDAR) produced topographical map (Figure 13) was produced and extensively ground-truthed by DU surveyors who also established an extensive system of elevation benchmarks throughout the site using Trimble Total Station surveying equipment. Ground-truthing revealed that the LiDAR data over-estimated the elevation by as much as 18 inches in areas dominated by dense sedge in spite of post-processing designed to correct for false elevation data.

Site preparation involved removing fencing and other structures, and improving conditions for the operation of heavy earth-moving equipment during the construction phase of the project. Cattle grazing was maintained on the site after acquisition by the Service in accordance with a Cooperative Land Management Agreement in order to keep the vegetation height low until the summer of 2009 when obliteration of the small ditches and trial excavation of several tidal channel segments occurred. This trial demonstrated that the planned excavation process was feasible, and helped estimate the time it would take to complete the project. Nearly 26 miles of fencing and gates were removed, much of which was salvaged for re-use by the Coquille Watershed Association. In order to dry the site out as much as possible to improve soil moisture conditions that would support of heavy equipment, tide gates were repaired and larger ditches were cleaned out to improve their drainage function.

Also integral to pre-restoration planning was the timely submission of all permit applications and completion of consultations with regulatory agencies and partners so all necessary approvals were in hand by the time the groundwork began. Most submissions occurred at least one year in advance. In compliance with the National Environmental Policy Act (NEPA), an environmental assessment (EA) of the restoration, powerline burial, and road project was prepared and completed in June 2009 (USFWS and FHWA 2009).

Well before the restoration would occur, it was necessary to plan the efficacy monitoring program and begin collecting baseline (pre-restoration) data. The program called for monitoring to begin two years before the earthwork began and tides were restored. An overview of the monitoring program is presented in Section 7 below.

Figure 13. Pre-restoration (2009) LiDAR elevation map of the restoration site
Note how the newly excavated channels (blue) were designed to extend from the low-lying (green) areas to one of the three outlets to the river and form three sub-basins with separate dendritic channel systems. The small ditches built by the ranchers to drain water to the larger ditches are clearly depicted in the pre-restoration LiDAR.



Oregon LiDAR Consortium (2009)

Table 7. Timing of major planning and preparation events leading up to restoration construction

There was some preliminary survey, biological monitoring, and archaeological work done before 2003 by various partners.

Event	2003	2004	2005	2006	2007	2008	Before June 2009	After June 2009	Before June 2010
1. Contract with Green Point Consulting and Siletz Tribe to develop monitoring plan	X								
2. Completed acquisition of restoration site		X							
3. Lease grazing rights to control vegetation		X	X	X	X	X	X		
4. Ground penetrating radar and geocoring study to locate historic channels and cultural resources			X						
5. Contract with Ducks Unlimited to begin conceptual plan and collect baseline data					X				
6. Model coastal marshes for channel design						X			
7. Initiate planning and design of North Bank Lane improvements						X			
8. Initate planning and design of CCEC powerline burial						X			
9. Initiate pre-restoration ecological monitoring						X			
10. Begin preparing restoration Environmental Assessment (EA)						X			
11. Repair tidegates; clean drainage ditches						X			
12. Consult with Tribes (CIT, CTSI)						X	X		
13. Consult with State Historic Preservation Office							X		
14. Apply for U.S. Army COE permit							X		
15. Complete conceptual plan							X		
16. Complete restoration EA							X		
17. ESA Section 7 consultation with NMFS							X		
18. Obtain OR Dept. of State Lands removal/fill permit							X		
19. Obtain OR Dept. of Env. Quality discharge permit							X		
20. Obtain County Planning land use consistency approval							X		
21. Consult with Coos County Commissioners							X		
22. Remove cattle and fences							X		
23. Conduct trial channel excavation								X	
24. Complete Engineering Plan; release contractor RFP									X

CCEC – Coos Curry Electric Cooperative, CIT – Coquille Indian Tribe, CTSI – Confederated Tribes of the Siletz Indians, COE – Corps of Engineers, ESA – Endangered Species Act, NMFS – National Marine Fisheries Service, RFP – Request for Proposals

5.3 Major design decisions

Due to the myriad landscape-scale (e.g. tectonic uplift, river hydrologic regime) and local (e.g. soil compaction and subsidence, obliteration of tidal channels) changes affecting the site since it was first converted to agricultural uses, it was not possible to actually restore the site to its former ecological state. The restoration team had to establish project goals that acknowledged these biological, topographical, and cultural constraints to achieving full restoration, but maximized the likelihood that the site would achieve its ecological potential to restore natural functions of a riverine tidal marsh in this location. Clearly this would require restoring a natural tidal regime to the site as the major ecological driver, but a series of design decisions needed to be taken about exactly what was necessary and sufficient to accomplish that and other goals with the financial and other resources available. This project was also occurring in the context of the developing science and practice of tidal marsh restoration in the Pacific Northwest, and due to its size and scope it presented a unique opportunity to test concepts and methods to inform planners of future projects. Finally, the team had to consider legal and regulatory constraints resulting from the presence of important biological and cultural resources on and near the site. Following is a discussion of the major project design decisions and the rationales for making them.

Tidal channel system

Critical to tidal marsh function is unobstructed tidal exchange with each tide cycle. In natural marshes this is facilitated by an extensive dendritic system of channels that have formed largely through marsh table accretion, and that are sized based on equilibration between erosive forces of the highest tidal velocities and the resistance of the soils and vegetation to those forces (Williams et al. 2002). The historic channel system of the site had been mostly replaced by approximately 15 miles of rectilinear drainage ditches ranging from swales or shallow ditches less than one foot deep, to large ditches 5 feet deep by 8 feet wide with adjacent elevated spoil banks (Figure 5); all ultimately leading to three tide gates in the river dike. The design alternatives considered were to:

1) Leave the ditches to serve as the tidal distribution system;
2) Re-grade the entire site to eliminate all ditches and excavate a new channel system;
3) Fill the large ditches and replace them with excavated higher order sinuous channels, but leave the small ditches unmodified; or
4) Fill the large ditches and replace them with excavated higher order sinuous channels, and disrupt small ditches by discing and minor grading

Alternative 1 was dismissed because it was believed that the rectilinear ditch system would not result in the channel morphological complexity (e.g. thalweg development, variation in benthic sediment characteristics, refugia pool development) necessary for high quality fish habitat found in sinuous channels, and, given the low erosive forces of the tides on this relatively flat site, it may have taken decades or longer for more sinuous channels to develop. It was therefore decided to fill all the larger ditches, but the small, parallel ditches throughout the site (see Figures 5 and 13) were too extensive to fill, and presented a separate decision addressed in alternatives 3 and 4.

Alternative 2 had the appeal of creating a "blank slate" on which to design a new channel system, but would have required replacement of native salt marsh species on the site before allowing the tides to inundate it, and the large amount of earth moving would have been prohibitively expensive.

Alternative 4 was chosen over alternative 3 because the team believed the extensive system of small ditches would potentially "short circuit" flows in the newly excavated system and result in a more rectilinear channel configuration than desirable. Therefore, the decision was taken to mow and disc 20 foot swaths centered on the ditches to roughen the surface (Figure 14), and move soil into the ditches. Later, it was decided to also construct small berms perpendicular to the ditches to disrupt their linearity and drainage function. The excavated channel system was limited to higher (third or higher) order sizes because material excavated from those plus material generated from dike removal would approximate the volume of material needed to fill the large ditches. Also, natural tidal marshes typically have several times more length of small (first and second order) channels than larger channels, and the cost of digging small channels and moving excess spoils off-site was prohibitive. The team predicted that the construction of the larger order channels would result in eventual development of the small channels through erosive processes.

Once the decision to construct a new channel system was made, the next questions were how extensive it should be, how it should be configured on the landscape, and what should channel cross-sectional dimensions be. To provide design guidance, there was an attempt in 2005 by a team of archaeologists and geologists to locate historic tidal channels and potential cultural sites that had been obliterated and replaced by the drainage ditch system. They analyzed aerial photos, deployed ground penetrating radar, and collected numerous shallow and deep soil core samples. Although some portions of buried channels were found using these methods, they were not sufficient to allow reconstruction of the historic system's configuration. Therefore, a morphometric study of four intact tide marshes on the Oregon coast was conducted to produce a spatial model of channel dimensions, densities, and sinuosities appropriate for the restoration site, given its size, elevation, and the tidal range to which it would be subjected (So et al. 2009). The ultimate design of the new channel system was based on a template of configuration and dimensions of larger order channels derived from that study (Table 8). However, to avoid constructing channels that might be larger than necessary for their function, and as a cost saving measure, channels would be dug one stream order size smaller than the model indicated for their respective locations within the system. This permitted more linear feet of channel to be constructed and required no excavated material to be removed from the site for the same cost, thus resulting in a more extensive system. It was expected that the channel dimensions would adjust as necessary to accommodate the maximum flows that would occur in a given reach.

Based on the results of site topographical surveys three sub-basins were delineated, each with its channel system uniquely connected to the river mainstem at existing tide gates (Figure 13). Since the new channels would generally follow existing topographical gradients, and to save costs, it was decided that the depths of the new channels would be measured from in situ surface grades as they were being dug, rather than using absolute grade control based on a known benchmark (Figure 15). The smallest sub-basin in area was the Redd Creek drainage in the eastern end of the site, which also had the most intact original channel system, and would therefore require only one constructed tributary and relocation of a portion of the creek's streambed that had been ditched. The central sub-basin without a named creek flowing from the upland was dubbed No Name, and would require all new channels except for the remnant natural channel at the lower end of the system. The largest sub-basin on the west end of the site would require relocation of about 2,800 feet of ditched Fahys Creek, and an extensive new channel system. Fahys Creek had been diverted from its historical mouth outside the diked area into a tide gate to the east, and it was decided to restore the flow to its historical confluence with the Coquille River.

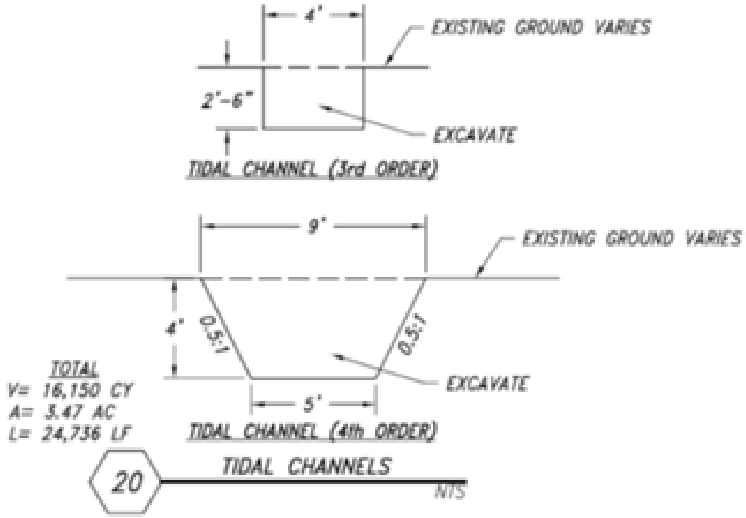
Figure 14. Mowing and discing treatment of the restoration site
Treatment of the many small ditches throughout the site involved mowing vegetation, ripping the soil surface and vegetation mat with a ripper on a bulldozer, and discing the top 8 to 12 inches with pulled disc mounted on a tracked farm tractor. The intent was for the broken soil to be pushed into and disrupt the small ditches, but this did not occur to a sufficient degree. Subsequently, small berms were bulldozed across the ditches to further disrupt their function.

Table 8. Tidal channel parameters used to design the new channel system, derived from a channel morphometric study of undisturbed marshes on the Oregon coast
Only third order channels and larger were excavated.

Channel Order	Drainage (Acres)	Width (Feet)	Depth (Feet)	Sinuosity (Length/ Distance)
1		1	0.7	1.1
2		2	1.6	1.15
3	1.6	4	2.5	1.38
4	6	9	3.8	1.45
5	24	22	4.9	1.92
6	25	60	5.9	1.46

So et al. (2009)

Figure 15. Contractor specifications for excavating third and fourth order channels



Levee modification

The natural levee along the north bank of the Coquille River, formed by sediment deposition during overbank flows, had been widened and raised up to 3.5 feet higher by previous landowners to keep the land dry during all but the most extreme floods of some years. Soil profiles exposed by erosion on the river side of the dikes clearly showed the extent of artificial fill on top of native soil (except near the Redd Creek sub-basin where soil profiles were difficult to interpret), and also revealed extensive historic and pre-historic cultural deposits left by early European settlers and Native Americans. Removal of tide gates would result in breaches through which most tides could flow with minimal restriction, but restoration of historic levee height would provide full historic equilibration between the marsh and river flooding regimes. Two major factors limited how much of the levee would be restored: (1) the volume of material available from dikes that was needed for fill within the project site (since transporting material from off-site was cost-prohibitive), and (2) the requirement to leave the cultural deposits undisturbed by maintaining at least a six-inch cap of soil above them. The decision was made to focus dike removal around the mouths of Fahys and No Name creeks to allow for maximum sheet flow during flood events at the lowest elevations of the marsh table in the respective sub-basin. River bank erosion had already removed some of the highest elevation natural levee in these areas, so the six-inch cap actually left the dike less than six inches higher than the historic levee elevation. Dike removal to the lowest elevation (near marsh table elevation) occurred at lower Fahys Creek where there was a section of dike not overlaying historic levee with cultural resources present.

Existing sections of artificial dike along the east and west boundaries of the site were elevated to restrict restored tidal flows from reaching adjacent private land. In addition, a check valve on a culvert under the west dike was installed to allow a drainage ditch servicing the adjacent property to function during low tides.

Large woody debris (LWD) placement

In order to create channel bottom habitat complexity for benthic invertebrates and fish, and to simulate natural tidal marsh channels in the Pacific Northwest that commonly include embedded wood, the restoration design team decided to include installation of tree trunks (Large Woody Debris; LWD) into the new channel system. The primary logs would be between 18 and 36 inches diameter at the base, 40 feet long, have a trimmed root wad attached, but stripped of all branches. Additional logs without root wads were used to anchor the primary logs in place. Keeping LWD in place in tidal channels where they are subject to regular submersion and reversing currents presents an engineering challenge, especially without using mechanical anchors.

The technical decisions about location and configuration of LWD were primarily the responsibility of the team's fish biologist who had experience installing LWD in tidal marshes, but recognized the need for more information about their habitat value and installation methods. In previous tidal marsh projects on the Oregon coast, two approaches had been used. The first occurred in smaller tidal marsh channels in the Siletz Estuary. This approached utilized local spruce with large root masses left in place and branches cut to a length of six feet. The majority of these whole trees were too heavy to transport via the only method possible (helicopter) and therefore root masses with short stems or stems only were used. Six years later during the Ni-les'tun planning effort, retention of these LWD was very high. The second approach was taken at the USFWS restoration site in the Little Nestucca Estuary in 2007. In this case, only smaller trees were available with no branches and limited root masses, and placement was done with heavy equipment that had limited access to the site. Two kinds of structures were used: multiple logs bolted together to form a floating structure that could rotate around an anchoring piling located in the center of the structure; and a single log chained to a piling driven into the channel bottom. At

Ni-les'tun, similar to earlier restoration sites, LWD was intended to form scour holes to provide low tide refugia to aquatic species. Due to a lack of trees with larger root masses and branches attached it was not possible to replicate the approach taken in the Siletz Estuary. In order to create scour holes, bars, increase channel sinuosity and to provide a more natural appearance than the vertical elements of the Little Nestucca structures, the team decided to anchor the LWD in the channels by driving the top ends into the channel banks with large excavators, or pinning them in place with smaller logs, or both.

Other design decisions included how many logs to install in what configurations, where to install them, and whether the heavy equipment could access all portions of the channel network. Important factors included local availability and associated costs of procuring, transporting, and installing the logs. The large size of this project presented the opportunity to test the habitat value of LWD placement. This was accomplished by creating experimental units of paired 100 m (330 feet) reaches of LWD clusters and reaches with no LWD in each sub-basin (Figure 16). This configuration would facilitate rigorous comparisons of fish use of the reaches with and without LWD. Ultimately, 131 logs plus 210 pin logs were installed in 18 reaches. Most LWD were located in the lower reaches of each drainage that would contain water during most low tides, and were therefore potential fish refugia. Details about how the LWD installation was conducted, and logistical issues that arose, are given in Section 6.8 below.

Riverbank pilings and rip-rap

With the intent of removing artificial structures that interfered with natural riverbank dynamics, the team considered removal of the scores of old wooden pilings that exist just outside of the river dikes. These are remnants of historic logging and cannery piers and other structures and are gradually decomposing. Due to additional permitting requirements related to historical preservation, jurisdictional issues (most of the pilings are on State land), the potential for pollution from creosote or other chemical releases from disturbing and disposing of the pilings, and the logistical difficulties associated with reaching them all from land, the team decided to leave them in place. There were similar concerns about removing rip-rap from places along the dike where it had been used for reinforcement and repair, but the likelihood of disturbing cultural sites and costs associated with its disposal were great enough to decide to leave that in place as well.

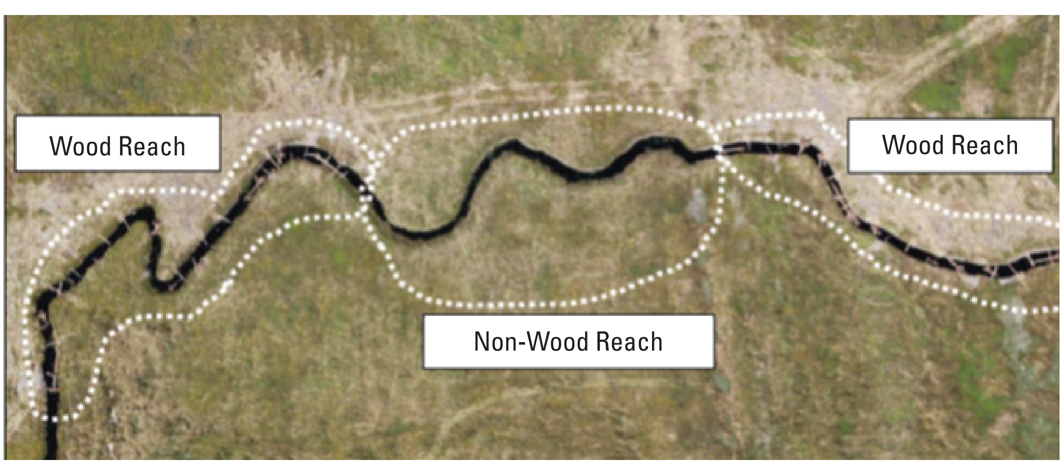
Re-vegetation of disturbed areas

Based on experimental seeding of soils disturbed during the 2009 small ditch discing and grading process, it became clear that there was an abundant natural seed bank present throughout the site. The 2009 experiment involved spreading native plant seeds on some disturbed areas, while leaving others as control (unseeded) areas. By the following spring, all areas were well vegetated, with no apparent differences in plant cover establishment. The combination of the seed bank, the presence on site of native tidal marsh species that were expected to dominate the restored marsh (see Section 2.4, Vegetation), and the plant propagule transport function of the new tidal regime, the team decided it was unnecessary to re-vegetate areas disturbed by the restoration construction. The expected low velocities of the tidal flow over the marsh table were deemed unlikely to result in significant erosion of bare soils before they would become naturally vegetated by early successional species such as *Atriplex* and *Cotula*. In the longer term, the plant community was expected to shift in response to the new inundation and salinity regimes that became established at each location within the marsh.

There were three exceptions to the decision not to re-plant the restoration site: (1) the upland equipment staging and access areas used by the excavation contractor, (2) new fill on enhanced east and west

Figure 16. Aerial view of an excavated channel showing the alternating reaches with and without LWD installed

Fish use of a LWD reach was compared to adjacent reaches without LWD to evaluate the habitat value of the LWD.



dikes, and (3) some upper marsh areas adjacent to the existing woodland that would be affected by the highest tides, and were historically tidal spruce swamp. The staging areas and dikes were seeded with a mixture of native grasses (see Section 6.9, Site repair). The potential tidal swamp areas (with ground elevations between 9.1 and 12 feet (NAVD 88) were dominated by thick sedges and grasses that severely inhibit natural woody plant establishment, so it was decided to plant a mix of native trees and shrubs in those areas to restore the woodland (Figure 17). Details of these woody plantings are given in Section 6.10, below.

Construction process considerations

Once all the design decisions were made, which defined the actual tasks that needed to happen to accomplish the restoration goals, the project team had to consider the logistics, constraints, and procedures that would determine how the tasks would be completed. The list of these considerations was developed by the design engineer, who would also be the construction supervisor overseeing the contractor, and each of these items would be addressed in the technical specifications comprising the bulk of the construction contract. Table 9 summarizes these considerations, and outlines the specifications that address them, or the logistical response. Details are presented in Appendix A, which contains the complete Project Technical Specifications, and Appendix B containing the Cultural Artifact Discovery Protocols.

The final construction plan (Figures 18 and 19) called for excavation of approximately 5 miles of new tidal channels, the filling of approximately 5 miles of large ditches, lowering of 5,400 linear feet of dike, removal of 3 tide gates, enhancement of 1,100 linear feet of dike, decommission of 0.5 miles of road, and installation of 131 large logs in channels.

Figure 17. Map of potential revegetation zones

The red outline defines the area within which small ditch discing occurred, and was considered for replanting with native tide marsh plant seed. The blue shading indicates areas at elevations (9.1–12 feet, NAVD 88) where wetland woody plants such as willow and spruce could be planted to facilitate shrub-scrub and forested tidal wetland restoration.

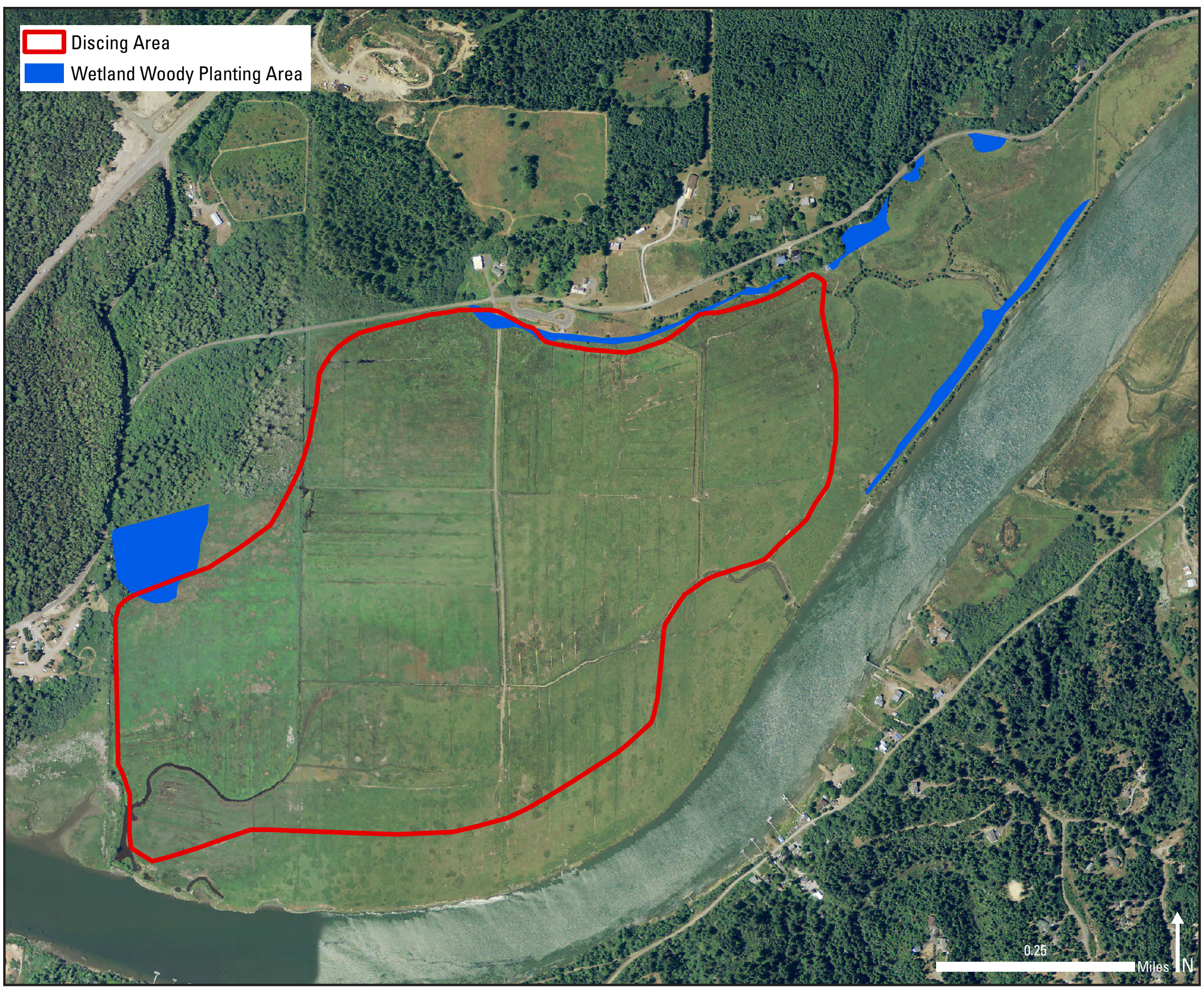


Table 9. Restoration construction-related considerations that needed to be addressed before construction commenced and how they were addressed

Item	Action/Specification
Excavation contractor selection	Complete bid package (construction drawings, specifications, submittal rules) by late April for mid-July start date; send to list of local and regional companies with appropriate capabilities.
Soft soils/stream crossing access for heavy equipment	Specify low ground pressure equipment; contractor responsibility to plan haul roads and temporary crossings for approval, and to decommission/repair significant damage.
Balance and transport of cut and fill material	Engineer calculated volumes to achieve balance; contractor provides enough equipment to handle volumes and transport distances
In-water work window	July 15 through September 15, as determined by NMFS due to presence of listed fish species (coho); includes all work directly affecting fish-bearing waters
Sediment and erosion control	Turbid water release only during in-coming tide; work in the dry whenever possible; seed and mulch disturbed upland areas
Tide intrusion	Maintain tide gates on streams; remove dike incrementally during low high tide cycle; install temporary tide gate on Fahys Creek during mouth relocation
Continuity of stream flows during channel relocation	Divert water into new channels only when excavation is complete
Biological salvage from ditches and abandoned stream channels (salmonids and other aquatic animals)	Contractor must notify manager before filling fish waters or diverting flows; biologist works to remove fish before filling/draining, and is present to capture aquatic animals appearing during activities; stream diversions scheduled during water temperatures above salmonid tolerance
Marsh table damage and repair	Equipment operators avoid soft soils; haul roads abandoned if ruts develop; contractor required to repair surface damage
Cultural resource preservation	All excavation in native soils monitored by archeaologist or trained representative; established protocol for response to artifact discovery, including stopped work, documentation, and redirected digging

Figure 18. Overview of the final restoration construction plan by Ducks Unlimited

The configuration shown of the new channels is conceptual; the actual final layout is shown in Figure 19.

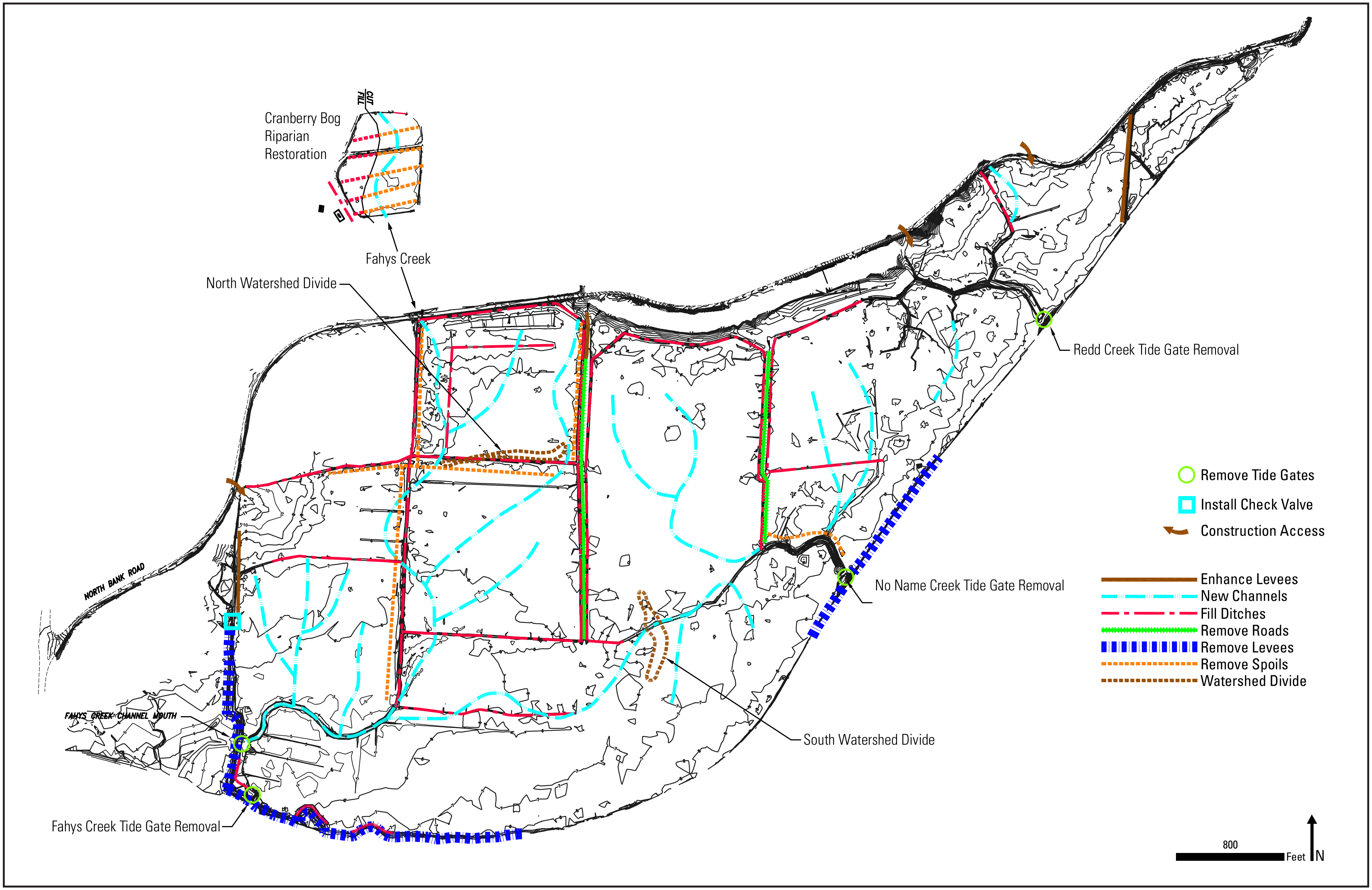
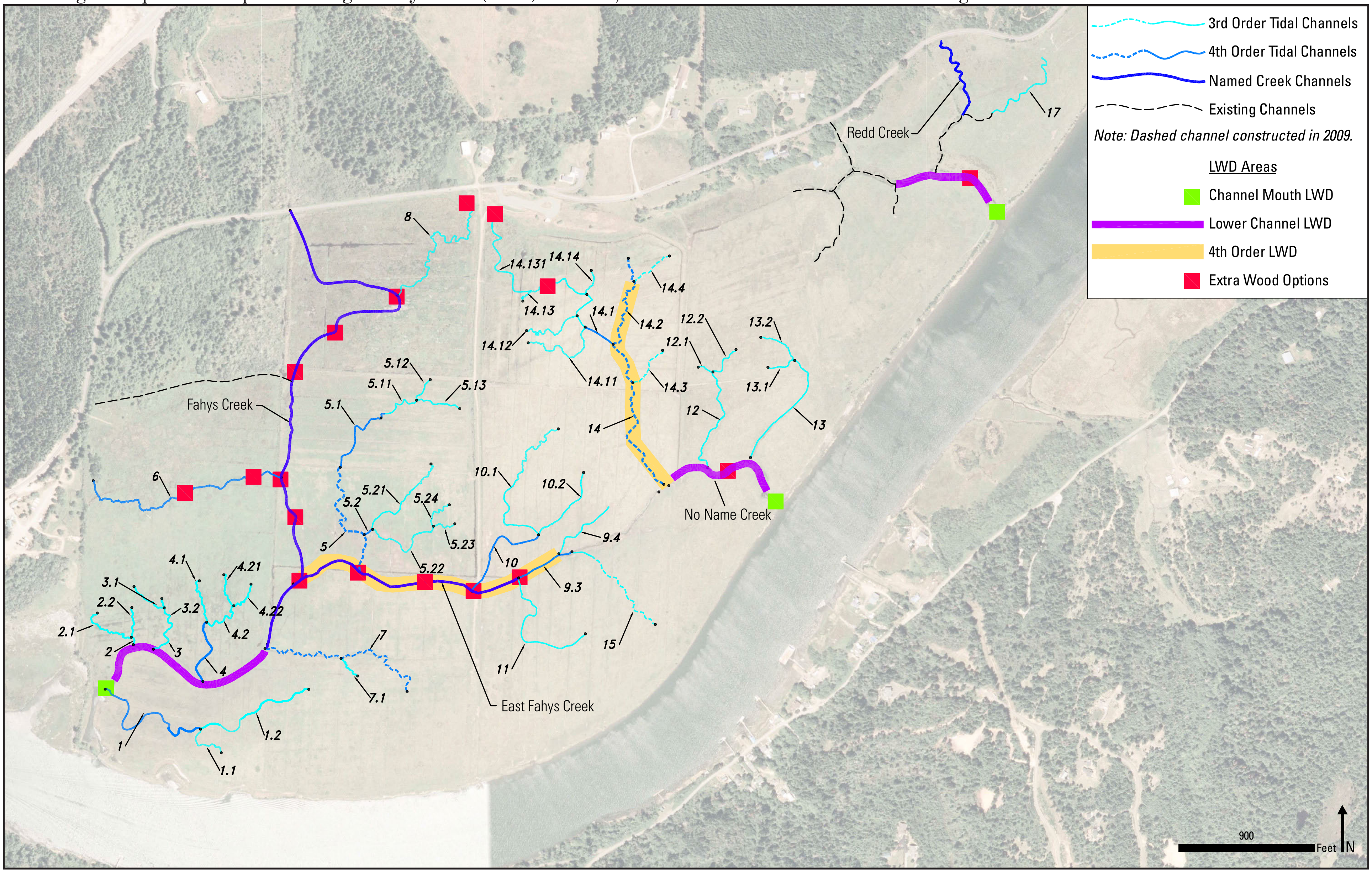


Figure 19. The new tidal channel system, as built, showing incorporated pre-existing channels, relocated stream channels, and excavated distributional channels with number labels

Red and green squares were potential large woody debris (LWD) locations; actual LWD installations are shown in Figure 32.



6. Restoration Construction

Management of restoration construction and contracts was performed by Ducks Unlimited. An on-site pre-bid meeting for potential contractors was held on May 13, 2010. A total of 14 contractor representatives attended the mandatory pre-bid meeting. Five companies submitted formal bids for the restoration construction contract, which was awarded to Knife River Corporation's Coos Bay office (KR) who submitted the lowest bid, and demonstrated that they had the necessary resources and experience to do the job. They submitted a detailed schedule of work (Appendix C) containing all the construction items mentioned in the Engineering Plans and Specifications. Prior to the KR arrival, the DU engineer and surveyor began staking out the channel locations, staging areas, locations of monitoring stations, and other field markers to direct the construction operations. KR mobilized two crews to operate two large excavators, two bulldozers, and several dump trucks in early July 2010. During a pre-construction meeting on-site between the contractor's project manager and foreman, DU project manager, and Refuge staff, operational procedures and specifications were reviewed, including orientation to the site features, worker safety and environmental protection practices, notification procedures for tasks involving coordination with archaeological monitors and biological salvage personnel, and coordination with the other contractors working on ancillary projects (road improvements and utilities relocation) on the Refuge.

6.1 Unplanned delay

The original plan was to complete the restoration construction in 2010, but multiple delays in the burial of the CCEC electrical transmission line crossing the floodplain and bisecting the restoration site resulted in missing the annual low high tide series in late August, when the staged lowering of the dikes needed to occur. As this window approached and it became clear that dike removal would not happen this season, the remaining time was focused on completing all interior earth work in preparation for dike removal in 2011. While this was somewhat anticlimactic to the team anxious to see the tides return to the marsh, it actually permitted time to consider adjustments to the channel plan, allow disturbed areas to stabilize before inundation, and to obtain and install additional LWD. It did result in additional mobilization and de-mobilization charges from the contractor, but fortunately, not beyond the contingency funds in the budget.

6.2 Major ditch filling and channel excavation

Material used to fill the large drainage ditches came partly from existing spoil piles adjacent to the ditches, but mostly from soils excavated from new channel construction. Due to concerns about trapping or burying fish and other aquatic animals present in the ditches (see Section 6.3, Fish salvage operation), filling started at the top of each drainage, and proceeded downstream to permit the water and its occupants to be pushed ahead of the fill. Trucked-in fill was dumped on dry soils and pushed into the ditch with the bulldozer in lifts that resulted in better compaction and less subsidence later (Figure 20).

Some of the larger ditches contained several inches of very fluid muck at their bottoms which would flow ahead of the fill and accumulate. In some cases, to avoid pushing this muck into flowing streams containing fish, or to prevent it from becoming incorporated into the fill, the muck was removed with an excavator and spread on the marsh surface to de-water.

The sequence of channel digging locations was designed to minimize the distance the spoils would have to be trucked to where it was needed, and to avoid building channels where they would obstruct hauling traffic. Several culverts were temporarily installed at strategic locations to allow equipment traffic over channels. Over most of the site, the ground was firm enough to support the rubber-tired dump trucks without extensive rutting, although repeated use of the same route would eventually rut even the drier areas, and on several occasions trucks became mired in soft soils. In the wettest areas, mostly in the western quarter of the site, the required use of tracked dump trucks with smaller load capacities than the rubber-tired trucks slowed the rate of transport and digging.

Channels were kept isolated from standing or flowing water whenever possible by delaying any connections to streams or water-filled ditches until all other portions of the channels were completed. The resulting "dry" digging conditions (Figure 21) greatly facilitated maintenance of channel specifications, speed of excavation, visibility for cultural monitoring, and the supply of minimal saturated material for ditch filling. Channel plugs that were used for this purpose were ultimately removed on an incoming tide to allow filtration and settling of sediments before water returned downstream.

Figure 20. Large ditch filling
Large ditches were filled continuously from the top of the drainage downward with adjacent spoils, or fill trucked in from channel excavation (*left*). Fill was pushed in with the bulldozer (*right*) for greater compaction, and to permit the water in the ditch to flow unimpeded toward the outlet.

Figure 21. Excavation of a fourth order channel
The excavator followed a path flagged by the project engineer. The spoils were loaded directly into a truck and transported to fill locations. A contractor worker (*white hat*) monitored the channel width and depth, and an archaeology monitor (*yellow hat*) kept watch for exposed cultural artifacts.

6.3 Fish salvage operation

Most of the agricultural ditches, and all of the channelized stream beds contained native fish and amphibian species that were jeopardized by ditch filling and dewatering as drainages were shifted to the new channels. These fish species included coho and chinook salmon, coastal cutthroat trout, and several non-game species. With the guidance and cooperation of ODFW and Confederated Tribes of the Siletz Indians staff, Refuge personnel undertook an intensive salvage operation to remove and relocate aquatic vertebrates from ditches and channels slated for filling before and during the filling process. This salvage effort was conducted under the conditions specified by an ACOE permit (#NWP-2008-146/1), and an ODFW Scientific Taking Permit (#15084).

Our overall salvage strategy was to locate fish in harm's way, capture and relocate as many animals as possible before filling or dewatering occurred, and closely monitor during disturbance to capture animals remaining in harm's way.

Approximately two weeks prior to restoration earth moving operations, a survey was conducted using seine nets and hoop net traps to determine where fish, especially salmonids, were located within the areas to be affected. Removal of fish from the ditches that were scheduled to be filled first began a week before construction started. Where feasible, seine nets were used to drive fish downstream to channels that would not be filled, and then screen barriers were installed to prevent re-entry. Otherwise, hoop net traps were set overnight for several nights at each site to capture fish that would be relocated to the main channel of Coquille River, or other suitable release sites nearby. Very poor visibility in most of the ditches due to vegetation, tannic water, and fine sediments precluded electrofishing to remove fish except in two situation: fish that became isolated during stream diversion associated with installation of a new road culvert on Fahys Creek, and before and after dewatering of an 800 foot section of Fahys Creek north of North Bank Lane.

With the close cooperation of KR equipment operators, all ditches were filled by pushing fill into the upper ends of the ditches, and proceeding to push fill downward while allowing fish to swim downstream to refugia below the fills. During the filling process, salvage personnel monitored the disturbed water ahead of the fill, and captured any stressed or stranded fish and amphibians with dip nets. Captured animals were regularly transferred from buckets to coolers containing cool, aerated water for holding until release. As required by the salvage permit, all salmonids handled during this process, and mortalities of coho salmon that occurred were tallied and recorded. Captured non-native fish were euthanized.

Table 10 summarizes the numbers of fish and amphibians captured and released in each of the three drainages flowing through the restoration site between July 9 and September 21, 2010. Careful records were kept of all salmonids handled, but numbers of non-game fish and amphibians are definitely underestimates. Non-native bullfrogs (*Rana catesbeiana*) are not listed but were also observed, but not salvaged.

Seven of the 10 coho mortalities occurred during the dewatering and filling of 2,700 feet of channelized Fahys Creek, which happened in one day (August 26, 2010). The ditch below the filling was constantly monitored, and live fish were captured as they were observed. Five of those mortalities happen within a few minutes at the end of the day when temperatures were highest and water turbidity was severe. Filling was terminated when those fish were discovered, and monitoring continued to make sure that any remaining live fish had an escape route to deep and cleaner water. The last 100 feet of filling occurred the next morning, and no further stressed or dead fish were seen.

The vast majority of rough-skinned newts and red-legged frogs were adults; Northwest salamanders were larvae in at least two size classes, except for two large neotenic adults in upper Fahys Creek.

Table 10. Captured and relocated aquatic vertebrates during the 2010 construction period

Species	Fahys Creek	No Name Creek	Redd Creek	Total
Coho salmon (*Oncorhynchus kisutch*)	315	114	37	466
Coho mortalities	9	0	1	10
Chinook (*Oncorhynchus tshawytscha*)	20	5	0	25
Coastal cutthroat trout (*Oncorhynchus clarki clarki*)	277	26	35	338
Three-spined stickleback (*Gasterostreus aculeatus*)	5,129	4,576	5	9,710
Sculpin (*Cottidae* spp.)	185	328	5	518
Bullhead (*Ameiurus* spp.)	81	1	7	89
Bluegill (*Lepomis* spp.)	11	0	0	11
Gambusia (*Gambusia affinis*)	6	22	0	28
Largemouth bass (*Micropterus salmoides*)	5	0	0	5
Smallmouth bass (*Micropterus dolomieu*)	3	0	0	3
Rough-skinned newt (*Taricha granulose*)	4,747	563	5	5,315
NW Salamander (*Ambystoma gracile*)	569	8	0	577
Red-legged frog (*Rana aurora*)	173	20	4	197
Total	11,530	5,663	99	17,292

6.4 Cultural resource monitoring and protocols

Appendix B details the plans and protocols for dealing with cultural resources (CR) discovered during construction. In summary, KR was required to notify the construction manager in advance of any excavation, who would then consult with the CR monitor. The monitor would determine if there was the potential to disturb artifacts, i.e. any penetration to depths below the summer saturated soil level where artifacts might be preserved, and any depth below the natural levee surface within the dikes; and, if so, would be present at the excavation. The CR monitor had the authority to halt excavation to avoid damaging archaeological deposits if necessary.

In the event an artifact was discovered, excavation would be stopped while the discovery was documented and mapped to avoid further disturbance of the site. If the delay in digging was significant, the contractor would be advised by the monitor to skip over the site and continue digging or to redirect the course of the channel excavation to work around the site. The most common discovery was that of a fishing weir made of vertical sticks in a line. Typically, the weir crossed the channel obliquely, and was seen after the excavator bucket passed over and broke the sticks cleanly at the bottom of the channel. In these cases, the weir sticks were flagged for later documentation, and the digging continued as planned. If the weir was discovered to be paralleling the channel and would therefore be continuously disturbed by the excavation, the channel would be re-routed to avoid the projected footprint of the weir.

Two depository areas within the site were designated as archaeological quarantine sites where any spoil material containing artifacts would be placed. Such material was most likely to be from the river levee where past dike construction or repair had resulted in artifact-bearing strata mixing with fill used to build up the dike. As this was discovered during the dike removal process, the spoils were directed to one of the quarantined zones. These zone locations (GPS coordinates) are registered with the State Historic Preservation Office (SHPO).

6.5 Streambed transitions between tidal and non-tidal elevations

Over the decades when tidal influence was largely removed from the two streams flowing into the site (Fahys Creek and Redd Creek), sedimentation had elevated the streambeds above their historical range within the intertidal zone. This was most extreme in Fahys Creek which continuously transports sand downstream due to the Pleistocene sand dunes within its watershed. In order for these streams to function as tidal channels within the marsh, their streambeds had to be lowered by several feet where they entered the tide marsh, and this necessitated an armored transition structure to prevent severe head-cutting up the stream that would greatly disturb the existing non-tidal floodplains and associated wetlands. For both streams, the logical place for this transition was immediately upstream from the new culverts providing passage under North Bank Lane, since the newly elevated roadbed was the topographical boundary between tidal and non-tidal elevations.

For both streams, the culvert also was the point where multiple channels coalesced into a single stream, so the transition structure had to accommodate water flowing in from several directions. Therefore, an amphitheater-type structure was built out of rip rap that included channels for the various streams (Figures 22 and 23). At monthly high tides, water levels are at or near the top rim of the structures, and at seasonal high stream flows migrating salmon can easily pass over the structures.

Figure 22. Aerial views of finished culverts and streambed transition zones between tidal and non-tidal elevations
Note the opposite perspectives of the two photos. Amphitheater-like structures made of rip rap were constructed to stabilize the streambed slopes on the north side of each culvert. Several stream channels converge at these structures.

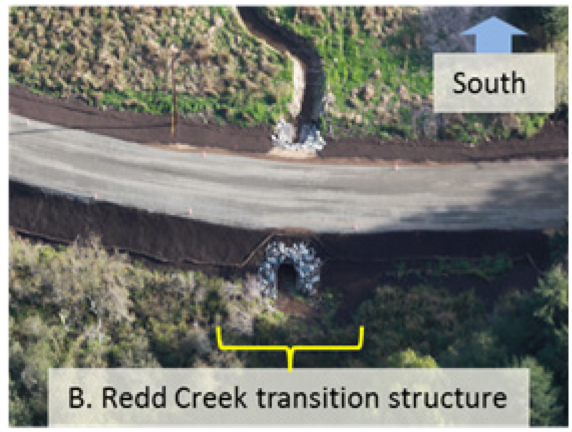


Figure 23. Ground view of the Fahys Creek transition structure, looking east
Note the culvert entrance on the far right center of the picture, and multiple streams flowing down the structure.

6.6 Dike and tide gate removal

After all tidal channel construction was finished in the summer of 2011, the process of allowing the tides back on the marsh by lowering stretches of the river dike, and ultimately removing the three tide gates began. This process was timed to coincide with a period of lower high (neap) tides that occurred in August, which would allow the dikes to be taken down to design elevations without being overtopped by the tides, thus preventing premature flooding of the site that would affect heavy equipment operation. The total amount of time needed to lower the dikes was longer than the lower high tide window, so dike removal occurred in two stages (lifts). The first stage removed material along the entire length to be lowered to within six inches above the predicted high tides of the following two weeks (or design elevation, if higher), and also substantially narrowed the dike to minimize the volume of material remaining for the second stage. The second stage occurred during the lowest high tide window, and brought the dike down to design elevations (Figure 24). Final elevations varied along the 5,400 feet of lowered dike, with the lowest elevations (5.5 feet NAVD8 8 datum) at the southwest corner of the site near the new mouth of Fahys Creek, which is also the lowest area of the marsh table. The spoil generated from the dike excavation was used to fill the lower channel of Fahys Creek that was to be abandoned (Figure 25), to build two separate sub-basin divides, and to raise the elevations of the east and west dikes that protected neighboring properties from flooding.

Immediately after the dike removal was completed, the three tide gates were removed and stream mouths were formed during incoming tides on three different days, starting with Redd Creek (Figure 26), then No Name Creek, and finally Fahys Creek on August 18 (Figure 27).

Figure 24. The second stage of dike removal, bringing the dike to the design elevation

Figure 25. Aerial photographs showing how the mouth of Fahys Creek was restored to its historic location
Left: Photo taken after new channel construction occurred in 2010 shows how the creek had been re-routed from its historic outlet to a tide gate by the landowners decades ago. *Right*: The spoil from the dike removal was used to fill the old lower creek basin, and the creek was directed into its historic outlet channel. During the dike removal and filling process, the creek flowed through a temporary tide gate located where the creek now crosses the old dike footprint.

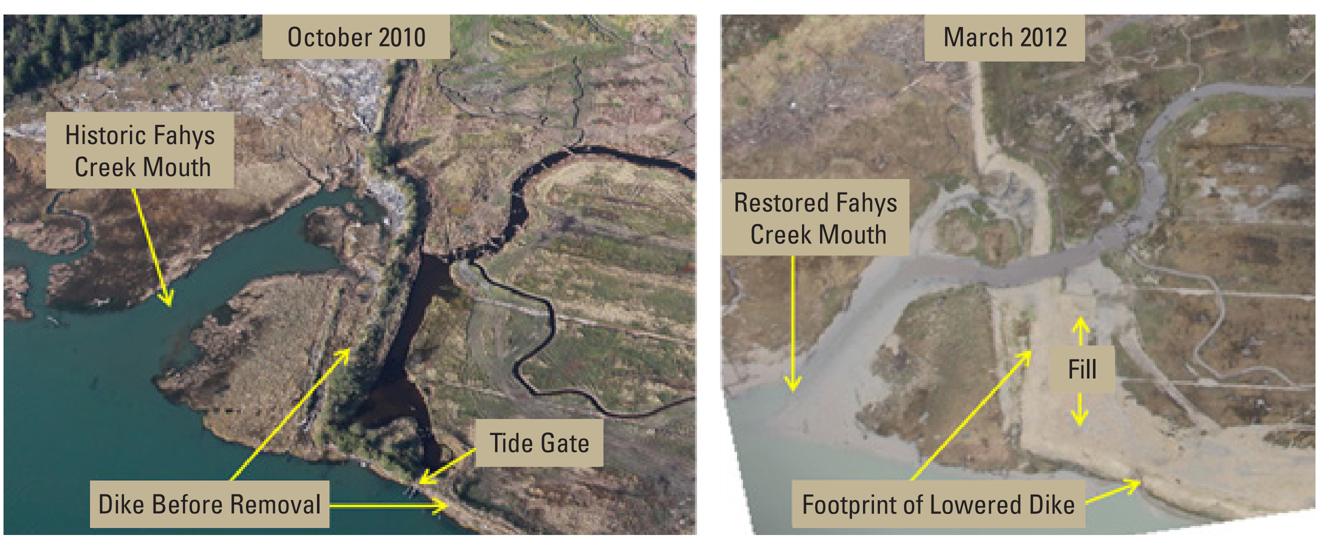


Figure 26. The final stages of the Redd Creek tide gate removal and mouth construction
The breach was timed to coincide with an incoming tide to push turbid water upstream where it will have time to clear up before the next ebb tide flows back to the river.

Figure 27. Upon removal of the Fahys Creek temporary tide gate on August 18, 2011, the tides return to all of Ni-les'tun for the first time in over 100 years
Local Coquille Tribe members paddled a traditional canoe into Fahys Creek on the first incoming tide to celebrate the restoration of traditional tribal fishing grounds.

6.7 Restoring Fahys Creek mouth

The historic lower channel of Fahys Creek had become extensively filled by sediment over the decades since normal flows passed through it, leaving its minimum elevation several feet above the river bottom, and the design elevation of the excavated channel leading down to it. However, since it had been outside of the dike and subject to tides, the banks of the channel were too soft to permit access needed by the excavators and trucks to remove the sediment, and it was decided to rely on erosion from the newly restored flows to deepen the channel until it equilibrated with the tidal forces. To facilitate this process, and to allow function of the temporary tide gate culvert installed to divert the creek's flow into the historic channel, a hand dug ditch was built (Figure 28) through the soft sediment toward the river. This ditch rapidly enlarged in the weeks following restoration of the tides (Figure 25), and continued to erode for at least four years.

6.8 Large woody debris (LWD) installation

In 2010, approximately eighty 40 foot long logs with root masses attached, plus additional smaller logs without roots attached, were obtained from a sheep ranch about 20 miles away. All pieces were delivered to a staging area at Ni-les'tun. The root mass pieces were between 18" and 36" diameter at breast height (DBH), and the vast majority of them were Douglas-fir. The root masses had been cleaned of soil and trimmed somewhat for transport, and all branches were removed. In 2011, additional logs were obtained from the same source, with the upper size limited to 24" DBH. Ultimately 131 logs with root masses were installed on the site, with an additional 210 smaller LWD pieces.

The process of LWD installation was the same each year, and began with KR using a log loader to carry two or three logs at a time to flagged staging areas near where LWD clusters would be installed. Under the direction of the fish biologist, an excavator operator would retrieve a staged log, place it in position, and maneuver the excavator to where it could use its bucket to push the log into the channel bank (Figure 29). To facilitate the penetration, a worker used a chain saw to bevel the small end of each log into a point. The goal was to push each 40 foot log into the soil at least 20 feet, but this was beyond the capability of the excavator for some of the larger logs (i.e. the log was embedded something less than 20 feet), and the reason the logs ordered in 2011 were limited to 24" DBH. If the soils had a large sand component, it was also more difficult to push in the logs, and this factor became limiting about midway up Fahys Creek, where even smaller logs could not be sufficiently embedded and planned installations were relocated to other channels.

In order for the LWD to have the desired effect on the streambed (create scours, bars, and sinuosity), and to maximize the holding capacity of the soils into which the logs were pushed, the preference was to install the logs as close to the channel bottom as possible, and space them about two channel widths apart. Due to the length of the logs relative to the channel width, and the diameter of the root masses, it was difficult to keep the root masses from being suspended above the streambed because of a too-steep penetration angle from horizontal. To avoid this, it was sometimes necessary to dig out a portion of the bank opposite from the insertion point to permit a lowering of the root mass, and thus a more horizontal alignment before insertion. In general, logs with root masses were only pushed directly into banks in the wider channels, or where a bend in the channel permitted pushing the log into the outside of the bend, and otherwise were anchored with pin logs as shown in Figures 29 and 30. Logs were chained to their pins in a few cases where the pins alone could not be relied on to anchor the logs (Figure 31).

Figure 28. The hand dug "pilot" channel to direct flow through the sedimented historic Fahys Creek lower channel

The pilot channel was intended to focus the erosive forces of the outflow and begin the process of channel adjustment to the restored flow rates.

Figure 29. Installation of LWD using an excavator to push logs into the banks
In this case, a large log laid down the center of the channel is being held in place with two pin logs. In other cases, the root mass log was pushed into the bank.

Figure 30. Schematic representations of various log arrangements that were combined to make up a LWD cluster within a channel reach
Portions of logs shown outside the channel banks (blue lines) would be driven underground.

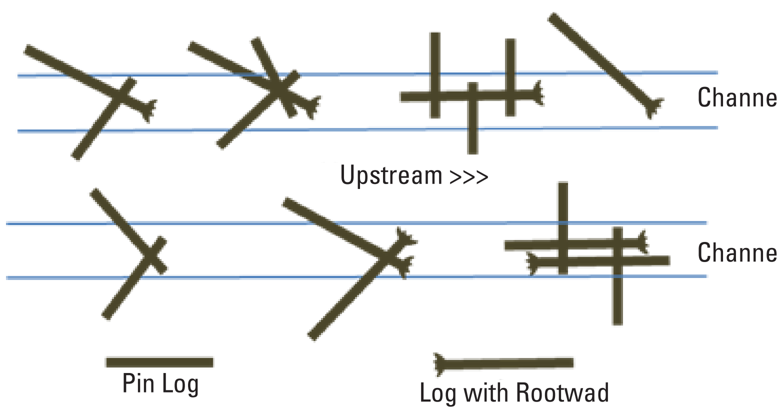


Figure 31. Corrosion-resistant chains used to help anchor logs against tidal forces

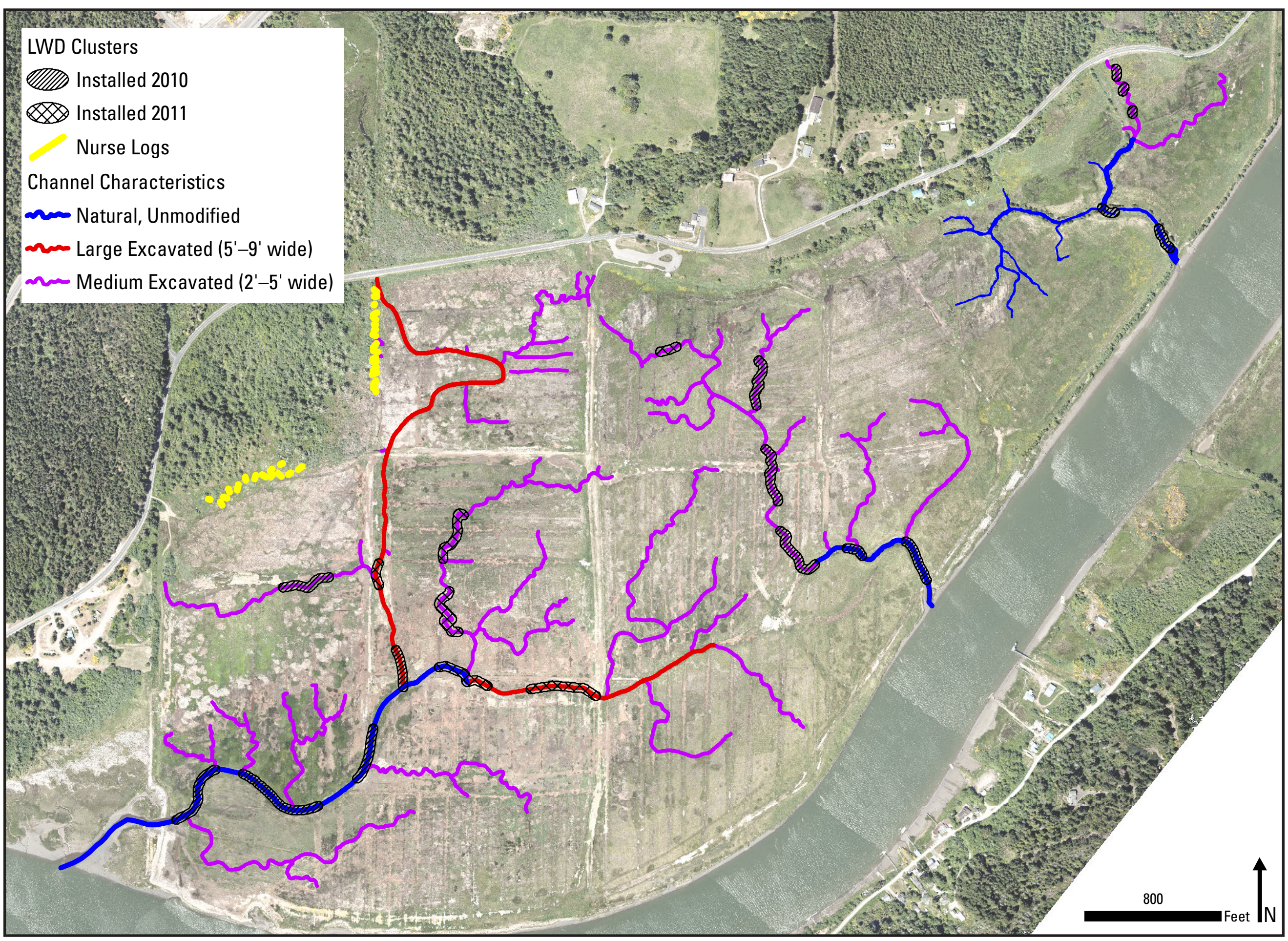
In addition to LWD placed in channels to enhance fish habitat, large diameter logs donated by the Coquille Indian Tribe and others sold at cost by Moore Mill and Lumber Company were distributed along the edge of the spruce swamp forest in the northwest corner of the site as future nurse logs for woody plant establishment. These were of various lengths (10' to 16') and diameters (24" to 48"), and selected because they were showing signs of heart rot, which meant they were on their way to a state of decomposition that would encourage tree and shrub seeds to germinate and grow on them. These locations are at elevations where it is likely that forest or woodlands existed before the land was converted. Annual high tide would cause some of these logs to float, but they were unlikely to move anywhere except further upslope, where they would still serve their intended function. The location of all LWD installations is shown in Figure 32.

6.9 Site repair

In the course of the construction various types of inorganic debris were discovered or generated, and it was the contractor's obligation to remove and dispose of it. These included fencing material, old culverts and damaged tide gates, new culverts that were temporary channel crossings, old pilings, and miscellaneous metal and plastic trash. One salvageable tide gate was turned over to the Coquille Watershed Association for recycling. Organic debris, such as LWD off-cuts, felled trees, or unburied wood was left on the marsh table as habitat elements. One large spruce tree that had been growing on a portion of the dike that was removed was dragged with branches and roots intact (Figure 33) to the mid-channel of Fahys Creek, where a LWD cluster had been planned, but could not be embedded due to sandy soils.

The construction specifications required the contractor to repair haul roads with excessive (as determined by the engineer) rutting, and decommission farm roads by ripping and grading to marsh table elevations. In most cases haul road ruts were repaired by the excavators side-casting their buckets to smooth out the ruts. In a few cases, spoils were used as fill material to level deep ruts. The main central north-south farm road had been built up over the years with compacted gravel and sand, and was elevated above the surrounding surface for most of its length, and so could not be easily graded down without disposing of significant spoils. The decision was made to cut the highest portions down by spreading material out with a bulldozer, and to then rip the roadbed to about a foot deep to loosen the substrate enough to support plants (Figure 34).

Figure 32. Overview of locations of LWD in channels and nurse logs on the marsh table



While it was not necessary to revegetate disturbed areas of the marsh, adjacent upland areas were seeded with a mix of native and annual grasses to control erosion, and inhibit colonization by invasive plants. These areas included the east and west boundary dikes, and the main equipment access and staging area west of the overlook parking lot. The last element of construction was a raised, gravel-topped pedestrian trail extending about 300 feet south from the staging area, and seeding of the disturbed soils near the trail also occurred (Figure 35). KR chose to apply the seed mix using a hydro-seeding method; combining the seed mix with an erosion-resistant binder that was sprayed over the area. The seed mix contained blue wildrye (*Elymus glaucus*), California brome (*Bromus vulgaris*), and annual ryegrass (*Lolium multiflorum*).

Figure 33. Dragging a spruce tree from where it had been growing on the old dike to be deposited in the Fahys Creek channel as LWD
The branches, root mass, and large size would serve to anchor it in the channel.

Figure 34. KR bulldozer ripping the farm road (*left*) and an aerial view of a portion of the decommissioned farm road showing the tracks left by the bulldozer ripping teeth, and the start of natural revegetation (*right*)
The roadbed remained elevated above the surrounding marsh in some areas.

Figure 35. Applying hydro-seed mixture to disturbed soils near the elevated gravel path into the marsh

6.10 Woody plantings

Woody plantings intended to facilitate restoration of tidal woodlands occurred in three phases after the completion of the tidal channels. In February 2011, 2000 willow whips (*Salix hookeriana*) cut from stock along the north side of North Bank Lane were inserted into pilot holes made with a driven steel rod in a row paralleling the road on the south side between Fahys Creek and the overlook parking lot. These willows were intended to provide erosion control for the roadbed. This planting was accomplished with the help of US Forest Service staff, volunteers, and Refuge staff. All but a handful of these whips survived and grew robustly, permitting the harvest of over 2800 cuttings from them to plant elsewhere in March 2013. These cuttings, plus others cut from Bullard's Beach State Park and other trees on the Refuge totaling 3,775 whips, were planted in March 2013 in the four numbered locations shown in Figure 36. This planting was done by a professional crew hired locally. Survivorship of these willows is discussed in Section 8.8.

In spring 2013, a local nursery was contracted to grow coastal stock of Sitka spruce (*Picea sitchensis*), Pacific crabapple (*Malus fusca*), and twinberry (*Lonicera involucrata*) in 3–5 gallon pots for planting in December 2013. All of these plants were planted within dense herbaceous vegetation, including slough sedge (*Carex obnupta*), reed canary grass (*Phalaris arundinacea*), soft rush (*Juncus effusus*), and velvet grass (*Holcus lanatus*), which had to be scalped before planting. Scalping was done with a power hedge-trimmer followed by a hoe to cut deeper roots. Grass cuttings were used to mulch the scalped area after planting. One spruce paired with one crabapple were planted in a scalped patch of about one square meter (Figure 37), and two to four twinberries were planted in separate square meter scalped areas. Locations for spruce/crabapple pairs were flagged by the biologist before the crew arrived, and were distributed evenly throughout the planting areas shown on the map. This resulted in spacing of 20 to 30 feet for the tree pairs, and the twinberries were then interspersed roughly one planting group per tree pair. To simulate rotten nurse logs, the spruce planting within the slough sedge (i.e., saturated soils within the planting hole) were raised so that the top of the tree root (potted soil surface) was 3–4 inches above the surrounding soil level (Figure 37). Coarse bark mulch was then used to fill around the roots out about a foot from the stem to provide an aerated substrate for root growth. The cuttings resulting from the scalping were then placed over the bark mulch to reduce competing growth of other plants. Table 11lists the numbers of each species planted by area.

Figure 36. Woody planting areas

The red polygons outline where willow whips cut mostly from the 2011 willow planting along North Bank Lane were planted in March 2013. The yellow polygons outline where Sitka spruce, Pacific crabapple, and twinberry were planted in December 2013.

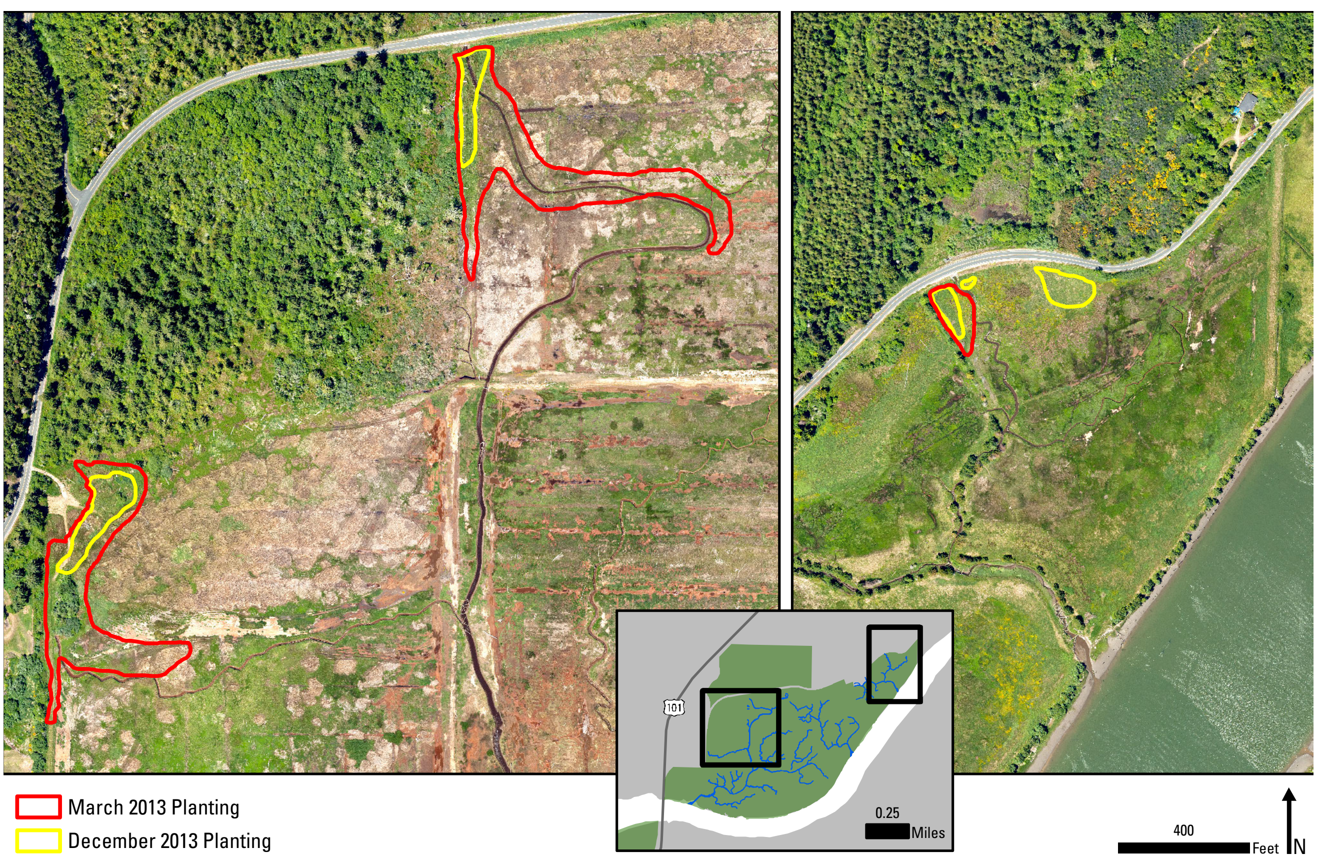


Figure 37. Sitka spruce planting technique

Left: Diagram showing how spruce roots planted in wet soils dominated by slough sedge were elevated about three inches above the surrounding marsh table and mulched with coarse bark to provide aerated soil for the roots. *Right*: The photograph shows the result of the grubbing to reduce sedge competition with the trees.

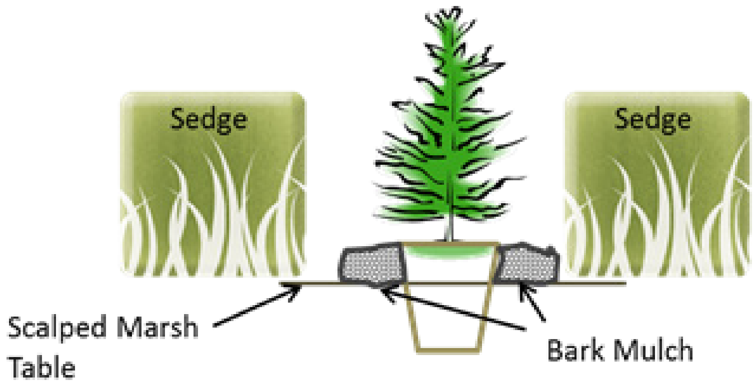


Table 11. The numbers of each woody plant species planted in the four planting areas shown in Figure 36 in 2013.

Species	Area 1	Area 2	Area 3	Area 4	Total
Sitka spruce	50	42	18	18	128
Pacific crabapple	50	42	20	36	148
Twinberry	195	113	87	76	471
Hooker's willow	1,225	2,175	375	0	3,775

7. Efficacy Monitoring

This section is a summary of the extensive restoration efficacy monitoring program which is described in detail in a series of reports submitted to the Oregon Watershed Enhancement Board (Brophy and van de Wetering 2012, Brophy et al. 2014, Brown et al. 2016), which funded the majority of the program. Links to these are included with the citations in Section 11, as is a separate report of changes in fish use (Silver et al. 2015, Silver et al. 2017). Another report of changes in bird use funded by *M/V New Carissa* Oil Spill Settlement funds is summarized in Section 7.4. This summary outlines the monitoring program design, the rationale for selecting which ecological parameters to measure, and major findings. Recommendations for future monitoring of this and other projects are discussed in Brophy et al. 2014 and Brown et al. 2016.

7.1 Program design and rationale

The restoration efficacy monitoring program was designed to:

1) Document key physical and biological factors integral to sustained ecosystem function;
2) Measure responses by biological communities;
3) Analyze linkages between restoration actions, recovery of site structure and function, native species recovery, and non-native species abundance and distribution; and
4) Broadly disseminate results, restoration guidelines and lessons learned.

Monitoring was conducted by Oregon State University, the Confederated Tribes of Siletz Indians, Green Point Consulting, Ducks Unlimited, and the U.S. Fish and Wildlife Service.

The collection of field data was organized around a Before-After-Control-Impact (BACI) concept; i.e. data for comparisons were collected before and after the restoration on both the restoration site and the Bandon Marsh Unit of the Refuge, which is a natural, minimally disturbed tidal marsh at similar elevations and tidal regimes as Ni-les'tun, and served as a control or reference site. This design allowed for direct comparisons of ecological parameters as they changed due to the restoration activities, and use of the parameters of the reference site as "targets" to evaluate the progress of the restoration site toward natural tide marsh function. The reference site also served as an experimental control to detect changes over the years that were due to factors other than the restoration. This BACI framework provides strong inference that the observed changes of ecological parameters may be attributed to the restoration process.

To yield meaningful results, the monitoring was designed from the top down: starting with each specific restoration objective (such as, restore the physical attributes necessary to create a tidal wetland), develop a corresponding monitoring objective (measure the hydrological connection between the river and marsh, and the vegetative response), develop one or more monitoring questions (was tidal hydrology successfully restored?; did a tide marsh vegetation community form?), and determine what metrics could be used to answer the question (water levels over time in the river and at various points within the marsh; plant community characteristics). From the list of metrics, a field data collection strategy was planned that would result in data that was directly relevant to assessing restoration efficacy. These monitoring results are also expected to inform planners of other similar restoration projects in the region so they could make their design and resource allocation decisions with greater certainty of the outcomes.

Monitoring parameters and the years they were sampled are summarized in Table 12, and maps of some sampling locations are shown in Figures 38 and 39.

Table 12. Monitoring parameters and the years when each was sampled
Baseline data was collected before the tides were restored to the site in August 2011.

Efficacy Monitoring Schedule	2010 Baseline	2011 Baseline	2012 Yr 1	2013 Yr 2	2014 Yr 3	2015 Yr 4
Tidal hydrology	X		X	X		X
Channel morphology		X		X		
Plant communities - emergent	X			X		X
Plant communities - shrub/forest		X		X		
Plant communities - mapping	X			X		X
Groundwater levels	X		X	X		
Soil organic matter, salinity, texture	X			X		
Water temperature and salinity		X		X		
Low tide fish density	X			X		
Tidal fish movements	X			X		
In-stream habitat	X			X		
LWD and non-LWD fish habitat use		X		X		
Macroinvertebrate density and community	X			X		
Bird use	X	X	X	X		X

Figure 38. Efficacy monitoring sampling sites for vegetation, soils, groundwater, tides, and fish use on the reference site

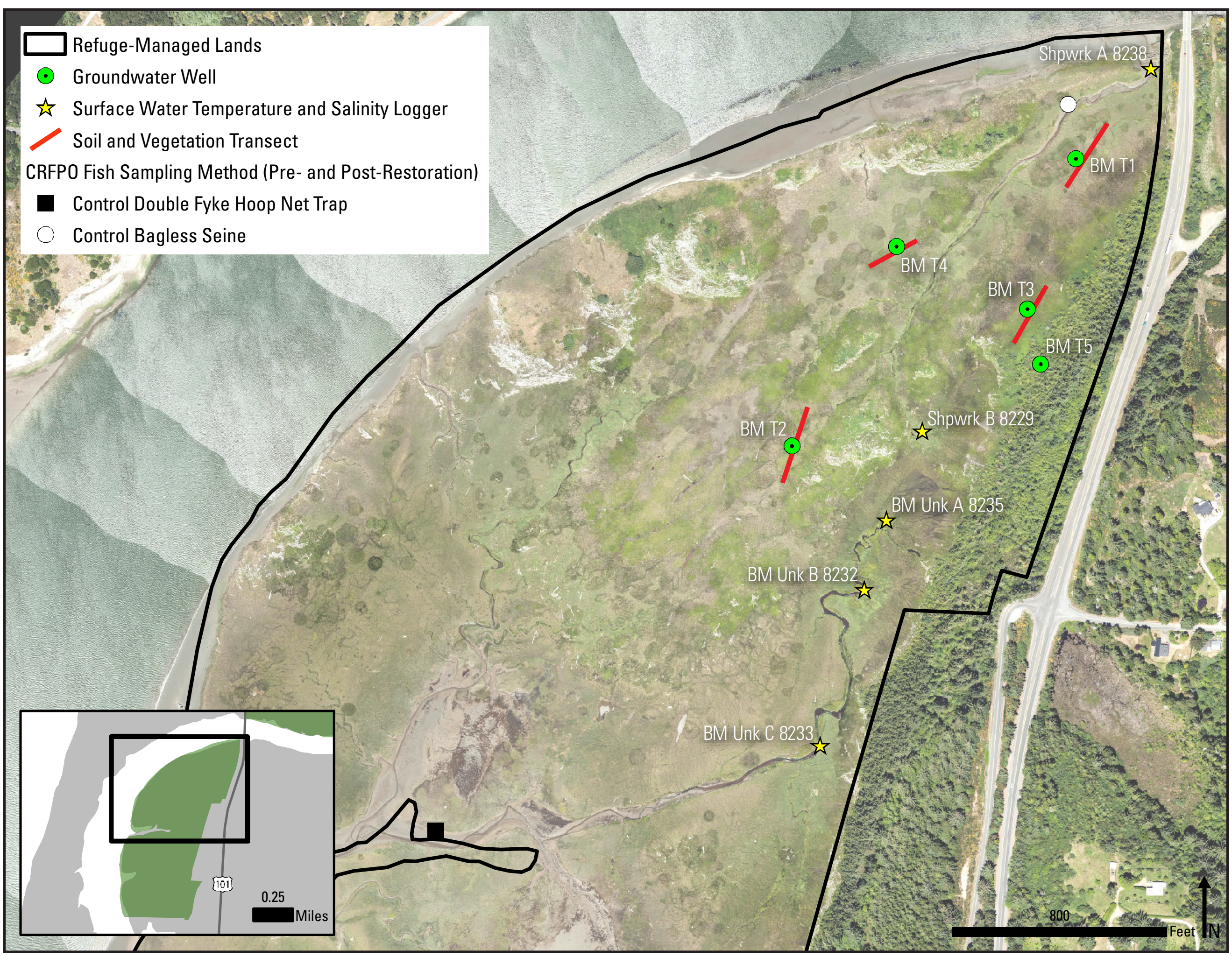
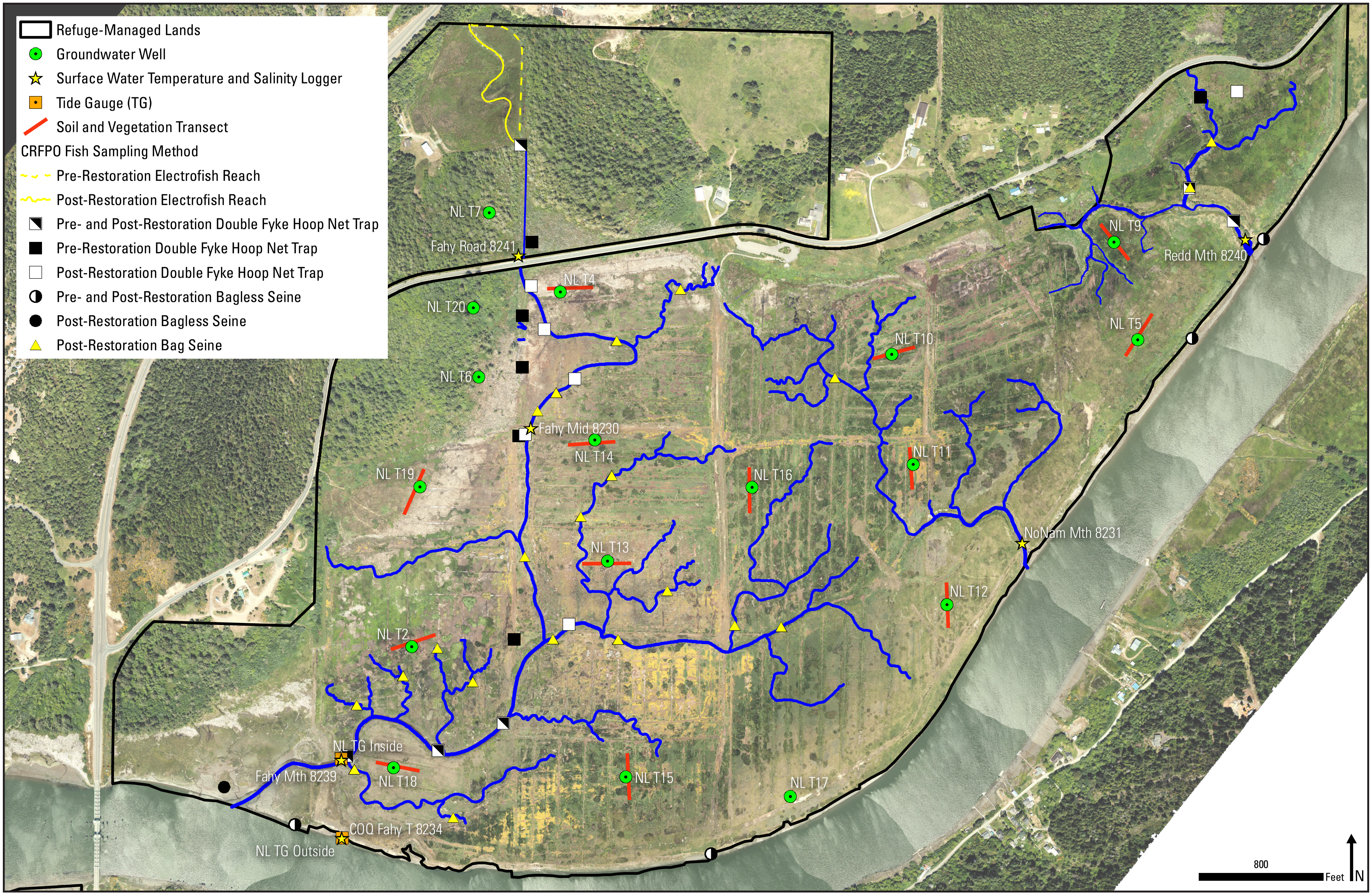


Figure 39. Efficacy monitoring sampling sites for vegetation, soils, groundwater, tides, and fish use on the restoration site



7.2 Baseline monitoring results

The first report of monitoring program results: *Ni-les'tun Tidal Wetland Restoration Effectiveness Monitoring: Baseline (2010–2011)*, Brophy and van de Wetering (2012) presented a comparison between the restoration and reference sites, and set the stage for the following post-restoration reports. A link to the full report accompanies the citation in Section 11. The following is an excerpt from the Executive Summary of that report:

> This report describes results of baseline monitoring at the Ni-les'tun tidal wetland restoration site, Bandon National Wildlife Refuge, Coquille River estuary of Oregon. Baseline monitoring provides a basis for comparison to post-restoration conditions, allowing future determination of project effectiveness. The report focuses on 2010–2011 baseline data, but it also includes information from our team's earlier monitoring efforts during 2003–2005. These earlier monitoring data leverage the 2010–2011 effort, providing a longer-term perspective and better understanding of site dynamics. We also provide some early glimpses of likely post-restoration conditions, based on data from the reference site and some preliminary post-restoration monitoring in fall 2011....
>
> Baseline monitoring revealed striking contrasts between the pre-restoration conditions at Ni-les'tun and reference conditions at the Bandon Marsh Unit. These contrasts are expected to diminish rapidly after restoration, and this report contains some preliminary results supporting that expectation. However, some physical and biological conditions will change more slowly. To accurately assess project effectiveness, our future (post-restoration) monitoring reports will evaluate results at Ni-les'tun by documenting the direction of change ("restoration trajectory") as well as the conditions at the time of monitoring. We will also compare results at Ni-les'tun to other tidal wetland sites in Oregon and the Pacific Northwest. This broad assessment of the Ni-les'tun restoration will provide important perspective and guidance for other restoration projects.
>
> ***Key findings:***
>
> - Emergent plant communities at Ni-les'tun had a high non-native component; native species dominated in the lower and wetter parts of the pasture, especially where brackish conditions prevailed due to limited tidal inflow through the tide gates. Forested wetland plant communities, which had never been ditched or used for pasture, were almost entirely native, with characteristics similar to non-tidal forested wetlands. With the return of the tides and brackish salinities, emergent and forested wetlands are expected to respond via shifts in species composition; the changes will be documented via post-restoration monitoring.
> - Soils at Ni-les'tun had about half the organic matter content compared to the reference site, and were much less saline. Soil characteristics at the reference site in 2010 showed a trend towards higher organic matter content and lower salinity compared to 2003.
> - Groundwater showed seasonal wetland characteristics across the majority of the Ni-les'tun pasture; forested wetlands and lower portions of the pasture were wet year-round. By contrast, groundwater fluctuated with the tides at the reference site's high marsh; the water table dropped well below the soil surface in summer between spring tide cycles, but each spring tide cycle "reset" the water table to the surface again. These patterns illustrate likely post-restoration conditions at similar elevations on Ni-les'tun.
> - Channel morphology at Ni-les'tun reflected the recent construction of the channel system, with morphology that matched the restoration design. Channel density is expected to increase and channel structure will evolve as the network develops; these developments will be documented during the post-restoration monitoring period.
> - Fish habitat opportunity was limited by the site's tide gates, dikes, and ditch conditions. Temperature and salinity conditions differed sharply from reference conditions, particularly in summer; conditions were often unsuitable for juvenile salmonids. Five miles of restored channels excavated in 2009–2010 are expected to provide significant increases in habitat availability, as measured by channel length, channel volume, and expected inundation frequency. Removal of the tide gates and dikes, completed in August 2011, is expected to improve water quality through restored tidal flushing. The addition of 193 large wood structures [consisting of one to four logs] will further enhance habitat opportunity during the post-restoration period.
> - Fish habitat capacity, as measured by macroinvertebrate abundance and community structure, was distinctly different at the restoration site versus the reference site. [Diversity and abundance were greater at the restoration site, as expected due to the preponderance of fresh water habitat.]
> - Fish habitat utilization differed sharply between the restoration site and the reference site. Although Ni-les'tun was used [by] many fish species prior to restoration, limited use by salmonids reflected access and habitat suitability limitations imposed by the restoration site's tide gates, dikes and ditches.

7.3 Two years post-restoration monitoring results

All ecological parameters were sampled in 2013, two years post restoration construction, and compared to baseline conditions. The major report describing those data is: *Ni-les'tun Tidal Wetland Restoration Effectiveness Monitoring: Year 2 Post-restoration* (2013) (Brophy et al. 2014), and an excerpt from the Executive Summary follows:

> Post-restoration monitoring in 2013 revealed many dramatic physical and biological changes since restoration, and a restoration trajectory that is moving towards conditions at the local reference site as well as a broader set of reference sites in Oregon. Some physical and biological conditions changed rapidly, while others appear to be changing more slowly—results which were expected and which are typical of restoration sites in general. Key findings are listed below.
>
> ***Tidal hydrology***
>
> 1) The tidal inundation regime at Ni-les'tun was successfully restored to closely match the adjacent river and the Bandon Marsh Unit reference site. Average daily high tides inside the restoration site were within 9 cm (3.5 in) of those in the river mainstem, showing that the site has free tidal exchange.
>
> 2) Strong post-restoration increases in channel water salinity and soil salinity across all parts of the restoration site (from the Coquille River to North Bank Road) provide clear evidence that brackish tidal flows were quickly returned to the entire site.
>
> 3) After restoration, groundwater regimes showed strong tidal influence, indicating tidal flows were affecting belowground processes as well as surface inundation.
>
> 4) Post-restoration changes in channel morphology showed that restored tidal flows are influencing channel width, depth, and substrate configuration.
>
> 5) The Ni-les'tun project restored highly prioritized Sitka spruce tidal swamp as well as tidal marsh, as shown by tidal inundation patterns in the forested areas of Ni-les'tun.
>
> ***Channel morphology***
>
> 6) Channels across Ni-les'tun deepened and strong head-cutting occurred in lower channels as the channels equilibrated with the restored tidal action.
>
> 7) Fine sediment was present in all excavated channels at depths ranging from 5 to 23 cm. Fine sediment is important for fish prey production, and it was absent from excavated channels prior to tidal flow restoration. Fine sediment depths were greater in non-excavated channels.
>
> 8) Longitudinal gradients differed between the reference and restoration site, but the restoration site is expected to change in the direction of the reference site.
>
> ***Vegetation***
>
> 9) Plant communities on the restoration site changed substantially since baseline; species that could not tolerate the restored tidal inundation and brackish salinity decreased in cover and/or condition.
>
> 10) Analyzed across the entire site, the composition of plant communities at the restoration site appears to be converging with the reference site.
>
> 11) Cover of non-native species at Ni-les'tun declined significantly after restoration; total plant cover also declined, due to increased bare ground where species that could not acclimate to restored tidal inundation and salinity died back. Cover of bare ground is expected to be temporary as brackish-tolerant native tidal wetland species re-colonize the site.
>
> ***Soils***
>
> 12) Soil salinity increased significantly at Ni-les'tun following restoration, and was similar to the reference site.
>
> 13) Soil carbon content increased significantly after restoration, although it was still lower than that of the reference site.
>
> ***Groundwater***
>
> 14) The Ni-les'tun pasture was a seasonal wetland prior to restoration, with soils that dried during summer. After restoration, the entire site was a tidal wetland year-round, with groundwater that fluctuated in response to tide levels and precipitation.
>
> 15) After restoration, the groundwater regime in middle to high elevations at Ni-les'tun followed the "spring tide reset" pattern typical of natural tidal marsh sites.
>
> 16) Using the 22 groundwater wells as "peak tide gauges", we were able to see variations in tidal inundation patterns across these large restoration and reference sites such as delays in tide peaks at wells far from the river, and variability in maximum tide heights. This information will be used to improve goal-setting and interpretation of monitoring results at other projects.

Channel water temperature and salinity

17) Restoration led to a significant increase in channel water salinity at Ni-les'tun during the spring and summer months. Post-restoration salinity in summer was somewhat lower at Ni-les'tun compared to the reference site, probably due to the restoration site's freshwater inflows and its location further upstream.

18) During spring and summer post-restoration, the daily salinity regime was very dynamic in tidal channels with freshwater flow (Fahys Creek and Redd Creek). This expanded daily range of salinities may provide osmotic regulation opportunities for juvenile salmonids and other anadromous fish during critical spring and summer periods.

19) Salinities in blind channels at Ni-les'tun slightly exceeded salinities at the reference site during summer, despite their location further upstream.

20) Restoration was associated with significantly lower water temperature at Ni-les'tun compared to the reference site in the upper portions of the channels. In other areas, water temperatures were similar to the reference site.

Wood structures and channel morphology

21) Of the 193 wood structures [consisting of one to four logs] placed in restored marsh channels, some were lost due to bank erosion. Channel reaches with lower wood density had less bank erosion and less loss of wood structures.

22) Channel reaches with wood structures showed more scour and fill of the substrate and bank, compared to channel reaches without wood structures. These processes helped create varied habitats, including low tide refugia scour pools and sediment bars.

23) Lower channel reaches (near channel mouths) showed more channel complexity in wood reaches compared to upstream reaches. This may have been due to greater tidal forcing in the downstream channels, or to the fact that the downstream channels were not excavated during restoration, so they had more fine sediment.

Salmonid habitat opportunity and suitability

24) Restoration led to dramatic increases in habitat opportunity (access) for migrating and non-migrating juvenile salmonids. Fish access to channels at Ni-les'tun was greatly enhanced by restoration, and was greater at Ni-les'tun than at the reference site.

25) Prior to restoration, salmonid rearing conditions (water temperature and salinity) were impaired by the site's dikes and tide gates. By year two after restoration, temperature and salinity were close to reference conditions, resulting in increased duration of temperatures that met the Oregon Administrative Rules' salmonid rearing criteria (<18° C) in most locations.

26) New salinity regimes created new rearing opportunities for specific fish species and age classes during the key period of summer low flow.

Salmonid habitat capacity (prey resources)

27) Macroinvertebrates colonized the newly excavated channels at Ni-les'tun. The restored benthic macroinvertebrate communities showed abundance, diversity and community structure similar to the reference site.

28) Macroinvertebrates also colonized the non-excavated, pre-existing channels at Ni-les'tun.

29) The macroinvertebrate taxa that dominated at Ni-les'tun at year two after restoration (primarily *Corophium* and polychaetes) are important prey for salmonids and Pacific staghorn sculpin, suggesting that the restoration provided enhanced salmonid foraging opportunities.

30) At year two, the restored marsh benthic macroinvertebrate communities were more diverse than those observed in the mainstem Coquille River habitats.

Salmonid habitat use

31) Restoration resulted in significant increases in use of key rearing habitats by age 0 chinook, age 1 coho, staghorn sculpin, and other fish species and age classes.

32) Rates of fish use of restored habitats increased both within and across seasons for age 0 chinook, age 1 coho, staghorn sculpin, and other fish species and age classes.

33) Tidal migration increased after restoration for age 0 chinook and age 1 coho.

34) About 300 age-0 coho reared in an oligohaline intertidal beaver dam pool on the restoration site. Intertidal beaver dam pool habitat is a key habitat that likely occurred at a greater rate prior to European settlement. Intertidal beaver dams and pools were also present at the Bandon Marsh Unit reference site.

35) Based on peak month catch data, we estimate the Ni-les'tun restoration site produced 6,022

Chinook smolts during 2013. If ocean survival is assumed to be 1.5%, a logical conclusion would be that the Ni-les'tun restoration resulted in 90 additional adult Chinook spawners.

Ecological linkages and other results

36) Percent inundation was significantly correlated with physical and biological site characteristics such as soil salinity and plant species richness. These relationships indicate that Ni-les'tun is developing in response to the restoration of tidal flows, evidence of effective restoration.

37) Many other species besides the target species, such as surf smelt, anchovy, pipefish, crangon shrimp, and larval Dungeness crab and bay pipefish, were observed using the restoration site; these were absent prior to restoration.

38) Effectiveness monitoring requires an understanding of natural changes over time at local sites. Before-After-Control-Impact (BACI) sample design and analysis is a framework that improves understanding of these changes and the effects of restoration. BACI allowed us to detect significant changes associated with restoration that would otherwise have been masked by year-to-year variability.

In addition to the fish use surveys done by the efficacy monitoring team and summarized above, a separate team from the USFWS Columbia River Fisheries Program Office (CRFPO) conducted regular fish sampling from 2007 through 2013 to document the restoration effects (Silver et al. 2015, Silver et al. 2017). This team used a variety of sampling methods; including seine nets, double hoop nets (traps), and electro-shocking. The CRFPO surveys largely corroborate the above findings that restoration resulted in fewer invasive species, more chinook salmon, and many more estuarine species at Ni-les'tun, but failed to document increases in coho salmon post restoration in tidal areas. Table 13 lists all fish species documented during the CRFPO surveys.

Table 13. All fish species identified during multiple surveys before and after restoration at Ni-les'tun (construction area) and at the reference site (Silver et al. 2015, Silver et al. 2017)

			Construction Area		Reference Area	
Species	Acronym	Genus Species	Pre	Post	Pre	Post
American shad*+	AMS	*Alosa sapidissima*		X	X	X
Bay pipefish+	BAP	*Syngnathus leptorhynchus*	X	X		X
Bluegill*	BG	*Lepomis macrochirus*	X	X		
Brown bullhead*	BBH	*Ameiurus nebulosus*	X	X		
Carp*	CARP	Cyprinus carpio	X			
Chinook salmon	CHN	*Oncorhynchus tshawytscha*	X	X	X	X
Coastal cutthroat trout	CCT	*Oncorhynchus clarki clarki*	X	X		
Coho salmon	COHO	*Oncorhynchus kisutch*	X	X	X	X
Cottid spp. +	SCP	*Cottidae sp.*	X	X	X	X
Crappie sp.	CRAP	*Pomoxis sp.*		X		
Gunnel fish sp.+	GUN	*Pholidae*	X	X	X	X
Hybrid CCT/STH	HYB	*Oncorhynchus sp.*	X	X		
Largemouth bass*	LMB	*Micropterus salmoides*	X	X		X
Mosquito fish*	MQF	*Gambusia affinis*	X	X		
Northern anchovy+	ANC	*Engraulis mordax*		X		
Pacific lamprey	PL	*Entosphenus tridentatus*				X
Smallmouth bass*	SMB	*Micropterus dolomieu*	X			
Smelt sp.+	SMELT	Osmeridae	X	X	X	X
Starry flounder+	STF	*Platichthys stellatus*		X	X	X
Steelhead	STH	*Oncorhynchus mykiss irideus*	X			
Shiner perch+	SP	*Cymatogaster aggregata*	X	X	X	X
Three spine stickleback +	SKB	*Gasterosteus aculeatus*	X	X	X	X
Trout fry (<100 mm)	TF	*Oncorhynchus sp.*	X	X		

* Introduced species + Estuarine species

7.4 Bird use surveys

In addition to the ecological parameters sampled by the contracted monitoring team, the Refuge biologist designed and implemented a bird survey protocol that would sample bird use of the restoration and reference sites along established transects (Figure 40). Distance sampling methods were used to monitor avian use of the Ni-les'tun Unit restoration site and the Bandon Marsh Unit reference site of the Bandon Marsh Refuge from November 2009 through August 2013. (Surveys were resumed April through September 2015, but those data have not been incorporated into the following results and analyses.) Surveys were conducted bi-weekly during the non-migration and non-breeding season (Oct.–Mar.) and weekly during migration and the breeding season (Apr.–Sept.) except in 2012 when limited resources resulted in biweekly surveys all year. These methods allow estimation of population densities of commonly detected species within the sampled areas. There were 154 surveys conducted pre-restoration, and 168 surveys post-restoration, totaling 322 surveys and 26,484 bird detections (Table 14).

A total of 176 bird species were identified over the study period, but only about 25 species were detected more than 50 times (i.e., about half of the time, on average) (Table 15).

Analyses of bird communities before and after restoration on the restoration and reference sites found a significant difference between the pre-restoration communities of the two sites that disappeared post-restoration, indicating that the community at Ni-les'tun shifted to become more like that of the reference site within two years of the return of the tides (Wishnek 2014). Further analyses showed that the portions (legs) of the Ni-les'tun transects in areas most affected by the tides (i.e. lower elevations) accounted for most of the change. Not surprisingly, the species driving these community responses were marsh and open water species (i.e., waterfowl, waders, and shorebirds), reflecting the most dramatic changes in the habitat. For further discussion of the bird use changes see Wishnek 2014.

The trend of increased waterfowl use of Ni-les'tun since the return of tidal influence evident in these data has continued since the regular surveys ended in August 2013. During the following fall and early winter the tidal marshes of the Refuge were heavily and regularly used by green-winged teal, mallard, northern pintail, American wigeon, and northern shoveler; all in numbers much higher than the previous years. This tidal habitat was particularly critical to waterfowl because the unusually dry weather prevented the development of seasonally flooded pastures elsewhere in the Coquille River basin that are typically available.

Figure 40. Bird survey transects regularly sampled for all bird species using distance sampling methods

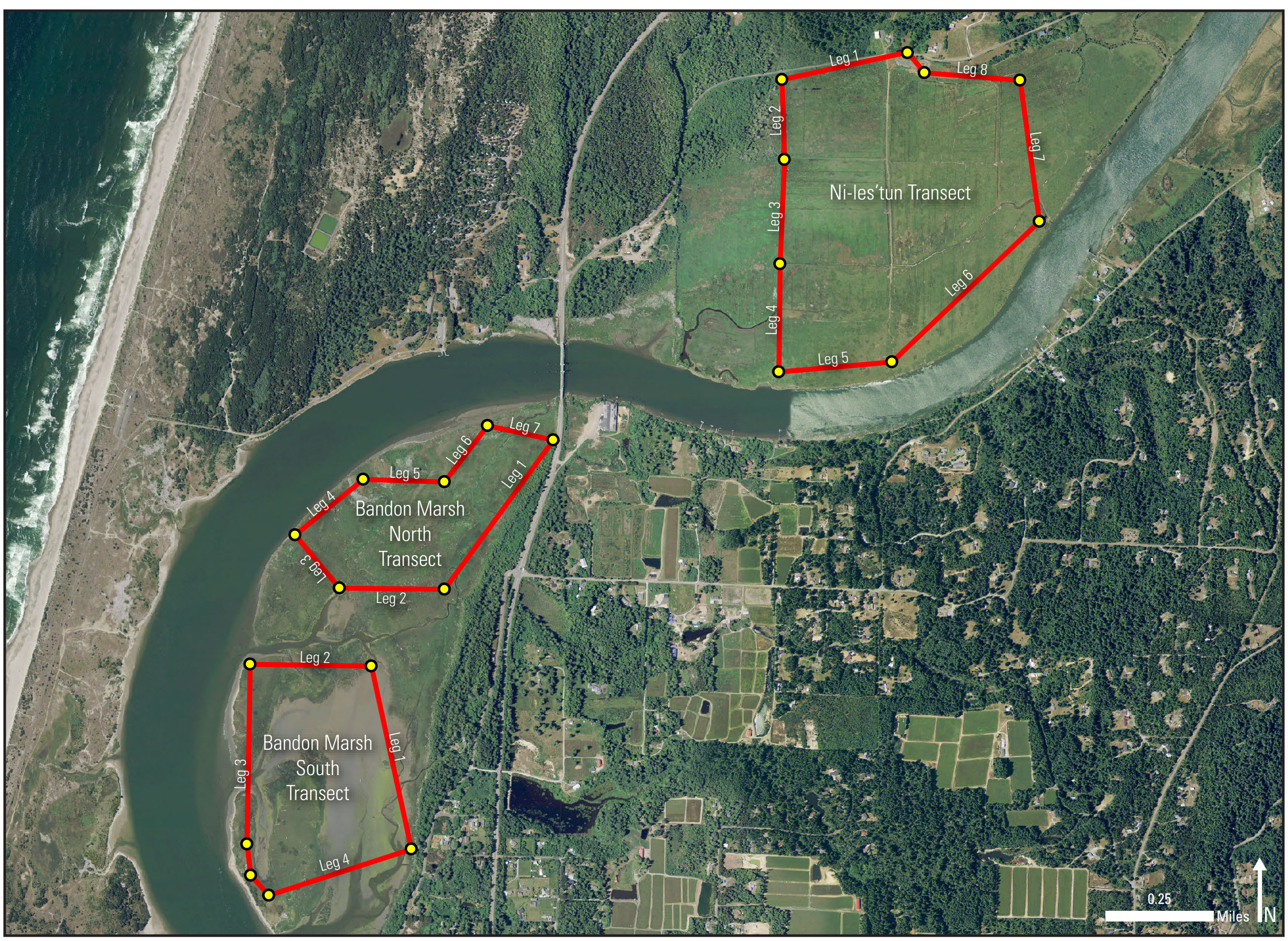


Table 14. Number of bird surveys conducted and bird detections at each site over the four year study

	Pre-restoration		Post-restoration		
Transect	Surveys	Detections	Surveys	Detections	Total Detections
Ni-les'tun	53	7,313	56	5,942	13,255
Bandon Marsh North	50	3,725	56	3,349	7074
Bandon Marsh South	51	3,075	56	3,080	6155

Table 15. Species detected at Ni-les'tun at least 50 times during surveys, arranged in order of percent change from two years before (pre) to the two years after (post) restoration of the tides to the site

	Detections			Individual Birds			
Species	Pre	Post	Difference	Pre	Post	Difference	% Change
Least sandpiper	6	45	39	38	1,052	1,014	2,668.4
Mallard	42	138	96	180	1152	972	540.0
Great blue heron	10	45	35	10	47	37	370.0
Green-winged teal	8	76	68	754	2,287	1,533	203.3
Wilson's snipe	18	51	33	31	89	58	187.1
Virginia rail	23	52	29	29	67	38	131.0
Killdeer	36	51	15	81	137	56	69.1
Canada goose	65	111	46	848	1,182	334	39.4
Cedar waxwing	67	43	-24	145	193	48	33.1
Orange-crowned warbler	24	29	5	28	33	5	17.9
Yellow-rumped warbler	30	31	1	61	69	8	13.1
Marsh wren	1,194	1,288	94	1,455	1,601	146	10.0
White-crowned sparrow	93	48	-45	101	110	9	8.9
Common yellowthroat	150	152	2	174	173	-1	-0.6
Song sparrow	1,280	1,089	-191	1,710	1,433	-277	-16.2
American goldfinch	93	70	-23	204	170	-34	-16.7
Wrentit	65	52	-13	70	56	-14	-20.0
American crow	39	21	-18	94	65	-29	-30.9
Savannah sparrow	1,415	856	-559	1,810	1,201	-609	-33.6
Swainson's thrush	64	38	-26	65	41	-24	-36.9
Steller's jay	95	66	-29	125	78	-47	-37.6
Tree swallow	41	18	-23	81	47	-34	-42.0
Northern flicker	44	30	-14	55	31	-24	-43.6
American robin	143	55	-88	178	89	-89	-50.0
Black-capped chickadee	111	55	-56	250	105	-145	-58.0

7.5 An unforeseen problem: mosquitoes

In summer 2012, Refuge staff noted an increase in mosquito numbers within the newly restored salt marsh habitat and received several telephone calls and one letter describing increased mosquito numbers from landowners directly across the river from the Ni-les'tun Unit. The Refuge manager began consulting with officials of the Coos County Public Health (CCPH) in fall 2012 concerning the complaints of increased mosquito numbers. Since Coos County did not have a mosquito management program, and recognizing the need to understand the Refuge's role in potential mosquito production, the Refuge staff began scoping out funding needs for Service-led inventory and monitoring of mosquitoes.

During the winter of 2012–2013, Refuge staff began discussions of mosquito inventory and monitoring needs on the Refuge with the Oregon Mosquito and Vector Control Association and private vector control managers. Discussions continued with CCPH concerning inventory and monitoring needs on Refuge lands. In the spring of 2013, Refuge staff coordinated with the Centers for Disease Control and Prevention, Oregon State Health Department, U.S. Geological Survey, and mosquito research organizations, but failed to locate outside funding for inventory and monitoring of mosquitoes. Instead, the Service established an agreement with Oregon State University's Entomology faculty enlisting student help to inventory and monitor mosquitoes on the Refuge in summer 2013.

By June 2013, the local mosquito population had grown tremendously, reaching levels unprecedented according to local residents (no formal mosquito surveys had ever been done in the area). On June 27, 2013, Refuge staff and an Oregon State University (OSU) entomology student began biweekly monitoring of mosquito larvae and adult abundance and species identification on the Bandon Marsh and Ni-les'tun units of the Refuge. The monitoring and species identification was coordinated with Multnomah County Health Department and Benton County Health Services due to the lack of local expertise. Of the five species of mosquitoes identified, about 90% of the adult mosquitoes sampled were the "summer salt marsh mosquito" (*Aedes dorsalis*), making this species the target of management.

Depressions that retained water during low tides were located in many of the shallow ditches that were disced and incompletely filled, along some large ditches where the fill settled, and along tracks left by heavy equipment. Many of these depressions were filled only by semi-monthly high tides and retained water long enough to permit the mosquitoes time to complete their development before drying or the next tidal flushing, thus providing ideal breeding habitat for salt marsh mosquitoes. Late July mosquito sampling following the monthly higher high tide series found larvae in great abundance in nearly every pool between elevations six to eight feet above mean low tide on the Ni-les'tun Unit south of North Bank Lane (Figure 41), foreshadowing a major fly-off of salt marsh mosquito adults. Adult trapping data confirmed that large numbers of adult females were using the restored tidal marsh as a breeding site and dispersing to adjacent habitats on the refuge and nearby private lands.

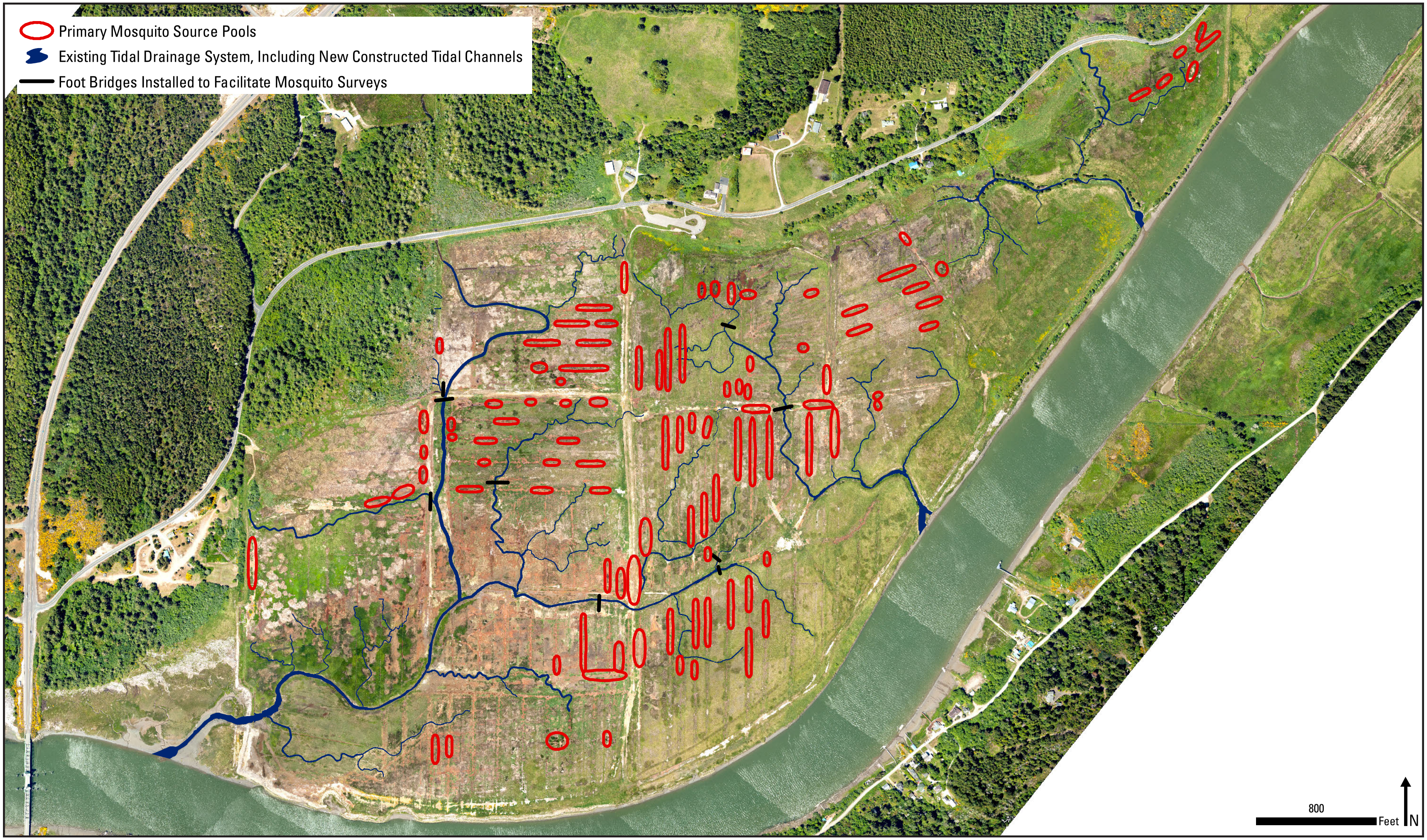
Beginning in June and continuing through August, local citizens complained of being unable to go outside for most of each month during this period without being overwhelmed by large numbers of aggressively biting mosquitoes. Staff on the Refuge had similar experiences. The Service also received reports of local residents, including children, as well as some domestic animals, needing medical attention due to allergic reactions to numerous bites. By late summer 2013, Refuge staff collected sufficient data to conclude that:

1) The Ni-les'tun Unit was indeed the source of the mosquito outbreak,
2) The sole species involved was *Aedes dorsalis*,
3) The dramatic population increase was a response to a large area of nearly ideal breeding habitat created inadvertently by the restoration construction, and
4) That mosquito breeding habitat could not be considered a normal feature of regional tidal marshes.

Given these realities, it was incumbent on the Service to institute remedial management of mosquitoes at Ni-les'tun. By late August Coos County Public Health issued a health advisory for citizens to protect themselves from mosquito exposure in the area around the Refuge. The first control action was taken in September 2013 after consultation with mosquito control experts and the Coos County Public Health officials. Recommendations included aerial spraying of the breeding pools with an insect growth regulator-based larvicide (Methoprene), and/or aerial spraying of a broad-spectrum adulticide (Naled) over a ten-square mile area around the Refuge. These two options were explained to a well-attended public meeting where commercial cranberry growers, organic gardeners, beekeepers, and others expressed their opposition to spraying any area outside of the Refuge, although many residents favored spraying. Due to the opposition, and the seasonal decline in the mosquito populations occurring, the decision was taken to apply the larvicide to the Refuge. This treatment was contracted by the County, but funded by the Service, and took place on September 12. For the sake of all the victims of the outbreak, and as a responsible member of the community, the Service committed to preventing the likely repeat in 2014 and beyond of the severe outbreak of 2013.

Figure 41. Major mosquito production areas based on 2013 surveys

Major mosquito production areas corresponded strongly with the footprints of the old shallow ditches that were disced in an attempt to disrupt linear flow and fill them. Within most ovals are “chains” of small pools, rather than inundation of the entire areas. Note that there was no production in the western lower elevations that are flooded by most tides. The breeding pools are within elevations of six to eight feet above mean low tide, corresponding to the height of the semi-monthly high tides that fill them.



7.5.1 Integrated Marsh Management as a solution

An expert panel on the scientific management of mosquitoes in tidal marshes was convened in Bandon in late October 2013 for the purpose of developing recommendations for a comprehensive treatment plan. The outcome of that meeting was the development of an adaptive management response to the mosquito problem in the form of an Integrated Marsh Management (IMM) approach described in two Environmental Assessments (EAs) drafted for public comment in March 2014 (USFWS 2014a, 2014b). The IMM approach focused on a long-term solution of modifying the restoration site hydrology to eliminate most of the mosquito breeding pools that had been inadvertently created; described in one EA (USFWS 2014a). However, the ground work needed to accomplish that could not be completed in time to prevent the expected large fly-offs in 2014. To manage mosquito numbers until plans to eliminate breeding habitat were implemented and began to be effective, it was most practical to use larvicides to kill mosquitoes before they developed past their aquatic life stages. The larvicide application proposed in the second EA (USFWS 2014b) included the use of three products: (1) a bacterial-based; highly specific to mosquitoes; non-toxic to plants, most invertebrates, and all vertebrates; non-persistent larvicide *Bacillus thuringiensis israelensis* (*Bti*); (2) a juvenile growth hormone-based, toxic to all juvenile aquatic invertebrates, moderately persistent larvicide called methoprene; and (3) a mineral oil-based, toxic to all air-breathing aquatic invertebrates, moderately persistent larvicide/pupacide called CocoBearTM. The proposal was to rely on *Bti* due to its target specificity unless conditions for its efficacy were not met (it must be applied early in the larvae development), and to resort to the less specific alternatives only if needed to prevent a fly-off of adults.

Ultimately, in concurrence with Service policy to minimize non-target effects of pest control methods, and receiving assurances from the application contractor that management goals could be met, the Service chose to depend entirely on *Bti* to treat mosquito larvae. By May 1, 2014 when the first salt marsh mosquitoes of the season were expected to hatch, all permits, environmental reviews, and contracts were in place to begin intensive mosquito monitoring and implement the larvicide treatment program. By late September 2014, 11 separate *Bti* treatments were applied to breeding pools (one aerial application, 10 backpack sprayer applications on foot) throughout the site in response to egg hatches highly synchronized with semi-monthly high tides (Figure 42), and except for some localized adult outbreaks, the plan successfully prevented a major fly-off. A detailed report of the monitoring and treatments conducted in 2014 is in Appendix D. Due to the installation of new channels that drastically reduced the mosquito breeding habitat (see below) only a small fraction of the amount of *Bti* applied in 2014 was necessary to treat the remaining pools in 2015, and no *Bti* application was necessary after 2015.

Based on the locations of mosquito breeding pools determined in 2013, a Ducks Unlimited (DU) engineer was contracted to design a system of new channels that would connect the pools to the existing tidal channel system. The design process included calculating the volume of water each basin held when filled by the tide, and determining what channel dimensions and slope were needed to allow that volume of water to drain over the distance to the nearest receiving channel within one low tide period. This design occurred early in 2014 as part of the preparation of a construction bid package. That bid package needed to be ready to send out to prospective contractors by mid-spring to allow for contractor selection and mobilization to occur in time for mid-summer construction. As the mosquito breeding season got underway in May, monitoring revealed that there were additional breeding pools not discovered the previous year that would need connection to the tidal channels. By this time, it was too late for the engineer to design these channels, but they were added to the drawings (Figure 43) that were sent out for bid as “add alternates.” Due to the likelihood that there would be a need for even more new channels as the season progressed, the bidders for the contract were instructed to provide a cost per linear foot for each of the two sizes of channels; to be applied to channels added after the contract was awarded. As was the case for the original restoration project, the construction, contracting, and contract management for construction of the new channels was performed by DU.

The request for bids package, including project description, technical specifications, proscribed best management practices, bid items, and construction drawings; all prepared by the DU engineer was released in May 2014 to interested contractors (see Appendix F for Technical Specifications and sample construction drawings). Magnus Pacific Corporation (MP) based in Rocklin CA was awarded the contract to construct the new channels on June 20, and they mobilized to begin excavations on July 14. Construction was jointly supervised by DU and USFWS staff, with assistance from an Oregon Department of Fish and Wildlife (ODFW) fish habitat specialist, and USFWS archeologists on site during excavations in case cultural resources were discovered. A more complete description of the new channel construction process is in Appendix E.

Figure 42. The correlation between predicted daily higher high tides (blue line) and salt marsh mosquito egg hatches (numbers and brackets) in 2014

Larvae resulting from hatches two through 12 were treated with *Bti* larvicide. Lower tides resulted in fewer breeding pools flooded, and correspondingly less *Bti* applied. Small numbers of larvae appeared after the late September high tides and were spot treated, but the hatching season essentially ended at hatch number 12.

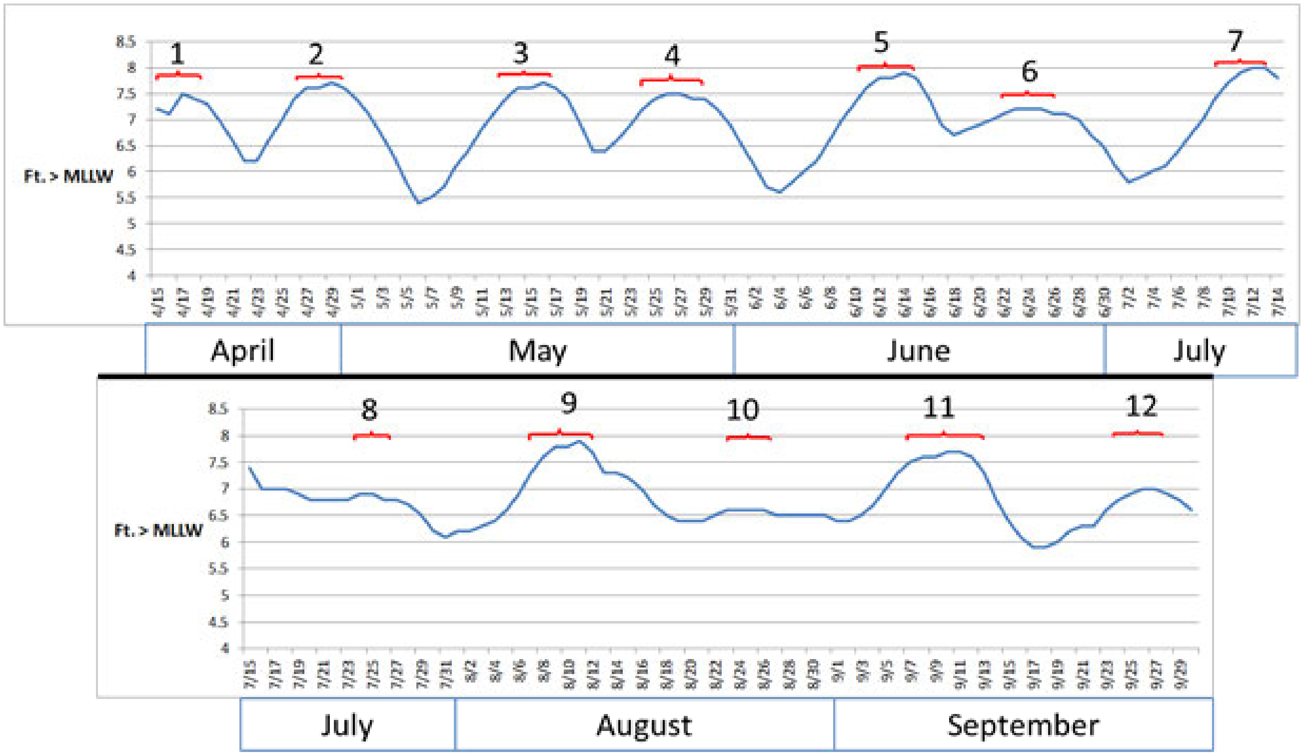
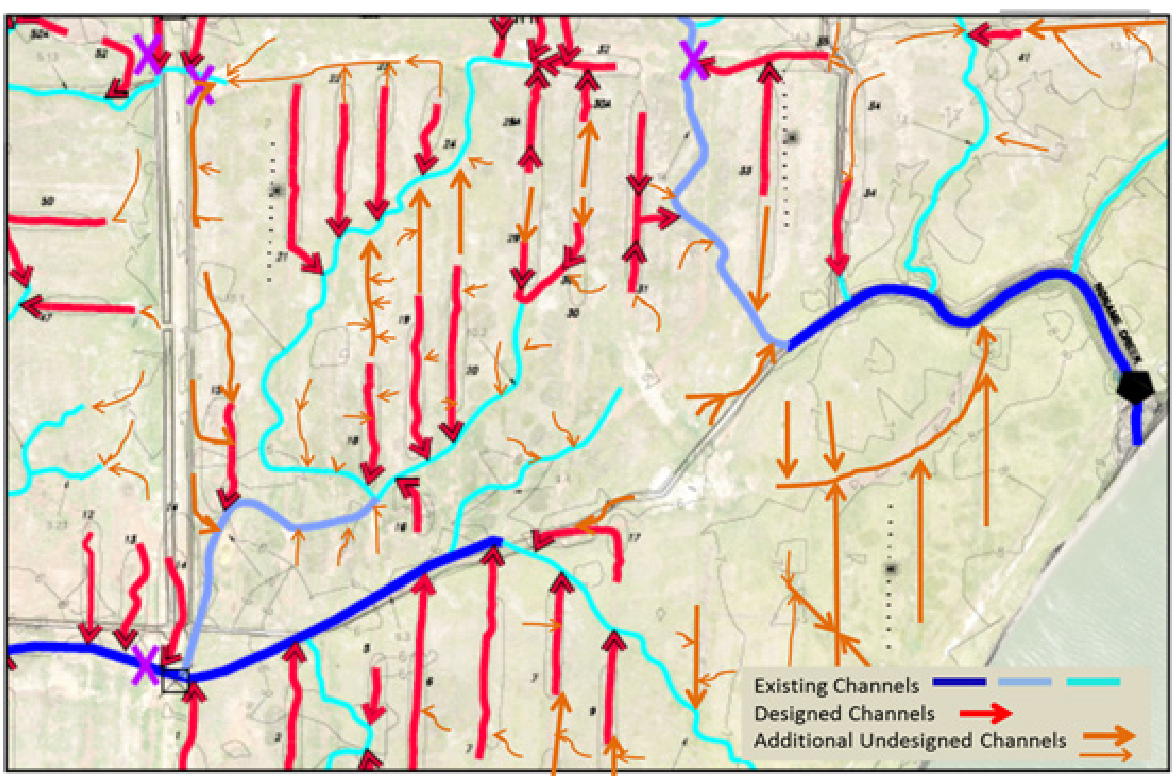


Figure 43. A portion of a construction drawing showing some locations of new first and second-order channels (with arrowheads) designed to connect mosquito breeding pools with the existing tidal channel system

Numbered red arrows indicate pre- engineered channels (designed depth and slope); orange channels were added later and designed in the field.



Far more channels were dug than the 47,000 linear feet (designed channels plus estimated add alternates) in the contract. MP estimated that 47,000 feet would take two months with the crew and equipment mobilized, but they ultimately dug 80,681 feet in only seven weeks. The success of this strategy for eliminating breeding pools was immediately apparent (Figure 44) as monitoring confirmed the lack of mosquito production in areas treated. Additional channels dug by hand crews, and later by a USFWS excavator and operator brought the total new channel length to approximately 120,000 feet or almost 23 miles in 2014 (Figure 45). In 2015, Refuge staff used Refuge equipment and hand crews to dig another 9,000 feet totaling almost 24.5 miles of channel. It is anticipated that there will be a few more pools needing connection in 2016, but this program has effectively reduced the salt marsh mosquito population to pre-restoration levels, precluded further larvicide treatment, and simultaneously advanced the restoration of tidal marsh function by greatly improving daily tidal exchange.

7.6 Four years post-restoration monitoring results

A link to the final *Efficacy Monitoring report: Ni-les'tun tidal wetland restoration effectiveness monitoring: Year 4 post-restoration (2015)*, Brown et al. 2016 is given in Section 11. This study was limited to a subset of ecological parameters covered in the previous reports, as described below. A summary of the study and key findings of that report are excerpted here:

> ***Purpose***
> This report describes the results of effectiveness monitoring of tidal hydrology, plant community composition, and plant community extent (vegetation mapping), at the Ni-les'tun tidal wetland restoration site, Bandon National Wildlife Refuge, Coquille River estuary, Oregon. The parameters monitored are a subset of the full suite of parameters that have been monitored at Ni-les'tun during the baseline and post-restoration periods. The monitoring described in this report was conducted during 2015, which was the 4th year after the site's dikes and tide gates were removed, restoring tidal flows to the site. Effectiveness monitoring was designed to determine whether the project is meeting its goals, and to provide information to help guide other restoration projects. The results and "lessons learned" through the monitoring at this landmark project are already helping to advance restoration science at many projects in Oregon, the Pacific Northwest, and beyond.
>
> ***Summary of results***
> Post-restoration monitoring in 2015 showed a consistent trajectory towards full recovery of tidal wetland functions at Ni-les'tun. Tidal hydrology was completely restored to the site, with daily maximum tides matching precisely between Ni-les'tun and the adjacent Coquille River. Plant communities remain very dynamic in response to the reintroduction of tidal hydrology and salinity, with salt-tolerant early colonizers spreading across the site and pasture grasses continuing to decline. Plant community changes observed between 2013 and 2015 indicate that plant communities are far from stabilization and can be expected to continue to change substantially for a number of years. Key findings are listed below.

Tidal hydrology and wetland surface elevation

1) The tidal inundation regime at Ni-les'tun was successfully restored to fully match the adjacent river. Average daily high tides inside the restoration site were 2.1 m NAVD88, identical to those in the mainstem river, showing the site had full tidal exchange.

2) Even the transects at the highest elevations were tidally inundated for at least part of the year, compared to zero inundation before restoration.

3) Inundation time was higher at all restoration transects in 2015 compared to 2013, supporting our conclusion that the tidal inundation regime has been fully restored.

4) Average wetland surface elevation in sample transects at Ni-les'tun was 2.1 m NAVD88. Samples transects at the Bandon Marsh Unit were slightly higher (2.3 m).

5) The elevation of sample transects at Ni-les'tun and Bandon Marsh was, on average, 4.6 cm higher in 2015 than 2011. This result could be due to differences in survey methods and survey conditions, or to sediment accretion.

Emergent wetland plant community composition

6) Within vegetation sample transects, there were no significant changes to species richness, total cover, native plant cover, or non-native plant cover from 2013 to 2015.

7) Plant species richness and total cover were still significantly lower in 2015 compared to baseline (2010) at the Ni-les'tun restoration site – the product of reduced diversity as vegetation adjusts to the increased stress of inundation and salinity.

8) Across all transects at Ni-les'tun, percent cover of two species changed significantly between pre-restoration (2010) and year 4 post-restoration (2015): common orache (a native species) increased from 0.1% average cover in 2013 to 10.6% in 2015, and birdsfoot trefoil (a non-native) dropped from 11.7% average cover in 2013 to $< 0.01\%$ in 2015.

9) At the Bandon Marsh reference site, cover of two low marsh species increased significantly between 2010 and 2015: fleshy jaumea (5.0% in 2010 versus 11.5% in 2015), and pickleweed

(3.1% in 2010 versus 9.6% in 2015).

10) The composition of plant communities at the restoration site appeared to be moving towards low salt marsh rather than precise convergence with the reference site. This result was not unexpected, since the reference site transects were chosen to represent the original high marsh that was found at Ni-les'tun historically, so their elevation is higher than the subsided wetland surface at Ni-les'tun.

Emergent wetland plant community mapping

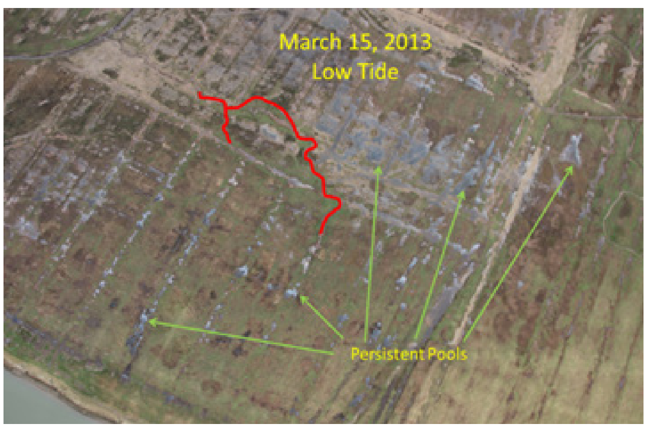
11) Plant communities at Ni-les'tun changed substantially between 2013 and 2015. Native-dominated communities increased by about 17 ha (42 acres), and non-native dominated communities decreased correspondingly.

12) Salt-tolerant early colonizing species such as brass buttons and common orache dominated a larger area of the site in 2015 compared to 2013, indicating vegetation is far from stabilized and is still changing rapidly in response to the 2011 restoration actions.

13) The area dominated by the non-native pasture species tall fescue was halved in 2015 (39.4 ha) compared to 2010 (94.8 ha). Prior to restoration, tall fescue was the most prevalent grass at the site. In 2015, most areas formerly dominated by tall fescue were dominated by the native high tidal marsh species Baltic rush.

14) Plant community patterns in 2015, even more than in 2013, showed intergraded distributions of individual colonizing species, and corresponding lack of zonation. These characteristics indicate the site is still in the early stages of vegetation recovery.

Figure 44. Aerial photographs of the same area of Ni-les'tun before and after new channel construction in 2014
The red line indicates the same existing channel in both views for reference. Note that the pools that did not drain during low tide showing in the *Left* photo do not persist after the new channels were constructed (*Right*). These pools had provided breeding habitat for mosquitoes. The pale "dotted lines" visible in the *Right* photo are the unvegetated spoil piles adjacent to the channels.



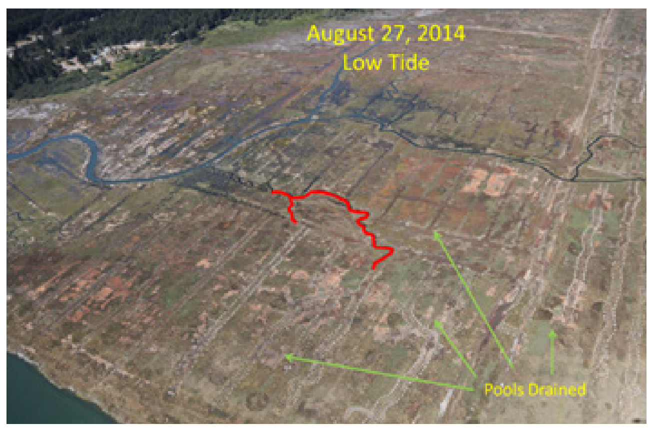
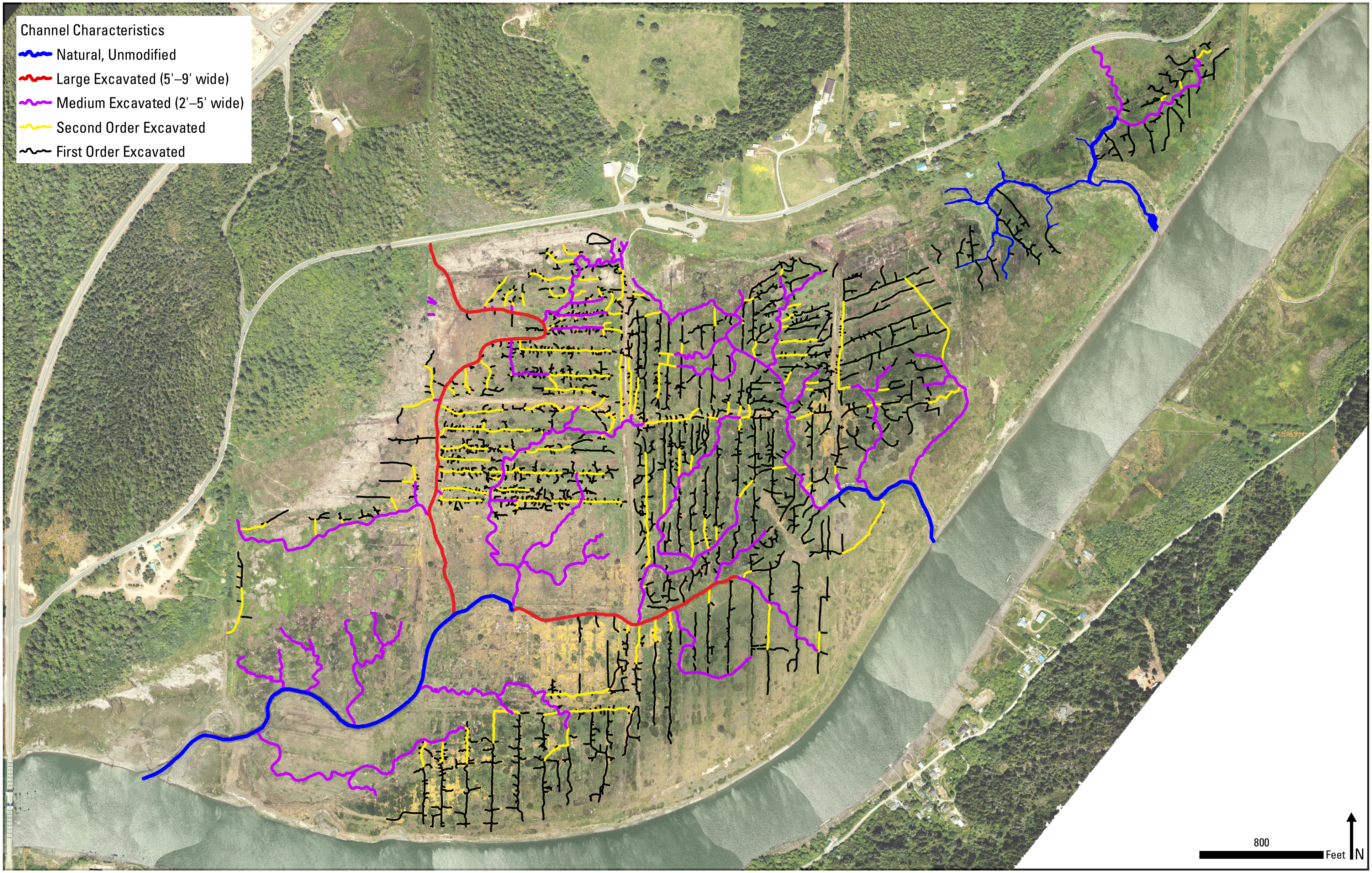


Figure 45. Map of the complete tidal channel system of Ni-les'tun after 22.7 miles of first and second order channels were constructed in 2014
Note that the new small channels were aligned with the old minor ditches with short branches connecting to small adjacent basins.



8. Four Years after the Tides Return – Consequences and Lessons Learned

8.1 The restoration was a success

The term "restoration" as used in this report refers both to the physical changes made on site to alter the hydrology and improve fish and wildlife habitat (i.e., tide gate and dike removal, construction of the tidal distribution system, LWD placement, woody plantings); and the ongoing process of development toward full ecological function of the tidal marsh initiated by these changes. By all metrics employed to monitor the restoration, it is a success in both meanings of the term. The primary ecological driver of the return of the daily tidal flows had the immediate effect of initiating the biological responses to the new conditions that are shifting the entire ecological community toward that of a fully functioning tidal marsh system. Those responses were accelerated by the later construction of the smaller channels that greatly facilitated the extent of the tidal exchange. The inherent mobility of animals permitted their rapid response to the new conditions: birds, fish, mammals, and invertebrates that had been absent, or nearly so, on site before started using the site almost immediately after the tides returned. Plants intolerant of the new salinity and inundation regimes began to die shortly after exposure, and the slower process of colonization by tidal marsh species began. Plant and microbial responses to gradual biophysical changes in the marsh soils will continue for many years, but those processes are underway. No one knows how long it will take for the marsh to achieve its full potential for productivity and high quality habitat for species of conservation concern, but it is indisputable that it is already well on its way to that goal, and is already providing important benefits.

This success notwithstanding, one of the most important objectives of this report is to communicate what has been learned to date about the consequences of the design and implementation decisions (Section 2, Major design decisions) that were taken by the restoration team, whether those consequences were positive or negative relative to the project goals. The intent is to provide enough information so future restorationists can decide if these lessons apply to their projects, and, if so, increase confidence that their decisions will lead to desired outcomes.

8.2 Design decision: Replace existing ditch system with constructed undersized, larger order tidal channels only

Rationale

Rectilinear ditch system did not provide sufficient aquatic habitat diversity; undersizing larger channels permitted more channel length for same cost, and channel dimensions would adjust to flows; excavating first and second order channels was cost prohibitive and it was assumed they would develop with time.

Consequences and Lessons Learned

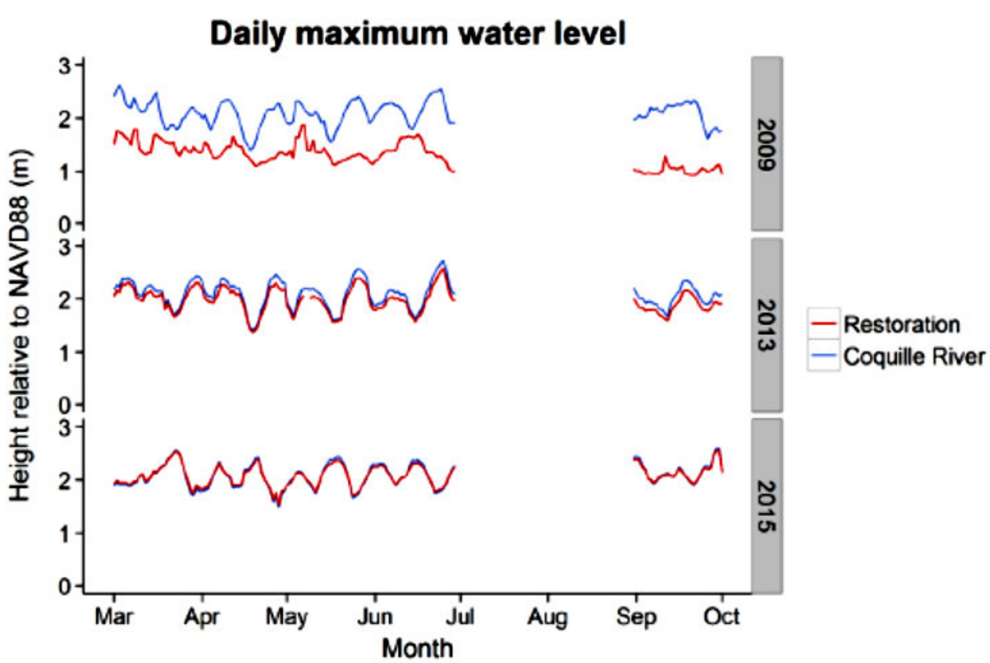
Excavated channel adjustments generally followed predicted patterns: sloped banks became vertical or undercut as widening occurred, and the most rapid and extensive changes occurred in the lower parts of the systems where flow rates and volumes were highest. On average, excavated channels throughout the marsh became deeper (Brophy et al. 2014). The least amount of change occurred near the heads of distributional channels with no significant fresh water input. Contrastingly, the lower mainstems of the three streams experienced headcutting from the river upstream that deepened them significantly, while bank erosion also caused substantial widening. All channels developed a diversity of benthic habitat characterized by thalweg formation and adjacent deposition of fine sediments. One result of the strategy to dig undersized channels is that sediment exported to the estuary, although not quantified, was likely substantial, and the potential effects of that on the river need to be considered.

The natural development of new lower order unexcavated channels was very limited. Erosive forces strong enough to form headcuts occurred in only a handful of places where marsh table topography focused water draining from large areas during ebb tides. Besides the relatively low energy of the slow moving water over most of the table, the dense roots and stems of living and dead vegetation covering most of the site add to the resistance to soil erosion. It is difficult to predict how long it would have taken to develop the extensive system of small channels necessary to maximize tidal exchange efficiency, but based on the slow start, it would certainly have taken several decades, and perhaps it would never have reached the channel density seen in naturally developed tidal marshes (Figure 46). The new lower order channels dug in 2014 and after have rendered such speculation moot.

The combination of undersized channels and no low order channels had a dampening effect on the tidal exchange. The unexcavated new mouth of Fahys Creek also contributed to tidal muting, especially truncating low tide levels (Brophy et al. 2014). However, the channel adjusted rapidly by widening and deepening, and tide and ground water level gauges showed that by the second year post-restoration, high tide levels across the site closely approximated those of the adjacent river (Brophy et al. 2014). By 2015 (Figure 47) the channel enlarged enough so that the high tide water levels in the marsh matched those in the adjacent river. Large channel enlargement in all three sub-basins has continued since then, and that plus the extensive additional lower order channels excavated in 2014 and after have undoubtedly increased the tidal prism.

Figure 46. Aerial photograph of a tidal marsh in Coos Bay that has been partially diked, but with most of the natural channel system remaining, illustrating the typical preponderance of low order channels
Examples of naturally developed channels that provide alternate pathways (short circuits) between sub-watersheds for tidal flow are indicated by the arrows.

Figure 47. Pre-restoration (2009) and post-restoration daily maximum tide heights for the Ni-les'tun restoration site (red), compared to the adjacent Coquille River (blue)
Note the poor synchrony before restoration; nearly matching curves in 2013 indicating some dampening of the highest tides in the marsh by restricted flow capacity of the main channel; and by 2015 the channel had adjusted to permit unrestricted tidal exchange with the river.



8.3 Design decision: Break up ground around small drainage ditches by discing and installing small check dams

Rationale

Prevent ditches from "short-circuiting" new channel system; avoid cost of filling.

Consequences and Lessons Learned

This turned out to be a very consequential decision, because it resulted in hundreds of small pools filled by bi-monthly high tides and providing extensive new mosquito breeding habitat. The design team predicted that some of these pools would exist, and considered whether they would constitute a fish stranding hazard, but that risk seemed minor and the depressions were expected to eventually silt in or develop connecting channels. The exploitation of the pools by mosquitoes was not predicted because no previous tidal marsh restoration in the team's experience had created a mosquito problem, in spite of at least a couple of them resulting in shallow ponding. The reason this problem arose at Ni-les'tun is because the extensive system of small drainage ditches there was atypical, and represented a novel challenge to the team.

This oversight could possibly have been avoided if mosquito experts familiar with the habitat requirements of *Aedes dorsalis* and other species had been consulted in the design phase.

The specific lesson in this region is to avoid creating tide pools at elevations above the average monthly high tide and below the highest high tides, where they would be periodically flooded and then abandoned by tidal exchange. The general lesson is that if there is any atypical aspect of the site or the implementation of the restoration plan that results in features not normally found in the system that is the target of the restoration, make the effort to involve relevant experts outside the design team for review and comment on the plan details. As a precaution, it would also be wise to conduct pre- and post-mosquito monitoring for any wetland restoration, and have the restoration plans reviewed by experts in the local mosquito species.

Ultimately, the construction of low order channels to solve the mosquito problem resulted in largely restoring the function of the small ditches that had been disrupted. In some cases, this did result in "short circuiting" tidal flow in the larger channels by creating channels connecting small sub-watersheds, but with little apparent consequence since flow in the large channels is still dominant, and such connections can readily be observed in natural tide marshes (Figure 46).

The necessity of placing the new low order channels in the paths of the original small ditches for them to function as intended resulted in less than natural sinuosity of these channels (Figure 45). It would be difficult to quantify the ecological implications of this, but it may reduce the benthic habitat diversity, and lengthen the time it will take for the channels to develop natural cross-sectional geometry. In cases where the second order channels were dug with larger cross sectional areas than necessary to accommodate tidal flows, fine sediments have accumulated and made them shallower. However, in most cases the concentrated flow through the channels has maintained or enlarged the constructed dimensions.

8.4 Construction process decision: Excavate most channels to design depth measured from local ground surface, rather than grade control from an established benchmark

Rationale

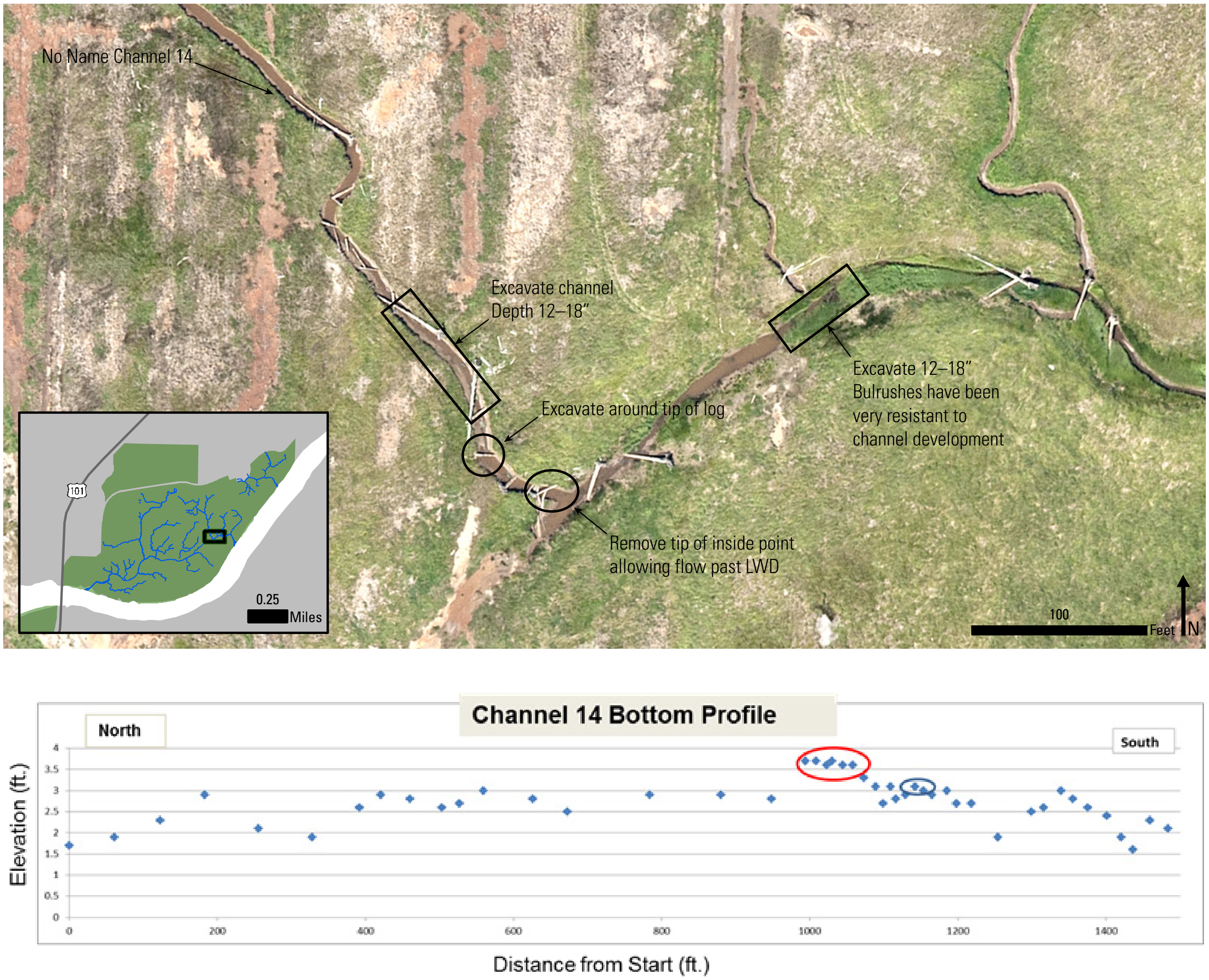
Save construction time and cost; channels would adjust over time.

Consequences and Lessons Learned

In spite of the channel system being designed with separate sub-basins based on general sloping of the site to the mouths of the three drainages, there were enough grade changes on site to result in several channels (other than stream channels, which were graded for positive drainage) with undulating bottom elevations. In the worst case, mid-portions of the channel were two feet higher than the lowest reaches upstream (Figure 47), resulting in substantial residual water in these low reaches at low tide. That water was potentially a hazard to salmonids if lack of tidal exchange allowed it to warm too much in the summer. Also, in the upper portions of the No Name Creek channel system, the restricted drainage during some high tide cycles was enough to interfere with the functioning of the low order channels installed to drain mosquito breeding pools. When this became apparent in 2014 during the new channel excavation, one excavation crew was diverted to remove the highest parts of the bottom of the No Name mainstem.

Figure 48 illustrates that remediation, and it was effective at reducing the time it took for water to drain out during low tide periods. The lesson learned from this experience is that it is worth the relatively minor extra time and expense to dig all channels to grade, and avoid this problem.

Figure 48. Illustration of the additional excavation of No Name channel 14 to improve flow capacity
The graph (*bottom*) shows the results of the DU channel bottom survey, and high spots in the channel bottom (in ovals) that were excavated. Spoils were spread on the adjacent marsh table. Refer to Figure 10 to see the topography of this area.



8.5 Design decision: Reduce some portions of the dike to nearly natural levee height, but leave part of the dike intact

Rationale

Avoid cost of disposing of large volume of spoils and disturbance of cultural resources; sheet flow through the designed dike breaches would be adequate for tidal and sediment exchange.

Consequences and Lessons Learned

The designed dike breaches have allowed near-equilibrium in water height over tidal cycles between the river and the marsh, although observations of currents over the marsh table during incoming high tides indicate that No Name sub-basin receives overflow from the Fahys Creek sub-basin as the tide breaches the divide. This may indicate that the No Name mouth has insufficient capacity to fill its basin directly; but it may also simply be because the Fahys mouth is approximately a mile downstream of the No Name mouth. Nonetheless, the fact that the dike was lowered most extensively at the southwest corner of the site does result in the bulk of the tidal prism passing over that area. Perhaps the most likely effect of leaving much of the dike intact is the reduction of the volume and distribution of water-borne sediments coming in from the river when it is at flood stage and carrying the most suspended sediment. Observations confirm that during flood events and high tides turbid water flows over most of the marsh, but it is relatively rare for river levels to overtop the intact dike and remove all barriers to intermixing. This may result in sediment deposition occurring disproportionately at the southwestern portion of the site, as opposed to areas adjacent to the river as would be expected if only the natural levees were present. If so, this could have implications for the marsh's resilience to sea level rise. In the final analysis these presumed effects have not been quantified, nor their ecological implications evaluated, and it is uncertain whether the additional costs associated with removing much more of the dike could be justified.

8.6 Construction process decision: Use mixed local material to fill large ditches; grade to surrounding ground level

Rationale
Maintain cut/fill volume balance on site; save cost of extensive hauling; avoid constructing barriers to surface drainage.

Consequences and Lessons Learned
Large ditches were filled with adjacent spoil piles when available, plus spoils from new channel excavation. This resulted in fill material of uneven texture, moisture content, and organic content that made it difficult to compact consistently and predict how much it would settle after final grading. Technical Specifications developed by the project engineer (Appendix A) instructed the contractor to limit fill lift thickness and compact each lift with heavy equipment; and to grade the fill to the level of the surrounding ground. Nevertheless, settling in some large ditch fill areas resulted in depressions that held water and provided mosquito breeding habitat. In retrospect, overfilling the largest ditches by approximately four inches probably would have minimized formation of breeding pools. In cases where such raised fill would significantly impede surface drainage, intermittent cross-swales a few feet wide could have been constructed.

8.7 Design decision: Place large diameter LWD in lower channels; rely on log insertion into bank for anchoring

Rationale
Larger logs would result in greater scouring effect; excavation of trenches and burial of logs would be more time-consuming and yield less reliable anchoring.

Consequences and Lessons Learned
A large proportion of LWD installed in mid to upper reaches of the respective sub-basins remained in place throughout the four years since restoration of the tides. However, by the second year substantial dislocation of LWD installed in lower mainstems was observed, especially in the unexcavated portion of Fahys Creek which suffered nearly complete loss. Figure 49 illustrates LWD retention at two year intervals over the entire site which averaged 66.4% of all logs with root masses, and 71.8% of all LWD pieces. The vast majority of LWD loss occurred due to a combination of factors: (1) log buoyancy and current forces, greatest on the largest logs, overwhelming soil resistance to breakout, (2) difficulty of inserting large logs deep enough to prevent fracture of overburden, and (3) extensive erosion of channel banks, likely exacerbated by the LWD, unburying the inserted portions of the logs. Most LWD dislocations occurred during winter high tides in conjunction with storm winds that produced the greatest stress on the logs. Dislodged LWD were generally pushed higher into the marsh and none were known to exit the site.

Although the pre-restoration channel modeling exercise (So et al. 2009) was used to estimate how wide the new lower drainage channels should be, there was a large variation of similar order natural channel sizes, making the data difficult to interpret. This, and the presumption that the width of the remnant channels approximated their historical widths, led to a substantial underestimation of the channels' enlargement that would occur as they adapted to the new tidal flows. Apparently, the channel remnants had actually been either intentionally or incidentally narrowed during the years they had been non-tidal. It is also possible that the remnant Fahys Creek channel did not historically carry the tidal volumes to which it is now subjected. In retrospect, had the team allocated funds to allow for a hydraulic model for this largest channel (Fahys) given the size of the watershed and tidal prism volume, it might have been clear that bank insertion would not be adequate for anchoring the LWD. The cost of a hydraulic model in 2009 would have likely been between $30,000 and $50,000 compared to $115,000 for materials and implementation of the complete LWD design for the site. Alternatively, obtaining soil profiles adjacent to the remnant channels might have revealed more information about historic channel widths and depths. Soil profiles could have been obtained using coring or trenching in strategic locations.

Most of the LWD was still intact in summer 2013 when monitoring found that LWD was having the desired effect on channel habitat diversity and fish use, and these effects are likely continuing where LWD remain. LWD loss could perhaps have been mitigated by a combination of using smaller diameter logs of a denser species (e.g. Sitka spruce), thus reducing the loosening forces against the logs and allowing deeper insertion; and avoiding installation in reaches where strong currents and substantial bank erosion could be anticipated.

8.7 Design decision: Promote and hasten tidal swamp restoration with woody plantings and nurse log placement

Rationale
Natural establishment of woody plants is greatly inhibited by dense existing marsh vegetation and shallow aerobic soils.

Consequences and Lessons Learned
Due to the demands associated with the mosquito crisis, intentions to better maintain and monitor these plantings were not realized, and survival rates suffered. No systematic count of woody plant survival was conducted, but the areas were monitored informally. Survival of the woody plantings was variable depending on species and planting area. Hooker's willows have some tolerance for salinity, but clearly many of the plantings were exposed to too much salt and mortality was nearly 100% in the lower parts of Area 1 and 2 (Figure 50), but survival of willows planted in slightly higher elevations was well over 75%, and for

the roadside plantings nearly 100% . That was expected because willows were intentionally planted out into the marsh to establish where the salinity became too great for their survival. Many willows and some spruce were cut down by beavers in areas 2 and 3; some of the willows are re-sprouting, but the spruce trees were killed. Many of the Pacific crabapples and twinberry were subjected to heavy deer browse, and did not survive. There was good survival of the spruces planted using scalping and elevated mulch beds, and the planting of tall stock that could compete with the dense grass and sedges for light undoubtedly contributed to their survival. Spruce survival ranged from an estimated 75% in areas 1 and 4, to about 50% in the remaining areas. The greatest survival for all species also occurred in areas 1 and 4 where there was no beaver activity, and the ultimate goal of expanding the area of woody growth closer to the natural ecotone boundary was achieved.

Some nurse logs placed around the edge of the spruce swamp were moved by winter flood waters, but they all remained near where they were placed. Most of these logs have not decomposed enough to make good germination beds for woody plants yet, but a few are supporting a few small plants. The logs that were installed have been supplemented by LWD that had become naturally stockpiled along the west boundary dike before restoration, and have been moved into the restoration site by high water events since the dike was removed. Many of these are decayed enough to serve as nurse logs now, and others will be in the next few years.

Figure 49. The number of LWD elements (logs plus pins) installed by 2011 before tides returned, and numbers remaining in place in 2013 and 2015

Logs are 40 foot trunks with root masses attached, and “Total pieces” refers to Logs plus the smaller pins used to anchor them.

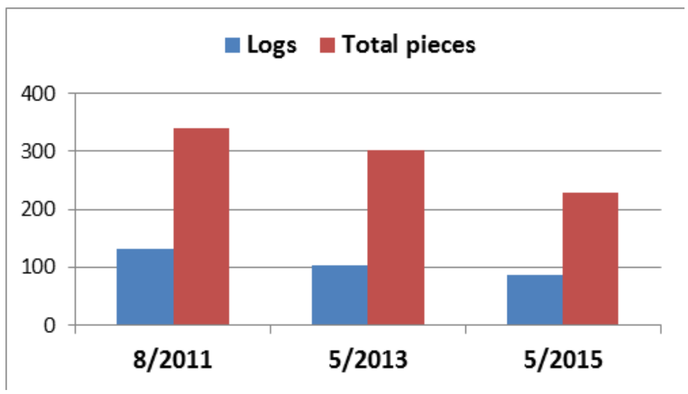
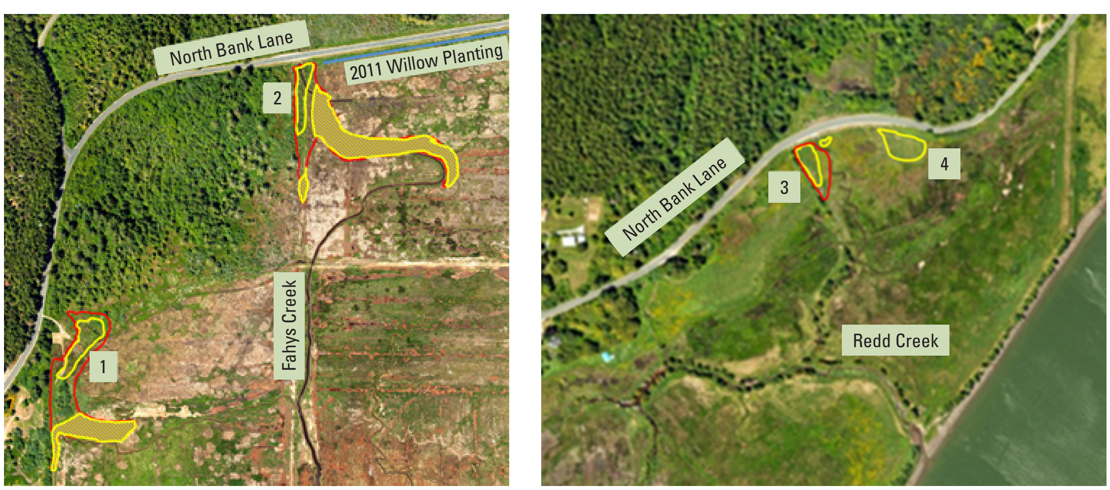


Figure 50. The fate of woody plantings

The shaded parts of areas 1 and 2 show where willows died due to salinity exposure. Trees planted in areas 2 and 3 close to the respective streams suffered extensive beaver cutting. Some crabapple and twinberry in area 1 suffered from deer browse. The 2011 willow planting along North Bank Lane shown in the left image continued to thrive except at the extreme west end where beavers have cut them. The red polygons outline where willow whips were planted in March 2013. The yellow polygons outline where Sitka spruce, Pacific crabapple, and twinberry were planted in December 2013.



9. Actual Costs

Total costs for the tidal wetland restoration project include costs of the ancillary projects (road upgrade, power line burial, and non-tidal riparian restoration), and costs incurred that were not expected or obtained in 2009 (additional efficacy monitoring, mosquito abatement). Table 16 lists those costs and funding sources. The total cost of the efficacy monitoring (approximately $500,000) was funded from several sources, and is included in the Restoration Construction and Monitoring Total. Not included in Table 15 or this report are costs associated with acquisition and management of the Ni-les'tun Unit, nor salaries of all the USFWS staff who worked on various aspects of the restoration.

Table 16. Costs and funding sources associated with completion of the Ni-les'tun Restoration Project, including efficacy monitoring, infrastructure improvements, and the adaptive management response to the mosquito problem

Funding Source	US $
Ni-les'tun Restoration Construction and Monitoring	
M/V New Carissa Oil Spill Settlement	1,625,000
OR Watershed Enhancement Board	902,331
USFWS	516,400
National Fish and Wildlife Foundation	45,000
Ducks Unlimited	142,000
Cape Arago Audubon Society	10,000
Restoration Construction Total	3,240,731
North Bank Lane Improvement	
Federal Highway Administration - Western Division	4,200,000
USFWS - Refuge Roads	372,107
Road Improvement Total	4,572,107
Coos Curry Electric Cooperative Powerline Burial	
USFWS - American Recovery and Reinvestment Act	2,719,440
Mosquito Management Plan 2013–2016	
OR Watershed Enhancement Board	196,434
USFWS	839,022
Mosquito Management Total	1,035,456
Project Grand Total	**11,567,734**

10. Conclusion and Recommendations

Due to its size, complexity, and ecological importance, the Ni-les'tun tidal wetland restoration project presents an outstanding opportunity to examine the many decisions made by the restoration team during the planning and execution of the project and the consequences of those decisions relative to the goals and objectives of the restoration, for the benefit of managers of this Refuge, and to inform future tidal wetland restoration projects. This report and its appendices were compiled to present a complete record of the project for that purpose. Although it is not possible to include the content of uncounted thousands of hours of discussion among the team members and with others that had influence on the outcomes, an attempt was made to include adequate information to the reader for an understanding of the factors considered during the most important decision takings, why the decisions were taken, and what the results of those decisions were on the ground. Perhaps even more edifying, we have presented illustrations of the inherent risks of unintended consequences from manipulating a large and complicated landscape, and important lessons in humility. Some things that were predicted did not happen, and some things happened that were not even considered. In spite of these, the project successfully restored a functioning tidal marsh, with all of its intended benefits. There are many conclusions, lessons, and recommendations implied and explicit in this report and its appendices, but the following is a summary of the major recommendations derived from the collective experience of the restoration team:

1) Prepare for unexpected contingencies. Given the scarce resources available for restoration projects this may seem like a luxury, but when developing a budget be liberal with estimated costs. It is very likely that some line items will end up costing more than expected, and unanticipated items may arise. Fortunately for the Ni-les'tun project, the contractor's bid was well under the engineer's estimate of the construction costs, and the remainder became available for many unplanned, but needed expenses. The budget also included an explicit contingency fund of approximately 20% of estimated costs, which is entirely prudent for projects of this complexity. Apart from this, cultivating strong agency and institutional supporters for the project will be helpful if the need for additional resources arises.

2) If the historic tidal channel system is not intact, place a high priority on creating as nearly a natural configuration of all channel orders as possible. If the budget can only afford a given volume of earth-moving, it is better to excavate undersized channels to get more linear feet of channel from that volume. Undersized channels will adjust to hydraulic forces, so consider what effects sediment export to receiving waters will have. Design a system that will connect all small basins on the site to the tidal exchange. Do not assume that channels will develop on their own unless that can be justified with appropriate hydrological and geophysical studies.

3) Develop and maintain strong local community support for the project with a systematic public education plan implemented early in the project planning process. Engage community leaders and organizations with detailed information about the justification, goals, and benefits of the restoration. Present plans to community groups, and encourage open field trips to the site to demonstrate how the project will change the landscape, and continue that process throughout and after the project is completed. This community support will be critical for balancing opposition to the project, and building political capital and good will in case unforeseen problems develop.

4) It is a cliché among restorationists, but nonetheless true that efficacy monitoring is extremely important, especially for large or otherwise highly visible projects. It is also true that it is becoming increasingly difficult to fund a comprehensive monitoring program, but the effort is worth it. For the Ni-les'tun project, monitoring set in a BACI framework not only provided scientifically defensible facts about the benefits of the restoration to counter spurious claims about the lack of benefits, but was critical for evaluating the consequences of choices made by the design team to inform other teams faced with similar choices. Finally, monitoring is integral to adaptive management, and unexpected outcomes requiring a management response are highly likely in large, complex projects.

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Appendix A. DU Technical Specifications and Selected Construction Drawings

Ducks Unlimited, Inc.

MAIN MARSH
TECHNICAL SPECIFICATIONS

NILESTUN UNIT RESTORATION:
UFWS BANDON MARSH NWR
DU PROJECT NO. OR-23-2

April 21, 2010

REGISTERED PROFESSIONAL ENGINEER
14898PE
OREGON
MAY 22, 1990
RANDOLPH K. VAN HOY

EXPIRATION DATE: 6/30/10

INDEX TO TECHNICAL SPECIFICATIONS

MAIN MARSH

SECTION 2000
DESCRIPTION OF WORK

Part 1 - General

1.01 DESCRIPTION

The Main Marsh portion of the project contains the following work. The excavation work involves levee, road, spoil and tide gate removal; and stream channel excavation. The fill work involves levees, grading, ditch plugs, and ditch fill. Other work includes rock riprap, large woody debris placement, tidegates, site preparation, and erosion control.

1.02 PROJECT LOCATION & ACCESS

The site is 2 miles north of Bandon, Oregon. The site is located just east of Highway 101 on the north bank of the Coquille River in Coos County. The site is part of the Oregon Coast National Wildlife Refuge Complex and is owned by the US Fish and Wildlife Service (USFWS).

1.03 ELEMENTS/TASKS

There are nine elements to the Main Marsh portion of the project, described below.

A. Site Preparation
B. Levee, Road, Spoil and Tidegate Removal
C. Excavate Stream Channels and Tidal Channels
D. Levee and Watershed Divide Installation
E. Ditch Plugging and Filling
F. Rock Riprap
G. Tidegates
H. Large Woody Debris Installation
I. Erosion Control

1.04 PERMITS

All permits have been obtained by the owner, USFWS. Copies of permits shall be supplied to the Contractor to be kept on site by the Contractor. It is the Contractors responsibility to follow all conditions in the permits.

1.05 PRIORITY OF WORK

The Contractor shall prioritize and order construction to meet the contract and specification requirements.

1.06 CONSTRUCTION SCHEDULE

A draft construction schedule shall be submitted with the bid package. The draft construction schedule shall include beginning and end dates for each bid item and the equipment proposed to be used on each bid item.

Within 7 days after a contract is signed the Contractor shall submit a final construction schedule. The final construction schedule shall include beginning and end dates for each bid item, order and the equipment proposed to be used on each bid item. The Contractor shall be responsible for providing all scheduling information as required in the specifications below.

1.07 CONTRACTOR COORDINATION

Construction by Others is scheduled on and near the project site during the Summer of 2010. The U.S Department of Transportation Contractors will be working on North Bank Road during the summer of 2010 with a projected work window of June 1 to October 15, 2010. US Fish and Wildlife Service Contractors will be working on the main powerline on the east side of the project site with a projected work window of June 14 to August 20, 2010. Coordination between The U.S Department of Transportation, US Fish and Wildlife Service, Ducks Unlimited, Inc. and their Contractors shall be required. Coordination meetings shall be held weekly or as needed to ensure safe and viable working conditions.

Utility work is also scheduled along North Bank Road and in the Cranberry Bog area by the local Utilities.

1.08 CONTRACTOR'S QUALITY CONTROL

It is the intent of these specifications and the contract drawings that the work performed under the contract shall result in a complete operating system in satisfactory working condition with respect to the functional purpose of the installation, and no extra compensation will be allowed for anything omitted but fairly implied. The prices paid for various items in the proposal shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and doing all work necessary to complete the finished product as provided in the plans and specifications.

The statement "or equal" in these specifications shall mean that the Contractor may substitute another manufacturer's product as a substitute for that specified. The Contractor will thereby warrant that the product will perform as good or better than that replaced. The statement "or approved equal" in these specifications shall mean that the contractor must submit information and obtain prior approval from the Engineer before making a substitution. Acceptance as equal by the Engineer does not relieve the Contractor of responsibility for the performance of the substitute product.

Where the contract requires that materials or equipment be provided or that construction work be performed, and detailed specifications of such materials, equipment, or construction are not set forth, the Contractor shall perform the work using materials and equipment of a quality comparable to the materials and workmanship specified for other parts of the work and at least equal to the general standard of quality found within existing work, from firms of established good reputations, and shall follow best practices in the performance of construction work. The work performed shall be in conformity and harmony with the intent to secure the best standard of construction and equipment of work as a whole or in part.

1.09 SUBMITTALS

The Contractor shall be responsible for providing submittal information for approval as required in these specifications to the Engineer before purchasing the material or performing the work. The Engineer will review and approve or reject initial submittals in writing within 7 working days after receipt by the Engineer. Where the Engineer requests additional information or rejects an initial submittal, the Engineer shall use such time as is necessary to review the additional materials or new submittals.

1.10 INSPECTION AND TESTING

All work performed by the Contractor shall be inspected by the Ducks Unlimited Project Engineer or his appointed Representative. All final decisions shall be made by Ducks Unlimited Project Engineer. Inspection and testing will be performed in accordance with specifications. Where inspection is required, the Contractor shall provide 48 hours notice to the Engineer. The Engineer shall make every effort to provide inspection on shorter notice.

1.11 CONSTRUCTION STAKING

The Engineer shall provide initial elevation reference points and horizontal alignments. It is the Contractors responsibility to establish and maintain construction staking as required to meet the specified tolerances.

1.12 CONTRACTOR SUPERINTENDENT

The Contractor shall at the start of construction designate a Superintendent or other employee to act as liaison for all communication on the project. This individual shall be responsible for requesting inspection, notifying the Engineer when segments of work are complete, and communication of instructions to all employees and sub contractors on the site. Except in emergency situations all specified notifications, submittals, and communications shall be considered valid only if they are received from the Superintendent. The Superintendent shall attend coordination meetings with Other Contractors weekly or as needed to ensure safe and viable working conditions.

1.13 SITE PROTECTION

The work location is open to the public. The Contractor shall provide protection devices including barricades, fencing, warning signs, lights, and other devices necessary to ensure security and safety within the project site during all aspects of the work.

In accordance with generally accepted construction practices, the Contractor shall be solely and completely responsible for the conditions of the jobsite, including safety of all persons and property during the performance of work. Excavations shall meet the requirements of OSHA 29

CFR 1926, Subpart P, Excavations. The duties of the Project Engineer do not include the review of the adequacy of the Contractor's safety in, on or near the jobsite.

1.14 UTILITIES

It is the responsibility of the Contractor to comply with the provisions of ORS 757.541 to 757.571. The Contractor is responsible for locating utilities prior to the start of construction. The Contractor shall be liable for any damage to utilities caused by construction activities. It is the Contractor's responsibility to contact the Utilities Underground Location Center at 1-800-424-555. Ducks Unlimited makes no representations as to the existence or nonexistence of utilities.

1.15 CULTURAL RESOURCE MONITORING AND SENSITIVE AREAS

Cultural Resource monitoring shall be performed by a combination of US Fish and Wildlife Service staff, consultants, and staff of the Coquille Indian Tribe. All ground disturbing earthwork or traffic that affects the natural ground surface shall be considered for monitoring. Details from the report approved by the State Historic Preservation Officer are contained in the following table:

CULTURAL RESOURCE MONITORING

No.	ITEM	CR Monitoring Required	Comments
	Main Marsh		
1	Mobilization	None	
2	Site Preparation	None	
3	Mowing	None	
4	Temporary Crossings	None	
5	Construction Access	None	
6	Access Rock	None	
7	Remove old culverts	None	
8	Remove debris/junk/fences,etc.	None	
9	Remove Pilings	None	
10	Excavate Tidal Channels	Continuous	Lower Area
		Continuous	Sensitive Areas
		Intermittent	Elsewhere
11	Excavate Redd Creek Channel	Intermittent	
12	Fill Redd Creek Ditch	None	
13	Remove Spoils	Intermittent	
14	Enhance East Levee	Intermittent	Stripping
15	Enhance NorthWest Levee	Intermittent	Stripping
16	Install Tidegate at NW levee	None	

17	Install Ditch Plugs	Continuous	During stripping
		None	During Fill
18	Fill Ditches	None	Note: Quarentine Areas
19	Fill Minor Ditches	None	-
20	Install Temporary Tide Gate at Fahys	Continuous	
21	Plug Fahys Ditch Mouth	Continuous	During stripping of plugs
		None	During Fill
22	Rock Riprap	None	
23	Excavate Fahys Channel	Continuous	Lower Area
		Intermittent	Upper Area
24	Fill Fahys Ditch	None	
25	Install Watershed Divides	Intermittent	Stripping
26	Install LWD	None	
27	Remove Farm Roads	None	
28	Remove Temporary Crossings	None	
29	Remove Levees	Continuous	River Levee
		Intermittent	NoName Levee
		Continuous	West end NoName
		Intermittent	Sothwest Levee
30	Remove Tide Gates	Continuous	
31	Excavate Fahys Creek Mouth	Continuous	
32	Repair Haul Roads	None	
33	**Cranberry Bog**	None	

The Contractor shall provide notification prior to undertaking any of these activities requiring monitoring. Extra care to ensure monitoring shall be taken in Sensitive Areas, as shown on the drawings or as flagged at the construction site. All earthwork in the Sensitive Areas requires Continuous Monitoring. Access shall be limited and controlled in Sensitive Areas. A traffic plan in Sensitive Areas must be submitted by the Contractor and approved by the Engineer. If human remains are discovered stop construction immediately, secure the site and contact the County Sheriff. If cultural materials are discovered stop construction immediately and contact the Project Engineer. The Contractor shall be responsible for mitigating any damages to sensitive areas that are a result of construction activities not monitored by the Archeologist and approved by the Project Engineer.

Other Sensitive Areas
Other sensitive areas are shown on the plans and shall be staked in the field. The following conditions shall apply to Other Sensitive Areas:

1. USGS 'SET' LOCATIONS: Do not disturb, Maintain a 30 foot radius buffer.
2. USGS GROUNDWATER LOCATIONS: Do not disturb, Maintain a 10 foot radius buffer.
3. ENDANGERED PLANT LOCATIONS: Do not disturb, Maintain a 10 foot buffer.
4. VEGETATION STUDY AREAS: Limited access, no heavy traffic. Any access or traffic in these areas shall be approved by the Engineer.

1.16 CONTROL OF SURFACE/SUBSURFACE WATER

The Contractor is responsible for control of surface water, subsurface water and drainage during the construction period. All temporary fills, crossings, or culverts necessary to promote drainage will be installed and removed at the Contractor's expense prior to acceptance of the work. The Contractor shall order and schedule channel excavation and ditch filling to maintain drainage of surface and sub-surface water to prevent wet working conditions, damage to haul roads and the existing marsh surface. Any claims arising from upstream or downstream damages as a result of the construction or failure of these temporary works will be the Contractors responsibility. No additional payment will be made to the Contractor for any work to be done as a result of adverse weather conditions or changing site conditions during the construction period.

1.17 TIDES

The site will be affected by tidal fluctuations. Tide predictions for Bandon, Oregon may be found at http://tidesandcurrents.noaa.gov/tides10. Predicted tide elevations are based on mean lower low water level (MLLW) and the plans are based on the vertical datum, NAVD88. Where the MMLW elevation is 0.00, the NAVD88 elevation is 0.03 feet. Tide predictions are calculated for basic conditions at Bandon, Oregon. Actual tide elevations on the site may vary from those predicted.

1.18 DUST CONTROL

The Contractor shall comply with all regulatory requirements for dust control on the project site.

1.19 BURNING

Burning of brush or slash shall not be allowed. Fire prevention measures shall be taken to prevent the start or spreading of fires which result from construction activities.

1.20 SANITARY FACILITIES

Sanitary facilities such as chemical toilets shall be located at least 100 feet from moving water to prevent contamination of surface or subsurface water.

1.21 STAGING AND FUELING EQUIPMENT

Designated staging areas will be determined in the field to minimize air, soil, and water pollution. The Contractor shall park all inactive equipment in only these designated locations. Refueling shall be performed at least 100 feet from the Coquille River and flowing streams and channels. All fuel and oil spills shall be cleaned up and disposed at the sole expense of the Contractor. The Contractor shall have onsite at all times a spill containment kit. The Contractor's employees shall be trained in the use of the kit.

*** END OF SECTION ***

SECTION 2050
MOBILIZATION

Part 1 - General

1.01 DESCRIPTION

The work shall include the supply and transport of all labor, material and equipment to successfully complete that project as shown on the plans or described by the Engineer. Mobilization shall also include securing all permits for moving equipment on public roadways, construction permits, and other applicable permits.

Part 2 - Materials (not used)

Part 3 - Execution

3.01 GENERAL

The Contractor shall conduct all mobilization operations in a timely orderly manner. Unless otherwise approved by the Engineer, mobilization operations shall commence no later than one week after the notice to proceed. De-mobilization shall be finished within two weeks after substantial project completion.

During all operations, the Contractor is responsible for maintaining public and private property in original condition. Damage to existing roadways, roadway shoulders, fences etc shall be repaired to the satisfaction of the Engineer at the Contractors expense.

Part 4 - Measurement and Payment

Mobilization shall be measured and paid on a lump sum basis (L.S.) for the entire project. 50% of contract unit price shall be paid at the first billing. The remaining 50% of the contract unit price shall be paid at project completion.

A Contractor is eligible for a separate mobilization payment when the Contractor is required to discontinue work by the Corporation for reasons other than seasonal termination of work. The payment shall be payment in full for supply of all necessary labor, equipment, and materials to perform mobilization operations herein described and all work in this specification. The payment shall be commensurate to the amount of equipment and materials that are required to be removed from the project site and that payment shall not exceed the original unit price specified for mobilization.

*** END OF SECTION ***

SECTION 2100
SITE PREPARATION

Part 1 - General

1.01 DESCRIPTION

This specification shall cover the supply of all labor, materials, and equipment required for mowing, clearing, grubbing and stripping on the site as well as site access and demolition and removal.

1.02 SCOPE OF WORK

A. Mowing
B. Clearing, grubbing and stripping
C. Site Access
D. Demolition and Removal

Part 2 - Materials (not used)

Part 3 – Execution

3.01 MOWING

Mowing shall consist of the cutting grass, sedges and other ground cover to facilitate construction staking by the Engineer. Areas to be mowed shall be designated by the Engineer. Equipment suitable for the vegetation and ground conditions shall be used.

3.01 CLEARING

Clearing shall consist of the cutting, removing, and disposal of all brush, trees, logs, vegetation, rocks, and stones larger than 6 in. in any dimension, and rubbish as needed to install items of work. Trees greater than 18 inches in diameter shall be grubbed and used in Large Woody Debris, not cut. The rootwad shall remain intact.

3.02 GRUBBING

Grubbing shall consist of the complete removal of all stumps and roots 1.5 inches or greater in diameter. Tree stumps greater than 6 inches in diameter shall be grubbed to a depth of 3 feet below the existing ground. Brush stumps less than 6 inches in diameter shall be grubbed to a depth of 12 inches below the existing ground.

3.03 STRIPPING

Stripping shall be done in the area to receive Engineered Fill and the areas specified below to receive Compacted Fill and in all excavation areas for Mineral Soil. The intent of stripping is to eliminate organic materials from excavated materials for subsequent fill and to provide a mineral soil base for earthfill. Organic materials shall be stripped regardless of the depth of material encountered to the satisfaction of the Engineer. Stripped material may used as Topsoil or Mixed Material.

3.04 DISPOSAL OF MATERIALS

Trees greater than 18 inches in diameter shall be incorporated into Large Woody Debris as directed by the Engineer.

Unless otherwise specified, woody material less than 18 inches in diameter shall be scattered on the footprint of the removed levee or the adjacent marsh surface as directed by the Engineer.

Woody material less than 1 ½ inches in diameter may be incorporated in Packed Material.

All stripped materials shall be used in Topsoil or Mixed Materials as specified in Earthwork. The Contractor shall coordinate stockpiles and respreading activities on nearby and more distant areas of the project site.

3.05 SITE ACCESS

Access to the work is the responsibility of the Contractor. During all operations, the Contractor is responsible for maintaining public and private property in original condition. Damage to existing roadways, roadway shoulders, fences etc shall be repaired to the satisfaction of the Engineer at the Contractors expense.

The Contractor's use of North Bank Road shall be in compliance with all applicable local, state and federal regulations. The Contractor shall contact the State and County highway departments as required. The required items may be, but are not limited to: Safety signage, flaggers, dirt control, and road cleaning.

The Contractor shall coordinate with Other Contractors working on North Bank Road. The U.S Department of Transportation Contractors will be working on North Bank Road during the summer of 2010 and 2011. The USDOT work window has been reported as June 1 to October 15, 2010. Road closures on North Bank Road have been reported as a total of 21 days between July 12 and August 21, 2010. Road closures are expected at Fahys Creek for 14 days and at Redd Creek for 7 days. Each of these two road closures will occur at separate times. Access to the site at the center farm road should be available from either the east or the west at all times. Access to the site should remain open at all times at the Northeast and Northwest Construction Accesses. However, road filling operations around Fahys Creek and Redd Creek may cause temporary delays and require coordination with the Road Contractor.

U.S. Fish and Wildlife Service Contractors will be working on the main powerline on the east side of the project site with a projected work window of June 14 to August 20, 2010. Trenching across the entire project site is expected as well as boring to the north and south of the site.

Access across trench may require coordination with the Utility Contractor.

Utility work is also scheduled along North Bank Road and in the Cranberry Bog area by the local Utilities.

Do not operate equipment or vehicles hauling material or equipment on Randolph Road between Highway 101 and North Bank Road.

Onsite Access
Onsite access to work areas on the site is varied. Maintaining access over the site and limiting damage to the natural ground surface is the responsibility of the Contractor. Low ground pressure equipment shall be preferred in all natural ground areas.

The Contractor shall submit a Hauling Plan by July 1, 2010 for approval by the Engineer. The Hauling plan shall be used to limit damage to the existing wetland surface and the areas requiring haul road decommissioning. The Hauling Plan shall include the following items. Haul roads shall be designated for long distance and high volume hauling. For short distance and lower volume hauling haul patterns shall be designated for tidal channel segment excavation and ditch fill areas. Travel paths may be spread to reduce rutting in short haul areas and lower volumes. Final haul routes shall be designated for final levee and tidegate removal. Haul routes in sensitive areas shall be designated. The haul plan shall include haul road improvements, esp. at the SW levee and haul road maintenance benchmarks to maintain functional access and limit damage to the wetland surface.

All Haul Roads and damaged haul routes and patterns shall be repaired as specified in SECTION 2200:EARTHWORK, Decommission Haul Roads.

Temporary Crossings and Construction Access Ramps shall be as described in SECTION 2200:EARTHWORK.

3.06 DEMOLITION AND REMOVAL

Demolition and Removal consists of removing existing pipe, metal, concrete, plastics, treated wood and other debris from project work areas. Demolition may include removing fencing, culverts, pipe and other materials found during construction and not necessarily shown on the plans. All materials shall become the property of the Contractor and be removed from the site in compliance with all applicable local, state and federal laws.

All tidegates shall be salvaged by the Contractor, returned, undamaged, to the USFWS and stockpiled onsite.

Part 4 - Measurement and Payment

Mowing shall be measured and paid on a per acre (AC) basis. Measurements shall be made by the Engineer.

Clearing, Grubbing, Stripping, Disposal of Materials, and Site Access shall be considered incidental to Earthwork, no separate payment shall be made.

Demolition and Removal shall be measured and paid on a cubic yard basis (CY) removed from the site and properly disposed of. Measurement shall be based on dump tickets from a disposal site or landfill measured to the nearest tenth of a cubic yard.

*** END OF SECTION ***

SECTION 2200
EARTHWORK

Part 1 - General

1.01 DESCRIPTION

The work shall include the supply of all labor, material and equipment required to complete the work as shown on the plans and as staked in the field. The excavation work involves levee, road and tidegate and spoil removal; and stream channel excavation. The fill work involves levees, watershed divide, ditch plugs, and ditch fill.

1.02 SCOPE OF WORK

A. Levee, Road, Spoil and Tidegate Removal
B. Excavate Stream Channels and Tidal Channels
C. Levee and Watershed Divide Installation
D. Ditch Plugging and Filling
E. Access Improvements
F. Rock Riprap

1.03 INSPECTION

The Engineer will perform onsite inspection during construction. In addition, the Contractor shall call for inspection at the following points of construction:

A. Upon discovery of major changes in soil composition during excavation
B. Prior to ground disturbing activities requiring Cultural Resource monitoring
C. Prior to tidegate removal
D. Prior to excavation of 'natural' stream channels
E. Prior to working in very wet areas
F. Prior to final top soil placement
G. Prior to installing rock riprap

1.04 CUT AND FILL VOLUMES

All earthwork quantities are based on in-place material; engineered, compacted, packed, or natural. Haul quantities are not considered. Cut and fill are balanced. However, excess material may be excavated from the Cranberry Bog if required. The Contractor shall manage topsoil excavation and stockpiling to ensure coverage of completed fills where specified.

Part 2 - Materials

2.01 MINERAL SOIL

Mineral soils shall consist of clean, onsite soils. No boulders, organic material or muck shall be permitted in mineral soil. Mineral soils shall be used for Compacted or Engineered Fill. If granular or organic materials are exposed during construction the Contractor shall immediately notify the Engineer. Granular or organic materials shall not be used for Mineral Soil.

2.02 MIXED MATERIAL

Mixed material shall consist of mixed mineral soil, topsoil, and rock generated from general excavation operations. No woody vegetation greater than 3 inch in diameter shall be permitted in mixed material.

2.03 TOP SOIL

Topsoil shall consist of mineral soil and organics generated from stripping and excavating operations. No woody vegetation greater than ½ inch in diameter or rock greater than 2 inches in diameter shall be permitted in topsoil. Topsoil shall be used to cap fills areas as specified below.

2.04 ROCK RIPRAP

Stone for riprap shall conform to the following gradation:

Rock Size	Percentage Passing
18"	100
15"	50-90
9"	20
6"	5

All rock riprap shall be composed of hard, durable, and resistant to abrasion. All material shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings. The apparent specific gravity shall be a minimum of 2.5. Rounded rocks and cobbles shall not be used.

Part 3 - Execution

3.01 EXCAVATION AND FILL TOLERANCES

Excavations and fills shall be constructed to within 0.1 ft of elevations shown on the plans. Horizontal orientation shall be as shown on the plans and staked in the field by the Engineer.

Should fill settlement occur during the construction and within seven days of substantial completion, and prior to acceptance of the work, additional material shall be placed and trimmed to achieve final grade by the Contractor at his own expense. After fills have been constructed to grade, they shall be leveled and trimmed to conform to the lines, grades and cross-sections shown on the plans and/or as staked.

3.02 ENGINEERED FILL

Engineered Fill shall be composed of Mineral Soil excavated onsite. Engineered Fill material shall be placed in loose lifts of not more than 8" thickness and shall compacted by three passes of a sheepsfoot roller. With the Engineer's approval the initial layer may be increased in thickness in wet areas to provide a working pad capable of supporting the construction equipment.

The footprint of Engineered Fill shall be cleared, grubbed and stripped in accordance with Site Preparation. The initial lift shall be placed on disturbed soil after stripping is completed. Engineered Fill material shall be placed in successive layers across the entire width of the fill area. The Engineered Fill at all times must be maintained in a reasonably level condition and compaction equipment shall be directed over the full width of each layer to facilitate uniform compaction. Stockpiling on the fill surface shall not be permitted. All fill construction must be as continuous as possible and the fill maintained such that drainage is assured at all times. If material is excessively wet, mixing of dry and wet material may be required.

3.03 COMPACTED FILL

Compacted Fill shall be composed of Mineral Soil or Mixed Material excavated onsite, as specified below. Compacted Fill material shall be placed in loose lifts of not more than 12" thickness and shall be compacted by three passes of a sheepsfoot roller or wheel tired equipment. With the Engineer's approval the initial layer may be increased in thickness in wet areas to provide a working pad capable of supporting the construction equipment.

The footprint of Compacted Fill shall be cleared, grubbed and stripped in accordance with Site Preparation, for the items specified below. The initial lift shall be placed on disturbed soil after stripping is completed. Compacted Fill material shall be placed in successive layers across the entire width of the fill area. The Compacted Fill at all times must be maintained in a reasonably level condition and compaction equipment shall be directed over the full width of each layer to facilitate uniform compaction. Stockpiling on the fill surface shall not be permitted. All fill construction must be as continuous as possible and the fill maintained such that drainage is assured at all times. If material is excessively wet, mixing of dry and wet material may be required.

3.04 PACKED FILL

Packed Fill shall be composed of Mixed Material excavated on site. Packed Fill material shall be placed in successive layers not more than 18 inches thickness or dumped and spread in 18 inch layers ahead of hauling equipment. With the Engineer's approval lift thickness may be increased in wet areas to provide a working pad capable of supporting the construction equipment. Packed Fill material shall be compacted by three passes of wheel tired or tracked equipment.

No stripping is required; the initial lift shall be placed on the existing ground surface. If material is excessively wet, mixing of dry and wet material may be required.

3.05 TEMPORARY CROSSINGS

Temporary Crossings of existing ditches and excavated channels may be installed by the Contractor as required for site access. Temporary Crossing designs and locations shall be submitted to the Engineer for approval. Temporary Crossings shall be designed by the Contractor to provide construction access, provide fish passage and to limit sediment generation and turbidity. The Contractor is responsible for the function and maintenance of Temporary Crossings. Temporary Crossings constructed of culverts and neat compacted earthfill are acceptable. All Temporary Crossings shall be removed by the Contractor.

3.06 CONSTRUCTION ACCESS RAMPS

Construction Access Ramps shall be Compacted Fill of Mineral Soil installed in accordance with the plans at the two locations shown. Ramps shall be filled for smooth access to North Bank Road. Stripping shall not be required. The minimum length of rocked surface shall be 50 feet. Access rock shall be well graded 3 inch minus.

Installation of Construction Access Ramps shall be coordinated with the Roadwork Contractor.

3.07 EXCAVATION: LEVEE REMOVAL

All interior work possible shall be completed prior to final levee and tidegate removal. To ensure that levee removal is performed in a timely manner, the Contractor shall provide a detailed, written Levee Removal Plan by August 1, 2010. This plan shall include timelines, daily goals, production rates, planned fill areas, tidegate removals and equipment to be used. The plan shall also include haul road improvements and maintenance during the final removal as soil conditions get wetter. It shall also include a demobilization plan for the removal of access roads and final clean up after the levee is removed and tidal fluctuations are restored. The Contractor is responsible for completing all work contained in these plans and specifications.

The existing levees shall be removed as shown on the plans. The final removal elevations shall be as shown on the profiles. No excess material shall be removed due to cultural resource concerns. Levee excavation shall be performed out of the water at lower tides to prevent over topping and to maintain access. No in-water work shall be allowed without the written permission of the Engineer.

Levees shall be removed in stages. Levees on higher ground shall be removed first. Larger levees shall be removed in two stages to reduce the amount of material to be removed during the final window. The elevations and dimensions of the second removal stage of the levee shall be coordinated between the Contractor and the Engineer. The final levee removal window shall be a period of lower high tides from August 17, 2010 to September 4, 2010.

Excavated material to be used for Mineral Soil shall be cleared, grubbed and stripped in accordance with Site Preparation to provide clean mineral soil without organic material. Excavated material to be used for Mixed Material shall be only cleared and grubbed in accordance with Site Preparation to provide fill material without wood or brush. Mixed material excavated from the Southwest levee may contain woody vegetation up to 3 inches in diameter.

Noname Levee
The Noname Levee is located on the highest natural ground with final elevations of El. 8.5 feet to 9.0 feet. Do not disturb the old, wooden tide box remnants and pilings.

Southwest Levee
The Southwest Levee is located on the lowest and wettest natural ground. The Southwest Levee is covered in brush and two large trees. It is the Contractor's responsibility to remove the entire levee from STA. 0+00 to STA. 12+75 to the elevations shown on the profiles without disturbing the adjacent natural wetlands or adjacent cultural resources. Access is critical in this area and access improvements shall be required. Access improvements may include matts, plating, rock or other improvements. All access improvements shall be confined to the footprint of the existing levee and be removed as the levee is removed. The Contractor shall include these access improvements in the Levee Removal Plan. The plan shall include a written, detailed access plan including access improvements, access maintenance, and equipment to be used with the levee removal plan. Clearing and grubbing are not required on the Southwest Levee, except that the two large tress shall be salvaged and incorporated into Large Woody Debris as directed by the Engineer. Pilings along the west side of the Southwest Levee shall be removed, see item 3.21: PILING REMOVAL.

Remnant Levee
West of the current Southwest Levee are about 400 feet of the remains of a previous levee. This remnant levee shall be scarified to disturb the vegetation and loosen the soil to promote natural erosion. The remnant levee shall be scarified to the same elevation as the adjacent levee removal footprint as shown on the plans. No disturbance of the soil below this elevation shall be allowed due to cultural resource concerns. During scarification soil may be moved off the remnant levee footprint but no haul out is required. The Contractor shall include this work in the Levee removal Plan including access, equipment used and elevation monitoring methods. Pilings and wooden wall along the remnant levee shall be removed, see Item 3.21: PILING REMOVAL.

River Levee
The River Levee is the largest levee and is located on ground that ranges from low to higher. The larger portions of the River Levee shall be removed in two stages to reduce the amount of material to be removed during the final levee removal window. The western end of the River Levee is located in a sensitive area for cultural resources. Levee material from STA. 4+00 to STA 10+50 shall be used as fill in two "Quarantine Areas" so that possible disturbed cultural resources are confined to designated areas. The two Quarantine Areas are the Northwest Levee and the northern end of the ditch west of the center farm road. These areas shall be marked and monitored by the Engineer. All material removed from this section of the River Levee must moved to these two areas.

3.08 EXCAVATION: REMOVE FARM ROADS

The Farm Roads shall be excavated as shown on the plans to the natural ground surface as staked in the field by the Engineer. Material removed shall be used as ditch fill. Rocky material removed shall be placed in the bottom of ditches and covered with at least 12 inches of Topsoil. The footprint of the Removed Roads shall not be smooth graded but graded to match adjacent natural ground micro topography to provide a more 'natural' appearance.

The northern 300 feet of the center farm road shall be regraded to a foot trail as shown on the plans. The finished trail alignment shall have a sinuous 'natural' shape adjacent to the nearby excavated tidal channel (Reach #8). The foot trail shall be Compacted Fill as specified above.

3.09 REMOVE SPOILS

Existing spoils along ditches and channels shall be removed as shown on the plan. Spoil shall be removed to the existing ground level as staked in the field by the Engineer.

Excavated material to be used for Mineral Soil shall be cleared, grubbed and stripped in accordance with Site Preparation to provide clean mineral soil without organic material. Excavated material to be used for Mixed Material shall be only cleared and grubbed in accordance with Site Preparation to provide fill material without wood or brush.

3.10 EXCAVATION: TIDEGATE REMOVAL

The tidegates, appurtenances and earthen channel plugs shall be removed as shown on the plans and staked in the field by the Engineer. At Fahys Creek and Redd Creek all headwalls and pilings shall be removed, see Item 3.21: PILING REMOVAL. At Noname Creek the old, wooden tide box remnants and pilings shall not be disturbed. Tidegate removals shall be coordinated with levee removal and tide elevations. Tidegate excavation shall be out of the water at low tides wherever possible. In-water work shall be during low, incoming tide to reduce turbidity in the Coquille River. The Fahys Creek tidegate shall be removed during the installation of the Fahys Creek Plug Protection.

Pipes, metal, plastics, headwall and piling wood debris shall become the property of the Contractor and be removed from the site in compliance with all applicable local, state and federal laws as described in SECTION 2100: SITE PREPARATION, Demolition and Removal. All tidegates shall be salvaged by the Contractor, returned to the USFWS in existing condition and stockpiled onsite.

Excavated material to be used for Mineral Soil shall be cleared, grubbed and stripped in accordance with Site Preparation to provide clean mineral soil without organic material. Excavated material to be used for Mixed Material shall be only cleared and grubbed in accordance with Site Preparation to provide fill material without wood or brush.

3.11 EXCAVATION: FAHYS CREEK HISTORIC MOUTH

The Fahys Creek Historic Mouth shall be excavated as shown on the plans and staked in the field by the Engineer. This excavation shall be coordinated with the removal of the Southwest Levee. Excavation shall be out of the water at low tides wherever possible. In-water work shall be during low, incoming tide to reduce turbidity in the Coquille River.

Excavated material to be used for Mineral Soil shall be cleared, grubbed and stripped in accordance with Site Preparation to provide clean mineral soil without organic material. Excavated material to be used for Mixed Material shall be only cleared and grubbed in accordance with Site Preparation to provide fill material without wood or brush.

Temporary Tidegate
Prior to excavation a temporary tidegate shall be installed to maintain drainage of Fahys Creek during the installation of the Fahys Mouth Plug, See SECTION 2600, PIPES AND TIDEGATES. The temporary tidegate shall be at least 3 feet in diameter and have an invert below El. 3.0. The temporary tidegate shall be designed, installed, maintained and removed by the Contractor.

3.12 EXCAVATION: TIDAL CHANNELS

Excavate Tidal Channels to the line and grades shown on the plans and staked in the by the Engineer. The horizontal alignment shall follow a curved and "natural" shape. Excavate to the channel depth shown on the plans following the ground surface. Bottom elevations and grades will follow the ground surface and are not pre-set.

Excavated material to be used for Mineral Soil shall be cleared, grubbed and stripped in accordance with Site Preparation to provide clean mineral soil without organic material. Excavated material to be used for Mixed Material shall be only cleared and grubbed in accordance with Site Preparation to provide fill material without wood or brush.

3.13 EXCAVATION: NAMED CHANNELS

Named Channels to be excavated are Fahys Creek, East Fahys Creek and Redd Creek. Excavate Named Channels to the line and grades shown on the plans and staked in the field by the Engineer. The horizontal layout follows curved and "natural" shape. Bottom elevations, grades and cross-sections shall be as shown on the plan profiles.

Excavated material to be used for Mineral Soil shall be cleared, grubbed and stripped in accordance with Site Preparation to provide clean mineral soil without organic material. Excavated material to be used for Mixed Material shall be only cleared and grubbed in accordance with Site Preparation to provide fill material without wood or brush.

Flows in Named Creeks shall be maintained in each existing ditch until the new channel is constructed. Flows will then be diverted to the new channel. A temporary tidegate shall be installed at the Fahys Creek Historic Mouth, See SECTION 2600, PIPES AND TIDEGATES. Fish removal from the existing ditch shall be coordinated with the Engineer prior to diverting flows to the new channel.

The Fahys Creek and Redd Creek channels shall connect to new culverts under North Bank Road to be constructed by Others. The connections to the new culverts shall be coordinated with the Engineer and the Road Contractor.

The Redd Creek channel shall be extended upstream (north) of North Bank Road and the new culvert by Others. This channel shall be excavated as staked in the field by the Engineer.

Fish Removal
Fish Removal from the named Channels shall be coordinated with the Engineer prior to filling ditches. Fish Removal shall be performed by USFWS and ODFW staff under existing permits. Fish Removal shall be required, at a minimum, on Fahys Creek, East Fahys Creek, Redd Creek and the main east-west ditch.

3.14 COMPACTED FILL: EAST AND NORTHWEST LEVEE ENHANCEMENT

The East and Northwest Levee Enhancements shall be Compacted Fill as specified above, using Mineral Soil. The existing levees and the footprint of the levees shall be cleared, grubbed and stripped in accordance with Site Preparation. The levees shall be installed as shown on the plans at the locations staked in the field. Stripped material shall be respread over the levees after they are completed to grade. Each levee is located near neighboring properties. The property lines shall be marked by Others. No access, work or damage to neighboring properties shall be allowed.

The Northwest Levee is a designated “Quarantine Area” for River Levee material from between STA. 4+00 to STA 10+50. This area shall be marked and monitored by the Engineer.

3.15 COMPACTED FILL: WATERSHED DIVIDE

The Watershed Divide fill shall be Compacted Fill as specified above, using a combination of 50% Mineral Soil and 50% Mixed Material. Stripping shall be required. Stripped material shall be respread over the Watershed Divide. The Watershed Divide fill shall be installed as shown on the plan and staked in the field. The final grading shall follow a curved and “natural” shape.

3.16 ENGINEERED FILL: FAHYS MOUTH DITCH PLUGS

The Fahys Mouth Ditch Plugs shall be engineered fill and rock riprap. The Engineered Fill shall be as specified above, using Mineral Soil. The Engineered Fill shall be installed as shown on the plans at the locations staked in the field and shall have a top width of 20 feet and 2:1 sideslopes. The Engineered Fill shall be installed in the dry, using low tides, cofferdams and/or pumping as required. The footprint of the Engineered Fill shall be cleared, grubbed and stripped in accordance with SECTION 2100, SITE PREPARATION and muck removed.

On the bank of the Coquille River the Fahys Mouth Ditch Plug shall be installed after installing a temporary tidegate at the Fahys Creek Historic Mouth and removing the existing Fahys Creek tidegate.

Rock Riprap
Rock riprap shall be installed in a 2 foot layer on each outside face of the engineered fill where the fill is exposed. The rock riprap shall be machine placed as shown on the plans and staked in the field. Dumping in place shall not be allowed. Rock shall be placed to form an interlocked mass of larger and smaller stones.

3.17 PACKED FILL: FAHYS MOUTH FILL

The Fahys Mouth Fill shall be Packed Fill as specified above, using Mixed Material. The Fahys Mouth Fill shall be filled as shown on the plan and staked in the field after the Fahys Mouth Ditch Plugs are installed. Fill shall be placed after removing water from the ditch. Muck that builds up to prevent Packing shall be removed from the ditch. Removed muck may be used as Topsoil for ditch fill. No clearing, grubbing or stripping is required. The ditch shall be filled to the adjacent ground level as staked by the Engineer.

3.18 COMPACTED FILL: DITCH PLUG (TYPICAL)

Ditch Plugs shall be Compacted Fill as specified above, using Mineral Soil. Ditch Plugs shall be installed as shown on the plans at the locations staked in the field. Ditch Plugs shall be installed in the dry. The footprint of the ditch plugs shall be cleared, grubbed and stripped in accordance with Site Preparation and muck removed. Removed muck may be used as Topsoil for ditch fill. The top of each plug shall be one half foot above the adjacent land level as staked in the field. Ditch plugs sideslopes shall be 3:1.

3.19 PACKED FILL: FILL DITCHES

The existing ditches shall be filled with Packed Fill as specified above, using Mixed Material. The existing ditches shall be filled as shown on the plan and staked in the field after ditch plugs are installed. Ditch fill shall be placed after removing water from the ditch. Muck that builds up to prevent Packing shall be removed from the ditch. Removed muck may be used as Topsoil for ditch fill. No clearing, grubbing or stripping is required. The ditch shall be filled to the adjacent ground level as staked by the Engineer. The Contractor shall order and schedule channel excavation and ditch filling to maintain drainage of surface and sub-surface water to prevent wet working conditions, fish entrapment, damage to haul roads and the existing marsh surface.

The northern end of the ditch west of the center farm road is a designated “Quarantine Area” for River Levee material from between STA. 4+00 to STA 10+50. This area shall be marked and monitored by the Engineer.

Fish Removal
Fish Removal from the existing ditches shall be coordinated with the Engineer prior to filling ditches. Fish Removal shall be performed by USFWS and ODFW staff under existing permits.

Fish Removal shall be required, at a minimum, on Fahys Creek, East Fahys Creek, Redd Creek and the main east-west ditch. Fish Removal may be required on other ditches if conditions remain suitable for regulated fish during the summer months. Determination of which ditches require fish removal shall be by USFWS and ODFW staff.

3.20 PACKED FILL: FILL MINOR DITCHES

Most minor ditches were filled and or scarified in 2009. Some minor ditches will require additional filling. The minor ditches shall be filled with Packed Fill as specified above, using Mixed Material. The minor ditches shall be filled as staked in the field by the Engineer. The ditch shall be filled as staked by the Engineer. No ditch plugs, water removal, clearing, grubbing or stripping is required for filling minor ditches.

3.21 PILING REMOVAL

At Fahys Creek and Redd Creek all headwalls and pilings shall be removed. At NoName Creek the old, wooden tide box remnants and pilings shall not be disturbed. Pilings along the western side of the Southwest Levee shall be removed.

Pilings shall be removed by breaking off at or below the existing ground level using equipment onsite and chains as required. If pilings cannot be broken off at ground level they may be cut off. Full piling extraction is not desired or required. Excavation for piling removal is not allowed. Piling Removal shall be out of the water at low tides wherever possible. In-water work shall be during low, incoming tide to reduce turbidity in the Coquille River.

Piling materials shall become the property of the Contractor and be removed from the site in compliance with all applicable local, state and federal laws as described in SECTION 2100: SITE PREPARATION, Demolition and Removal.

3.22 DECOMMISSION HAUL ROADS

All haul roads shall be decommissioned by ripping and discing to reduce compaction and level the ground surface. Damaged haul routes and patterns shall also be decommissioned. All ruts more that 2 inches shall be repaired by the Contractor. Final grading shall smooth the ground surface to match the existing ground. Concentrated areas of rutting and damage shall be repaired by the Contractor to the satisfaction of the Engineer. If ruts are excessive and cannot be leveled with discing, the disturbed area shall be filled with Packed Fill, as specified above.

Part 4 - Measurement and Payment

Temporary Crossings shall be considered incidental to Earthwork.

Construction Access Ramp installation and removal shall be measured and paid on an individual (EA) basis. Measurement shall be made by the Engineer. Access rock shall be considered incidental to Construction Access Ramps.

All excavation and fill items, unless otherwise specified, shall be paid based on plan quantities on a cubic yardage basis (CY). Plan quantities are based on in place and/or compacted volumes. No separate measurement of excavation or fill shall be made after construction. The Contractor shall satisfy himself as to the accuracy of the plan quantities prior to bidding.

Filling Minor Ditches shall be measured and paid on a cubic yardage basis (CY). Measurements shall be by the Engineer,

The supply and placement of Rock Riprap shall be paid on a ton (TN) basis. Measurement shall be based on weight tickets from a certified scale measured to the nearest tenth of a ton.

Piling Removal shall be measured and paid on a lump sum basis (L.S.) for the entire project. Material disposal shall be included in Demolition and removal.

Decommission Haul Roads shall be measured and paid on a lump sum basis (L.S.) for the entire project.

*** END OF SECTION ***

SECTION 2600
PIPE AND TIDEGATES

Part 1 - General

1.01 DESCRIPTION

The work of this section shall include the supply of all labor, materials, and equipment required to install the permanent and temporary pipes and tidegates as called for on the drawings and/or specified herein.

Temporary Tidegate
The temporary tidegate shall be at least 3 feet in diameter and have an invert at El. 2.0. The temporary tidegate shall be designed, installed, maintained and removed by the Contractor.

1.04 SUBMITTALS

The Contractor shall submit plans and material list for the temporary and permanent tidegates and connections to the pipes.

1.04 INSPECTION

The Contractor shall request inspection of pipe installation 48 hours prior to placement of permanent pipe to allow inspection of the excavation and initial backfill.

Part 2 - Materials

2.01 APPURTENANCES

The Contractor shall supply all nuts, bolts, sealants, and all accessories recommended by the material manufacturer or necessary for a complete installation. All permanent pipe and materials shall be new. Materials supplied may be subject to inspection and tests by the Engineer or his representative. Temporary pipes and tidegates shall be functional quality but need not be new.

2.02 TIDEGATE

The permanent tidegate shall be a standard 24 inch aluminum flap gate, Waterman AF-41 or approved equivalent. The flap gate shall a spigot back type for attaching to the pipe. The dimensions of the spigotback and the outside diameter of the pipe shall be verified and submitted to the Engineer for approval. The method of attaching shall be submitted to and approved by the Engineer.

The temporary tidegate shall be a minimum of 36 inches in diameter and of functional quality.

2.03 HDPE PIPE

Permanent HDPE Pipe shall be 24 in diameter plastic pipe and have a smooth interior and annular exterior corrugations and shall be Hancor "Blue Seal" or approved equal. The HDPE pipe shall meet the requirements of AASHTO M294, Type S. Pipe and fitting material shall be high-density polyethylene meeting ASTM D3350 minimum cell classification 33542C. The corrugations shall be drilled on the outside to prevent floating. Each corrugation shall be drilled at 2 and 8 o'clock. Drill holes shall be 3/8 inch diameter.

The temporary pipe shall be a minimum of 36 inches in diameter and of functional quality.

2.04 CUTTOFF COLLARS

Cutoff collars shall be 6'X6' Agri Drain Anti-Seep Collars or approved equivalent.

2.05 ROCK RIPRAP

Rock shall be 18 inch diameter riprap. All rock riprap shall be composed of hard, durable, and resistant to abrasion. All material shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings. The apparent specific gravity shall be a minimum of 2.5. Rounded rocks and cobbles shall not be used.

2.06 CLAY SOIL

Clay Soil shall be class CL or ML according to the Unified Soil Classification System. If Clay Soil cannot be found onsite it shall be imported. The Contractor shall submit a 5 pound sample to the Engineer for approval. No boulders, organic material or muck shall be permitted in Clay Soil.

Part 3 - Execution

3.01 HANDLING AND STORAGE OF MATERIALS

All materials shall be handled and stored in careful and workmanlike manner to the satisfaction of the Engineer. Any damage to materials from storage or handling during transportation or installation shall not be allowed. The Contractor shall be responsible for replacement and reinstallation of the damaged materials at his/her own expense. Welding, drilling, bolting or otherwise attaching devises (temporary or permanent) to the structure to assist in structure installation is prohibited.

3.02 UNSUITABLE MATERIAL

No boulders, rock, organic material, muck or debris shall be permitted in the trench. This material will be classified as unsuitable material and treated as such.

3.03 EXCAVATION

Excavation, pipe assembly and backfill shall take place in dry conditions. The Contractor shall not overexcavate below specified lines and grades. If, in the opinion of the Engineer, the Contractor overexcavates material in an area, he shall replace at his expense the overexcavated material with suitable site material and compact that material to a density equal to the surrounding in-situ material, or to 95% of Standard Proctor whichever is greater.

3.04 ASSEMBLY OF PIPE

The Contractor, after preparation of the bed, shall assemble the pipe in accordance with the manufacturer's instructions and submitted methods approved by the Engineer. All pipe supplied to site shall be inspected prior to assembly for chipping or damage in handling and shall be repaired as directed by the Engineer. All materials damaged, distorted by more than 5 percent of nominal dimensions, lost, broken or deemed unsuitable due to the Contractor's method of installation, handling or from neglect shall be replaced by the Contractor at his expense.

The pipe connections to the tidgegate shall be assembled as submitted by the Contractor and approved by the Engineer. The tidegate and pipe shall be bolted together with stainless steel bolts, ½ inch in diameter, at a minimum. The connection shall be sealed and watertight using silicone sealant. The Cutoff Collar shall be installed as shown on the plans.

The assembled pipe is to be inspected by the Engineer before it is backfilled.

3.05 INITIAL BACKFILL

Initial backfill shall be, Clay Soil, deposited in horizontal, uniform layers not exceeding 6 inches in thickness before compaction. Each layer shall be thoroughly compacted throughout to ensure thorough tamping of backfill under the haunches and around the pipe. Compaction is to be achieved by hand and/or mechanical compaction, to a density of at least 95% of Standard Proctor. Compaction shall be done with care to minimize disturbance of in-situ subgrade. In the event the subgrade is too soft for efficient compaction, the initial backfill is to be compacted as directed by the Engineer. Compacted initial backfill shall extend to a depth of 2 feet above the top of the pipe for the entire width of the trench. Compaction equipment or methods that produce horizontal or vertical earth pressures which may cause excessive displacements or which may damage the installation shall not be used. Vehicles shall not be permitted to cross the pipe until initial backfill is completed.

3.06 FINAL BACKFILL

After initial backfilling has been completed, the remaining backfill, consisting of Mineral Soil, shall be placed in layers not exceeding 8 inches before compaction. Each layer shall be compacted by mechanical means to a density equivalent of at least 95% of Standard Proctor. Compaction shall be done with care to minimize disturbance of in-situ subgrade. Compaction equipment or methods that produce horizontal or vertical earth pressures which may cause excessive displacements or which may damage the installation shall not be used.

3.07 ROCK RIPRAP

The inlet and outlet of the pipe shall be protected with 12 tons of 18 inch riprap at each end. Riprap shall be machine placed over the pipe, dumping shall not be allowed.

Part 4 - Measurement and Payment

Permanent tidegate installation shall be measured and paid on an individual basis (EA) for each complete structure. Pipe, connections, cutoff collar, excavation, backfill, onsite clay soil, rock and all appurtenances shall be considered incidental to the installation.

Imported Clay Soil shall be measured and paid on a cubic yard basis(CY). Measurement shall be by the filled trench volume. All measurements shall be made by the Engineer.

Temporary tidegate installation shall be measured and paid on an individual basis (EA) for each complete structure. Pipe, connections, excavation, backfill, rock and all appurtenances shall be considered incidental to the installation.

*** END OF SECTION ***

SECTION 2700
LARGE WOODY DEBRIS (LWD)

Part 1 - General

1.01 DESCRIPTION

The work of this section shall include the supply of all labor, materials, and equipment required to complete the installation of large woody debris (LWD) as shown on the plans and as staked in the field. Large woody debris shall be provided by others and stockpiled onsite. All large woody debris shall be installed prior to levee and tidegate removal.

1.02 SCOPE

A. Place logs for Large Woody Debris
B. Install Large Woody Debris.
C. Install log pins
D. Install log piling anchors

1.03 INSPECTION

The Engineer or his appointed Representative shall be the designated Inspectors for this work. The Contractor shall call for inspection prior to the placement of all large woody debris. Inspection shall be continuous for placing, pinning, and anchoring large woody debris.

Part 2 - Materials

2.01 LOGS

Logs are provided by others and stockpiled onsite. At a maximum, logs are 24 inch to 36 inch DBH and 40 feet long. Many logs include attached rootwads. All rootwads shall be maintained in the existing condition. Some logs may need to be trimmed and/or cut to length on the site.

2.02 LOG PILINGS

Logs used for piles shall be selected or cut from the available stockpiled logs. In general, piles should be straight and have a reasonably uniform taper. The minimum butt diameter shall be 12-18 inches. Piles shall free from decay and unsound or grouped knots. Sound knots shall be less than 1/3 the pile diameter and less than 5 inches. Branches and snags shall be trimmed flush.

2.03 CLEARED TREES

Trees with a diameter of 12 inches or greater that are cleared or grubbed in conjunction with other work shall be stockpiled and used in conjunction with Large Woody Debris. Grubbed trees shall retain the rootwad. No trees will be cleared or grubbed specifically for large woody debris.

2.04 CHAIN

Chain shall be 3/8 inch Trawlex Marine chain or approved equivalent.

Part 3 - Execution

3.01 TRANSPORTATION OF LOGS

Logs are stockpiled onsite by Others.

3.02 PLACING LOGS FOR LARGE WOODY DEBRIS (LWD)

Logs shall be sorted and placed at the locations required for prior to installing Large Woody Debris (LWD) Large Woody Debris locations shall be staked in the field by the Engineer. The locations shown on the plans are schematic, not precise. Individual logs may be designated and marked by the Engineer for each Large Woody Debris unit.

3.03 INSTALLING CHANNEL MOUTH LARGE WOODY DEBRIS (LWD)

Three clumps of Channel Mouth Large Woody Debris (LWD) shall be placed in approximately 150 feet of each of the three main channels. Fahys Creek LWD begins upstream of the filled Fahys Mouth Ditch Plug. Noname Creek LWD has one clump below the existing tidegate and two clumps upstream of the existing tidegate. Redd Creek LWD begins just upstream of the exiting tidegate.

Each clump of Channel Mouth LWD shall consist of three individual logs anchored with pilings and pin logs. Individual logs shall be installed in general in accordance with the plans. Precise log location, angle, and orientation shall be determined by the Engineer during installation. Each individual log shall be installed on the channel bottom and anchored with a piling and pin log.

Log Piling Installation
All log pilings shall be driven in the presence of the Engineer. Log pilings shall be driven into the bottoms or sides of the channels. Piles shall be driven to a minimum depth of 10 feet below the existing ground surface or channel bottom. The top of all piles shall be below the top of channel bank. The top of the piling should not be flat cut but be rough and not uniform. The piles shall be protected during driving from splitting or cracking. Any pile split in driving, driven out of its proper location or driven below the specified elevation shall be corrected by one of the following methods, as approved by the Engineer:

1) The defective pile shall be pulled out and replaced or redriven.
2) A new pile shall be provided by the Contractor and driven adjacent to the defective pile

Each horizontal log shall be connected to an individual log with chain. The chain shall be wrapped around the log and piling twice. The chain ends shall be connected with ½ inch stainless steel bolts. The chain shall be stapled to the log and piling with 3-4 inch logging staples each. The chain shall be slightly loose to allow some movement of the individual log with the rootwad.

Pin Log Installation
All pin logs shall be driven in the presence of the Engineer. Pin logs shall be driven into the bottoms or sides of the channels. Pin logs shall be driven to a minimum depth of 10 feet below the existing ground surface or channel bottom. The top of all piles extend 5 feet above the ground surface. Pin logs should be driven at an angle to hold the main log to the channel bottom. The pin logs shall be protected during driving from splitting or cracking. Any pin log split in driving, driven out of its proper location or driven below the specified elevation shall be corrected by one of the following methods, as approved by the Engineer:

1) The defective pin shall be pulled out and replaced or redriven.
2) A new pin shall be provided by the Contractor and driven adjacent to the defective pile

3.04 INSTALLING LOWER CHANNEL LARGE WOODY DEBRIS (LWD)

Lower Channel Large Woody Debris (LWD) shall be single logs placed at approximately 100 foot intervals along the three main channels. Fahys Creek LWD shall be placed for approximately 1600 feet. Noname Creek LWD shall be placed for approximately 1000feet. Redd Creek LWD shall be placed for approximately 800 feet. Single logs shall be installed in general in accordance with the plans. Precise single log location, angle, and orientation shall be determined by the Engineer during installation. Single logs will be installed in channels of varying widths and vary in length from 40 feet to 30 feet. Some logs may be cut or trimmed to fit under the direction of the Engineer. Single logs will be installed by horizontally driving the cut end of the log into the bank. Excavation shall not be allowed. The driving depth shall be approved by the Engineer during installation. Pin logs shall be added if driving depths and angles are not approved.

3.05 INSTALLING 4th ORDER LARGE WOODY DEBRIS (LWD)

4th Order Large Woody Debris (LWD) shall be installed at approximately 50 foot intervals along tidal channel segments 14.0 and 14.2. 4th Order LWD shall be installed in general in accordance with the plans. Precise single log location, angle, and orientation shall be determined by the Engineer during installation. Three different types of LWD will be used: single logs, double logs-under and double logs over.

Single Logs
Single logs will vary in length from 15 feet to 20 feet. Some logs may be cut or trimmed to fit under the direction of the Engineer. Single logs will be installed by horizontally driving the cut end of the log into the bank. Excavation shall not be allowed. The driving depth shall be approved by the Engineer during installation. Pin logs shall be added if driving depths and angles are not approved.

Double Logs-Under
Double Logs-Under shall consist of an individual log with a rootwad in the bottom of the channel that is pinned under a log driven horizontally into the bank. Excavation shall not be allowed. The driving depth shall be approved by the Engineer during installation. Pin logs shall be added if driving depths and angles are not approved. Log lengths shall be as shown on the plans. Some logs may be cut or trimmed to fit under the direction of the Engineer.

Double Logs-Over
Double Logs-Over shall consist of a horizontal log with an individual log with a rootwad chained on top of the horizontal log. The horizontal log shall be driven into the bank in the bottom of the channel. Excavation shall not be allowed. The driving depth shall be approved by the Engineer during installation. Pin logs shall be added if driving depths and angles are not approved. Log lengths shall be as shown on the plans. Some logs may be cut or trimmed to fit under the direction of the Engineer.

Each horizontal log shall be connected to an individual log with chain. The chain shall be wrapped around the log and piling twice. The chain ends shall be connected with ½ inch stainless steel bolts. The chain shall be stapled to the log and piling with 3-4 inch logging staples each. The chain shall be slightly loose to allow some movement of the individual log with the rootwad.

3.06 INSTALLING ADDITIONAL LARGE WOODY DEBRIS (LWD)

If extra logs are available, Additional Large Woody Debris (LWD) shall be installed. Additional Large Woody Debris (LWD) shall be single logs driven horizontally into the steam banks. Precise single log location, angle, and orientation shall be determined by the Engineer during installation. Single logs will be installed in channels of varying widths and vary in length. Some logs may be cut or trimmed to fit under the direction of the Engineer. Single logs will be installed by horizontally driving the cut end of the log into the bank. Excavation shall not be allowed. The driving depth shall be approved by the Engineer during installation. Pin logs shall be added if driving depths and angles are not approved.

Part 4 - Measurement and Payment

Channel Mouth LWD shall be measured and paid on an individual basis (EA) for each clump of three logs installed. Placing, trimming, pinning, driving piles and chaining shall be considered incidental to the installation of each clump.

Lower Channel LWD units shall be measured and paid on an individual basis (EA) for log installed. Placing, trimming, pinning shall be considered incidental to the installation of each log.

4th Order Single LWD shall be measured and paid on an individual basis (EA) for log installed. Placing, trimming, pinning shall be considered incidental to the installation of each log.

4th Order Double Log-Under LWD units shall be measured and paid on an individual basis (EA) for each double log unit installed. Placing, trimming, pinning shall be considered incidental to the installation of each unit.

4th Order Double Log-Over LWD units shall be measured and paid on an individual basis (EA) for each double log unit installed. Placing, trimming, pinning and chaining shall be considered incidental to the installation of each.

Additional LWD units shall be measured and paid on an individual basis (EA) for log installed. Placing, trimming, pinning shall be considered incidental to the installation of each log

*** END OF SECTION ***

SECTION 2800
EROSION CONTROL

Part 1 - General

1.01 DESCRIPTION

The work of this section shall include the supply of all labor, seed, materials, and equipment required to complete installation of erosion control measures described below.

1.02 SCOPE

A. Seed and mulch areas specified below

1.03 INSPECTION

The Contractor shall call for inspection after preparing areas to be seeded.

Part 2 - Materials

1.04 SEED

Seed shall be labeled in accordance with the state laws. Bag tag figures will be evidence of purity and germination. Minimum purity shall be 95%. Minimum germination shall be 85%. The maximum percent of weed seed allowable shall not exceed 0.5%. No seed will be accepted with a date of test of more than 9 months prior to the date of delivery to the site. Seed that has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

A. Seed species: Species used shall conform to the following:

Common Name	Species
Blue wildrye	Elymus glaucus
California Brome	Bromis vulgaris
Tufted hairgrass	Deschampsia cespitosa
Tall fescue	Any Variety
Annual Ryegrass	'Golf' variety

B. Seed Mix: The following seed mix shall be used as specified:

Species	% Total by Weight	Lbs/Acre
Blue wildrye	9.1%	5 #/ac
California Brome	9.1%	5 #/ac
Tufted hairgrass	9.1%	5 #/ac
Tall Fescue	73.7%	40 #/ac
	100.0%	55 #/ac

1.04 STRAW MULCH

Straw mulch shall be clean, grass seed straw from local sources. Noxious weed seeds shall not be allowed.

Part 3 - Execution

1.01 SEEDBED PREPARATION

Areas to be treated shall be dressed to a smooth, firm surface. The seedbed shall be prepared by scarifying if necessary to provide a roughened surface so that broadcast seed will stay in place. Areas covered with strippings shall be over-seeded.

1.02 SEEDING

The seed mix shall be applied to the newly installed:

East Levee
Northwest Levee
Trail

And to the following disturbed areas within 200 feet of North Bank Road and above elevation 7.0:

Mobilization and Staging Areas
Construction Accesses

All seeding operations shall be performed in such a manner that the seed is applied in the specified quantities uniformly on the designated areas. Seed shall be spread by the broadcast method and raked or harrowed into the ground to provide seed soil contact. Seeding shall be done within 2 days after final grading is complete.

1.03 STRAW MULCH

Straw mulch shall be applied to all seeded areas. Mulch shall be applied at the rate of 1-50# bale/ 300 SF.

Part 4 - Measurement and Payment

Erosion Control shall be measured and paid on a per acre (AC) basis. Measurements shall be made by the Engineer.

*** END OF SECTION ***

Ni-les'tun Unit Restoration
USFWS Bandon Marsh NWR
OR-23-2

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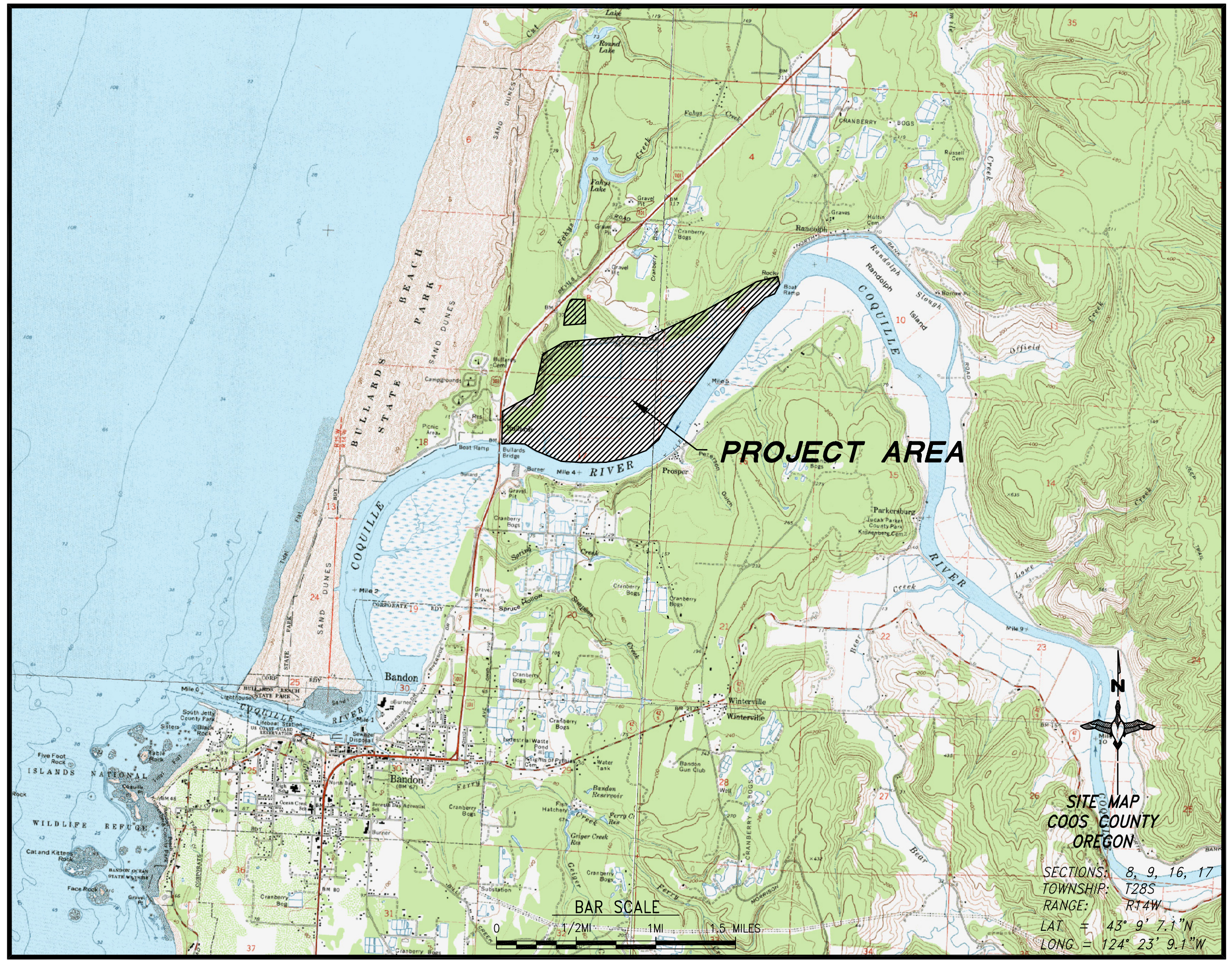

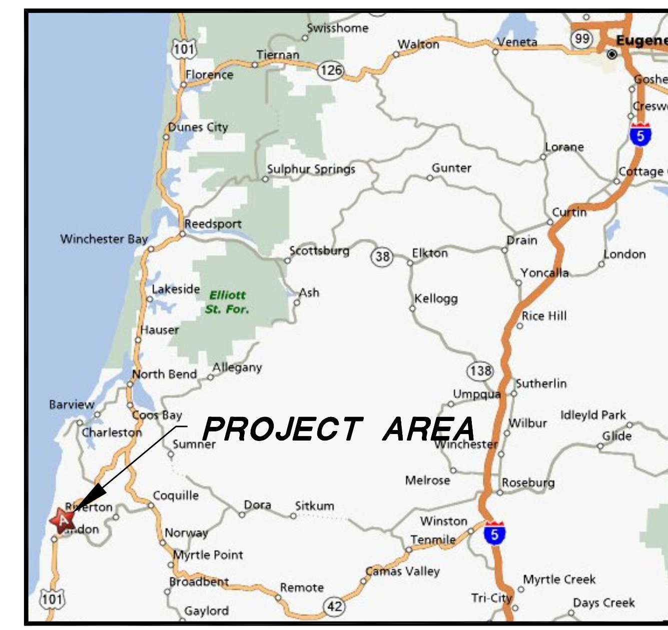

VICINITY MAP

GENERAL NOTES:

1. SHOULD THE CONTRACTOR FIND ANY DISCREPANCIES BETWEEN THE CONDITIONS EXISTING IN THE FIELD AND THE INFORMATION SHOWN ON THE DRAWINGS, HE SHALL NOTIFY THE ENGINEER BEFORE PROCEEDING WITH CONSTRUCTION.
2. SHOULD IT APPEAR THAT THE WORK TO BE DONE, OR ANY MATTER RELATIVE THERETO, IS NOT SUFFICIENTLY DETAILED OR EXPLAINED ON THESE PLANS OR IN THE SPECIFICATIONS, THE CONTRACTOR SHALL CONTACT THE PROJECT ENGINEER FOR SUCH FURTHER EXPLANATIONS AS MAY BE NECESSARY.
3. DUCKS UNLIMITED MAKES NO REPRESENTATIONS AS TO THE EXISTENCE OR NONEXISTENCE OF UTILITIES. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO COMPLY WITH THE PROVISIONS OF ORS 757.541 TO 757.571. THE CONTRACTOR IS RESPONSIBLE FOR LOCATING UTILITIES RPIOR TO THE START OF CONSTRUCTION. THE CONTRACTOR WILL BE LIABLE FOR ANY DAMAGE TO UTILITIES CAUSED BY CONSTRUCTION ACTIVITIES.
4. IN ACCORDANCE WITH GENERALLY ACCEPTED CONSTRUCTION PRACTICES THE CONTRACTOR WILL BE SOLELY AND COMPLETELY RESPONSIBLE FOR THE CONDITIONS OF THE JOB SITE INCLUDING SAFETY OF ALL PERSONS AND PROPERTY DURING PERFORMANCE OF THE WORK. EXCAVATIONS SHALL MEET THE REQUIREMENTS OF OSHA 29 CFR 1926, SUBPART P, EXCAVATIONS. THE DUTIES OF THE PROJECT ENGINEER DO NOT INCLUDE THE REVIEW OF THE ADEQUACY OF THE CONTRACTORS SAFETY IN, ON OR NEAR THE JOBSITE.
5. THE ENGINEER PREPARING THESE PLANS WILL NOT BE RESPONSIBLE FOR, UNAUTHORIZED CHANGES TO OR USES OF THESE PLANS. ALL CHANGES MUST BE IN WRITING AND MUST BE APPROVED BY THE PREPARER OF THESE PLANS.

ABBREVIATIONS

C-C	CENTER TO CENTER	N	NORTH
CMP	CORRUGATED METAL PIPE	NO	NUMBER, NORTH
DIA	DIAMETER	NTS	NOT TO SCALE
Dp	PIPE DIAMETER	OC	ON CENTER
Dr	RISER DIAMETER	PP	POWER POLE
DU	DUCKS UNLIMITED, INC.	PSI	POUNDS PER SQUARE INCH
EL, ELEV	ELEVATION	PVC	POLYVINYL CHLORIDE
EX	EXISTING	R	RIGHT
FB	FLASHBOARD	RD	ROAD
FG	FINISHED GRADE	REF	REFERENCE DIMENSION
FL	FLOW LINE	REQD	REQUIRED
FT	FOOT, FEET	SCH	SCHEDULE
FTG	FITTING	SO	SOUTH
GA	GAUGE	SP	SPECIAL
H	RISER HEIGHT	STA	STATION
ID	INSIDE DIAMETER	TE	TOP ELEVATION
IE	INVERT ELEVATION	TYP	TYPICAL
IN	INCH, INCHES	USA	UNDERGROUND SERVICE ALERT
INV	INVERT	VLV	VALVE
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LBF	POUNDS-FORCE	W	WATER
LF	LINEAR FEET	WS	SURFACE
MAX	MAXIMUM	WWF	WELDED WIRE FABRIC
MIN	MINIMUM	WCS	WATER CONTROL STRUCTURE
MISC	MISCELLANEOUS		

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UNAUTHORIZED CHANGES & USES
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SHEET INDEX

DRAFT

SURVEY DATUM	
SURVEY DATE:	2008
HORIZONTAL DATUM:	OREGON STATE PLANE SOUTH ZONE NAD83
VERTICAL DATUM:	NAVD88
GEOID MODEL:	GEOID99
CONTOUR INTERVAL:	1'
AERIAL PHOTO:	X

REV. NO.	DESCRIPTION	DATE	APPROVED
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4			
3			
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1			

DUCKS UNLIMITED INC.
PacNW Field Office
(360) 885-2011

PROJECT NO. US-OR-23-2
Ni-les'tun Unit Restoration
USFWS Bandon Marsh NWR

GENERAL INFORMATION
DESIGNED BY: RVH
DRAWN BY: DMC
SURVEYED BY: JPS
CHECKED BY:

DATE: 2-25-10
SHEET NO. 1
APPROVED BY:

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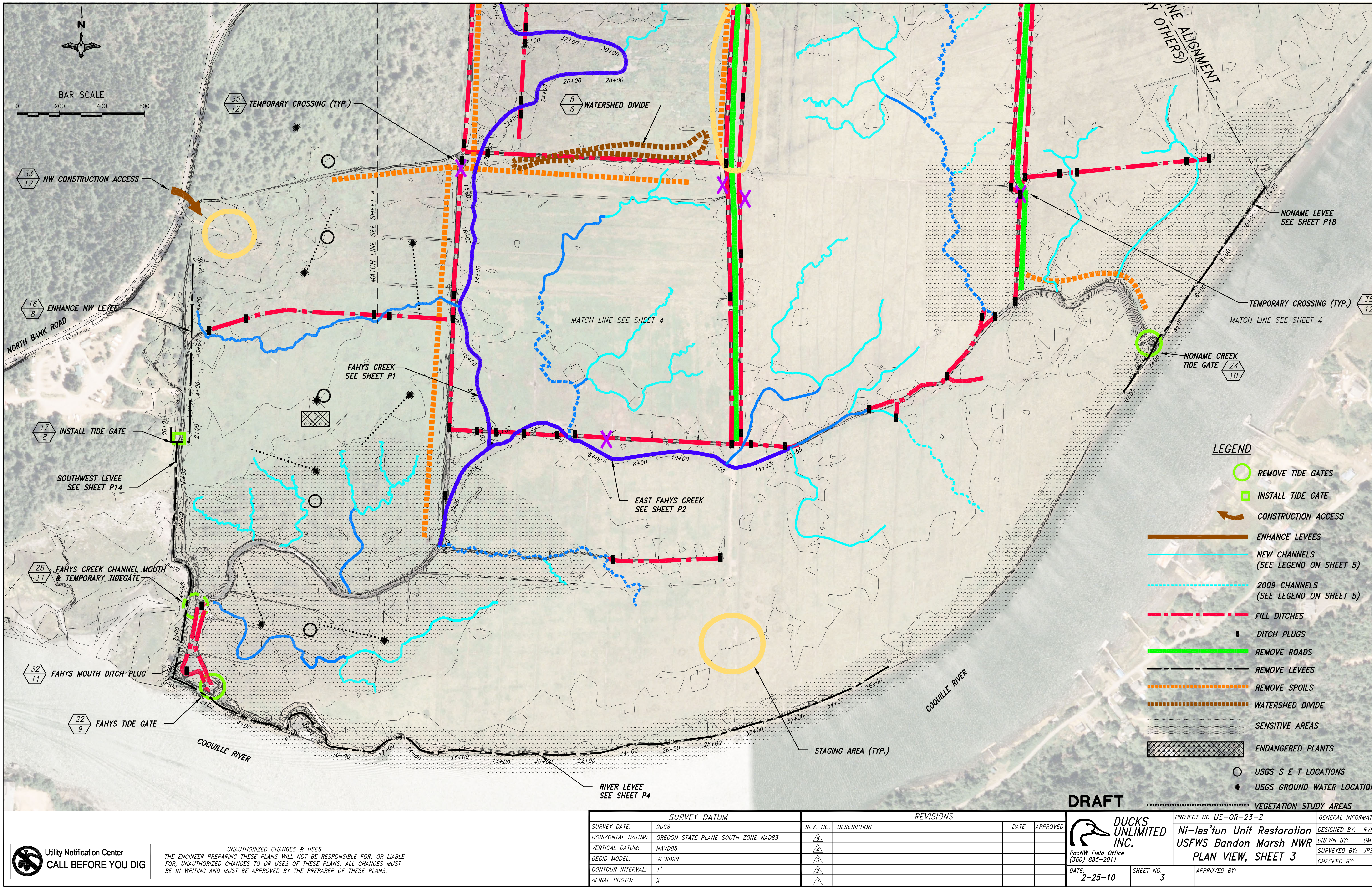

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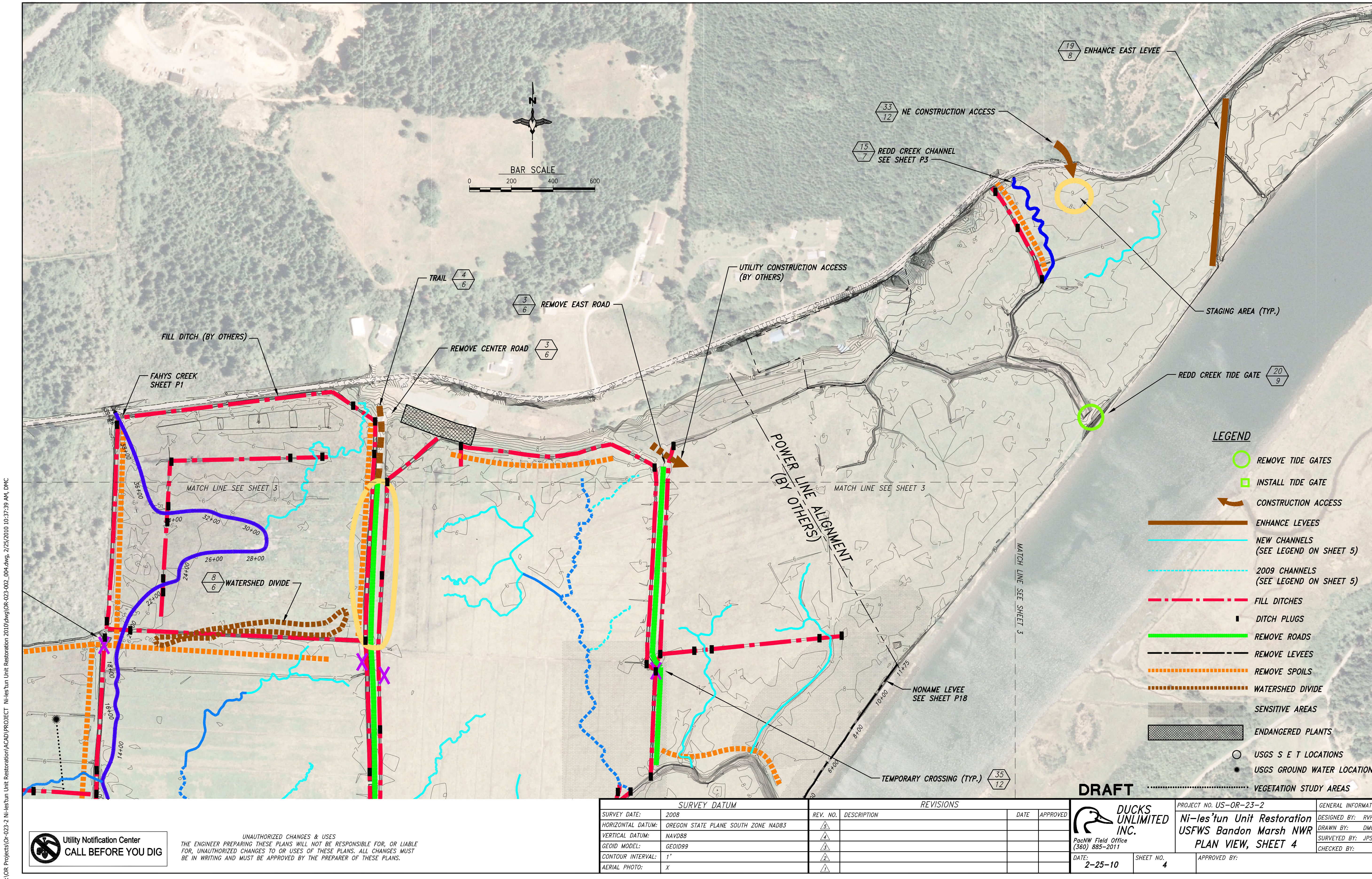
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19/8 ENHANCE EAST LEVEE
33/12 NE CONSTRUCTION ACCESS
15/7 REDD CREEK CHANNEL SEE SHEET P3
STAGING AREA (TYP.)
REDD CREEK TIDE GATE 20/9
UTILITY CONSTRUCTION ACCESS (BY OTHERS)
TRAIL 4/6
3/6 REMOVE EAST ROAD
REMOVE CENTER ROAD 3/6
FILL DITCH (BY OTHERS)
FAHYS CREEK SHEET P1
MATCH LINE SEE SHEET 3
POWER LINE ALIGNMENT (BY OTHERS)
MATCH LINE SEE SHEET 3
8/6 WATERSHED DIVIDE
NONAME LEVEE SEE SHEET P18
TEMPORARY CROSSING (TYP.) 35/12
LEGEND
REMOVE TIDE GATES
INSTALL TIDE GATE
CONSTRUCTION ACCESS
ENHANCE LEVEES
NEW CHANNELS (SEE LEGEND ON SHEET 5)
2009 CHANNELS (SEE LEGEND ON SHEET 5)
FILL DITCHES
DITCH PLUGS
REMOVE ROADS
REMOVE LEVEES
REMOVE SPOILS
WATERSHED DIVIDE
SENSITIVE AREAS
ENDANGERED PLANTS
USGS S E T LOCATIONS
USGS GROUND WATER LOCATIONS
VEGETATION STUDY AREAS
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SURVEY DATUM
SURVEY DATE: 2008
HORIZONTAL DATUM: OREGON STATE PLANE SOUTH ZONE NAD83
VERTICAL DATUM: NAVD88
GEOID MODEL: GEOID99
CONTOUR INTERVAL: 1'
AERIAL PHOTO: X
REVISIONS
REV. NO. DESCRIPTION DATE APPROVED
DUCKS UNLIMITED INC.
PacNW Field Office
(360) 885-2011
PROJECT NO. US-OR-23-2
Ni-les'tun Unit Restoration
USFWS Bandon Marsh NWR
PLAN VIEW, SHEET 4
DATE: 2-25-10
SHEET NO. 4
APPROVED BY:
GENERAL INFORMATION
DESIGNED BY: RVH
DRAWN BY: DMC
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Appendix B. Procedures for Inadvertent Archaeological Discoveries

Procedures for
Inadvertent Archaeological Discoveries
During the
Ni-les'tun Unit of Bandon Marsh NWR Restoration and North Bank Lane Improvement Project **U.S. Fish and Wildlife Service**

Purpose: To outline procedures for the inadvertent discovery of human remains or significant cultural resources identified during implementation of the Ni-les'tun Unit of Bandon Marsh NWR Restoration and North Bank Lane Improvement Project (Project)**.**

Authority
Archeological and Historic Preservation Act of 1974 [(16 U.S.C. § 469-469c) AHPA]; National Historic Preservation Act of 1966, as amended [(16 U.S.C. § 470 et seq.) NHPA]; Archaeological Resources Protection Act of 1979, as amended [(16 U.S.C. § 470aa-470mm) ARPA]; Native American Graves Protection and Repatriation Act of 1990 [(25 U.S.C. § 3001 et seq.) NAGPRA]; Historic Sites Act of 1935 (49 U.S.C. 303); The Protection of Historic Properties (36 CFR Part 800); Curation of Federally-Owned and Administered Archeological Collections (36 CFR Part 79); Protection of Archaeological Resources (43 CFR Part 7); Native American Graves Protection and Repatriation Act Regulations (43 CFR Part 10); and Managing Museum Property (411 DM 1-3).

Procedures

A. The following procedures for handling inadvertent archaeological discoveries shall be adopted for all phases and aspects of work carried out by any contractor on the Project. The USFWS shall communicate these procedures to contractors prior to project implementation, whose superintendent shall notify all crew members, through safety briefings or other appropriate meetings. The intent is to avoid or minimize direct or indirect impacts to archaeological resources that may qualify for inclusion in the National Register of Historic Places (NRHP).

1. **General Procedures**

The USFWS shall designate at least two Points of Contact (POC) for inadvertent archaeological discoveries, who shall be contacted immediately upon the unearthing of prehistoric or historic cultural materials, including Native American remains and /or grave goods. The POC shall be an individual is capable of making a rapid assessment of the potential significance of any find, assist in the notification and consultation with other appropriate parties, and develop and implement a Plan of Action in consultation with those parties. Implementation of the Project will be monitored by professional archaeologist(s) who will be a POC.

2. **Specific Procedures**

a. Ground-disturbing activities shall be immediately stopped when human remains or potentially significant archaeological materials are discovered. Examples include, but are not limited to: (a) concentrations of historic artifacts (e.g., bottles, ceramics) or prehistoric artifacts (chipped stone, obsidian, or glass arrow points and other tools, wood fish weirs or lattice panels, (b) culturally altered ash-stained midden soils associated with pre-contact Native American habitation sites, (c) concentrations of fire-altered rock and/or burned or charred organic materials, and (d) historic structure remains such as stone-lined building foundations, wells or privy pits. Ground-disturbing project activities may continue in other areas that are outside the discovery locale.

b. An "exclusion zone" where unauthorized equipment and personnel are not permitted shall be established (e.g., cordoned / taped off) around the discovery area plus a reasonable buffer zone by the contractor's superintendent or authorized representative, or party who made the discovery and initiated these Procedures.

c. The discovery locale shall be secured (e.g., 24-hour surveillance) as directed by FWS if considered prudent to avoid further disturbances.

d. The contractor's superintendent, an authorized representative, or party who made the discovery and initiated these procedures, shall be responsible for immediately contacting by telephone the parties listed below to report the find in order to initiate the consultation process: (1) FWS Refuge Manager, Dave Ledig (541 347-1470 / 541 270-3191), (2) FWS Cultural Resources Team (Office: 503 625-4377, Cell: 503 803-8156) and (3) Tribal Representatives, Don Ivy or Nicole Norris (1-800 622-5869 / 541 267-4587).

e. In cases where a known or suspected human burial or skeletal remains are uncovered, the Sheriffs Office (541-396-3121 ext 371 / 541 396-2106) shall be contacted by POC or any party listed in 2(d). In addition, Refuge Law Enforcement Officer Dan Huckel will also be contacted (541-867-4550 office / 541-961-9399 cell). See section 3 below for further instructions.

f. Ground-disturbing project work at the discovery locality shall be suspended temporarily while FWS, consulting archaeologists, Tribes, the State Office of Historic Preservation staff, consult to evaluate the significance of the find, and if determined eligible for the NRHP, develop measures to mitigate adverse effects and arrange for disposition of any archaeological materials removed during the investigations.

g. FWS employees and agents, including contractors, shall be obligated to protect significant cultural resource discoveries and may be subject to prosecution if applicable State or Federal laws are violated. In no event shall unauthorized persons collect artifacts.

h. Any and all inadvertent discoveries shall be considered strictly confidential, with information about their location and nature being disclosed only to those with a need to know. FWS representatives shall coordinate to respond to any requests by or contacts to the media about a discovery.

3. Inadvertent Discovery of Native American Remains.

a. In addition to the steps above, especially 2(d), the following policies and procedures for treatment and disposition of inadvertently discovered Native American remains will apply. These procedures are to simplify and clarify the Native American Graves Protection and Repatriation Act (NAGPRA) and promulgated regulations. NAGPRA law and regulation fully apply.

b. Discovery of Native American remains is a very sensitive issue and serious concern of affiliated Native Americans. If human remains are encountered, they shall be treated with dignity and respect. Information about such a discovery shall be held in confidence by all project personnel on a need-to-know basis. The rights of Native Americans, to the extent permitted by Federal laws, to practice ceremonial observances on sites, in labs and around artifacts shall be upheld.

c. To facilitate application of this section a description of what constitute burial items, funerary objects, sacred objects, and items of cultural patrimony as defined in NAGPRA may be provided by the tribe(s) to the POCs and archaeologist providing monitoring of construction activities. Information may be provided in a manner of the tribes choosing. Oral presentation is acceptable. Specific NAGPRA contacts and traditional religious leaders may be designated by Tribal Chairs.

d. As provided in 36CFR800 FWS will have 'sufficient control" over lands not held in fee title to apply NAGPRA procedures during the restoration activities. (e.g., the North Bank Lane Improvement).

e. The Sheriffs Office, or designated County Coroner, or Medical Examiner, shall have two working days to examine the remains in situ, after being notified of the discovery. The purpose of the Sheriffs involvement is to determine if inadvertently discovered human remains represent a crime scene, or are not of native American origin. If determined to be a crime scene then the rest of these procedures do not apply, the Sheriffs Office will determine the next course of action.

f. Immediately upon determination that the human remains are of native American origin then contact with designated tribal NAGPRA coordinators shall be undertaken by the FWS archaeologist. Nothing in these procedures is meant to prevent prior contact, if deemed prudent. If possible contact will be made with the Most Likely Descendant (MLD).

g. Within three working days of notification the tribal NAGPRA coordinator shall provide recommendations to FWS for treating, with appropriate dignity, the human remains and any associated grave goods. The recommendation will address the scientific removal analysis of human remains and items associated with Native American burials. The human remains and associated grave offerings may be re-buried with appropriate dignity on the property in a location not subject to further subsurface disturbance.

4. Documenting Inadvertent Archaeological Discoveries

a. The contractor's superintendent or authorized representative, or party who made the discovery and initiated these procedures, shall make written notes and digital photographs available to FWS, describing the date, time, location and nature of the discovery; the date and time each party was informed about the discovery; and when and how security measures were implemented.

b. FWS Cultural Resource Team member and project manager shall prepare or authorize the preparation of a summary report which shall include: the time and nature of the discovery; who and when parties were notified; outcome of consultations with appropriate agencies and Native American representatives; how, when and by whom the approved Plan of Action was carried out; and final disposition of any collected archaeological specimens.

c. The contractor's superintendent or authorized representative shall record how the discovery downtime affected the immediate and near-term contracted work schedule, for purposes of negotiating contract changes where applicable.

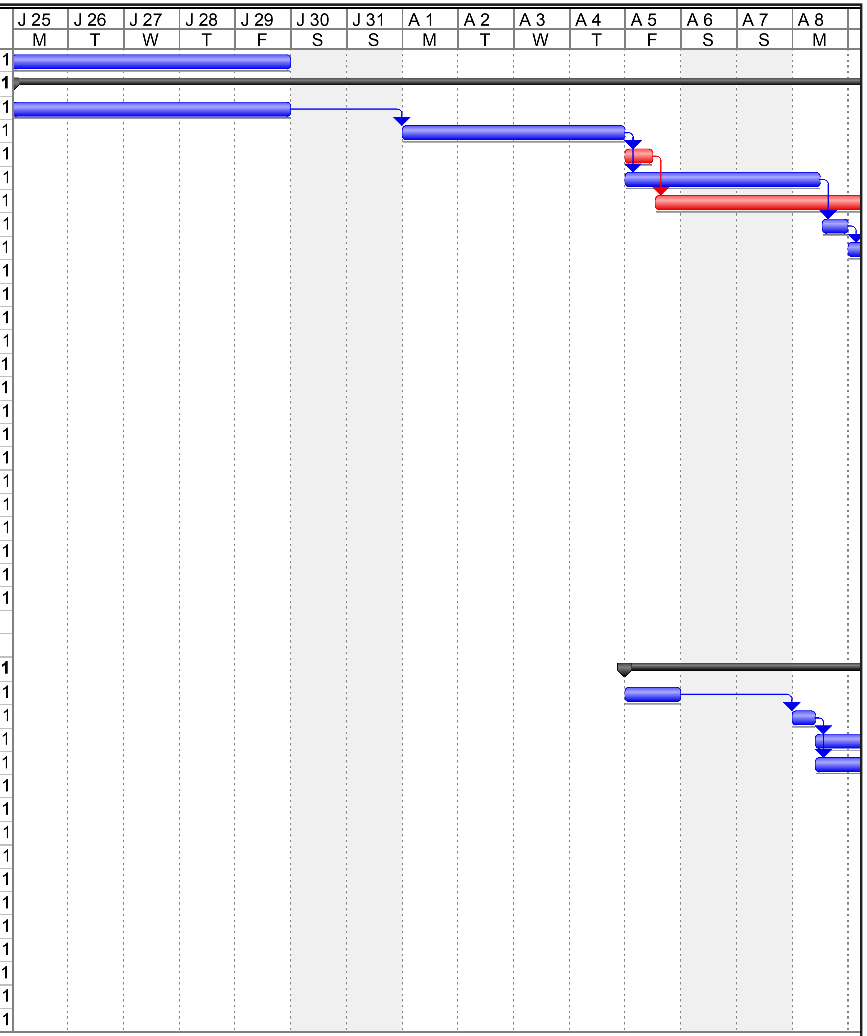
d. Consulting archaeologists and Native American representatives shall maintain daily field notes, on the inadvertent discovery.

e. A Plan of Action and corresponding archaeological evaluation and data-recovery reports shall be authored by professionals who meet the Federal criteria for Principal Investigator Archaeologist and reference the *Secretary of the Interior's Standards and Guidelines for Archaeological Documentation* (48 FR 44734-44737).

f. Final disposition of all collected archaeological materials shall be documented in a technical report. Long-term storage of collections may be housed at the facility nearest to the discovery locale that conforms to Federal guidelines for curation of archaeological collections (36 CFR 79).

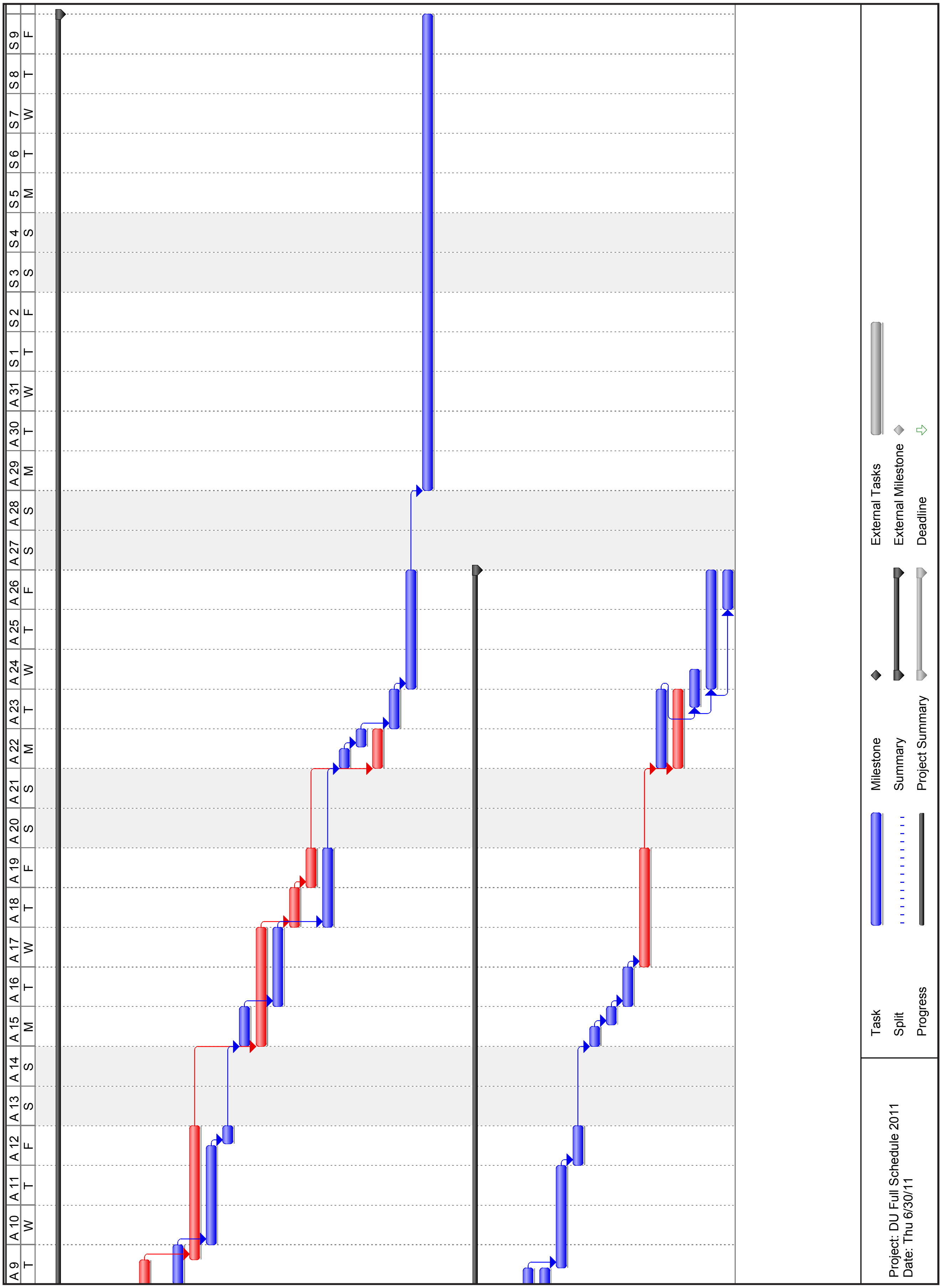
Appendix C. Knife River Construction Schedule

ID	Task Name	Duration	Start	Finish
1	Mobilization	5 days	Mon 7/25/11	Fri 7/29/11
2	**CREW #1**	**35 days**	**Mon 7/25/11**	**Fri 9/9/11**
3	Install 4th Order Single LWD	5 days	Mon 7/25/11	Fri 7/29/11
4	Install 4th Order Double Log-Under LWD	4 days	Mon 8/1/11	Thu 8/4/11
5	Strip East Levee	0.5 days	Fri 8/5/11	Fri 8/5/11
6	Remove Noname Levee - (Start)	1.5 days	Fri 8/5/11	Mon 8/8/11
7	Enhance East Levee	2.25 days	Fri 8/5/11	Tue 8/9/11
8	Remove Redd Creek Tide Gate - (Partial)	0.5 days	Mon 8/8/11	Mon 8/8/11
9	Remove Noname Levee - (Finish)	1 day	Tue 8/9/11	Tue 8/9/11
10	Fill Minor Ditches/Watershed Divides	3.25 days	Tue 8/9/11	Fri 8/12/11
11	Remove River Levee - (STA 37+00 - 15+00)	2.5 days	Wed 8/10/11	Fri 8/12/11
12	Remove River Levee - (STA 15+00 - 10+50) Part	0.5 days	Fri 8/12/11	Fri 8/12/11
13	Remove Quarantine Material	1 day	Mon 8/15/11	Mon 8/15/11
14	Enhance Northwest Levee	3 days	Mon 8/15/11	Wed 8/17/11
15	Install Temporary Tide Gate	2 days	Tue 8/16/11	Wed 8/17/11
16	Fill Minor Ditches	1 day	Thu 8/18/11	Thu 8/18/11
17	Remove Spoils	1 day	Fri 8/19/11	Fri 8/19/11
18	Remove River Levee - (STA 4+00 - 0+00) Part	2 days	Thu 8/18/11	Fri 8/19/11
19	Remove Redd Creek Tide Gate - (Final)	0.5 days	Mon 8/22/11	Mon 8/22/11
20	Remove Noname Tide Gate - (Final)	0.5 days	Mon 8/22/11	Mon 8/22/11
21	Fahys mouth plug	1 day	Mon 8/22/11	Mon 8/22/11
22	Remove Tide Gate	1 day	Tue 8/23/11	Tue 8/23/11
23	Remove Remaining River Levee w/ Quarantine	3 days	Wed 8/24/11	Fri 8/26/11
24	Extra Fish Passage Work	10 days	Mon 8/29/11	Fri 9/9/11
25				
26				
27	**CREW #2**	**16 days**	**Fri 8/5/11**	**Fri 8/26/11**
28	EXTRA- Place Nurse Logs	1 day	Fri 8/5/11	Fri 8/5/11
29	Excavate Tidal Channels	0.25 days	Mon 8/8/11	Mon 8/8/11
30	Remove Farm Roads	1 day	Mon 8/8/11	Tue 8/9/11
31	Erosion Control	1 day	Mon 8/8/11	Tue 8/9/11
32	Decommission Haul Roads	2.75 days	Tue 8/9/11	Thu 8/11/11
33	Gain Access to Southwest Levee	1 day	Fri 8/12/11	Fri 8/12/11
34	Remove Remnant Levee	0.5 days	Mon 8/15/11	Mon 8/15/11
35	Remove Wood Pilings	0.5 days	Mon 8/15/11	Mon 8/15/11
36	Install Permenent Tide Gate	1 day	Tue 8/16/11	Tue 8/16/11
37	Fahys Mouth Plug	3 days	Wed 8/17/11	Fri 8/19/11
38	Fahys Mouth Plug Protection	2 days	Mon 8/22/11	Tue 8/23/11
39	Fill Minor Ditches/Watershed Divides	2 days	Mon 8/22/11	Tue 8/23/11
40	Rock Riprap	1 day	Tue 8/23/11	Wed 8/24/11
41	Remove Southwest Levee	3 days	Wed 8/24/11	Fri 8/26/11
42	Decomission Haul Roads- (Final)	1 day	Fri 8/26/11	Fri 8/26/11



Project: DU Full Schedule 2011
Date: Thu 6/30/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline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Project Summary
External Tasks
External Milestone
Deadline

Appendix D. Bandon Marsh NWR Mosquito Monitoring and Treatment – 2014

Bandon Marsh NWR Mosquito Monitoring and Treatment – 2014

Monitoring of mosquito populations is fundamental to the Integrated Marsh Management approach* adopted by the U.S. Fish and Wildlife Service (Service) for managing mosquito production at Bandon Marsh National Wildlife Refuge (Refuge). Monitoring is required to determine mosquito species present, the relative abundance of adults and larval stages, locations of infestations, and timing of control efforts for maximum effectiveness. Although Coos County Public Health (CCPH) staff and their contractor Vector Disease Control International (VDCI) were charged with conducting monitoring and treatment operations and setting decision trigger thresholds, Service staff assisted, and all mosquito management decisions were made in consultation with the Service.

Target area

The primary target of mosquito management is an approximately 300 acre portion of the Ni-les'tun Unit of the Refuge that was restored from diked pasture to tidal marsh in 2011 (Figure 1). Mosquito breeding pools were unintentionally created along old drainage ditches and other depressions that remained after the restoration, and are filled with water during semi-monthly high tides. In 2013, Service staff and cooperators determined that a population of salt marsh mosquito (*Aedes dorsalis*) has successfully exploited this new habitat to the degree that active management is necessary, and this species is the focus of the larvae monitoring and treatment program. Adult monitoring via CDC traps in 2014 took place around the perimeter of the marsh, and also extended to areas well beyond the Refuge boundaries to document movement away from the breeding sites.

Starting in mid-July, construction of new tidal channels designed to reduce mosquito breeding habitat was implemented. As a result, by the end of the season the target area was about 20% of its initial extent, substantially reducing the monitoring and treatment effort.

Several native mosquito species have been found breeding on the Refuge, but the salt marsh mosquito is the sole species that has greatly benefitted from the creation of many temporary pools that fulfill its breeding requirements. This species is adapted to flooding and drying cycles, in this case created by the varying high tides that occur on the Refuge. Semi-monthly high tides fill depressions situated high in the intertidal zone and cause mosquito eggs to hatch. As the high tides recede and leave the pools disconnected from tidal influence, the mosquito larvae race to develop into adults before the pool dries up or becomes flushed with the next high tide. Depending on the height of the flooding tide, the elevation of the marsh depression, and timing of rainstorms, the number and location of the breeding pools each lunar cycle varies.

Focal species and pertinent natural history

An understanding of the mosquito development process is critical for timing the monitoring and subsequent treatment of larvae with larvicide. In the Ni-les'tun tidal marsh, the timing of monitoring is generally predictable based on published tide tables and tracking of the high tide cycles, but is variable enough that observational data is necessary to confirm predictions (Figure 2). The larvae develop through four successively larger stages (instars) and then enter a pupa stage when they do not feed. Within a couple days, the adult emerges from the pupa, and in a few hours the females are ready to fly

**Described in:* Draft Plan and Environmental Assessment for Mosquito Control for Bandon Marsh NWR, USFWS, 2014 away to find a blood meal. The entire process from egg hatch to adult flight may take 7 to 12 days, depending on water temperature; warmer temperatures hasten the process. Hatching of eggs generally began when the rising daily high tides exceeded seven feet above mean sea level (MSL). In many cases, the daily high tide would remain above seven feet for several days, with new hatching

Figure 1. Aerial photograph of the Ni-les'tun Unit with constructed tidal channels indicated in purple. The red ovals surround concentrations of mosquito breeding pools based on 2013 surveys. Black and blue bars indicate footbridges installed to facilitate access.

occurring on each high tide. This staggered hatching resulted in larvae in two or three instars in the same pool by the end of the high tide series. The larvicide selected for use by the Service is *Bacillus thuringiensis israelensis* (Bti), which is most effective if applied before larvae reach the fourth instar. This is because Bti must be ingested by the larvae to release its toxins, and feeding rate slows and eventually stops during the fourth instar. Therefore monitoring and treatment had to be completed during the time the larvae were in the second and third instars, which may be a window of only 3 or 4 days in hot weather. Larvae monitoring was designed to detect when the second instar is reached for most of the current brood, and then to systematically inspect the entire potential breeding area of the marsh to locate all pools needing treatment.

Monitoring protocol: Larvae monitoring

Dip counts and Action thresholds: Larvae were sampled in potential breeding pools using standard dipping methods yielding dip counts (average larvae per dip). Dip counts are acquired by using a 350 ml dipper cup with a three foot handle to scoop water from the pools to be examined for the presence of larvae. Generally, five to ten dips per pool (depending on pool size) were made in areas most likely

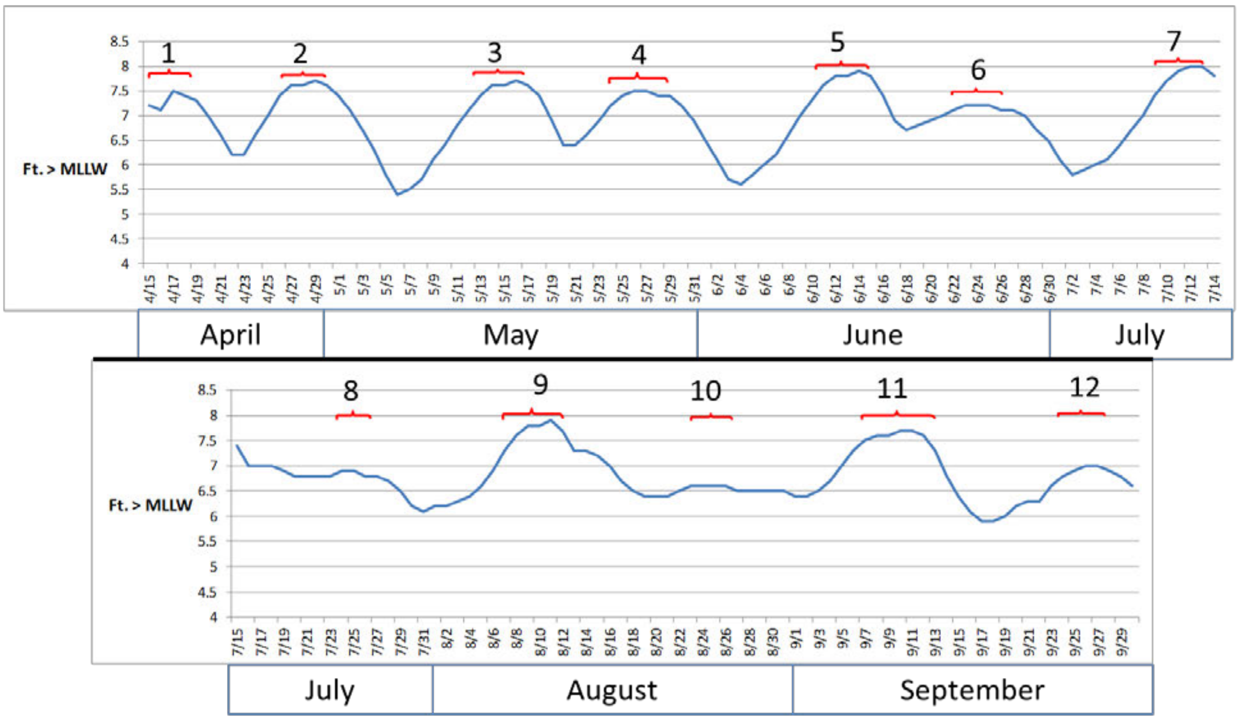


Figure 2. The correlation between predicted daily higher high tides (blue line) and salt marsh mosquito egg hatches (numbers and brackets) in 2014. Larvae resulting from hatches two through 12 were treated with Bti larvicide. Small numbers of larvae appeared after the late September high tides and were spot treated, but the hatching season essentially ended at hatch number 12.

harbor larvae, such as shaded spots adjacent to emergent vegetation. Dip counts are useful as presence/absence and relative abundance indicators, but it must be noted that they are not unbiased, statistically valid samples that can lead to population or density estimates. In addition to being taken at non-random locations, there are many uncontrolled variables that affect the number of larvae collected and counted in any given sample, including observer skill and precise method of dipping, water transparency, depth of water in the pool, larvae reaction differences to disturbances, and light and wind conditions. Nonetheless, it is a mosquito control program convention to establish treatment action numeric thresholds based on larval dip counts (or adult trapping results), i.e., if average counts are X per dip or greater, treatment will be considered.

Given that the situation at the Refuge in Spring 2014 included a huge bank of mosquito eggs left from 2013 ready to hatch, the potential for *A. dorsalis* adult populations to grow exponentially with each high tide series, the presence of many acres of available mosquito breeding habitat that would not be drained until mid-summer, the fact that the breeding habitat was unintentionally created and an unwanted byproduct of restoration, and the goal of preventing significant adult fly-offs from the marsh that could lead to more eggs being laid, the threshold for treatment of a breeding pool was set at an average of one larvae per 10 dips. This threshold permitted a rapid response to emerging broods that ultimately reduced the amount of Bti applied over the season by preventing production of larvae from newly laid eggs. In practice, due to the large egg bank, most pools in the first half of the season produced larval concentrations that resulted in dip counts much higher (over 50) than the threshold.

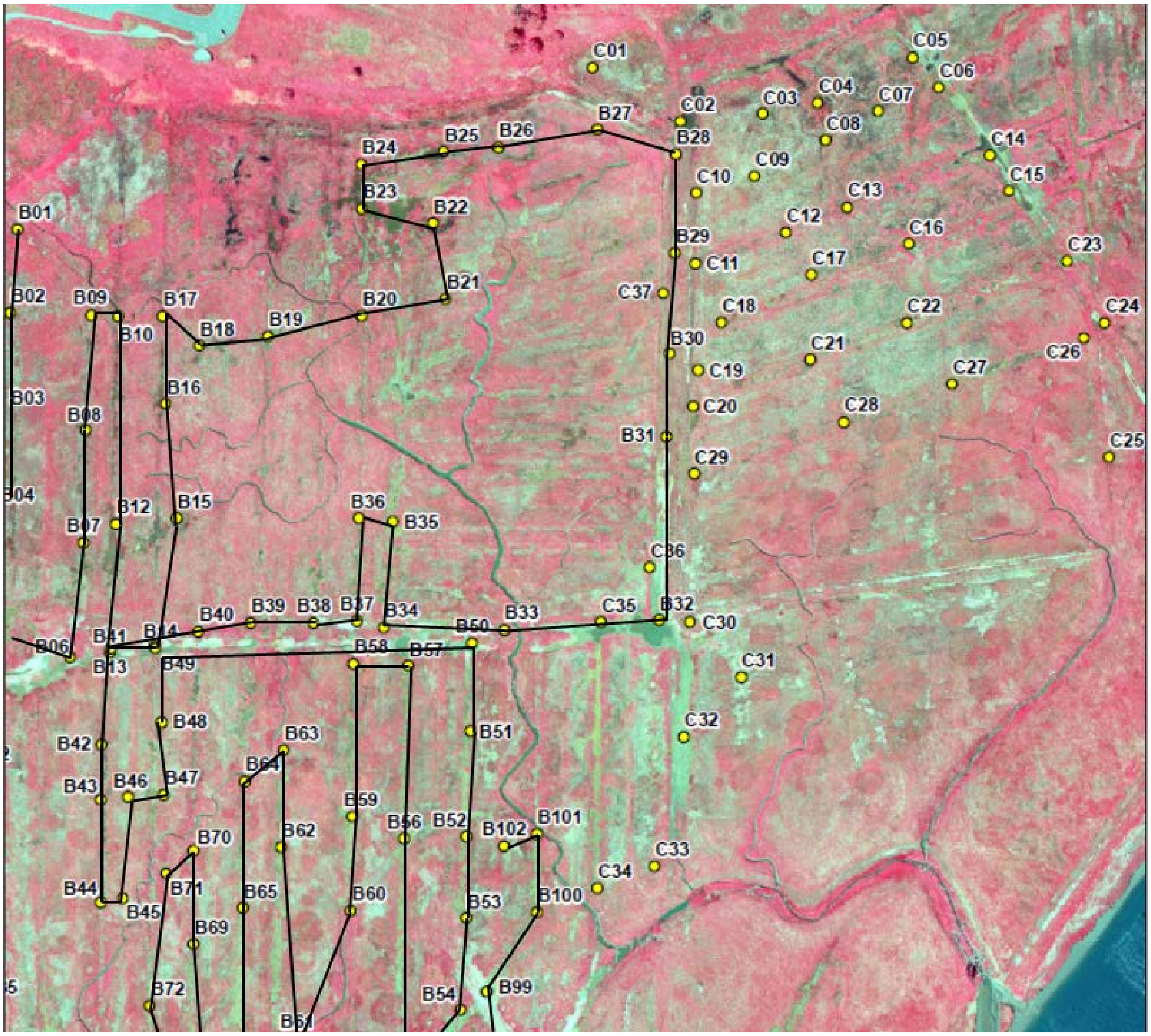


Figure 3. Examples of mosquito larvae monitoring transects that were established in April, 2014 at the Ni-les'tun Unit of Bandon Marsh NWR. Numbered dots are locations of numbered pin flags within blocks (B,C) that were followed sequentially by monitoring staff as shown in block B. Initially, all breeding pools encountered along the transect were sampled (dipped) for larvae presence, and flagged if the treatment threshold was met to direct the applicators. Later, only representative areas were monitored rather than entire transects (see text).

Field methods: Based on 2013 surveys, known breeding pools were mapped on a recent aerial photograph of the Ni-les'tun Unit (Figure 1), and the entire area was divided into blocks, labeled A through F. In each block, a sampling path was laid out such that every pool could be sampled as the path was walked. These paths, or transects, were marked in the field with orange pin flags, each of which was numbered, located with GPS coordinates, and mapped. (Figure 3) The intention was for members of the monitoring team to walk each of these transects at weekly intervals while recording on field data sheets the larvae dip counts, locations (by transect flag number), and development stage of larvae encountered. Color coded pin flags were placed in or near pools with dip counts above the threshold to direct the larvicide applicators, who would replace the flags with another color that indicated where treatment had been done. This system allowed the applicators to walk directly to pools needing treatment, keep track of where treatment had occurred, and direct post-treatment efficacy monitors to treated pools. However, after several weeks of monitoring, it became apparent that mosquito hatches were highly synchronized with predicted tides, and that when larvae were discovered in certain pools it was likely that they were also present in similar concentrations over larger areas.

These realizations meant that it was not necessary to sample every week, nor to sample entire transects, which was extremely time consuming. The monitoring schedule was therefore adjusted to correspond with high tide series (generally bi-weekly), and representative areas were sampled for larvae rather than the entire lengths of all the transects. This reduced the labor required for each monitoring cycle considerably. Up to this point, each monitoring cycle required help from three USFWS biologists, one USFWS technician, one CCPH technician, and two VDCI staff. The revised method could be completed without the field help of the three USFWS biologists.

Larvae surveys were initiated the day the tides peaked for that cycle, or earlier if seven feet above MSL tides occurred, and were focused on areas newly inundated by those tides. When the majority of the larvae were projected to be in the second or third instar, usually by the second or third day after the peak tide, Bti treatment would begin (see below).

Monitoring protocol: Adult monitoring

All adult monitoring was conducted by CCPH and VDCI staff. Seven sites in and around the Refuge (Figure 3) were selected for placement of CDC traps one night per week beginning late April through October. CDC traps were charged with dry ice that released a steady plume of CO_2 gas to attract adult female mosquitoes seeking ectotherm hosts. A battery-operated fan on the trap forces approaching mosquitoes into a capture net. The technicians typically hung a trap from a tree branch late in the afternoon, and retrieved the trap early the following morning. The capture nets were removed and closed to contain the captives, placed in a freezer for 10 minutes to immobilize the captives, which were then sorted by species and counted. Figures 4a-g show the counts of all species of mosquitoes and counts of *A. dorsalis* for the season at all trapping locations. A total of nine species of adult

Table 1. Mosquito species identified in adult traps 2014.
Aedes cinerius
Aedes dorsalis
Aedes excruciens
Aedes implicatus
Aedes washinoi
Coquillettidia perturbans
Culex tarsalis
Culiseta inornata
Culiseta particeps

mosquitoes were identified in the traps. (Table 1.)

Larvicide Application

As mentioned above, Bti larvicide (product used: VectoBac G granule, Valent BioSciences Corp.) is effective if the larvae are exposed to it while actively feeding between hatching and mid-fourth instar. Since egg hatches were strongly correlated with the biweekly high tide cycles (Figure 2) it was predictable when preparation for treatment should commence, although the actual initiation of treatment was timed according to the monitoring observations. Treatment began when the majority of larvae were in the second and third instars, and continued until all known breeding sites were treated, which took about three days. By the end of the season, eleven marsh-wide applications occurred, corresponding to all tide-induced hatches except the first one of the season in late April. Monitoring had begun by this first hatch, but all the permitting and technical preparations were not in place to allow treatment until after May 1. The adult fly-off resulting from this un-treated hatch is responsible for the high adult numbers trapped in mid-May at many locations (Figures 4a-e).

Field methods: VDCI personnel planned and conducted the treatments, with logistical support from CCPH and USFWS staff. The principle application method was by gas powered backpack mist dusters (Maruyama MD155DX) modified to handle granular material. Personnel calibrated their dusters with their walking speed to assure application within manufacturer's label recommendations (2.5 to 10 lbs./acre). The average target was 5 –7 lbs./acre, but higher application rates were used if larvae densities or suspended organic material was high in a subject breeding pool. Bti was applied directly to breeding pools with over threshold dip counts, except on two occasions when aerial applications were used due to expected extensive flooding and high larvae densities. Aerial applications were focused on the central area of the marsh dominated by breeding pools, and were supplemented with backpack applications to peripheral and isolated pools. By necessity, aerial applications drop larvicide on dry ground at the same rate as the pools, so significant amounts of material are wasted. Figure 5 shows the acres of the marsh that were treated each application, and the two highest bars represent the aerial treatments including the dry ground, and therefore do not reflect the actual acreage of breeding pools. The extent of breeding pools varied depending on the actual maximum tide height of the series, which determined how many pools were filled. As the breeding pools were connected by newly constructed channels designed to drain the pools at low tide from mid-July through September, the area of breeding pools needing treatment declined drastically from the maximum of approximately 138 acres to less than 25 acres, as reflected in Figure 5.

Each backpack application to the marsh was an intensive effort by the entire mosquito management team. Each backpack operator was supported by a helper who checked pools for larvae, flagged and kept track of treated areas, and resupplied the backpacks with larvicide. Meanwhile, an amphibious vehicle operator staged bags of larvicide in strategic locations of the marsh to minimize walking by the helpers as they refilled backpacks. Working around high tides, applicators would walk many miles over long days to complete the application within the narrow window before most larvae reached fourth instar. The decision to use aerial application during the mid-June hatch was intended to drastically reduce the area needing ground application, but a malfunction of the airplane spreader resulted in inconsistent application rates and some areas receiving too little larvicide. Once this was discovered, it was determined that many areas needed re-treatment by backpack applicators, largely nullifying the hoped-for advantage. Some areas were ultimately not treated in time, and significant numbers of adults flew off the Refuge. However, the second aerial application went as planned, and did substantially reduce the effort needed by the ground applicators. Subsequent applications were manageable by ground treatment due to dryer conditions, and the reduction of treatment area by the ongoing channel construction. The last marsh-wide treatment occurred around September 12 as new hatching was ending for the season, but a few spot treatments of larvae occurred until early October. A total of approximately 12,450 pounds of larvicide was applied over the season.

Efficacy monitoring

After each larvicide treatment, technicians walked the treatment area to look for dead and surviving larvae to evaluate the effectiveness of the treatment. In some cases more larvicide was applied, but, in general efficacy was confirmed. The notable exception was the mid-June aerial treatment, when it was difficult to find all the areas that were missed by the malfunctioning airplane spreader and treat them before mosquitoes reached the pupa stage. This was also the hatch that produced the highest densities of larvae seen this season. As a result, significant numbers of adults successfully flew off the Refuge from that brood, as was documented by the adult trapping data (see Figures 4a,b,c, and e) showing spikes in numbers in early July.

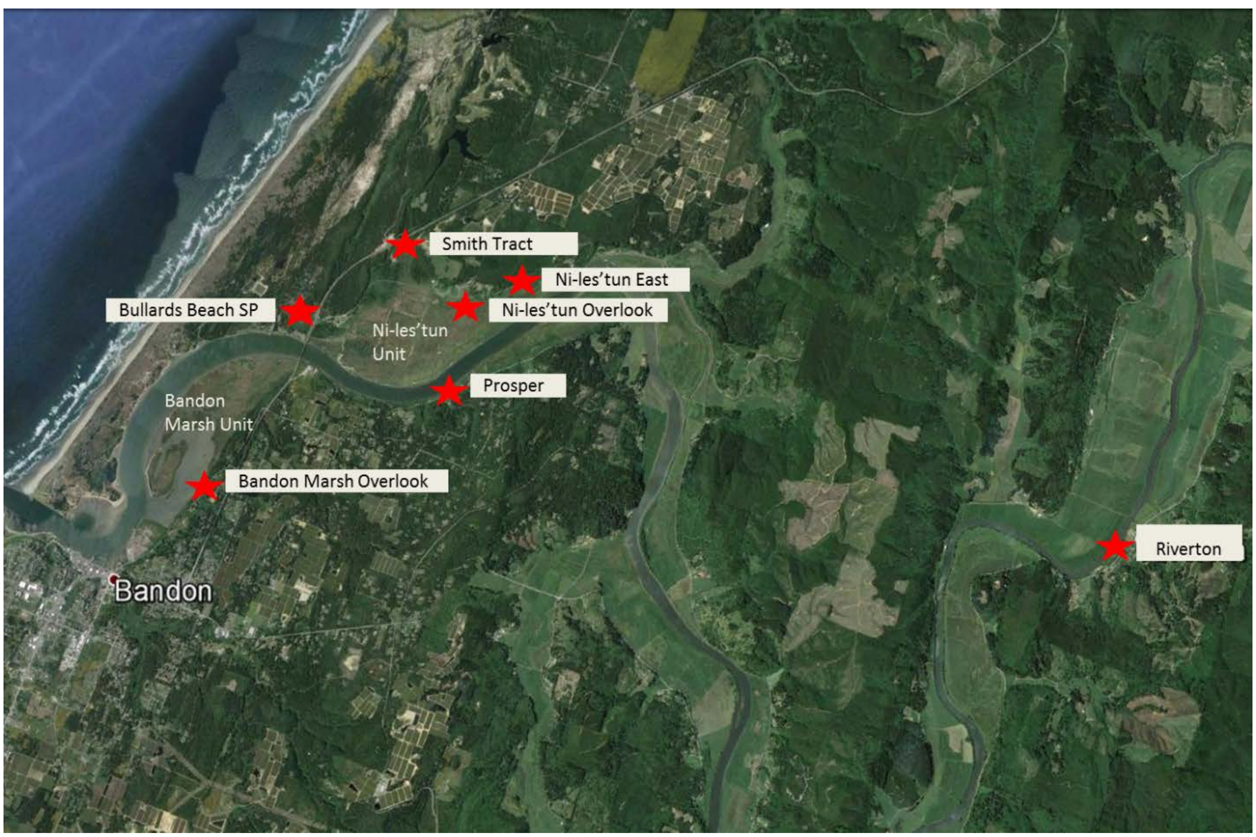
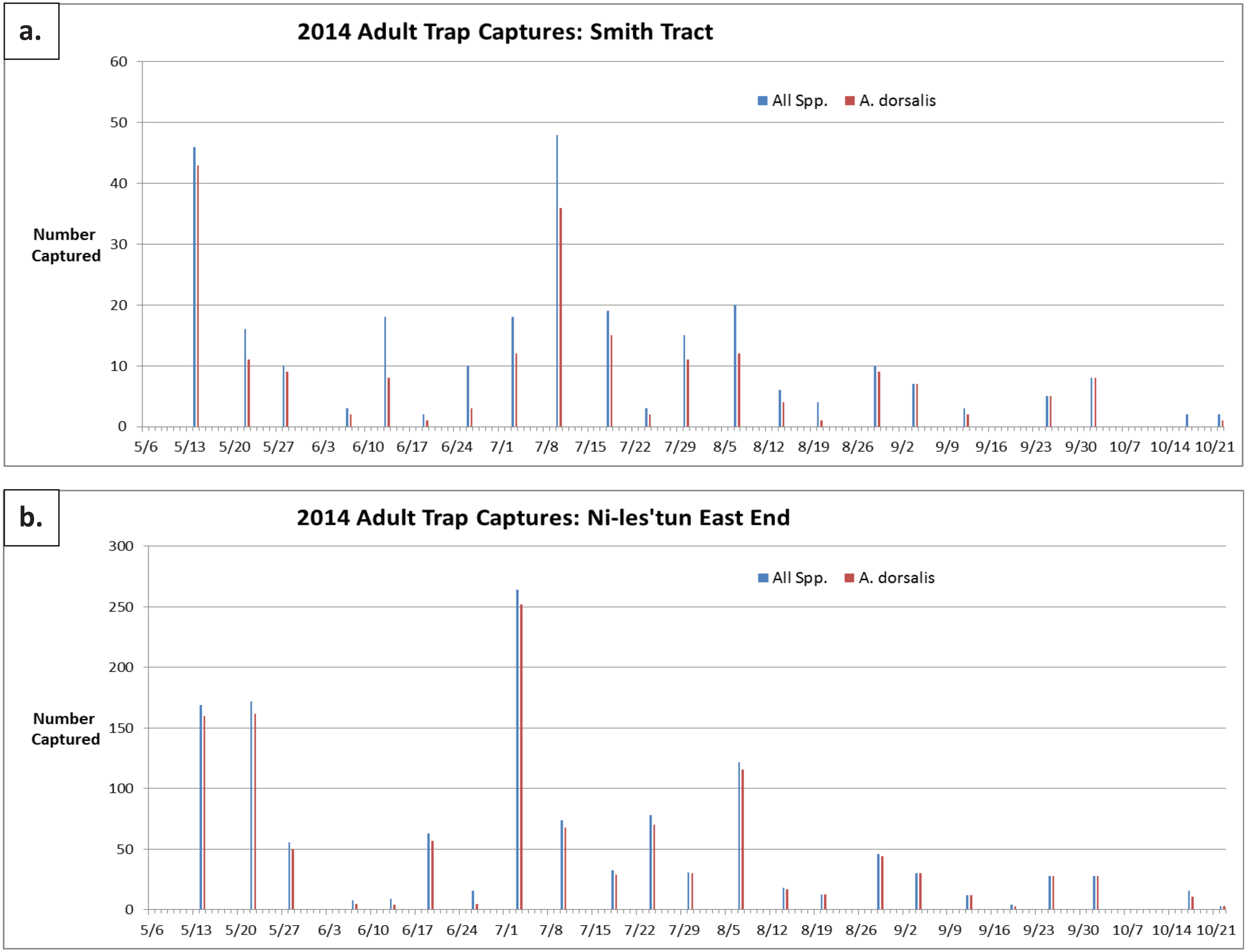
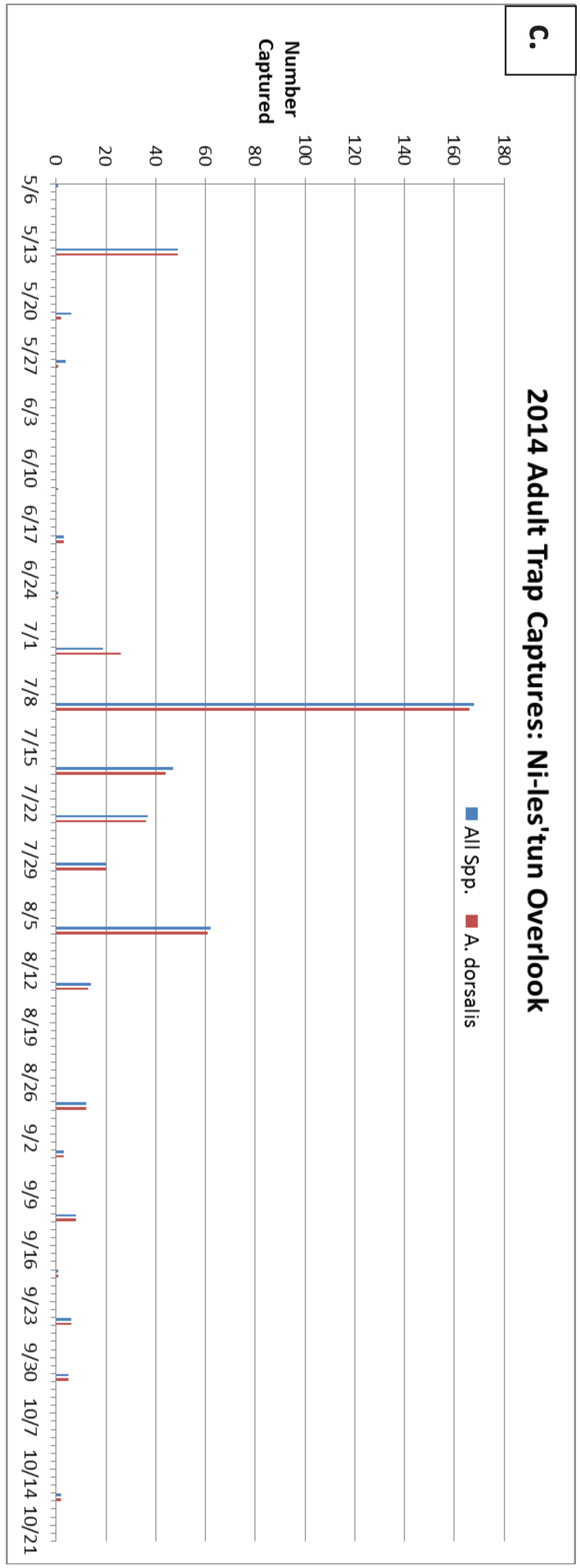
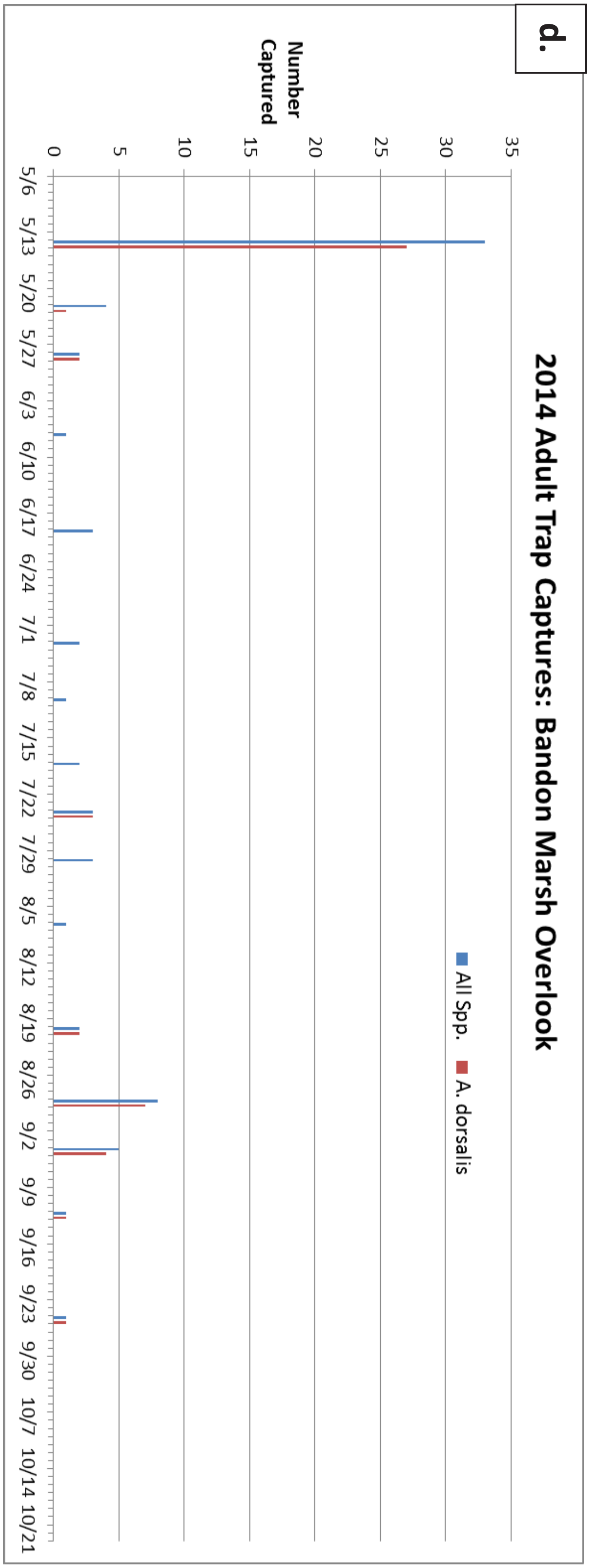
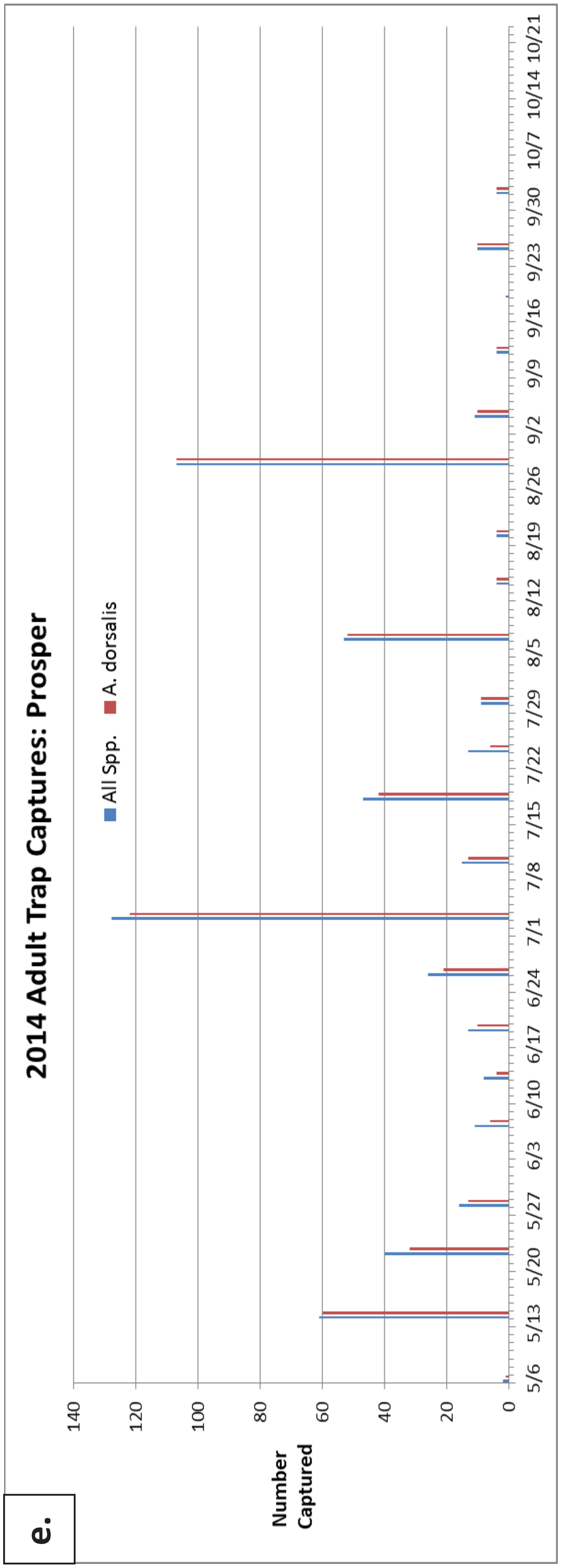


Figure 3. Locations of adult monitoring traps.


a.
2014 Adult Trap Captures: Smith Tract
Number Captured
60
50
40
30
20
10
0
All Spp.
A. dorsalis
5/6 5/13 5/20 5/27 6/3 6/10 6/17 6/24 7/1 7/8 7/15 7/22 7/29 8/5 8/12 8/19 8/26 9/2 9/9 9/16 9/23 9/30 10/7 10/14 10/21
b.
2014 Adult Trap Captures: Ni-les'tun East End
Number Captured
300
250
200
150
100
50
0
All Spp.
A. dorsalis
5/6 5/13 5/20 5/27 6/3 6/10 6/17 6/24 7/1 7/8 7/15 7/22 7/29 8/5 8/12 8/19 8/26 9/2 9/9 9/16 9/23 9/30 10/7 10/14 10/21


c.
2014 Adult Trap Captures: Ni-les'tun Overlook
All Spp.
A. dorsalis
Number Captured
0
20
40
60
80
100
120
140
160
180
5/6
5/13
5/20
5/27
6/3
6/10
6/17
6/24
7/1
7/8
7/15
7/22
7/29
8/5
8/12
8/19
8/26
9/2
9/9
9/16
9/23
9/30
10/7
10/14
10/21


d.
2014 Adult Trap Captures: Bandon Marsh Overlook
All Spp.
A. dorsalis
Number Captured
0
5
10
15
20
25
30
35
5/6
5/13
5/20
5/27
6/3
6/10
6/17
6/24
7/1
7/8
7/15
7/22
7/29
8/5
8/12
8/19
8/26
9/2
9/9
9/16
9/23
9/30
10/7
10/14
10/21


e.
2014 Adult Trap Captures: Prosper
All Spp.
A. dorsalis
Number Captured
0
20
40
60
80
100
120
140
5/6
5/13
5/20
5/27
6/3
6/10
6/17
6/24
7/1
7/8
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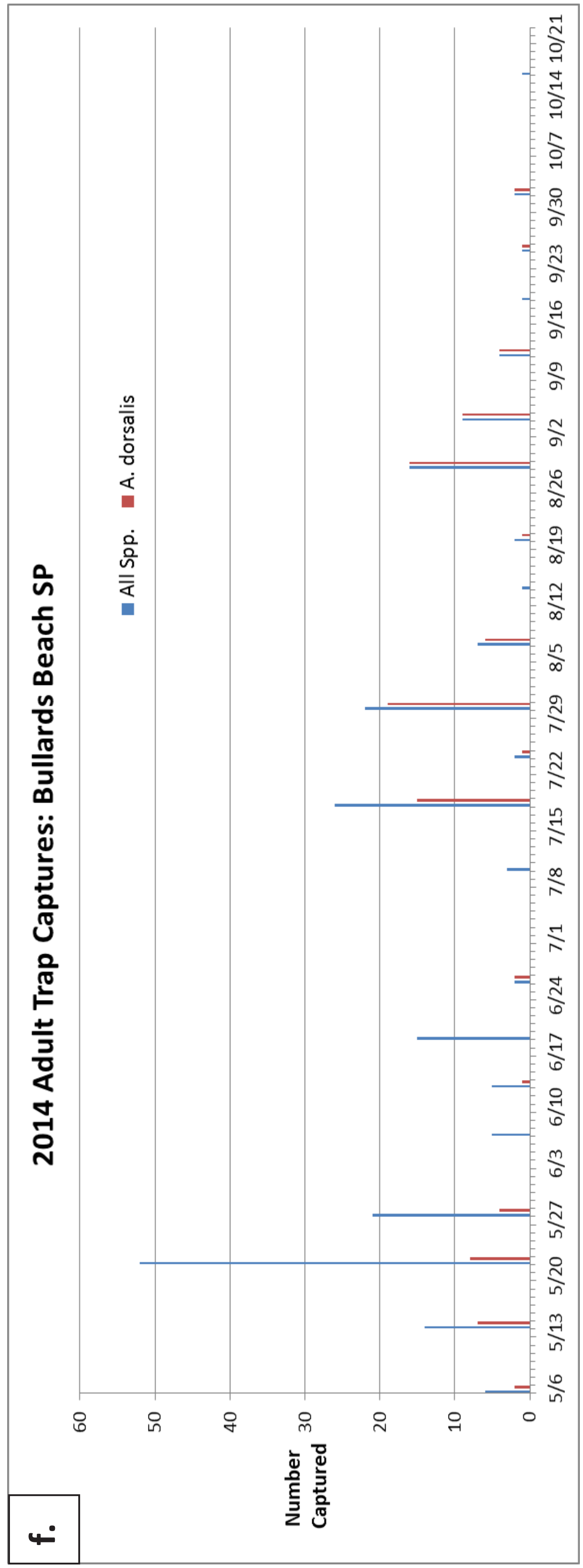
10/21


f.
2014 Adult Trap Captures: Bullards Beach SP
All Spp.
A. dorsalis
Number Captured
0
10
20
30
40
50
60
5/6
5/13
5/20
5/27
6/3
6/10
6/17
6/24
7/1
7/8
7/15
7/22
7/29
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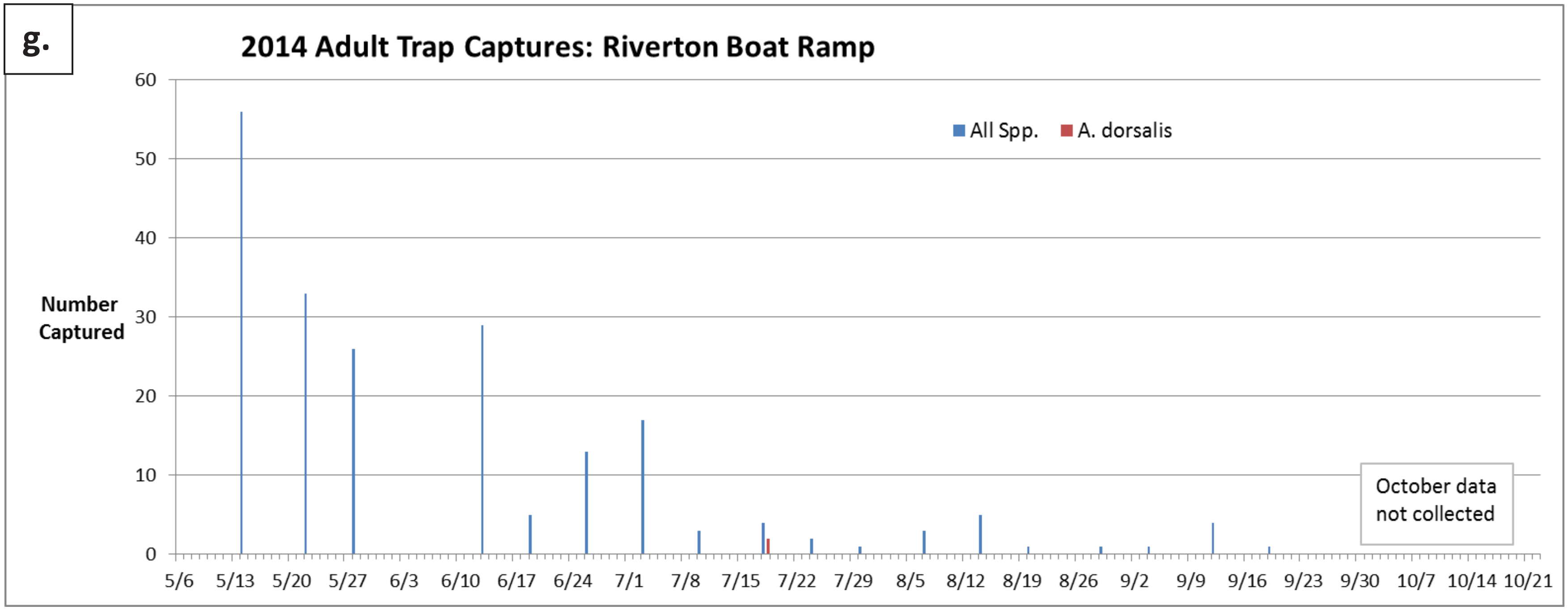
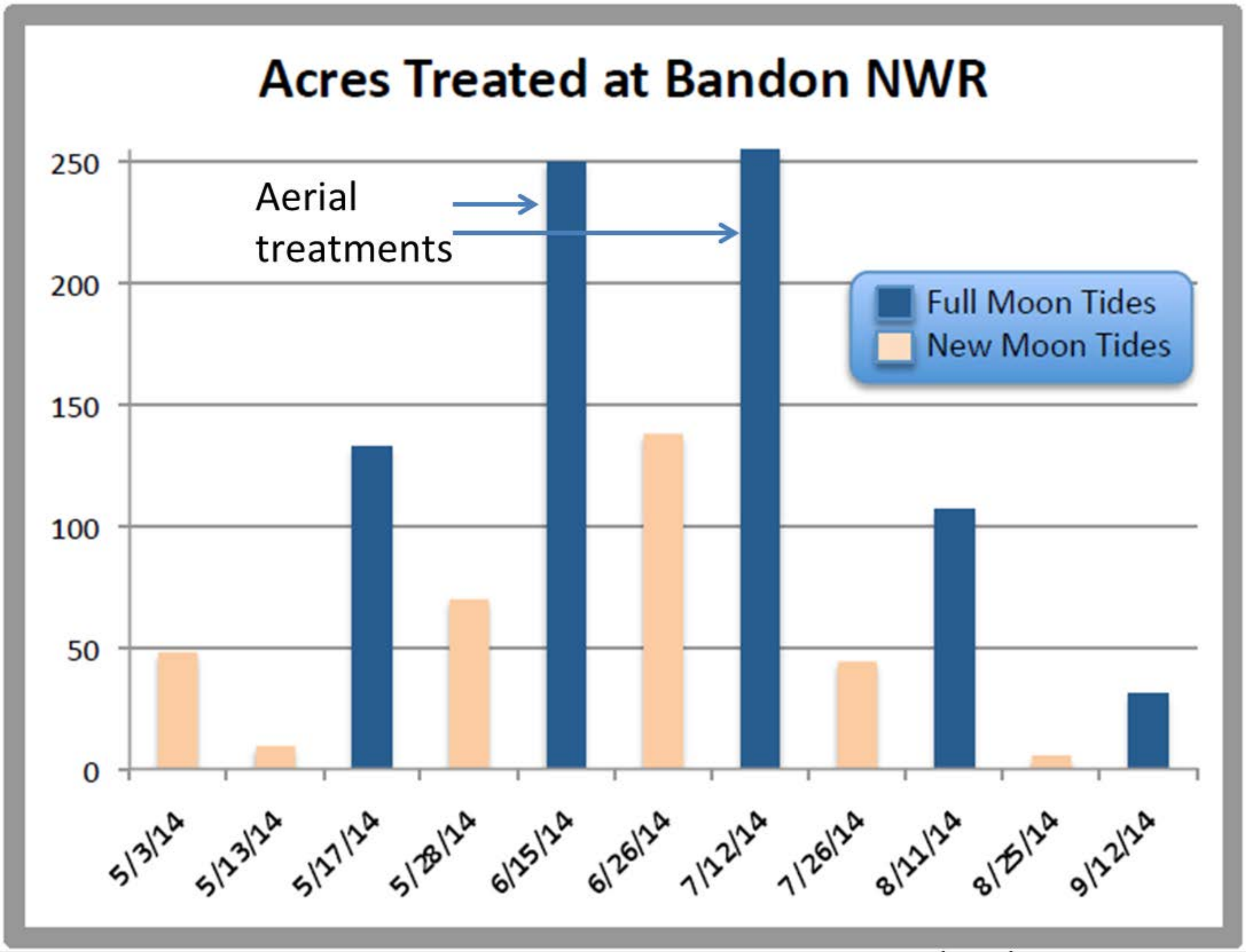
9/30
10/7
10/14
10/21



Figures 4 a-g. Mosquito adults captured at seven locations in 2014. Blue bars indicate the total of all species captured, and red bars indicate how many of the total were *Aedes dorsalis*, the focal species that bred in the restored tidal marsh. High numbers in some locations early in the season likley reflect those in the first brood of the year, which went un-treated. Spikes in early July resulted from an incomplete treatment of the mid-June hatch (see text). Note that trapping sites further from the Ni-les'tun Unit (d, f, g) had high proportions of species other than *A. dorsalis*.



Dan Markowski, VDCI

Figure 5. Estimated acres treated during each of the 11 treatments with Bti larvicidein 2014. The two highest bars represent the only two aerial applications that occurred, which include many acres of dry ground (non-breeding habitat). The other acreages approximate the area of breeding pools that existed at the treatment dates. The decline of acres treated between 8/11 and 9/12 reflects the reduction of breeding pool area accomplished by new channel construction.

Appendix E. Ni-les'tun Tidal Marsh Restoration – Phase 4, First and Second Order Channel Construction, 2014

Ducks Unlimited, Inc.

TECHNICAL SPECIFICATIONS

NILESTUN UNIT RESTORATION, PHASE IV
UFWS BANDON MARSH NWR
DU PROJECT NO. OR-23-2

May 18, 2014

REGISTERED PROFESSIONAL ENGINEER
14898PE
OREGON
MAY 22, 1990
RANDOLPH K. VAN HOY

EXPIRATION DATE: 6/30/16

INDEX TO TECHNICAL SPECIFICATIONS

MAIN MARSH

SECTION 2000
DESCRIPTION OF WORK

Part 1 - General

1.01 DESCRIPTION

The project contains the following work site access, tidal channel excavation, ditching, and track remediation.

1.02 PROJECT LOCATION & ACCESS

The site is 2 miles north of Bandon, Oregon. The site is located just east of Highway 101 on the north bank of the Coquille River in Coos County. The site is within Bandon Marsh National Wildlife Refuge, owned and administered by the US Fish and Wildlife Service (USFWS).

1.03 ELEMENTS/TASKS

There two main elements of the project, described below.

A. Site Preparation
B. Tidal Channel Excavation

1.04 PERMITS

All permits have been obtained by the owner, USFWS. Copies of permits shall be supplied to the Contractor to be kept on site by the Contractor. It is the Contractors responsibility to follow all conditions in the permits.

1.05 PRIORITY OF WORK

The Contractor shall prioritize and order construction to meet the contract and specification requirements.

1.06 CONSTRUCTION SCHEDULE

A draft construction schedule shall be submitted with the bid package. The draft construction schedule shall include beginning and end dates for each bid item and the equipment proposed to be used on each bid item.

Within 7 days after a contract is signed the Contractor shall submit a final construction schedule. The final construction schedule shall include beginning and end dates for each bid item, order and the equipment proposed to be used on each bid item. The Contractor shall be responsible for providing all scheduling information as required in the specifications below.

1.07 CONTRACTOR COORDINATION

Other activities, such as biological monitoring, refuge management, mosquito control by USFWS, DU, Coos County, and partners will occur on and near the project site during the Summer of 2014. Coordination between US Fish and Wildlife Service, Ducks Unlimited, Inc. and the Contractor shall be required. Coordination meetings shall be held weekly or as needed to ensure safe and viable working conditions.

1.08 CONTRACTOR'S QUALITY CONTROL

It is the intent of these specifications and the contract drawings that the work performed under the contract shall result in a complete operating system in satisfactory working condition with respect to the functional purpose of the installation, and no extra compensation will be allowed for anything omitted but fairly implied. The prices paid for various items in the proposal shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and doing all work necessary to complete the finished product as provided in the plans and specifications.

The statement "or equal" in these specifications shall mean that the Contractor may substitute another manufacturer's product as a substitute for that specified. The Contractor will thereby warrant that the product will perform as good or better than that replaced. The statement "or approved equal" in these specifications shall mean that the contractor must submit information and obtain prior approval from the Engineer before making a substitution. Acceptance as equal by the Engineer does not relieve the Contractor of responsibility for the performance of the substitute product.

Where the contract requires that materials or equipment be provided or that construction work be performed, and detailed specifications of such materials, equipment, or construction are not set forth, the Contractor shall perform the work using materials and equipment of a quality comparable to the materials and workmanship specified for other parts of the work and at least equal to the general standard of quality found within existing work, from firms of established good reputations, and shall follow best practices in the performance of construction work. The work performed shall be in conformity and harmony with the intent to secure the best standard of construction and equipment of work as a whole or in part.

1.09 SUBMITTALS

The Contractor shall be responsible for providing submittal information for approval as required in these specifications to the Engineer before purchasing the material or performing the work. The Engineer will review and approve or reject initial submittals in writing within 7 working days after receipt by the Engineer. Where the Engineer requests additional information or rejects an initial submittal, the Engineer shall use such time as is necessary to review the additional materials or new submittals.

1.10 INSPECTION AND TESTING

All work performed by the Contractor shall be inspected by the Ducks Unlimited Project Engineer or his appointed Representative. All final decisions shall be made by Ducks Unlimited Project Engineer. Inspection and testing will be performed in accordance with specifications. Where inspection is required, the Contractor shall provide 48 hours notice to the Engineer. The Engineer shall make every effort to provide inspection on shorter notice.

1.11 CONSTRUCTION STAKING

The Engineer shall provide initial elevation reference points and horizontal alignments. It is the Contractors responsibility to establish and maintain construction staking as required to meet the specified tolerances.

1.12 CONTRACTOR SUPERINTENDENT

The Contractor shall at the start of construction designate a Superintendent or other employee to act as liaison for all communication on the project. This individual shall be responsible for requesting inspection, notifying the Engineer when segments of work are complete, and communication of instructions to all employees and sub contractors on the site. Except in emergency situations all specified notifications, submittals, and communications shall be considered valid only if they are received from the Superintendent. The Superintendent shall attend coordination meetings with Other Contractors weekly or as needed to ensure safe and viable working conditions.

1.13 SITE PROTECTION

The work location is open to the public. The Contractor shall provide protection devices including barricades, fencing, warning signs, lights, and other devices necessary to ensure security and safety within the project site during all aspects of the work.

In accordance with generally accepted construction practices, the Contractor shall be solely and completely responsible for the conditions of the jobsite, including safety of all persons and property during the performance of work. Excavations shall meet the requirements of OSHA 29 CFR 1926, Subpart P, Excavations. The duties of the Project Engineer do not include the review of the adequacy of the Contractor's safety in, on or near the jobsite.

1.14 UTILITIES

It is the responsibility of the Contractor to comply with the provisions of ORS 757.541 to 757.571. The Contractor is responsible for locating utilities prior to the start of construction. The Contractor shall be liable for any damage to utilities caused by construction activities. It is the Contractor's responsibility to contact the Utilities Underground Location Center at 1-800-424-

555. Ducks Unlimited makes no representations as to the existence or nonexistence of utilities.

1.15 CULTURAL RESOURCE MONITORING AND SENSITIVE AREAS

Cultural Resource monitoring shall be performed by a combination of Archaeologists and US Fish and Wildlife Service staff. All ground disturbing earthwork or traffic that affects the natural ground surface shall be monitored. The Contractor shall provide notification prior to undertaking any of these activities requiring monitoring.

If human remains are discovered, stop construction immediately, secure the site and contact the County Sheriff. If cultural materials are discovered, stop work in the area immediately and contact the Archaeologist and Project Engineer for the evaluation of the cultural materials. Work may continue in another area during the evaluation with the approval of the Archaeologist and Project Engineer. Work may resume in the stop work area with the approval of the Archaeologist and Project Engineer.

The Contractor shall be responsible for mitigating any damages to cultural resources that are a result of construction activities not monitored by the Archaeologist and approved by the Project Engineer.

Sensitive Areas
Sensitive areas are shown on the plans and shall be staked in the field. The following conditions shall apply to Sensitive Areas:

1. USGS 'SET' LOCATIONS: Do not disturb, Maintain a 30 foot radius buffer.
2. USGS GROUNDWATER LOCATIONS: Do not disturb, Maintain a 10 foot radius buffer.
3. WATER QUALITY STATIONS: Do not disturb, Maintain a 10 foot radius buffer.
4. SIGNIFICANT PLANTS: Do not disturb, Maintain a 10 foot buffer.
5. VEGETATION STUDY AREAS: Limited access, no heavy traffic. Any access or traffic in these areas shall be approved by the Engineer.
6. PHOTO POINTS: Do not disturb, Maintain a 30 foot radius buffer.

1.16 CONTROL OF SURFACE/SUBSURFACE WATER

The Contractor is responsible for control of surface water, subsurface water and drainage during the construction period. All temporary fills, crossings, or culverts necessary to promote drainage will be installed and removed at the Contractor's expense prior to acceptance of the work. The Contractor shall order and schedule channel excavation to maintain drainage of surface and sub-surface water to prevent wet working conditions, damage to haul roads and the existing marsh surface. Any claims arising from upstream or downstream damages as a result of the construction or failure of these temporary works will be the Contractors responsibility. No additional payment will be made to the Contractor for any work to be done as a result of adverse weather conditions or changing site conditions during the construction period.

1.17 TIDES

The site will be affected by tidal fluctuations. Tide predictions for Bandon, Oregon may be found at http://tidesandcurrents.noaa.gov/noaatidepredictions/. Predicted tide elevations are based on mean lower low water level (MLLW) and the plans are based on the vertical datum, NAVD88. Where the MMLW elevation is 0.00, the NAVD88 elevation is 0.03 feet. Tide predictions are calculated for basic conditions at Bandon, Oregon. Actual tide elevations on the site may vary from those predicted.

1.18 DUST CONTROL

The Contractor shall comply with all regulatory requirements for dust control on the project site.

1.19 BURNING

Burning of brush or slash shall not be allowed. Fire prevention measures shall be taken to prevent the start or spreading of fires which result from construction activities.

1.20 SANITARY FACILITIES

Sanitary facilities such as chemical toilets shall be located at least 100 feet from moving water to prevent contamination of surface or subsurface water.

1.21 STAGING AND FUELING EQUIPMENT

The Contractor shall use the staging areas shown on the plans or as approved by the Engineer. The Contractor shall consider high tide elevations for all uses within the staging area. The Contractor shall use staging areas to store all materials, including hazardous materials. The Contractor shall use staging areas to store, fuel, or service heavy equipment, vehicles and other power equipment with tanks larger than 5 gallons. All fuel and oil spills shall be cleaned up and disposed at the sole expense of the Contractor. The Contractor shall have onsite at all times a spill containment kit, with supplies and instructions for cleanup and disposal, adequate for the types and quantity of hazardous materials present. The Contractor's employees shall be trained in the use of the kit. After construction is complete, obliterate all staging, storage, or stockpile areas, stabilize the soil, and revegetate the area.

*** END OF SECTION ***

SECTION 2050
MOBILIZATION

Part 1 - General

1.01 DESCRIPTION

The work shall include the supply and transport of all labor, material and equipment to successfully complete that project as shown on the plans or described by the Engineer. Mobilization shall also include securing all permits for moving equipment on public roadways, construction permits, and other applicable permits.

Part 2 - Materials (not used)

Part 3 - Execution

3.01 GENERAL

The Contractor shall conduct all mobilization operations in a timely orderly manner. Unless otherwise approved by the Engineer, mobilization operations shall commence no later than one week after the notice to proceed. De-mobilization shall be finished within two weeks after substantial project completion.

During all operations, the Contractor is responsible for maintaining public and private property in original condition. Damage to existing roadways, roadway shoulders, fences etc shall be repaired to the satisfaction of the Engineer at the Contractors expense.

Part 4 - Measurement and Payment

Mobilization shall be measured and paid on a lump sum basis (L.S.) for the entire project. 50% of contract unit price shall be paid at the first billing. The remaining 50% of the contract unit price shall be paid at project completion.

A Contractor is eligible for a separate mobilization payment when the Contractor is required to discontinue work by the Corporation for reasons other than seasonal termination of work. The payment shall be payment in full for supply of all necessary labor, equipment, and materials to perform mobilization operations herein described and all work in this specification. The payment shall be commensurate to the amount of equipment and materials that are required to be removed from the project site and that payment shall not exceed the original unit price specified for mobilization.

*** END OF SECTION ***

SECTION 2100
SITE PREPARATION

Part 1 - General

1.01 DESCRIPTION

This specification shall cover the supply of all labor, materials, and equipment required for site access as well as mowing and debris removal, if required.

1.02 SCOPE OF WORK

A. Site Access
B. Mowing
C. Debris Removal

Part 2 - Materials (not used)

Part 3 – Execution

3.01 MOWING

Mowing is allowed using the appropriate low ground pressure equipment. Track remediation shall be required for mowing.

3.02 DEBRIS REMOVAL

Logs and surface debris may be moved as required to complete channel excavation. Logs and surface debris may be moved out of the work area and left onsite.

3.03 SURFACE SMOOTHING

Surface smoothing to improve trenching equipment operation is allowed in small areas using the appropriate low ground pressure equipment. Track remediation shall be required for surface smoothing.

3.04 CLEARING

No clearing is required for channel excavation.

3.05 GRUBBING

No grubbing is required for channel excavation.

3.06 STRIPPING

No stripping is required for channel excavation.

3.07 SITE ACCESS

Access to the work is the responsibility of the Contractor. During all operations, the Contractor is responsible for maintaining public and private property in original condition. Damage to existing roadways, roadway shoulders, fences etc shall be repaired to the satisfaction of the Engineer at the Contractors expense. Paved roads shall be maintained in a clean condition. Material tracked onto paved roads shall be limited and cleaned up daily as required.

Construction access is available at three locations off North Bank Lane. There are two public boat ramps located just upriver of the site and downstream at Bullard's Beach State Park.

The Contractor's use of North Bank Road shall be in compliance with all applicable local, state and federal regulations. The Contractor shall contact the State and County highway departments as required. The required items may be, but are not limited to: Safety signage, flaggers, dirt control, and road cleaning.

Do not operate equipment or vehicles hauling material or equipment on Randolph Road between Highway 101 and North Bank Road.

Part 4 - Measurement and Payment

Site Preparation shall be measured and paid on a lump sum (LS) basis.

*** END OF SECTION ***

SECTION 2200
EARTHWORK

Part 1 - General

1.01 DESCRIPTION

The work shall include the supply of all labor, material and equipment required to complete the work as shown on the plans and as staked in the field. The excavation work involves tidal channel excavation.

1.02 SCOPE OF WORK

A. Onsite Access
B. Temporary Crossings
C. Tidal Channel Excavation
D. Track Remediation

1.03 INSPECTION

The Engineer will perform onsite inspection during construction. In addition, the Contractor shall call for inspection at the following points of construction:

A. Prior to ground disturbing activities requiring Cultural Resource monitoring
B. Prior to working in very wet and soft areas
C. Prior to beginning work in a new area to allow for fish monitoring and salvage.
D. Prior to installing a temporary crossing.
E. Prior to crossing a first, second, or third order channel without an approved Temporary Crossing.

Part 2 - Materials

2.01 BIODEGRADABLE LUBRICANTS

Biodegradable lubricants and hydraulic fluids will be required in all equipment that will be operated within the wetland. For additional information and suppliers of biodegradable hydraulic fluids, motor oil, lubricant, or grease, see, Environmentally Acceptable Lubricants by the U.S. EPA (2011)

2.02 LOW GROUND PRESSURE EQUIPMENT

Low Ground pressure equipment is required. Equipment shall have a ground pressure of no more than 1.5 pounds per square inch. Equipment ground pressures will be verified by manufacturers specifications or actual equipment weights from a certified scale provided by the Contractor and track measurements by the Engineer. LGP equipment is required due to the soft to very soft ground of the tidal marsh and the requirement to limit tracks.

2.03 EQUIPMENT CLEANING

Before entering wetlands or within 150 feet of a waterbody, replace all petroleum-based hydraulic fluids with biodegradable products in accordance with Environmentally Acceptable Lubricants by the U.S. EPA (2011). Before entering the project site, power wash all heavy equipment, vehicles and power tools, allow them to fully dry, and inspect them to make certain no plants, soil, or other organic material adhering to the surface. Before operation within 150 feet of any waterbody , and as often as necessary during operation, thoroughly clean all equipment, vehicles, and power tools to keep them free of external fluids and grease and to prevent leaks and spills from entering the water.

Before entering the water, inspect any watercraft, waders, boots, or other gear to be used in or near water and remove any plants, soil, or other organic material adhering to the surface. Inspect all equipment, vehicles, and power tools for fluid leaks before they leave the staging area.

Part 3 - Execution

3.01 ONSITE ACCESS

Onsite access to work areas on the site is varied. The ground of the restored marsh is soft to very soft. Vegetation types and cover is variable.Maintaining access over the site and limiting damage to the natural ground surface is the responsibility of the Contractor. Low ground pressure equipment is required.

3.02 TEMPORARY CROSSINGS

Temporary crossings of existing stream and tidal channels may be installed by the Contractor if desired. Temporary Crossing locations and design shall be approved by the Engineer in writing. The Temporary Crossings design shall provide access, provide fish passage and limit sediment generation and turbidity. The Contractor is responsible for the function and maintenance of Temporary Crossings. Do not place Temporary Crossings in areas that may increase the risk of channel re-routing or avulsion, or in potential spawning habitat, *e.g.*, pools and pool tailouts. Minimize the number of Temporary Crossings. Install temporary bridges and culverts to allow for equipment and vehicle crossing over perennial streams and tidal channels during construction. Wherever possible, vehicles and machinery must cross streams at right angles to the main channel. Obliterate all temporary stream crossings as soon as they are no longer needed, and restore any damage to affected stream banks or channel.

Equipment may cross first, second and third order tidal channels without a Temporary Crossing under the following conditions. The existing channel is not damaged significantly by bank collapse or rutting. Minor damage that is immediately repaired may be acceptable. Sediment and turbidity in the water are not increased. Water flow and fish passage are not impaired. Existing vegetation is not destroyed. All crossings occur under the inspection of the Engineer. If, in the opinion of the Engineer, ongoing channel crossings create regular, significant damage the practice shall not be allowed.

3.03 EXCAVATION TOLERANCES

Excavation shall be out of the water at low tides wherever possible. In-water work shall be during low, incoming tide. No in-water excavation is allowed during a falling tide.

Excavations shall be constructed to within 0.1 ft of elevations shown on the plans. Horizontal orientation shall be as shown on the plans and staked in the field by the Engineer.

Channels shall be excavated to clean neat lines. The top edge of ditches shall be clear of debris that may restrict drainage into the channel to prevent ponding next to the channel. Ditch edges shall not be greater than 2 inches. If greater than 2 inches, ditch edges should be cleared for drainage at 10 foot intervals. The ditch cross-section should be clean and neat without clumps and debris to block or reduce flow. Clumps and debris greater than 4 inches shall be cleaned from the channels. Maintaining clean lines may require hand labor.

3.04 TRACK REMEDIATION

Equipment tracking is limited in order to not create additional shallow ponding. In order to reduce tracks, the Contractor shall use minimal turn paths. Equipment tracks shall not be deeper than 2 inches or track remediation shall be required. Track remediation shall consist of shallow ditching to provide positive drainage of the track or smoothing or filling the track to where ponding is less than 2 inches. Tracks shall be inspected for ponding after the next high tide and additional remediation may be required. Track remediation may require hand labor.

3.05 EXCAVATION: SECOND ORDER TIDAL CHANNELS

The purpose of Second Order Tidal Channels is to provide drainage to the mapped pools shown on the plans in a larger general region. Second Order Tidal Channels are shown as "New Channels" on the plans. Second Order Tidal Channels are typically 100- 500 feet long and 1' to 2' deep.

Excavate Second Order Tidal Channels to the line and grades shown on the plans and staked in the field by the Engineer. The horizontal alignments are not straight but are designed with a sinuosity of 1.1. Slight meandering of the channels will allow excavating through the lowest areas for full drainage. Excavate to the slope and invert elevations on the plans to ensure full drainage during low tides for reducing fish entrapment and ponding water.

3.06 EXCAVATION: FIRST ORDER TIDAL CHANNELS

The purpose of First Order Tidal Channels is to drain small, local pools not generally indicated on the plans. First Order Tidal Channels are not shown on the plans. First Order Tidal Channels are typically less than 100 feet long and 0.5' to 1.5' deep.

Excavate First Order Tidal Channels to the line and grades staked in the field by the Engineer. The horizontal alignments will be slightly curved to straight. Excavate to the slope and invert elevations designated in the field to ensure full drainage during low tides for reducing fish entrapment and ponding water. Excavation of First Order Tidal Channels may require hand labor due to site conditions.

3.07 EXCAVATION: ADDITIONAL CHANNELS

Additional Channels as shown on the plans and are an Add Alternate item. The Additional Channels shown include First Order Tidal Channels and Second Order Tidal Channels as described above. The line and grades of Additional Channels will be staked in the field by the Engineer.

Excavate Additional Channels to the line and grades staked in the field by the Engineer. The horizontal alignments will be slightly curved to straight. Excavate to the slope and invert elevations designated in the field to ensure full drainage during low tides for reducing fish entrapment and ponding water.

3.08 SPOILS

Material excavated from the channels shall be spoiled onsite, along the excavated channel. Spoils shall not prevent drainage into the ditch, restrict tidal flows and/or create ponding. Spoils piled shall not be continuous. Spoils shall be widespread and/or placed in tracks to create a uniform surface. Spoils shall not be deeper than 4 inches. Spoils may be used for track remediation. . If, in the opinion of the Engineer, spoils placement will result in ponding of greater than 2", additional spreading of the spoils may be required.

3.09 FISH MONITORING AND REMOVAL

The Contractor shall coordinate with the Engineer when moving to a new work area for fish monitoring and removal. Fish monitoring and removal shall be performed by USFWS and Others to the following standards. All ponds and tidal channels within the active work area will be visually inspected or sampled with dip net, seining, or electroshocking methods prior to work. Captured or shocked fish will be released into adjacent tidal channels not connected to the work area. If no fish are observed or captured and the ponds are less than 1 foot deep with water temperatures in excess of 70 degrees, they will be considered too warm to support salmonids.

3.10 WORK ORDER FOR FISH STRANDING PREVENTION

The Contractor shall coordinate with the Engineer when moving to a new work area for fish stranding prevention. The following strategies will be applied to specific construction scenarios:

Scenario 1: The channel construction will be completed in one low tide period. Excavate the channel at low tide when the channel is dry or on the incoming tide. Excavate from existing channel to ponded water or from ponded water to existing channel and complete. There is full fish access both ways after construction and thus no stranding.

Scenario 2: Completing the channel will/may take more than one low tide. Excavate the channel at low tide when the channel is dry or on the incoming tide. Excavate from existing channel to ponded water with no ditch plug to maintain fish passage during and after a high tide. Continue excavation on the next low tide. There is full fish access both ways during high tides and after construction and thus no stranding.

Scenario 3: Completing the channel will/may take more than one low tide in high ground areas where the elevation of the surrounding marsh is sufficient to fully prevent high tides and fish from moving overland into the partially constructed channel.

Option A: Excavate from existing channel to ponded water leaving a ditch plug, or from ponded water to existing channel, thereby leaving a defacto ditch plug. There is no access for fish at low or high tide during construction and thus no stranding. The ditch plug will be removed at low or incoming tide after completion of the channel work providing full access both ways.

Option B: Excavate from existing channel to ponded water with a screen at the channel outlet rather than a ditch plug to exclude fish from the excavated channel. They cannot get in overland as the ground is high. There is no access for fish at low or high tide during construction and thus no stranding. Screen will be removed when construction is completed providing full access both ways.

Scenario 4: The channel will/may take more than one low tide in high ground areas where the surrounding marsh will be inundated prior to completion. Under this scenario, excavation will proceed from the channel to ponded water. Fish will have continuous access to tidally influenced channels.

3.11 SEDIMENT MANAGEMENT

Channels shall be excavated in the dry or on an incoming tide to force sediments and turbidity upstream to settle out in the marsh. Ditch plugs may be used to contain sediments and turbidity until the ditch plug is removed on an incoming tide.

Should greater than 1 inch of rain fall in a 24 hour period, the Engineer and USFWS may direct the Contractor to cease work until the work area dries to avoid mobilization of marsh table sediments. .

3.12 GENERAL HAND LABOR

General Hand Labor shall be for incidental excavation items selected by the USFWS and Engineer. The Contractor shall make available a crew of a minimum of 6 people, including a working crew chief.

General Hand Labor does not include Track Remediation, excavation of First Order Tidal Channels or finish work to achieve Excavation Tolerances.

Part 4 - Measurement and Payment

Onsite Access, Temporary Crossings, Track Remediation shall be considered incidental to Earthwork.

All Channel Excavation items, unless otherwise specified, shall be paid based on a lineal foot basis (LF). Measurements shall be made in the field by the Engineer.

General Hand Labor shall be paid on an individual hourly basis (HR) per crew member.

*** END OF SECTION ***

SECTION 2800

EROSION CONTROL

Part 1 - General

1.01 DESCRIPTION

The work of this section shall include the supply of all labor, seed, materials, and equipment required to complete installation of erosion control measures described below.

1.02 SCOPE

A. Seed and mulch areas specified below

1.03 INSPECTION

The Contractor shall call for inspection after preparing areas to be seeded.

Part 2 - Materials

2.01 SEED

Seed shall be labeled in accordance with the state laws. Bag tag figures will be evidence of purity and germination. Minimum purity shall be 95%. Minimum germination shall be 85%. The maximum percent of weed seed allowable shall not exceed 0.5%. No seed will be accepted with a date of test of more than 9 months prior to the date of delivery to the site. Seed that has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

A. Seed species: Species used shall conform to the following:

Common Name	Species
Blue wildrye	Elymus glaucus
California Brome	Bromis vulgaris
Tufted hairgrass	Deschampsia cespitosa
Tall fescue	Any Variety

B. Seed Mix: The following seed mix shall be used as specified:

Species	% Total by Weight	Lbs/Acre
Blue wildrye	9.1%	5 #/ac
California Brome	9.1%	5 #/ac
Tufted hairgrass	9.1%	5 #/ac
Tall Fescue	73.7%	40 #/ac
	100.0%	55 #/ac

2.02 STRAW MULCH

Straw mulch shall be clean, grass seed straw from local sources. Noxious weed seeds shall not be allowed.

Part 3 - Execution

3.01 SEEDBED PREPARATION

Areas to be treated shall be dressed to a smooth, firm surface. The seedbed shall be prepared by scarifying if necessary to provide a roughened surface so that broadcast seed will stay in place

3.02 SEEDING

The seed mix shall be applied to the decommissioned:

Mobilization and Staging Areas
Construction Accesses

All seeding operations shall be performed in such a manner that the seed is applied in the specified quantities uniformly on the designated areas. Seed shall be spread by the broadcast method and raked or harrowed into the ground to provide seed soil contact. Seeding shall be done within 2 days after final grading is complete.

3.03 STRAW MULCH

Straw mulch shall be applied to all seeded areas. Mulch shall be applied at the rate of 50# / 300 SF.

3.04 HYDROSEEDING

Hydro-seeding may be used to apply seed and mulch.

Part 4 - Measurement and Payment

Erosion Control shall be measured and paid on a per acre (AC) basis. Measurements shall be made by the Engineer.

*** END OF SECTION ***

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