Action Effectiveness Monitoring for the Lower Columbia River Estuary Habitat Restoration Program

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Action Effectiveness Monitoring for the Lower Columbia River and Estuary Habitat Restoration Program Annual Report for Year 9 (September 2012 to September 2013)

Annual Report for Project Number: 2003-007-00, **Contract Number:** 59063

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1 Executive Summary

The goal of the Action Effectiveness Monitoring (AEM) program is to provide the Estuary Partnership, primary funding agencies (Bonneville Power Administration [BPA] and Environmental Protection Agency [EPA]), restoration partners (e.g., US Army Corps of Engineers [USACE] and Columbia River Estuary Study Taskforce [CREST]), and others with information useful for evaluating the success of restoration projects. The implementation of a new prioritization strategy resulted in the selection of four AEM sites in 2013. Kandoll Farm Phase 2, Steamboat Slough, Dibblee Slough, and Sauvie Island North Unit Phase 1 restoration sites and four associated reference sites were monitored for vegetation composition and terrestrial macroinvertebrates.

At pre-restoration sites, invasive Reedcanary grass was the dominant vegetation, while bare ground was the highest cover class at post restoration sites and reference sites. Pre-restoration sites had a lower vegetation species richness and lower vegetation species diversity than reference or post restoration sites. Regarding terrestrial macroinvertebrates, Diptera was the most prevalent order of macroinvertebrate found at pre-restoration, post restoration, and reference sites. No clear patterns were observed related to terrestrial macroinvertebrate species richness or diversity at pre-restoration, post restoration, or reference sites. A PIT tag array installed at Horsetail/Oneonta creek detected 72 unique tags. Both upriver and lower Columbia wild and hatchery salmonids were detected at the site. In the first year of implementation, programmatic action effectiveness can only evaluate the status of restoration sites; however, with subsequent years of monitoring, the impact of restoration actions in the lower Columbia River and estuary and can be evaluated.

2 Introduction

The Lower Columbia Estuary Partnership's Action Effectiveness Monitoring (AEM) Program focuses on quantifying the impact of restoration efforts (primarily sponsored by the BPA and USACE) in the lower Columbia River and estuary. On-the-ground AEM efforts collect the data needed to assess the performance and functional benefits of restoration actions in the lower Columbia River and estuary (LCRE).

The goals of the Estuary Partnership's Action Effectiveness Monitoring Program are to:

- Improve restoration techniques to maximize impact of habitat restoration actions and better track long term project success
- Identify how restoration techniques address limiting factors for salmonids
- Determine the impact of restoration actions on salmon recovery at the site, landscape, ecosystem scale
- Use intensive monitoring to inform extensive monitoring efforts to improve multi-scale AEM

To meet AEM program goals, the Estuary Partnership are engaged it the following tasks:

- Implementing AEM as outlined in the Estuary RME plan (Johnson et al. 2008), Programmatic AEM plan (Johnson et al. 2013), and following standardized monitoring protocols (e.g., Roegner et al. 2009) where applicable
- Developing long-term datasets for restoration projects and their reference sites
- Implementing a programmatic plan for AEM to provide improved efficiency and coordination between stakeholders
- Disseminating data and results to facilitate improvements in regional restoration strategies
- Developing of a regional cooperative effort by all agencies and organizations participating in restoration monitoring activities to maximize the usefulness of monitoring data

Additionally, the Estuary Partnership aims for the Action Effectiveness Monitoring Program to complement our existing Ecosystem Monitoring Program (BPA project # 2003-007-00). The Ecosystem Monitoring Program (EMP) implements monitoring activities to characterize undisturbed emergent wetlands and assess juvenile salmonid usage of those habitats. The EMP provides valuable information for improving restoration effectiveness, provides a baseline ecosystem condition from which compare action effectiveness monitoring data, and provides pertinent information regarding which extensive monitoring metrics relate to improved opportunity and capacity related to juvenile salmonids. For example, several sites monitored by the Ecosystem Monitoring Program were included in the Estuary Partnership's Reference Site Study funded by BPA (Borde et al. 2012). One of objectives of the study was to determine if structural data from multiple reference sites can be used to evaluate restoration action effectiveness. The concept of using multiple reference sites is important because a paired reference site is not always available at or near a restoration site. Borde et al. found that sediment accretion, elevation, inundation, water temperature, vegetation composition and similarity, and channel morphology are useful metrics for evaluating restoration effectiveness between a restoration site and multiple reference sites. The Estuary Partnership's EMP continues to monitor many parameters likely to be included in AEM (e.g., vegetation, water quality, food web, and salmon) and the collection of comparable datasets by the two programs (where possible) will continue to fill data gaps and add to our understanding of habitat conditions and juvenile salmonids in the lower river.

2.1 Background on Estuary Partnership's Action Effectiveness Monitoring

The Estuary Partnership's mission is "to preserve and enhance the water quality of the estuary to support its biological and human communities." The goal of the Action Effectiveness Monitoring Program is to provide the Estuary Partnership, primary funding agencies (the BPA and the EPA), restoration partners (e.g., USACE and CREST), and others with information useful for evaluating the success of restoration projects. Such evaluations supported by AEM facilitate improvements in project design and management, increase the success of restoration projects for ESA listed salmonids, and address RPA 60 of the 2008 Draft BiOp.

Effectiveness monitoring commenced in 2008 when EOS members recommended four projects for AEM. Mirror Lake, Sandy River Delta, Scappoose Bottomlands, and Fort Clatsop were first sampled in 2008 and monitored annually until 2012. The selected AEM sites represented different restoration activities (culvert enhancement to improve fish passage, large wood installation, re-vegetation, cattle exclusion, and culvert removal for tidal reconnection), habitats (bottomland forest, riparian forest, emergent wetland, and brackish wetland), and geographic reaches of the river (Reaches H, G, F, and A, ranging from tidal freshwater in Reach H, or the Columbia River Gorge, to saltwater intrusion in Reach A, near Astoria, Oregon). The initial phase of AEM resulted in the standardization of monitoring methods and evaluated the effectiveness of restoration actions at the site level. However, the initial phase of AEM highlighted the need for expanded coverage of monitoring to evaluate reach and landscape scale ecological uplift along with the necessity of associated reference sites with each restoration site.

2.2 Programmatic Action Effectiveness Monitoring and Research

In 2012, the Estuary Partnership, BPA, and US Army Corps began to update the AEM program applying lessons learned during initial AEM efforts. "*A Programmatic Plan for Restoration Action Effectiveness Monitoring and Research in the Lower Columbia River and Estuary"* (Johnson et al. 2013) was developed to determine the success of restoration actions not only at the site level, but also at landscape and estuary-wide scales. The intended outcome of this programmatic AEM plan is to achieve efficiency, coordination, and consistent conduct of AEM across the LCRE over the next six years of the FCRPS BiOp (2013-2018). In addition, this programmatic AEM guidance was incorporated into technical proposals during the Estuary/Lower Columbia River categorical review within the Northwest Power and Conservation Council's Fish and Wildlife Program in early 2013. Regional stakeholders began to use this programmatic approach to provide context for their project-specific AEM efforts and help project-level goals synchronize with landscape level efforts of the Columbia Estuary Ecosystem Restoration Program (CEERP) where concern is for the collective ecological success of multiple restoration projects across multiple landscapes in the LCRE. Stakeholder research, monitoring, and evaluation (RME) plans involve using AEM to determine if their restoration actions were successful in meeting the project's objectives, identify improvements to restoration design and execution, and recognize cost efficiencies in AEM efforts. Overall, the programmatic approach to estuary AEM will be better coordinated with the broader estuary restoration effort through the Estuary Partnership, and with Columbia River tributary habitat AEM and the federal RME effort under the 2008 Federal Columbia River Power System Biological Opinion (NMFS 2008).

3 Site Selection

In 2013 restoration sites were prioritized using the criterion outlined in Johnson et al. 2013. Four restoration sites were selected for extensive "Level2" monitoring (**Error! Reference source not found.**). After restoration sites were selected, four associated reference sites were chosen to put pre-restoration site data into an ecological context. The full results of the 2013 site selection process can be found in Appendix B.

Horsetail Creek was selected for fish monitoring prior to the establishment of AEM prioritization process. Horsetail creek was selected for fish monitoring to determine residency time in upriver streams and address uncertainty related fish passage through long culverts.

Table 1. Five restoration sites and associated reference sites selected for "Level 2" monitored indicators (Johnson et al. 2013)

Restoration Site	**Location**	**Reference Site**	**Restoration Project Proponent**
Kandoll Farm	Rkm 37 and approximately 5 km up the Grays River	Seal Slough swamp	Columbia Land Trust
Steamboat Slough	Rkm 57	Welch Island	US Army Corps of Engineers
Dibblee Slough	Rkm 104	Dibblee Point	CREST
Sauvie Island North Unit Phase 1(Ruby Lake)	Rkm 145	Cunningham Lake	CREST
Horsetail Creek	Rkm 223		Estuary Partnership

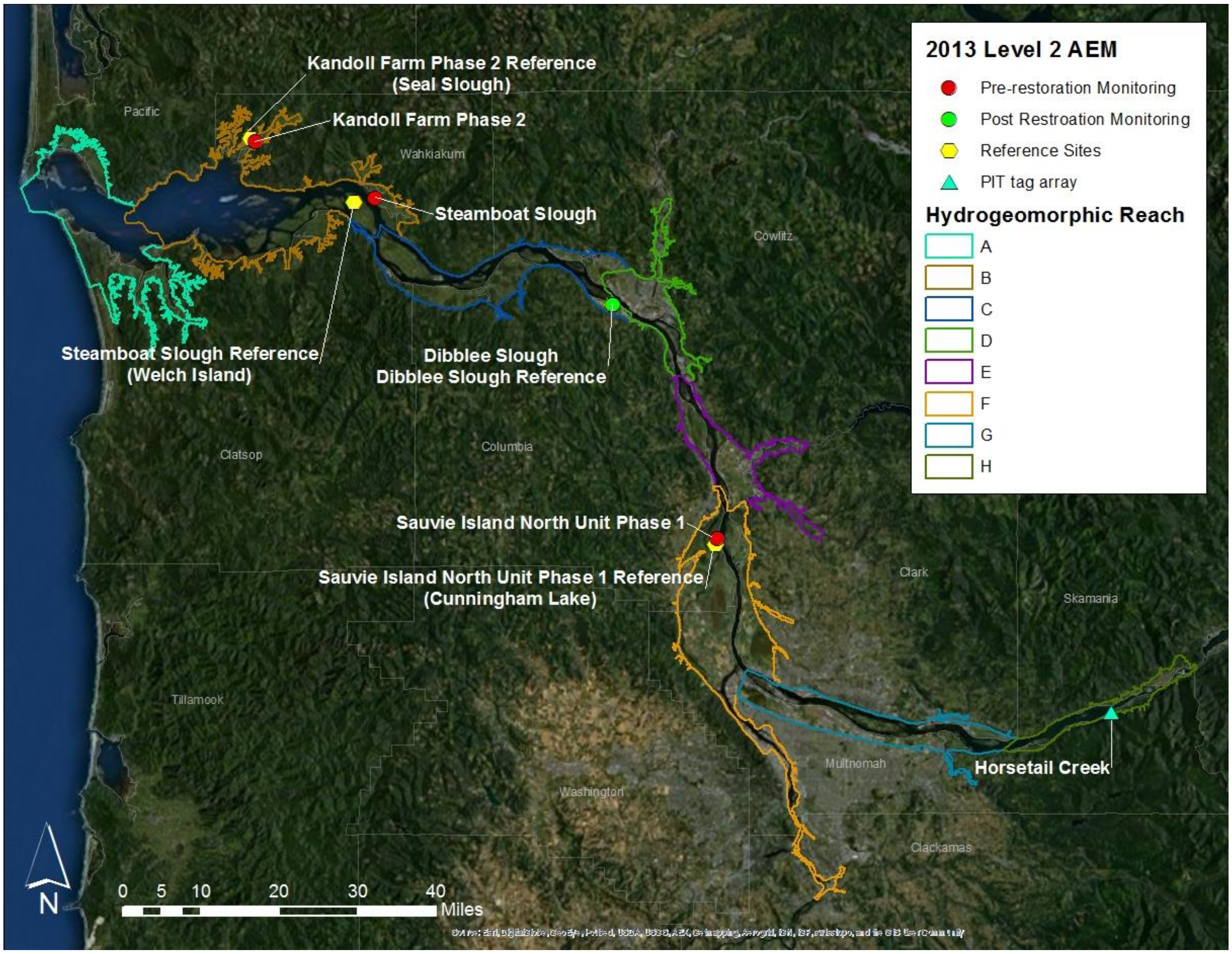

Figure 1. 2013 Level 2 AEM pre-restoration, post restoration, and reference site monitoring locations.

4 Methods

4.1 Vegetation and Terrestrial Macroinvertebrate Monitoring

Monitoring methods followed those defined in Roegner et al. (2009, Protocol ID: 460) and are found in Monitoringmethods.org. Level 2 monitoring in 2013 included vegetation assemblage cover and composition (Method ID: 822), elevation (Method ID: 818), and macro-invertebrate sampling (USGS and Nisqually Indian Tribe 2012). At all sites photo points were established (Method ID: 820) near the vegetation sampling area. Sediment accretion stakes were measured (Method ID: 818) when stakes were previously installed at a site, but no new installations were conducted.

Species Richness and Shannon-Wiener Diversity Index was calculated for both vegetation and terrestrial macroinvertebrates. Species Richness is the number of species represented in the sampled ecological community. Shannon-Wiener Diversity Index (Equation 1) represents abundance and evenness of species present in a sampled ecological community.

Equation 1. Shannon-Diversity Index

$$H' = -\sum_{j=1}^{s} p_i \ln p_i$$

where H' = Shannon-Wiener diversity index
p_i = importance probability in column
i= matrix elements relativized by row totals (see Greig-Smith 1983, p.163; based on Shannon and Weaver 1949).

4.2 Fish Monitoring

A passive integrated transponder (PIT) tag detection system (**Error! Reference source not found.**) was installed in the culvert system at the confluence of Horsetail and Oneonta Creeks on May 9, 2013. The system consists of a Biomark FishTRACKER IS1001-MTS distributed Multiplexing Transceiver System (MTS), which powers 10 antenna units mounted within the culvert system at Horsetail/Oneonta Creek site beneath Interstate-84 (Figure 1). The MTS unit receives, records and stores tag signals from these 10 antennas, which measure approximately 6’ by 6’ and are mounted on both ends of the 5-barrel culvert system running under the freeway. The system is powered by an 840 watt solar panel array and supported by a massive 24-volt, 800 amp-hour battery bank backup. The unit is also connected to a fiber optic wireless modem that allows for daily downloads of tag data and system voltage monitoring updates.

5 Results

5.1 Vegetation and Terrestrial Macroinvertebrates

5.1.1 Vegetation

In 2013, Kandoll Farm Phase 2, Steamboat Slough, and Sauvie Island North Unit Phase1 were monitored pre-restoration and Dibblee Slough monitored one year post restoration along with associated reference sites (Figure 1). Each restoration site had two vegetation monitoring areas to capture an area that would be directly impacted by restoration actions and an area that would be indirectly impacted by restoration actions (Appendix A). Having two vegetation monitoring areas can better quantify the overall impact of restoration actions across the site.

When all pre-restoration sampling areas were averaged together, invasive Reedcanary grass was the dominant cover at 45%. At reference sites, Reedcanary grass represented 14% of the total cover and 4% total cover at the post restoration site. Bare ground at reference sites was the highest cover class at 20%, which contrasts with 6% bare ground at pre-restoration sites. Bare Ground was the highest cover class at post restoration sites with 29% cover. Although reedcanary grass was the second most common species at reference sites, it was slightly more prevalent than native Lyngby Sedege at 13% cover (Figure 2).

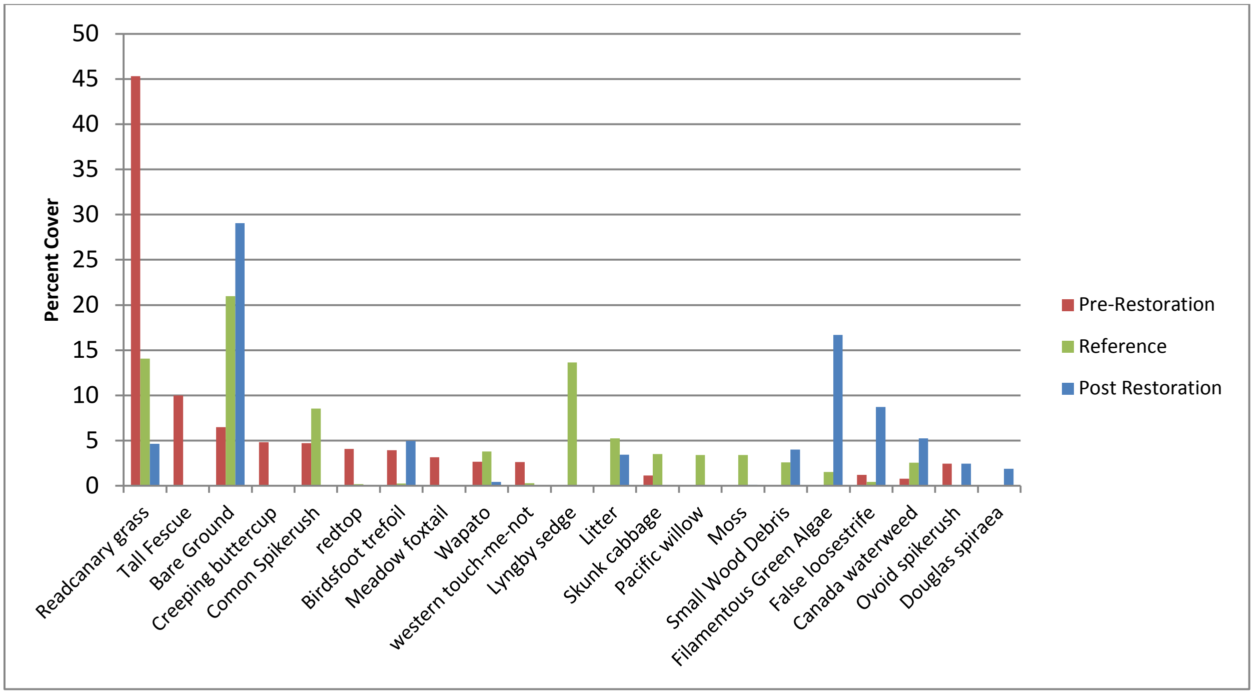

Figure 2. Percent Cover of most common species found at Pre-restoration, post restoration, and reference sites.

At the site level, species richness and species diversity (Shannon-Wiener diversity index) was calculated. In general, pre-restoration sites contained fewer overall species and lower diversity than associated reference sites (Table 2). Species richness varied greatly depending on the restoration action at the vegetation sampling area at the post restoration site. The Diblee channel site, which was directly impacted by soil scrape down, has a higher species richness compared to the Diblee pond site, which was not directly impacted by restoration actions. Although the Diblee channel has high species richness, the species diversity at the channel and pond vegetation sampling area was similar.

Table 2. Vegetation species richness and species diversity for pre-restoration, post restoration, and reference sampling areas.

Site	Species Richness	Species Diversity	Average Elevation (m, NAVD 88)
Kandoll Farm (Pre-restoration)			
Site E	20	1.384	2.10
Site A	32	2.558	2.16
Reference	44	2.794	
Steamboat Slough (Pre-restoration)			
Site East	44	2.677	1.42
Site West	14	1.668	1.92
Reference	49	2.602	1.86
Diblee Point (Post Restoration)			
Channel	64	2.209	2.78
Pond	34	2.494	2.50
Reference	49	2.457	2.33
Sauvie Island North Unit Phase 1 (Pre-restoration)			
South	11	1.324	2.82
North	3	0.158	3.14
Reference	17	1.832	2.80

5.1.2 Terrestrial Macroinvertebrates

Kandoll Farm Phase 2, Steamboat Slough, Dibblee Slough, and Sauvie Island North Unit Phase 1 restoration sites and associated reference sites were monitored for terrestrial macroinvertebrates in 2013 (Figure 1). At each restoration site a total of four macroinvertebrate fall out traps were installed; two fall out traps were installed in proximity to vegetation sampling areas to capture the species assemblage of terrestrial macroinvertebrates.

The top ten macroinvertebrate species by family from restoration and reference sites were grouped to order. Diptera was the most prevalent macroinvertebrate order at pre-restoration, reference, and post restoration sites at 48%, 61%, and 58% respectively (Figure 3). Hymenoptera was the second most prevalent order found at sites regardless of site condition with pre-restoration at 15% and reference and post restoration at 29% (Figure 3).

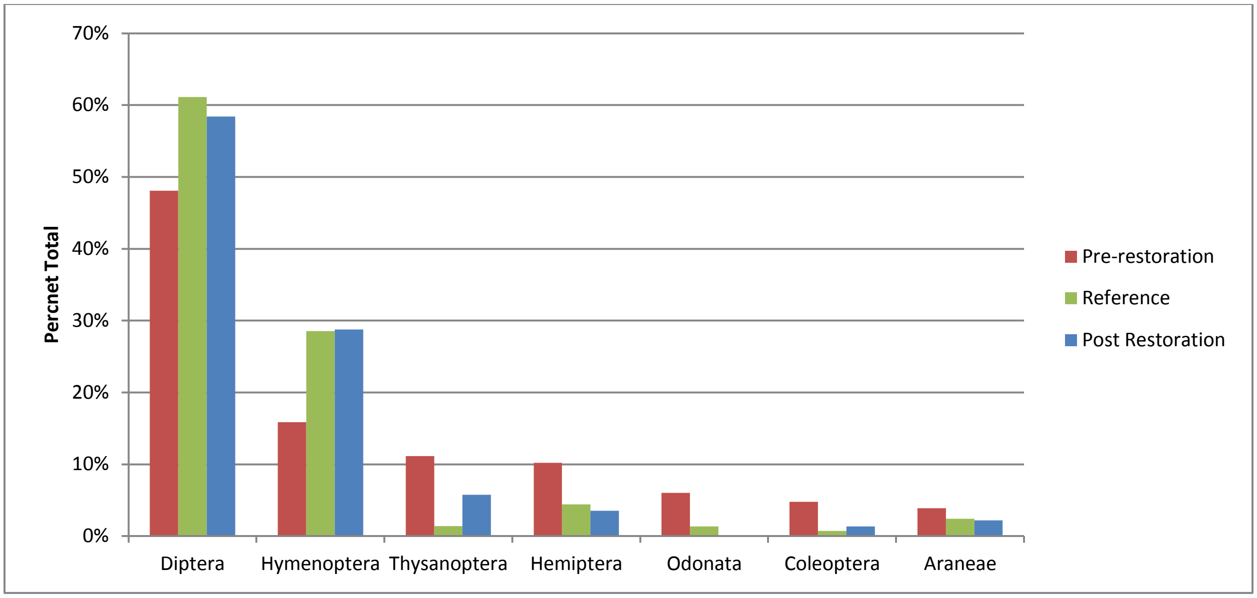

Figure 3. Percent macroinvertebrate found at pre-restoration, post restoration, and reverence sites.

At the site level, species richness for pre-restoration sites was slightly higher than reference sites (Table 3). Conversely, at the post restoration site, number of macroinvertebrates was slightly lower than the reference site. With respect to macroinvertebrate species diversity, no trends were found at pre-restoration sites. Species diversity was found to be both higher and lower depending on the pre-restoration site (Table 3). At the post restoration site, species diversity was higher at the reference site (Table 3).

Table 3. Terrestrial Macroinvertebrate Species Richness and Species Diversity for pre-restoration, post restoration, and reference sampling areas.

Site	Species Richness	Species Diversity
Kandoll Farm Pre-restoration	20	2.153
Kandoll Farm Reference	16	2.307
Steamboat Slough Pre-restoration	34	2.664
Steamboat Slough Reference	33	2.17
Diblee Point Post Restoration	25	2.537
Diblee Point Reference	29	2.923
Sauvie Island North Unit Pre-restoration	32	2.701
Sauvie Island North Unit Reference	24	2.682

5.2 PIT-tag array monitoring at Horsetail/Oneonta Creek

5.2.1 PIT-tag Operation

The successful installation of the PIT-tag array at Horsetail/Oneonta Creek was the culmination of nearly 18 months of work. The effort included obtaining permits from multiple groups/agencies, the fabrication and testing of antennas during the Fall/Winter 2012, installation of all 10 antennas in January 2013, installation of a 17' steel pole, installation of the solar components in February, and final placement of the battery bank and all system components in April. Final electrical connections, power-up and tuning of the entire system was completed on May 9, 2013.

In the first year of operation, the system functioned remarkably well through much of the calendar year; however, we did experience some technical issues that led to interruptions in data collection. After the initial set-up, the system functioned well until early June when a tripped circuit breaker on the solar input line caused a significant voltage drop in the batteries. This voltage drop forced the MTS receiver into standby mode. At the time, we did not have the wireless modem installed and did not became aware of this problem until June 14 during a planned site visit. A wireless modem was installed on June 14 allowing for daily system updates.

We also encountered problems with several of the antenna control nodes (ACN), resulting in periods of no data collection for several antennas. One faulty ACN was replaced within a couple weeks of discovery; another faulty ACN was not discovered for several months. This particular ACN was on the western most barrel on the north side, and corresponds to the culvert barrel that has a fish ladder type structure within it to facilitate upstream migration. It was initially believed that the ACN failed the hourly internal 'test tag' protocol due to the barrel being completely filled with sediments (as was observed in previous years). However, after the barrel was cleared of sediments in late summer, the antenna continued to fail the hourly test tag. It was determined that the ACN was defective and upon this discovery the antenna was connected to a functioning node.

A further interruption of tag data collection occurred July 18 when all 5 of the south side antennas were disconnected and removed to allow for restoration activities at the site. Restoration activities were completed in early September and the antennas were reinstalled and connected to the receiver on September 11, but not powered up because 4 of 5 barrels were dry. The south antennas were powered back up on September 29, but 3 of them failed to come back on due to what was later determined to be a faulty wire connection. The 3 failed antennas were reconnected and back in operation on October 13.

In general, for the first year of operation, the entire system (antennas, receiver, modem, solar panels and batteries) functioned exceptionally well. With a couple exceptions, we had nearly continuous tag data collection for most antennas through November 26, despite the significant decline in solar power generation that started in late September. In early December the voltage drop in the battery bank backup accelerated dramatically and the entire system was powered off on December 4 to preserve the integrity of the batteries.

For 2014, we need to replace a faulty ACN on the north side and also boost (charge) the battery bank backup in order to power it back up and make it fully operational. This will take place in late January and we plan to continue charging the battery bank as needed with a generator until spring time, when the system should be self-sufficient on solar power generation.

5.2.2 Fish Detection and Passage

In total, the system collected tag data for nearly 7 months and recorded 591 detections, which corresponded to 72 unique tags. The first detection occurred on May 11 and the last detection was on November 23. Using the PTAGIS database we were able to determine species and site origination info for all but 2 of these tags (Table 4). Nearly all of the fish detected from May through the end of July were juvenile salmonids that had been released earlier in the year. The exceptions were an adult sockeye and Chinook salmon that were tagged in the lower river for an upstream migration study. Most of the juvenile fish were hatchery Chinook salmon, comprising both spring and fall stocks, but we also detected some hatchery coho and a hatchery summer Steelhead. There was also a juvenile wild Chinook that had been tagged upriver as part of a survival study. The hatchery Chinook salmon originated from as far away as the Rapid River (tributary of the Salmon River) Hatchery near Riggins, ID and as nearby as the Little White Salmon Hatchery in Stevenson, WA (above Bonneville Dam). The coho salmon originated from hatcheries (or rearing ponds) near Winthrop and Wenatchee, WA.

The last juvenile salmon was detected on July 28 with no detections for the entire month of August and most of September. The absence of detection coincides with the restoration construction on Horsetail and Oneonta Creeks. Fish were detected again in late September on an almost daily basis though late November. The fish dectected were predominantly adult Chinook and coho salmon that had been captured and tagged in the lower river as part of an upstream migration study. There were also a couple of juvenile wild steelhead that had been tagged upriver and released and a pair of juvenile hatchery coho salmon from the Kooskia National Fish Hatchery Hatchery in Idaho that had been released in February and April.

Of the 21 juvenile salmon and steelhead that were detected at the site in the spring and early summer, nearly all of them were encountered for only a day or two. From this group, it appears that only 2 individuals (a hatchery coho and a hatchery spring Chinook) were able to successfully navigate all the way through the culvert. An adult sockeye salmon also transited the culvert system in mid-July and was able to make it through the eastern most barrel (w/o a fish ladder structure). In contrast to the spring/summer juveniles, nearly twice as many adult salmon were encountered at the site in autumn, and many were present for long periods of time. For example, one adult Fall Chinook was detected 57 times over the span of a 15-day period. These adults were more successful in transiting through the culvert system, with at least 14 individuals (both coho and Chinook) detected by a south side antenna. In most cases, these fish passed through the western most barrel with the fish ladder structure. Interestingly, the only two juvenile wild steelhead (released in Spring) were observed going all the way through the culvert in the Fall. A more in depth analysis of this data to look at duration of time encountered at the site and also success in transiting the culvert structure will be presented in a future report.

Table 4. Fish detected in 2013 at Horsetail Falls PIT-tag array

			Months present							
Species	***# of fish detected***	***length (mm)***	April	May	June	July	Aug	Sept	Oct	Nov
Juvenile hatchery spring Chinook	11	99-128	■	■	■	■				
Juvenile hatchery summer steelhead	2	n/a				■				
Juvenile hatchery fall Chinook	4	74 - 80		■		■				
Juvenile wild steelhead	2	147, 151							■	
Juvenile hatchery coho	4	107 - 124						■	■	■
Adult spring Chinook	1	n/a			■					
Adult fall Chinook	10	605 - 855						■	■	■
Adult coho	28	400 - 920						■	■	■
Adult sockeye	1	n/a				■				
Adult hatchery fall Chinook	3	380 - 640						■	■	■
Adult hatchery coho	2	610 - 660						■	■	■

6 Discussion and Conclusion

For the four new sites selected for AEM, only the status of sites can only be assessed in the first year of monitoring. In subsequent years, collected data at both pre and post restoration sites will be used to evaluate if restoration objectives are being met. In addition to assessing effectiveness of restoration actions at the site level, data from AEM will address applicable management questions at larger spatial scales:

- "*Are aquatic, riparian, and upland estuary habitat actions achieving the expected environmental, physical or biological performance objectives?*" – Based on restoration project goals, AEM data will examine if habitat actions are achieving expected performance objectives
- *"What are the limiting factors or threats in the estuary/ocean preventing the achievement of desired habitat or fish performance?"* – AEM data will measure established limiting environmental factors like temperature and will attempt to address emerging limiting factors related to habitat and prey resources
- *"What are the relationships between estuary habitat actions and fish survival or productivity increases?"* – The AEM program is designed to collect pertinent extensive and basic environmental and biological metrics which can be related to fish survival and productivity through ratio estimators (Johnson et al. 2013)
- *"What actions are most effective in restoring ecological processes or improve fish habitat carrying capacity, growth, life history diversity and survival?"* – AEM will track the impact of

restoration actions on ecological processes which affect fish opportunity and capacity. Specifically, the AEM program will evaluate the effectiveness of controlling Reedcanary grass (Phalaris Arundinacea) by lowering wetland elevations.

In subsequent years, pre and post restoration data from multiple sites will begin to track the impact restoration at the reach and landscape scale. Long term AEM coupled with status and trend monitoring can provide context for the cumulative impact of restoration efforts in the lower Columbia River and estuary.

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8 Appendix

Appendix A: Site Sampling Reports

The summaries are presented in the chronological order in which sites were sampled. Additional background information about the sites sampled in the AEMR Program is often available in restoration project planning documents and reports, or in previous monitoring reports. To the extent possible, these are cited in the descriptions of each site.

8.1.1 Equipment

Equipment for each of the metrics sampled is outlined below.

- *Vegetation*: 100-m tapes for the baseline and transects, a compass for determining the baseline and transect azimuth, 1-m quadrat, data sheets, plant books for species identification. GPS to identify location of base stakes and quadrats.
- *Insect Fallout Traps:* 4 tubs (26.7x15.8 inches) for trapping macroinvertebrates. 125µm sieve, garden sprayer, 96% denatured ethanol, and plastic jars with lids were used to field process macroinvertebrates for transport back to the lab for identification.
- *Sediment Accretion Rate:* 2 gray 1-inch PVC conduit pipes, at least 1.5m long, construction level, meter stick. GPS to identify location of stakes.

- *Photo Points:* camera, stake for including in photo, previous photos at location for reference, GPS to identify location of point.
- *Elevation*: GPS with real-time kinematic (RTK) correction. Other survey equipment in case GPS equipment is non-functional, including an auto-level, tripod, and stadia rod.

Additional equipment was required at the Kandoll Farm swamp reference site which is located in a Spruce Swamp. During sampling in the swamp reference site, no significant equipment issues or losses were reported. Wear and tear on equipment was higher in swamps than in marshes, and waders and tapes will be repaired as needed. The Estuary Partnership's model Ashtech ProMark 200 GPS received good satellite coverage under the tree canopy, a significant improvement over coverage during sampling in prior years because of the greater availability of satellites, but the GPS unit could not make accurate elevation measurements. CREST diameter tapes were in inches not centimeters so PNNL's metric tape was not used; these data will need to be converted during the next phase of the project. Broken tapes or tapes without stakes required tying off in the field.

8.1.2 Teaming: Roles and Responsibilities

At each of the restoration and reference sites four individuals comprised the AEMR Level 2 monitoring team. The team included Estuary Partnership Ecologist Matthew Schwartz (Program Manager), PNNL Wetlands Ecologist Amy Borde (Vegetation Sampling Lead), CREST Lead Ecologist April Silva, and CREST Habitat Restoration Biologist Jason Smith. Additional staff was necessary at the Kandoll Reference swamp; the team and their roles for that site are defined within the site report below.

In general, the roles and responsibilities of team members were as follows:

- Types of sampling for this site were determined according to the Estuary Partnership's Scope of Work.
- PNNL staff prepared the site sampling design prior to the field work, based on prior knowledge of the site and the protocols for randomization, and brought navigation information previously collected in GPS or created in GIS for the following:
    - baseline start point; 10 transects (endpoints and azimuths); 9 pairs sediment accretion stakes; 3 insect fallout traps; 2 HOBO pressure sensors; and 2 photo points.
- Estuary Partnership staff collected GPS points on sampling locations.
- PNNL staff trained CREST and Estuary Partnership staff on setting up transects in the swamp environment, sampling shrub and tree plots according to the Roegner et al. (2009) protocols, and specialized equipment needs and uses (e.g., navigation compass, staking tapes, tree and shrub sampling equipment).
- PNNL staff recollected all photo point, sediment accretion, and water surface elevation and temperature data, in an effort to maximize inter-annual consistency at these sampling locations which had been previously established by PNNL staff under the three research projects described above.

8.1.3 Kandoll Farm

8.1.3.1 General Site Location

Grays River

8.1.3.2 Ecosystem Type

Restoration site, formerly diked.

8.1.3.3 Sampling History in the CEERP

The US Army Corps of Engineers' Cumulative Effects Team intensively sampled the Kandoll Farm Restoration Site (Thom et al. 2012) in 2005 (pre-restoration), 2006 (year 1), and 2009 (year 4). Additional metrics (and more intensive sampling of standard metrics) were also sampled in dissertation research by Heida Diefenderfer at this site starting in 2005 (Diefenderfer 2007; Diefenderfer et al. 2008; Diefenderfer and Montgomery 2009).

8.1.3.4 Current Role of Site in the CEERP

Kandoll Farm is a restoration site in the second phase of restoration actions. The first phase occurred in 2005 and included 1) the replacement of a small tide gate with 2 large 13-foot culverts at the end of Seal Slough; 2) the breaching of the Grays River dike in three locations; and 3) tree and shrub plantings in locations throughout the site. The second phase restoration is planned for late summer 2013 and includes channel excavation, along-channel mounding, filling, and dike removal.

8.1.3.5 Dates of Sampling in 2013

25-28 June

8.1.3.6 Types of Sampling in 2013

- *Vegetation*: Herbaceous cover (2 sample areas, 66 quadrats total) and point intercept of all species (2 lines, 97 meters (m) and 150 m long)
- *Insect Fallout Traps:* 4 traps
- *Sediment Accretion Rate:* measured one previously installed pair of stakes
- *Photo Points:*
    - photographed three previously established photo points near Seal Slough culverts and two previously established photo points on Grays River dike.
    - Established new photo points at the following locations:
        - Area A Vegetation Sampling area at 0 m on baseline
        - Area E Vegetation Sampling area at 0m on point intercept and 70 m on transect baseline
- *Elevation*: collected elevation at all vegetation quadrats and the end points of the point intercept lines

8.1.3.7 Vegetation Sampling Design

Status Sampling. This site had been previously monitored as part of the Phase 1 restoration. However, the previous vegetation sample areas were in a location that would be completely modified by the Phase 2 restoration plans. Therefore, new vegetation sample areas were established to capture the current condition and potential change that would occur with Phase 2 as follows:

Area A Vegetation sample area

- Located in area near the dike removal and the channel excavation; in the area where "mounds" will be created.
- 60 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 101° magnetic
- Transect azimuth: 11° magnetic
- Transect spacing: 10m, random start: 9
- Quadrat spacing: 10 m, random starts: 5, 7, 6, 6, 4, 9
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

Area E Vegetation sample area

- Located in area that will be affected by the dike removal, but away from the channel excavation.
- 70 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 101° magnetic
- Transect azimuth: 11° magnetic
- Transect spacing: 12m, random start: 5
- Quadrat spacing: 10 m, random starts: 0, 7, 6, 6, 7, 4
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

<u>Trends Sampling</u>. Within the new vegetation sample areas, we established and marked permanent quadrats locations for future trends sampling. In addition, two line intercept transects that were previously sampled in 2005, 2006, and 2009 were resampled as part of this effort. The transect specifications are as follows:

Area A Line Intercept -

- 97 m long, with 0 at the western end
- Azimuth 101° magnetic
- Sampled every meter

Area E Line Intercept -

- 150 m long, with 0 at the western end
- Azimuth 101° magnetic
- Sampled every meter

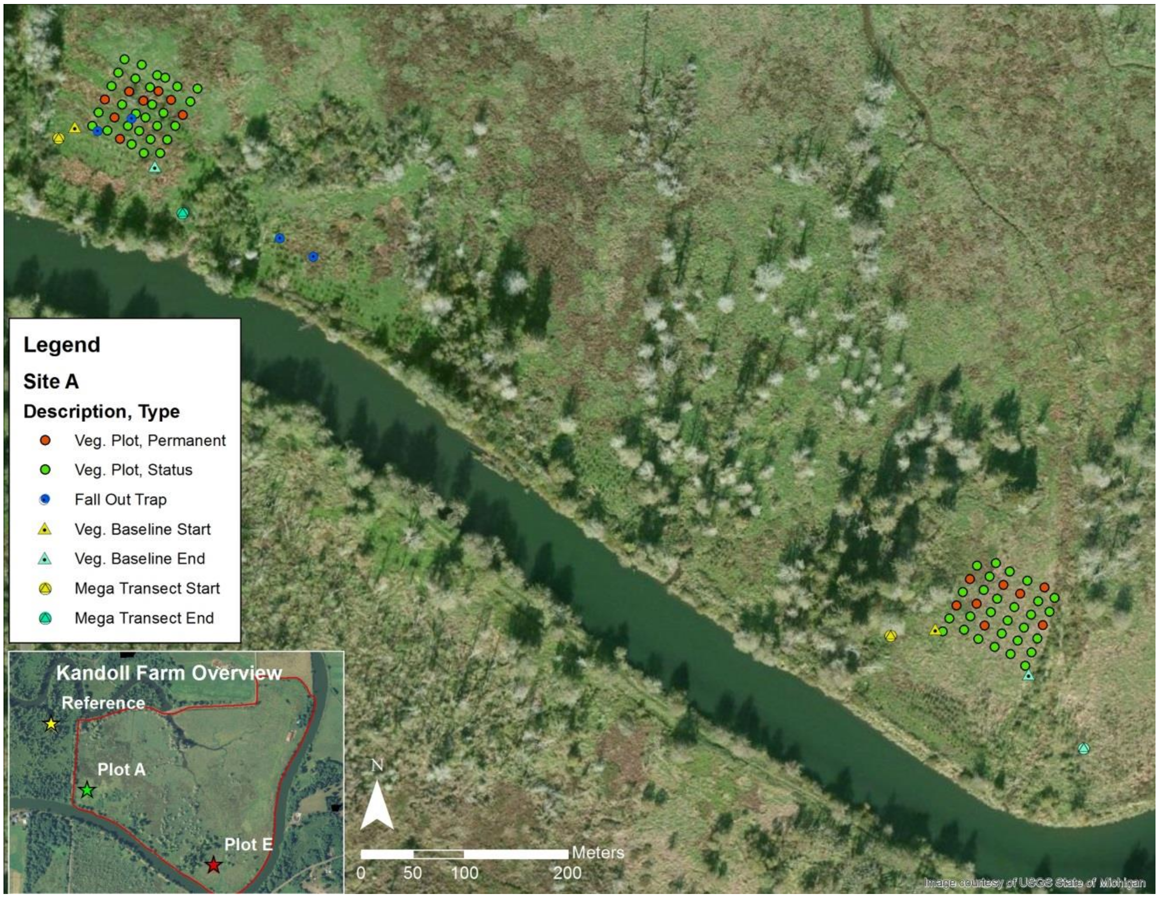

Figure 4. 2013 vegetation and macroinvertebrate sampling locations at Kandoll Farm restoration site.

8.1.3.8 Markers Left on Site

All marking stakes are white ¾ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample area.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).
- End stakes of the point intercept transects.

In addition the gray 1 inch PVC sediment stakes that were placed at the site in Area B in 2005 were measured and left at the site.

8.1.3.9 Macroinvertebrate Sampling

Macroinvertebrate fall out traps were placed in two seperate locations. Two fall out traps were placed in vegetation sampling area A. Two fall out traps were placed in an area adjacent to proposed channel construction and dike breach.

8.1.4 Kandoll Reference Site (Seal Slough Swamp)

8.1.4.1 General Site Location

Grays River

8.1.4.2 Ecosystem Type
Sitka Spruce Swamp

8.1.4.3 Sampling History in the CEERP
The Corps of Engineers' Cumulative Effects Team intensively sampled Kandoll Reference Site 2005-2009 as a paired site for Kandoll Farm Restoration Site (Thom et al. 2012). The 2009 sampling was also included as part of an LCRE-wide suite of sites for the Estuary Partnership/BPA Reference Sites project (Borde et al. 2011, 2012a, 2012b). Additional metrics (and more intensive sampling of standard metrics) were also sampled in dissertation research by Heida Diefenderfer at this site starting in 2005 (Diefenderfer 2007; Diefenderfer et al. 2008; Diefenderfer and Montgomery 2009).

8.1.4.4 Current Role of Site in the CEERP
Seal Slough Swamp is a reference site is being sampled as baseline pre-restoration monitoring for the restoration actions being conducted in 2013 at Kandoll Farm

8.1.4.5 Dates of Sampling in 2013
July 8-11

8.1.4.6 Types of Sampling in 2013
- *Vegetation*: Trees (30 plots) Shrubs (6 plots) Herbs (36 quadrats)
  Note: Morphometric data on trees were not collected due to time limitations.
- *Insect Fallout Traps* (4 traps, 3 at locations previously sampled)
- *Sediment Accretion Rate* (9 previously installed pairs of stakes)
- *Water Surface Level and Temperature, Atmospheric Pressure* (replaced two previously installed HOBO pressure sensors)
- *Photo Points* (photographed two of three prior photo points (the 3rd required boat access)
- *Global Positioning System (GPS) Sampling Locations* (where feasible, collected GPS information about sampling points)

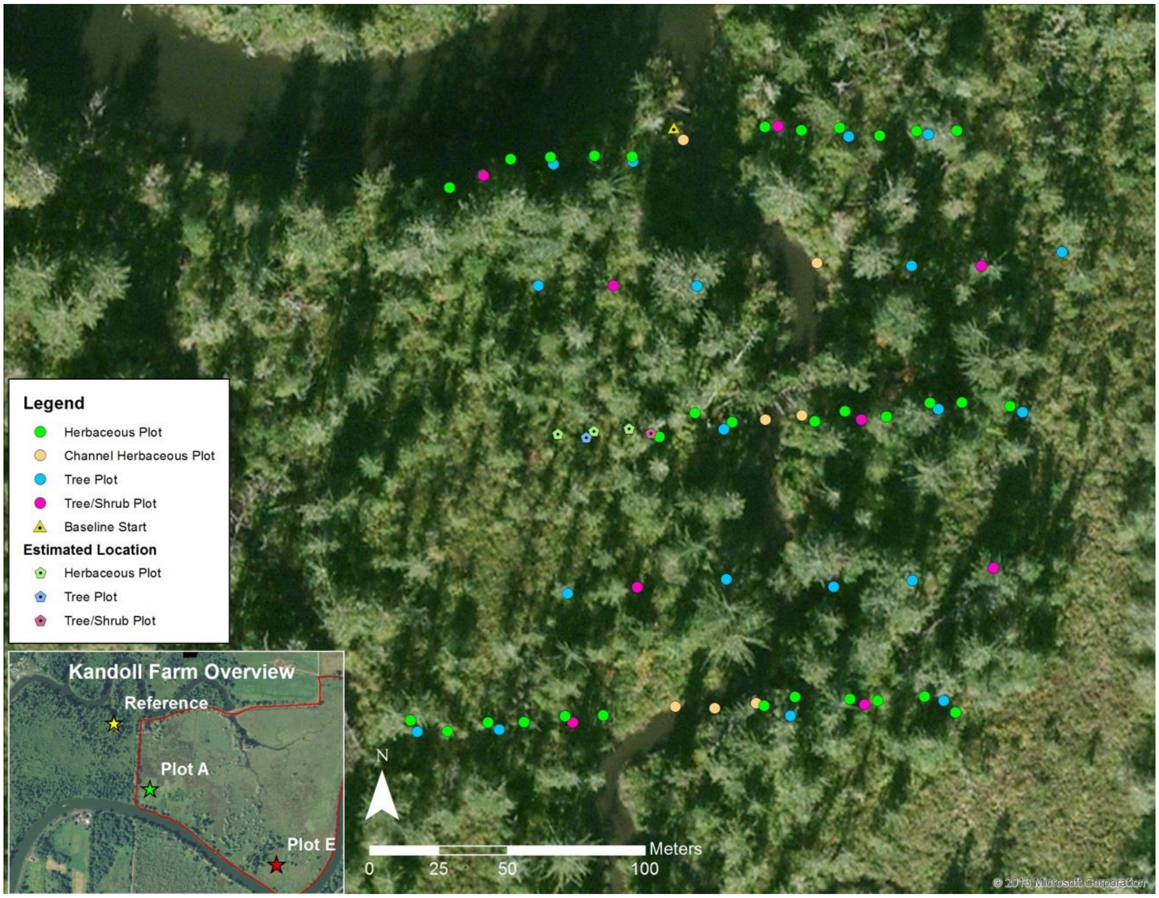

Figure 5. 2013 vegetation and macroinvertebrate sampling locations at Seal Slough reference site.

8.1.4.7 Vegetation Sampling Design

Status only. Permanent plots were not previously marked in the field, and we estimated that the variability associated with GPS location would be unacceptably high for trends sampling. We established and marked potential permanent plots for future trends sampling.

8.1.4.8 Markers Left on Site

White PVC stakes were installed on both channel banks at the 0-point on transects 54E, 94E, 134E, 174E, 94W, 134W, 174W.

White PVC stakes were installed at the center of tree/shrub plots at 54E-36, 94E-15, 94W-28, 134E-48, 134W-29, 174E-28, and 174W-18.

White PVC stakes were installed at the NW and SE corners of herb plots at 174E-1, 174E-21, 174E-41, 174W-10, 174W-30, and 174W-50.

8.1.4.9 Macroinvertebrate Sampling

Macroinvertebrate traps were placed at three locations that were previously sampled. One fall out trap was placed at the site in order to have the same level of sampling at the restoration and reference site.

8.1.4.10 Challenges

Line of sight is extremely limited by vegetation, which impacts efficiency in survey work and overland travel. To limit the removal of vegetation, transect tapes are sometimes laid in the air over vegetation or through vegetation instead of on the ground.

8.1.4.11 Additional Notes

Six staff members were on site for four days. In addition to the 4-member core AEMR Team, PNNL Restoration Ecologist Heida Diefenderfer participated all four days. CREST Coastal Planner Ryan Crater participated July 8-10 and a CREST Intern participated July 11.

8.1.5 Steamboat Slough

8.1.5.1 General Site Location

Julia Butler Hansen (JBH) National Wildlife Refuge

8.1.5.2 Ecosystem Type

Formerly diked, restoration site.

8.1.5.3 Sampling History in the CEERP

The Corps of Engineers' Cumulative Effects Team sampled some areas of the JBH refuge in 2007, prior to tide gate installations at Winter Slough, Duck Slough, and Ellison Slough. Fish sampling at JBH has been conducted by Jeff Johnson at USFWS in association with the tide gate installations. However, no previous sampling is known to have been conducted in this specific location.

8.1.5.4 Current Role of Site in the CEERP

The restoration at Steamboat Slough is planned for 2014 and involves a dike breach in two locations, channel excavation, and the creation of berms along the channels. A cross dike will protect the rest of the refuge from inundation.

8.1.5.5 Dates of Sampling in 2013

18-19 July

8.1.5.6 Types of Sampling in 2013

- *Vegetation*: Herbaceous cover (2 sample areas of 36 quadrats, 72 quadrats total)
- *Insect Fallout Traps:* 4 traps
- *Photo Points:* 2 photo points, 1 at each vegetation sample area
    - East Sample area – panorama taken at 70m on baseline
    - West Sample area – panorama taken at 0m on baseline
- *Elevation*: collected elevation at all vegetation quadrats

8.1.5.7 Vegetation Sampling Design

East Vegetation Sample area

- Located at east end of site in former constructed wetland low elevation area. Vegetation sample area spanned elevation gradient from lowest elevation with submerged aquatic vegetation (SAV) and bare mud through low marsh up to high elevation that was not formerly excavated.
- 70 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 330° magnetic
- Transect azimuth: 240° magnetic
- Transect spacing: 12m, random start: 10
- Quadrat spacing: 10 m, random starts: 7, 8, 1, 1, 1, 0
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

West Vegetation Sample area

- Located in area that will be affected by the dike removal, near proposed site of excavated channel.
- 70 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 312° magnetic
- Transect azimuth: 42° magnetic
- Transect spacing: 12m, random start: 10
- Quadrat spacing: 10 m, random starts: 0, 7, 3, 9, 1, 5
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

<u>Trends Sampling</u>. Within the new vegetation sample areas, we established and marked permanent quadrats locations for future trends sampling.

Figure 6. 2013 vegetation and macroinvertebrate sampling locations at Steamboat Slough restoration site.

8.1.5.8 Markers Left on Site

All marking stakes are white ¾ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

8.1.5.9 Macroinvertebrate *Sampling*

Insect fall out traps were randomly placed in the two vegetation sampling areas. Two traps each were placed at the east and west vegetation sampling area to characterize the macroinvertebrate species richness and diversity.

8.1.6 Steamboat Slough Reference (Welch Island)

8.1.6.1 General Site Location

Welch Island is located on the northwest (downstream) corner of the island at rkm 53, which is part of the Julia Butler Hanson Wildlife Refuge.

8.1.6.2 Ecosystem Type
Tidal emergent wetland

8.1.6.3 Sampling History in the CEERP
Two other areas of the island were monitored as part of the Reference Sites Study in 2008 and 2009 (Borde et al. 2011).

8.1.6.4 Current Role of Site in the CEERP
The area was selected as a long-term monitoring site in 2012 for the Estuary Partnership's Ecosystem Monitoring Program.

8.1.6.5 Dates of Sampling in 2013
23 July

8.1.6.6 Types of Sampling 2013
- *Vegetation*: Herbaceous cover (46 quadrats)
- *Insect Fallout Traps:* 4 traps
- *Sediment Accretion Rate:* measured one previously installed pair of stakes
- *Photo Points: one previously established point located at the 0 m end of the vegetation sample area baseline*
- *Elevation*: collected elevation at all vegetation quadrats.
- *Water surface elevation and temperature:* hourly measurements collected in the channel adjacent to the vegetation sampling area; continuous collections since December 2011.

8.1.6.7 Vegetation Sampling Design
Status Sampling. The same sample areas sampled for vegetation for the ecosystem monitoring program were used for action effectiveness monitoring.

Vegetatioin Sample area
- Located near a tidal channel in emergent marsh vegetation.
- 100 m x 80 m, with 40 quadrat locations and 6 quadrats located in the tidal channel to the east of the sample area.
- Baseline azimuth: 322° magnetic
- Transect azimuth: 232° magnetic
- Transect spacing: 20m, random start: 12
- Quadrat spacing: 10 m, random starts: 6, 5, 4, 5, 0
- the same quadrats are monitored each year for the trends sampling, no permanent markers were used to mark quadrat locations.

8.1.6.8 Markers Left on Site
All marking stakes are white 1" inch PVC. We marked the end stakes of the transects within the vegetation sample areas. One set of 2 sediment stakes are also located at the site, which are gray 1" PVC. The depth sensor is located inside 1 ½" PVC on a t-post in the channel.

8.1.6.9 Macroinvertebrate Sampling

Macroinvertebrate fall out traps were randomly placed at locations along the edge of the vegetation sampling area in order to avoid disturbance to the vegetation in the sampling area.

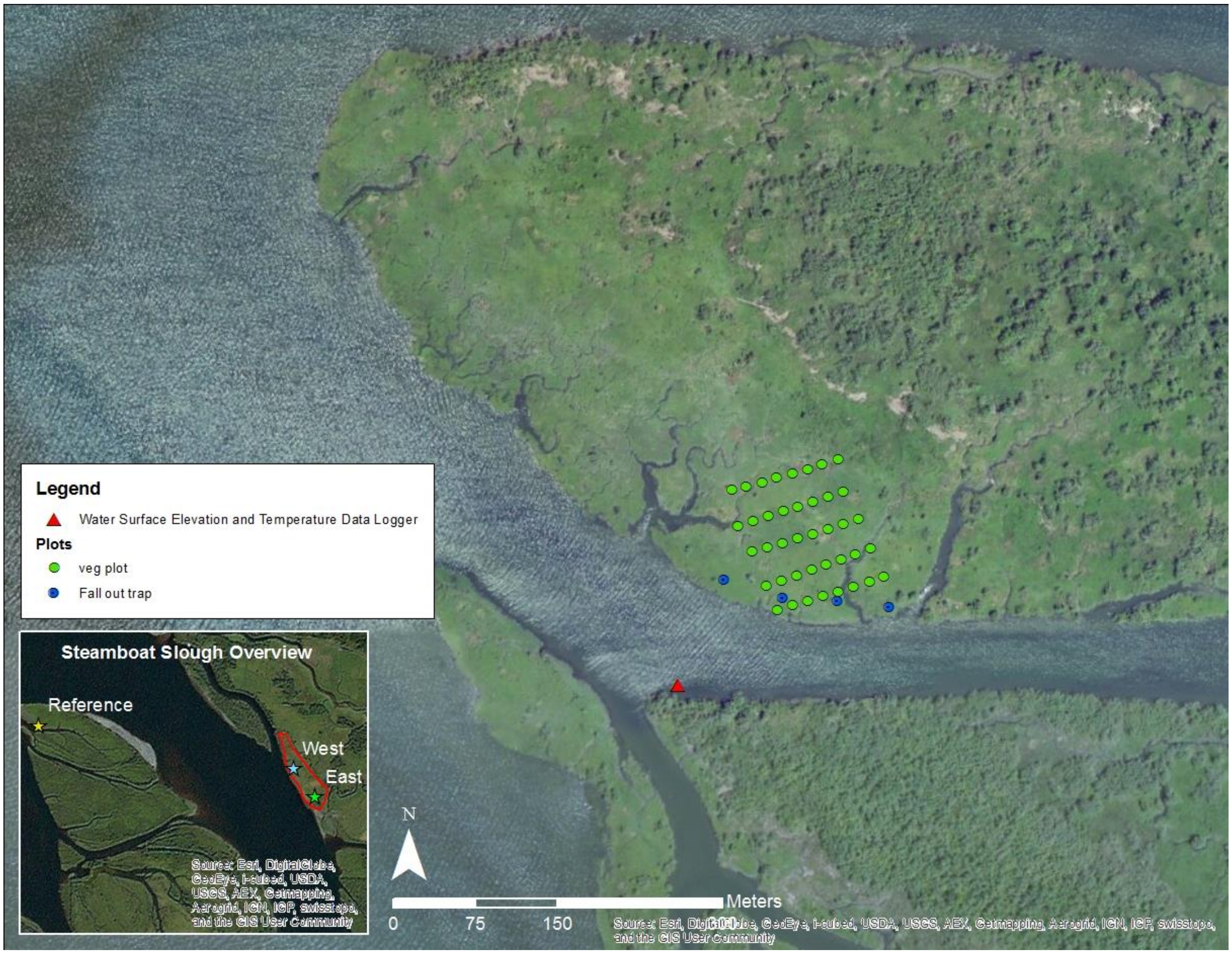

Figure 7. 2013 vegetation and macroinvertebrate sampling locations at the Welch Island reference site.

8.1.7 Sauvie Island North Unit Phase 1

8.1.7.1 General Site Location

North End of Sauvie Island on the Oregon Side of the River at rkm 144.

8.1.7.2 Ecosystem Type

Pre-restoration condition, tidally impaired wetland

8.1.7.3 Sampling History in CEERP

Vegetation sampling was conducted during the pre-restoration feasibility phase of the project to characterize the vegetation found at the site.

8.1.7.4 Current Role of Site in the CEERP

The restoration at Sauvie Island North Unit Phase 1 is planned for 2014 and involves the removal of tide gate and soil scrape down at the site. The site was chosen for Level 2 restoration monitoring as a result of the AEMR prioritization process and will be monitored years 1, 3, and 5 post restoration.

8.1.7.5 Dates of Sampling in 2013

30 July

8.1.7.6 Types of Sampling in 2013

See map below for sampling locations (**Error! Reference source not found.**)

- *Vegetation*: Herbaceous cover (2 sample areas of 36 quadrats, 72 quadrats total)
- *Insect Fallout Traps:* 4 traps
- o *Photo Points:* 1 photo point at the South Sample area – 180° from permanent plot 47-59, looking south
- *Elevation*: collected elevation at all vegetation quadrats

8.1.7.7 Vegetation Sampling Design

North Vegetation Sample area

- Located at north end of the southern part of the site. Vegetation sample area spanned elevation gradient which contained only Reedcanary grass and would be scraped down to an elevation to prevent recolonization of Reedcanary grass.
- 70 m x 60 m, with 36 quadrat locations
- Baseline azimuth: 180° magneticTransect azimuth: 270° magnetic
- Transect spacing: 11m, random start: 2
- Quadrat spacing: 10 m, random starts: 9, 1, 5, 2, 3, 5
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

South Vegetation Sample area

- Located at the southern end of the southern part of the site. Vegetation sample area spanned elevation gradient from lowest elevation SAV and bare mud through low marsh up to an elevation dominated by Reedcanary grass.
- 70 m x 80 m, with 36 quadrat locations
- Baseline azimuth: 191° magnetic
- Transect azimuth: 281° magnetic
- Transect spacing: 11m, random start: 3
- Quadrat spacing: 13 m, random starts: 0, 10, 1, 2, 7, 8
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

<u>Trends Sampling</u>. Within the new vegetation sample areas, we established and marked permanent quadrats locations for future trends sampling.

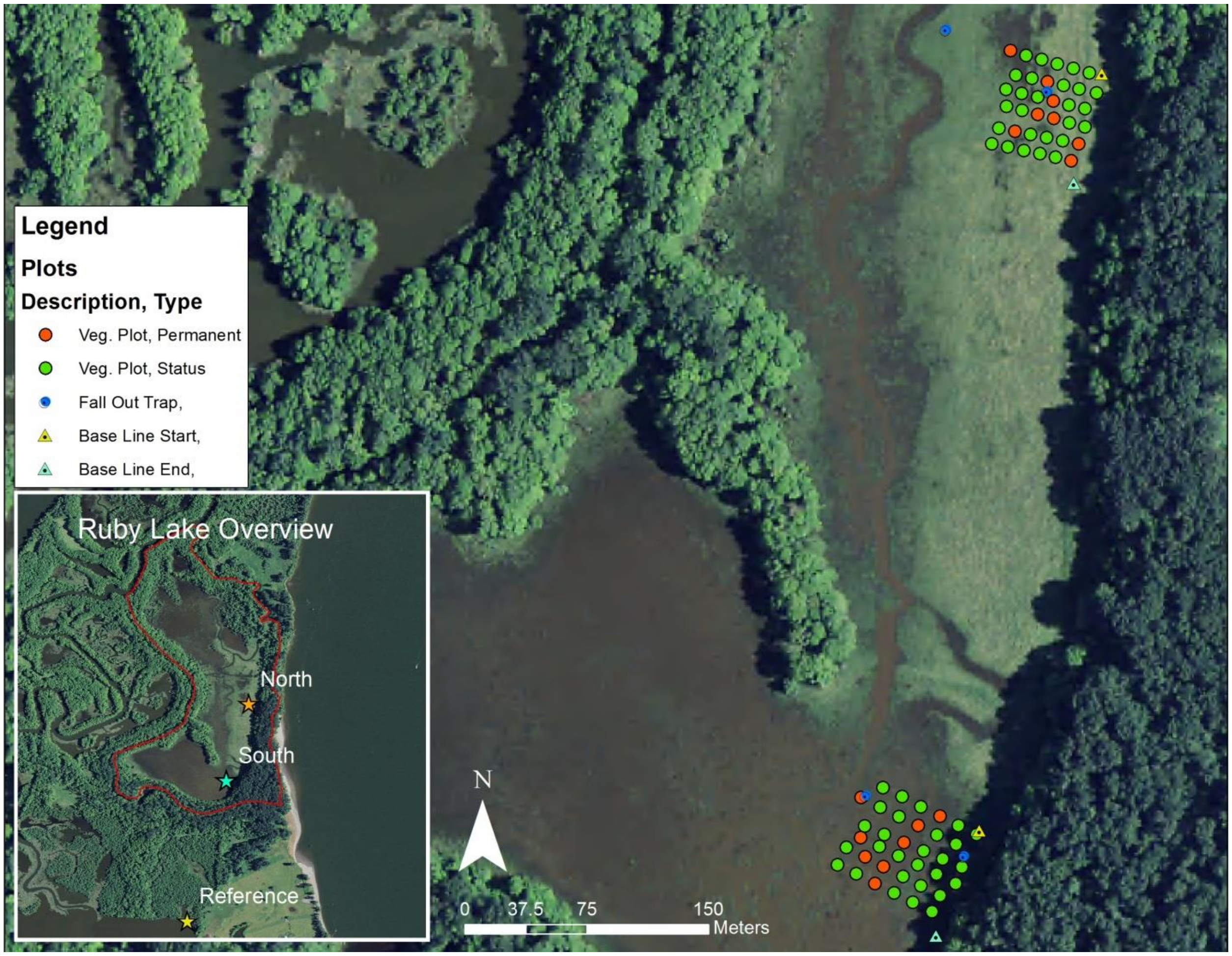

Figure 8. 2013 vegetation and macroinvertebrate sampling locations at the North Unit Phase 1 restoration site.

8.1.7.8 Markers Left on Site

All marking stakes are white ¾ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

8.1.7.9 Macroinvertebrate Sampling

Insect fall out traps were randomly placed in the two vegetation sampling areas. Two traps each were placed at the north and south vegetation sampling area to characterize the macroinvertebrate species richness and diversity.

8.1.8 Sauvie Island North Unit Phase 1 Reference (Cunningham Lake)

8.1.8.1 General Site Location

Cunningham Lake is a floodplain lake located at rkm 145 on Sauvie Island in the Oregon DFW Wildlife Area. The mouth of the Slough is located between rkm 142 and 143 close to where Multnomah Channel meets the Columbia River. The end of Cunningham Slough is approximately 8.7 km from Multnomah Channel.

8.1.8.2 Ecosystem Type

Reference Site, Fringing Emergent Marsh at the upper extent of the extremely shallow "lake"

8.1.8.3 Sampling History in the CEERP

This long-term monitoring site has been surveyed annually since 2005 site as part of the Estuary Partnership's Ecosystem Monitoring Program.

8.1.8.4 Current Role of Site in the CEERP

Cunningham Lake is being sampled as a reference site for baseline pre-restoration monitoring for the restoration actions being conducted in 2013 at Sauvie Island North Unit Phase 1.

8.1.8.5 Dates of Sampling in 2013

29th July

8.1.8.6 Types of Sampling in 2013

See map below for sampling locations (**Error! Reference source not found.**).

- *Vegetation*: Herbaceous cover (36 quadrats total)
- *Insect Fallout Traps:* 4 traps
- *Photo Points:* 1 photo point
    - Panorama taken location near south end of vegetation sample area.
- *Elevation*: collected elevation at all vegetation quadrats

8.1.8.7 Vegetation Sampling Design

Vegetation Sample area

- Located along the fringe of the very shallow Cunningham Lake. Vegetation sample area spanned elevation gradient from unvegetated flats to the shrub/tree zone.
- 70 m x 25 m, with 36 quadrat locations
- Baseline azimuth: 147° magnetic
- Transect azimuth: 57° magnetic
- Transect spacing: 11m, random start: 10
- Quadrat spacing: 4 m, random starts: 2, 4, 0, 2, 1, 5
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

8.1.8.8 Markers Left on Site

All marking stakes are white ¾ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

In addition, 2 1" gray pvc sediment accretion stakes are located on the site and a depth sensor is located inside 1 ½" PVC on a t-post in the channel.

8.1.8.9 *Macroinvertebrate Sampling*

Insect fall out traps were randomly placed in sampling areas. The four traps each were placed at the vegetation sampling area to characterize the macroinvertebrate species richness and diversity.

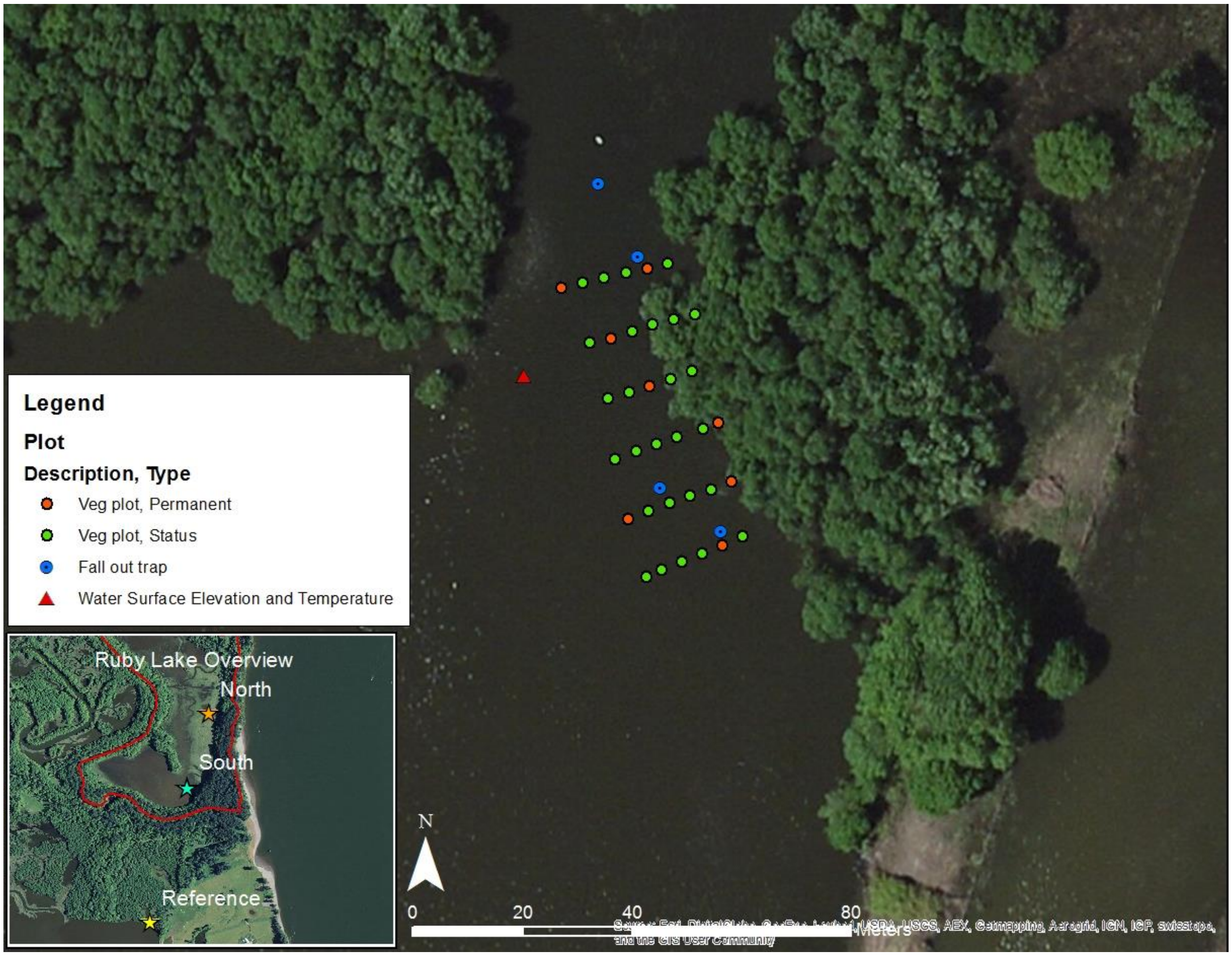

Figure 9. 2013 vegetation and macroinvertebrate sampling locations at the Cunningham Lake reference site.

8.1.9 Dibblee Slough

8.1.9.1 *General Site Location*

Downstream from Longview, WA on the Oregon side of the River at rkm 104.

8.1.9.2 *Ecosystem Type*

Restored tidal emergent wetland

8.1.9.3 *Sampling History in the CEERP*

Pre-restoration vegetation sampling was conducted by CREST in 2012.

8.1.9.4 Current Role of Site in the CEERP

The restoration at Dibblee Slough was conducted in early 2013 and included channel excavation and removal of a water control structure to allow connectivity to a former ponded area. No excavation was conducted in the area inside the culverts; the area was already a low elevation depression.

8.1.9.5 Dates of Sampling in 2013

6-7 August

8.1.9.6 Types of Sampling in 2013

See map below for sampling locations (**Error! Reference source not found.**).

- *Vegetation*: Herbaceous cover (2 sample areas of 36 quadrats, 72 quadrats total)
- *Insect Fallout Traps:* 4 traps
- *Photo Points:* 3 photo points, 1 at West sample area and 2 at East sample area
    - West Sample area – panorama taken at 0m on baseline, 3 m west of endstake
    - East Sample area – panorama taken at 74m and on baseline, 2 m south of endstake
    - East Sample area – panorama taken at 0m and on baseline, 2 m south of endstake
- Elevation: collected elevation at all vegetation quadrats Vegetation Sampling Design

West Veg Sample area

- Located outside the culvert. Veg sample area spanned elevation gradient from one side of the channel to the bank on the other side.
- 74 m x 30 m, with 36 quadrat locations
- Baseline azimuth: 90° magnetic
- Transect azimuth: 0° magnetic
- Transect spacing: 12m, random start: 2
- Quadrat spacing: 5 m, random starts: 4, 0, 4, 1, 4, 0
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

East Veg Sample area

- Located on north side of area inside culvert in the upper end of herbaceous wetland vegetation in natural inlet.
- 74 m x 30 m, with 36 quadrat locations
- Baseline azimuth: 180° magnetic
- Transect azimuth: 270° magnetic
- Transect spacing: 12m, random start: 3
- Quadrat spacing: 5 m, random starts: 4, 0, 2, 1, 3, 4
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

<u>Trends Sampling</u>. Within the new vegetation sample areas, we established and marked permanent quadrats locations for future trends sampling.

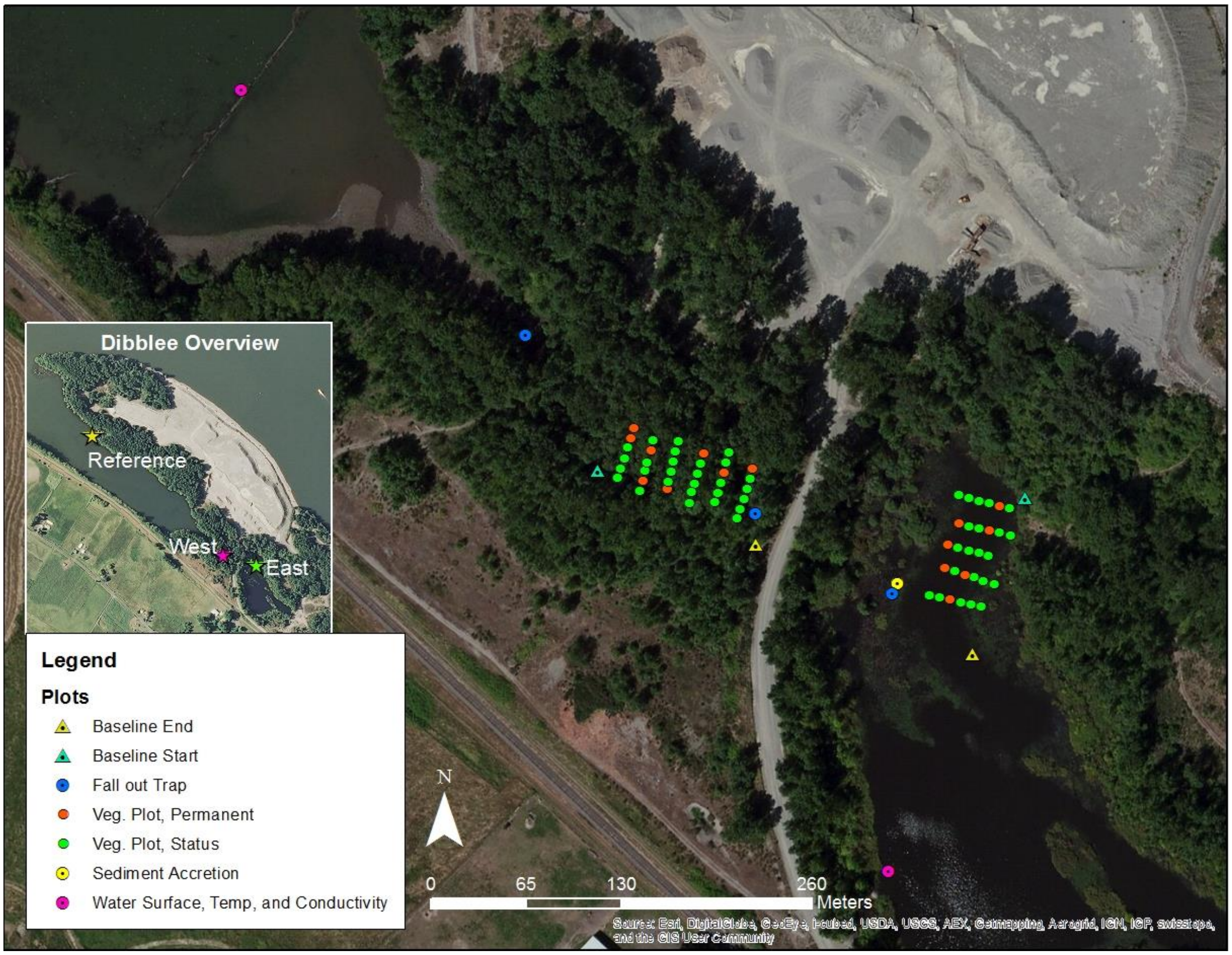

Figure 10. 2013 vegetation and macroinvertebrate sampling locations at Dibblee Slough restoration site.

8.1.9.7 Markers Left on Site

All marking stakes are white ¾ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

8.1.9.8 Macroinvertebrate Sampling

8.1.10 Dibblee Slough Reference

8.1.10.1 General Site Location

Downstream from Longview, WA on the Oregon side of the River at rkm 104.

8.1.10.2 Ecosystem Type

Tidal emergent wetland

8.1.10.3 Sampling History in the CEERP

The site was created from dredge material and was not present on the historic maps from the 1880's. The area is owned by the State of Oregon and managed by the Division of State Lands. The site was monitored in 2005 as part of the Reference Site Study (Borde et al 2010).

8.1.10.4 Current Role of Site in the CEERP

The original vegetation monitoring sample area could not be found. A new vegetation monitoring sample area was established to reflect expected reference conditions at Diblee restoration site.

8.1.10.5 Dates of Sampling in 2013

8 August

8.1.10.6 Types of Sampling in 2013

See map below for sampling locations (**Error! Reference source not found.**).

- *Vegetation*: Herbaceous cover (1 sample area, 36 quadrats total)
- *Insect Fallout Traps:* 4 traps
- *Photo Points:* 1 photo point taken near 0 m on baseline, looking west
- *Elevation*: collected elevation at all vegetation quadrats and the end points of the point intercept lines

8.1.10.7 Vegetation Sampling Design

- Located along the wetland fringe in the inlet inside Dibblee Point. Veg sample area spanned elevation gradient from unvegetated flats up to the shrub/tree zone.
- 60 m x 30 m, with 36 quadrat locations
- Baseline azimuth: 240° magnetic
- Transect azimuth: 330° magnetic
- Transect spacing: 10m, random start: 9
- Quadrat spacing: 5 m, random starts: 4, 1, 2, 1, 3, 2
- 8 permanent quadrats, randomly selected, systematically to ensure coverage on all transects

<u>Trends Sampling</u>. Within the new vegetation sample areas, we established and marked permanent quadrats locations for future trends sampling.

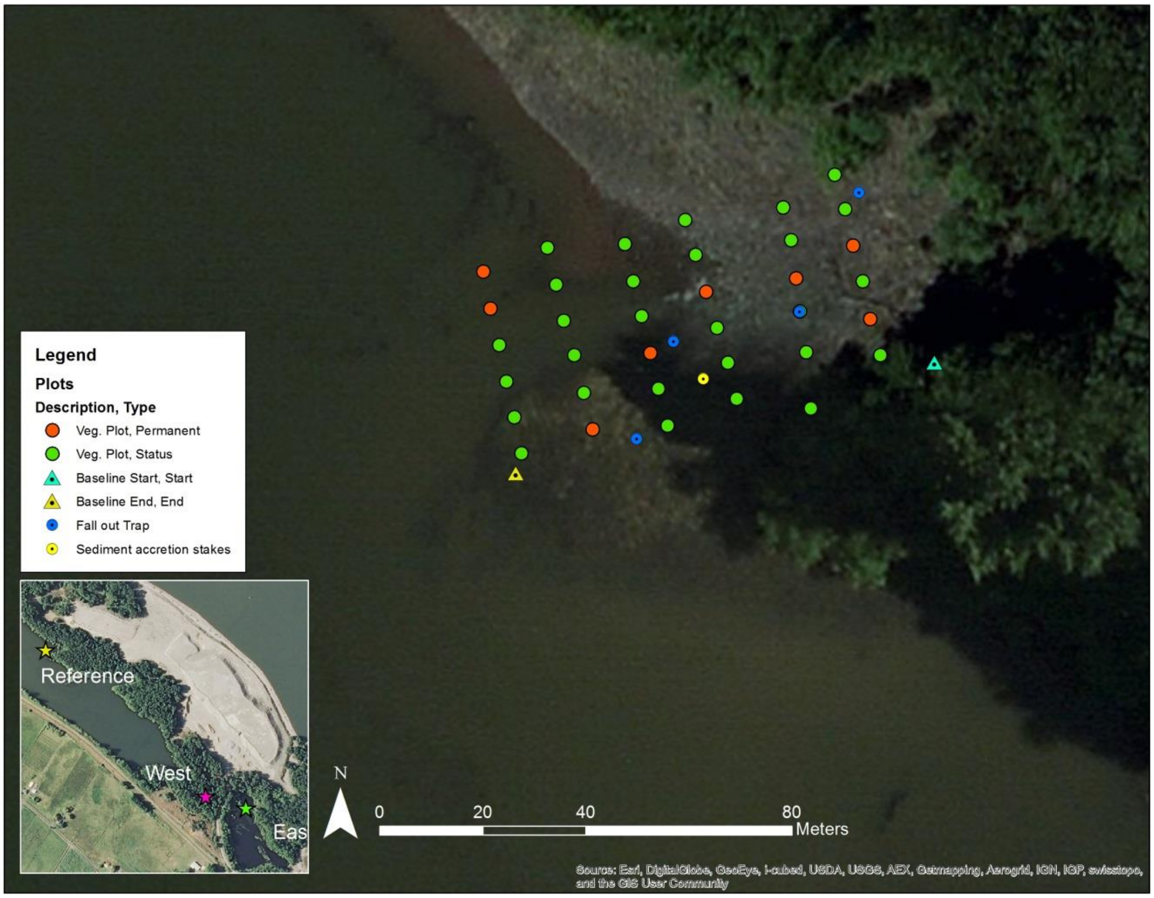

Figure 11. 2013 vegetation and macro-invertebrate sampling locations at Dibblee Slough reference site.

8.1.10.8 Markers Left on Site

All marking stakes are white ¾ inch PVC with orange duct tape or flagging at the top. We marked the following locations:

- End stakes of the baseline for the vegetation sample areas.
- Permanent quadrat stakes; 2 stakes per location in the diagonal corners (SW and NE).

8.1.10.9 Macroinvertebrate Sampling

Insect fall out traps were randomly placed in sampling areas. The four traps each were placed at the vegetation sampling area to characterize the macroinvertebrate species richness and diversity.

Appendix B: Site Prioritization Results

Name	Location (Col RM, Reach)	Score	construction year
CSR − Full Restoration Phase	Mainstem Columbia River (122, E)	25	TBD
Youngs/Walluski Confluence – Restoration Phase	Youngs/Walluski River (12, A)	22	2015
Grays Bay - Kandoll Farm Restoration Phase 2	Gray's River (37, B)	22	2013
East Fork Lewis	East Fork Lewis River (138, E)	21	2015
Sandy River Dam Removal	Sandy River Delta (195, G)	20	2013
Thousand Acres – Sandy River Delta Restoration	Sandy River Delta (200, G)	20	2014
Steamboat Slough	Mainstem Columbia (B)	20	2013
Dairy Creek 1135 – Sturgeon Lake	Mainstem Columbia River (159, F)	19	TBD
Sauvie Island, North Unit Phase 1	Sauvie Island (143, F)	19	2013
Grays Bay – Deep River Confluence Restoration	Grays Bay (21, B)	19	TBD
Julia Butler Hansen NWR − Tenasilahe Island Phase 2, Option A/B	Mainstem Columbia River (56, B)	19	TBD
Wapato Access	Sauvie Island (163, F)	19	TBD
Dibblee Point	Mainstem Columbia River (103, C)	19	2012
Colewort Creek	Lewis and Clark River (19, A)	18	2012
Horsetail Creek	Horsetail Creek (222, H)	18	2013

Appendix C: Photo Points

Kandoll Farm Restoration Site

Area A, 0 m on baseline for veg sample area

Area E, 0m on point intercept transect

Area E, 70 m on baseline for veg sample area

Previously established photo point (PP1)

Previously established photo point (PP2)

Previously established photo point (PP4E)

Previously established photo point (PP4SE)

Previously established photo point (PP4SW)

Previously established photo point (PP4W)

Previously established photo point (PP5)

Previously established photo point (PP6N)

Previously established photo point (PP6NW2)

Previously established photo point (PP6NW1)

Previously established photo point (PP6 Baseline)

Previously established photo point (PP6E)

Previously established photo point (PP6SE2)

Previously established photo point (PP6SE1)


Previously established photo point (PP6SW2)


Previously established photo point (PP6SW1)


Previously established photo point (PP6W)


Previously established photo point (PP7N)


Previously established photo point (PP7S)

Previously established photo point (PP8S)

Previously established photo point (PP8N)

Kandoll Farm Reference Site (Seal Slough Swamp)

Previously established photo point (KR-PP3SW)

Previously established photo point (KR-PP3SE)

Steamboat Slough Restoration Site

East veg sampling area photo point at 70 m end of baseline

West veg sampling area photo point at 0 m end of baseline

Steamboat Slough Reference Site (Welch Island)

Reference veg sampling area photo point at 0 m end of baseline

Dibblee Slough Restoration Site

West veg sample area at 0 m of baseline, looking toward culvert

East sample area at 0 m of baseline, looking south

East sample area at 70 m of baseline, looking north

Dibblee Slough Reference Site (Dibblee Point)

Reference photo point near 0 m of baseline, looking west

Sauvie Island North Unit Phase 1 (Ruby Lake) Restoration Site

South vegetation survey area photo point at permanent plot 47-59, 180° looking south

Sauvie Island North Unit Reference Site (Cunningham Lake)

Photo point near west end of vegetation survey area, looking north