Final Report for Phase One:

Establishing Appropriate Benchmarks For Site Development By Documenting Successional Characteristics.

Arvid Lindstrum and Mark Maurer

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Contents

Introduction

In recent decades, compensatory wetland mitigation has become an increasingly common occurrence in the Pacific Northwest (Kentula et al. 1992). Developers, regulators and consultants work at the task of mitigating for impacts to systems that are complex, varied and poorly understood. As the process of wetland mitigation becomes more costly and the success of current methods comes into question, the demand for scientific explanation of the natural processes of wetlands increases (Azous et al. 1998). Despite the investments put into wetland mitigation, these managed systems have had a conspicuous lack of research conducted on them to explain the processes at work. As a result, there is little scientifically derived data on which to base success standards. Some attempts have been made to compare levels of functioning of natural reference wetlands to those of mitigation sites (Brown 1991, Kentula et al. 1993, Azous et al. 1998) yet none of these efforts has resulted in a widely accepted set of performance standards. This leaves biologists and designers involved in compensatory mitigation efforts to use their "best professional judgment". The Washington State Department of Transportation (WSDOT), with funding from the Environmental Protection Agency (EPA), has undertaken this study to identify appropriate "benchmarks" for standards of success in compensatory wetland mitigation.

The impetus for this study comes from the Standards of Success Workgroup, an informal group of wetland professionals comprised of representatives of WSDOT, Oregon Department of Transportation , EPA, Washington Department of Ecology, King County, US Fish and Wildlife, The Army Corps of Engineers, and several consultants from Oregon and Washington. Formed by Mary Ossinger, formerly of WSDOT, the workgroup was created to assist in the completion of a WSDOT guidance document entitled "Success Standards for Wetland Mitigation Projects - a Guideline" (Ossinger 1999). In this document, the need for research-derived performance standards is outlined.

Overview of Phase One

This initial planning phase of the study to produce scientifically derived benchmarks for success standards is charged with four primary tasks:

- Literature Review- Evaluate the state of the science pertaining to our understanding of the physical development of wetland mitigation sites and review previous work on the development of performance standards.
- Identification of Sites for Further Study- Compile a database of established mitigation sites in Oregon and Washington on which to conduct research.
- Work Plan for Phase Two- Propose a course of action by which these mitigation sites might be studied to identify appropriate benchmark standards.
- Pilot study- Test the methods on a sample of the study sites.

This report summarizes the activities of Phase One.

Literature Review

While biologists have been documenting the energy flows and population shifts of terrestrial ecosystems for many years, there has been much less work done on wetlands. Of the work done specifically on wetlands, tidal salt marsh systems have received much attention (Zedler and Callaway 1999, Thom 1997, Kusler and Kentula 1989, Demgen 1988, among others) while inland, freshwater wetlands have been the subject of less study. Of the work on wetlands of the Pacific Northwest that has been published, much of it has been on the subject of evaluating mitigation designs and verifying permit compliance (Mockler et al. 1998, Shiach and Franklin 1995, Gwin and Kentula 1990) and on the effects of urbanization on wetlands (Azous and Horner 1997). There have been recent publications from the EPA Environmental Research Laboratory in Corvallis, Oregon on the physical characteristics of naturally occurring wetlands and mitigation wetlands. These include comparisons of the hydrology and hydrogeomorphic classes

(Gwin et al. 1999, Shaffer et al. 1999), the soil organic matter concentrations (Shaffer and Ernst 1999) and plant richness (Magee et al. 1999) in naturally occurring wetlands versus mitigation wetlands. Around the country, work on the early stages of wetland development has been published by various researchers. Noon (1996) described primary plant succession in created wetlands on a reclaimed lignite mine in Texas and Mitsch et al. (1998) described the progress of side-by-side comparisons of planted and unplanted created wetlands in Ohio. A group at Pennsylvania State University (Cole et al. 1999) is also documenting the early developmental stages of created wetlands, but as of yet has not published results. Azous, Bowles and Richter (1998) proposed guidelines for performance standards for deperssional flow-through wetlands of western Washington based on the work of the Washington State Wetland Function Assessment Project. Kentula et al. (1993) recommended a method of using existing data on mitigation wetlands to set performance criteria for new projects. No studies were found addressing primary plant succession in wetlands of the Pacific Northwest or the long-term development of created, freshwater wetland systems in the Pacific Northwest.

Identification of Sites for Further Study

The second element of Phase One was to compile a database of wetland mitigation sites in Oregon and Washington to use for further study. Sites of interest were those that met the criteria of:

- palustrine (Cowardin et al 1979),
- built and planted prior to 1995, and
- monitored for vegetation.

Sources for this information that were approached were state and federal regulatory agencies, county offices, utility districts, ports, resource agencies and wetland consultants through out Oregon and Washington. The offices that were the primary contributors to the data set included the Seattle, Portland, and Astoria branches of the Army Corps of Engineers, King County, Clark County, Oregon Division of State Lands, David Evans and Associates, Shapiro and Associates, Wiltermood Associates, B-Twelve Associates, Fishman Environmental Services and WSDOT. For each site identified in this initial outreach, information such as that found in monitoring reports was recorded. A summary of the preliminary data collection appears in Appendix A.

A total of 130 sites were identified in Oregon and Washington that met the initial criteria listed above. Using the information collected on the 130, a database was created to facilitate the final selection of the sample population. Of the 130 sites, 65 met the additional criteria of:

- having quantitative vegetation sampling data from the third year or later, and
- are located in the Puget Trough or Willamette Valley.

This group of 65 wetlands was identified as the pool from which to draw the sample set for the second phase of this case study. The exact number of sites to be monitored will be determined by the limits of the budget, the length of the monitoring season, obtaining right of entry, and the physical variability of the sites. The decision to include wetlands only within the Puget Trough and the Willamette Valley was made to limit geographic and climatic variability among sites. Additionally, the majority of compensatory wetland mitigation takes place around the densest urban centers which, for Washington and Oregon, occur in the Puget Trough and the Willamette Valley. Benchmarks developed for these regions should have the greatest benefit to the most projects.

Proposed Work Plan

The third component of Phase One was the work plan for Phase Two. For the purpose of identifying appropriate benchmarks, we propose to monitor the sample wetlands in order to assess their state of development. With this data on the plant community and physical conditions, the development of these wetland mitigation sites can be analyzed through three windows:

- initial conditions after construction
- the midterm monitoring done for regulatory compliance (years three to five)
- current site conditions

The current monitoring will focus on the plant communities to quantify their percent cover and species composition. In addition a wetland rating (Washington Department of Ecology 1993), function assessment (Hruby et al. 1999), and other evaluation techniques will be performed to ascertain the overall conditions of the wetland. The monitoring protocol is outlined in Appendix B.

With the view of wetland development gained from the three windows mentioned above, we intend to produce a range of trajectories for expected cover by vegetation from third year to tenth year of site development, based on the type of the wetland and overall site conditions. This follows the concept outlined by Kentula et al. (1993) who monitored sites of different ages in a single season to produce observed “performance curves”. These performance curves demonstrate a range of observed levels of functioning in mitigation sites with similar physical parameters. Benchmark standards can be drawn from these curves.

For data analysis, sites will be grouped into similar landscape settings and hydrologic regimes to highlight trends in the cover by plant communities. The zones defined by the Cowardin classes for palustrine wetlands (Cowardin et al. 1979) will be used to stratify the plant communities within each wetland. A function assessment will be used to group the sites as “high scoring” and “low scoring”. Analysis will focus on the plant community development observed over time by three major Cowardin classes (emergent, scrub-shrub and forested) in given landscape settings and hydrologic regimes. From the information extracted in this analysis, we will answer the following questions:

- Does a given percent cover by vegetation in a given Cowardin class, measured at year three or five, predict a certain percent cover at year ten for a set of wetlands with similar physical and hydrologic characteristics and function assessment scores?

- Is there a correlation between landscape setting/surrounding land use and the development of overall plant cover in years three to ten?
- What level of potential performance of functions is present in mitigation wetlands in the first ten years of their development?

Based on the answers to these questions, we will propose appropriate benchmarks for standards of success for emergent, scrub-shrub and forested Cowardin classes in wetland mitigation sites for western Oregon and Washington.

Pilot Study

In the course of developing the methodology for the Phase Two study, it became apparent that a pilot study would provide a desirable level of predictability to the accuracy of the proposed sampling. Without knowing the variability of the vegetation on the sample wetlands, it would have been difficult to determine the sampling method and density required to accurately assess the vegetation. Since the initial EPA grant had not included a pilot, the Wetland Strategic Plan Implementation Project and WSDOT agreed to provide funding for the pilot study which followed Phase One. The vegetation sampling methods being considered were tested on the three WSDOT sites in the sample pool of mitigated wetlands.

Methods

Three methods of assessing herbaceous cover were tested for efficiency and accuracy in wetland mitigation sites. Ocular measures of cover in two plot sizes were compared to frequency measures for time required to conduct sampling and variance between plots. All sampling was done on randomly located transects oriented perpendicular to the hydrologic gradient. Only vegetation under 1 meter in height was sampled in this trial. For the ocular measures of cover, plots one meter square were oriented systematically at regular intervals, with a random start, along the entire length of each transect. Each species present was registered in a cover class according to Daubenmire (1959). The same process was completed for plots one-half by two meters. For the frequency sampling, species were measured for presence/absence in a five centimeter square plot as recommended by Tear (1999). A random number table was employed in the field to locate one frequency sampling plot in each square meter along the right side of the entire length of each transect.

Results

Each of the sampling techniques took roughly the same amount of time to execute, though the frequency sampling was much less dense compared to the cover measurements. To sample frequency at the same density as the cover measurements would take eight times the amount of time.

For the purposes of this inquiry, ocular measures of percent cover were compared directly to percent frequency of occurrence as measures of a species' dominance over a site. The mean percent frequency derived for plant species on the three sites was between 0.3% and 700% of the mean percent cover measurements. Greater than 73% of species present had a frequency mean >150% of the cover means. In addition, cover measures picked up more uncommon plant species on each site than frequency measures. These results correspond to the findings of Tear (1995), Floyd and Anderson (1987) and Dethier et al. (1993) who all found that measures of frequency overestimate dominance in comparison to cover measures especially for less common species. Tear and Dethier et al. also report that frequency measures often miss less-common species altogether.

The range of a 95% confidence interval for each of the means in the three different sampling methods show, with few exceptions, that ocular measures of cover in 0.5 x 2 meter plots have the least variability.

Discussion

Based on the results of the pilot study, this project will use 0.5 x 2 meter plots and Daubenmire cover classes to measure percent cover by herbaceous vegetation. Despite concerns raised about the variation between observers and between observations with cover measurements (Tear 1995, Sykes et al. 1993, Kennedy and Addison 1987), for this project, cover measurements appear to be most appropriate. They are shown to be less labor intensive and provide more precise estimates. In addition, the majority of historic vegetation data on the mitigation sites of this study is assumed to be derived from visual estimates of cover. Given the significantly higher means produced by frequency measures, the current data collected would not be comparable to the historic data should frequency measures be used.

The data from the pilot study was also used to calculate the density necessary for accurate sampling. Based on formulas published by Elzinga et al. (1998) that use the standard deviation and the mean from pilot sampling, a protocol for sampling density based on wetland size was developed. Details are found in Appendix B with proposed monitoring protocols.

Proposed Time Line

With the successful completion of Phase One of the project, the components for Phase Two of the study are in place. WSDOT has submitted a grant proposal to the Environmental Protection Agency for the Phase Two study and, if approved, will begin work as soon as the funds become available. Phase Two is expected to take approximately fourteen months to complete. Assuming a start date of February 2000, the spring would be spent securing right of entry and gathering mitigation plans and monitoring reports on the study sites. June through August would be spent collecting field data. The fall and winter would be spent analyzing the data and compiling the report. The final document could be expected in early 2001.

Conclusion

Even though the value of scientifically derived benchmark standards for judging success of wetland mitigation projects is widely acknowledged, the research has not yet been done in the Pacific Northwest. In the first phase of this study to identify benchmarks, WSDOT completed the background work. This included a literature review of the status of the science, compiling of a database of mitigation sites to perform research on, the creation of a methodology to guide the research and conducting a pilot study to test the methods. With continued support from the Environmental Protection Agency we will complete the project and produce appropriate benchmark standards for measuring success in compensatory wetland mitigation.

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Appendix A

Breakdown of the 65 sites in the sample pool.

Of the 130 wetland mitigation sites in the database of potential study sites, 65 are in the Puget Trough or Willamette Valley, were built and planted prior to the growing season of 1995, and have quantitative vegetation data from the 3rd to fifth year. The following is a breakdown of the 65 sites by county and age.

Distribution by county:	
Washington	
Clark	1
King	23
Kitsap	2
Lewis	1
Pierce	3
Snohomish	5
Whatcom	1
Oregon	
Lane	5
Clackamas	1
Multnomah	5
Washington	11
unknown*	7
Total	65

Distribution by year of construction:	
1982	1
1983	1
1984	1
1985	3
1986	5
1987	2
1989	3
1990	10
1991	4
1992	15
1993	9
1994	9
1995	2
Total	65

* Wetland mitigation sites used in an EPA study on wetlands of the Northern Willamette Valley. Remaining details forthcoming.

The following shows the distribution of historic monitoring data available for the 65 sites.

Number of sites with quantitative vegetation data: 65

Number of sites with bird or wildlife data: 11

Number of sites with hydrologic data: 28

Number of sites with water quality data: 9

Preliminary information collected on the 65 sites in the sample pool.

Code #	County	Cowardin Class	Creation Acres	Enhan-cement Acres	Resto-ration Acres	Year Installed	Year Last Monitored	Other Monitoring	Veg. Data *	Wildlife Data *	Hydrology Data *	Water Quality Data *
1	Watcom	POW, PEM, PSS, PFO	1.28	10.8	0	1992	1996	1993, 1994, 1995	yes	yes	yes	yes
2	King		0.6	0	0	1989	1997	1990, 1991, 1992, 1993, 1994, 1995	yes	yes		
4	Snohomish		13.3	0	0	1989	1995	1992, 1993, 1994	yes	yes		yes
5	Clark	PEM	0	11.25	11.25	1992	1998	1993	yes			
7	Pierce	PEM, PAB, POW	7	0	7	1990	1995	1991, 1992, 1993, 1994	yes	yes		
8	Lewis	PSS, PFO	0	2	0	1992	1998	1993, 1996	yes		yes	
9	Pierce	PSS, PFO	1.4	1.4	0	1992	1997	1993, 1994, 1995, 1996	yes	obs		yes
12	King	PEM, PSS	0.63	0	0	1992	1997	1992, 1993, 1994, 1995, 1996	yes	yes		yes
14	Snohomish		1.2	0	0	1989	1994	1990, 1991, 1992, 1993	yes	yes		yes
17	King		?	?	?	1993	1997	1996	yes	obs	yes	
19	King		?	0	0	1994	1997	1995, 1996	yes		obs	
20	King	POW, PEM, PSS, PFO	0	0	?	1992	1997	1994, 1996	yes	obs	yes	
25	King		?	0	0	1993	1997	1995	yes	obs	obs	
29	King	PSS	0.17	?	?	1994	1998	1995	yes		obs	
30	King	PEM, PSS, PFO	0.1	0.62	0	1995	1998	1996	yes	obs		
37	King	PEM, PSS	0.16	0	0	1994	1997	1996	yes			
38	King		0	0	0.48	1994	1997	1995	yes	obs		

Preliminary information collected on the 65 sites in the sample pool.

Code #	County	Cowardin Class	Creation Acres	Enhan-cement Acres	Resto-ration Acres	Year Installed	Year Last Monitored	Other Monitoring	Veg. Data *	Wildlife Data *	Hydrology Data *	Water Quality Data *
39	King	PEM, PSS	?	?	?	1991	1994	1991, 1992, 1993	yes		yes	
40	Pierce	PEM, PFO	4.3	0	0	1990	1995	1991, 1992, 1993	yes	obs	yes	
42	Kitsap	PEM, PSS	1.2	0	0	1992	1998	1994, 1995, 1996, 1997	yes	obs	obs	yes
43	Kitsap	PEM, PSS	0.5	0	0	1992	1997	1993, 1994, 1995, 1996	yes	obs	yes	
47	Washington		0	1.36	0	1985	1993	1987, 1991	yes		yes	
48	Washington		0	0.93	0	1986	1993	1987, 1991	yes		yes	
52	Multnomah		1.23	13.4	0	1994	1997	1995, 1996	yes	yes	yes	
56	Multnomah		4.9	0	0	1993	1998	1994, 1995, 1996, 1997	yes	yes	yes	yes
58	Washington ?		0	5	0	1994	1997	1995, 1996	yes	obs	yes	obs
64	Washington	PSS	1.26	0	0	1990	1996	1991, 1992, 1994	yes	obs		
68	Washington	PEM	0.4	0	0	1983	1993	1987	yes	obs	yes	
70	Clackamas		0.7	0	0	1990	1993	1991, 1992	yes		yes	
82	Washington	PEM, POW	3.3	0	0	1986	1993	1987, 1991	yes		yes	
87	Washington	POW, PEM, PSS	13.5	0	0	1990	1993	1991, 1992	yes	yes		yes
91	Lane	PEM	2.2	2.2	0	1994	1997		yes	obs	obs	
92	Lane	PEM	4.8	0	0	1993	1997	1995, 1996	yes	obs	obs	
97	King	PEM, PFO	3.62	0	0	1993	1998	1994, 1995, 1996, 1997	yes	yes	yes	
98	King	PEM	0	0.15	0	1990	1995		yes	obs		
99	King	PEM, PSS	0	1.93	0	1991	1997	1992, 1993, 1994, 1995,	yes	yes		yes

Preliminary information collected on the 65 sites in the sample pool.

Code #	County	Cowardin Class	Creation Acres	Enhan-cement Acres	Resto-ration Acres	Year Installed	Year Last Monitored	Other Monitoring	Veg. Data *	Wildlife Data *	Hydrology Data *	Water Quality Data *
								1996				
100	King	PEM, PSS, PFO	1.62	0	0	1990	1996	1991, 1992	yes	obs	yes	
101	Snohomish	PFO	0	0	0.04	1992	1995	1993, 1994	yes		yes	
102	King	PEM	?	0	0	1992	1995		yes	obs	obs	
103	King		?	0	0	1992	1995		yes	obs	obs	
105	Lane		0.81	0	0	1991	1994	1992, 1993	yes	obs	obs	
107	King	PEM	0.04	0	0	1993	1996		yes	obs		
108	King	PSS	0.18	0	0	1991	1994	1992, 1993	yes	obs		
109	King		0		0	1990	1993	1991	yes			
110	King	PEM, PSS, PFO	0	0		1987	1991	1988, 1990	yes	obs	yes	
111	King	PSS, PFO	0.19	0	0	1992	1995	1993, 1994	yes	obs	obs	
112	Snohomish?		0.8	0	0	1990	1993	1991, 1992	yes			
115	King	PEM, PSS, PFO	0	0.2	1.4	1992	1998	1993, 1994, 1996	yes	obs	obs	
116	?		?	?	?	1982	1993	1987	yes		yes	
117	?		?	?	?	1986	1993	1987	yes		yes	
118	?		?	?	?	1984	1993	1987	yes		yes	
119	?		?	?	?	1986	1993	1987	yes		yes	
120	?		?	?	?	1985	1993	1987	yes		yes	
121	?		?	?	?	1985	1993	1987	yes		yes	
122	?		?	?	?	1986	1993	1987	yes		yes	
123	Lane	PEM	0	0	16.8	1993	1998	1994, 1995, 1996, 1997	yes			
130	Multnomah	PEM	4.26	0	0	1992	1997	1993, 1994, 1995, 1996	yes	obs	obs	
131	Washingotn	PEM	?	?	?	1994	1997	1996	yes	obs	obs	
133	Washington	PEM, PSS	0.5	4.1	0	1992	1997	1993, 1994, 1995, 1996	yes	obs	yes	
137	Washington	POW,	0.5	1.38	0	1995	1998	1996, 1997	yes	obs	yes	

Preliminary information collected on the 65 sites in the sample pool.

Code #	**County**	**Cowardin Class**	**Creation Acres**	**Enhan-cement Acres**	**Resto-ration Acres**	**Year Installed**	**Year Last Monitored**	**Other Monitoring**	**Veg. Data ***	**Wildlife Data ***	**Hydrology Data ***	**Water Quality Data ***
		PEM, PSS										
139	Multnomah	PEM, POW, PSS, PFO	3.56	2.16	0	1994	1998	1995, 1997	yes	obs	obs	
140	Multnomah	POW, PEM, PSS	2.85	2	0	1993	1996	1995	yes	obs		
141	Washington	POW, PEM, PFO	0	1.1	0	1993	1996		yes			
142	Lane	PEM, PSS, PFO	0	0	27.4	1990	1994	1993, 1992	yes	obs		
143	Snohomish	PEM	0.9	0	0	1987	1992		yes	obs		

* yes- indicates described and systematic method of data collection.
obs- indicates data in the form of observations with no described method.

Appendix B
Phase Two Monitoring Protocol

Each wetland in the sample set will be monitored with the same protocol. Adjustments may be made to accommodate variations in overall size of the sites in order to maintain an accurate sample. Vegetation, the main focus of the monitoring, will be assessed quantitatively by a restricted-random sampling methodology. In addition to the quantitative vegetation sampling, each wetland will have a function assessment and wetland rating performed on it as well as other physical characteristics recorded. These serve to qualify the physical conditions of the wetland in a broader sense and help put the vegetation data in context.

Vegetation

The following protocols generally follow the recommendations of Horner and Raedeke in their "Guide for Wetland Mitigation Project Monitoring" (1989). The vegetation on each site will be classified as cumulative cover by species and total aerial plant cover, both measures stratified by vegetation zone. Each vegetation zone, as demarcated by the Cowardin classes (Cowardin et al., 1979), will be sampled as an independent plant community. The sampling will be based on transects placed randomly along a baseline and running perpendicular to the hydrologic gradient through the wetland. Transects shall be placed at right angles to the baseline and extend through the wetland to the upland boundary on the other side.

For all woody vegetation over one meter in height, line-intercept sampling (Canfield 1941) will be used along the entire length of each transect. To account for the error introduced into the line-intercept method by attempting to sight over one's head to the edge of a tree or shrub canopy, a strait, wooden stick with a plumb-level attached to it will be used to sight a more accurate vertical drop from the edge of the canopy to the point on the transect.

All herbaceous vegetation will be sampled using ocular estimates of cover within a 0.5 x 2 meter plot. Within each plot, all species present will be marked in a cover class following Daubenmire (1959). Any bare ground within the plots will also receive a cover class rating in accordance with the percent of the plot that is open to direct sun light. Plots will be placed systematically every six meters along the entire length of each transect. From the wetland boundary, the first plot will be placed one meter into the wetland on the transect and each successive plot at six-meter intervals from the starting point. At each boundary between Cowardin classes, the next plot will be placed one meter into the new Cowardin zone and then each successive plot at six-meter intervals from that point. Any plot not falling entirely within a Cowardin zone will not be sampled. All data will be grouped by Cowardin class, including the line intercept data. This will give a total aerial cover measurement for all vegetation and a relative cover measurement for each species sampled. These two measures of cover will be reported for each Cowardin class in each wetland.

Twenty to thirty plots will be placed in most of the wetlands for the vegetation sampling. For a site of less than one acre with two or less Cowardin classes, twenty plots will be placed. For a site larger than two acres with more than three Cowardin Classes, thirty plots will be placed. For sites over five acres or sites with highly complex plant communities, forty or more plots should be placed. Following these guidelines, the final decision will be made by the researcher on a site-by-site basis.

To calculate the number of transects required for each site, the number of plots to be placed on site will be multiplied by six meters and the result divided by the estimate of the average transect length (width of wetland) in meters. To place the transects, the length of the baseline will be divided into sections by the number of transects to be placed. A random number table will be used to locate each transect in its section.

Characterization and Classification

In order to characterize and classify the condition of the wetlands, we propose the following information be collected on each site.

1. Hydrogeomorphic (HGM) classification- as identified by Washington State Wetland Function Assessment Methodology (Hruby et al., 1999)
2. Function Assessment- Washington State Wetland Function Assessment Methodology (Hruby et al., 1999) In addition, we are looking at the possibility of running the Semi-Quantitative Assessment Methodology (Modified Reppert) concurrently on all sites and then comparing the two methods on riverine and depressional sites.
3. Wetland rating- (Washington Department of Ecology, 1993)
4. Wetland Area/Vegetation Zones- We will use a GPS unit to map the boundary of the wetland with each Cowardin zone. The backup plan is a sketch-map of the approximate wetland boundary and plant communities drawn on an overlay of the planting plan or grading plan.
5. Surrounding Land Use- % of area within 2 kilometers in different uses as described by Washington State Wetland Function Assessment Method.
6. Condition of Buffer- as described by Washington State Wetland Function Assessment Method.
7. Hydrology- notes on all observations of hydrology.
8. Soils- dig two test pits per site in wetland area and describe soils according to WSDOT Wetland Monitoring Program Protocol.
9. Wildlife and Birds- observations of individuals and signs of presence while on site.

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