

# Evolution of Self-designed Wetlands in the Snohomish River Estuary, Washington, USA

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## Abstract

Compliance with the no net loss of wetland acreage and function goals of the Clean Water Act and completion of ecologically successful wetland creation and restoration remains unacceptably low. Self-designed wetlands incorporate natural succession and can be used successfully in some circumstances. This case study documents use of the self-design concept to restore brackish, riverine flow-through wetlands and in the Snohomish River Estuary in Everett, Washington, USA. Native trees and shrub plantings are used to enhance buffers.

Self-design is the process of allowing natural primary succession processes to shape plant communities. In this case study, dikes were breached and pulled back following grading plans prepared as part of an agency-approved compensatory wetland mitigation plan. Native emergent plants naturally colonized the restored wetlands from propagules originating in adjacent areas in Smith Slough, a distributary of the Snohomish River. Initial grading of 2.3 acres of emergent wetlands (Figure 1) was completed in February 2005 to replace functions provided by 1.8 acres of agricultural ditches determined to be jurisdictional wetlands by the U.S. Army Corps of Engineers (USACE), Washington State Department of Ecology (Ecology), and City of Everett. All specified performance standards in permits have been met. It is expected that the USACE, state, and local government agencies will approve closure of the permits later this year, seven growing seasons after dike removal.

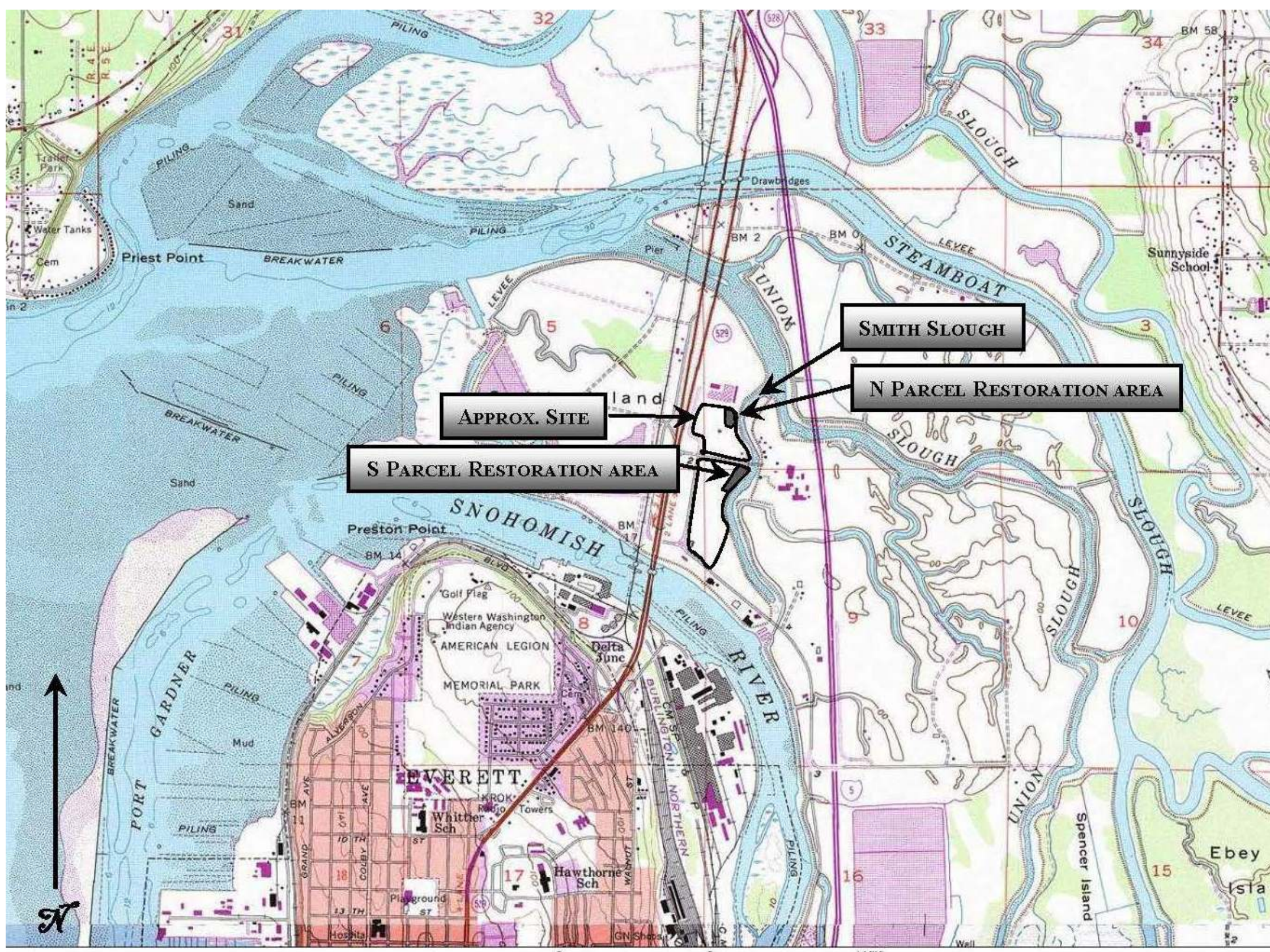


Figure 1. Site location

## Methods

Conceptual, draft, and final mitigation plans and specifications were prepared and approved by the USACE, Ecology, and City of Everett. The approved mitigation plan contained specific goals and objectives, detailed grading plans, erosion control plans, planting plans (upland buffers only), performance standards (Table 1), quantitative and qualitative monitoring plan, and maintenance plans.

Final design plans and specifications were provided to bidders and a contractor selected to construct the project as designed. Construction oversight was provided by the owner's engineer and more limited construction oversight was provided by the mitigation plan designer. Before construction began, the contractor, owner's engineer and mitigation plan designer met onsite to review the plans and discuss the overall project goals and objectives.

Quantitative monitoring methods included a mixture of line-intercept (woody species) and quadrat sampling using standard methods along two transects extending from the adjacent uplands through each of the two wetland restoration areas (northern and southern). All sampling locations were randomly established and permanently marked. Hydrology and vegetation were monitored based upon an agreed upon schedule. Slopes in the restored wetlands were designed to be approximately 0.6 percent over a distance of about 175 feet. Islands were formed from dike remnants breached in the northern restoration area (Figure 2). A large volume of wood waste, 2,800 cubic yards was removed to restored grades in the southern wetland restoration area (Figure 3).

Table 1. Wetland buffer enhancement and restoration area performance standards.					
Buffer Enhancement Areas					
Criterion	Year 1	Year 2	Year 3	Year 5	Year 7
Total areal cover of native or naturalized plants in %.	30 to 40	35 to 55	55 to 75	60 to 80	>75
Survival of installed plants in %.	100	80	80		
Total areal cover of invasive species in %.	<15	<15	<15	<20	<20
Wetlands Restoration Areas					
Total areal cover of native or naturalized plants in %.	20 to 30	25 to 40	35 to 60	55 to 70	>65
Saturation within 12 inches of the ground surface for at least the specified number of consecutive days (12.5% of the growing season).	30	30	30	30	30
Total areal cover of invasive species in %.	<10	<10	<15	<15	<15

Qualitative monitoring included establishment of permanent photopoints. Compass direction of photographs were recorded at each photopoint so orientation could be maintained to facilitate evaluation of changes in vegetation from year to year. As-built plans were created using a survey-grade global positioning system (Figure 2 and Figure 3).

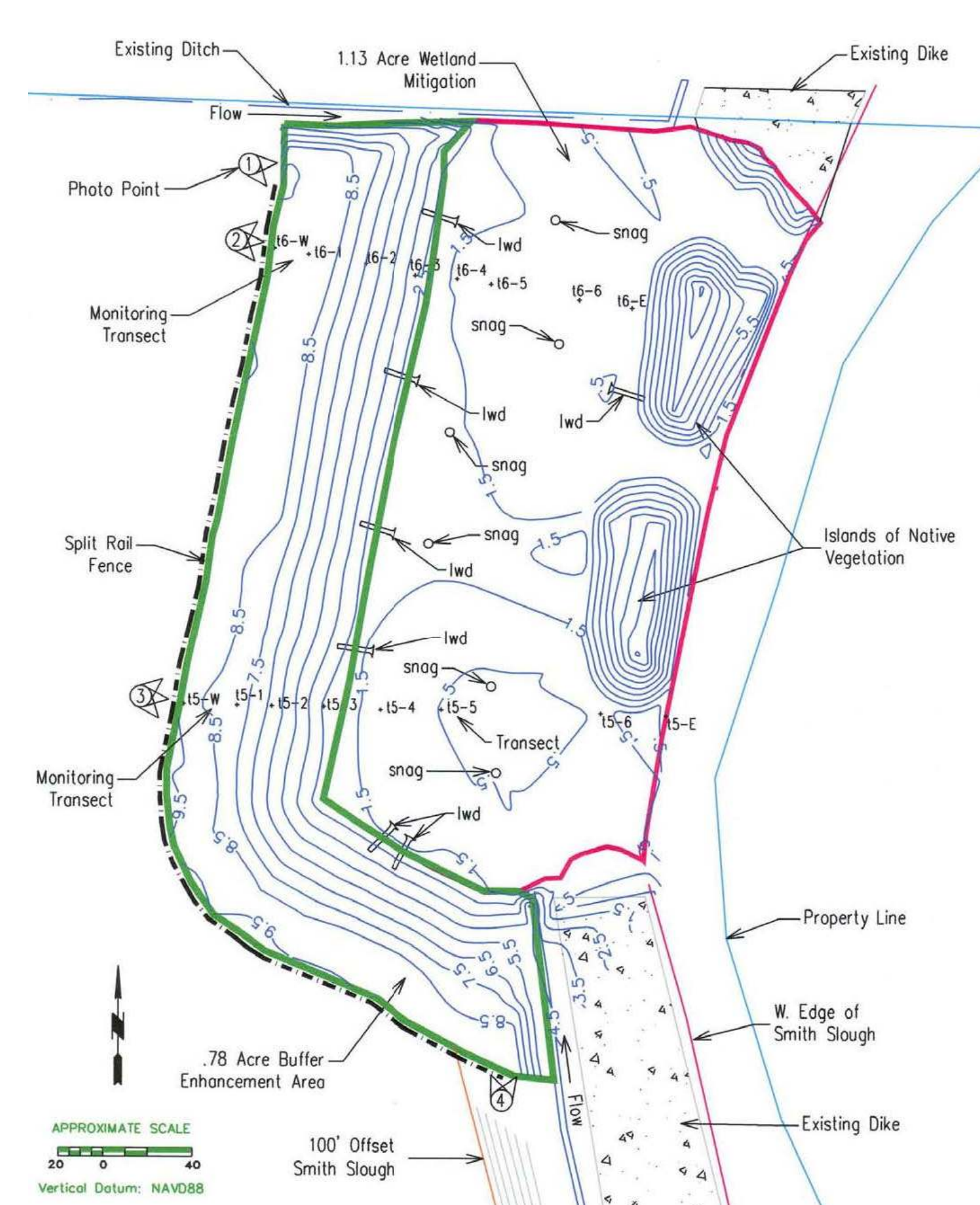


Figure 2. As-built plan for the northern restoration area

Annual and semi-annual quantitative and qualitative monitoring was used to document changes in vegetation structure and quality and compare these to interim (i.e., Year 1, 2, 3, and 5) and final (i.e., Year 7) performance standards. Compliance with performance standards were part of federal, state, and local government permit conditions.

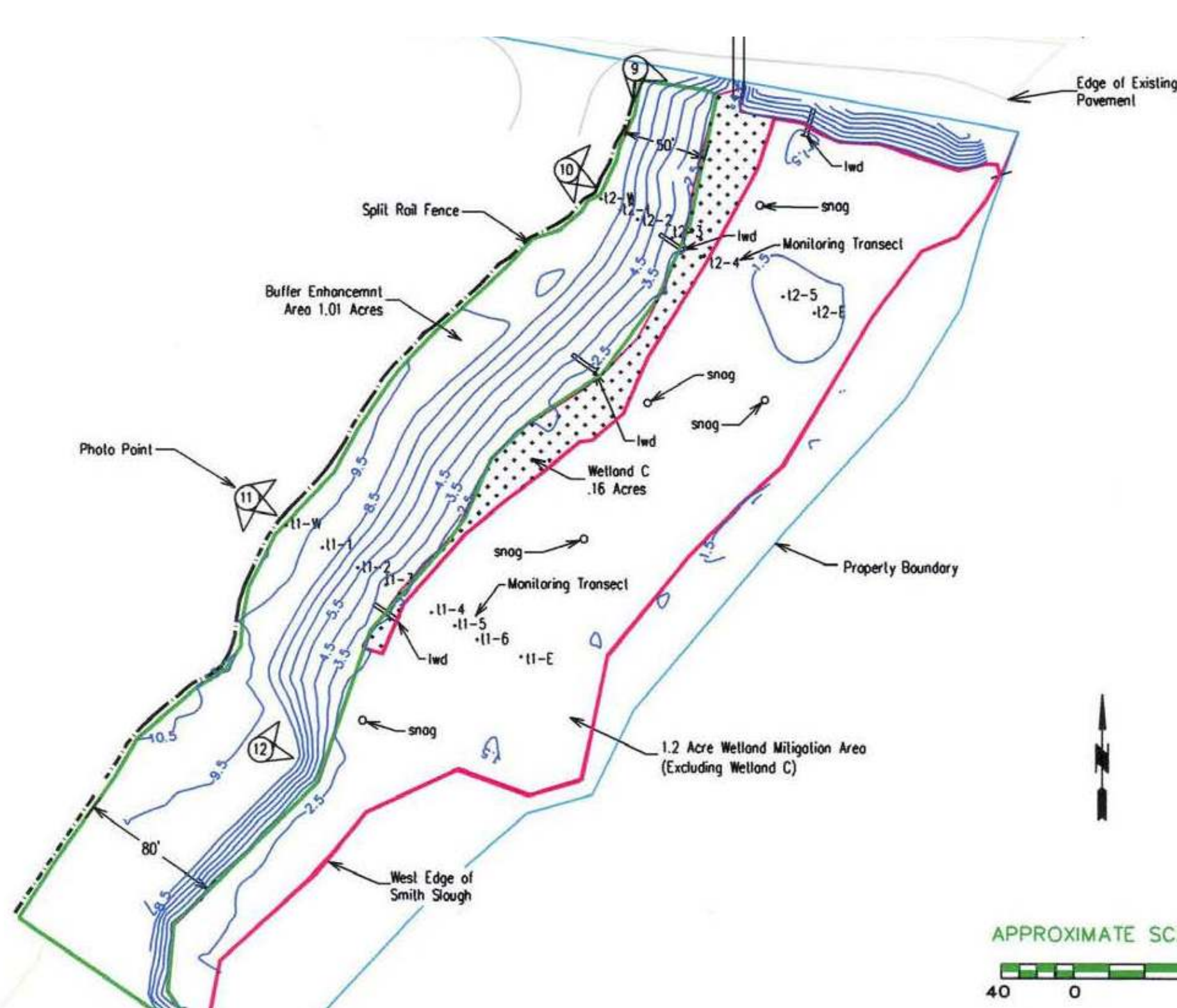


Figure 3. As-built plan for the southern restoration area

## Results and Discussion

Changes in areal cover of woody and emergent species over the monitoring period are presented for three native plants in the enhanced forested buffer plant association and three emergent species in the self-designed wetland restoration areas. Within the buffer, a typical native deciduous shrub; pioneer, deciduous, tree species; and a later successional, evergreen tree species were selected to demonstrate the patterns and changes in average cover observed on the four line-line intercept transects. Two native sedges species and one non-native, invasive grass species in the two wetland restoration areas were selected to demonstrate the general patterns and trends observed in those areas.

As shown by the arithmetic mean (Avg) and standard deviation (Std) data in Table 2, cover of all species was highly variable in both space and time. For example, within the forested buffer plant association, average cover of red-osier dogwood (*Cornus sericea*) ranged from zero in 2005 to 9 percent in 2011. However, in each year that monitoring was conducted variation as estimated by the standard deviation around the mean was quite high, particularly from 2007 (Year 3) through 2011 (Year 7). There are several reasons for this variability, including predation by animals (voles, deer, and beaver) deer, plant mortality, and the inherent imprecision of the sampling method. Herbivory and mortality were the major drivers of this variation through about 2007 (Year 3). Inherent imprecision in the line-intercept sampling methodology appears to have contributed some to observed variation after 2007. Although permanent markers identified the transect endpoints and sample plots, it became increasingly difficult to precisely and accurately align the sampling tape as shrub and tree cover and density increased over time.

Table 2. Changes in average areal cover (n=12) of selected native and invasive species.							
Buffer Enhancement Areas							
Plant Species	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Red-osier dogwood ( <i>Cornus sericea</i> )	Avg 0.00	1.25	6.50	5.75	6.75	7.50	9.00
	Std 0.00	1.50	8.54	6.65	5.38	8.19	8.16
Red alder ( <i>Alnus rubra</i> )	Avg 0.25	5.00	7.50	11.25	19.75	28.50	30.75
	Std 0.50	10.00	15.00	12.34	16.76	26.66	30.41
Western red cedar ( <i>Thuja plicata</i> )	Avg 0.75	1.75	1.75	3.00	5.00	5.50	6.50
	Std 1.50	2.87	2.87	3.56	6.27	6.35	7.51
Wetlands Restoration Areas							
Maritime bulrush ( <i>Schoenoplectus maritimus</i> )	Avg 0.00	0.42	2.08	7.92	9.58	6.67	13.25
	Std 0.00	0.83	4.17	9.17	11.25	7.82	15.35
Common cattail ( <i>Typha latifolia</i> )	Avg 1.67	2.08	9.58	15.00	17.08	22.08	25.25
	Std 1.92	4.17	11.58	10.63	8.43	8.96	7.14
Reed canarygrass ( <i>Phalaris arundinacea</i> )	Avg 0.83	1.67	0.83	2.92	3.33	3.75	7.50
	Std 0.96	1.36	0.96	4.79	3.60	3.70	6.74

Similar patterns were observed for other native shrubs and trees in the enhanced forested buffers. Figure 4 shows the changes in vegetation structure in buffer enhancement and wetland restoration areas on the southern parcel restoration area.



Figure 4. South parcel buffer enhancement and wetland restoration area before construction.

In Figure 4, note the developed nature of the area and presence of multiple stressors and sources of disturbance. Agricultural activities (hayfield) and roads about the ditch wetlands. A large volume of wood waste placed in Smith Slough (a historical wetland fill) contributed to a loss of wetlands, high biological oxygen demand and adverse impacts to wetland water quality.

After construction, buffer enhancement and wetland restoration reduced the amount of habitat fragmentation and provide a more natural continuum of upland forest plant associations to riverine flow-through emergent wetlands. A bridge was removed over Smith Slough. In addition, approximately 2,800 cubic yards of wood waste in the form of planter shavings were removed from the riverine wetlands as part of the restoration (Figure 5).



Figure 5. South parcel buffer enhancement and wetland restoration after completion of grading in 2005.



Figure 6. South parcel wetland restoration (foreground) and forested buffer (background) in October 2011 (Year 7).

Figure 6 shows dense maritime bulrush and reed canarygrass at the edge of the southern wetland restoration area looking west from the east end of monitoring transect two. The maturing mixed deciduous and evergreen forest plant association is visible in the background.

## Conclusions and keys to "success"

Self-design is a process that works for riverine flow-through wetlands. Our findings on plant structure and composition are similar to those observed by Bill Mitsch and others (2012) at the Olentangy River Research Park wetlands at Ohio State University. Species composition and diversity in these compensatory wetland mitigation restoration areas are similar to that in relatively undisturbed reference wetlands in similar landscape positions. Though some non-native, invasive grass (reed canarygrass) remains on the margins of the restored wetlands, cover is relatively low as shown in Table 2. It is almost completely absent within the interior of the restored wetlands, which are densely covered by native emergent plants, including common cattail, softstem bulrush (*Schoenoplectus tabernaemontani*) and maritime bulrush. Keys to "success:"

- Construction oversight to ensure wetland restoration is built as designed;
- Use of a temporary irrigation system (upland buffer) for the first two years improved planting survival;
- Careful management and control of invasive plants through use of mechanical, cultural, and herbicide (Rodeo® and Habitat®) and treatments;
- Control of predation by voles, deer and beaver.