Appendix A: Replacement Ratios: a field assessment of mitigation replacement ratios in Puget Sound

REPLACEMENT RATIOS: A FIELD ASSESSMENT OF
MITIGATION REPLACEMENT RATIOS IN PUGET SOUND

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EXECUTIVE SUMMARY

This study assessed the effectiveness of replacement ratios to compensate for permitted wetland losses and assessed functioning of designed compensation wetlands. During the course of the study, critical design components affecting compensation success were identified and discussed.

Local agency staff were contacted to assist in identifying appropriate compensation sites. Agency files were reviewed to identify sites that had permit requirements for compensatory mitigation and that had pre-existing site data available. Constructed sites were field checked and assessed by traversing and completing a data form.

A total of eleven potential compensation sites were identified in King and Snohomish Counties; eight of these sites were selected as study sites. Compensation implementation on the other three sites was too new to assess success.

The results of this study indicate the majority of compensation sites met their stated goals because the goals were written so broadly that only outright failure of a compensation could be interpreted as a failure to meet the goals. None of the goal statements provided a quantifiable method of determining success, thus they provided no means for an agency to assess success/failure or to require remediation.

The level of functional value of the compensation site was most often dependent upon the functional value of the pre-existing contiguous wetland communities.

Only one of the compensation areas was created on non-wetland substrate, all other compensation areas were constructed in pre-existing or historical wetlands. The compensation wetland substrate composition and hydroperiod were significant factors in determining success in compensation plans.

The elements of detailed design, implementation and monitoring of compensation plans are the most critical components in successful compensation. Time may be the most critical non-controllable component that allows these systems to stabilize, increase species diversity, increase spatial complexity through natural attrition, and provide more of the functions and values associated with older, natural wetland systems.

No measurable field data was found that would form the basis for establishing variable quantifiable replacement ratios. However, requiring variable replacement ratios as an incentive to not impact certain communities should not be ignored.

I. INTRODUCTION

Background

The Washington State Department of Ecology (Ecology) requested an evaluation of the effectiveness of wetland replacement ratios used in compensatory mitigation designs for permitted wetland losses. The evaluation consisted of a review and synthesis of existing literature, an agency survey of existing requirements within local, state and national regulatory programs; the development of an annotated bibliography of applicable literature; and a field analysis of mitigation replacement ratio effectiveness. The following is the compilation and analysis of data collected during the site specific field component of the study. Based on the analysis, a series of recommendations regarding critical components of successful site compensation are presented. For this portion of the study, the term "compensation" will be used to mean actions taken to replicate or compensate for permitted wetland losses.

Purpose

The purpose of the field study was to assess the effectiveness of replacement ratios in compensating for permitted wetland losses. Another objective identified during the course of the study was to assess the functioning of designed and constructed compensation wetlands. Specific study objectives were to:

- to assess the effectiveness of compensation in meeting no-net-loss of wetlands;
- to assess the effectiveness of requiring variable replacement ratios based on wetland vegetation community types; and
- to determine critical design components that affect compensation success.

To accomplish these objectives the following questions were tested:

- Was the compensation wetland implemented as designed?
- Was the compensation wetland successful over time?
- What were the critical components of compensation design and implementation that most significantly affected success?
- What additional questions need to be answered when assessing the effectiveness of compensation?

II. METHODOLOGY

Agency Contact and Permit Identification

Local governmental agency staff were contacted to assist in the identification of appropriate sites, especially those sites containing constructed compensation. Agency staff provided a list of potential sites identified by permit application. A list of agency and staff contacts is provided in Attachment 1.

Permit File Review and Site Selection

King County files for short plats, formal subdivisions, commercial permits, and wetlands were reviewed, along with SEPA files from the City of Kirkland, and the 404 permit files from the Army Corps of Engineers. Information from Snohomish County files examined during the course of a previous study was used as well. Over four years of permit files were reviewed.

Potential sites were identified based on the following criteria:

- presence of permit requirements for compensation;
- availability and thoroughness of pre-existing site data;
- availability of compensation planting plans;
- age of compensation projects;
- availability of photographic record for the site;
- location and accessibility of project; and
- agency staff or field personal knowledge of the site.

Field Data Sheet Development

Data needs for the site-specific assessment were identified, and individual field data sheets were developed. The field data sheets are located in Attachment 2.

The compensation data sheets were designed to collect consistent information on each site regarding pre-existing conditions, permit requirements, design goals and objectives, existing site conditions, and qualitative assessments of success and function of the compensation mitigation. Data sheets were structured to collect both permit file and field data in the following general categories of information:

Pre-existing site conditions

Pre-existing conditions, present before the compensation project was constructed, included plant species diversity, dominant species, community type, pre-existing wetland type and size, surrounding land use, and functioning of wetland. Pre-existing conditions information was obtained both from review of the files and from personal knowledge of the site by field personnel, or both.

Permit requirements and compensation goals
Permit requirements and goals information were obtained from review of files.

Construction/implementation of permit requirements
Construction details were obtained from review of the files. Implementation of permit requirements was assessed both from review of the files and from on-site analysis.

Existing wetland and compensation wetland conditions
Site conditions were separated into:

existing wetland: any wetland on-site that had not been enhanced, created or restored, that was present prior to the construction of the compensation project;

compensation wetland: any wetland specified in the compensation plan for restoration, enhancement or creation.

Site conditions for both existing and compensation wetlands included plant species diversity, dominant species, viability of species, community type, wetland type and size, buffer type and size, and surrounding land use. Site condition information was assessed on-site.

Compensation wetland functioning
Information gathered regarding functioning of the compensation wetland included: achievement of stated goals; evidence of wildlife use of the area; vigor and/or stability of planted vegetation species; and impacts to the compensation or pre-existing wetland. This information was gathered on-site.

Summary Assessment
The assessment included the identification of probable factors affecting compensation wetland functioning, and a general analysis of the wetland system. Summary information was gathered on-site and was based on site conditions and investigators' knowledge of Pacific Northwest wetlands.

Field Site Establishment and Assessment

Potential sites identified during permit review were field checked. Actual sites selected for analysis were a subset of the field checked sites. Selection of actual sites was based on the following criteria:

- construction and implementation of compensation project;
- ability to locate the site; and
- access to site.

Once a site was determined to be appropriate for inclusion in the study, the field assessment was conducted using the field data forms. Sites were assessed by traversing the area to locate the compensation area and the pre-existing area, and filling in the forms. A detailed description of the methodology that explains the basis for the field data form questions is provided in Attachment 3.

Data Analysis

Information collected in the field was reviewed and findings and conclusions were drawn from the information and assessments were recorded on the forms. Within this report, a clear distinction is made between findings based solely on the results of this study and those based on the findings of this study in conjunction with the professional experience of the project investigators.

III. FINDINGS

A total of eleven potential compensation sites, located in Snohomish and King Counties, were identified from agency permit files (Figure 1). One potential study site in Snohomish county was identified through the Puget Sound Wetlands and Stormwater Management Research Program, based on personal knowledge of the site and the availability of pre-existing site conditions.

Potential sites were field checked and several were eliminated from consideration. Sites were eliminated for several reasons. If the development project and/or wetland compensation had not yet been implemented, the site was eliminated. For several sites, the compensation had been implemented within the past year and no evaluation of success was possible. In order to attempt to determine success of the compensation it was necessary to use compensation sites that had been in place for as long as possible. One site was not used as it was not located.

Eight sites were selected as compensation study sites. Names and locations of the final study sites are summarized in Table 1, approximate locations are noted in Figure 1. The eight sites include two commercial-industrial sites, one commercial-business park site, and five residential sites.

On-site wetland compensation for the sites ranged from 0.07 to 14 acres (Table 2). One site had 14 acres of compensation; one site had 4 acres of compensation on-site with an additional off-site compensation area; and the remaining six sites had less than 2 acres of compensation each. Implementation dates for the compensation ranged from 1985 to 1990.

Five of the sites were partial compensation where a portion of a previously existing wetland was used to accomplish compensation. Three of the sites were total compensation where either the entire area was a newly-created wetland, or the compensation incorporated the entire area of a pre-existing wetland.

Two of the sites included wetland creation. One of these was entirely created and the other included a small, created scrub-shrub wetland as a part of a larger compensation. Of the remaining six sites, one consisted of restoring an historical wetland and the other five included a combination of enhancement and restoration.

Site information recorded on the field data forms is located in Attachment 4.

Figure 1. Location of Compensation Sites in the Study Area

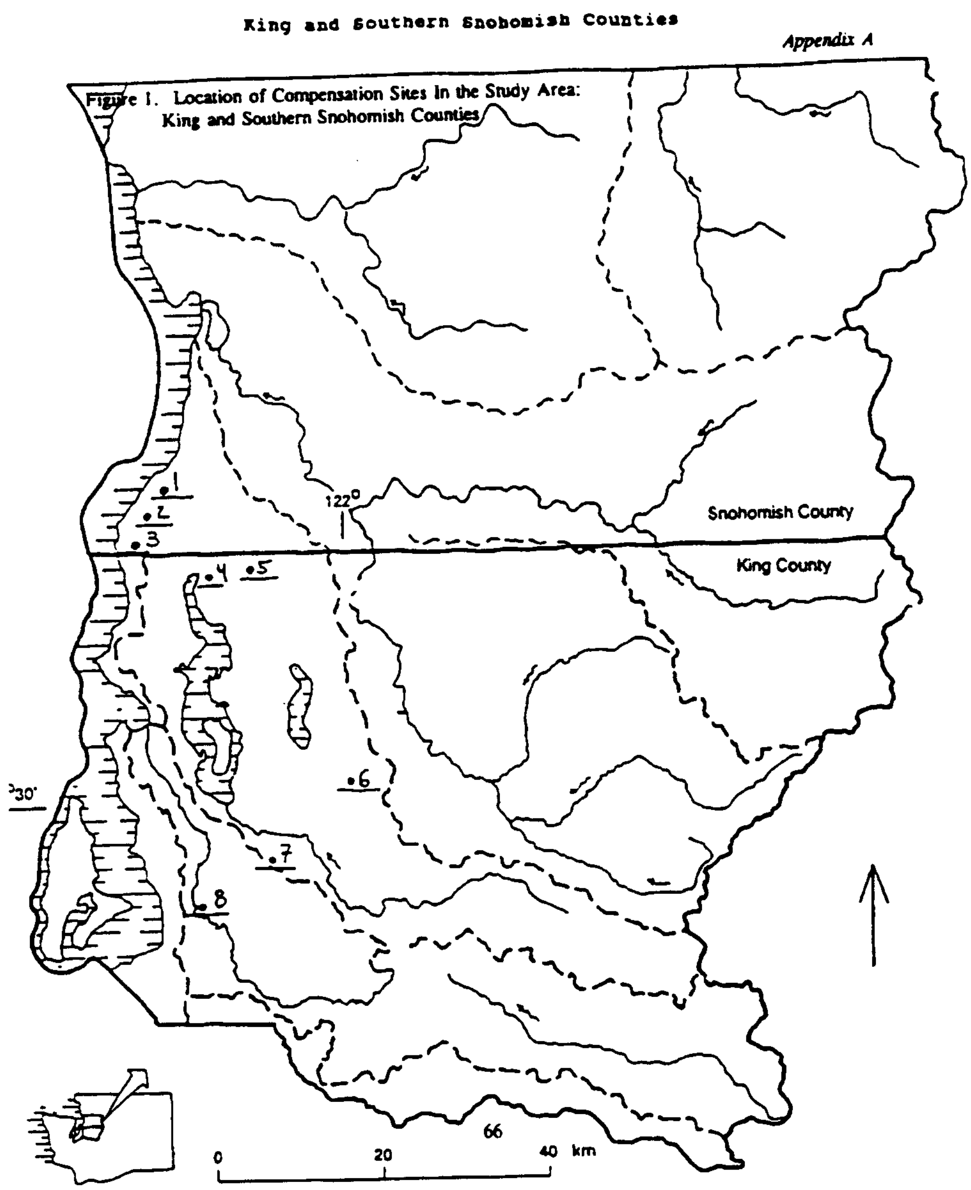

Table 1. Preliminary and Final Compensation Sites

Sites are arranged by County from North to South.

SITE LOCATION	COUNTY	COMPENSATION	SITE USED	IF NOT, WHY NOT	SITE#
Airport Road/ 100th Street SW NE quadrant	Snohomish	Yes	Yes		1
Airport Road South of West Casino Road SW quadrant	Snohomish	Yes	No	Comp. too young (fall of 1990)	
Harbor Point Blvd./ 55th Place West SW quadrant	Snohomish	Yes	Yes		2
83rd Avenue West/North of 224th Street West	Snohomish	Yes	Yes		3
South of 175th Street on the Sammamish Slough	King	Yes	Yes		4
North Creek Pkwy/ NE 195th Street	King	Yes	Yes		5
Issaquah Pine Lake Road/238th Way SE	King	Yes	Yes		6
148th Avenue SE/ SE 183rd Street	King	Yes	Yes		7
64th Avenue South/ James Street	King	Yes	Yes		8
SE 265th Street/ 117th Avenue SE	King	No	No	Comp. not built	
SE 265th Street/ 117th Avenue SE		No	No	Comp. not built	

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Table 2. Compensation Site Characteristics.

SITE#	APPROX ACRES OF COMP	COMPENSATION TYPE*	YEAR IMPLMTD	DEVELOPMENT TYPE
1	<1 acre	P; C	1989	Commercial, Bus. Park
2	<1 acre	P; E	1989	Residential, Single Family
3	1-2 acres	P; R	1990	Residential, Single Family
4	<1 acre	P; R, E	1989	Commercial, Warehouse
5	14 acres	T; E, R	1985	Commercial, Business
6	1-2 acres	T; R, E	1986	Residential, Single Family
7	<1 acre	T; E	1990	Residential, Single Family
8	4 acres	P; E, C	1988	Residential, Multi Family

* Compensation Type

Restoration (R) - actions taken on an historical wetland that is not now a wetland to restore lost functions.

Creation (C) - design and construction of wetland where none historically existed.

Enhancement (E) - actions taken on a pre-existing wetland to improve some or all of its functional characteristics.

Partial (P) - Compensation uses only a portion of the pre-existing wetland.

Total (T) - Compensation includes all of the pre-existing wetland.

IV. DISCUSSION

The original two objectives of the field study were to assess the effectiveness of compensatory mitigation in achieving no-net-loss of wetlands, and to assess the effectiveness of requiring variable replacement ratios based on wetland vegetation community types to compensate for permitted wetland losses.

To assess the effectiveness of compensatory mitigation within the scope of this study, a qualitative measure of success or failure of compensation sites was needed. It was necessary to establish a qualitative assessment of functional equivalency. To determine whether the proposed compensation was successful or not, a series of questions were asked to establish pre-existing conditions, compensation goals, existing site conditions and to establish whether the goals were achieved. The preliminary set of questions generated a second series of questions related to the definition of success, functioning, and equivalency. Simply put, the main question became: if shrubs are planted in a wetland, has a shrub-scrub wetland community been created?

Detailed quantified studies have been conducted to define and determine what constitutes functional equivalency. For the purposes of this field study, it was assumed that a compensation project met the goal of functional equivalency if the target communities within the compensation zone provided the same or better level of functional value as the pre-existing wetland on-site, for the five functions outlined below. For certain sites, th' pre-existing wetland may have been significantly degraded, in which case equivalency was determined by using a standard "reference" of the target community (e.g., a typical spirea/willow shrub, or cattail/water-plantain/sedge emergent community commonly found in the central Puget Trough area).

As a result of the questions developed for determining the effectiveness of compensatory mitigation, a series of critical components for compensation design, implementation, and monitoring were identified. A third objective was added to the study: to determine what criteria or critical design components significantly affect compensation "success."

Based on the results of this study, we address the appropriateness of requiring variable replacement ratios factored on wetland vegetation community types to compensate for permitted wetland losses. In addition, we provide a discussion of the adequacy of compensation plan goals to provide for creation of wetland communities.

Parameters of Success

In order to determine if the proposed compensation plans were successful in meeting their goals, a series of questions were asked at each site. The intent of the questions was to establish pre-existing conditions, to determine if the compensation project was constructed as it was designed, and to determine if the compensation site currently existed as was predicted within the compensation design.

Was a pre-site analysis completed?
Pre-site analyses of varying degrees of complexity were completed on all eight sites. These analyses were not all available within the files reviewed for this study; however, according to documentation or references located within the files, they were completed.

Because many of the pre-existing site assessments were not available for our review, no assessment of pre-compensation to post-compensation wetland conditions could be completed on a number of sites.

Was the compensation implemented as planned?
Most sites were implemented as planned, with minor exceptions. Ornamental landscaping species were substituted for some of the native species on two of the sites. Shrubs were planted at much lower densities than what was proposed on one large site.

Is the compensation mitigation site functioning?
All sites were functioning as wetland. However, it is critical to note that with one exception, all the sites used for compensatory mitigation were either wetlands (or portions thereof) prior to the compensation action, or were sites that were historically wetland that had been filled, and the compensation involved removal of fill to restore lost functions to the compensation portion.

All sites involved only a portion of a pre-existing wetland. In other words, the compensation wetland site was either contiguous with or adjacent to an existing, functioning wetland system. This physical relationship to a functioning wetland significantly improved the "functioning" of the compensation areas.

Were the compensation goals met?
In order to answer this question, a clear statement of goals defined at the outset of each project was needed. Most of the goal statements, if present, were general phrases such as "to create 0.2 acres of emergent marsh..." or "to create a scrub-shrub wetland." Given the general and sometime vague description of the goals, results of this study indicate that goals were met at these sites. Many of the compensation areas were providing wetland functions such as stormwater attenuation, biofiltration, sediment deposition, groundwater discharge, and species or habitat diversity. However, most of the compensation sites provided very limited wetland community functions, except that provided by the presence of the pre-existing adjacent wetland community.

Functioning of Compensation Sites

The last two questions above generated discussion and questions regarding the functioning of compensation wetlands. All compensation sites reviewed by this study were functioning as wetlands; however, not all target wetland communities were currently functioning as communities. As mentioned above, all the compensation areas were located adjacent to or contiguous with a pre-existing wetland. and many of the compensation sites were enhancements of portions of pre-existing wetlands.

Functional values associated with the compensation wetlands included stormwater attenuation, water quality, groundwater effects, aesthetics, and wildlife habitat.

Stormwater Attenuation
Six of the eight sites (sites 1, 3, 4, 5, 6 and 8) were designed to control stormwater, to act as flood backwaters, or had stormwater directed towards them as a source of water. Sites 3 and 6 were designed and engineered to provide stormwater retention/detention (R/D) and outlet structures were present to provide storage on these sites. Sites 4 and 5 were designed to collect backwater floods from adjacent riparian systems. Site 1 was designed to receive stormwater from an upland site approximately 1,000 feet away; stormwater was directed to the site to provide a source of water, not to provide storage.

The use of the compensation wetland areas for R/D has had a variety of impacts on the pre-existing wetland systems. Site 3 is a sphagnum bog, and the alteration in nutrient balance from incoming stormwater is adversely impacting the vegetation community within the bog. Site 6 provides for R/D within a dredged pond down gradient from the pre-existing mature forested system. The flood storage occurs primarily within the pond and no direct adverse impacts were readily visible within the forested community. However, no attempts were made to assess pre-construction and post-construction conditions within this forested community for the identification of species or community impacts.

Site 4 is a relatively low gradient backwater located on the Sammamish Slough. No evidence of excessive sedimentation or siltation within the backwater channel was observed; however, observations were limited to off-site viewing with binoculars.

Site 5, located on North Creek, was flooded repeatedly in the winter storms preceding this study. As a result, silt and debris from the flood waters covered the backwater area vegetation that consisted almost exclusively of reed canary grass. It is not known if the reoccurring flooding and deposition of sediment has influenced the viability of other species of the vegetation in the area. The area is providing a flood storage function within a riparian system where high levels of sedimentation are known to be a problem.

Water Quality
Water quality functions can be provided by biofiltration; of sediments within a system, by nutrient uptake within the vegetation system, and/or by providing a settling basin for the deposition of suspended solids.

The dense cover of dead winter reed canary grass provides very effective biomass for biofiltration; consequently, the North Creek compensation site (Site 5) provides excellent biofiltration and settling for suspended solids.

The other study sites were likely have minimal effect on water quality, as only minor amounts of degraded water enter the compensation area without first having passed through the pre-existing wetland. Several of the sites have no observable stormwater input.

Groundwater Effects
Wetlands can influence groundwater by acting as discharge and/or recharge points for shallow aquifers and/or adjacent streams. Wetlands can discharge water to deep aquifers by means of infiltration through deep hydric soil deposits and through pervious substrate beneath the body of the wetland allowing for the transport of surface water to subsurface aquifers. Wetlands may also function as discharge zones for groundwater, commonly referred to as spring-fed systems.

Wetlands may also provide a critical function for stream recharge, by metering stored open water or water within the soils out to down-gradient streams. Wetlands can extend the stream recharge over a longer period of time than impervious surfaces or upland soils. This function can have major significance for systems associated with salmonid streams with either perennial or seasonally intermittent flows.

Full study of the effects of compensation areas on groundwater was beyond the scope of this study; however, some general observations are provided. On sites 2, 3, 6 and 8, open water was created by excavating to expose groundwater. Creation of these open water ponds likely had no effect on deep aquifers, but may have served to increase evapotranspiration from the water surface. Site 5 is located on very deep organic peat deposits; occasional flooding of the compensation area likely provides recharge to the peat that then can release water to North Creek for a longer period of time. As a result of the flooding, the recharge function of the wetland may be improved over the pre-existing dredged farm ditch conditions.

Aesthetics
Wetlands can provide several solely human-identified values that are here termed aesthetics. Such values are associated with open space and views, with opportunities for passive recreation such as walking/birdwatching, and with opportunities for education (either formal or informal). Aesthetic developments within wetlands may include placing of trails in the wetland or buffer, placing observation decks or structures within or on the wetland edge, and/or planting of non-native ornamental species for their color, foliage, fruits, or blooms.

Sites 2, 3, 5, 6, 7 and 8 were designed to be incorporated into residential settings and/or to provide passive recreation and open space. Features designed to enhance aesthetics, such as colorful species, attractive blooms, trails, boardwalks and interpretive signs, were included. All of these sites are successfully providing aesthetic/open space values.

Site 3 is located within a public park and incorporates detailed interpretive signs, a walkway, and an overlook system. Site 5 is located in a commercial business park; an extensive walkway is provided, as well as interpretive signs.

Site 6 was designed to provide an "entrance statement" to a residential subdivision; the excavated pond was landscaped to provide views of the open water for passengers in vehicles entering the site. Maintenance of the aesthetic function is affecting other functions of this site. Planted and volunteer shrubs and trees located in the area that would block the view of the pond are mowed as part of an active maintenance program, thus eliminating a large part of the desired habitat diversity.

Incorporation of wetlands and compensation areas within residential areas provides opportunity for interpretation and interaction, however, it also provides for intrusion by humans and domestic animals. Walkways and trails on all sites were used by humans, some heavily, and domestic animals were observed in several sites during the field visits.

The perception that open water provides a more positive image than dense vegetation has promoted the dredging of ponds (sites 2, 6 and 7) within residential areas.

Wildlife Habitat

All eight site plans listed enhancement of wildlife habitat as a compensation goal. Habitat can be provided in a variety of ways, including increasing vegetation species diversity, increasing structural complexity, and providing missing habitat types such as open water, shrubs, or emergent zones. The discussion of vegetation community status is provided within this wildlife section because species diversity and community complexity can be a significant factor in wildlife use. Sites 2, 3, 4, 6, 7 and 8 each provided open water to increase wildlife habitat diversity and in some instances provide for R/D. Open water was created successfully at all sites by dredging out material to expose groundwater or capture adjacent surface waters.

Within the open water community, all six sites attempted to create an emergent vegetation community to provide increased species diversity. The emergent areas were planted in the margins of the dredged zones. The viability and vigor of the emergent vegetation plantings at the sites was varied (see the Design Component discussion below for more detail). Site 1 attempted to create an emergent community on former fill; at the time of this study, the compensation area was entering its second growing season and the vegetation appeared to be viable and at adequate densities. Site 4 (viewed from off-site) appeared to have established a complex and robust emergent community within a dredged portion of pre-existing wetland.

Sites 5 and 8 contained large portions of emergent wetland dominated by reed canary grass. On site 5, reed canary grass almost exclusively dominated the emergent zone; however, on site 8, an effort had been made to add structural diversity by planting various shrub and tree species within the existing reed canary grass emergent zone. Although the reed canary grass-dominated areas are technically emergent wetland communities, they were not providing species diversity or habitat complexity.

Emergent species were planted on the margins of the excavated ponds on sites 2, 3, 6, and 7. The extent of the emergent zone was limited by substrate and water depth on sites 2 and 6. Timing of the field work for this study and the young age of the emergent areas on sites 3 and 8 made an assessment of presence or viability of the emergent species impossible.

Shrub species had been planted to create scrub-shrub habitat on all sites. The survivability of the shrubs varied. At least half of the shrubs on site 1 died. Survivability seemed to be correlated to water regime, with those shrubs outside of the wetted zone not surviving.

Shrub species planted with appropriate hydrologic regimes had a much higher survival rate on sites 2, 5, 6 and 7. Some of the shrubs in sites 5 and 6, and most of the shrubs on site 2, were planted on steep, well-drained slopes; those species that did survive were stressed. Many of the shrubs on site 5 seemed to be outcompeted by the reed canary grass; in addition, shrub species were planted at a far lower density than called for in the plans. On site 6, ongoing maintenance (mowing) to assure views of the adjacent pond eliminates a significant portion of the proposed shrub community. Some portions of this site along the pond margin are not mowed, and are filling in with volunteer red alder saplings at high densities.

Although site 3 is too new for the assessment of survivability, the vegetation appeared to be planted at densities adequate for a dense shrub "community" over time. Vegetation on site 4 is surviving and is planted in appropriate locations; however, the density of plantings will not allow a shrub "community" to become established without the introduction of volunteer species overtime. Site 8 also contains pockets of shrub plantings that, although too young for the assessment of community structure, appear to have adequate densities.

Although trees were planted in many of the sites, only the large transplanted black cottonwood trees within the riparian zone of site 5 are currently providing any "tree functions"; trees on other sites are too new to provide structural complexity or, in some cases, even fruits. Within all sites providing open water, waterfowl use was observed. The most common species observed were mallards and Canada geese. The use of ponds by geese and mallards is ubiquitous in this region, and does not provide a good indicator of wildlife habitat.

Coots, blue-winged teal, widgeon, gadwall, and buffleheads were seen at sites 3, 5 and 6. Great blue heron were sighted at sites 5 and 6, and a green heron was observed in the riparian zone at site 5. Passerine birds were observed at all sites.

Beaver were actively harvesting trees and shrubs along the riparian corridor of site 5. An active dam structure and a possible bank den were observed.

Sites 2, 3, 5, 6, and 8 created elements of structural diversity within the wetland community that were not present prior to the compensation, primarily in the form of open water and edge habitat. Wildlife use of this habitat was variable, and assessment is limited by the single field observation of each site.

Functioning of the compensation wetlands, especially for wildlife habitat, was dependent upon the adjacent wetland. No assessment of the wildlife habitat functions of the compensation wetland in isolation from the pre-existing wetland was possible; indeed, such an assessment might be inappropriate.

Critical Compensation Plan Components

Critical components that contribute to the successful functioning of compensation wetlands are identified in Table 3. The components generally fall into four categories: design, implementation, maintenance, and time.

Design Components

Soil: Lack of appropriate substrate contributed to lowered functioning of portions of sites 2 and 6. The open water and emergent areas were created by dredging down to till. It appears that the planted emergent species are limited by lack of suitable substrate; growth is restricted, and an increase in the community beyond the planted specimens does not appear to be occurring.

Table 3. Components of Compensation Site Functioning

COMPONENTS OF COMPENSATION SITE FUNCTIONING

1.	Design	Soil		Presence Type Contours/Grading
		Hydrology		Source/Quality Hydroperiod Input Method
		Vegetation		Species Composition Species Diversity Planting Density Placement
2.	Implementation	Quality Control	Grading Contours	Erosion Control Timing Species Use/Placement
3.	Maintenance	Type		Irrigation Mowing Replanting Control of Invasives
		Frequency		
4.	Time			

In contrast, vegetation on sites where existing or recovered hydric soils were used (Sites 3, 4, 5 and 8) was more robust. These sites are likely to expand and develop a more extensive community over time.

Hydrology: Inadequate site planning for hydroperiod and water source, including quality and method of conveyance to the wetland, lowered the success of compensation at several sites.

Site 1 receives limited amounts of stormwater from an upland warehouse located over 1,000 feet from the wetland. No direct contamination source exists at the source and the water passes through 300 feet of vegetation-lined ditch. Because the water quantity is limited, water levels within the wetland are very low during winter months, and no standing water is present during the summer season. It is unknown if this site will continue to function over time with this hydrologic regime.

Hydrologic cycles were considered in the design of Site 5; however, the design did not consider the unpredictable nature of deep organic soils. The compensation wetland site has "rebounded" above the designed elevations, thereby lying higher than the average floodplain elevation of the creek. The wetland seems to be under stress due to a lack of sufficient water.

Poorly constructed or designed side slopes and bottom contours in compensation areas has resulted in water regimes beyond the tolerance level of some hydrophytic species. Lack of extensive shallow water zones limits the extent of emergent habitat. Water levels consistently over two feet deep, or areas where the seasonal hydroperiod includes deep flooding to absolute drying, is resulting in species mortality.

Lack of appropriate water levels may be contributing to lack of a natural succession and species diversity within site 8. The area is characterized by deep hydric soil deposits; however, the soils appear quite dry, even during the field visit in the early spring of an exceptionally wet year. Lowering of the site elevation by only several inches might have increased the soil saturation to the level preferred by hydrophytic species. Planted species present are not stressed; however, the lack of saturation may provide for the continued presence and dominance of reed canary grass.

Hydrology at site 3 appears to be appropriate and, as a result, the plant community is developing and functioning well, even though it is very young.

Vegetation: Low planting densities contributed to a lowered potential for vegetation groupings' functioning as a community in sites 2, 4, 5, and 6. Although appropriate species were planted, the specimens were placed at extremely low densities and will likely never mature into a functioning shrub community, unless pioneering species such as red alder "fill in the gaps." There appeared to be a consistent pattern of providing appropriate shrub species, but not providing densities high enough to create a community over a reasonable time frame.

Shrub planting densities on site 5 were much lower than those specified in the plan, and as a result, the shrub community within the wetland has not developed. Species diversity on the emergent portion of this site was low when the site was constructed, and the compensation area has not significantly changed that composition. Reed canary grass totally dominates the emergent zone; other planted emergent species are present in very limited numbers, scattered throughout the area. Although the emergent wetland zone functions as an emergent zone, there appears to have been little increase in functional value, and the target communities were not created.

Appropriate use of plant densities and species diversity likely contributed to higher success of the compensation areas at sites 1, 3, 4, 6, and 8. Portions of site 8 are functioning as planned, specifically, the portions furthest from human disturbance and adjacent to the pre-existing wetland area.

Species placement in a design is critical; often wetland shrub and buffer species were placed on steep fill slopes surrounding the wetland area, so that survivability and success of these plantings is extremely limited, due to lack of appropriate substrate and availability of water.

Implementation Components
In general, implementation was as specified in the plans, with the exception of substitutions with non-native and ornamental species. It is not known how many of the sites were constructed with a wetland ecologist or landscape architect on-site to oversee construction.

Maintenance Components
Lack of proper type or level of maintenance following implementation contributed to lowered functioning of portions of several of the compensation wetlands.

Lack of irrigation at Site 1 likely resulted in some species mortality. Lack of control of invasive species at site 5 and 8 has contributed to limited community functioning.

Active site maintenance on sites 2 and 6 has adversely impacted the functioning of the target communities. Location of compensation sites within areas designed for aesthetics can result in maintenance activities that limit the functional value of the wetland communities.

Shrubs at site 6 are regularly being mowed and are not allowed to grow; elimination of this maintenance would result in development of the shrub area. Mowing, removal of shrubs, clearing of underbrush, and planting of ornamental species all impact functioning to varying degrees.

Time
One criteria for site selection was for sites that had been constructed for as long as possible. The two sites with the longest history (sites 5 and 6) have been constructed since 1986. Most of the other sites averaged less than 2 years; two sites had been constructed for only one year.

Time is a critical factor of compensation functioning that cannot be controlled by design. Most of the sites in this study would provide higher functional value over time if they were allowed to mature and develop complexity in response to natural determinants, not human maintenance activities.

Replacement Ratios

A primary objective of the study was to assess the effectiveness of requiring variable compensation replacement ratios based on the vegetation community type.

The results from this study of a small number of regional compensation sites indicate that while all of the compensation sites are providing some wetland functions, few sites are providing those functions exclusive of the contribution of the adjacent pre-existing wetland. The sites surveyed are a sub-set of compensation sites within the Puget Sound area; it is our opinion that they provide a representative sampling of compensation areas.

The field study found that there was little success in replicating fully-functioning wetland communities. Factors contributing to this lack of success were for the most part, controllable factors, except for one variable: time. All of the compensation areas will function more fully over time. Plant specimens will mature and stable communities will establish as planted and volunteer species combine.

Given the lack of long-term compensation projects to assess, there is no basis for providing a time-line of functional equivalency. The collected data does not allow conclusions regarding which wetland community type can be more easily replicated; as a result, no direction as to appropriate ratio assignments can be provided. A general assumption of wetland professionals is that emergent wetland communities are the easiest to replicate; however, this study did not test this hypothesis.

Because of the lack of quantified data on pre-existing conditions, it was not possible to deduce whether the amount of functional wetland allowed to be eliminated was replaced or compensated for within the compensation areas. In order to assess whether proposed replacement ratios are appropriate, wetland <u>communities</u> lost to development must be quantified and compared to wetland <u>communities</u> successfully created. As mentioned above; it was extremely difficult to find created wetland communities that were providing equivalent functions to established wetland communities.

Within the compensation sites there was often a mosaic of success, i.e., some portions of the compensation area were functioning, while some portions were not. Although all compensation areas were providing wetland functions, most compensation areas were not providing wetland <u>community</u> functional values.

V. CONCLUSIONS

One of the primary objectives of the field study was to determine the effectiveness of compensation in achieving no-net-loss of wetland resources. Effectiveness could be assessed by comparing existing wetland conditions before and after construction, and drawing conclusions as to the net gain or loss of functional value; or by comparison of the prescribed goals of the compensation plans to the achievement of those goals resulting in replication of equivalent functional values.

When assessing achievement of no-net-loss, it is important to consider whether the compensation project created wetland out of non-wetland; restored an area that was historically wetland (i.e., the area was filled or drained, and was no longer functioning as wetland); or enhanced an existing wetland area. Creation or restoration could result in a potential replacement or net gain in wetland area; enhancement may result in an increase of existing wetland functional value but no net gain in wetland area. If the goal is to provide for no-net-loss of wetland, and if a functional wetland is allowed to be eliminated by development proposals, then creation or restoration actions may be of higher priority than enhancement of existing wetland systems.

The compensation plans were proposed and implemented to provide for the replacement or improvement of wetland communities that were permitted to be eliminated. It was outside the scope of this field study to thoroughly determine pre-existing conditions or to determine whether the created compensations represent a replication or improvement of former wetland conditions. Therefore, this field study considered whether the constructed compensation plans met their proposed goals.

During the course of reviewing the proposed goals stated in the compensation plans, it became clear that the goal statements were so general and unspecified that only outright total failure of a compensation wetland area could be interpreted as a failure to meet the goals. Goal statements, when they existed, were generally written to specify the creation of certain habitat types, often with no reference as to size or functional level. Quantified areas were often provided for the entire compensation wetland; in few cases were the areas of target wetland community types broken into separate quantities.

None of the goal statements provided a quantifiable method of determining success. Because the goal statements did not define the target communities by their functional values and spatial dimensions such as species numbers, densities, spatial patterns, and growth patterns, there is no method to determine if the goals have been met.

This lack of clearly discernable and quantifiable goals resulted in an inability to determine "success" and, as a result, provided no means for an agency to request remediation or contingency actions to provide additional functional value.

In field checking the constructed sites, another primary objective was to note whether the created wetland compensation areas were providing wetland functions and whether the proposed target communities were functioning as communities. In general, it was found that all of the compensation areas were providing a variety of wetland functions and values. As noted in the text, the level or amount of function varied significantly, depending on the functional values present within the pre-existing wetland communities and on how well the compensation was designed.

Within this field study, it was not always possible to clearly isolate certain functions provided by the compensation area from those provided by the pre-existing wetland. Wildlife habitat and use was the most critical function that seemed dependent upon the pre-existing wetland and adjacent land uses. For other functions and values (e.g., flood attenuation, water quality impacts, and aesthetics), it was easier to differentiate between those provided by the compensation area from the pre-existing wetland, depending upon the site. Location of the compensation wetland in relation to the source of floodwaters, degraded surface water, or human view, affected the degree and significance of its functioning.

It was important to define what was meant as "functional equivalency" for this study, in order to set some parameters for a qualitative comparison. For the purposes of this field study, it was assumed that a compensation project met the goal of functional equivalency if the target communities within the compensation zone provided the same or better level of functional value as the pre-existing wetland on-site; or the on-site wetland, though degraded, met the functional value of a "representative wetland" community. Using this definition, it was most often found that the target wetland communities were not created, except for the open water components.

Although emergent communities were often present, they were too often severely limited in their extent and complexity, due to the limitations of the considerations during site design. Functional shrub communities were not found within many of the compensation sites, except where the presence of volunteer red alder and willow had filled amongst the planted specimens to provide the dense "brushy" aspect found in more natural wetland communities.

Forested communities did not exist in any of the compensation areas. In one site, where large cottonwood trees had been transplanted along a riparian corridor, the trees were surviving; however, no element of "forest" was yet present. Tree plantings were provided in many sites, but given the relative age of the sites, it is not possible for any forest functional element to have been created.

The study found that the design, implementation, and monitoring of compensation projects are the most critical components in successful compensation functioning. Design considerations include the analysis of soils, grading contours, water source and hydroperiod, and detailed landscaping plans including appropriate native species, planting densities, species groupings, and size of planting zones.

Implementation, monitoring and maintenance of compensation projects was found to be critical for the long-term functions of the site. Routine maintenance of some communities within residential settings was found to significantly reduce the function of the compensation wetland for wildlife habitat.

Beyond the design and follow-up of the compensation plans, the other most significant factor was time. Time may allow many of these systems to stabilize, to increase their species diversity by natural inclusion of volunteers, to increase their spatial complexity with age and natural attrition, and to provide more of the functional values associated with "older" natural wetland systems.

The significance of the time factor should not be diminished; it is an important element that may provide for "success" to be achieved. The passage of time will allow pioneer species to volunteer within a compensation area and to mask the limitations of the planted zones. The natural process of succession and change will occur within the created systems in spite of certain design limitations.

It is critical to note that only one of the eight compensation areas was created on non-wetland substrates. All others were either constructed in existing wetlands or in areas that were historically wetlands. The wetland substrate composition may be a very significant factor in determining ultimate success in compensation plans. Volunteer native species may only colonize sites that have appropriate hydroperiods on appropriate substrates. The one exception was a well-establishing emergent community created on tight compacted upland fill soils; it is not known how this community will function over time.

The level of detailed design contained within the sites reviewed covers a range of compensation designs from the last five years. The design plans ranged from simple bubble diagrams with target community types shown on the drawings and an accompanying list of proposed vegetation species within a text or table; to detailed assessments with engineered calculations of grades, floodplains, and hydroperiod, as well as species composition and position. Unfortunately, the reviewed site that entailed some of the most detailed engineering design was constructed on a deep peat system and did not calculate the natural substrate rebounding within the system; therefore, although the design utilized detailed quantified analysis, a critical factor was overlooked and the site is not functioning as proposed.

It is the opinion of the investigators that with more detailed compensation designs incorporating as many site variables possible, there would be an increased likelihood of success of compensation plans. By providing detailed plans (i.e., grading contours, substrate composition, hydroperiod, species composition, spatial arrangement, nursery species types and conditions, timing of construction and planting), the created systems can more accurately approximate a natural system. If the compensation wetland more accurately mimics a natural system, especially in species composition, extent, and density, then over a reasonable time period, the compensation area will likely begin to approximate more closely the functional values of natural systems.

The results of this field study provide little basis for establishing quantified, variable replacement ratios based on measurable field data. This is due to the failure, in our opinion, of the compensation sites to provide for replacement or replication of the functional values present within a mature wetland community. It is understood that the assessment of failure could likely be reversed over time as sites mature and volunteer species fill in the gaps present in the compensation areas.

Because of the lack of adequate pre-existing data analysis and the lack of quantifiable "success" of the compensation designs, this study does not provide quantified justification for variable replacement ratios. But the lack of quantified justification cannot eliminate the recognition that certain communities require a longer period of establishment before beginning to achieve any functional equivalency. Created forested and shrub communities are limited in their inherent functional equivalency because of the physical complexity required internally before they provide wetland community functions.

The findings of this study of a small sub-set of sites within the central Puget Trough area, does not imply that a 1:1 replacement ratio is appropriate for the goal of no-net-loss of wetland functional value. To the contrary, the findings illustrate that the achievement of functional equivalency, using the methods of these compensation designs and over relatively short time periods, has not occurred. The study further illustrates that due to the inability of many of the compensation sites to achieve functional equivalency, there is an overall net loss of wetland resources.

The one clear effect of requiring variable replacement ratios is the incentive to not impact certain wetland community types. Those communities requiring the greatest ratio of replacement will be the ones most likely to be avoided by applicants where possible, because of the implications of cost and space on a project.

VI. RECOMMENDATIONS

The following recommendations are based on the findings and results of this field study and on the professional experience of the authors. In addition to this study, there are other field studies that corroborate the findings, conclusions, and recommendations of this study. Citations of those studies are included within the references.

The recommendations are formulated based on several consistent findings: first, that a pre-existing conditions assessment is often not conducted or is incomplete; and second, that compensation goals must be provided in some quantifiable manner that allows an accurate determination of subsequent success or failure.

Pre-existing Conditions Assessment

A pre-existing conditions assessment must be conducted for the wetland communities proposed to be eliminated and for the wetland community (if present) located within the proposed compensation zone. This provides a reference, in the future, of the wetland community types eliminated. It also provides for a characterization of the pre-existing wetland (if any) within the compensation zone to assess any change in functions and values. Finally, a detailed assessment of the communities proposed to be lost can provide the quantified description of the target communities to be created.

The assessment must be conducted in a process that <u>quantifies</u> the existing wetland characteristics. For each wetland community present within the wetland, a sample plot large enough to provide for a representative sampling must be established. Within each plot the following data should be collected:

- vegetation listed by percent presence and presence within the community (groundcover, emergent, shrub, sub-canopy, canopy; sapling, mature, dead, dormant, etc.). All species present within the plot or within the greater wetland should be noted, not just species of 20% presence or greater.

- relative spacing of species within the plot; i.e., red-osier shrubs present at approximately 2 feet on center, spirea present in a continuous coverage, Sitka spruce at 12-foot centers;

- relative heights of the vegetation, community complexity, vegetative edge complexity. Relationships of the various vegetation canopy and community compositions; i.e., skunk cabbage located under a red alder canopy, or under a salmonberry/devil's club sub-canopy with an overstory of mixed red cedar and hemlock.

The hydroperiod of the wetland must be determined on a seasonal basis to determine the water fluctuations to which the existing species are adapted. A thorough hydrological analysis, including the source of the water within the system, the method by which it enters the wetland (e.g., surface sheetflow, pipe, stream, subsurface) and whether or not the wetland is a closed depression. Water quality conditions should be established based on field observation of sources, sediment input, and existing or documented conditions.

Soil conditions within the wetland must be established, dealing with whether the system contains parent material or fill, whether it is primarily mineral or organic in origin, relative depths of organic deposits, and the presence or absence of an impervious layer that may be allowing surface water to be perched and exposed.

The functional value of the wetland proposed to be eliminated and within the proposed compensation site (if present) must be provided. At a minimum, the five functions as outlined in this report should be assessed.

A detailed quantified analysis of the square footage proposed to be eliminated, by wetland community type, must be provided. By providing the quantities of wetland communities proposed to be lost, it would be possible to ascertain the success of replacement over time.

By establishing measurable characteristics of the wetland proposed to be eliminated, or, if appropriate, the pre-existing wetland within the compensation zone, one can create a quantified description of the wetland communities targeted to be created within the compensation zone.

If replication of the wetland communities existing on site is proposed, then one must provide a detailed quantified assessment of those communities in order to determine if the compensation goals have been met. If the wetland communities on site are degraded, it may be more appropriate to provide a detailed quantified characterization of an identifiable representative wetland community located off-site, but within the vicinity.

Establishing Compensation Goals and Objectives

The goals and objectives of the compensation must be provided in a manner that allows for the determination of success or failure. As noted, most goal statements are written so broadly as to virtually assure compliance. In order to provide a quantifiable goal, the target communities proposed to be created must be described in detail. The detail is provided by the pre-existing site assessment as described above. The goal is to replicate either the pre-existing wetlands on-site, or the wetlands identified as a representative community (if on-site wetlands are already degraded).

Goals and objectives must include square footage by wetland community type, by plant community species composition percentage, and by relative density (stem spacing or amount of coverage).

Given the fact that success of compensation is determined by time as well as design, a proposed time line should be provided (i.e., years to establish specific height and density, years to replicate specific community). It is understood that such time approximations will be speculative at first, but as the data collection for this science accrues, it will allow for the refinement of these time estimates.

Compensation Plan Design

Based on the assessment of the target community, the compensation design should attempt to replicate that target community to every extent possible. The design must incorporate detailed analysis of substrate composition, grades and elevations, hydroperiod, source of hydrology, potential water quality impacts, sediment sources, and vegetation community composition.

As noted repeatedly, vegetation community composition must include species, and spatial design (percentage of presence, density of plantings, community structure).

Designs must include detailed grading plans, hydrologic analysis and landscaping plans that include planting specifications, sources of material, and a guarantee of plant material availability for large projects.

Implementation

Appropriate timing for planting and construction depends upon site conditions. Obvious factors include grading during the dry season and irrigation during the first growing season. The wetland ecologist and/or landscape architect responsible for the design should be on-site during construction and implementation. Planting of certain materials should be undertaken at optimum seasons, e.g., late fall for woody species to stabilize them before the dormant winter season; spring for some emergent species and for some species that are seeded, to eliminate winter foraging by birds. Timing of plantings is species-specific and site-specific.

Control of erosion and sediment movement during construction and post-construction can be crucial for certain projects.

Maintenance

Follow-up and maintenance should be outlined within the plan. Maintenance may include control of invasive non-natives, irrigation, shrub pruning to promote certain growth habits, removal of dead specimens, planting of quick-growing species to provide shade for less tolerant target species (e.g., planting alder or cottonwood saplings to provide shade for red cedar saplings until the cedar becomes established, and then removing the deciduous trees if desired).

Monitoring

Establish a quantifiable monitoring program that relies on quantified targets: percentage of survivability, percentage of relative species composition within a target community (assuring that the targeted 60% dogwood/40% vine maple has not become 80% willow /20% spirea), and achievement of relative densities.

By establishing quantified standards at the outset, and a relative time-line of compliance, the monitoring element should be able to assess relative success of the compensation plan in achieving its goals.

To summarize, in order to be able to determine whether the goal of replacement has been achieved, it is necessary to establish a quantified assessment of the wetland communities targeted to be created. This assessment is also necessary if the proposed action is to enhance an already existing wetland community. One must be able to describe, in a quantifiable manner, the community that one is attempting to replicate.

Existing stable, functionally diverse wetland communities should be used as models in the establish of standards for the target communities to replicate.

VII. STUDY LIMITATIONS

This field study has provided some valuable insights into the effectiveness of wetland compensation. However, inherent in a study of this size and scope are several limitations.

The compensation sites assessed in this study are a small subset of available compensation sites present only within the Puget Sound Basin. It was outside the scope of this study to field check sites located in the major portion of the state of Washington. It is the opinion of the field investigators that the compensation sites visited actually represent a relatively realistic sample of "typical" freshwater compensation sites designed in the late 1980's within the central Puget Sound region.

The geographic scope of the study was limited by time and resources to the west side of the Cascade Mountains, and was also was limited within the Puget Trough to those areas easily accessible within two days field work (total) and on which pre-existing permit information was readily available.

No attempt was made during the study to review all available development permit files or to identify all possible compensation sites; the number of sites chosen was limited by available field time and a realistic travel radius.

In addition, as noted within the body of the report, site selection was conducted to assess those sites that had been in place as long as possible and for which adequate background data was readily available in the files. Some older compensation sites exist within the study area, but were not assessed due to the lack of readily available background and/or permit data.

Assessments were conducted on a qualitative scale only, as it was beyond the scope of the study to provide for any quantitative assessment of functioning.

Sites were visited only once during this study. Sites were assessed during March, when many plant species are still dormant or just beginning to break dormancy. As a result, ability to assess health of the system, as well as viability and robustness of some species, was limited.

Assessment of the functioning of various plant groups within the entire wetland was limited and might have been different if the site were visited later in the year. For example, shrub functioning may have been underestimated in some wetlands because the shrubs were not leafed out. Evaluations of site functioning over time are speculative and are based on site conditions during the visit and investigator expertise.

Study sites consisted for the most part of younger sites (less than or equal to 2 years of age); very few older sites with adequate background material were located within the current files. A more long-term study would allow the accessing of archived files from the agencies, which would allow for the incorporation of more older sites. The limited number of sites more than two years old with adequate

background data limited the thorough assessment of compensation development and functioning over time.
This age limitation is a reflection of the relatively young "science" presented as wetland compensation. The presence of very broadly defined goals within the compensation plans results in general conclusions that many compensation plans were successful in meeting their goals; this is a reflection of the undefined nature of the goals themselves, and the lack of consensus as to what constitutes functioning.

Although the conclusions that can be drawn from this study are limited, the critical components of important compensation wetland functioning identified during this study are appropriate to be considered during the permitting and design phases of future wetland compensation projects.

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Attachments

Attachment 1: Agency and staff contacts

The following agencies and staff were contacted to provide a list of potential sites:

KING COUNTY, Building and Land Development
Technical Services Section
Tina Miller, Heather Stout, Laura Kaye
Subdivision Products Section
Howard Haemmerle

CITY OF KIRKLAND,
Joan Brill

CITY OF BELLEVUE,
Toni Craemer

ARMY CORPS OF ENGINEERS,
Michelle Walker

Attachment 2 - Compensation Site Field Data Forms

Investigator(s) ____________________ Date ____________

____________________________ County ____________

____________________________ Weather ____________

Site/Project Name ________________________________

Site Location/Address ________________________________

Was a Buffer Form completed for this site? Y / N When?

1. **PERMIT REQUIREMENTS**

A. Was a pre-existing conditions assessment done? Y / N
Was a report prepared?

B. **PRE-EXISTING VEGETATION SPECIES/COMMUNITY DIVERSITY**

COMMUNITY TYPE	Dominant Species	Comments/Conditions
POW		
PAB		
PEM		
PSS		
shrubs		
herbs		
PFO		
canopy		
sub-canopy		
shrubs		
herbs		

How was the information listed above determined?

C. **TYPE OF COMPENSATION REQUIRED**

	Partial	Entire	Describe
Enhancement			
Creation			
Restoration			

2. **IMPLEMENTATION**

A. Was the compensation implemented? Y / N

B. When?

3. **CONSTRUCTION DETAILS**

A. Was the compensation implemented as specified in the permit? Y / N

B. How much (acreage) compensation was specified? What type of wetland was to be created?

SOILS

C. Were hydric soils used? Y / N

D. If used were they:

a) in situ
b) placed on upland soils

c) recovered from under fill

E. Comments on soil conditions/use.

HYDROLOGY

F. Is the hydrological regime within the Compensation wetland natural or created? If created, describe how.

G. Does the hydrological regime seem appropriate? Why or why not?

H. Is the Compensation Wetland being used for detention/retention purposes? Y / N

Was the Compensation Wetland created to provide detention/retention? Y / N

VEGETATION

J. Was the vegetation design appropriate? Why or why not?

K. Were native vegetation species planted within the Compensation Wetland?

L. Was the density of plantings appropriate for compensation? Y / N
Comments.

4. **CONDITIONS ADJACENT TO WETLAND** (within 200 feet)

A. **SIZE OF BASIN**

	Small	Medium	Large
Size of Basin			

B. **LOCATION OF WETLAND IN BASIN**

	Upper third	Middle third	Lower third
Location of wetland in basin			

C. **CURRENT LAND USE ADJACENT TO WETLAND**

Zoning	Use	Percent	Comments/Conditions
Residential			
single family			
multi family			
Commercial			
Industrial			
Business Park			
Agriculture			
Native Vegetation			

D. Historical Land Use Adjacent to Wetland. How was the historical land use determined?

5. EXISTING WETLAND CONDITIONS (non compensation wetland)

A. **EXISTING WETLAND TYPE AND SIZE**

Community Type	% Total Wetland	Size of wetland (acres)
POW		
PEM		
PSS		
PFO		
PAB		

B. DOE Wetland Category:

C. **EXISTING WETLAND VEGETATION**

Strata	Species (listed by dominance)
Canopy	
Subcanopy	
Shrubs	
Herbs	
Grasses/sedges	

COMPENSATION WETLAND CONDITIONS

A. COMPENSATION WETLAND TYPE AND SIZE

Community Type	% Total Wetland	Size of wetland (acres)
POW		
PEM		
PSS		
PFO		
PAB		

B. DOE Wetland Category:

C. COMPENSATION WETLAND VEGETATION

Strata	Species (listed by dominance)
Canopy	
Subcanopy	
Shrubs	
Herbs	
Grasses/sedges	

D. **COMPENSATION WETLAND FUNCTIONS**

Wetland Functions	Pre-existing	Goal	Existing
Biofiltration/sediment			
Nutrient uptake			
Habitat Diversity			
Aesthetics			
Flood storage			
Veg. Comm. Diversity			

E. **COMPENSATION WETLAND CONDITIONS**

	Yes	No	Specifics/Comments
Runoff to Wetland/Buffer			
point source			
non point source			
chemical			
physical			
Turbidity in wetland			
Oil/grease			
Erosion			
Siltation (low, med, high)			
Wildlife use			
birds			
mammals			
fish			
amphibian/reptiles			
prey species			
Habitat Features			
snags/cavities			

brush/cover			
food species			
vegetation complexity			

7. **COMPENSATION WETLAND SUCCESS**

A. Are there invasive species present? Y / N Are they competing with the target species? Y / N Describe:

B. Which species appear to be robust, stable?

C. Which species appear to be stressed? Probable cause:

D. Is there debris in the area? (i.e. trash, tires) Describe type and level:

E. Are there other impacts to the compensation wetland? Y / N Probable cause:

F. How much of the compensation wetland is functioning? Describe:

G. Is the compensation community functioning as a viable entity? Y / N

as a community? Y / N

as a part of the larger system? Y / N

H. Were the compensation wetland goals met? Why or why not?

8. SUMMARY

A. What aspects appear to be functioning in the compensation wetland? What aspects do not appear to be functioning?

B. What variables were not addressed in the design?

C. Suggestions for improving functioning?

Additional Comments:

Attachment 3 - Field form methodology

The compensation data sheets were designed to collect consistent information on each site regarding pre-existing conditions, permit requirements, design goals and objectives, existing site conditions, and qualitative assessments of success and functioning of the compensation sites. Data sheets were structured to collect both permit file and field data, however all portions of the field data sheets were recorded on site.

Preliminary information was entered into the data sheet before proceeding to the remainder. This information included investigators name(s), date, site name and site location.

Section 1 was designed to assess permit requirements and conditions present before the compensation project was constructed. This information was obtained primarily from the permit files, however, in several cases where the investigator was familiar with the site, the information was known.

Pre-existing wetland community types were identified (according to the Cowardin classification), as well as the dominant species present in each strata, if known. This information was obtained from the descriptions of pre-existing site conditions in the permit files.

Sections 2 and 3 were designed to describe implementation and construction details. Soil, hydrology and vegetation aspects of the planned compensation were described. This information was also obtained from the permit files.

Several questions in sections 2 and 3 were designed to elicit the opinion of the investigators as to the appropriateness of the various aspects of the proposed compensation. This was strictly an assessment based on the investigators expertise and site conditions.

Section 4 was designed to assess land use within 200 feet of the wetland. Basin information can be obtained from USGS topographic maps. Current land use was identified by viewing at the surrounding area.

Section 5 addresses existing wetland conditions. The existing wetland was defined as any wetland on site that had not been enhanced, created or restored that was present prior to the construction of the compensation project. If no pre-existing wetland existed, this was noted on the field form and section 6 was left blank. If a pre-existing wetland was present, major community types and dominant plant species within each strata were identified. Total existing wetland size was estimated.

Section 6 addresses compensation wetland conditions. The compensation wetland was defined as any wetland specified in the compensation plan for restoration, enhancement or creation. Information described above for the existing wetland was gathered.

This section was also designed to assess functions and conditions of the compensation wetland. Wetland functions existing before the compensation wetland was constructed and the goals of the compensation were obtained from the files (or if the site was known, from investigators expertise). If goals were not specifically outlined in the plan. they were surmised from the information given. Existing wetland functions were identified based on type and conditions of the wetland and the expertise of the investigator.

Conditions of the compensation wetland were assessed by identifying potential or actual runoff to the site, water quality, sediment input, turbidity or erosion. Probable causes were noted. Comments were made regarding each item, if needed.

Wildlife habitat features such as snags, logs, beaver dams, brush, and forage were noted. Actual wildlife use was identified on the basis of observed wildlife, tracks, holes or nests. Some assumptions regarding wildlife use were made based on site conditions. Additional detail was provided when needed.

Section 7 consists of general questions designed to assimilate data collected on the field form and make some assessments of the site. This portion of the form was filled in based on investigators expertise.

Section 8 is a summary section. Probable factors affecting compensation wetland functioning were identified and a general analysis of the wetland system was given. This section provided an opportunity for further comments not solicited from specific questions on the form.

Attachment 4 - Field data site summaries

SITE # 1 LOCATION: Airport Road/100th St. SW
THOMAS BROS. PAGE: 42, Snohomish **DRAINAGE:** Pigeon Creek

TYPE OF DEVELOPMENT: Commercial; Warehouse **APPROX. ACRES OF COMP.:** <1

PRE-EXISTING SITE CONDITIONS: Graded compacted upland fill adjacent to existing open water and emergent marshes. No water entering the site except for precipitation and limited sheet flow. Species predominantly weedy pioneers. Hydroseed including scots broom, white clover, thistle, fescue and brome grasses. Within wheel ruts in the fill, trace specimens of cattail, toadrush and daggerleaf rush were present.

COMPENSATION REQUIREMENTS: Remove fill to lower grade by 6-12"; direct stormwater from distant proposed warehouse site through grass-lined swale into wetland; maintain distinct berm between compensation wetland and adjacent existing wetland to west. Plant emergent area with native emergent plugs and seed. Plant transitional shrubs along three sides of wetland to provide buffer from upland.

COMPENSATION GOALS: Create emergent wetland with seasonal shallow water plus protective shrub buffer zone. To NOT provide waterfowl habitat because of the adjacency of Paine Field Airport.

PLANT SPECIES PROPOSED:
EMERGENT: small fruited bulrush, water plantain, smooth rush
SHRUB: red-osier dogwood, willows, spirea

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1989-1990

IMPLEMENTED AS PLANNED? Yes

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Most species called for are present. Site is new, difficult to assess establishment and viability of species.

Does not appear to be any water source to the site.

Microtopography appears highly important on this site. Depressional areas with access to water allow more robust growth of plants.

CRITICAL COMPONENTS OF FUNCTIONING: Shrub and emergent loss in those areas out of the seasonally flooded zone. Plantings most likely not dense enough.

WERE THE COMPENSATION GOALS MET? Yes, except shrub buffer is not robust and provides little buffer at this time.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Yes, an emergent seasonally wet wetland was created; volunteer species are present including daggerleaf rush and american speedwell, narrow leaved cattail, and slough sedge. Shrub zone is stressed and not providing shrub community buffering functions.

SITE # 2 LOCATION: Harbor Pt. Blvd/55th Place W.
THOMAS BROS. PAGE: 47, Snohomish County **DRAINAGE:** Puget Sound

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TYPE OF DEVELOPMENT: Single family residence **APPROX. ACRES OF COMP.:** <1

PRE-EXISTING SITE CONDITIONS: Forested and scrub-shrub wetland area dominated by red alder, western red cedar, willow, red-osier dogwood, douglas spirea, labrador tea, salal, evergreen blackberry.

COMPENSATION REQUIREMENTS: Create open water and emergent wetland by dredging to expose water table.

COMPENSATION GOALS: To increase habitat diversity and provide an open water and emergent wetland component.

PLANT SPECIES PROPOSED: Unknown

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?**

IMPLEMENTED AS PLANNED Unknown

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Open water with scrub-shrub and emergent component consisting of willow, red-osier dogwood, common cattail, and soft rush.

Heavy nutrient input into the system.

Area was dredged to till and as a result the emergent area may never develop to the extent desired.

CRITICAL COMPONENTS OF FUNCTIONING: Lack of hydric soil in emergent zone, high nutrient input into small system.

WERE THE COMPENSATION GOALS MET? Yes, the area is providing habitat and vegetation community diversity.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Yes, they were created, however, the emergent area may never function well due to lack of hydric soil.

SITE # 3 LOCATION: 83rd Ave West/North of 224th St. West
THOMAS BROS. PAGE: 58, Snohomish **DRAINAGE:** Lake Ballinger

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TYPE OF DEVELOPMENT: Single Family Residential **APPROX. ACRES OF COMP.:** 1-2

PRE-EXISTING SITE CONDITIONS: Site was previously fill and historically a sphagnum peat bog. No pre-existing data available.

COMPENSATION REQUIREMENTS: No compensation requirements were available.

COMPENSATION GOALS: Unknown

PLANT SPECIES PROPOSED:
FORESTED: western red cedar, red alder, western hemlock, pine spp.
SHRUBS: willow, evergreen huckleberry, common snowberry, salal, douglas spirea
EMERGENT: labrador tea, sphagnum, swamp laurel, pacific silverweed, common cattail, slough sedge, slender rush, soft rush, lady fern, eleocharis

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1989-1990

IMPLEMENTED AS PLANNED? Not known. Soils were recovered from under fill. Hydrologic function was created to provide flood storage.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Open water, scrub-shrub and forested wetland areas are present. The open water is connected to a relatively undisturbed existing peat bog.

Plant species present are for the most part natives, although several landscaping species are present.

Although the wetland is new, it appears healthy and given similar environmental conditions for a few more years will function very well.

CRITICAL COMPONENTS OF FUNCTIONING: Age of site.

WERE THE COMPENSATION GOALS MET? Unknown. Currently the site is providing biofiltration/sediment retention, habitat diversity, aesthetics, flood storage and community diversity.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Unknown. However emergent and the scrub-shrub areas will probably work given time.

SITE # 4 LOCATION: South of N.E. 175th St. on the Samm. Slough
THOMAS BROS. PAGE: 3, King County **DRAINAGE:** Sammamish River

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TYPE OF DEVELOPMENT: Commercial; Warehouse **APPROX. ACRES OF COMP.:** <1

PRE-EXISTING SITE CONDITIONS: Open water of the slough, emergent and scrub-shrub wetland area totalling 1-2 acres. The wetland was dominated by red-osier dogwood, reed canary grass, and rushes. A portion (.07 acres) of this wetland was filled during construction.

COMPENSATION REQUIREMENTS: Replace and enhance filled wetland by recovering hydric soils from under fill and replanting the area.

COMPENSATION GOALS: To increase species diversity, storm and flood water storage.

PLANT SPECIES PROPOSED:
FORESTED: black cottonwood, western red cedar, western hemlock, vine maple
SHRUB: hazelnut, willow, red-osier dogwood, red elderberry, snowberry, thimbleberry, salal, oregon grape, salmonberry
EMERGENT: yellow flag, soft rush, common cattail, slough sedge, hardstem bulrush

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1989

IMPLEMENTED AS PLANNED? Yes

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
It was not possible to physically access the site, therefore observations were made from an area adjacent to the site. The enhanced area of the wetland consisted of a small dredged area dominated by iris and limited open water. The wetland is still dominated by reed canary grass and the planted shrub species are at such low density that a functional shrub community is not present. Vegetation diversity within the emergent zone may be more extensive than what was able to be determined from a distance. An open water channel was present out to the slough.

CRITICAL COMPONENTS OF FUNCTIONING: The lack of adequate planting densities to create the target communities. The scattered shrubs and several sapling trees will not mature into a shrub/forested community due to the distance between specimens and the competition provided by invasive species such as reed canary grass. Lack of adequate design densities to create the target community.

WERE THE COMPENSATION GOALS MET? Partially; species diversity was introduced, some shallow water emergent community was created, and some structural diversity was provided.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Not completely. The emergent community was functioning by providing habitat for species other than reed canary grass; shallow water was present. The shrub and "forested buffer" community was not present and does not appear likely to be able to develop over time due to lack of species density and competition from aggressive plant species.

SITE # 5 LOCATION: North Creek Parkway and N.E. 195th St.
THOMAS BROS. PAGE: 4, King County DRAINAGE: North Creek

TYPE OF DEVELOPMENT: Commercial; Business Park **APPROX. ACRES OF COMP.:** 14

PRE-EXISTING SITE CONDITIONS: Scrub-shrub wetland of willow and black cottonwood on deep organic peat soils. Additional species included reed canary grass, creeping buttercup, velvet grass, orchard grass, brome grass, himalayan blackberry.

COMPENSATION REQUIREMENTS: Realign North Creek through the site, develop an associated riparian border, a scrub-shrub wetland and an emergent wetland. Fill portions of the compensation wetland with peat from other areas on-site to elevate wetland so that salmonids are not stranded during high water events. Compensation acreage totals 14 acres.

COMPENSATION GOALS: The stream and its riparian border were to be developed to provide fish and wildlife habitat and stream shading. The adjacent wetland was to be a rush/sedge/grass marsh that would provide flood storage and wildlife habitat.

PLANT SPECIES PROPOSED:
FORESTED AND SCRUB-SHRUB: willow, red osier dogwood, black cottonwood
EMERGENT: creeping spike sedge, liverwort, Glyceria, common water-plantain, pacific silverweed, water smartweed, slough grass, bent grass

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1986

IMPLEMENTED AS PLANNED? Yes, except several native tree species were replaced with ornamentals; shrubs were not planted at the designed densities within the wetland shrub zone.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
The creek and riparian zone appear to be functioning as designed. The stream bed is developing some diversity and structural integrity, especially with the presence of active beaver dams. The emergent wetland community is totally dominated by reed canary grass to the relative exclusion of all other species. The emergent wetland is essentially dry, except for occasional flooding during extremely large flood events. Planted shrubs are severely stressed or dead, outcompeted by the reed canary grass or the dry conditions. Buffer and transitional species planted along the steep berm sides are severely stressed due to the overdrained conditions. The backwater flooding design element appears to be non-functional except in extreme floods, therefore the emergent community is essentially dry. The emergent wetland community is not functioning as a wetland; species diversity is limited to the extent that the community is essentially monotypic reed canary grass. The shrub community has not developed within the wetland although the riparian zone is filling in and diversifying. Some flood storage is provided within the backwater area, and sediment removal and subsequent water quality improvement does take place. The stream itself has a high sediment load present due to upstream conditions.

CRITICAL COMPONENTS OF FUNCTIONING: Lack of control of final elevations within the proposed emergent wetland. No control on the reed canary grass so that it is so invasive and persistent that even planted woody species have not apparently been able to compete. The extremely well drained conditions on the steep berm slopes has not been conducive to transitional species viability. The shrub zones were not planted at the designed densities, and survival has been severely limited. Irrigation may have been a necessary component in early stages.

WERE THE COMPENSATION GOALS MET? Partially. The stream is more diverse and productive than the historic dredged ditch on site. However, the goal of creating a diverse emergent and shrub wetland community has not been met.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
No. Technically an emergent wetland community was created with dense reed canary grass on deep organic peats. The soil

saturation is likely at the surface with enough frequency to meet the criteria as wetland. However, the area probably provided greater functional value prior to the attempted enhancement.

SITE # 6 LOCATION: Issaquah-Pine Lake Road and 238th Way S.E.
THOMAS BROS. PAGE: 30, King County **DRAINAGE:** East Lake Sammamish

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TYPE OF DEVELOPMENT: Single family residential **APPROX. ACRES OF COMP:** 1-2

PRE-EXISTING SITE CONDITIONS: Area of compensation was formerly wet pasture with likely some shrub community present. Historically grazed and hayed.

COMPENSATION REQUIREMENTS: Dredge old wet pasture, and use recovered hydric soils to create an open water pond, emergent wetland and surrounding open grassy areas. Retain existing forested and scrub-shrub wetland areas.

COMPENSATION GOALS: To provide wildlife habitat, wetland community diversity, flood storage and aesthetics. Use pond for retention/detention.

PLANT SPECIES PROPOSED:
FORESTED AND SCRUB-SHRUB: western hemlock, western red cedar, willow, western crabapple, red-osier dogwood, indian plum, red-flowering currant, evergreen huckleberry
EMERGENT: common cattail, slough sedge, spatterdock, american water-lily, yellow flag
GRASS: colonial bent grass, red fescue, perennial rye grass, white clover

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1986

IMPLEMENTED AS PLANNED? Yes, except that several native tree species were replaced with ornamentals; native species required to be placed in addition to the ornamentals.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
All species required in the plan are present. Many of the wetland and transitional shrubs species are planted on the steep side slope above the wetted zone on the north and east sides of the pond. Most of these are regularly cut down and mowed so the majority of planted shrubs are no longer alive due to impacts of mowing and perhaps lack of water. No scrub-shrub wetland has developed on the north and east edges of the pond margins. The emergent wetland is present as a very restricted band (less than 3 feet wide on average) on portions of the pond margin. Appears that the edge of the pond has a very steep gradient as a result of the dredging, and little if any organic substrate is present in the emergent zone. The open water provides a habitat element that was not present previously, waterfowl and Blue Heron were present. The existing forested and scrub-shrub wetland remain intact to the south. Some emergent portions of the wetland are functioning.

CRITICAL COMPONENTS OF FUNCTIONING: Dredging of the pond did not leave a graduated shallow margin for emergent species to colonize. Deep water near the pond margins may have precluded emergent vegetation. In addition, the soils near the margins are quite gravelly and lack any strong organic component for rooting. Site maintenance has severely impacted the buffer shrub community by repeated mowing and clearing that has now killed the majority of the planted shrubs. Shrub removal may be intentional in order to maintain a view of the open water pond to people driving into the development. Cedar snags left for habitat niches were removed within the first year of the compensation.

WERE THE COMPENSATION GOALS MET? Yes. The pond is providing open water wildlife habitat that was not previously present, the open pond is maintained for its aesthetics, and the wetland area is providing flood storage for portions of the development.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Partially. The open water pond component is present and is being used by wildlife species. The emergent community is present along the very margins of the pond, provides extremely limited habitat value due to small size. The shrub community is not establishing on the majority of the pond margin, however it is present on the west and south pond margins where red alder has colonized. No created forested component is present.

SITE # 7 LOCATION: 148th Avenue SE/SE 183rd Street
THOMAS BROS. PAGE: 42, King **DRAINAGE:** Lower Cedar River

TYPE OF DEVELOPMENT: Single family residential **APPROX ACRES OF COMP:** <1

PRE-EXISTING SITE CONDITIONS: Several small scrub-shrub and emergent wetland areas in a drainage swale dominated by willow, skunk cabbage, slough sedge, douglas spirea, devil's club, pacific water-parsley, lady-fern and creeping buttercup.

COMPENSATION REQUIREMENTS: Construct a 5 to 10-foot wide, 60 to 70-foot long meandering drainage swale to convey 100-year storm events. Enhance drainage swale and allow for wetland development by placing four log weir control structures to provide back-up flow. Over excavate the swale, line with impervious membrane and backfill with peat.

COMPENSATION GOALS: Provide for conveyance of the 100 year storm event, allow development of wetlands and provide biofiltration and sediment removal.

PLANT SPECIES PROPOSED:
SHRUBS: vine maple, red-osier dogwood, black cottonwood, willow, western red cedar, red flowering currant, snowberry
EMERGENT: slough sedge, velvetgrass, soft rush, skunk cabbage, creeping buttercup, red fescue, colonial bent grass

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1990

IMPLEMENTED AS PLANNED? No. Species were substituted and the swale was not constructed to meander; it is straight. Area was not backfilled with peat.

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Swale is straight and not undulating as required. Does not allow sediment trapping.

Site is very dry and the densities of plantings is sparse with lots of mortality.

CRITICAL COMPONENTS OF FUNCTIONING: Hydrology is inappropriate, too dry, high mortality, density of plantings is too low.

WERE THE COMPENSATION GOALS MET? Partially. The area is providing flood storage, however the wetlands are not developing and the straight channel does not allow much sediment removal. No species diversity.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
No. Site is very dry and wetlands are not developing as planned.

SITE # 8 LOCATION: 64th Avenue South/James Street
THOMAS BROS. PAGE: 48, King **DRAINAGE:** Lower Green River

TYPE OF DEVELOPMENT: Multi family residential **APPROX. ACRES OF COMP:** 4

PRE-EXISTING SITE CONDITIONS: 12.87 acres of forested, scrub-shrub, emergent and open water wetlands occurring in patches. Dominant species included black cottonwood, red alder, willow, red-osier dogwood, douglas spirea, velvet grass, reed canary grass, creeping buttercup, soft rush, horsetail, spike rush, red-top, bluegrass, and marsh cinquefoil.

COMPENSATION REQUIREMENTS: Enhance 3.54 acres of wetland and create .54 acres of scrub-shrub and open water wetland. Dredge existing soils to create open water. In addition, off-site compensation was required.

COMPENSATION GOALS: Increase wildlife habitat, storage of flood water, and increase the aesthetic value of the site.

PLANT SPECIES PROPOSED:
FORESTED: black cottonwood, red alder, western red cedar, douglas fir, white angel crabapple, red-twig dogwood, willow, yellow twig dogwood, spirea, salmonberry, red flowering currant, vine maple
EMERGENT: yellow flag, common cattail, hardstem bulrush, white waterlily, redtop bent grass, red fescue, meadow foxtail, tall fescue
GRASS: colonial bent grass, red fescue, perennial rye, tall fescue, annual rye, white clover, orchard grass, california poppy

WAS THE COMPENSATION IMPLEMENTED? Yes **WHEN?** 1988

IMPLEMENTED AS PLANNED? Yes

COMPENSATION WETLAND: CURRENT CONDITIONS AND FUNCTIONING
Most of the species required in the plan are present. Most of the site wetlands appear to be robust.

CRITICAL COMPONENTS OF FUNCTIONING: Lack of water to a portion of the site, flooding of the littoral area.

WERE THE COMPENSATION GOALS MET? Yes. The wetland is functioning as wildlife habitat, floodwater storage and is providing aesthetic value.

WERE THE PROPOSED WETLAND COMMUNITY TYPES CREATED? FUNCTIONAL?
Partially. Scrub-shrub enhancements will probably for the most part be functional. However, the creation may not ever fully function due to elevation of site.

Attachment 5 - Species list

Trees

Alnus rubra - Red Alder
Populus trichocarpa - Black Cottonwood
Pseudotsuga menziesii - Douglas' Fir
Thuja plicata - Western Red Cedar
Tsuga heterophylla - Western Hemlock
Pyrus fusca - Western crabapple
Salix spp. - Willow
Pinus spp. - Pine

Shrubs

Acer circinatum - Vine Maple
Cornus stolonifera - Red Osier Dogwood
Gaultheria shallon - Salal
Ledum groenlandicum - Labrador Tea
Rubus spectabilis - Salmonberry
Sambucus racemosa - Red Elderberry
Spirea douglasii - Douglas' Spirea
Symphoricarpos albus - Snowberry
Rubus discolor - Himalayan blackberry
Ledum groinlandicum - Indian plum
Berberis nervosa - Oregon grape
Rubus laciniatus - Evergreen blackberry
Vaccinium ovatum - Evergreen huckleberry
Cyutisus scoparius - Scots broom
Corylus cornuta - Hazelnut
Rives sanguinieum - Red flowering currant
Cornus spp. - Yellowtwig dogwood

Ferns/Horsetails

Athyrium felix-femina - Lady Fern

Herbs

Lysichitum americanum - Western Skunk Cabbage
Ranunculus repens - Creeping Buttercup
Iris pseudachorus - Yellow Flag
Alisima plantago-aquatica - Common water plantain
Trifolium spp. - White clover
Cirsium spp. - Thistle
Sphagnum spp. - Sphagnum

Potentilla pacifica - Pacific silverweed
Nuymphaia odorata - American water lily
Nuphar polysepalum - Spatterdock
Eschscholzia californica - California poppy
Ricciocarpus nutans - Liverwort

Grasses/Sedges and Rushes

Typha latifolia - Common cattail
Typha augustifolia - Narrow leaf cattail
Agrostis stolinifera - Red-top
Holcul lanatus - Velvet grass
Juncus effusus - Smooth rush
Phalaris arundinaceae - Reed canary grass
Scirpus microcarpus - Small-fruited bulrush
Agrostis tenuis - Colonial bentgrass
Beckmannia syzigachne - Sloughgrass
Polygonum spp. - Water smartweed
Dactylis blomerata - Orchard grass
Scirpus acutus - Hardstem bulrush
Juncus tenuis - Slender rush
Juncus effusus - Soft rush
Festuca rubra - Red fescue
Bromus spp. - Brome grass
Carex obnupta - Slough sedge
Festuca arundinaceae - Tall fescue
Alopecurus pratensis - Meadow foxtail
Poa spp. - Bluegrass
Eleocharis spp. - Spike rush
Equisetum arvense - Horsetail
Lolium perenne - Perennial ryegrass
Lolium tremulentum - Annual rye
Glyceria spp. - Manngrass

Appendix B - Information Sources

Information was obtained from a review of published literature as well as from oral and written personal communications. The following sources of information were utilized:

a. Computer search programs.
AFSA; Enviroline; Water Resources; NTIS; Pollution; Life Sciences; AGRICOLA; and Biosis.

b. On-line library collections.
University of Washington libraries: Natural Sciences; Fisheries; Forestry; Engineering; and Architecture.

c. Existing bibliographies.
King County Sensitive Areas Ordinance Bibliography (1990); "Wetland Buffers: An Annotated Bibliography (Castelle et al., 1992a); "Wetland Compensatory Mitigation Replacement Ratios: An Annotated Bibliography (Castelle et al., 1992b); "Wetlands Protection" (USEPA Bibliographic Series, 1988)

d. Research centers.
Natural Resources Research Institute (Duluth, MN); Center for Wetlands (University of Florida, Gainesville); School for Oceanography (Louisiana State University, Baton Rouge); College of Forest Resources (University of Washington, Seattle); College of Forestry (Oregon State University, Corvallis).

e. Washington state agencies.
Department of Ecology; Puget Sound Water Quality Authority; Department of Fisheries; Department of Transportation.

f. Federal agencies.
Federal Highway Administration; U.S. Fish and Wildlife Service; U.S. Soil Conservation Service; U.S. Forest Service; Environmental Protection Agency; and the U.S. Army Corps of Engineers.

g. State agencies.
California Department of Fish and Game; Oregon Department of Transportation; Idaho Transportation Department; Maryland Department of Natural Resources; Delaware Department of Wetlands & Aquatic Protection.

h. County planning departments.
King; Kitsap; Pierce; San Juan; Snohomish; Thurston; Whatcom.

i. City planning departments.
Auburn; Bellevue; Bellingham; Des Moines; Everett; Federal Way; Kirkland; Redmond; Renton; Tukwila.

j. Professional organizations.
Association of State Wetland Managers; Environmental Law Institute.

k. Environmental organizations.
Audubon Society; Conservation Foundation; Geraldine R. Dodge Foundation.

l. Individuals contacted.
J. Hoffmann, URS Consultants, Cleveland, Ohio; G. Rollins, California Dept. of Fish and Game; P. Dykman, Oregon Dept. of Transportation; D. Evans, City of Eugene Public Works; R.B. Tiedemann, Idaho Transportation Dept.