CITY OF PORTLAND BUREAU OF PLANNING AND SUSTAINABILITY

WHI Environmental Foundation Study

FINAL

JULY, 2010

PREPARED BY

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Executive Summary

INTRODUCTION

The City of Portland (City) is considering annexation and development of a long-term land use plan for West Hayden Island (WHI). This process requires not only annexing and zoning the property, but also an assessment of natural resources, potential conflicting land uses, and marine industrial and recreational uses. WHI is approximately 800 acres and is the undeveloped western portion of Hayden Island, located in the Columbia River near the confluence with the Willamette River. WHI is owned by the Port of Portland, and was added to the region's urban growth boundary in 1983 for marine industrial purposes. It is both a potentially important economic resource and an important natural resource, containing undeveloped open space in a location with habitat value. WHI is designated as Marine Industrial Land on Metro's 2040 Growth Concept Map, and as a Regionally Significant Industrial Area on the Title 4 map in the Urban Growth Functional Plan. WHI is also identified by Metro as a high value riparian area and a Habitat of Concern in the regional inventory, and as a Moderate Habitat Conservation Area in Title 13.

The WHI Environmental Foundation Study will serve as a foundation study for the zoning and annexation of WHI and is intended to provide background information for the current planning process and future WHI studies. The objective of the study is to identify and describe the functional values of natural resources on WHI. The study is intended to address some of the requirements of Oregon Administrative Rules, Chapter 660 and Division 5. This work will also inform the Economic, Social, Environmental, and Energy (ESEE) Analysis to be completed as part of the City land use plan for WHI.

The Environmental Foundation Study provides a detailed understanding of the condition, function, and value of WHI natural resources. The study also identifies the limiting factors or constraints to natural resource function if there are mixed uses (e.g. recreation and/or marine industrial activities) on WHI. A companion study, the Economic Foundation Study, provides information about marine-related industrial land needs relative to WHI and its surroundings over the next 30 years. A third recreation study describes recreation participation, development potential, and value on and around WHI. Together these studies provide information on the importance and potential contribution of WHI in three different land uses: habitat, marine-industrial use, and recreation.

Broadly, the scope of this work is to analyze and build upon existing data and studies to 1) document the historical and current natural resource conditions on WHI; 2) evaluate the quantity and quality of WHI natural resources and the ecological importance of WHI within the larger ecosystem context; 3) assess the limiting factors or constraints from a natural resource function perspective on mixed land use of WHI; 4) identify opportunities for restoration of natural resource function on WHI; and 5) estimate the economic value of ecosystem services provided by natural resources on WHI.

In terms of geographic scope, the analysis is focused on WHI within the context of natural resources in the City of Portland. In order to identify the regional role and importance of WHI natural resources, the analysis also includes a limited review of natural resources located throughout the Lower Columbia River. Due to time and resource constraints, the scope of the analysis is based on existing data and readily available information.

The study is intended to utilize the best available data to identify, quantify, and evaluate natural resources on WHI. To accomplish this scope of work within the allotted timeframe and resources, certain assumptions were necessary. Furthermore, the study is limited by the existing data, information collected from interviews, and two field-based tours. While the field tours allowed analysts to calibrate habitat classifications for aerial

photograph analysis, additional field data collection was not included in the scope of work. To compensate for these data gaps, the study assumed spatial and classification reliability of Port-derived GIS data and relied on key literature and reports and interviews with regional experts.

There are seven additional sections of this report that cover, respectively, 1) methodology, 2) regional context for natural resource evaluation, 3) natural resource quality and quantity evaluation, 4) natural resource importance evaluation, 5) limiting factors to natural resource function in the presence of mixed use development, 6) potential for restoration on WHI to restore natural resource function, and 7) the economic value of ecosystem services provided by WHI natural resources.

METHODOLOGY

The evaluation framework is structured to provide information on WHI resources, including: identification, location, quantity, relative quality, and regional importance. The evaluation framework is based on the City's Natural Resource Inventory Update (NRIU). The framework includes two components for evaluating WHI natural resources: a quality/quantity evaluation and an importance evaluation. The purpose and geographic area of analysis of the quality/quantity and importance evaluations are highlighted below:

- **Quality/Quantity Evaluation.** This evaluation rates the relative quality and quantity of WHI natural resources relative to other natural areas in the City of Portland. The quality/quantity evaluation rates the WHI natural resources based on such factors as landscape features, vegetation, and associated ecosystem function. The criteria for rating WHI resources vary by habitat type. The analysis is a WHI-scale evaluation that results in a quality/quantity rating at each location on WHI.
- **Importance Evaluation.** This evaluation rates the relative local importance of WHI natural resources in the context of other natural areas within a broader study area (defined below) including other islands and natural areas within the Columbia River corridor. The importance evaluation rates the importance of WHI natural resources in the broader ecosystem context, and incorporates such factors as location, resource size, and relationship to other resources in the study area. The importance evaluation is separate from the City's significance determination that will occur as part of the ESEE analysis required by the State of Oregon.

Relationship to City's Natural Resource Inventory Update (NRIU)

The structure of the quality/quantity evaluation framework is based on the City's NRIU and Metro's regional inventory of riparian corridors and wildlife habitat. The City's NRIU rates the quality/quantity of natural resources in the City based on ecosystem function and landscape attributes. The City's NRIU is a city-wide, GIS based inventory of natural resources and the functions provided by those resources. WHI has been included in the GIS mapping and modeling. The NRIU assesses riparian corridor functions and wildlife habitat attributes provided by the natural resources. The NRIU also ranks the relative quality and quantity of the natural resources. The ENTRIX evaluation framework expands and enhances the NRIU by defining and separately analyzing different wildlife habitat types. Additionally, the ENTRIX evaluation framework enhances the NRIU by including an additional analysis of the importance of WHI resources based on their function and role at the larger study area scale; this analysis incorporates information on the size, location, and interrelationship of WHI resources to other resources in the study area.

The Environmental Foundation Study will inform the City's development of an area-specific Natural Resources Inventory (NRI) for WHI. The area-specific NRI will include refined GIS mapping and modeling as well as narratives that provide more detailed information obtained from the Environmental Foundation Study.

Geographic Scale of Analysis

There are two geographic scales defined for the current conditions analysis: the planning area and the study area. WHI is the focus of the analysis and constitutes the planning area; it is the relatively undeveloped western portion of Hayden Island, which is located in the Columbia River along the Oregon shoreline near the confluence with the Willamette River. WHI encompasses 827 acres of the 1,400-acre Hayden Island.

The waterways on both sides of Hayden Island are federally-authorized navigation channels. Hayden Island extends from just upstream of the mouth of the Willamette River, near Columbia River Mile (RM) 102, to where it merges with Tomahawk Island near RM 106. The WHI planning area includes all land on Hayden Island that is westward of the Burlington Northern Santa Fe Railroad line that crosses the island (see **Map ES-1**). Natural resources in the WHI planning area are assessed in this analysis for their quality/quantity and for their regional ecological importance. The Columbia River stretch that includes WHI has been designated as critical habitat for federally-listed salmon and steelhead and is designated as Class 1 riparian habitat and a "Habitat of Concern"[1] under Metro's Title 13.

The second geographic scale is the study area (see **Map ES-1**). The study area defines the region in which the importance and ecological context of WHI resources are assessed. The study area for the importance evaluation is based on geographic features, including the Columbia River from the confluence with the Sandy River to the Lewis River; regional habitat areas including Ridgefield Wildlife Refuge, Shillapoo Natural Area, Vancouver Lake, Smith and Bybee Wetlands; the Willamette River upstream to the Willamette Falls; and others. The study area recognizes WHI as part of a chain of low islands of deposited sediments. This area includes such geographic features as the Lower Willamette River, Columbia River estuary, Government Island, Vancouver Lake, Forest Park, Ridgefield National Wildlife Refuge, Shilapoo and Sauvie Island Wildlife areas, Smith and Bybee Lakes, extensive agricultural lands, extensive private forest land, and various intensities of urban/suburban development, including Portland's metropolitan area. In some instances, the analysis also considers some factors that influence the quality and importance of WHI resources from the broader region that includes the area of the Sandy River Delta, areas upstream of Portland Harbor to Willamette Falls, and large contiguous public and private forestlands west of WHI.

Natural Resource Habitats Definition and Evaluation Criteria

Seven types of natural resources on WHI are defined and separately analyzed. These include three types of aquatic habitat: shallow water (SWH), upper beach (UBC), and wetlands (WET). Four types of terrestrial habitat are also defined: riparian fringe (RIP), forest/woodland (FW), shrubland (SHR), and grassland (GRA). In general, each location on WHI is defined as one habitat type. The exception is RIP, which is defined as the zone within 150 feet of the Columbia River or wetland shoreline. All areas within this zone are classified as riparian fringe and as another habitat type based on the vegetation present, whether FW, SHR, or GRA.

The quality/quantity evaluation rates the condition of WHI habitats based on landscape features and associated level of ecosystem function. It is a site-specific evaluation that results in an overall quality/quantity rating (on a scale from 0 to 3, or low to high) for each habitat at each location on WHI. This rating is a comparative rating relative to other natural areas in the City of Portland with this habitat type, and portrays the varying quality of habitat across WHI. Criteria and scoring rules are defined for each habitat type and used to determine the site-specific quality/quantity rating. These criteria are based on peer-reviewed science.

[1] Boundaries of Class 1 Riparian Areas through Metro include vegetated area within the first 50 feet of surface streams and canopied or woody vegetation within the first 100 feet of wetlands. Habitats of Concern are areas recognized as important to overall goals of conservation, protection and restoration. The designation recognizes the importance of stream and river corridor connectivity to adjacent upland habitats.

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122°50'W 122°45'W 122°40'W 122°35'W 122°30'W 122°25'W

45°50'N 45°45'N 45°40'N 45°35'N 45°30'N 45°25'N

St. Helens
McCormick Park
Lewis River
McNulty Creek
Scappoose Bay
Warren
Multnomah Channel
Columbia County
Clark County
Scappoose Creek
Scappoose Industrial Airpark
Gilbert River
Ridgefield
ALAN CANYON
McCormick Creek
Gee Creek
Hughes Creek
East Fork Lewis River
Daybreak Park
Lewisville Park
Lewisville
Heisson
Cherry Grove
Battle Ground
Weaver Creek
178m
Venersborg
158m
Dollar Corner
502
503
501
Flooding Creek
Whipple Creek Park
Whipple Creek
Mill Creek
Meadow Glade
Salmon Creek
Morgan Creek
Hockinson
Columbia County
Multnomah County
Mount Vista
Salmon Creek
Salmon Creek Park
Felida
Barberton
Curtin Creek
Brush Prairie
Mill Creek
Fifth Plain Creek
Lake Shore
Hazel Dell North
Five Corners
Orchards
Vancouver Lake Park
Vancouver Lake
Hazel Dell South
Walnut Grove
Lacamas Creek
Proebstel
Holbrook
OAK RIDGE
Multnomah Channel
Ash Slough
Minnehaha
Arnold Park
Spring Branch
245m
Howell Territorial Park
Kelley Point Park
Planning Area
West Hayden Island
Burnt Bridge Creek
David Douglas Park
Mill Plain
Folkenberg
Miller
Pearson Field
Vancouver
Marine Park
MILL PLAIN
GRASS VALLEY
Clark County
Multnomah County
Columbia River
PRUNE HILL
Camas
Pier Park
East Delta Park
Lemon Island
Columbia Slough
Portland International Airport
Government Island
University of Portland
Willamette River
Portland Community College
McGuire Island Park
Blue Lake Regional Park
Chinook Landing Marine Park
Rockcreek
Oak Hills
Cedar Mill
Portland
174m
ROCKY BUTTE
Fairview
CORNELL MOUNTAIN
Macleay Park
Terpenning Recreation Park
Marlene Village
West Haven-Sylvan
Washington Park
Quatama
MOUNT TABOR
Mount Tabor Park
Cedar Hills
Tualatin Hills Park
Aloha
West Slope
Nature Park
SENTINEL HILL
George Himes Park
Ross Island
KELLY BUTTE
GRANT BUTTE
Gresham
Raleigh Hills
Powell Butte Nature Park
WALTERS HILL
Beaverton
Gabriel Park
Garden Home-Whitford
Metzger
SEXTON MOUNTAIN
Jenkins Estate Park
236m
Greenway Park
PALATINE HILL
Johnson Creek
Willamette National Cemetery
MOUNT SCOTT
HAPPY VALLEY
284m
PLEASANT VALLEY
SUNSHINE VALLEY
Milwaukie
Harmony Point
Happy Valley
Clackamas Town Center
Sunnyside
Kinton
MT. SYLVANIA
Briarwood
MOUNT TALBERT
BULL MOUNTAIN
Tigard
Lake Oswego
Oak Grove
OATFIELD HILL
Oatfield
Damascus
Clackamas
Durham City Park
Durham
COOKS BUTTE
Hazelia
Jennings Lodge
Gladstone
Carver
Outlook
ONION FLAT
Tualatin
Shadowood
Wankers Corner
West Linn
Meldrum Bar Park
Camassia

1:210,000
1 inch = 17,500 feet

0 2 4 6 8 Miles
0 3 6 9 12 Kilometers

Map ES-1
Study Area

West Hayden Island
Environmental Foundation Study

Map Extent: WA, OR, ID, CA, NV

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Map Projection: Mercator WGS84

REGIONAL CONTEXT FOR NATURAL RESOURCE EVALUATION

This section presents information regarding the historic and current contributions of WHI habitats and their functions. This provides the context for considerations of future land use. The evaluation addresses a variety of watershed functions relating to hydrology, water quality, and fish and wildlife habitat. For resource managers and planners, it is important to know the range of critical ecological processes and conditions that have characterized particular ecosystems over specified time periods and under varying degrees of human influences. Information on how ecosystems functioned and sustained themselves prior to major human modification provides a reference point for understanding the ecological potential of a landscape.

Key points regarding the regional context for WHI include:

- **Historic Conditions.** What is now Hayden Island was in the late 19th century two islands (Tomahawk Island and Hayden Island) with marshland connectivity. Placement of dredge material and accretion of sediment due to pile dikes and groins near Hayden Island have resulted in formation of the existing extent of the island. In addition to dredge material placement, habitats on WHI have been affected by dam operations which have reduced flood frequency/magnitude and flow variation on the lower Columbia River.

- **Influence of Columbia River.** Natural resource conditions on WHI are largely influenced and determined by the Columbia River. The Columbia River has the fourth highest discharge and the fourth largest drainage area for an American river. The shape and form of the Columbia River and its estuarine area is a product of two vastly different time scales. First, it is the product of long-term cumulative geologic, fluvial, and hydrologic processes and second, it is the product of comparatively recent hydrologic management and sediment management processes that have been implemented over the past century. The presence of hydroelectric dams has altered fundamental habitat-forming and maintenance processes in the Lower Columbia River.

- **Study Area.** The study area to assess the regional ecological importance of WHI natural resources includes the Portland-Vancouver-Beaverton metropolitan areas, with predominantly dense urban land use but also some preserved natural areas, narrow riparian areas along the Columbia River, and some agricultural lands. WHI links natural areas in the study area, including providing a linkage between the Vancouver Lake and the Smith/Bybee Lakes and wetlands complex. The area captures significant water bodies and large natural areas to provide a reasonable characterization of other areas that provide ecosystem functions in the study area.

- **Species and Habitat Associations.** Many fish and wildlife species rely on WHI as a migration corridor and area for nesting, breeding, foraging, and rearing young. At least 39 species of resident and anadromous fish, including 20 native species, have been documented in the lower Willamette River (Farr and Ward 1993) and most if not all have a reasonable chance of occurring in the WHI area. Many migratory birds nesting near or within the planning and study area also forage in the open water and nearshore habitats. These include piscivorous species such as bald eagle, osprey, double-crested cormorant, great blue heron, belted kingfisher, common and hooded mergansers, and other waterfowl. WHI riparian fringe, upper beach and shallow water habitats and their associated vegetation habitat is suitable for passerines and aquatic-associated birds. Cliff swallows, various waterbirds, and shorebirds such as spotted sandpiper utilize the beach/intertidal area for nesting and foraging.

  Mammals including mink and river otter use the riparian and upper beach as foraging corridors as well as shallow water habitats and are known to rear young along the shorelines. Northern red-legged frogs and Pacific tree frogs occur in the planning area, and long-toed salamander are expected in the planning area although comprehensive amphibian surveys have not occurred. The nearshore habitats, low water velocity areas, shoreline embayments, and ponds, in particular those that contain vegetative or woody structure, are important breeding and foraging areas for these amphibian species. Western painted turtles and

northwestern pond turtles use the lower Columbia corridor, in particular bottomland habitat, seasonal wetlands, and slow flow, low energy habitats such as ponds and sloughs. **Table ES-1** provides an overview of species-habitat use on WHI in relation to the habitats. The table is not intended to be comprehensive since many other species may use the island for various seasons and lengths of time.

Table ES-1 Species-Habitat Associations on WHI

Species	HABITAT TYPE USE						
	SHW	UBC	RIP	WET	FOR	SHR	GRA
FISH							
White crappie, black crappie, smallmouth bass, largemouth bass, bluegill, pumpkinseed, yellow perch, Northern pikeminnow, peamouth, largescale sucker, walleye Oregon chub, green sturgeon, white sturgeon, lamprey, coho, chum, Columbia River bull trout, cutthroat trout	X	X	X	X			
Listed: Snake River (SR) sockeye, SR Spring/Summer Chinook, SR Fall chinook, SR steelhead, Upper Columbia River (UCR) Steelhead , UCR Spring Chinook, Lower Columbia River (LCR) steelhead, LCR Chinook, Columbia River chum, Middle Columbia River steelhead, Upper Willamette River (UWR) Steelhead, UWR Chinook	X	X	X				
MAMMALS							
Raccoon, coyote, mole, brush rabbit			X	X	X	X	X
Listed: Columbia White-tailed deer						X	X
BIRDS							
Resident birds: dark-eyed junco, song sparrow, American robin, black-capped chickadee, and red-breasted nuthatch, warbler sp., tricolored blackbird, olive-sided flycatcher, little willow flycatcher; Overwintering: fox sparrow, white throated sparrow; Nesting and Foraging: pileated woodpecker, black-capped chickadee, swallow s.;			X	X	X	X	X
Raptors, Hawks and Owls: osprey, northern harrier, bald eagle, hawks (up to 6 species), owls (up to 6 species)			X	X	X	X	X
Waterfowl: mallard, sea ducks, brant, wood duck, cinnamon teal, canvasback, Canada goose, Ross's goose, double-breasted cormorant	X	X		X			
Loons, grebes, herons, egrets and bitterns	X	X	X				
Listed: Aleutian Canada goose (potential use), bald eagle				X		X	X
AMPHIBIANS AND REPTILES							
Oregon Spotted frog, Northern Red-legged frog, Northwestern pond turtle, painted turtle, Pacific chorus frog, long-toed salamander, garter snakes	X	X	X	X	X		
INVERTEBRATES							
Lepidoptera (butterfly) sp., Heterocera (moth sp.), cabbage white, satyr angelwing, painted lady, mylitta crescent, spring azure			X	X	X	X	
BENTHIC COMMUNITY							
Nematode, oligochetes, bivalves, stone fly, caddis fly, mayfly, isopods, amphipods	X	X					
MACROINVERTEBRATES							
Mayflies, dragonflies, damselflies, Daphnia, scud, water beetles, water boatman, midges, fairy shrimp, water striders	X		X	X	X		
PLANTS							
Listed: Howellia, Wilamette daisy, Bradshaw's lomatium, golden paintbrush, Kincaid's lupine, Nelson's checkermallow			X	X	X	X	X

Sources: Port of Portland 1995 (based on probable use/potential use drawing from Puget Island sub-population), ODFW species distribution descriptions

NATURAL RESOURCE QUALITY AND QUANTITY

The purpose of this section is to describe the quality and quantity of WHI natural resources relative to other natural resources located in the City of Portland. The quality/quantity evaluation is conducted at the site-specific scale, and rates the quality/quantity of WHI keystone elements based on landscape features and ecosystem function at the site. As described above, the criteria for evaluating WHI natural resources is largely based on the criteria developed for the City's NRI, with additional criteria developed specifically for WHI habitat types. All criteria used to evaluate quantity/quality of WHI resources are derived using available geospatial data as well as analysis using aerial photographs.

This section contains three parts. The first part describes the quantity and location of WHI habitats, while the second presents the results of the quality/quantity analysis. The third part places the findings in context by describing other considerations that affect the assessment of quality on WHI.

The land area of WHI, noted in regional reports, varies between 820 to 830 acres depending on study boundaries. This assessment includes additional acreage for aquatic habitats of SWH and UBC, bringing total acreage evaluated to 1,045. Of this 1,045, there are 260 acres that are also evaluated based on their location in the RIP, defined as the area within 150 feet of the Columbia River or a wetland. Vegetation in this zone is classified as habitat both according to its vegetation type and for its location in the RIP. The acreage in each habitat type is presented in Table ES-2. Nearly half (415 acres) of WHI habitat is FW (of which 158 acres is located within RIP). SWH and RIP are the second most abundant habitats (260 and 240 acres, respectively). The next most abundant habitat type is GRA with 227 acres, of which 101 acres are located in the dredge material management area. **Table ES-2** summarizes WHI acreage by habitat type, while Map ES-2 spatially presents location and extent of the habitat types on WHI.

Table ES-2 WHI Habitat Acreage

Habitat		Acres
Shallow Water		240
Upper Beach		28
Riparian Fringe (260 acres)	Shrubland	31
	Forest/woodland	158
	Grassland/herbaceous	70
Wetland		59
Forest/woodland		415
Grassland/herbaceous		227
Grassland/herbaceous (Dredge Material Storage Area)		*101*
Shrubland (acres outside of Riparian Fringe)		76* (45)
TOTAL (not including duplicative Riparian Fringe area)		1,045

1. This criteria was used to capture unclassified or covers not used in forming habitats such as developed area, roads, facility.

* Includes acreage of this vegetation community found in Riparian Fringe

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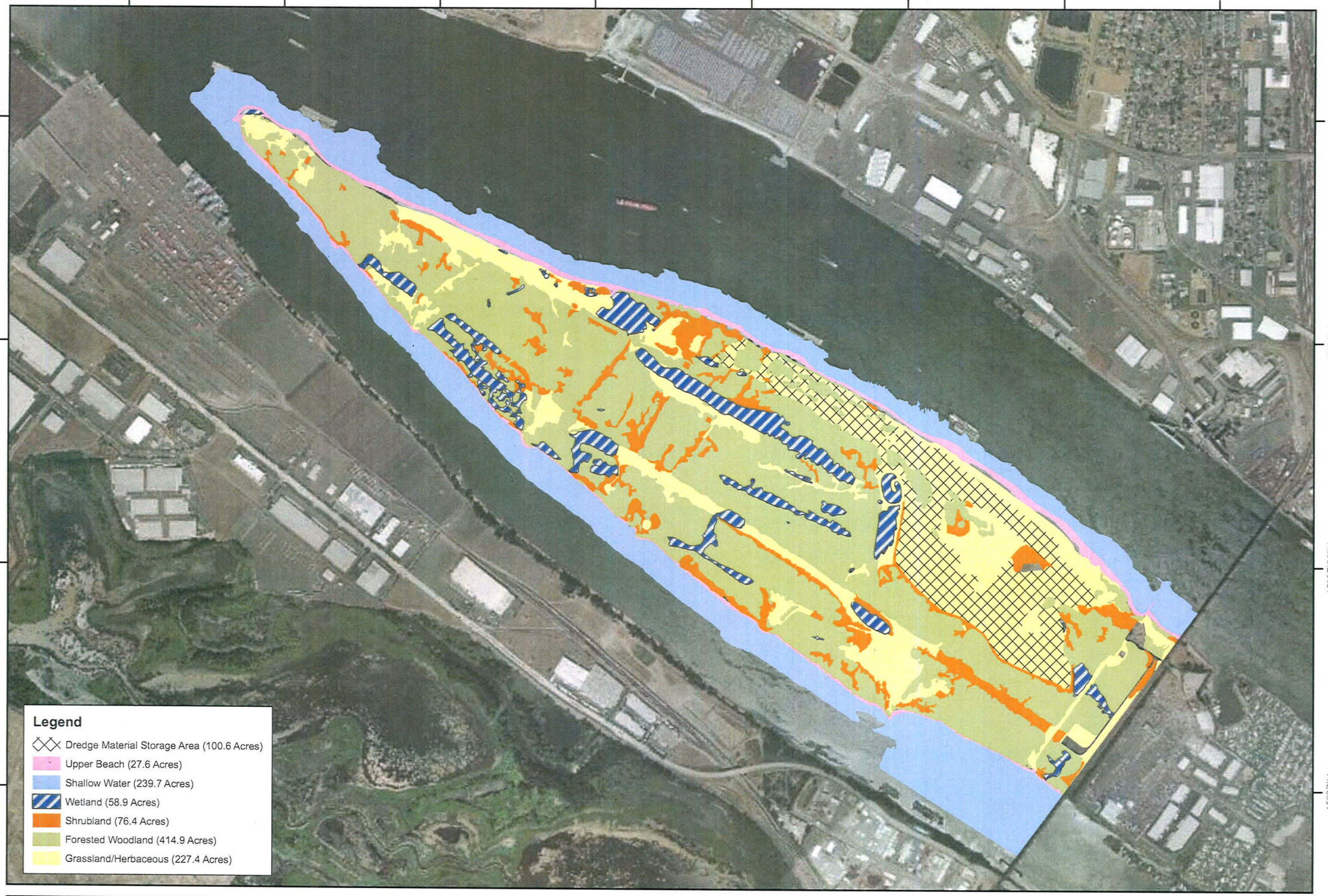
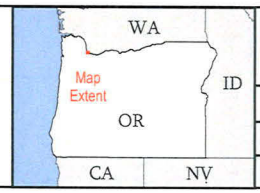


Scale = 1:30,000
1 inch = 2,500 feet

0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Map ES-2
Habitat Classification Map

West Hayden Island
Environmental Foundation Study



ENTRIX
Down to Earth. Down to Business.™
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July 2010
Map Projection: Mercator WGS84

Overall quality/quantity ratings developed for WHI habitat are provided on a continuous scale from 0 (low) to 3 (high). These overall quality ratings are based on the average score resulting from a collection of criteria and scoring rules defined for each habitat type. Overall quality/quantity ratings of WHI habitat at specific sites range from a low of 0.4 to a high of 3.0. As indicated in **Figure ES-1**, much of the habitat on WHI is rated between 2.0 to 2.5, with 60 percent of the acreage falling in this range. Nearly all habitat acreage (approximately 86 percent) is rated between 1.5 and 2.75. Six percent of all acreage rates below 1.5, with acreage of all habitat types except SHR occurring in this lower rating range on WHI. With the exception of WET and FW, all habitat types have acreage rated above 2.75. Habitat rating above 2.75 accounts for eight percent of all acreage on WHI.

In general, habitat on WHI is rated on the higher end of the quality/quantity scale due to the large size of the natural area, the diversity of vegetation, and the connectivity to water on the island. Within the context of an urban ecosystem, these attributes result in a relatively high quality habitat area. However, this is not to say that the habitat on WHI is currently at its full ecological potential. Past land use impacts have affected the natural development and productivity potential. As described in **Appendix A**, it is expected that restoration actions on the island would result in enhanced wildlife habitat resources and enhanced overall ecological functioning.

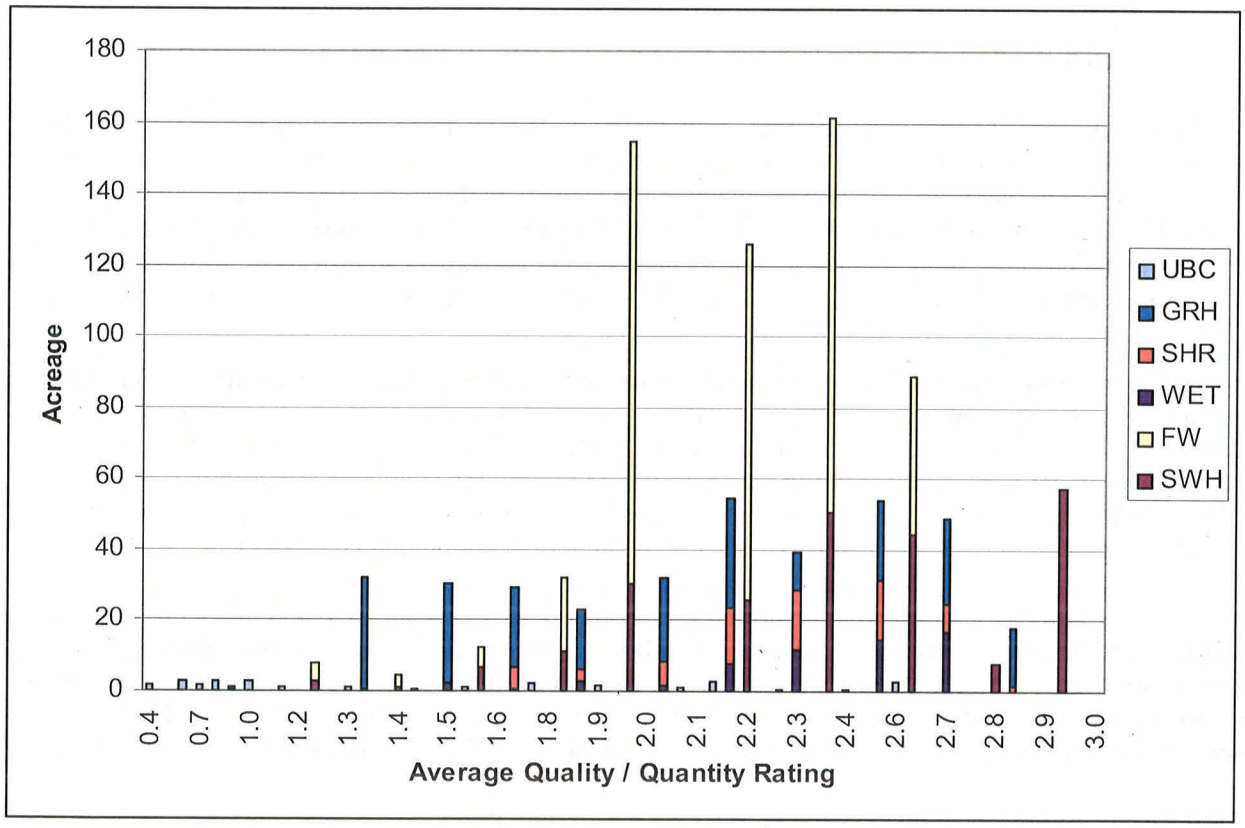

Figure ES-1 Habitat Types and Acreage Distribution by Quality

NATURAL RESOURCE IMPORTANCE

The importance evaluation is conducted at a broader geographic scale and rates the importance of WHI natural resources in the context of the larger study area, as depicted in **Map ES-1**. The study area includes the larger river corridors and nearby significant natural areas in the Columbia River corridor. This geographic

scale accommodates larger-scale processes than observed in the immediate WHI locale, provides for considerations of connectivity between large natural areas for migratory birds, and includes consideration for similar habitats within the river corridor.

As described above, the importance evaluation incorporates such factors as location (geographic factors), resource size, trends (temporal factors), and relationship to other resources in the study area. A review of regional environmental resource reports finds WHI and the Columbia River/Willamette reach containing it as: 1) a fish migration corridor, 2) a center for multiple regional flyways, 3) a key terrestrial-aquatic habitat area within a region of isolated forest blocks, and 4) an area that hosts viable bottomland forest community that supports highly diverse species populations.

These findings are considered in developing criteria to qualitatively describe the importance of WHI resources in a regional context at both the **Habitat Level** and the **Island Level**. The habitat level analysis evaluates the importance of each WHI habitat type based on status and trends in scarcity and abundance of the habitat type and relative contribution to threatened and endangered species. The island-level importance rating evaluates the importance of the assemblage of WHI natural resources, based on the following four criteria: size of habitat area, relationship to other natural resource areas, connectivity to water, and geographic location.

Key findings are as follows:

- **Habitat Level.** At the habitat level analysis, each habitat on WHI is rated with high importance. WHI contains a small component of each habitat type represented in the study area. Loss of these particular habitats would only represent a small percentage of the habitats in the study area. The baseline conditions of these habitats in the study area indicate drastic losses from historic conditions.[2] Small reductions of habitat in an increasingly small habitat inventory have greater ecological significance. Resource use becomes concentrated in these shrinking habitats, magnifying the importance of maintaining larger tracts of habitat, particularly for river and watershed corridors.[3]

  Due to these considerations, as well as regional habitat conservation guidance documents, all WHI habitat types are rated as high importance. Regional habitat conservation guidance documents indicate that WHI habitat types are considered to be of high importance (ODFW Conservation strategy). For example, Oregon Department of Fish and Wildlife has identified the following strategy habitats within the Willamette Valley and West Cascades: grasslands, wetlands, freshwater aquatic habitats, oak woodlands, late successional conifer forests, and riparian habitats (including cottonwood galleries). Of these habitats, all are present on WHI with the exception of oak woodlands and late successional conifer forests. These strategy habitats were identified based on habitat loss since 1850 and based on historical importance at the ecoregional scale, ecological similarity, amount of remaining habitat managed for conservation value, limiting factors, and importance to strategy species. While all habitats are rated with high importance, wetlands and shallow water habitat are potentially the habitats with the highest importance on WHI due to their distribution in the study area and their contribution to sensitive species.

- **Island Level**. At the island level analysis, WHI is rated at high importance based on spatial location and at medium importance based on habitat patch size, importance of functioning in other natural areas, and level of connectivity to water. In general, findings are that WHI provides relatively high quality habitat in a unique location. WHI is positioned at both an aquatic and terrestrial intersection at the Columbia River/Willamette River confluence habitat and floodplain area. It is a large undeveloped tract amidst a fragmented urban landscape that provides nesting and stopover opportunities for migratory birds using the Pacific Flyway. The WHI habitat area viewed at the island-level as an assemblage of habitat types has

[2] Oregon Department of Fish and Wildlife. 2006. The Oregon Conservation Strategy. Oregon Department of Fish and Wildlife. Portland, OR.

[3] USDA NRCS. 1999. Conservation Corridor Planning at the Landscape Level: Managing for Wildlife Habitat.

greater importance due to its diverse habitat types located in close proximity, its relatively large size in the context of the Portland metropolitan area, its location at the center of migratory routes, and its connectivity through its wetlands and shoreline areas to water.

LIMITING FACTORS TO NATURAL RESOURCE FUNCTION WITH MIXED USES

The purpose of this section is to identify potential limits to maintaining natural resource function in the face of development. The section draws from preceding sections to identify and evaluate limiting factors to natural resource function in the presence of mixed use development on WHI (particularly focusing on marine terminal and recreation development). As described in the Economic Foundation Study, industrial development would likely consist of marine terminals and potentially other marine industrial facilities. Recreation development would vary based on the activities and facilities provided, but would likely include beach access and boat docks or ramps. Hereafter, mixed use development refers to recreation and marine-related industrial uses in conjunction with habitat preservation.

Details of the type, size and location of recreation or marine-related economic development of WHI are not available at this time. However, the likely developments of commercial infrastructure, marine terminal(s) and/or recreational facilities may be on the order of 200 to 500 acres. There may be some combination of buildings of various sizes and configurations, lighting and communications structures, parking lots, roads, rail spurs, hiking/biking trails, maintained greenways, marine terminals; shoreline bulkheads, river channel dredging, and other infrastructure. Associated with these facilities and activities may be noise, vibration, artificial lighting, human activity, changes in surface and ground water hydrology, and other non-natural disturbances, any or all of which may limit the natural resource function on WHI. These "limiting factors" are the subject of this section.

While the effect will change based on the specific development and the species under consideration, in general reduced habitat area due to development would be expected to result in an overall decrease in the population size and diversity of animals and plants on WHI. With greater loss of any particular habitat type, a decline in use by species adapted to that habitat would be expected. The magnitude, time frame, and sequence of these population-level impacts are difficult to quantify without comprehensive baseline information about WHI population abundance and distribution and their seasonal use of adjacent habitats such as mainland, other island, and open water areas. In general though, the development of WHI is expected to lead to a decline in size, location, and diversity of habitats and thus to a decline in species use, abundance and diversity on WHI.

This section identifies and describes six key limiting factors that may be most critical, or most limiting, to natural resource function and species use in the face of development on WHI: hydrodynamics and shallow water habitat function, habitat patch size and configuration, riparian function, wetland function, wildlife movement and island habitat diversity, and disturbance associated with human activity.

The limiting factors have varying effects on key indicator species, which are species with a narrow range of ecological tolerance to one or more limiting factors. The presence of such species provides a general indication of environmental conditions

Key findings regarding the effects of these limiting factors on key indicator species groups are as follows:

- **Fish**. Although there are many species of freshwater fish using mainstem Columbia River habitats, Pacific salmon, especially juveniles, are one of the more sensitive genera to water quality and quantity, and physically diverse and complex habitats. On habitats associated with WHI, these effects are mostly related to food web dynamics and use of sheltered (i.e., low current energy) shoreline areas for refuge during extended outmigration periods. The highly migratory salmon do not necessarily have a threshold limitation at the scale of WHI habitat (considered in the context of their overall Columbia River habitat)

but the presence of WHI shallow water habitat components are beneficial to their freshwater survival. In larger rivers such as the Columbia River that serve as migratory corridors, the continuity of habitats along shoreline will contribute more towards survival factors of individuals than capacity of a watershed. WHI shoreline areas provide this very important component of survival particularly for downstream migrants. The functionality curve of shallow water habitats will be most directly influenced by the presence or absence of complex habitats, embayments, or connected wetland habitats and a reasonable goal is to have these features occur every one-quarter mile along the migration corridor.

- **Amphibians**. Amphibian populations are dependent on a variety of habitat types to meet the annual requirements of their various life history stages. In particular, amphibians thrive in the moist terrestrial and aquatic environments that WHI offers. The loss of any one of these habitats or the impairment of movement between habitat types could result in the extirpation of the local population. The combination of large river access, wetlands, and adjacent forested and shrub areas provide habitats for complete life history of several amphibian species. Amphibian populations are highly sensitive to patch size and configuration of habitat, riparian and wetland function, and the maintenance of wildlife corridors to assist in their distribution. Relative to many other amphibians, this requirement for a seasonal mosaic of habitat types makes northern red-legged frogs particularly vulnerable to habitat loss or alteration. Maintaining 20 acres of the combined habitats per breeding pair of red-legged frog should allow populations to be maintained.

- **Reptiles**. Reptiles are most sensitive to factors concerning patch size, wetland and riparian function, movement corridors and human disturbance. In the Portland metropolitan area, turtles have been observed making short-distance movements of at least 1 km around wetland complexes, but movement can be much longer given aquatic connectivity and lengthy aquatic corridors (Gervais et al. 2009). A 56-acre area can be a suitable area requirement for a breeding pair of turtles. One main consideration for the extent of this acreage is the importance of visual screening from disturbances and predator avoidance. In addition to the key limiting factors, the populations of western painted turtles are limited by predation by bullfrog and non-native predatory fishes (bass). Potential road infrastructure could contribute to road mortality and since western painted turtles are easily disturbed while basking, recreational activities could disrupt behaviors. Rights-of-way of either de-vegetated areas or roadways can hinder migration or cause road mortality, particularly for female turtles seeking nest sites. Provision of nesting habitat that is free of human disturbance and close to water is important.

- **Birds**. The most abundant and diverse terrestrial wildlife group using WHI is birds. WHI provides protective characteristics of an island habitat for many species. Habitat patch size, habitat diversity, and disturbance from human activity are the key limiting factors for bird species. Riparian function is a limiting factor, though to a lesser extent, as all of WHI can function as riparian habitat. Even with some impacts to habitat, riparian-obligate species such as belted kingfisher, great blue heron, and mallards are likely to sustain a population on WHI, provided that adequate habitat patch size and connectivity between forests and aquatic habitats are maintained. Different bird species require different amounts of habitats to remain viable. Generally there are broad ranges of core habitat acreage needed for species and the forest characteristic (age, structure) affects the required patch size, which can vary from less than 19 acres to several hundred acres). WHI, with its high bird species diversity, hosts some species whose reproductive success could be limited by loss of extensive forest/woodland or shrub habitat. Travel across fragmented habitat can also have physiological effects on individuals and thus can affect breeding success.

- **Mammals.** Mammalian species are a diverse group, but in large part their successful productivity depends on complex habitat structure, landscape connectivity, and access to water. Because these features are often associated with riparian areas, riparian habitats may have more abundant small mammal populations than upland areas (Doyle 1990; Bellows et al. 2000). Mammals are thus most sensitive to the reduction in patch size and lack of diverse, adjacent habitats, so development occurring in areas of greatest habitat diversity such as riparian areas would likely have the most impact on these species. Although there is limited regional information on patch size requirements for small mammals, Murphy (2005) suggests that small mammals such as short-tail weasel, Oregon vole, Northern flying squirrel,

shrews and chipmunks may need 25 acres of habitat patch to persist. Estimates per breeding pair of small mammals are not available and the island geography will influence estimates that have been made on larger landscapes. On an island biogeography, species often adapt to fulfilling life history requirements in smaller areas than the regional population would on larger landscapes.

- **Summary. Table ES-4** is a summary of the expected relative sensitivity between indicator species and the limiting factors for WHI. Following the table, a summary description is provided for each species group regarding species requirements and their sensitivity to the limiting factors. The relative sensitivity is based on Pacific Northwest ecology and species-habitat relationships. The ratings relate to their influence on WHI in the context of proposed mixed use development. A high sensitivity indicates that the limiting factor is a primary influence of the habitat on the abundance, productivity, survival, or other measure(s) for a particular species or species group. A medium sensitivity indicates influence on these same population factors but to a lesser degree, possibly because the species could complete life history needs with some reductions in habitat or are known to adapt to local changes. A low sensitivity suggests a minor response to the influence of known limiting factors.

Table ES-4 Summary of Relative Sensitivity of Limiting Factors on WHI Indicator Species

		Relative Influence of Limiting Factors					
Species Group	Species	Patch Size/ Configuration/ Continuity	Hydrodynamics/ Shallow Water Habitat	Riparian Function	Wetland Function	Wildlife Movement / Habitat Diversity	Disturbance from Light, Noise, Human Presence
Fish	Chinook	Medium Habitat continuum; shoreline connectivity every ¼ mile	High	Medium	High May utilize connected pond for short time periods as outmigrants	Low	Medium
	chum	Medium Habitat continuum; shoreline connectivity every ¼ mile	High	Medium	Medium	Low	Low
Amphibians	Red-legged frog	High Averages 20 acres per breeding pair	Medium May not utilize large river margin as much as wetland	High	High	High Potentially distant migration	Low
	Northwestern salamander	Medium Wet habitats and adjacent forest required	Low	High	High	High	Low
Reptiles	Western pond and western painted turtles	High 56 acres per breeding pair	Medium	High	High	High Although able to navigate somewhat across culvert barriers	High
Birds	Forest breeding songbirds	Very high 5-50 acres	Low	Medium	Medium	High	High
	Pileated woodpecker	High 650+ acres	Low	Medium	Medium	High	Medium
	White breasted	High	Low	Medium	Medium	High	Medium

		Relative Influence of Limiting Factors					
Species Group	Species	Patch Size/ Configuration/ Continuity	Hydrodynamics/ Shallow Water Habitat	Riparian Function	Wetland Function	Wildlife Movement / Habitat Diversity	Disturbance from Light, Noise, Human Presence
	nuthatch	Up to 98 acres					
	Streak horned lark	Very High Up to 12.6 acres	Low	Medium	Medium	High	High
	Swainson's thrush	High Up to 12 acres average. Average is 1 to 5 acres	Low	Medium	Medium	High Needs interior habitat, not edge	Medium
Mammals	Yuma myotis Yuma bat	Medium Unknown, most limited by stand type	Low	High	Medium	Medium	High
	Small mammals	Medium 25 acres	Low	High	Medium	High	Medium Can elude disturbances, nocturnal behavior modifications
Comparative Sensitivity to Limiting Factors		Most sensitive Birds, mammals Least sensitive Fish	Most sensitive Fish Least sensitive Reptiles	Most sensitive Birds, mammals Least sensitive None	Most sensitive Fish, reptiles, amphibians, Least sensitive Mammals	Most sensitive Mammals, Birds Least sensitive Fish	Most sensitive Birds, mammals Least sensitive Fish, amphibians

a Hayes et al. (2002) observed 100 adults in 2,800 acre industrial area with natural corridors.

b A large range of recommended minimum habitat use is reviewed by Hennings and Soll (2010).

RESTORATION POTENTIAL

Appendix A presents an analysis conducted by Parametrix to evaluate restoration potential on WHI. For this work, Parametrix created a restoration concept plan with the goal of increasing the level of ecosystem services provided on WHI. The evaluation of the current conditions and ecosystem services potential is based on a review of existing conservation planning and management documents for the site as well as a review of documentation related to similar sites in the region. Other than a brief site visit made to confirm certain assumptions about current conditions, no site-specific data was collected for this study. Current and potential ecosystem services levels are estimated with a qualitative measure.

Review of the site conditions and restoration options indicate opportunity for modest ecosystem services gains through restoration actions. Three ecosystem services provide the most opportunity for gains: biodiversity support, natural hazard protection through flood management, and climate regulation. The proposed restoration actions in the concept plan aim to address four primary ecological challenges on the island. These challenges are: changes to the flood regime and hydrograph; loss of habitat diversity; invasive plan introduction; and loss of floodplain connectivity. The management activities that are identified in the concept plan address these four factors, and do so by attempting to use natural processes as much as possible to address these factors.

The restoration actions proposed include the development of new connections between and across the island's interior and the Columbia River, as well as addressing invasive species on the island. The proposed connections include excavating the current dredge material management area to create an off channel aquatic

habitat and a series of grass and shrub habitat areas. The large interior wetland is proposed to be seasonally connected with a new channel that would cross the island from the Columbia River to the North Portland Harbor. Finally, all of the forested area on the island is proposed to be treated to manage the spread of invasive species and to support natural recruitment in the forested areas. This treatment also includes the introduction of conifer cover to provide year-round shade to help limit the spread of invasive species. Additional grassland and wetland restoration actions are proposed for current dredge material management areas.

Biodiversity Support

Biodiversity improvements provide the greatest opportunity for uplift on the site, and a restoration focused scenario provides an opportunity to add new habitat and functions to this portion of the Columbia River. The current conditions and restoration opportunities present on the island provide an example of the cumulative need for restoration actions throughout the lower Columbia River Basin. Biodiversity support benefits are best improved by addressing the loss of habitat diversity from historic conditions. The proposed activities seek to restore a mix of forested, wetland and prairie habitats, along with improved connectivity to the Columbia River where feasible. Instead of focusing on a specific list of targeted species, the biodiversity support assessment performed for this report focuses on restoration of the diverse set of habitats needed to support an equally diverse set of species. It is important to note that no restoration scenario at this scale can provide a species population response that can easily be measured.

Management activities include the creation of new off-channel alcoves and shallow water habitat in dredge disposal areas. The primary dredge disposal site is proposed to include an alcove and wetlands and grasslands along the new shorelines. In addition to this development at the dredge material management site, other connections are proposed across the island. The largest of these is a possible connection for the interior wetland to the Columbia River. This connection may also be extended to the southeast to the North Portland Harbor. Other opportunities for connections to the main channel include lowering berms and other older dredge material disposal sites to increase the frequency of inundation. Forested areas are proposed to have invasive species treatments and management strategies applied. The strategies include selected introduction of conifers that are tolerant of the site hydrology to provide year-round canopy to limit the spread of invasive species.

Climate Regulation

Climate regulation-related ecosystem services on the site are provided by the proposed forest and grassland management areas. Carbon sequestration capabilities will vary among the habitat areas on the island, with the forested areas and the grassland areas sequestering and storing carbon differently. Carbon management strategies were evaluated under the system developed by the Voluntary Carbon Standard (VCS). The VCS protocols define the accepted measures to produce carbon offset credits. Under this system the maintenance of healthy forests and grasslands areas are able to be recognized for carbon benefits (as opposed to standards that focus primarily on re-forestation.) The initial review of the carbon potential on the site is less than optimal for a market-based transaction. However, land management activities that enhance carbon sequestration generate co-benefits, such as increased biodiversity and soil conservation, support the goal of the WHI restoration program and contribute to overall increased ecosystem services on the island.

Natural Hazard Management

Flood management is the primary potential natural hazard management service on the site. However, the site is low in the watershed, and has low elevation in relation to river stages. Due to these factors, it is anticipated that flood attenuation or delay in a landscape context can only modestly be affected by implementing the proposed increased flood storage and off channel connections. The proposed actions will likely reduce the

energy and flow during storm events, especially for immediately adjacent areas, and the restoration actions will make a minor contribution to moving channel dynamics from a constricted profile to a less constricted one. These changes are recognized to improve natural hazard management services and many other riverine ecosystem services. Numerous areas appear to be candidates for increasing onsite flood storage and providing new floodplain connections. While not hugely significant in a landscape context, when these actions are combined with other actions in the watershed, they can contribute to very significant cumulative benefits.

Summary

WHI's natural areas provide multiple ecosystem services for the region, and the opportunity to increase these services is primarily found in the most highly disturbed areas of the site, where dredge material placement has occurred. Forest improvements are possible, but these areas are currently providing services at higher levels of performance. The greatest opportunity for increasing ecosystem service provision is through the reintroduction of seasonal inundation and the creation of off-channel aquatic habitat. Vegetation management will continue to play an important role in maintaining forest health, particularly for biodiversity support and climate regulation.

The main concern in the forested areas is the reduction in natural forest regeneration. If the forested and grassland portions of the island are not managed actively, it is likely that the existing cottonwood forested areas will convert to invasive cover. The loss of forested cover has been identified as a concern in other reports and can be seen at other sites along the lower Columbia River such as the Sandy River Delta, Government Island, and Mirror Lake further up in the Columbia River Gorge. These sites are all in various stages of restoration and management today, but each has seen domination by an invasive monoculture. This is a threat for WHI as well.

The loss of the forested areas due to spread of invasive species would greatly impact all ecosystem services on the site. The largest impact on ecosystem services would be on biodiversity, climate regulation, and water quality. Biodiversity would be impacted by removing the last of habitat diversity on the island and removing a key source for structure in near shore habitats. Climate regulation services would also be lost, and this may represent a net carbon emission. Water quality impacts would primarily stem from increased solar exposure to ponded waters and shallow water areas currently shaded by forests. This may contribute to water temperatures that are harmful to salmonid species.

ECOSYSTEM SERVICES VALUE

The economic value of the ecosystem services provided by WHI natural areas is discussed in **Appendix B**. The appendix focuses on the current value of the primary ecosystem services provided on WHI, but also explores the potential change in ecosystem services values based on restoration or development. While this analysis focused on the economic valuation of ecosystem services, it is important to acknowledge that non-anthropocentric values of ecosystems, including the intrinsic value of species and nature that is not related to human considerations, can also play an important role in environmental decision-making.

The primary economic value of ecosystem services on WHI is related to the provision of wildlife habitat, with estimates of value also provided for climate regulation as well as air and water purification. No estimates of value are provided for flood regulation.

Key findings are summarized below by ecosystem service type.

Wildlife Habitat and Species

- **Cultural Services** People value habitat both for its own sake, and also for its value in sustaining biodiversity and producing wildlife. The importance to people of wildlife habitat and associated species is evident in the local, state, and federal regulations protecting species and habitat; the voluntary contributions of individuals to organizations that restore and conserve habitats; and the time and expenditures invested by people to visit wildlife habitat areas to recreate. Cultural services of habitat and species include benefits related to recreation, aesthetics, scientific knowledge, and spiritual/cultural values. Benefits are derived through direction interaction with habitat and species resources (use values), but can also be derived separate from any interaction with the resource (non-use). Adding use and non-use values together provides an estimate of total economic value of a resource.
- **Total Habitat Value** As the available literature varies by habitat type, the analysis is able to quantify benefits associated with wetlands, forest, and shallow water habitat with very little quantification feasible for the remaining habitat types. This does not indicate that these habitats have less value, but that they are not yet studied to the same extent. The total habitat value associated with wetlands, forest, shallow water habitat, and upper beach habitat is estimate to range from $550,000 to $4.5 million.

Air Purification

- **Vegetation and Air Purification** Trees and other vegetation improve ambient air quality by removing air pollutants. Specifically, vegetation absorbs and intercepts such potentially harmful pollutants as nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide.[4] These pollutants are removed by vegetation through gaseous uptake, as well as through physical deposition of particulates on vegetation surfaces. The air purification services of vegetation that reduce ambient air concentrations of pollutants has economic value because of 1) improved health and reduced incidents or severity of respiratory illness such as asthma, bronchitis, lung disease, and respiratory infections, and 2) improved aesthetics through increased visibility.
- **Value of Pollution Removal** Based on a US Forest Service model of Portland vegetation, the annual pollution removal by WHI vegetation for carbon monoxide, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide is estimated. Across all pollutants, total removal is estimated at 18.6 tons annually, and is estimated to range in value from $39,500 to $142,000 annually.

Climate Regulation

- **Vegetation and Sequestration** The human release of carbon dioxide and other greenhouse gases (GHG) has been directly linked to climate change by many scientific studies and is consequently a major environmental concern. Climate regulation services on WHI are related to carbon sequestration by WHI vegetation. The carbon sequestration services provided by WHI come from terrestrial sequestration, which removes CO_2 from the atmosphere and stores it for long periods in vegetation or soil.
- **Annual Sequestration Estimates** It is estimated that each acre of forestland and grassland on WHI sequesters approximately 0.6 tons of carbon annually.
- **Value of Carbon Sequestration** Carbon sequestration is expected to reduce the effect of global climate change and thereby contribute to human well-being through reducing economic damages associated with the earth's temperature rising. The economics literature provides estimates of this avoided cost value, which can be compared with the value in nascent carbon markets as well as the cost of developing carbon sequestration projects. Based on the avoided damage to society and the cost of sequestering carbon

[4] Nowak, David J. Daniel E. Crane, Jack C. Stevens, 2006, 'Air pollution removal by urban trees and shrubs in the United States,' Urban Forestry and Urban Greening, 115-123.

elsewhere (ranging from $41 to $149 per ton), the total value of carbon storage on WHI is estimated to range from approximately $13,000 to $48,000 annually.

Water Purification

- **Vegetation and Water Purification Benefits** Water contaminants processed through phytoremediation include many of the toxics described earlier in this section as being of highest concern in the Lower Columbia River. Plant species capable of remediating toxics of concern in the Lower Columbia River are found on WHI. As with air quality, improved water quality has economic value through its effect on human health and aesthetics, as well as through effects on the health of economically and culturally important wildlife populations. Vegetation is capable of removing toxic compounds from polluted water and soil.
- **Value of Water Quality Improvement by WHI wetlands** Based on an existing meta-analysis of 39 economic studies, a range of values between $148 and $644 per acre is utilized to estimate the water quality benefits of WHI wetlands. Based on these values, the water quality benefits of the 58.9 acres of WHI wetlands are estimated at between $9,000 and $38,000 annually.

Flood Regulation

- **WHI and Flooding** Flooding of the lower Columbia River has the potential to inflict substantial economic costs. These costs include direct economic costs related to damage of infrastructure and economic assets such as homes, businesses, roads, bridges, and agricultural crops. Additionally, flood damage results in indirect economic costs from interrupted business operations, which reduces local income. The wetlands and riparian vegetation on WHI store and convey storm and floodwaters, thereby increasing water storage and conveyance capacity in the river channel and reducing flooding. The value of this water storage and conveyance capacity depends on the relative volume of water stored and conveyed, the frequency and magnitude of flood events in the local area, and the value of economic assets that may be impacted by flooding.
- **Flood Storage Volume**_On average, it is estimated that in a 100-year flood 2.8 feet of flood waters can inundate WHI. Given that there are 790 acres of habitat on WHI (excluding shallow water habitat), the total volume of water that can be stored or conveyed on WHI at any given time during a 100-year flood event is estimated at 26,560 acre-feet.
- **Value of Flood Storage**_Due to the low relative volume of water that can be stored or conveyed at WHI, the avoided cost associated with natural flood control at WHI is expected to be minimal. As noted above, the U.S. Army Corps of Engineers (ACOE) manages the Columbia River dams to control flooding in the lower Columbia River. Interviews with ACOE confirm that the flood storage capacity in WHI relative to the size of the river and the volume of flood waters in the Columbia River, and that operation of the dams would not differ based on changes in flood water storage and conveyance on WHI

Summary

- **Current Value**_Total ecosystem service benefits quantified under current conditions are estimated to be valued from $613,000 to $4.7 million annually, as summarized in the table below. Findings from the analysis indicate that the primary economic benefits provided by WHI resources are cultural service values elated to the provision of wildlife habitat and support of biodiversity. These cultural service values, which stem from both use and non-use benefits derived from natural habitat areas, account for approximately 89 percent to 95 percent of all current ecosystem services values estimated for WHI. As additional services may be provided by WHI that are not quantified in this analysis, including habitat and biodiversity services provided by grassland and shrubland habitats, pollination services, and others, the

figures in the table are expected to underestimate the total economic value of ecosystem services provided on WHI.

- **Restoration** The primary benefits from restoration are likely to be increased services from habitat and biodiversity, with some additional benefits accruing from climate regulation, water purification, as well as flood control and air purification. Quantified benefits (for habitat/biodiversity, climate regulation, and water purification) are estimated to range from a minimum of $171,000 to at least $1.7 million based on proposed management actions.
- **Development Value** Under development, the effect on ecosystem services depends greatly on the type, size, and level of use of developed areas and facilities. Development that includes increased recreation access and opportunities would have the potentially to increase recreation and aesthetic values of WHI natural areas, but development would also be expected to reduce the amount of vegetation and acreage of habitat, with associated loss of air and water purification, climate regulation, and biodiversity services unless fully mitigated. The net effect of these changes would thus depend on the level of increased access and recreation opportunities on WHI and the level of mitigation for habitat loss and associated ecosystem service impacts.

Table ES-5 Summary of Quantified Ecosystem Services Values on WHI

			Change from Current Conditions			
	Current Conditions		Restoration		Development	
Ecosystem Service	Low	High	Low	High	Low	High
Cultural Services of Habitat & Biodiversity[1]	$552,000	$4,501,000 +	$160,000	$1,640,000 +	Decrease	Increase
Air Purification	$39,000	$142,000	Increase	Increase	Decrease	Depends on Mitigation
Climate Regulation	$13,000	$47,000	$5,000	$65,000	Decrease	Depends on Mitigation
Water Purification	$9,000	$38,000	$6,000	$26,000 +	Decrease	Depends on Mitigation
Flood Regulation	Positive	Positive	Increase	Increase	Likely No Change	Likely No Change
Total Quantified Services	**$613,000 +**	**$4,729,000 +**	**$171,000 +**	**$1,731,000 +**	**Decrease**	**Potential Increase**

[1] Cultural services associated with habitat and biodiversity include recreation, aesthetics, scientific knowledge, spiritual, and cultural values.

SECTION 1

Introduction

1.1 BACKGROUND

The City of Portland (City) is considering annexation and development of a long-term land use plan for West Hayden Island (WHI). This process requires not only annexing and zoning the property, but also an assessment of natural resources, potential conflicting land uses, and marine industrial and recreational uses. WHI is approximately 800 acres and is the undeveloped western portion of Hayden Island, located in the Columbia River near the confluence with the Willamette River. WHI is owned by the Port of Portland, and was added to the region's urban growth boundary in 1983 for marine industrial purposes. It is both a potentially important economic resource and an important natural resource, containing undeveloped open space in a location with habitat value. WHI is designated as Marine Industrial Land on Metro's 2040 Growth Concept Map, and as a Regionally Significant Industrial Area on the Title 4 map in the Urban Growth Functional Plan. WHI is also identified by Metro as a high value riparian area and a Habitat of Concern in the regional inventory, and as a Moderate Habitat Conservation Area in Title 13.

1.2 PURPOSE

The WHI Environmental Foundation Study will serve as a foundation study for the zoning and annexation of WHI and is intended to provide background information for the current planning process and future WHI studies. The objective of the study is to identify and describe the functional values of natural resources on WHI. The study is intended to address some of the requirements of Oregon Administrative Rules, Chapter 660 and Division 5. This work will also inform the Economic, Social, Environmental, and Energy (ESEE) Analysis to be to be completed as part of the City land use plan for WHI.

The Environmental Foundation Study provides a detailed understanding of the condition, function, and value of WHI natural resources. The study also identifies the limiting factors or constraints to natural resource function if there are a mix of uses (e.g. recreation and/or marine-related economic activities) on WHI. A companion report, the Economic Foundation Study, provides information about marine-related economic developmentl land needs relative to WHI and its surroundings over the next 30 years. A third recreation study describes recreation participation, development potential, and current value on and around WHI. Together these studies provide information on the importance and potential contribution of WHI in three different land uses: habitat, marine-related economic use, and recreation.

1.2.1 WHI Public Planning Process

The City's Bureau of Planning and Sustainability (BPS) is leading a collaborative public process to evaluate alternative long-term uses for WHI. To help the City in determining future plan designations, the City has created a Community Working Group (CWG). This study is intended to provide information for the CWG, which is tasked with advising the Portland City Council on "how marine industrial, habitat, and recreational

uses might be reconciled on [WHI]; and if the CWG determines that a mix of uses is possible on WHI, to recommend a preferred concept plan."[5]

The CWG is made up of stakeholders with diverse backgrounds and interests in WHI land use. CWG members include representatives of local businesses and industries, non-profit organizations, surrounding neighborhoods, and staff with the City, Metro Region, and the Port of Portland. Reaching agreement on a planning framework for the site will allow planning, management and enhancement efforts to proceed. The City will coordinate this effort with planning work currently being done on the Columbia River Crossing (CRC) project and East Hayden Island.

1.3 SCOPE

Broadly, the scope of this work is to analyze and build upon existing data and studies to 1) document the historical and current natural resource conditions on WHI; 2) evaluate the quantity and quality of WHI natural resources and the ecological importance of WHI within the larger ecosystem context; 3) assess the limiting factors or constraints from a natural resource function perspective of a mix of land uses on WHI; 4) identify opportunities for restoration of natural resource function on WHI; and 5) estimate the economic value of ecosystem services provided by natural resources on WHI.

In terms of geographic scope, the analysis is focused on the quantity and quality of WHI natural resources within the context of natural areas in the City. In order to identify the regional role and importance of WHI natural resources, the analysis also includes a limited review of natural resources located throughout the Lower Columbia River. Due to time and resource constraints, the scope of the analysis is based on existing data and readily available information.

1.4 LIMITATIONS

The study is intended to utilize the best available data to identify, quantify, and evaluate natural resources on WHI. To accomplish this scope of work within the allotted timeframe and resources, certain assumptions were necessary. Furthermore, the study is limited by the existing data, information collected from interviews, and two field-based tours. While the field tours allowed verification of existing data on habitat classifications, additional field data collection was not included in the scope of work. Summarized below are the key study assumptions used in the analysis as well as the data gaps that were identified.

1.4.1 Study Assumptions

Lower Columbia River ecosystem science and species information is extensive across many disciplines. The study used mutually-agreed upon reports that are most significant and most relevant to the planning and study area.

The following assumptions were used to identify and evaluate natural resources on WHI:

- The GIS and aerial imagery data provided from the City and the Port of Portland for the study are a reasonably accurate portrayal of WHI natural resources.
- Columbia River processes have the most significant effects on the type and quality of habitat on WHI. However, this analysis assumes that WHI features have important localized effects that differentiate the quality of natural resource function across WHI.

[5] From the West Hayden Island Community Working Group Charter, March 17, 2009.

- The geographic area used as the basis for relative quality/quantity rating of WHI natural resources is the City. In other words, the quality of WHI natural resources on WHI is evaluated based on criteria developed to differentiate the quality of natural areas within the geographic area of the City.
- All undeveloped areas on WHI, including the dredge materials management area, provide some level of natural resource function and habitat to native species.
- Where no criteria existed in the City's Natural Resource Inventory methodology that would describe functionality of resources, common habitat features recognized in Lower Columbia River ecology were used to define additional evaluation criteria.

1.4.2 Data Gaps

The study is also limited to existing, readily available data. The following data gaps were among those identified during the course of the study:

- Site visits were not comprehensive to thoroughly verify existing GIS data.
- There is limited documentation of species use on WHI. Documentation of species occurs as a species list for WHI.
- There is limited available research on riparian area inputs and functionality for large rivers such as the Columbia River as much of the research has been conducted on smaller sized streams and rivers.
- There is limited available data regarding current conditions of invasive species, other than large patches of non-native blackberry.
- There is limited available research on species acreage requirements, and uncertainty regarding the applicability of existing research to WHI. For example, acreage requirements for bird species for the region on are primarily derived from the Willamette Valley, Coast range, or extensive natural areas that differ in key attributes from WHI.
- The study used field-verified vegetation data provided by the Port of Portland, but to create a reasonable number of habitat types to evaluate, non-forest vegetation classes were combined into grassland and shrubland habitat types. There is uncertainty about the sensitivity of certain bird species toward shrub and grassland classification on WHI.
- There is uncertainty about the overall net effects that sea level rise would have in the region's fish and wildlife resources. Sea level rise will likely mean some changes in habitat type and function on WHI in particular wetland and other low lying areas. Because of the complexity of the estuarine function and large river influences, it is difficult to determine what the impacts would be to WHI fish and wildlife resources. These impacts are not addressed in this scope of work.

To compensate for these data gaps, the study assumed spatial and classification reliability of Port-derived GIS data and relied on key literature and reports and interviews with regional experts.

1.5 REPORT ORGANIZATION

Following this introduction, there are seven additional sections. **Section 2** describes the natural resource evaluation methodology, including criteria used to rate WHI natural resources. **Section 3** provides an overview on historic conditions and current trends in natural resources on WHI and in the Lower Columbia River study area. **Section 4** presents results from the natural resource quantity/quality evaluation, while **Section 5** presents results from the assessment of the ecological importance of WHI natural resources within the regional context. **Appendix A** was conducted by Parametrix consultants and evaluates the potential for restoration on WHI to restore natural resource function, while **Appendix B** quantifies, where feasible, the economic value of ecosystem services provided by WHI natural resources.

SECTION 2

Natural Resource Evaluation Framework and Criteria

This section describes the framework used to assess the current conditions of natural resources on WHI. In addition to providing an overview of the assessment methodology and purpose (**Section 2.1**) and the geographic area of analysis (**Section 2.2**), this section also includes detailed information on the data used and the criteria developed to assess each type of natural resource on WHI (**Section 2.3** and **Section 2.4**).

2.1 OVERVIEW OF THE EVALUATION FRAMEWORK

The framework includes two components for evaluating WHI natural resources: a quality/quantity evaluation and an importance evaluation. The purpose and geographic area of analysis of the quality/quantity and importance evaluations are highlighted below:

- **Quality/Quantity Evaluation.** This is a site-specific evaluation that rates the relative quality and quantity of natural resources at each location on WHI. The quality/quantity evaluation rates the WHI natural resources based on the site-specific level of ecological function as determined by vegetation, soils, elevation, and other landscape features. The criteria for rating the quality/quantity of WHI resources vary by habitat type, so the ratings are comparable only within a given habitat type (i.e. the ratings for upper beach enable comparison of quality of different upper beach areas, but do not enable comparison of upper beach with forest or other habitat types). The criteria used to rate WHI natural resources are based on input from regional experts as well as a review of the scientific literature. The criteria are calibrated to reflect the level of quality possible in an urbanized area.
- **Importance Evaluation.** This evaluation rates the regional importance of WHI natural resources in the context of other natural areas within a broader study area (defined below) including other islands and natural areas within the Lower Columbia River corridor. The evaluation rates the importance of WHI natural resources in the broader ecosystem context, and incorporates such factors as location, resource size, and relationship to other resources in the study area. The importance evaluation is separate from the City's significance determination that will occur as part of the Economic, Social, Environment, and Energy (ESEE analysis) analysis required by the State of Oregon.

  The importance evaluation includes two components: a habitat level assessment and an island level assessment. Both assessments evaluate the importance of WHI habitats in the context of other islands and natural areas in the Lower Columbia River corridor. The habitat-level assessment evaluates the importance of each habitat type on WHI based on the scarcity and ecological importance of the habitat in the Lower Columbia River system. The island-level assessment evaluates the importance of WHI as a whole habitat area in the context of the Lower Columbia River system based on such factors as location, acreage, and relationship to other natural areas. These importance ratings are entirely separate from the quality/quantity ratings. The importance ratings are based on the type of natural resources on WHI and not their current condition.

2.1.1 Relationship to City's Natural Resource Inventory Update (NRIU)

The structure of the quality/quantity evaluation framework is based on the City's Natural Resource Inventory Update (NRIU) and Metro's regional inventory of riparian corridors and wildlife habitat. The City's NRIU rates the quality/quantity of natural resources in the City based on ecosystem function and landscape attributes. The City's NRIU is a city-wide, GIS based inventory of natural resources and the functions provided by those resources. WHI has been included in the GIS mapping and modeling. The NRIU assesses riparian corridor functions and wildlife habitat attributes provided by the natural resources. The NRIU also ranks the relative quality and quantity of the natural resources. The ENTRIX evaluation framework builds upon the NRIU by defining and separately analyzing different wildlife habitat types. Additionally, the ENTRIX evaluation framework includes an analysis of the importance of WHI resources based on their function and role at the larger study area scale; this analysis incorporates information on the size, location, and interrelationship of WHI resources to other resources in the study area.

The quality/quantity evaluation uses some (but not all) of the criteria used by the NRIU to assess natural resources, but there are several important differences. First, the quality/quantity evaluation for WHI includes several additional criteria that are not evaluated in the NRIU. The WHI quality/quantity evaluation also incorporates other habitat types (i.e., shallow water habitat and upper beach) that are not evaluated in the NRIU. Due to these differences, the results of the quality/quantity evaluation are not directly comparable to the NRIU results for the rest of Portland.

2.2 GEOGRAPHIC SCALE OF ANALYSIS

There are two geographic scales defined for the analysis of current conditions on WHI: the planning area and the study area. WHI is the focus of the analysis and constitutes the planning area; it is the relatively undeveloped western portion of Hayden Island, which is located in the Columbia River along the Oregon shoreline near the confluence with the Willamette River. WHI encompasses 827 acres of the 1,400-acre Hayden Island.

The waterways on both sides of Hayden Island are federally-authorized navigation channels. Hayden Island extends from just upstream of the mouth of the Willamette River, near Columbia River Mile (RM) 102, to where it merges with Tomahawk Island near RM 106. The WHI planning area includes all land on Hayden Island that is westward of the Burlington Northern Santa Fe Railroad line that crosses the island (see **Map 1**). Natural resources in the WHI planning area are assessed in this analysis for their quality/quantity and for their regional ecological importance. The Columbia River stretch that includes WHI has been designated as critical habitat for federally-listed salmon and steelhead and is designated as Class 1 riparian habitat and a "Habitat of Concern"[6] under Metro's Title 13.

The second geographic scale is the study area (see **Map 1**). The study area defines the region in which the importance and ecological context of WHI resources are assessed. The study area recognizes WHI as part of a chain of low islands of deposited sediments. This area includes such geographic features as the Lower Willamette River, Columbia River estuary, Government Island, Vancouver Lake, Forest Park, Ridgefield National Wildlife Refuge, Shilapoo and Sauvie Island Wildlife areas, Smith and Bybee Lakes, extensive agricultural lands, extensive private forest land, and various intensities of urban/suburban development, including Portland's metropolitan area. In some instances, the analysis also considers some factors that influence the quality and importance of WHI resources from the broader region that includes the area of the Sandy River Delta, areas upstream of Portland Harbor to Willamette Falls, and large contiguous public and private forestlands west of WHI.

[6] Boundaries of Class 1 Riparian Areas through Metro include vegetated area within the first 50 feet of surface streams and canopied or woody vegetation within the first 100 feet of wetlands. Habitats of Concern are areas recognized as important to overall goals of conservation, protection and restoration. The designation recognizes the importance of stream and river corridor connectivity to adjacent upland habitats.

The purpose of the quality/quantity assessment is to provide a relative rating for habitats on WHI. The assessment assigns a low (0) to high (3) rating for habitats at each location on WHI relative to other natural habitats within the City. The criteria used to rate relative habitat quality/quantity are specific to each habitat type, and are defined such that the methodology is transparent and replicable.

The four steps in the evaluation are:

1. Define and spatially delineate habitat types (see **Section 2.2.1** below),
2. Define reasonable and practical ecological criteria and scoring rules to rate quality / quantity of each habitat type (see **Section 2.2.2 and 2.2.3** below),
3. Develop spatial data corresponding to the ecological criteria,
4. Evaluate each habitat at each location on WHI according to the criteria and scoring rules, with the overall quality/quantity rating being an average of the scored criteria, and
5. Present the results of the analysis spatially and quantitatively (see **Section 4.0**).

2.2.1 Habitat Types and Spatial Data

Seven habitat types are defined for evaluation on WHI, including three aquatic habitats and four terrestrial habitats. The three aquatic habitats are: shallow water habitat (SHW), upper beach habitat (UBC), and wetlands habitat (WET). The four terrestrial habitats are: riparian fringe habitat (RIP), forest/woodland habitat (FW), shrubland habitat (SHR), and grassland habitat (GRA). All locations on WHI are classified as one habitat type. The exception is areas located within the riparian fringe, which is defined as the zone within 150 feet of wetlands and the Columbia River. Habitat in this zone is defined both according to its vegetation type (e.g. SHR, GRA, FW) and as riparian fringe. As discussed below, all of WHI functions as riparian habitat, but areas within the RIP are expected to provide the bulk of riparian functions.

Open water of the Columbia River is recognized as an important habitat, but is not assessed as part of this evaluation of WHI natural resources. Furthermore, although not assessed using the same evaluation framework, the analysis does quantify and value in economic terms the primary ecosystem services provided on WHI. These ecosystem services include: air purification, water purification, flood regulation, climate regulation (i.e. carbon sequestration), and cultural services (including recreation cultural, aesthetic, and spiritual values) associated with habitat and biodiversity. See **Appendix B** for this analysis.

Table 2-1 lists the spatial (GIS) data used to derive vegetation community groups, habitat boundaries, and criteria to evaluate these habitats.

Table 2-1 Spatial Data Used to Develop Habitat Delineation, Evaluation Criteria, and General Site Description

City NRI vegetation	Water Bodies (Streams, Lakes, Ponds, Wetlands, River)	Port NRI 2007 vegetation
Soils	NWI, Port of Portland Wetlands	NRIU input layers
LIDAR Terrain (Elevation)	Dirt Roads	Beaches / ESI Sensitivity Index
Aerial imagery – (2005-2008)	NOAA nautical chart	Combined flood area
Drainage districts	NRI habitat patches	NRI inventory sites
NRI project boundary	NRI riparian search areas	NRI special habitat areas
Slope greater than 25%	Port of Portland Vegetation	Upper Beach habitat complexity characterization

Depth and elevation contours are used to establish the boundaries of shallow water and upper beach habitats. Port of Portland vegetation community data are used to define the extent of forest/woodland, shrubland, and grassland/herbaceous habitats. Port of Portland GIS data (wetland cover), along with data from the National Wetlands Inventory, are used to create wetland habitat extent. Riparian fringe habitat is defined based on elevation and distance from the river. Detailed definitions of each habitat type are provided in **Section 2.2.3,** following an overview in **Section 2.2.2** of criteria used in the habitat quality/quantity evaluation.

2.2.2 Definition of Criteria for Quality/Quantity Evaluation of WHI Habitats

This section defines the criteria used to rate the quality/quantity of function and associated wildlife conditions in each of the seven habitat types. The criteria are defined in order to rate relative quality/quantity on WHI compared to other natural areas in the City; so a high rating represents the high habitat quality/quantity in the context of the City. The quality/quantity criteria represent a scientific understanding of the factors that determine the quality of habitat types on WHI, including landscape features and associated level of ecosystem function. WHI is primarily a floodplain habitat and many of the criteria used to analyze the habitat quality are elements of floodplain function (wood, water, sediment and nutrient functions).

The Port of Portland's vegetation geospatial data is the primary data source to classify the vegetation community. Aerial photos, LIDAR, topographic and bathymetric profiles were used for delineating and describing additional habitat features. This data was used in combination with scoring rules to evaluate the criteria at each location. It is important to note that due to data limitations, criteria for ecosystem function was often developed using proxies or representative indicators rather than directly measured. Furthermore, there are important quality indicators, such as vertical structure of vegetation, that were not feasible to analyze in this framework given the available data.

The NRIU criteria for wildlife and riparian resources are used when applicable. The NRIU criteria are supplemented with additional criteria that address functions and attributes specific to WHI. For instance, for beach and shallow water habitat, low elevation shoreline imagery is used to score shoreline complexity such as embayments and large woody debris accumulations. A comprehensive list of the criteria used is provided below, together with a brief discussion of how scoring rules are defined.[7] The specific criteria scoring rules for each habitat type are then presented.

It is recognized that as a big, low-gradient river with substantial upstream inputs, the Columbia River itself is the largest habitat influence. However, all of the following criteria have localized effects on the quality of WHI habitat.

Channel Margin Characteristics: The channel margin area is one of the most important habitat types for many aquatic species. Water level fluctuations, riparian association, and location in the river corridor determine habitat function. Areas on WHI that have a complex channel margin habitat (beach, embayments, and diverse riparian area) are rated as higher quality habitat than other areas. Forested riparian areas, visible down wood from low elevation aerial imagery, and observations from a field tour provided information to assign higher scores on segments where these more complex conditions were visible. Applicable habitat types are: SWH, UBC, and RIP.

Food Web and Nutrient Cycling: Forest systems near streams provide most of the energy sources used in the aquatic food web. Riparian vegetation types influence the abundance and timing of inputs, which in turn influence the development of prey sources in the food web. For instance, macroinvertebrate productivity can be influenced by temperature changes and increases/decreases in organic matter input. Vegetation type within

[7] This is not a comprehensive list of the functions and influences that WHI contributes to or is a recipient of. The Columbia River is a large, dynamic influence on the condition of the island and these criteria are evident at the island scale as well as through the Columbia River ecosystem.

or adjacent to a habitat is used to rate the level of nutrient input. Forest vegetation results in a higher rating than grassland and shrubland vegetation because of greater potential annual input of organic nutrients via litterfall. While a major proportion of nutrient inputs in the SWH, UBC, and riparian habitats are from upstream, proximity to different vegetation types also affects localized nutrient input. Applicable habitat types are: SWH, UBC, RIP, and WET.

Large Wood and Channel Characteristics: Evaluations of large wood function in streams has predominantly focused on small and mid-size streams. Channel response to wood is more noticeable in smaller streams. Wood in large rivers tends to collect on floodplains or channel margins, or contributes to island development by forming mid-channel jams, creating low energy areas for sediments to deposit. Submerged wood that is buried or settles at river bottoms contributes cover habitat and substrate for macroinvertebrates and algae. The value of large wood in this assessment is associated with its function as cover habitat in channel margins that fish use. The presence of forested habitat adjacent to river or wetland habitat also is assessed for its wood recruitment value. This criterion is rated using low elevation aerial imagery, creating a GIS coverage that noted debris accumulations and locations where riparian area is mature and contiguous. Abundant wood at wrack lines and embayments receives higher scoring than bare areas or with minimal woody debris association. Man-made structures may have mixed effects, and are not considered as substitutes for large wood. As noted elsewhere, the size and the scale of the Lower Columbia River is the dominant effect on channel dynamics, but large wood on the shore of WHI does have localized effects on channel characteristics, primarily as cover habitat and substrate for algae and macroinvertebrates. Applicable habitat types are: SWH, UBC, and RIP.

Wildlife Movement Corridors: Connectivity between habitats provides opportunities for wildlife sub-populations to connect and interbreed. Mating, feeding, nesting, predator evasion, and dispersal of young are some of the benefits of habitat connectivity for animal populations. The NRIU context for migration corridor is large scale. The scoring is based on the presence/absence of physical barriers between habitat types, such as linear infrastructure that would deter non-avian species movement. Applicable habitat types are: SWH, UBC, RIP, WET, FW, GR, and SHR.

Microclimate/Shade: Vegetation cover can affect air temperature, humidity and soil moisture, which in turn can affect adjacent water bodies. In addition, direct shade can influence the water temperature in streams and wetlands. For scoring purposes, vegetation community is used as a proxy for microclimate and shade. An overhead canopy from FW rated higher as an influence on microclimate and shade than GRA or SHR. Applicable habitat types are: UBC, RIP, and WET.

Bank function, Control of sediments: Riparian vegetation and riparian wetlands are generally the primary influence in controlling erosion and retaining sediments in floodplain areas. Woody and shrub vegetation can provide dense root networks to stabilize existing banks. Woody-stemmed vegetation such as willow and dogwood can pioneer areas of new deposits and also reduce velocities that help fine sediment to drop out of suspension and contribute to island building. Rating of bank function is influenced by forest and shrub vegetation. It is important to note that due to the dams on the Columbia River, sediment input is far less than historic levels. Sediment input has been beneficial to the river forming sandbar and shallow water habitats. Bank function and associated retention of sediments on WHI remains beneficial to WHI habitats and is therefore included as a criterion to assess quality on WHI. Applicable habitat types are: UBC, and RIP.

Fish Refuge /Water Storage: Channel margin area, in particular areas with low elevation, are valuable fish resting areas due to regular hydrologic connectivity. This elevation-based criterion is rated high at locations connected at ordinary high water mark and is only applicable to UBC.

Streamflow moderation and flood storage: Structure and dynamics of habitats are influenced by the characteristics of flow and water/land interaction. WHI contains some low elevation areas adjacent to the river channel margins that have regular connectivity with the Columbia River. This connectivity enables

flood waters to be stored on WHI, thereby reducing volume and energy of flood flows and trapping sediment from floodwater. While the magnitude of streamflow moderation and flood storage functioning on WHI is small relative to the size of the Columbia River, there are localized and cumulative effects that this criterion measures. This is an elevation-based criterion focused on hydrologic function and floodwater storage rather than fish refugia. Temporary floodplain connections can be detrimental to fish that move into areas that become disconnected from the channel or drain entirely. Applicable habitat types are: RIP, WET, FW, and GRA.

Habitat Diversity/Interspersion: A grid consisting of one-hectare hexagons was superimposed on WHI using geographic information systems (GIS) analysis. Diversity/interspersion of different habitat types in an area was then derived by counting the number of habitat types within each one-hectare grid cell. The greater the number of habitat types represented in the grid, the higher the score. Upland habitat diversity, defined as the number of habitat types within a given area, can influence fish and wildlife population abundance and productivity. Habitat diversity enables wildlife species to easily utilize different habitats. Higher score is given to habitats with greater numbers of habitat types within a one-hectare area. Applicable habitat types are: GRA, SHR, and RIP.

Vegetation Community Diversity: This criterion is a measure of the plant diversity within the SHR habitat and adjacent to the WET habitat type. SHR vegetation community diversity is derived from the Port of Portland's vegetation classification, while the WET vegetation community diversity is defined based on the number of habitat types (e.g. shrubland, forest/woodland, grassland, etc) located within 150 feet of the wetland. Applicable habitat types are: SHR, WET.

Habitat patch size (of one habitat type): Habitat fragmentation is one of the greatest threats to the conservation of biodiversity and has three components: habitat loss, patch connectivity, and patch size. Larger patches can support a larger number of individuals and a greater diversity of species, support a wildlife population for a longer time period, and provide greater opportunity for foraging and dispersal. Habitat patch size is measured for forest or wetlands as the total area of contiguous forest and/or wetland, and any adjacent woodland vegetation. The riparian fringe is not assessed for patch size because its size is based on a consistent distance from the river and it thus has a predetermined patch size. Applicable habitat types are: WET, and FW.

Interior Habitat (including other habitat types, measuring WHI as a whole): Interior area is defined as the portion of the habitat that is farther than 200 feet from a developed area. Compared to areas close to development interior areas are less affected by disturbance associated with human activities. Interior habitat area is important to maintain food and habitat diversity for resident species to survive and is particularly important for species that require larger areas of contiguous habitat.

Urbanization typically increases habitat fragmentation, resulting in more edge habitat and less interior habitat.[8] Increased fragmentation favors species that thrive on habitat edges, while the reproduction and survival of interior species declines (Soule 1991). Predators such as foxes and coyotes are better able to hunt along edge habitats where prey such as birds and small mammals are easier to find. Species such as the House Finch, Anna's Hummingbird, deer and raccoons are also able to use resources in human-altered landscapes.[9] Applicable habitat types are: RIP, WET, FW, SHR, and GRA.

Connectivity to water: Connectivity to water increases species diversity. The criterion is based on wildlife movement, and is defined using distance to water and lack of barriers to movement. The assumption is that

[8] Lidicker, W. Z., and W. D. Koenig. 1996. Responses of terrestrial vertebrates to habitat edges and corridors. Pages 85–109 in D. R. M c-Cullough, editor. Metapopulations and wildlife conservation. Island Press, Washington, D.C.

[9] Bolger, D. T., Scott, T. A. and Rotenberry, J. T. (1997) Breeding bird abundance in an urbanizing landscape in coastal southern California. Conserv. Biol. 11, 406–421.

the closer a bird, mammal, or amphibian is to an aquatic environment, the higher the ease of riparian area use. Habitat patches near water resources have increased diversity of wildlife. Most wildlife species use riparian areas for some aspect of their life history. Over 60 percent of mammals in the Northwest use riparian areas for breeding or feeding. Riparian corridors frequently serve as travel routes, especially in urban areas. This criterion provides for an increasing score according to nearness to water, with thresholds at 300 feet and 150 feet, and also requires no barrier to wildlife access. A variety of studies describe distance criteria recommended in the Pacific Northwest for maintaining riparian function.[10] Applicable habitat types are: SHR, GRA, FW, and RIP.

Soil conservation: Vegetation cover reduces erosion due to overland runoff. Applicable habitat types are: GRA.

Species Habitat Associations: While no criteria were defined to be species specific, the criteria and associated scoring rules were developed with consideration for the species that utilize each habitat type. Species associated with WHI habitats are discussed in the **Section 3.4**.

2.2.3 Natural Resource Habitats Definition and Evaluation Criteria

The quality/quantity evaluation rates the condition of WHI habitats based on landscape features and associated level of ecosystem function. It is a site-specific evaluation that results in a quality/quantity rating (on a scale from 0 to 3, or low to high) for each habitat at each location on WHI. This rating is a comparative rating relative to other natural areas in the City with this habitat type, and portrays the varying quality of habitat across WHI. Criteria and scoring rules are defined for each habitat type and used to determine the site-specific quality/quantity rating. These criteria are based on peer-reviewed science. Unless other wise noted, the primary supporting research articles for rationale and criteria are included in the NRIU.[11]

In general, each location on WHI is defined as one habitat type. The exception is RIP, which is defined as the zone within 150 feet of the Columbia River or wetland shoreline. All areas within this zone are classified as RIP, and as another habitat type based on the vegetation present, whether FW, GRA, or SHR. Areas within this zone are thus evaluated both according to criteria defined for the riparian fringe and also according to the criteria defined for their vegetation-based habitat type. Some habitats (SWH, UBC, WET) are defined based on elevation criteria, while all other habitat types are based on vegetation (FW, SHR, GRA). To prevent other habitat types from overlapping, the following rules were established: 1) WET, regardless of overlapping vegetation, are classified as WET, and 2) vegetated areas within the upper beach elevation band are classified according to their vegetation type.

Following the definition of each habitat and a discussion of general evaluation considerations, a table is provided that summarizes the criteria and specific scoring rules used to rate quality/quantity for that habitat type. Based on the GIS analysis, each habitat at a given location receives a score for each criterion defined for that habitat type. Scores are defined as: 0 (low), 1, 2, or 3 (high). As described above, the overall quality/quantity rating for habitat at a specific location is an average of the site-specific criterion scores.[12] For

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[10] Johnson, A. W., and D. M. Ryba. 1992. A literature review of recommended buffer widths to maintain various functions of stream riparian areas. Prepared for King Co. Surface Water Manage. Div., Aquatic Resour. Consult., Seattle. 28pp and United States Forest Service, United States Fish and Wildlife Service, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, National Park Service, United States Bureau of Land Management, and United States Environmental Protection Agency. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Rep. of the For. Ecosys. Manage. Team. U.S. Gov. Printing Office, Washington, D.C. and Gregory, S., and L. Ashkenas. 1990. Riparian management guide: Willamette National Forest. Oreg. Dept. Fish and Wildl. Portland. 120pp.

[11] City of Portland Bureau of Planning. In draft. Natural Resource Inventory Update. Riparian corridors and wildlife habitat (July 2008 Discussion Draft). City of Portland, OR.

[12] Some habitats or functions are island wide and cannot necessarily be spatially differentiated with different scores. For instance all of WHI island functions as a riparian zone and as a floodplain. We were not able to discriminate spatially where those functions may be more important on certain parts of the island than in other areas. In extreme floods, the entire island functions to retain water, and benefits from newly deposited

example, if there are four criteria defined for SWH habitat, then each location with SWH would be evaluated according to these four criteria and assigned a score for each criterion, such as 2, 2, 3, 3. These four scores would be averaged to obtain an overall score of 2.5 for the overall quality rating of SWH at that location.

2.2.3.1 Shallow Water

Definition: The shallow water habitats (SWH) extends from – 21.0 feet to +9.5 feet (NAVD88 vertical datum) and include side channels, sloughs, floodplains and salt marshes that throughout the tidal cycle maintain depths from 0.3 to 6.6 feet.[13]

Description and Evaluation Considerations: Human activities such as land use practices and modified river flows have altered this type of habitat by impacting sediment routing and shoreline characteristics. The diverse conditions in WHI SWH are due to the changing tidal amplitude in the lower Columbia River, changes in land elevation due to development, and possibly from reductions in the magnitude of spring freshets due to hydropower-related flow management.

SWH are important to salmonid fry and fingerling life history strategies as the salmon seek out and prefer shallow, low velocity, shoreline areas. SWH also provides refuge and nutrients for out-migrating salmonid smolts. Insects and epibenthic and pelagic amphipods are critical prey sources for salmonids present in this habitat. The sand and fine substrate typical of the lower Columbia may provide habitats for juvenile lamprey that reside in sandy substrates in shoreline areas. Migratory waterfowl and shorebirds also depend on shallow water habitats, utilizing aquatic vegetation and prey resources.

SWH habitat can be impacted by various management practices that affect tidal and riverine energy regimes and sediment processes. Migratory movements on the edge of the island are rated according to complexity of the upper beach habitats and features that would provide cover for rearing and prey resources for migratory salmonids. There is some evidence that lamprey densities in the sediment may be higher at shallow sites in these types of habitats.[14] This may be due to higher oxygen concentrations in the sediments at these sites, or improved access to food.

The benthic community is an important resource associated with this habitat. McCabe and Hinton[15] provide an assessment of macroinvertebrate communities in beach nourishment areas, and up until that point not much was known about benthic invertebrate communities in freshwater, beach habitats of the Columbia River downstream from Bonneville Dam. Their taxa observations included nemerteans, oligochaetes, Asian clam, water amphipods and biting midge larvae. Lower estuary benthic invertebrate communities in the Columbia River downstream from river kilometer 50 have been studied more than upstream populations and upstream benthic invertebrate studies have been generally short-term or geographically limited. Fishman[16] characterized WHI sediments and benthic invertebrate communities and found the Asian clam and brackish water amphipod to be the most abundant species on the north side of the island and oligochaete worms and chironimids (midge fly) larvae to be most abundant on the south side of the island. Species richness overall was low and likely a function of small sediment particle sizes. The transient nature of sediments and the disruptive current and

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sediments and nutrients that build the organic topsoil of the island. Floodplain functions also include flood storage, sediment retention, nutrient and pollutant filtration, organic waste processing and groundwater recharging.

13 The elevation criteria were selected to include the tidal influence. Shallow water habitat's spatial extent is dynamic and these broad elevation criteria intend the capture the range of where it could occur from high to low tide heights.

14 Altman, B. C.M. Henson, and I R Waite. 1997. Summary of Information on Aquatic Biota and Their Habitats in the Willamette Basin, Oregon, through 1995. Water-Resources Investigations Report 97–4023. Prepared in cooperation with the USFWS and as part of the National Water-Quality Assessment Program.

15 McCabe G.T. Jr. and S.A. Hinton. 1996. Benthic invertebrates and sediment characteristics in freshwater, beach habitats of the lower Columbia River, 1994-95. National Marine Fisheries Service Northwest. Seattle WA 98112.

16 Fishman Environmental Services, LLC. 1995. West Hayden Island Development Program. Technical Report: Aquatic Biology Investigations. Prepared for: Port of Portland Property and Development Services. Portland, OR.

wave action can also prohibit establishment of diverse and abundant benthic invertebrate communities. The brackish water amphipod are seasonally important in the diets of juvenile salmonids. Muir and Emmett[17] found that these and *Corophium spinicorne* were the dominant prey for juvenile salmonids collected during the spring of 1984 at Bonneville Dam.

Criteria and Scoring Rules:

The criteria used to asses SWH areas were primarily based on features that would benefit shore birds, salmonids, and macroinvertebrate productivity. Specifically, the criteria relate to level of energy/flow, complexity of shoreline areas, degree of debris concentration at the wrack line, vegetation on shoreline for organic material and insect input, and presence of artificial impediments to movement. It is recognized that large wood on the shore of WHI does not influence lower Columbia River channel dynamics, but is important on the localized scale.

Flow characteristics are very important in this habitat type. While macroflow characteristics are common across the island, there are localized effects due to channel margin dynamics that are included in the evaluation criteria. Flow and substrate data for shallow water habitat around WHI has not been collected. As field data collection was not conducted as part of this work, no flows were measured nor were substrates analyzed on-site in SWH. A proxy for flow, which is a main contributing factor for the quality of salmonid refugia habitat, is slope of the river channel margin. A proxy for substrates is the UBC adjacent to the SWH. SWH slope data is not available, so the slope of the adjacent UBC, as well as existence of embayment or alcove features, was used. Slope is defined using the traditional equation of vertical rise divided by horizontal run.

Temperature is also important in this habitat type, but localized effects are limited due to the size of the Columbia River. This factor, combined with the lack of existing data, resulted in no criterion being developed related to temperature.

Table 2-2 Habitat Evaluation Quality/quantity Criteria: Shallow Water Habitat

	Scoring Rules			
Criterion	0	1	2	3
Nearshore/Bank Influence	Hardened bank, seawalls, artificial structures not functioning with habitat benefit	Hardened Bank	Vegetation combined with bank hardening or artificial structure providing habitat benefit	Natural or vegetated, may have enhancement feature
Channel Margin Characteristics	Developed structures (cement/rip rap) on shoreline.			Fine and coarse grained sand beaches.
Food Web and Nutrient Cycling, Microclimate,Shade	Forest/woodland farther than 170 feet from landward boundary.	Forest/woodland within 170 to 70 feet from landward boundary.	Forest/woodland within 25 to 70 feet from landward boundary.	Forest/woodland within 25 feet (provide rationale for 25 ft) of landward boundary.
Large Wood and Channel Dynamics	Upper Beach Score = 0 for channel margin characteristics.	Upper Beach Score = 1 for channel margin characteristics.	Upper Beach Score = 2 for channel margin characteristics.	Upper Beach Score = 3 for channel margin characteristics.
Wildlife Movement Corridor (Parallel to Beach)	Artificial barriers to shoreline movement (Piers, docks, etc) within 300 feet along the shore).			Absence of artificial shoreline barriers within 300 feet along the shoreline.

[17] Muir, W. D., and R. L. Emmett. 1988. Food habits of migrating salmonid smolts passing Bonneville Dam in the Columbia River, 1984. Regul. Rivers: Res. & Manage. 2:1-10.

2.2.3.2 Upper Beach

Definition: Upper Beach habitat (UBC) extends from +9.5 feet to +18 feet (NAVD88 vertical datum) and is comprised of the upper intertidal beach not included in SWH. The +18 feet NAVD88 elevation is slightly higher than the National Marine Fisheries Service elevation criteria of "normal line of high water" (58 FR 68543) in order to include the extreme high water areas. To the extent that vegetation types are present within this elevation zone, the habitat is not classified as UBC but rather classified according to the vegetation class (e.g. if there is shrubland within the UBC elevation zone, the habitat is classified as shrubland rather than UBC). The main intent of this habitat delineation is to capture the dynamics and contribution of the riparian/beach interface. In very large rivers, the vegetation demarcation of the ordinary high water mark can be less discrete than in smaller rivers.

Description and Evaluation Considerations: Beach habitat forms the northern and extreme southern boundaries of the island. UBC is connected to open water emergent wetlands on both shores. Beach habitat is either barren or very sparsely vegetated with weedy species such as dock, plantain, and Canada thistle. Through aerial photo validation, beach or nearshore habitat is bordered by the riparian fringe, which may include such vegetation types as meadow, forest, grassland, or shrubland which often contain extensive stands of Himalayan blackberry. The primary functional contributions of UBC is benthic invertebrate habitat, fine sediment characteristics that are not accounted for in the SWH area and riparian/beach ecotone that is used by mammals and birds for nesting/denning, foraging, or migration. High quality/quantity UBC can also provide a complex channel margin habitat used by fish species during migration, foraging, or rearing. While UBC provides fish habitat only during short periods of inundation, it can provide a significant feeding opportunity for fish.

The quality of the habitat is indicated by the presence of large woody debris at the wrack line or in channel margin areas where debris has accumulated, which is associated with a forested riparian area. Low slope beaches have some risk of wind-generated or ship wake wave-generated waves running up on to the beach potentially stranding juvenile salmon. Sloped beaches reduce the risk of stranding juvenile salmonids due to ship wake waves.[18] Although ship traffic may be slower along the WHI reach area that Pearson et al. evaluated, the channel confinement[19] is much less than some of the areas evaluated. Embayment or alcove features receive high scoring. These areas do not have a slope criterion because they serve as refugia during high water periods regardless of slope, either tidally or during flooding. We used aerial imagery to locate embayments or alcove-type habitats and the presence of flotsam/jetsam. This material suggests low velocity or eddy areas that collect food resources for fish and wildlife. Excessive beach slope suggests higher energy dynamic, erosion and sediment transport functions that may not provide the low velocities more conducive to salmon rearing and foraging and reduced risk of juvenile ship wake wave stranding.

Criteria and Scoring Rules:

As noted above, beach slope is defined using the traditional equation of vertical rise divided by horizontal run. The highest score for upper beach is received for a combination of gently sloped beach and signs of low energy, as well as proximity to vegetation providing microclimate/shade, bank function, and nutrient inputs. Substrate is used as the best proxy indicator of channel margin characteristics.

[18] Pearson, W.H., G. E. Johnson, J. R. Skalski, G. D. Williams, K. L. Sobocinski, J. A. Southard, M. C. Miller, and R. A. Buchanan. 2006. A study of stranding of juvenile salmon by ship wakes along the Lower Columbia River using a before-and-after design: Before-Phase Results. Report No. PNNL-15400. Prepared for the U.S. Army Corps of Engineers, Portland District. Portland, Oregon. 206 p.

[19] Channel confinement is a strongly correlated to the potential for ship wake effects because of shorter wave travel distance and water level rise due to displacement from large vessels in a confined area.

Table 2-3 Habitat Evaluation Quality/Quantity Criteria: Upper Beach

	Scoring Rules			
Criterion	0	1	2	3
Channel Margin Characteristics	Developed structures (cement/rip rap) on shoreline.	Fine and coarse grained sand beaches with slope < 2.5% or > 5%[a] and no embayments/alcoves.	Fine and coarse grained sand beaches with slope between 2.5% and 5% and no embayments or alcoves.	Embayment or alcove feature[b].
Microclimate/Shade	No / Sparse vegetation within 30 feet.	GRA or SHR within 30 feet Upper Beach (microclimate).	FW within 30 to 300 feet (shade and microclimate).	FW within 30 feet of Upper Beach.
Foodweb and Nutrient Cycling	FW farther than170 feet from landward boundary.	FW between 70 and 170 feet from landward boundary.	FW between 25 and 70 feet from landward boundary.	FW within 25 feet of landward boundary.
Large Wood and Channel Dynamics	Absence of woody debris.		Woody debris present in a non-embayment feature suggesting transient nature of wood.	Woody debris present in embayment feature.
Bank function, Control of sediments	No vegetation/sparse vegetation within or bordering Upper Beach.	GRA borders or within Upper Beach.	SHR vegetation borders or within Upper Beach.	FW vegetation borders or within Upper Beach.
Fish Refuge / Water Storage	No off channel connection at ordinary high water mark.			Access to side channel / off channel habitat – off- channel connected at 18' NAVD88 (15' NGVD29) (ordinary high water mark).
Wildlife movement corridors (non-avian species)	Artificial impediments blocking passage visible within 300 feet.	No vegetation/sparse vegetation within or bordering Upper Beach but no artificial impediments blocking passage within 300 feet.	GRA vegetation and no artificial impediments blocking passage within 300 feet.	SHR or FW vegetation and no artificial impediments blocking passage within 300 feet.

[a] Rise over run slope used for this habitat located at terrestrial/aquatic interface. Slope criteria is based on risk for juvenile ship wake wave stranding.

[b] No slope criteria is needed for a 3 rating because the value of embayments and low velocity areas are favorable conditions for fish species.

2.2.3.3 Wetland

Definition: WHI wetland habitat (WET) is derived primarily from the Port of Portland's 1999 wetlands delineation inventory that was based on topography and field verification and the National Wetlands Inventory. Additionally, any area with hydrophytic vegetation or delineated as a pond in the Port vegetation data is classified as WET. There is no distinction between natural versus mitigation wetland; the analysis evaluates all wetlands according to the same criteria as defined below.

Description and Evaluation Considerations: Wetlands provide important water quality functions, including water quality improvement, wildlife habitat, and water storage. They reduce the impacts of excess nutrients in storm water runoff on downstream waters. Essentially equivalent to pollution removal, a wetland contributes to water quality by trapping sediment during periods of heavy rainfall, keeping it from entering adjacent downstream resources. Wetlands also trap nutrients such as nitrogen and phosphorus, helping to prevent or minimize algal blooms and subsequent oxygen deficiencies downstream. Wetlands reduce downstream flood peaks and store floodwaters by acting as flood regulators, trapping water during periods of high precipitation or flooding, and slowly releasing the flow downstream. The wetland forest plant community (approximately 11 acres) is very similar to that of the upland riparian forest. The difference between the two is based upon the dominant plants, which are either obligate wetland species or species that are more strongly associated with wetlands than uplands. These WHI habitats provide food and cover resources for a variety of migrant and resident species and provide critical habitat for several species

Placement of dredging material since the 1940s has changed the elevation of the island and likely the vegetation community and succession. Additional elevation criteria were used to recognize hydrologic connectivity to mainstem Columbia hyporheic zones and the potential influence of stage on wetland water levels. Hydrology and associated riparian areas are the biggest driver for WET functions and so wetland quality/quantity is scored primarily in terms of size, elevation, and proximity to other habitats. Size and elevation suggests that larger and lower elevation habitats may be used by more species for longer time periods. Proximity to other habitats suggests provides for the potential for the habitat to be used by a greater number of species.

In the NRIU all wetlands provide primary functions and there is no differentiation between wetland size, type, etc. In contrast, this analysis recognizes that larger wetlands provide greater streamflow moderation, as well as control of sediments, nutrients, and pollutants. WHI contains 34 discrete wetlands, with the largest wetland being Benson pond at 5.5 acres. Five other WHI wetlands are larger than 3 acres. For comparison of the level of nutrient, sediment, and pollution control function on WHI, wetland size is used as a proxy for function. The level of streamflow moderation and control of sediments, nutrients, and pollutants at a given wetland also varies by location based on the volume and quality of runoff being filtered through the wetland. This location factor is included in the criteria based on connectivity of a given wetland to the mainstem of the Columbia River.

Quality of wetland is also assessed based on vegetation diversity. Vegetation community diversity is derived from the Port of Portland's vegetation classification, and is defined based on the number of habitat types (e.g. shrubland, forest/woodland, grassland, etc) located adjacent to a wetland. The vegetation community criterion suggests that a habitat characterized by diverse adjacent habitats is more productive and used by a broader range of species. Microclimate/shade criterion was based on the relationship that a greater percentage of canopy surrounding the wetland will contribute more shade. The Wildlife movement corridor criterion is an aquatic-based wildlife corridor for migrating from the island interior to the Columbia River based on elevation (the ability of perpendicular migration of wildlife between interior habitats and the river).

Upland meadow wetland occurs along the north shoreline, within powerline rights of way, and on pile dikes along WHIs southern shoreline. It is dominated by grasses and herbs or by extensive stands of Himalayan blackberry. Cattle grazing has had the most direct impact on the developing vegetation community by maintaining grasses and herbaceous vegetation at low heights via grazing or trampling, and also inhibiting seedling overstory tree species from turning into overhead canopy. Emergent wetlands occur throughout the site in open areas along the north shoreline, within meadow habitats (e.g., powerline corridors), and within or at the edge of forested habitat. These wetlands function as open water, mud flat, or meadow habitats for wildlife. Within the forest habitat most of the emergent wetlands are associated with willow, Oregon ash, or cottonwood/willow/ash plant associations. Reed canary grass is the common dominant species within emergent wetlands throughout the site. Other plants found within emergent plant communities include various grasses, knotweed, touch-me-not, and beggarstick. Ground cover within this habitat approaches 100 percent. In many instances, where water ponds during winter and spring months, bare ground areas are present in the summer and fall. Larger wetlands are given higher scoring since they can retain a higher volume of water and typically through a longer period depending on the depth.

Criteria and Scoring Rules:

The specific criteria and scoring rules for WET are provided in **Table 2-4** below. The quality rating is based on wetland size, adjacent vegetation diversity, absence of wildlife movement barriers, and contiguous forest/woodland habitat patch size.

Table 2-4 Habitat Evaluation Quality/Quantity Criteria: Wetland

	Scoring Rules			
Criterion	0	1	2	3
Stream Flow Moderation and Water Storage, Control of Sediments, Nutrients, Pollutants and Organic Inputs and Food web		wetland less than 3 acres.	> 3 acres,	> 3 acres AND connectivity to mainstem during flood stage (< 20' NAVD88) [a]
Vegetation Community Diversity (based on Port vegetation layer)	1 vegetation community type within 150 feet of wetland boundary.	2 vegetation community types within 150 feet of wetland boundary.	3 vegetation community types within 150 feet of wetland boundary.	4 or more vegetation community types within 150 feet of wetland boundary.
Microclimate and Shade	Less than 25% of vegetation within 100 feet of the wetland boundary is FW/SHR.	25-50% of vegetation within 100 feet of the wetland boundary is FW/SHR.		More than 50% of vegetation within 100 feet of the wetland boundary is FW/SHR.
Wildlife Movement Corridor (movement in riparian zone is captured in riparian habitat, this captures movement to and from river)		Elevation is greater than 20' NAVD88.	Connectivity to mainstem (OHWM from 9' to 20' NAVD88).	Connectivity to mainstem (9' NAVD88 or less).
Interior Habitat	Distance of less than 200' from developed surface or contiguous with 2 acres or fewer of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 2 to 15 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 15 to 500 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 500 or more acres of terrestrial habitat.
Habitat Patch Size (wetland and adjacent forest/woodland)	Contiguous FW and WET habitat less than 2 acres.	Contiguous FW and WET habitat 2 to 30 acres.	Contiguous FW and WET habitat 30 to 585 acres.	Contiguous FW and WET habitat is 585 acres or more.

2.2.3.4 Riparian Fringe[20]

Definition: All of WHI provides riparian function due to the island being surrounded by the Columbia River. For the purposes of this analysis the term "Riparian Fringe" represents the area of WHI bordering the shoreline area that provides the primary riparian functions. Riparian Fringe habitats (RIP) extend from +18' NAVD88 (general delineation of the shoreline elevation maintaining perennial woody vegetation) to 150 feet inland from the river.21 Additionally, riparian habitat is defined as areas within 150 feet[22] of wetlands. The +18' NAVD88 elevation is slightly higher than the National Marine Fisheries Service elevation criteria of "normal line of high water" (58 FR 68543) in order to delineate the additional characteristics of UBC. In defining the RIP, the analysis recognizes that the entire island is riparian but that the predominance of riparian function occurs within the 150-foot band near the Columbia River and wetlands. As noted above, areas that are classified as RIP are also classified based on their vegetation type. In all acreage calculations, this is clearly noted and acreage totals do not include this duplication in order to avoid double counting of this area.

Description and Evaluation Considerations: RIP are established and maintained through flooding and fluvial geomorphic processes that have been greatly modified from natural conditions. Large areas of the island that were once strictly riparian experiencing regular flooding now have some upland characteristics. This change in flood frequency can alter vegetation succession (in particular, cottonwoods are located in upland areas that were formerly regularly flooded, and once their die-off occurs they may be replaced by

20 In a regional context, all of West Hayden Island is considered a Riparian Habitat because of its mid-channel location within the floodplain. To evaluate the specific contribution of areas directly adjacent to water bodies, the habitat element "Riparian Fringe" was used in this assessment.

21 The +18' NAVD88 elevation is slightly higher than the National Marine Fisheries Service elevation criteria of "normal line of high water" (58 FR 68543) in order to delineate the additional characteristics of Upper Beach habitats.

22 150' is a distance of forested buffer that is known to provide the majority of streamside function (wood, shade, nutrient input, bank stability, overland runoff absorption) excluding microclimate. In large rivers, the microclimate function is less of a direct influence on stream cooling and insulation and the predominant influence on stream temperature is from upstream characteristics and direct solar input on the rivers large surface area.

other species, primarily alder.) The process of flooding contributes critical function in these areas including nutrient replenishment, groundwater recharge, and influence on vegetation succession. WHI riparian areas also include springs, seeps, and intermittent runoff areas coincident with the changing river flood levels and precipitation and are diverse in characteristic ranging from sparsely vegetated areas to sand/grass vegetation to shrub communities to a cottonwood ecosystem with diverse understory.

The quality of riparian fringe habitats is based on physical, biological, and chemical inputs to the aquatic environment and stream-adjacent terrestrial environment. Intact, contiguous riparian corridors provide essential healthy watershed functions including bank and bed function, food, shade, shelter vegetation, nutrients and sediment buffers, and are a source of large woody structure for terrestrial and aquatic wildlife. Vegetation community characteristics are a major determining factor in the criteria. Root structure and organic debris input are physical contribution factors, nutrient input and litterfall are biological contributions, and the litterfall and subsequent decomposition of organic matter provide chemical contributions. Providing structural habitat within the area is another physical contribution. Nutrient uptake of riparian areas is also a key function. Shade and related microclimate function are important roles in large rivers, although most of the riparian research has taken place on smaller rivers or within smaller watersheds. In larger rivers, microclimate can influence soil temperature which in turn can influence hyporheic flows (underground) depending on subsurface water levels, but groundwater volume may be too substantial for this to be the case on WHI. Most of our evaluation criteria assume that forested areas with canopy have a greater influence on inputs to the stream including large wood, nutrient, microclimate and bank function. Our ratings for habitat diversity and patch size are derived from a habitat adjacency analysis using one-hectare hexagons and NRIU criteria, respectively.

Riparian corridors also provide benefits for air, land, and water resources by trapping sediments and filtering runoff. Riparian corridors and associated wetlands and floodplains provide a valuable flood management function by reducing the force and volume of floodwaters, temporarily storing water therefore reducing peak flows and downstream flooding. Riparian shade, especially forest canopy, moderates temperature within and adjacent to a water resource and moderates soil temperature allowing cold-blooded amphibians to utilize broader streamside areas for feeding.

Criteria and Scoring Rules:

The specific criteria and scoring rules for RIP are provided in **Table 2-5** below.

Table 2-5 Habitat Evaluation Quality/Quantity Criteria: Riparian Fringe

	Scoring Rules			
Criterion	0	1	2	3
Organic inputs (Litterfall/nutrient) and food web	No vegetation.	Vegetation classified as Grassland/Herbaceous.	Vegetation classified as Shrubland.	Vegetation classified as Forest/Woodland.
Large Wood and channel dynamics[a]	Forest/woodland farther than 170 feet from location in the riparian fringe.	Forest/woodland between 70 and 170 feet.	Forest /woodland between 25 and 70 feet.	Forest/woodland within 25 feet.
Microclimate and Shade	No / Sparse vegetation within 30 feet.	Grassland/Herbaceous or shrubland within 30 feet of habitat edge. (microclimate).	Forest/woodland within 30 to 300 feet of habitat edge.	Forest/woodland within 30 feet of habitat edge
Bank function, control of sediments, nutrients, and pollutants[b]	Developed, or non-vegetated land within 100 feet.	Grassland/herbaceous vegetation land within 100 feet.	Forest/woodland/shrubland vegetation between 25 to 100 feet.	Forest/woodland/shrubland vegetation within 25 feet.
Streamflow moderation and flood		Riparian area inundated at extreme high flood events (>20'		Riparian area is elevation of

	Scoring Rules			
Criterion	0	1	2	3
storage / capture of sediments and nutrients		NAVD88).		18 - 20' NAVD88) .
Wildlife movement corridors (non-avian species)[c]	Artificial impediments blocking passage visible within 300 feet.	No vegetation/sparse vegetation but no artificial impediments blocking passage within 300 feet.	Grassland/herbaeous vegetation and no artificial impediments blocking passage within 300 feet.	Forest/woodland or shrubland vegetation and no artificial impediments blocking passage within 300 feet.
Connectivity to water		Farther than 300 feet from a river, stream, or wetland and no artificial barrier to movement.	Between 300 feet and 150 feet of a river, stream, or wetland and no artificial barrier to movement.	Within 150 feet of a river, stream, or wetland and no artificial barrier to movement.
Habitat diversity / Interspersion	Only riparian habitat type within a 1-hectare area.	Riparian and 1 additional habitat type within a 1-hectare area.	Riparian and 2 additional habitat types within a 1-hectare area.	Riparian and 3 additional habitat types within a 1-hectare area.

a Generally, the closer to the stream, the higher likelihood that a tree has to recruit to the stream. Certainly other factor such as bank erosion and windthrow can influence the distance. Pacific Northwest research has reported recruitment distances in terms of site potential tree height, and primarily the evaluations have been conducted in conifer forests in smaller streams. The distance categories provided here are reasonable calibrations for hardwood trees. McDade et al. (1990) estimated that 83% of hardwoods recruited to the channel came from within 30 meters of the channel margin.

[b] 25' is a reasonable representation of ½ crown width where roots structure would extend to the drip line. At this distance roots provide bank function features and can provide nutrient/pollutant uptake if adjacent to surface water.

[c] The assumption is that higher, denser, diverse vegetation is more conducive to migration for a variety of animal groups. 300' is the criteria used for NRIU corridor evaluation. Barriers are specific to terrestrial species as avian species are not impacted by on-the-ground barriers.

2.2.3.5 Forest/Woodland

Definition: Forest/woodland (FW) is a vegetation-based habitat that is derived from the Port of Portland vegetation survey and combines the following vegetation communities: 1) cottonwood, 2) cottonwood, willow scrub-shrub, 3) cottonwood, willow, ash forest, and 4) mixed conifer-hardwood. FW is also used as criterion for scoring habitat diversity when near other habitat types.

Forest and woodlands are distinctly different structures of forest. A forest has a largely-closed canopy; the branches and foliage of trees interlock overhead to provide extensive and nearly continuous shade. Woodlands, on the other hand, allow sunlight to penetrate between the trees, limiting shade. Woodlands may also support an understory of shrubs, herbs, or grasses. WHI woodlands transition to shrublands and grasslands. WHI FW has predominantly a woodland structure, which favors wildlife diversity.

Description and Evaluation Considerations: Forests and woodland habitats of WHI maintain a diversity of vegetative communities which contributes to their use by diverse species. FW helps preserve water quality by providing absorption and transpiration services. Forests absorb nitrogen in both surface and shallow groundwater, trap phosphorous-laden sediment, induce groundwater recharge and minimize flooding, and remove other pollutants resulting from adjacent land uses and from atmospheric deposition. These habitats are used by deciduous forest interior dwelling birds. These types of birds reproduce only in interior forests (i.e, Pacific slope flycatcher, Swainson's thrush, barred owl, pileated woodpecker, and brown creeper). Habitat patch size, the presence of wildlife corridors, and proximity to aquatic habitat are the primary components of habitat quality. Quality of forest/woodland areas is also influenced by the proximity of developed areas. An interior habitat criterion defined based on distance to developed areas is used to capture the influence of development and to provide a metric for evaluating potential future development.

Modern elevation rise of the island from dredge material placement and hydraulic controls on the river have allowed upland forest characteristics on WHI. WHI hosts a complex forest community occurring as several associations of black cottonwood that include Pacific willow, Oregon ash, red-osier dogwood, stinging nettle, snowberry, and other shrubs in various combinations. For instance, the black cottonwood/Oregon ash riparian

woodland within the eastern portion of the site has stinging nettle and snowberry as dominant understory plants. In the western and west central woodlands, the plant association is primarily black cottonwood/red osier dogwood/willow with gooseberry and wild rose in the shrub layer. Throughout the site, wetland forests occur mostly on the south side of the island in the lower elevation areas between the pile dikes. Pacific willow, Oregon ash, and black cottonwood are all present.

Criteria and Scoring Rules:

Criteria and rules for evaluating FW habitat are presented in **Table 2-6** below. Criteria are based on size and configuration of habitat, connectivity to the Columbia River as a proxy for flood water moderation and storage, and the ease of wildlife movement (based on absence of artificial barriers).

Table 2-6 Habitat Evaluation Quality/Quantity Criteria: Forest and Woodland

	Scoring Rules			
Criterion	0	1	2	3
Habitat patch size (wetland and adjacent forest/woodland)	Contiguous forest/woodland habitat less than 2 acres.	Contiguous forest/woodland habitat 2 to 30 acres.	Contiguous forest/woodland habitat 30 to 585 acres.	Contiguous forest/woodland habitat is 585 acres or more.
Wildlife movement corridor (non-avian species)	Artificial impediments blocking passage visible within 300 feet.			No artificial impediments blocking passage within 300 feet.
Connectivity to water		Farther than 300 feet from a river, stream, or wetland and no artificial barrier to movement.	Between 300 feet and 150 feet of a river, stream, or wetland and no artificial barrier to movement.	Within 150 feet of a river, stream, or wetland and no artificial barrier to movement.
Streamflow moderation/ Water Storage (connectivity to river)		Elevation is greater than 20' NAVD88.	Connectivity to mainstem (OHWM from 9' to 20' NAVD88)	Connectivity to mainstem (9' NAVD88)
Interior Habitat	Distance of less than 200' from developed surface or contiguous with 2 acres or fewer of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 2 to 15 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 15 to 500 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 500 or more acres of terrestrial habitat.

2.2.3.6 Shrubland

Definition: Shrubland (SHR) of WHI is comprised of non-forested or early successional forests, shrub, and other vegetated, non-grassland areas. The cover is derived from the Port of Portland vegetation survey and combines the following vegetation communities: 1) blackberry scrub-shrub, and 2) scrub-shrub.

Description and Evaluation Considerations: SHR communities have vegetative structure and diversity that provide vital nesting, brood rearing, and feeding habitats for wildlife. These communities are habitat patches with woody plants typically less than ten feet tall with scattered open patches of grasses and forbs often diverse in species. Pioneer species are expected to occupy SHR. On WHI, this habitat is dominated by dense thickets of Himalayan blackberry, sparse willow, Pacific ninebark and snowberry with stinging nettle, pennyroyal, touch-me-not, and other associated wetland shrubs.

WHI provides habitat for the many species of wildlife that require early-successional forest and shrub habitat for nesting, breeding, and brood rearing. This habitat also provides a variety of food sources for birds. SHR-dependent songbirds such as warbler species can often successfully nest in small isolated patches of shrubs within forested openings. Openings containing both herbaceous vegetation and shrubs are generally the most valuable for wildlife, because of the vegetative diversity and amount of food that they provide. SHR can also grow in soils of low fertility, as well as in better quality soils. WHI soil is primarily sand that allows shrubs to

serve as pioneer species. Insects, reptiles, and mammals also benefit from the cover habitat and food sources shrubs can provide.

Species use of SHR can be enhanced if surrounded by other types of habitats. Evaluation criteria for SHR include habitat diversity and connectivity to water. Adjacent forests and grasslands allow birds and wildlife to forage or hunt in grasslands while retaining nesting/denning/burrowing habitat within the SHR. Connectivity to water provides a greater potential for increased species diversity. The distance criterion for connectivity to water, although typically regarded as the distance for functional input, is a general rule in this element and related to wildlife movement not function.

Criteria and Scoring Rules:

Criteria and rules for evaluating SHR habitat are presented in **Table 2-7** below. Criteria are based on size and configuration of habitat, connectivity to the mainstem as a proxy for flood water moderation and storage, the ease of wildlife movement (based on absence of artificial barriers), and level of vegetation diversity both within the shrubland patch (number of vegetation classes) and also the degree of localized interspersion with other WHI habitat types (number of habitat types in vicinity).

Table 2-7 Habitat Evaluation Criteria: Shrubland

	Scoring Rules			
Criterion	0	1	2	3
Plant Diversity derived form Port vegetation data	Monotypic species representation or potential invasive species.	2 vegetation community types.	3 vegetation community types.	4 or more vegetation community types.
Habitat Diversity /Interspersion	Only shrubland habitat type within a 1-hectare area.	Shrubland and 1 additional habitat type within a 1-hectare area.	Shrubland and 2 additional habitat types within a 1-hectare area.	Shrubland and 3 additional habitat types within a 1-hectare area.
Interior Habitat	Distance of less than 200' from developed surface or contiguous with 2 acres or fewer of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 2 to 15 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 15 to 500 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 500 or more acres of terrestrial habitat.
Streamflow moderation/water storage		Elevation is greater than 20' NAVD88.	Connectivity to mainstem (OHWM from 9' to 20' NAVD88)	Connectivity to mainstem (9' NAVD88)
Wildlife Movement Corridor (non-avian species)	Artificial impediments blocking passage visible within 300 feet.			No artificial impediments blocking passage within 300 feet.
Connectivity to water		Farther than 300 feet from a river, stream, or wetland and no artificial barrier to movement.	Between 300 feet and 150 feet of a river, stream, or wetland and no artificial barrier to movement.	Within 150 feet of a river, stream, or wetland and no artificial barrier to movement.

2.2.3.7 Grassland/Herbaceous

Definition: Grassland/Herbaceous (GRA) habitats of WHI possess upland prairie characteristics with a substratum of well-drained sandy soils primarily comprised of dredge materials located outside the riparian fringe. The cover is derived from the Port of Portland vegetation survey and combines the following vegetation communities: 1) grass/forb mowed, 2) herbaceous upland, 3) herbaceous upland (planted), and 4) pervious wasteland/barren/weedy fill. This latter vegetation class describes the dredge material management area on the northeastern portion of WHI. This area is evaluated as grassland because the disturbance and ensuing vegetation growth functionally mimics some grassland features. Some incidental Himalayan blackberry that is not captured in shrubland, may also be included in GRA.

Description and Evaluation Considerations: Grasses (in general graminoids), forbs and wildflowers, are the predominant vegetation community with woody vegetation comprising less than 25 percent of the area. Sparsely vegetated areas, predominately comprised of exposed soil, are included in this category. These areas provide habitat for generalist species such as moles, voles, and other small mammals and are likely used by predators such as coyotes or raptors. Bird species requiring grassland habitat include the savannah sparrow, American pipit, Lazuli bunting, barn swallow, cliff swallow, Western kingbird, western meadowlark, horned lark, red-winged blackbird, and yellow-headed blackbird. GRA are also used by a variety of songbird species.

Grasslands, in particular when associated with river, streams, or wetlands, serve as migratory stopovers for north-south and east-west flyways in this region. Invasive plant species can be the biggest threat to GRA, as can colonization by woody-stemmed plants and succession into shrubland. GRA are more limited in terms of food supply and cover for wildlife. However, red-tailed hawks and owls use perch sites within the forest to located and feed on small mammals and ground feeding birds in GRA.

Criteria and Scoring Rules:

Criteria and rules for evaluating GRA habitat are presented in **Table 2-8** below. Similar to SHR and FW, criteria are based on size and configuration of habitat, connectivity to the mainstem as a proxy for flood water moderation and storage, the ease of wildlife movement (based on absence of artificial barriers), and level of vegetation diversity both within the shrubland patch (number of vegetation classes) and also the degree of localized interspersion with other WHI habitat types (number of habitat types in vicinity).

Table 2-8 Habitat Evaluation Quality/Quantity Criteria: Grassland/Herbaceous

	Scoring Rules			
Criterion	0	1	2	3
Soil conservation	Vegetation classified as: Pervious Wasteland/Barren/Weedy Fill.			All other vegetation.
Habitat Diversity / Interspersion	Only grassland / herbaceous habitat type within a 1-hectare area	Grassland/herbaceous and 1 additional habitat type within a 1-hectare area .	Grassland/herbaceous and 2 additional habitat types within a 1-hectare area.	Grassland/herbaceous and 3 additional habitat types within a 1-hectare area.
Streamflow moderation/Water Storage		Elevation is greater than 20' NAVD88.	Connectivity to mainstem (OHWM from 9' to 20' NAVD88).	Connectivity to mainstem (9' NAVD88).
Interior Habitat	Distance of less than 200' from developed surface or contiguous with 2 acres or fewer of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 2 to 15 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 15 to 500 acres of terrestrial habitat.	Distance of more than 200' of developed surface and contiguous with 500 or more acres of terrestrial habitat.
Wildlife Movement Corridor (non-avian species)	Artificial impediments blocking passage visible within 300 feet.			No artificial impediments blocking passage within 300 feet.
Connectivity to water		Farther than 300 feet from a river, stream, or wetland and no artificial barrier to movement.	Between 300 feet and 150 feet of a river, stream, or wetland and no artificial barrier to movement.	Within 150 feet of a river, stream, or wetland and no artificial barrier to movement.

2.3 IMPORTANCE EVALUATION METHODOLOGY

The quality/quantity assessment is supplemented with an assessment of overall importance based on the ecological role of WHI resources in the study area. The importance of natural resources on WHI is rated at two levels: the habitat level, and the island level.

The habitat-level importance evaluation results in one importance rating, Low, Medium, or High for each habitat type that applies uniformly across WHI. For example, if based on regional and temporal factors WHI riparian habitat is considered to have a high importance in the study area, then all riparian habitat on WHI is rated as highly important. Each habitat type on WHI is evaluated for its importance based on its role in the study area ecosystem. This assessment is primarily based upon the relative abundance as well as trends in resource conservation or degradation for reach habitat type. Habitat-level importance also is based on the relative contribution of each habitat type to facilitating at-risk, threatened, and endangered species recovery.

The second evaluation rates the overall importance of WHI viewed as one island habitat area. This evaluation considers the assemblage of all habitat types on the island to determine the level of regional ecological importance of the entire island. Factors such as size, location, and interrelationship of WHI resources to other resources are considered.

Table 2-9 summarizes the six importance criteria used to evaluate the importance of WHI natural resources; two criteria are related to habitat-level importance, and four criteria are related to island-level importance. These evaluation criteria reflect the main factors affecting properly functioning ecosystems as well as the main principles of regional fish and wildlife goals, such as conservation and habitat connectivity.

Table 2-9 Description of Criteria to Rate WHI Ecological Importance within the Study Area

Importance Criterion	Description
Habitat – Level Importance	**How important is each habitat type on WHI?**
1) Scarcity/Abundance and Trends of each WHI habitat type in relation to the Study Area	Assess the scarcity and abundance of particular habitats to attain an understanding of WHI level of uniqueness and contribution within the study area. The general trends in habitat quality and preservation (and potential threats from development) in the study area using available large scale resource status and trends documentation.
2) Relative Contribution of WHI to Sensitive and Endangered Species Conservation in relation to the Study Area	The general condition of the Columbia River and Willamette River Corridors, how they are serving to facilitate threatened and endangered species recovery, and how WHI contributes to that success.
Island-Level Importance	**What is the overall importance of WHI as a habitat resource?**
1) Relative Size/Quantity of WHI Habitat Patch Sizes in relation to the Study Area	The size of WHI habitats in terms of acreage compared to the size of other habitats in the study area.
2) Importance of WHI for Functioning in association with other Natural Areas	A broader view of regional parks and large contiguous forests explaining the importance of WHI species use and contribution as flyway stopover or other functions contributing to regional avian life histories.
3) Level of Connectivity to Water of WHI in relation to Habitat Types in the Study Area	WHI level of connectivity to water would compare to other similar land types in the study area.
4) Spatial Location of WHI in relation to the Study Area	WHI position within the Lower Columbia River ecosystem to describe the level of importance that location has relative to other habitats in the immediate area.

SECTION 3

Context for Natural Resource Evaluation

This section presents information regarding the historic and current contributions of WHI habitats and their functions. The section addresses a variety of watershed functions relating to hydrology, water quality and fish and wildlife habitat. For resource managers and planners, it is important to know the range of critical ecological processes and conditions that have characterized particular ecosystems over specified time periods and under varying degrees of human influences. Information on how ecosystems functioned and sustained themselves prior to major human modification provides a reference point for understanding the ecological potential of a landscape.

3.1 HISTORICAL CONDITIONS IN THE PLANNING AND STUDY AREAS

The Columbia River has the fourth highest discharge and the fourth largest drainage area for an American river. The shape and form of the Columbia River and its estuarine area is a product of two vastly different time scales. First, it is the product of long-term cumulative geologic, fluvial, and hydrologic processes and second, it is the product of comparatively recent hydrologic management and sediment management processes that have been implemented over the past century. This describes these functions within the modern-day setting. The presence of hydroelectric dams has altered fundamental habitat-forming and maintenance processes in the lower Columbia.

3.1.1 WHI Physical Characteristics

Hayden Island (historically Vancouver Island, amongst other names) has a diverse history of use and conditions. Mid- and late-19th century texts and mapping (1841 U.S. Exploring Expedition, 1852 GLO Surveys, 1863 Cadastral survey) describe a woodland forest land and lowland area on the southern portions of WHI located among shoals, other islands, and channels. Prior to placement of dredge material and natural accretion that connected Hayden Island with Tomahawk Island, a channel/slough connected the south channel to the mainstem of the Columbia River. Several pile dikes were installed by the United States Army Corps of Engineers (USACE) in the 1890s to trap sediment moving along the southern shoreline, and the island began receiving dredge materials starting in the 1920s. Placement of a series of five permanent groins during the early 1920s on the southeast shore of WHI serves to maintain channel depth in the southern channel. The observable effect of the groins from LIDAR and aerial image analysis is sediment accumulation and the formation of moderately sloped beaches on the west (downstream) side. Historic and modern log-booming practices also likely contribute to formation of low energy shoreline areas. Riparian vegetation succession has been hindered on some of the groins that remain exposed as rock substrate or have compacted topsoils.

Surface soils on WHI are sand and silt loams that primarily have been built through historic flood events. Flood disturbance played a key role in determining vegetation composition and, although less frequent, flooding still contributes to vegetation characteristic and island form and function through erosion and deposition. Portions of WHI's north shore have been used by the USACE to dispose of materials dredged from the Columbia River navigation channel since the 1920s. To a lesser extent, dredge deposits were also placed near the original south shoreline. The dredge materials are medium- to fine-grained sands. The subsurface soils include manmade fills, alluvial sands, and alluvial silts. In addition the sands that form the island are very permeable, allowing precipitation to rapidly percolate into the groundwater. During the rainy

season, the water table under the island may rise several feet above the river level because of water retention in the soil, but in late summer the water table is more closely related to the river level.

Presently, most of WHI's vegetation consists of black cottonwood with Himalayan blackberry understory and a variety of other native and non-native plants. There are also meadows, wetlands, open sandy fill areas, beach and shallow water areas. The conditions are in contrast to East Hayden Island which is a developed area with mobile homes, floating homes, condominiums, single-family site-built homes, major shopping areas, marinas, and industrial uses. WHI was added to the region's urban growth boundary in 1983 for marine industrial purposes, and was acquired by the Port of Portland in 1994.

3.1.2 Land Use of WHI

WHI is almost fully vegetated with an improved and unimproved roads network for accessing utilities. Agriculture and septic waste injection are past uses of the island. When dredging materials were stockpiled, heavy equipment operators used the area for training. Former wetlands were impacted by filling using dredge materials during the 1950s and 1960s. WHI has been used for agriculture and extensive cattle grazing through the 1990s. Powerline corridors and railroad right of ways are maintained on WHI in addition to a City dechlorination facility.

In 2007, two acres of forest and shrub habitat were created for mitigation purposes. The beach areas (about 5.7 miles length) are used for small recreational craft landings or recreation.

3.1.3 Columbia River Channel Maintenance and Altered Hydrology

The Lower Columbia River shipping activities require navigational channel maintenance from the mouth of the river to Portland, Oregon. Early dredging efforts started in 1864 at the mouth of the Columbia River and in 1898 the Columbia's main channel was deepened to 25 feet. Today the main river channel is up to 48 feet deep and 600 feet wide. The USACE dredges and disposes nearly 6.9 million cubic meters of dredge material annually in the Columbia River. The dredged material is disposed of in water, upland, or in shoreline (beach) areas. The beach disposal is generally considered a beach nourishment action. Intertidal and shallow subtidal habitats can benefit from this activity which replaces lost sediment that is either impounded in upstream reservoirs or locally displaced from currents and ship wake wave erosion.

The Columbia River Basin is the most hydroelectrically developed river system in the world. Eleven mainstem dams in the Columbia basin, the first being Rock Island Dam in 1932, have affected the flood regimes and sediment delivery processes that previously shaped WHI vegetation and wildlife access and use. The Bonneville Dam, completed in 1938, is the lowest dam on the Columbia River. Associated activities such as diking and ongoing dredging have altered the hydrologic processes that shaped the larger-scale historic floodplain and wetland ecosystems in the river corridor. Before dam effects, many of the islands and much of the floodplain were inundated several times a year. These historic flow variations contributed to creation of shoal and alluvial island formation. In addition, the varying topography within the floodplain facilitated development of diverse riparian areas by establishing various vegetation communities and forest stand age classes. The effect of reduced flow variation has been noted as a limiting factor in subbasin planning efforts in the Columbia River[23].

Mainstem and major tributary dams in particular have reduced peak river flows, and construction of dikes and levees has nearly eliminated flooding in many low-lying areas. Severe floods still occur, however, as evident by the 1996 flood in which nearly all of WHI was inundated (this was the highest crest experienced since

[23] Washington State Conservation Commission Limiting Factors Reports available via internet (http://www.scc.wa.gov/)

1956, see **Table 3-1**). As illustrated in **Table 3-1**, of the ten largest floods in the past 100 years, the 1996 flood is the only flood ranking in the top ten that has occurred in the last 45 years.

There have been major changes in the estuary habitat of the Lower Columbia River. Sherwood et al.[24] estimated that the area of tide flats, swamps, and wetland in the Columbia River estuary was reduced by 40 percent between 1870 and 1970. Estuarine conditions can be influenced by adjacent forests. Low velocity habitats are a key focus of restoration efforts in the region. Simplification and/or development of the migration corridor have altered predator/prey interaction through channel margin areas. Developed conditions can enhance predator efficiency (e.g. shadows from overwater structure or bulkhead areas).

Bottomland forest habitat, an extensive landscape feature formed primarily by sediment sources of historic volcanic eruptions and maintained by flood disturbance, have been drastically reduced. This particular habitat is known to support some of the highest diversity of neotropical migrants in the region. Extensive wood removal and changes in sediment dynamics were also major contributors to changes in estuarine processes.

Dredging of shipping channels has required disposal of massive quantities of sediments, resulting in creation of new islands that are used by wildlife and vegetation communities. Elevation changes have created extended dryer periods and allowed bottomland or woodland habitat to establish whereas more frequent inundation would preclude hardwood forest establishment. In some cases, however, this has led to reduced wetland filling and topographical change.

Table 3-1 Top ten historic flood events of record, WHI Area

Historical Crests (ranked in order of greatest to least) ft in NGVD29	Date
31.00 ft	06/13/1948
30.80 ft	06/01/1948
27.70 ft	12/25/1964
27.60 ft	06/04/1956
27.20 ft	**02/09/1996**
26.30 ft	06/19/1933
26.20 ft	05/31/1928
26.00 ft	06/12/1921
25.90 ft	06/26/1950
25.60 ft	06/16/1903

Compiled best estimates of the "Great Flood of 1894" had an estimated unofficial crest height of 33.0 feet in the Willamette River at Portland, OR.
Source: NOAA, National Weather Service, Vancouver Gauge (1903-current)

3.2 CONDITIONS AND TRENDS IN THE STUDY AREA AND BEYOND

This section describes trends in natural resource conditions in the study area and in three broader areas: 1) aquatic and riparian resources of the Columbia River mainstem from the Sandy River Confluence to the Willamette River, 2) aquatic and riparian resources of the Lower Willamette River, 3) aquatic and riparian resources of the Columbia River mainstem from the Willamette River to the Lewis River. Trends in these areas are described to provide a context for the conditions and role of WHI natural resources.

[24] Sherwood, C. R., D. A. Jay, R. B. Harvey, P. Hamilton, and Simenstad C. A. 1990. Historical changes in the Columbia river estuary. Prog. Oceanogr. 25: 271-297.

This study area incorporates some of the most diverse landscape and land use practices in the western United States, including a patchwork of private and public lands; natural areas, dense industrial, residential and commercial lands; rural-residential lands; agricultural and livestock use zones; recreational uses; managed and unmanaged forest land; and natural areas including riverine and estuarine habitats, wetlands and freshwater lakes, shallow and deepwater habitats, bottomland forests, shoals, sloughs, marshes, and bogs.

The study area encompasses the Portland metropolitan area, which has a population of nearly 2.2 million people. Since 2000, the region has had a population growth of nearly 11 percent, and further growth is expected. The focus on urban growth planning is to increase density of already established population areas. What can be expected in such patterns of growth are more impacts to water quality and water quantity due to further encroachment into remaining habitat fragments distributed throughout the growth boundaries. The reduction of physical habitat features can become increasingly difficult to detect in highly developed areas because large scale degradation has occurred leaving only smaller natural areas. The last remaining intact habitats can lose their resiliency and productivity is diminished. Over the last two decades however, extensive degradation practices have been curtailed or managed better, habitat cleanup and restoration is occurring, and with requirements for best management practices there should be a trend towards habitat recovery if large-scale restoration efforts are occurring upstream as well.

As indicated in the study area map (see **Map 1**) there is a lack of large contiguous forestlands upstream (east of WHI). Riparian areas on the Columbia River are characterized by a sparse or narrow-width vegetation band on the channel margins. Riparian habitat downstream, although contiguous for significant lengths, is often a narrow-band, encroached by agricultural lands or various intensities of development. Pale green coloration in **Map 1** predominantly represents non-forested areas, but can include natural areas such as grasslands, meadows, shrub or sparse non-coniferous forests. WHI is a north –south corridor greenway linkage that bridges Vancouver Lake and its associated riparian vegetation with the Smith and Bybee Lakes and wetland complex. From an east-west river corridor perspective, WHI is located very near the confluence of the Willamette and Columbia Rivers and within a reasonable distance of use by fishery resources originating from the Willamette River. WHI also appears to provide one of the substantial forested and/or shorelines with embayment areas, in addition to Government Island, downstream of the Sandy River Delta. For salmonids outmigrating from the whole Columbia River system, it is this region where they begin experiencing increased intertidal action due to the transition into the marine environment. Salmonid smolts can have extended outmigration periods through the freshwater and extended estuarine rearing prior to their marine life history phase[25] which are advantageous to marine survival and life history diversity.

The Lower Columbia River has been designated by the City as a Special Habitat Area (SHA) and includes the vegetated areas at Kelley Point Park, the Willamette River, the Columbia Slough and Smith and Bybee Lakes. In 2005, the National Marine Fisheries Service established Critical Habitat for nine evolutionarily significant units or distinct population segments of Pacific salmon. These areas provide especially or uniquely important fish and wildlife habitat values and function. SHAs contain or support special status fish or wildlife species, sensitive/unique plant populations, wetlands, native oak, bottomland hardwood forests, riverine islands, river delta, migratory stopover habitat, connectivity corridors, grasslands, and other unique natural or manmade structures.

3.2.1 Columbia Mainstem from Sandy River to Willamette River

The 1,800+ acre delta of the Sandy River was historically a wooded riparian wetland with components of ponds, sloughs, bottomland woodland, oak woodland, prairie, and low and high elevation floodplain. Delta habitat restoration projects currently focus on riparian hardwood restoration due to past alterations by

[25] Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

agricultural practices, deforestation, and invasive vegetation.[26] The area is part of a landscape restoration plan, aimed at improving long-term riparian function and habitat quality.[27]

One of the Port's long-term management objectives in The Government Island Management Plan is to preserve the natural character and quality of the natural resources of the island complex habitats (which also includes Lemon and McGuire Islands).[28] Government Island has a land use history and habitat characteristics similar to WHI including wetlands, open water (Jewitt Lake), and riparian and upland habitats that are a mixture of native and non-native plant species including relic cottonwood forests. The forest communities that depend on disturbances, such as the mature cottonwoods in riparian areas, are only a remnant of bottomland forests that may have existed prior to hydrologic controls from the hydropower system.

The Washington bank of the Columbia is predominantly hardened with artificial substrate primarily providing protection for private residences, and some commercial development. There is a minimal amount of forested areas adjacent to the high water mark indicating a degradation of the lateral shoreline areas. Similarly, the Oregon bank of the Columbia River is almost entirely levee from near the eastern edge of Government Island past Sauvie Island. Generally, the shoreline area and riparian habitats are simplified and these conditions will likely persist, except for maturing of the existing riparian forest fragments.

3.2.2 Lower Willamette River

The industrial and downtown areas of the Willamette River in Portland historically experienced diverse flow volume and velocity conditions. In the past, there was an extensive floodplain with flow through side channels and off-channel habitat. Shallow instream habitats would have provided rearing and feeding areas for fish and it was possible that in-channel islands may have provided gravel for anadromous fish spawning. Presently, many floodplains and off-channel habitats are disconnected. Lakes and side channels have been filled in and artificial banks have reduced the shoreline complexity of the reach. Areas of the North Reach that provide these habitats include Kelly Point, Harborton Wetlands, South Rivergate Corridor, Doane Lake, Willamette Cover, and Willamette Bluff. Tributaries that may have provided some spawning and rearing in the low gradient reaches such as Doane, Saltzman, and Balch Creek have blockage problems or altered hydrology that prohibit migratory adult salmon or retention of juvenile salmonids. Limited backwater areas exist in the Swan Island area and at the lower portion at Kelly Park, the egress to Smith and Bybee lakes. Foothill savanna, oak woodland, bottomland forest, scrub/shrub, and grassland habitats persist in low quantities dispersed in riparian areas, stream corridors, or open space areas, and can serve as wildlife corridors.[29]

Further upstream on the Willamette from the Portland downtown area was a complex channel with extensive shallow water areas and in-channel islands. Historically, the reach below the Willamette Falls shifted often. The connectivity to the extensive low-lying wetlands formed by the Columbia Slough and Sauvie Island was likely much stronger before channel constriction of the Lower Willamette River occurred. The dynamic hydrology of the river confluence would have favored channel movement and reworking of the large island delta system at the Willamette/Columbia River confluence. Large accumulations of wood would have been present in and along the channel, along the banks, and throughout the floodplain, and would have had a large role in influencing channel morphometry. Today, only about one-half of the riparian area within 100 feet of

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26 Dobson, R. 2008. Sandy River Delta Habitat Restoration. Annual Report Jan 2007 – Mar 2008. USDA Forest Service, Hood River, OR. Prepared for Bonneville Power Administration, Portland, OR.

27 Kelly, V., and R. Dobson. 2001 Sandy River Delta Habitat Restoration Project, 2001 Annual Report, Project No. 199902500, 20 electronic pages, (BPA Report DOE/BP-00005685-1).

28 Fishman Environmental Services, LLC. 2003. Government Island Management Plan. Prepared for: Port of Portland Property and Development Services. Portland, OR.

29 City of Portland Bureau of Planning. In draft. Natural Resource Inventory Update. Riparian corridors and wildlife habitat (July 2008 Discussion Draft). City of Portland, OR.

Portland's rivers and streams contains forest type tree canopy. Still, the resources that remain continue to provide critical watershed functions and benefits, albeit not at the same scale. Portland's Citywide Tree Project intends to simplify tree-related policies and update land use standards that help facilitate retention of large trees and groves. Such practices aim to improve hydrology, water quality air quality, reduce urban heat island effects, and provide wildlife habitat through the watersheds. Some of the main proposed outcomes are to help offset the past and ongoing effects of development and restore the landscape's ability to absorb precipitation and runoff – goals consistent with the City's stormwater management manual.

Anticipated future trends for conditions in this reach appear to be beneficial to the aquatic resources. There is much public attention and planning efforts to recovering habitats, although the scale of restoration may be limited due to the established infrastructure. At a minimum in this reach, current habitat conditions will likely be maintained in the short term due to increased regulatory discretion of permitted actions. Restoration efforts may focus on a particular species or be limited to highly site-specific projects due to the scarcity of candidate restoration areas in the Lower Willamette River.

3.2.3 Columbia River Mainstem from the Willamette River to the Lewis River

Floodplain area and off-channel habitats of the Columbia River were historically more abundant progressing downstream from the Willamette River. Regular flooding of island and shoal habitats created a complex mosaic of deep water, shallow water, instream, wetland, and marsh habitats. Extensive diking has isolated thousands of acres of floodplain from the mainstem river and tributaries that would otherwise be accessible during regular flood periods. Encroachment on the riparian area on both Oregon and Washington banks of the mainstem have resulted in noncontiguous stretches of riparian areas. Extensive areas of sandy beaches exist in part due to the ongoing beach nourishment practices, in particular on the Washington side of the channel. Frenchman's Bar, Caterpillar Recreation Area, Post Office Lake, Ridgefield Wildlife Refuge, other associated sloughs, side channels, and riparian forest and woodlands offer a portion of past conditions in the shoreline areas. Alteration in the hydrology of the Columbia River has resulted in a very low ratio of shallow water to deep water habitat, the reverse of historic conditions.

Channel margin large woody debris complexes are scarce and have been managed for navigational safety since the early days of large vessel navigation. Ecosystems are highly variable, and the past unregulated riverine systems had dynamic flows that were just as much a part of recovery process (natural floodplain deposition, vegetation) as they were a degrading process (tremendous scour and erosion). Commonly referred to as the "disturbance regime", these hydrologic processes shift wood in the channels changing shape and size of mid-channel islands, and periodically re-establish the floodplain extent. Historically, the largest impacts to the river's dynamism occurred with dam and navigation channel construction and widespread bank hardening in developed areas. More recent management activities such as maintenance of the navigation channel and regulation of flows also limit disturbance-based habitat formation.

3.3 REGIONAL FACTORS DETERMINING NATURAL RESOURCE QUALITY IN STUDY AREA

This section describes larger ecosystem processes that affect natural resource quality in the study area. While each ecosystem process is discussed independently, the combined processes are what comprises and sustains an ecosystem. There are many interconnected relationships between ecosystem processes such that an effect on one process may impact other processes.

3.3.1 Hydrology

The region of WHI includes two periods of significant freshets. The winter (December-February) and spring (April-June) freshets bring variable flows that serve the dynamic life histories of Pacific salmon utilizing winter freshets for spawning migration and spring freshets for outmigration. Surface and groundwater hydrology is most reliant on precipitation (average of 36.3 inches per year), river elevation, flood inundation, percolation through the soils from the Columbia River and North Portland Harbor into the interior of the island, and to a limited extent, tidal action.[30]

Flood conveyance and capacity are directly related to connectivity to the mainstream and the type and densities of trees and vegetation. WHI does not have stream channels, but does maintain ephemeral outlet channels from wetlands and forest interior areas for overland runoff during heavy rainstorms. During the 1996 flood, most of WHI was submerged. The sandy, well drained soil characteristics provided storage capacity for flood waters during this period. Combined severe flooding and extensive artificial banks in the Willamette and Columbia Rivers can exhaust flood conveyance capacity in the Columbia River and create high magnitude surface water which can back water upstream. Because of WHI's proximity to the Willamette River confluence, WHI is subject to extensive flooding when the Willamette River experiences high flood levels. This hydraulic effect along with other regional storm activity was a contributor to the Willamette River flood of 1996.

Shallow water habitat is highly susceptible to effects of managed flow variation of Columbia's hydropower dam network. Disconnection of the river from margin habitats and primary floodplain has occurred which can disrupt nutrient, energy, and migration pathways. This disconnect has varying consequences on fish and wildlife resources such as delayed migrations, reduced prey sources, changes in vegetation composition or habitat unavailability. The location of WHI in the mainstem ensures its hydrologic connectivity to the mainstem Columbia River.

3.3.2 Tidal Influence

WHI is a tidally-influenced habitat. Tidal action in this reach of the river is three to four feet. That contributes to maintenance of a dynamic shoreline area that includes embayments and a wrack line of woody debris accumulation and pocket beaches, particularly on the north shore. The Columbia River hydropower system has had effects on flow characteristics in relation to tidal ebb and flow dynamics; however, not much is known regarding how this has affected fish and wildlife life histories since pre-dam hydrology is not fully understood. Regardless, the daily water level fluctuations are a contributor to the dynamics of shallow water and beach habitats, providing food and physical energy input and outputs on the channel margins throughout the area of tidal influence.

3.3.3 Vegetation Communities

WHI is located in the bottomland riparian communities at the juncture of the Willamette Valley and Puget Trough Physiographic Provinces.[31] The site is a mosaic of five basic habitat types: upland riparian forest, wetland riparian forest, emergent wetlands that function as meadow and seasonal or year-round open water habitats, upland meadow, and shoreline (see **Map 2** attached). The upland riparian forests exist as differing plant associations of the black cottonwood community. The forest habitat, in general, dominates the site forming a matrix within which wetland and meadow habitats occur. The island's hydrology, which includes periodic flooding, has been modified by high bank dredged material and by water flows regulated at the

[30] USACE US Army Corps of Engineers. 2004. Portland-Vancouver Harbor Information Package. Second Edition. Reservoir Regulation and Water Quality Section. Portland, OR.

[31] Franklin, Jerry F. and C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Corvallis, OR: Oregon State University Press.

Columbia River dams. Interior island wetlands are saturated with back flow due to normal tidal influence, high-water (flood) events from the Columbia River and Oregon Slough, and with groundwater from Columbia River water moving through the alluvial soils. Depressions and old river channels provide the low topographic positions which support small emergent wetland plant communities throughout the site. These types of conditions can be found on other similar islands in the Lower Columbia River.

Large, mature cottonwood trees and their associated forests make a large contribution to the ecosystem relative to their abundance on the landscape. Breeding and migratory bird densities in these cottonwood habitats are generally the highest of all habitat types in North America. Large trees provide quality nesting habitat for larger birds that need big trees for their nests such as bald eagles, great-horned owls, and a number of colonial nesters including great blue herons. WHI maintains one of the largest stands of ash-cottonwood forests in the Lower Columbia River. Cottonwood establishment is generally fluvial-disturbance based. A combination of fewer disturbance level flows in Columbia River floodplains because of moderated hydrology, and the effects of livestock trampling/grazing or wildlife browsing have likely hindered the development of early successional stages of this WHI stand type in the recent past.

Grassland habitats border the forest woodland areas of WHI. In Oregon the greatest loss of grasslands has been in valley bottoms and foothills subject to changing land use such as the case in agriculture on WHI. Coast Range and Willamette Valley grasslands have experienced an estimated 99 percent reduction. Hawks, larks, vetches, and a variety of songbirds are some of the species associated with grasslands. In particular, meadowlark and horned lark population reductions are suggested to be related to this decreased habitat type.

Historic and current dredge material placement has provided opportunities for grassland-type habitats to develop. These unnaturally formed habitats provide some grassland function but lack either the disturbance regime that floodplain – type grasslands depend on using annual vegetation, or lack the nutrient base to maintain more permanent grassland features. Placement of dredge materials can also provide the "disturbance" in which non-native, noxious, or invasive weed species can establish.

Shrubland communities of the lower Columbia floodplains are diverse as a whole. WHI shrub communities, to a large extent, include invasive, non-native blackberry vegetation.

3.3.4 Sea Level Rise

Potential sea level rise will be a significant contributor to habitat changes in the coming decades. Recent studies show a sea level rise of 20 to 56 inches at Pacific Northwest beaches by 2100. A two-foot rise in Ordinary High Water Mark in the Study Area could alter the habitat composition of WHI. Changing vegetation communities and persistence of wetland habitats are anticipated in floodplains with hydrological connectivity to the Columbia River. There is however, uncertainty about the overall net effects sea level rise would have in the region's fish and wildlife resources given the complexity of the Pacific Northwest's coastal and marine ecosystem functions. Positive and negative benefits may occur for both terrestrial and aquatic species; some species may be able to respond by using new food and habitat resources, some may not.[32] Furthermore, the larger the elevation changes and rate of change, the harder it will be for most fish and wildlife species to adapt.[33] For example, a significant reduction in the area of estuarine beaches would affect important spawning habitat for forage fish, which make up a critical part of the marine food web. Unless species are able to find alternative spawning areas, their populations would decline. Inundation of tidal flats in some areas would reduce stopover and wintering habitat for migratory shorebirds.

[32] Inkley, D.B., et al. 2004. Global Climate Change and Wildlife in North America. Wildlife Society Technical Review 04-2. The Wildlife Society, Bethesda, Maryland.

[33] Inkley, D.B., et al. 2004. Global Climate Change and Wildlife in North America. Wildlife Society Technical Review 04-2. The Wildlife Society, Bethesda, Maryland.

3.4 WHI HABITAT SPECIES ASSOCIATIONS

Many fish and wildlife species rely on WHI as a migration corridor and area for nesting, breeding, foraging, and rearing young. At least 39 species of resident and anadromous fish, including 20 native species, have been documented in the lower Willamette River[34] and most if not all have a reasonable chance of occurring in the WHI area. Many migratory birds nesting near or within the planning and study area also forage in the open water and nearshore habitats. These include piscivorous species such as bald eagle, osprey, double-crested cormorant, great blue heron, belted kingfisher, common and hooded mergansers, and other waterfowl. WHI RIP, UBC, and SHW and their associated vegetation habitat is suitable for passerines and aquatic-associated birds. Cliff swallows, various waterbirds, and shorebirds such as spotted sandpiper utilize the beach/intertidal area for nesting and foraging.

Mammals including mink and river otter use the RIP and UBC as foraging corridors as well as SWH habitats and are known to rear young along the shorelines well. Northern red-legged frogs and Pacific tree frogs occur in the Planning Area, and long-toed salamanders are expected in the planning area although comprehensive amphibian surveys have not occurred. The nearshore habitats, low water velocity areas, shoreline embayments, and ponds, in particular those that contain vegetative or woody structure, are important breeding and foraging areas for these amphibian species. Western painted turtles and northwestern pond turtles use the lower Columbia corridor, in particular bottomland habitat, seasonal wetlands, and slow flow, low energy habitats such as ponds and sloughs. **Table 3-2** provides an overview of species-habitat use on WHI in relation to the habitats. The table is not intended to be comprehensive since many other species may use the island for various seasons and lengths of time.

Table 3-2 Species-Habitat Associations on WHI

Species	HABITAT TYPE USE						
	SHW	UBC	RIP	WET	FOR	SHR	GRA
FISH							
White crappie, black crappie, smallmouth bass, largemouth bass, bluegill, pumpkinseed, yellow perch, Northern pikeminnow, peamouth, largescale sucker, walleye Oregon chub, green sturgeon, white sturgeon, lamprey, coho, chum, Columbia River bull trout, cutthroat trout	X	X	X	X			
Listed: Snake River (SR) sockeye, SR Spring/Summer Chinook, SR Fall chinook, SR steelhead, Upper Columbia River (UCR) Steelhead , UCR Spring Chinook, Lower Columbia River (LCR) steelhead, LCR Chinook, Columbia River chum, Middle Columbia River steelhead, Upper Willamette River (UWR) Steelhead, UWR Chinook	X	X	X				
MAMMALS							
Raccoon, coyote, mole, brush rabbit			X	X	X	X	X
Listed: Columbia White-tailed deer						X	X
BIRDS							
Resident birds: dark-eyed junco, song sparrow, American robin, black-capped chickadee, and red-breasted nuthatch, warbler sp., tricolored blackbird, olive-sided flycatcher, little willow flycatcher; Overwintering: fox sparrow, white throated sparrow; Nesting and Foraging: pileated woodpecker, black-capped chickadee, swallow sp.;			X	X	X	X	X
Raptors, Hawks and Owls: osprey, northern harrier, bald eagle, hawks (up to 6 species), owls (up to 6 species)			X	X	X	X	X
Waterfowl: mallard, sea ducks, brant, wood duck, cinnamon teal, canvasback, Canada goose, Ross's goose, double-breasted cormorant	X	X		X			

[34] Farr and Ward. 1993. Farr, R. A., and D. L. Ward. 1993. Fishes of the lower Willamette River, near Portland, Oregon. Northwest Science 67:16-22.

	HABITAT TYPE USE						
Loons, grebes, herons, egrets and bitterns	X	X	X				
Listed: Aleutian Canada goose (potential use), bald eagle				X		X	X
AMPHIBIANS AND REPTILES							
Oregon Spotted frog, Northern Red-legged frog, Northwestern pond turtle, painted turtle, Pacific chorus frog, long-toed salamander, garter snakes	X	X	X	X	X		
INVERTEBRATES							
Lepidoptera (butterfly) sp., Heterocera (moth sp.), cabbage white, satyr angelwing, painted lady, mylitta crescent, spring azure			X	X	X	X	
BENTHIC COMMUNITY							
Nematode, oligochetes, bivalves, stone fly, caddis fly, mayfly, isopods, amphipods	X	X					
MACROINVERTEBRATES							
Mayflies, dragonflies, damselflies, Daphnia, scud, water beetles, water boatman, midges, fairy shrimp, water striders	X		X	X	X		
PLANTS							
Listed: Howellia, Willamette daisy, Bradshaw's lomatium, golden paintbrush, Kincaid's lupine, Nelson's checkermallow			X	X	X	X	X

Sources: Port of Portland 1995 (based on probable use/potential use drawing from Puget Island sub-population), ODFW species distribution descriptions

SECTION 4

Natural Resource Conditions: Quality and Quantity Results

The purpose of this section is to describe the quality and quantity of WHI natural resources relative to other natural resources located in the City. The quality/quantity evaluation is conducted at the site-specific scale, and rates the quality/quantity of WHI keystone elements based on landscape features and ecosystem function at every location on WHI. As described in **Section 2**, the criteria for evaluating WHI natural resources is largely based on the criteria developed for the City's NRIU, with additional criteria developed specifically for WHI habitat types. All criteria used to evaluate quantity/quality of WHI resources are derived using available geospatial data as well as analysis using aerial photographs. It is important to note that the analysis is conducted at the site-specific scale based on available geospatial and aerial photograph data. Limited field visits were conducted to groundtruth existing data, but did not include collection of additional data.

This section contains three parts. The first part describes the quantity and location of WHI habitats, while the second presents the results of the quality/quantity analysis. The third part places the findings in context by describing other considerations that affect the assessment of quality on WHI.

4.1 QUANTITY AND LOCATION OF HABITAT

As defined in **Section 2**, there are seven habitat types on WHI: shallow water (SWH), upper beach (UBC), riparian fringe (RIP), wetland (WET), shrubland (SHR), grassland/herbaceous (GRA), and forest/woodland (FW). The land area of WHI, noted in regional reports, varies between 820 to 830 acres depending on study boundaries. This assessment includes additional acreage for SWH and UBC. RIP is described as a habitat type even though the vegetation communities which comprise it are also habitat types. Areas classified as RIP, regardless of vegetation type, are evaluated according to the RIP criteria and according to the appropriate vegetation habitat criteria.

The acreage in each habitat type is presented in **Table 4-1**. Forty percent (415 acres) of WHI habitat is FW (of which 161 acres are located within RIP). RIP is the second most abundant area (260 acres) and consists of 11 percent SH, 62 percent FW, and 25 percent GRA. SWH is the next most abundant habitat, with 240 acres. GRA accounts for 227 acres, of which 101 acres are located in the dredge material management area. SHR, WET, and UBC habitats are the remaining 163 acres. **Map 2** presents location and extent of the habitat types on WHI.

Table 4-1 Environmental Foundation Study WHI Habitat Acreage

Habitat		Acres
Shallow Water		240
Upper Beach		28
Riparian Fringe (260 acres)	Shrubland	28
	Forest/woodland	161
	Grassland/herbaceous	65
	Inland of 18' elevation[1]	6
Wetland		59
Forest/woodland		415
Grassland/herbaceous		227
Grassland/herbaceous (Dredge Material Storage Area)		*101*
Shrubland ((acres outside of Riparian Fringe)		76
TOTAL (not including duplicative Riparian Fringe area)		1,045

1. This criteria was used to capture unclassified or covers not used in forming habitats such as developed area, roads, facility.

* Includes acreage of this vegetation community found in Riparian Fringe

4.2 QUANTITY/QUALITY RATING

This section presents results of the site-specific overall quality/quantity rating of WHI natural resources. These overall quality ratings are based on the average score resulting from a collection of criteria and scoring rules defined for each habitat type in **Section 2.2.3**. Each criterion is evaluated at each location and scored as 0, 1, 2, or 3 (with 3 being high, 2 being medium, 1 being low, and 0 being no contribution to habitat quality). Overall quality/quantity is the average of the scores for each criterion defined for each habitat type, and therefore can range continuously from a low of 0 to a high of 3.

Figure 4-1 presents the distribution of overall quality/quantity rating for WHI habitat; **Figure 4-1** does not include ratings for RIP to prevent double counting of acreage. Overall quality/quantity ratings of WHI habitat at specific sites range from a low of 0.4 to a high of 3.0. As indicated in **Figure 4-1**, much of the habitat on WHI is rated between 2.0 to 2.5, with 60 percent of the acreage falling in this range. Nearly all habitat (approximately 86 percent) is rated between 1.5 and 2.75. Six percent of all acreage rates below 1.5, with acreage of all habitat types except SHR occurring in this lower rating range on WHI. With the exception of WET and FW, all habitat types have acreage rated above 2.75. Habitat rating above 2.75 accounts for eight percent of all acreage on WHI.

In general, habitat on WHI falls on the higher end of the quality/quantity scale due to the large size of the natural area, the diversity of vegetation, and the connectivity to water on the island. Within the context of an urban ecosystem, these attributes result in a relatively high quality habitat area. However, this is not to say that the habitat on WHI is currently at its full ecological potential. Past land use impacts have affected the natural development and productivity potential. As described in **Appendix A**, it is expected that restoration actions on the island would result in enhanced wildlife habitat resources and enhanced overall ecological functioning.

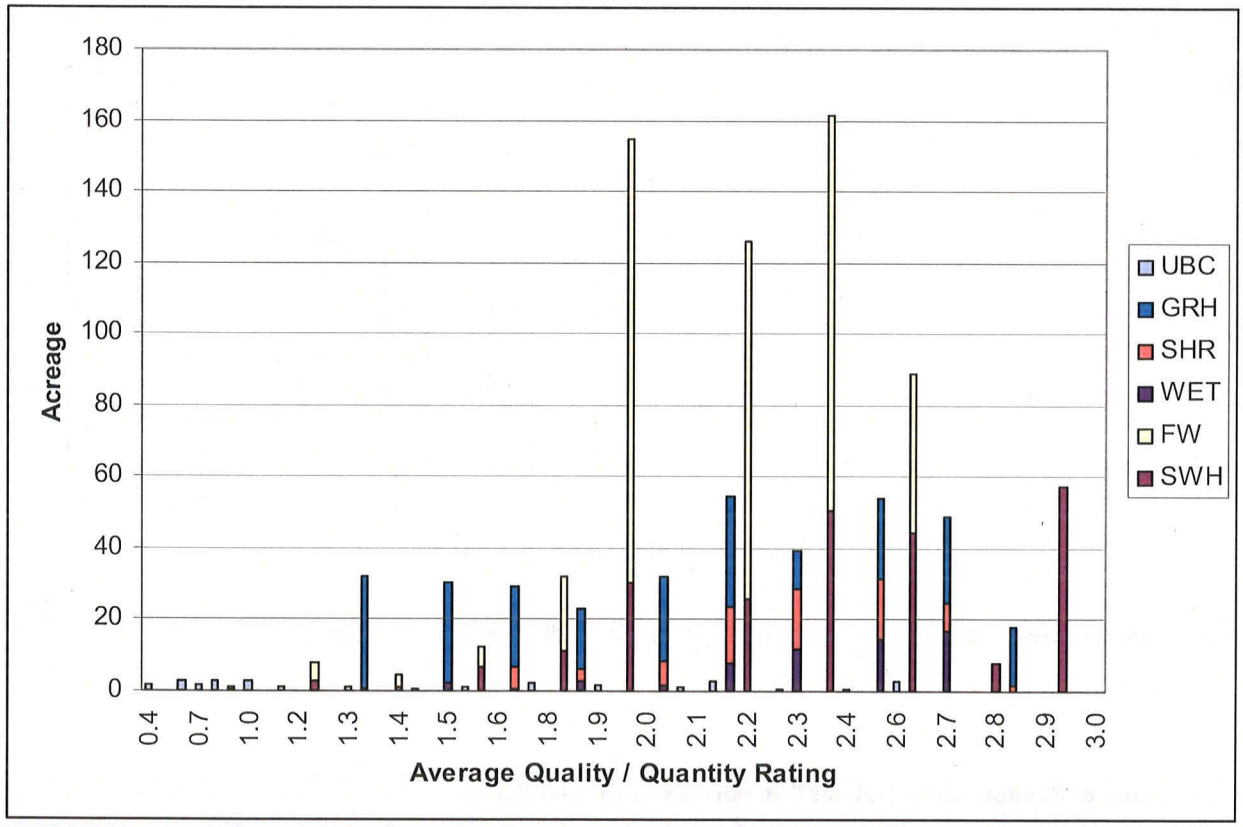

Figure 4-1 Habitat Types and Acreage Distribution by Quality

4.3 DETAILED QUALITY / QUANTITY EVALUATION RESULTS BY HABITAT TYPE

Detailed results based on the criteria scoring are presented below in **Tables 4-2 through 4-8** and **Figures 4-2** through **4-8**. Maps displaying distribution of the habitats and their quality/quantity rating are in the attached map appendix (attached **Maps 3** to **9**). Characteristics of each habitat are summarized in the following section.

4.3.1 Shallow Water

There are 240 acres of SWH. The quality/quantity ratings for SWH range from 0.4 to 3.0, with an average of rating across all SWH acreage of 2.45. Over 90 percent of SWH is rated between 2.0 and 3.0 (**Figure 4-2**). The highest quality SWH predominantly occurs on the south side of the island, particularly on the upstream side (**Map 3**). Extensive areas of channel margin characteristics delineated from aerial photos and the relative lack of lack of obstructions contributed to high ratings (**Table 4-2**). The highest rating area on the south side of WHI is due to forest land proximity and also evidence of large woody debris accumulations from aerial imagery analysis. Maintaining the continuity of shoreline habitats is important, fragmentation of the shoreline area can disrupt migratory behaviors of fish and aquatic birds migrating or foraging within this habitat type.

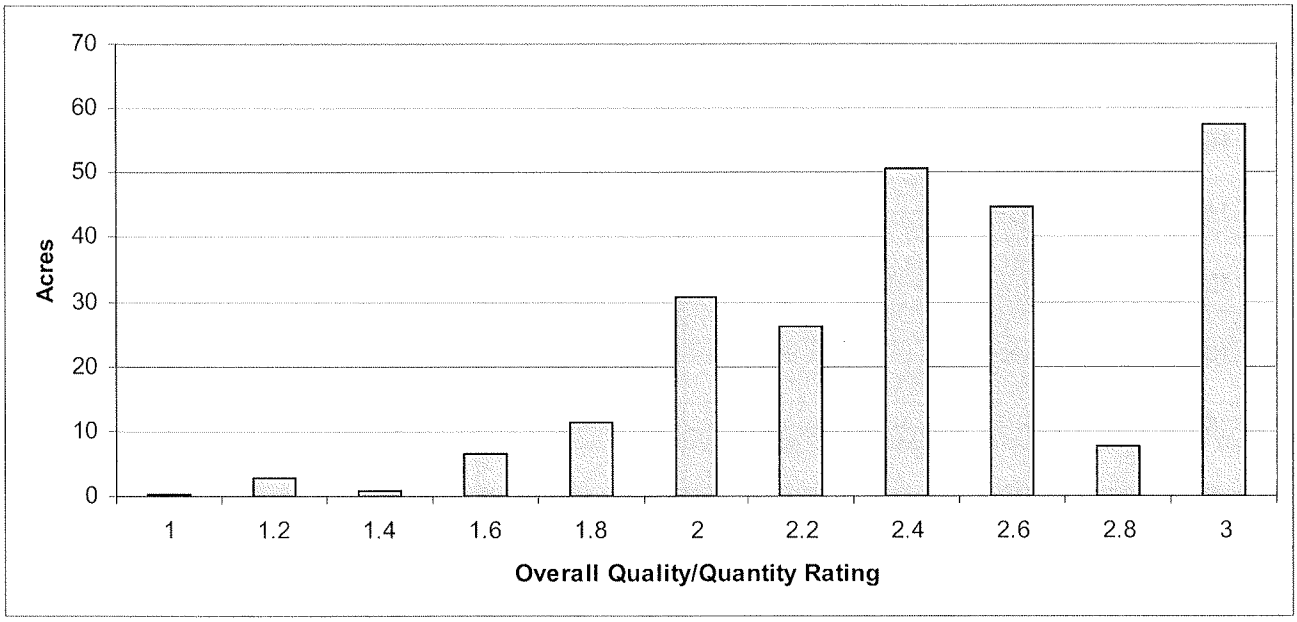

Figure 4-2 Acres of Upper Shallow Water Habitat by Overall Quality/Quantity Rating

Table 4-2 Acres of Shallow Water Habitat Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score = 1	Acres with Score = 2	Acres with Score = 3
Nearshore / Bank Influence		7.2	4.5	228.1
Channel Margin Characteristics	13.5			226.2
Food Web and Nutrient Cycling	32.4	53.5	61.4	92.5
Large Wood and Channel Dynamics	8.1	126.5	9.4	95.7
Wildlife Movement (parallel)	15.9			223.8

4.3.2 Upper Beach

There are 28 acres of UBC. The quality/quantity ratings for UBC range from 0.4 to 3.0 (**Figure 4-3**), with an average rating of 1.43 across all UBC acreage on WHI. Approximately 50 percent of UBC is rated between 0.4 and 1.3, while the other 50 percent is rated from 1.3 to 3.0. As indicated in **Table 4-3**, UBC rates particularly low on providing fish refuge as measured by provision of off-channel connection at ordinary high water mark, and low on channel margin/flow characteristics (as indicated by beach slope and substrate). Most areas also lack the presence of features that would lead to the accumulation of large woody debris. Nearly all areas of UBC score as a medium for the streamflow moderation criterion, while wildlife movement (as indicated by the absence of barriers) and microclimate/shade rate predominantly in the medium to high range. The UBC areas with higher overall quality/quantity ratings are predominantly on the southern shoreline of WHI (see **Map 4**).

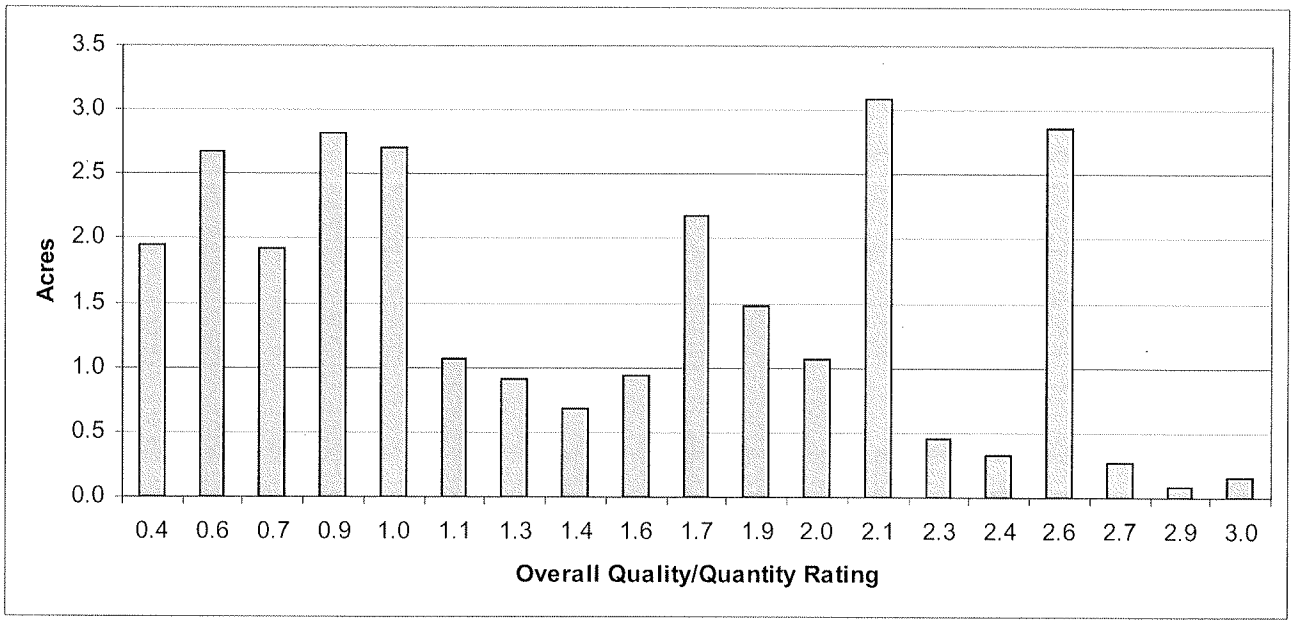

Figure 4-3 Acres of Upper Beach Habitat by Overall Quality/Quantity Rating

Table 4-3 Acres of Upper Beach Habitat Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score =1	Acres with Score = 2	Acres with Score = 3
Channel Margin / FlowCharacteristics	0.6	19.6	0.5	6.9
Microclimate/Shade	2.0	4.2	9.9	11.4
Food Web	10.2	2.6	3.9	10.9
Large Woody Debris	16.2		6.1	5.3
Bank Function	11.8	4.8	3.2	7.8
Fish Refuge	24.8			2.8
Wildlife Movement	0.8	3.5	10.6	12.7

4.3.3 Wetlands

There are 58.9 acres of WET. The quality/quantity ratings for WET range from 1.2 to 2.7 (**Figure 4-4**),w ith an average rating of 2.36 across all WET acreage on WHI. Approximately 86 percent of the habitat is rated between 2.0 and 3.0. WET is relatively high quality because of adjacency to forests (**Table 4-4**; **Map 5**) which provide several functions benefiting wetlands. Quality was also relatively high due to large patch sizes (including WET and adjacent FW acreage) and lack of edge habitat.

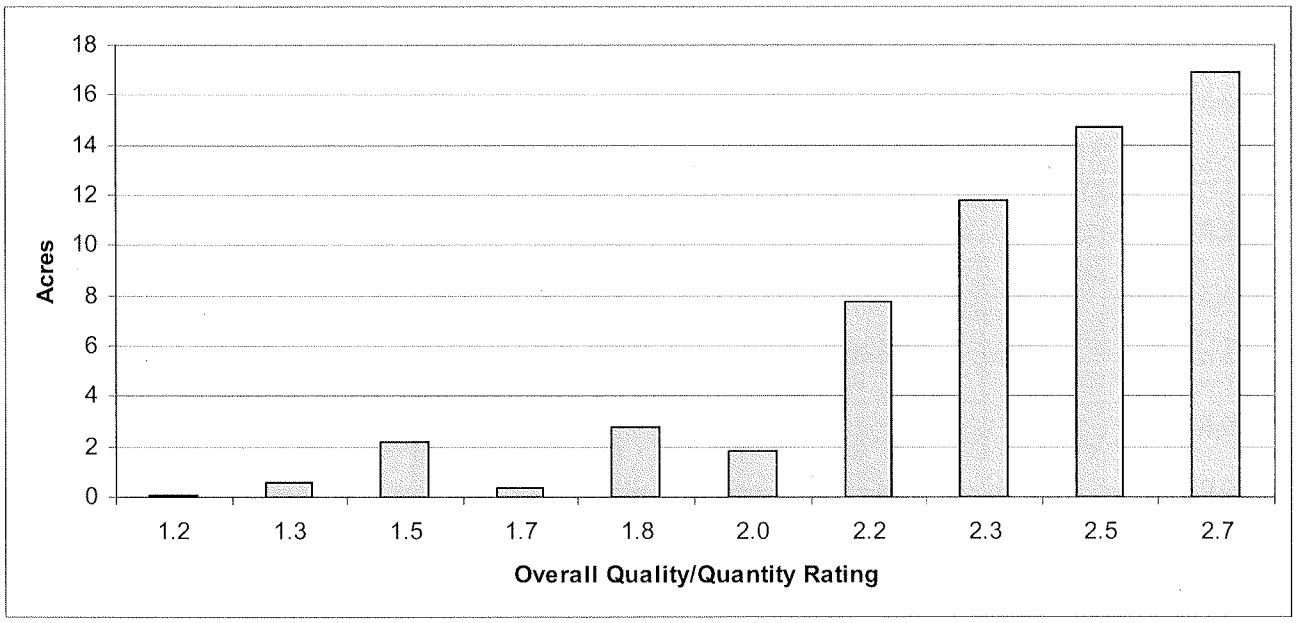

Figure 4-4 Acres of Wetland Habitat by Overall Quality/Quantity Rating

Table 4-4 Acres of Wetland Habitat Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score = 1	Acres with score = 2	Acres with score = 3
Streamflow Moderation	0.0	14.3	21.8	22.8
Vegetation Diversity	0.1	6.5	1.2	51.0
Microclimate/Shade	2.2	11.3	0.8	44.6
Wildlife Movement Corridor	0.0	1.7	57.2	
Interior Habitat	0.7			58.2
Habitat Patch Size		6.5	52.4	

4.3.4 Riparian Fringe

There are 260 acres of RIP. While all of WHI is considered riparian because of its mid-channel location within the floodplain, to evaluate the specific contribution of areas directly adjacent to water bodies, the 150-foot band immediately adjacent to water bodies is defined as the habitat "Riparian Fringe" and analyzed for riparian function. The quality/quantity ratings for RIP range from 1.25 to 3.0 (**Figure 4-5**), with an average rating of 2.52 across all RIP on WHI. Approximately 90 percent of the habitat is rated between 2.0 and 3.0, with 74 percent rated above 2.5. RIP on WHI is relatively high quality due to the presence of forest/woodland vegetation in 60 percent of the RIP. Forest/woodland in RIP enhances such ecological functions as organic inputs, large wood and channel dynamic functions, bank function, microclimate/shade, and wildlife movement. RIP also includes interior areas that contain standing water or saturated soils during wet periods. RIP areas rated lower than 2.0 are typically associated with sandy beach areas with the absence of forest/woodland (attachment **Map 6**).

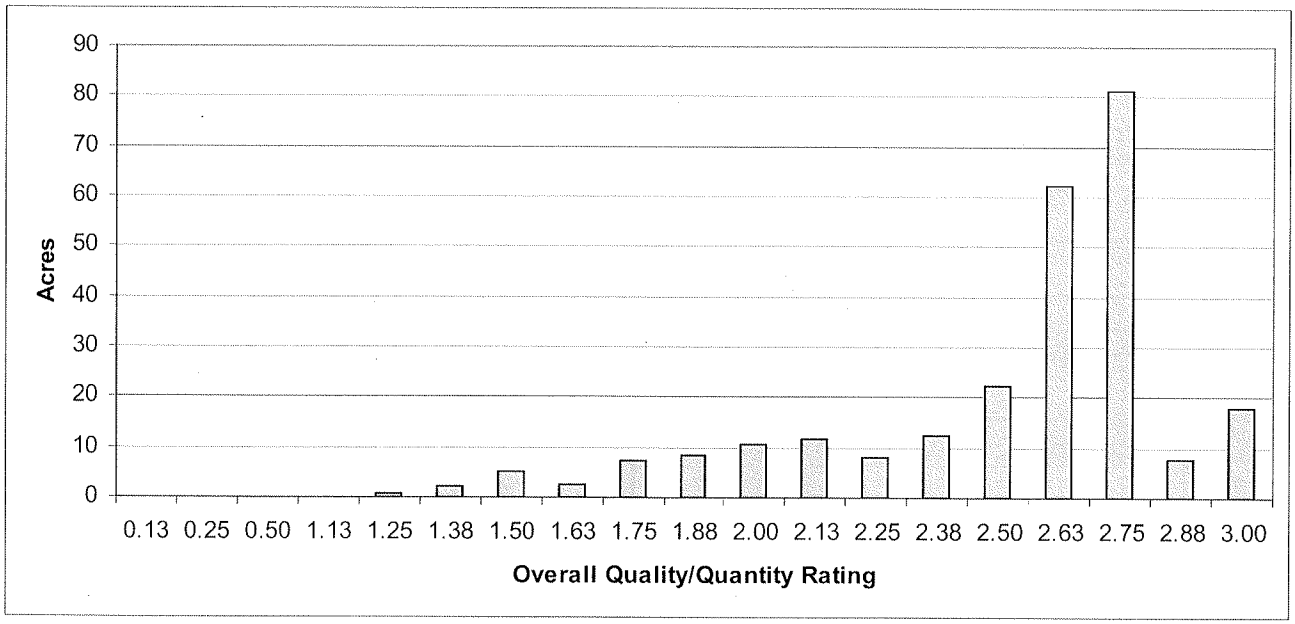

Figure 4-5 Acres of Riparian Fringe Habitat by Overall Quality/Quantity Rating

Table 4-5 Acres of Riparian Fringe Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score = 1	Acres with score = 2	Acres with score = 3
Organic Inputs	6.2	64.8	28.0	160.9
Large Wood and Channel Dynamics	23.2	20.1	25.9	190.6
Microclimate/Shade		10.8	54.1	195.0
Bank Function		22.0	27.4	210.5
Streamflow Moderation	43.0	172.2		44.7
Wildlife Movement			9.5	250.4
Habitat Diversity		3.0	48.1	208.8
Connectivity to Water				259.9

4.3.5 Forest / Woodland

There are 415 acres of FW. The quality/quantity ratings for FW range from 1.0 to 2.6 (**Figure 4-6**), with an average rating of 2.19 across all FW acreage on WHI. Approximately 81 percent of the habitat is rated between 2.0 and 2.5, with 91 percent rated above 2.0. FW is rated on the upper end of the rating scale because of relatively large patch sizes, lack of barriers to wildlife movement, and lack of edge habitat. (**Table 4-6**; **Map 7**). The small areas rated less than 2.0 are primarily due to adjacency to infrastructure or developed area. Although the large area of FW appears non-contiguous because of road/trail network and utility easements, proximity to other habitats outweighs these relatively narrow habitat breaks. WHI can flood in extreme events, however WHI rated low on the criterion measuring streamflow moderation since high flows akin to the 1996 floods are infrequent. The average quality rating for FW across WHI is 2.19.

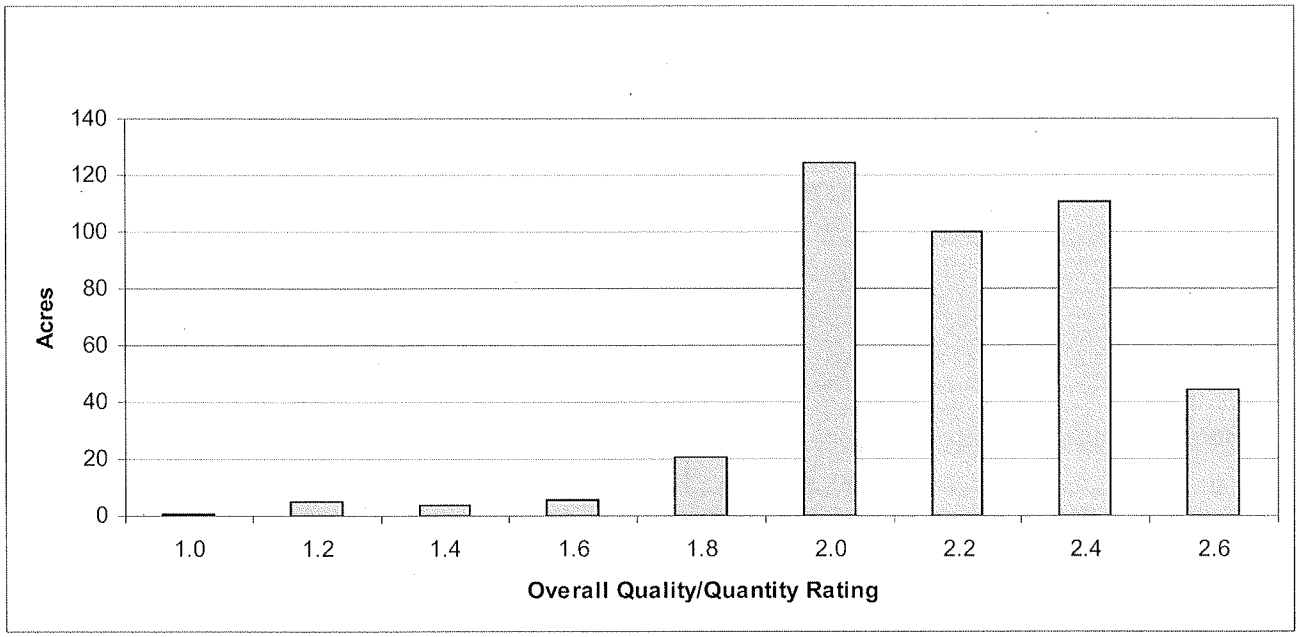

Figure 4-6 Acres of Forest/Woodland by Overall Quality/Quantity Rating

Table 4-6 Acres of Forest/Woodland Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score = 1	Acres with score = 2	Acres with score = 3
Habitat Patch Size	15.9	38.9	360.0	
Wildlife Movement				414.9
Streamflow Moderation		342.7	72.1	
Connectivity to Water		142.1	119.7	153.1
Interior Habitat	13.3			401.6

4.3.6 Shrubland

There are 76 acres of SHR. The quality/quantity ratings for SHR range from 1.5 to 2.8 (**Figure 4-7**), with an average rating of 2.27 across all SHR on WHI. Approximately 86 percent of the habitat is rated between 2.0 and 2.8, with 65 percent of acreage rating between 2.2 and 2.5. SHR is nearly all interior habitat, although the shape of SHR itself is mostly linear areas bordering forested areas (**Table 4-7**; **Map 8**). High scoring SHR is scattered in pockets throughout WHI and large amounts are affiliated with aquatic habitat.

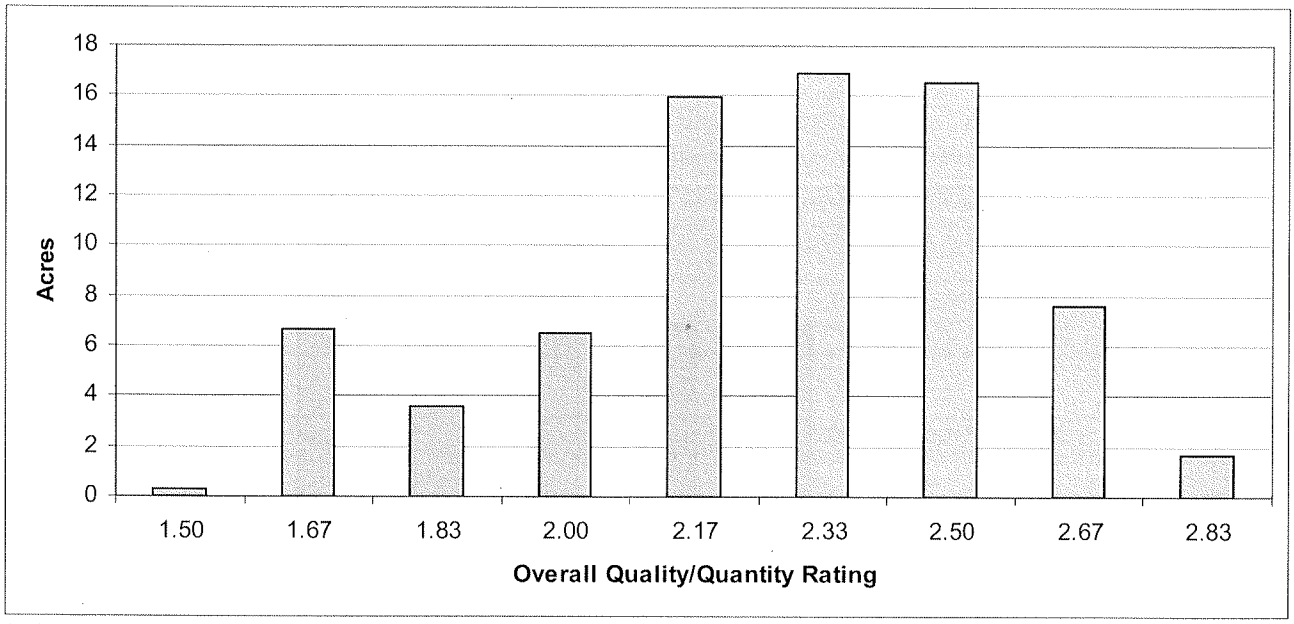

Figure 4-7 Acres of Shrubland by Overall Quality/Quantity Rating

Table 4-7 Acres of Shrubland Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score = 1	Acres with score = 2	Acres with score = 3
Vegetation Community Diversity		23.2	38.1	14.4
Habitat Diversity		16.7	29.2	29.8
Interior Habitat	2.9			72.8
Streamflow Moderation		62.6	13.2	
Wildlife Movement				75.7
Connectivity To Water		14.0	11.8	49.8

4.3.7 Grassland/Herbaceous

There are 227 acres of GRA, of which approximately 100 acres are within the dredge materials management area (as defined by the vegetation type of barren/weedy fill). While evaluated using the same criteria, the results for areas within the dredge materials management area are presented separately than for other grassland areas due to the different nature of this area.

Outside of the dredge material management area, there are 127 acres of GRA. The quality/quantity ratings for this acreage range from 1.5 to 2.8 (**Figure 4-8**), with an average rating of 2.36 across all GRA acreage located outside of the dredge material management area. Approximately 87 percent of the habitat is rated between 2.0 and 2.8, with 46 percent of acreage rating between 2.2 and 2.5.. These areas rate fairly high due to the interior habitat configuration, and the functions associated with soil conservation and lack of barriers to wildlife movement. (**Table 4-8**; **Map 9**). Areas of relatively lower quality provide less function as a streamflow moderator and less connectivity to water.

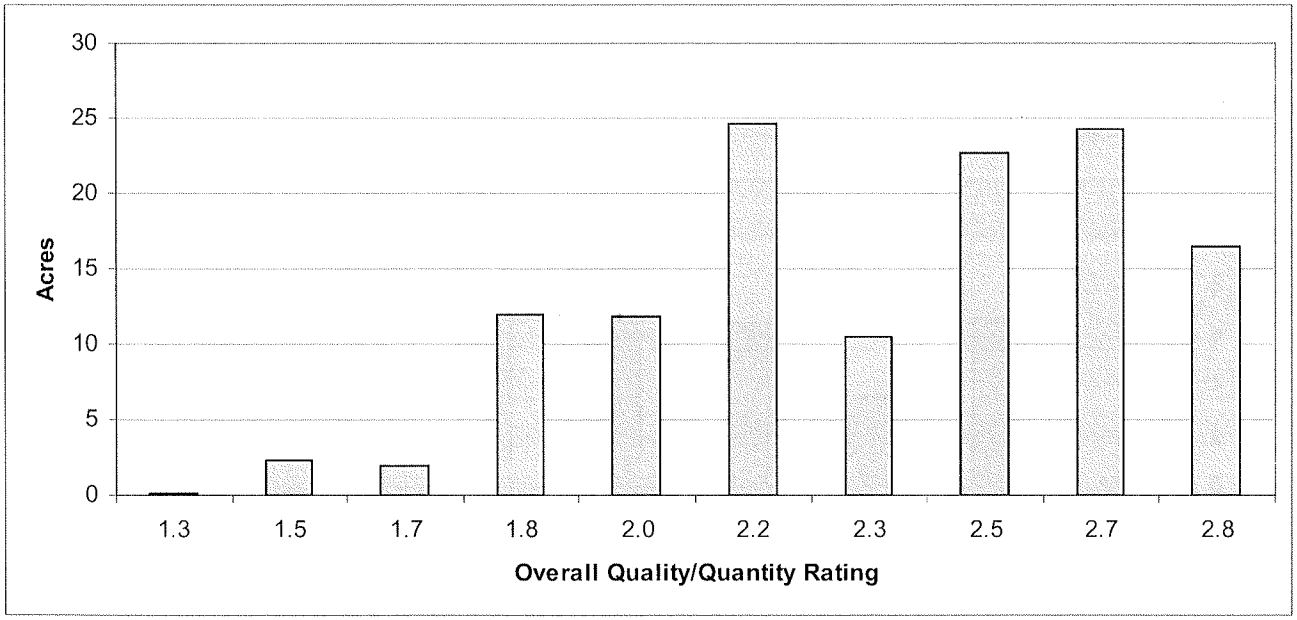

Figure 4-8 Acres of Grassland/Herbaceous NOT in Dredge Material Storage Area by Overall Quality/Quantity Rating

Table 4-8 Acres of Grassland/Herbaceous NOT in Dredge Material Storage Area Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score = 1	Acres with score = 2	Acres with score = 3
Soil Conservation	0.5	0.0	0.0	126.3
Habitat Diversity	11.9	16.6	42.8	55.6
Interior Habitat	7.5	0.0	0.0	119.3
Streamflow Moderation	0.0	96.8	30.0	0.0
Wildlife Movement Corridor	0.0	0.0	0.0	126.8
Connectivity To Water	0.0	48.1	35.2	43.4

Within the dredge material management area, there are 100 acres of GRA. Quality/quantity ratings for this acreage range from 1.3 to 2.3, with 77 percent falling in the range of 1.3 to 1.7 (**Figure 4-10**). The average quality rating for all GRA acreage in the dredge material management area is 1.60.While these areas also are characterized by large interior habitat areas, compared to other grassland areas, the patch size is smaller, vegetation diversity is lower, and there are more barriers to wildlife movement within the dredge material management area (see **Table 4-9**; **Map 9**).

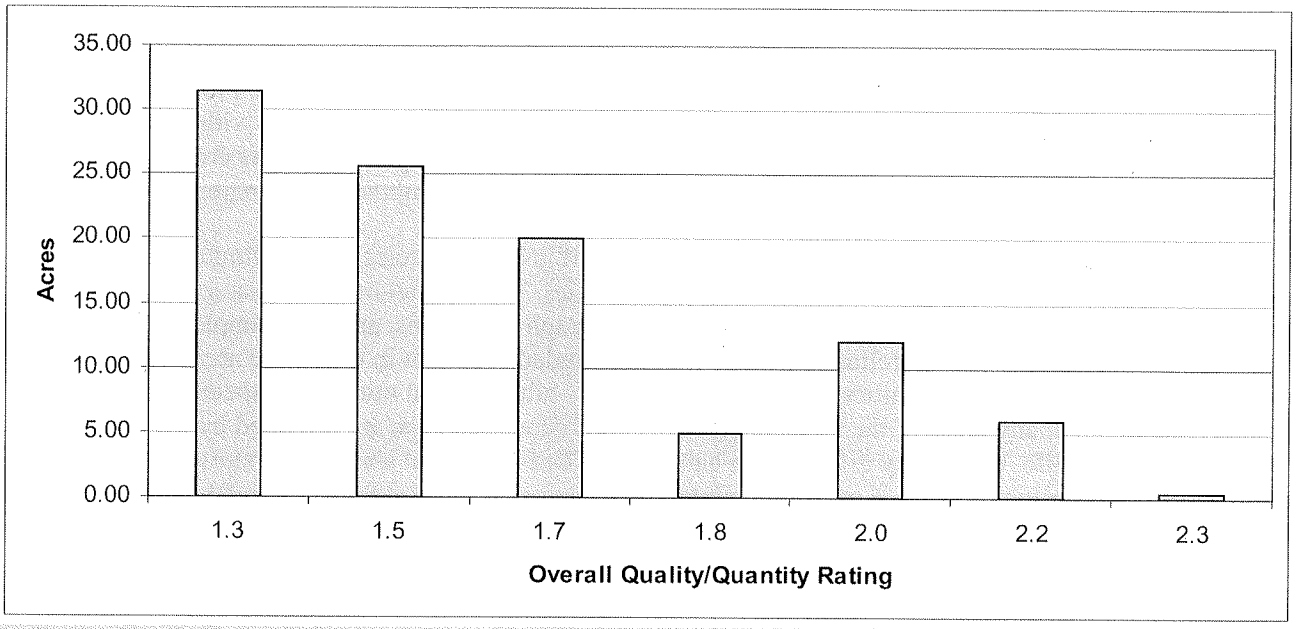

Figure 4-9 Acres of Grassland/Herbaceous in Dredge Material Storage Area by Overall Quality/Quantity

Table 4-9 Acres of Grassland/Herbaceous in Dredge Material Storage Area Categorized by Criteria Score

Criterion	Acres with Score = 0	Acres with Score = 1	Acres with score = 2	Acres with score = 3
Soil Conservation	100.6111			
Habitat Diversity	35.2	24.9	22.9	17.6
Interior Habitat				100.6
Streamflow Moderation		99.5	1.1	
Wildlife Movement Corridor				100.6
Connectivity To Water		72	19.8	8.8

4.4 CONSTRAINTS ON WHI NATURAL RESOURCE FUNCTION

Section 4.3 above describes the relatively high quality and quantity of habitat on WHI. WHI rates relatively high in quality largely due to the size and configuration (large areas of interior habitat) of habitats, as well as the diversity of vegetation communities. However, it is important to note that while WHI rates as relatively high quality, the quality and species utilization of WHI natural resource areas is limited due to its physical location in an urban area, its island geography, and the presence of invasive species.

The proximity of WHI to an urban/commercially developed area, with limited habitat resources, increases the importance of WHI as a habitat resource but decreases its quality compared to a similar habitat area located in a less developed area. Its location in an urban area adjacent to areas of intense land use reduces the quality of WHI habitat since there are elevated levels of noise from human activity, air and water pollution, and light pollution. These effects, however, are mitigated by the relatively large areas of interior habitat on the island.

The island nature of WHI results in both a resource opportunity and a resource constraint. While its extensive shoreline and connectivity to water enhance many natural resource functions, its island geography and lack of

wildlife movement corridors to other natural areas for terrestrial wildlife also limits its ability to serve as wildlife habitat for terrestrial mammals and other species. This physical separation can benefit wildlife in that it provides some isolation from the disturbances from the surrounding urban area and also provides bird species with protection from high populations of some terrestrial predators (in particular, within dense vegetation areas of WHI). On the other hand, the limited access to WHI, requiring a water crossing, constrains use by terrestrial wildlife and reduces population size and re-population after major flood events.

Finally, resource function on WHI is limited by the presence of invasive species and the limited natural flood disturbance necessary to maintain native vegetative communities. WHI maintains semi-natural soil characteristics that were initially formed under natural hydrograph conditions, and later supplemented by dredge material placement and shoreline structures that impounded sediment in nearshore areas. WHI supports native vegetation communities that establish on sandy-silt soils, but non-native species such as blackberry dominate many areas of the understory. Cover and food resources are provided by blackberries for many species of wildlife, but quality differs from habitat provided by natural shrub understory, particularly as natural shrubs provide longer periods of useful habitat. Also new cottonwood forest establishment on WHI is constrained because of the cottonwood forest's dependence on flood disturbance and sediment deposition for establishment. The natural flood disturbance and sedimentation regime has been disrupted by the construction and operation of the Columbia River dams.

Given these constraints, **Appendix A** discusses opportunities to enhance natural resource function on WHI.

SECTION 5

Natural Resource Conditions: Importance

The importance evaluation is conducted at a broader geographic scale and rates the regional role/contribution of WHI natural resources in the context of the larger study area, as defined in **Section 2.0** and depicted in **Map 1**. The study area includes the larger river corridors and nearby significant natural areas in the Columbia River corridor. This geographic scale accommodates larger-scale processes than observed in the immediate WHI locale, provides for considerations of connectivity between large natural areas for migratory birds, and includes consideration for similar habitats within the river corridor.

As described in **Section 2.4**, the importance evaluation incorporates such factors as location (geographic factors), resource size, trends (temporal factors), and relationship to other resources in the study area. A review of regional environmental resource reports finds WHI and the Columbia River/Willamette reach containing it as: 1) a fish migration corridor, 2) a center for multiple regional flyways, 3) a key terrestrial-aquatic habitat area within a region of isolated forest blocks, and 4) an area that hosts viable bottomland forest community that supports highly diverse species populations.

These findings are considered in developing criteria to qualitatively describe the importance of WHI resources in a regional context at both the **Habitat Level** and the **Island Level**. The habitat level analysis evaluates the importance of each WHI habitat type based on status and trends in scarcity and abundance of the habitat type and relative contribution to threatened and endangered species. The island-level importance rating evaluates the importance of the assemblage of WHI natural resources, based on the following four criteria: size of habitat area, relationship to other natural resource areas, connectivity to water, and geographic location.

5.1 WHI HABITAT TYPES LEVEL OF IMPORTANCE

The WHI habitat types in this analysis are representative of the types found in the area and each play a role in supporting the present diversity of fish and wildlife species. Each habitat type provides functions directly or in synergy with other habits (such as how forested areas provide shade in adjacent grasslands). Two criteria are used to rate the habitat-level importance of each WHI habitat: relative abundance of the habitat type, and the role of the habitat type in supporting threatened and endangered species. This section builds on **Section 3.2** that provided an overview of general trends and habitat conditions in various segments of the study area.

5.1.1 Habitat-Level Criterion 1: Scarcity/Abundance and Trends of Habitat Type in the Study Area

SHALLOW WATER HABITAT (SWH) The island configuration of WHI results in abundant SWH (240 acres). Migratory fish use shoreline areas for foraging and navigating river corridors and continuity of healthy habitat is important. Using the elevation-based SWH definition in this analysis, there is abundant SWH within the study area. However, there is a declining portion of SWH that is not affected by artificial structures and surfaces. Thus, the importance of this habitat type is not so much related to its overall scarcity, but to the scarcity of areas that are functioning as habitat.

SWH is a key habitat that has been affected throughout the study area by shoreline development, channel deepening, and flow management. WHI's SWH, in particular the higher quality, "protected"[35] habitats on the southern side of the island, provide a type of habitat that has been reduced due to bank-hardening. The trend for this habitat type in the navigation channel is to remain simple and transient. Viable SWH is expected to persist in alcove, embayment and side channel areas and in undeveloped reaches of the lower estuary. Flow management will continue to affect the formation of these habitat types that were often formed via sediment transport and shoaling during flood events. **Importance Rating: HIGH**

UPPER BEACH HABITAT (UBC) UBC includes tidally-influenced area[36] located at the water/upland interface. This habitat is the lowest acreage (28 acres) on the island yet provides elements to the channel margin habitat that are used by fish and wildlife species for aquatic and terrestrial migration and foraging. UBC habitat provides a limited, yet valuable function of connecting the river to margin floodplain habitats. These access areas are very limited in the study area as a result of shoreline development and bank hardening. Woody debris that collects along the high water mark is typically managed as a nuisance and removed in developed areas or removed for navigational purposes elsewhere. Although UBC habitat is abundant elsewhere, functional UBC habitat is scarcer in the immediate study area until downstream of the Willamette River, and farther downstream the Columbia River approaching the Lewis River confluence.

The historic trend for this habitat in the last century has been a rapid decline during regional waterfront development in the major port areas (Vancouver, Portland Harbor) and in various landings and urban/commercial developments encroaching on riparian areas. The present trend is to have less UBC impacted as restoration efforts seek opportunities to preserve this habitat link between aquatic and upland habitats. The quantity of this type of habitat is lacking in the study area locale but not in the larger ecoregion of the Columbia River estuary. **Importance Rating: HIGH**

WETLAND HABITAT (WET) The abundance of wetland habitat has declined significantly in the study area, and even when present on elevated floodplains, these wetlands are often disconnected from surface water. Only until reaching the area downstream of Sauvie Island are there increased instances of wetland/floodplain connectivity at frequent intervals. The location of WET on the margins of WHI makes them valuable for use by fish and wildlife using the Columbia River corridor. WHI WET along upper beach and riparian areas are also priority habitats for recovering species such as salmon and steelhead.

Although there is not a substantial area of WET (six percent of all habitat acreage), the presence of wetlands increases WHI habitat diversity and contributes to species' diversity. The presence of large wetland areas nearby (Smyth and Bybee Lakes complex and Vancouver Lake) and other smaller-scale areas contained in parks and natural areas, suggest that based on a scarcity and abundance perspective, WHI WET comprise a small percentage of study area wetlands. The importance of WHI WET is in their connectivity/proximity to the river. The location in the corridor, connectivity to mainstem aquatic habitats, and contribution to island biodiversity are unique and provide importance.

Significant amounts of wetland habitats in the Lower Columbia area receive formal protection as state and federal national wildlife refuges/areas (Table 6.2). In addition to these areas, The Nature Conservancy, and other environmentally-based land management groups, as well as local governments have set aside conservation areas that include wetlands. Due to these protections, WET in the study area is no longer steadily declining and wetland restoration efforts may actually increase acreage in the study area.
Importance Rating: HIGH

[35] The channel on the south side of WHI has historically been a shallow area which can indicate lower velocities. Dike structures are also contributing to sediment accretion on shoreline beaches also suggests a somewhat "protected" environment from mainstem channel flows and ship wake wave action. Overwater structures in the developed portions of Hayden Island likely contribute to this relatively lower energy area.

[36] The Columbia River is tidally-influenced up to the Bonneville Dam.

RIPARIAN FRINGE HABITAT (RIP) RIP provides diversity of function and encompasses a large area on WHI. The RIP provides vital links from the aquatic to interior island habitat and increases the value of adjacent habitats. It is abundant throughout the island (260 acres), however, the resilience and proper functioning of this habitat type is partly because of its abundance. Literature supports that wider riparian zones function more effectively. The width and vegetation characteristics (primarily forest/woodland) of WHI RIP are rare along the Columbia River in the study area.

In the Vancouver area, and on the mainland on the south side of Hayden Island and for several miles up the Willamette River, RIP quality and abundance is low. There is a scarcity of functional riparian habitat, and where present, it is often tightly clustered and not dispersed over larger areas making the RIP highly important in the local area yet moderate to low in importance on a large regional scale. Current regulations will slow or halt the effects on RIP, and some recovery is expected due to ongoing riparian and stream restoration. **Importance Rating: HIGH**

FOREST/WOODLAND HABITAT (FW) Mature cottonwood forests in the bottomland areas of the Lower Columbia River are in low quantity and WHI contains one of the largest stands in the region. Cottonwood-ash forest was once the dominant habitat type along the Lower Columbia, but today WHI represents approximately four percent of all that remains between Astoria and the Bonneville Dam. The altered hydrologic regime may be a significant reason why cottonwood-ash forests are no longer prevalent. Many of the floodplain areas that were naturally disturbed in pre-dam hydrology provided ample opportunities for cottonwood establishment. New sediment, seed sources, and a non-competitive environment allowed establishment of cottonwoods in the floodplain. Now there is connectivity only during very high flood events, limiting the opportunities for cottonwood species to establish throughout the study area. Cottonwood forests generally only establish above RM 40 and are the main component of island and river edge habitat along with Oregon ash. Some cottonwood plantations persist through the lower Columbia but are typically harvested in short life spans (10 – 20 years) and do not provide the type of complex habitats provided by mature forests.

The trend for WHI FW is that some of the more mature cottonwood stands may die out and lacking a regular hydrologic disturbance regime on the island, may be a limiting factor to new forest development. Understory shrubs that grow under woodland type forests may eventually predominate when overhead trees die off and can inhibit the growth of other tree species. **Importance Rating: HIGH**

SHRUBLAND HABITAT (SHR) Bird species on the island, in particular songbird species, are expected to be diverse due to the widespread and well-distributed SHR. In the region, SHR abundance has also been reduced in agricultural and developed areas. One particular threat to native SHR is the occurrence of invasive shrub species (Himalayan blackberry, knotweed, and purple loosestrife (shrub-like forb), in particular those associated with aquatic environments. Native SHR are labor–intensive to establish and maintain to recovery so the value of existing native SHR is important. Himalayan blackberry is abundant as a shrub or understory shrub so the loss of this particular habitat would not be significant to the larger region.

The trend for SHR quality and abundance in the study area is to remain somewhat stable. While SHR habitat also exists as the understory of woodland habitat, some species prefer open area SHR habitat, which can contain denser foliage than understory shrubs. Native SHR disturbed through land use, often do not recover with the native species but with more opportunistic non-native invasives. With the limits on native SHR to recover without restoration or management, remaining intact SHR habitat is important in maintaining regional biodiversity. SHR importance is based primarily on its scarcity on WHI and in the region due to loss of open space. **Importance Rating: HIGH**

GRASSLAND/HERBACEOUS HABITAT (GRA) GRA is primarily represented in the northeast portion of WHI in the area of past dredge disposal. To a large extent, GRA are an artifact of past land-use practices (agriculture and dredge material deposition) rather than historic conditions. In the larger region, native GRA has declined up to 99 percent in the Coast Range, West Cascades, and Willamette Valley (ODFW 2006). With the drastic

reductions of GRA in the region, WHI GRA has greater importance. Few GRA habitats remain in the City. However, Powell Butte, the St. Johns Landfill, and several large grassy areas in the Columbia Corridor provide functions that mimic native grasslands and are currently used by native grassland-associated species. Ross Island and WHI also provide unique island habitats in the Willamette and Columbia rivers, respectively. In general, native grasslands are a highly imperiled habitat in the United States and in Oregon, valley bottoms and foothills are the places where most loss has occurred due to land conversions.

Remaining native GRA remains threatened by continued development. On the other hand, there are ongoing strategies/efforts to restore this habitat type. Agricultural lands and low-profile vegetation open space can partially function as grasslands areas to compensate for the low amounts of GRA in the area, and grassland-associated species can survive through the use of these alternate habitats. However, agricultural lands, farmlands, or other open space that has been previously managed but is restored may not provide the quality and functions that native GRA habitats provide. **Importance Rating: HIGH**

5.1.2 Habitat-Level Criterion 2: Relative Contribution of WHI to Sensitive and Endangered Species Conservation in Relation to the Study Area

SHALLOW WATER HABITAT (SWH) AND UPPER BEACH HABITAT (UBC)

Ten Evolutionarily Significant Units (ESUs) of anadromous salmonids (salmon and steelhead) in the region are listed as threatened or endangered under the Endangered Species Act. Probably the most drastic stock reduction is the once-prolific Columbia basin chum which is down to about one percent of historic levels. All the anadromous species within the Middle and Lower Columbia stocks may have association with WHI via migratory pathway for adults moving upstream to their spawning ground and juveniles moving downstream to the ocean. This land-water interface provided by WHI and similar shoreline habitats is a key piece of integrating fish wildlife interactions as Cederholm et al. (2000) noted in a regional review of wildlife dependence on salmon.

The lower Columbia River and many tributaries in the study area have been designated as Critical Habitat with important elements necessary for salmon recovery and conservation (see **Map 11**). WHI shoreline and shallow water use could include fish originating from the Willamette River because of WHI proximity to the Columbia/Willamette River confluence. Threatened and endangered species (Chinook and chum) have been observed during beach seining assessments around WHI. The limited extent of observations, however, does not preclude a lack of abundance. Abundance is difficult to establish by beach seining in large rivers or other methods that may encounter turbid conditions. WHI offers shoreline areas that are not obstructed by piers or other overwater structures. Overwater structures can provide cover areas for predators that limit their visibility and reduces predator avoidance by threatened and endangered species. **Importance Rating: HIGH**

Wetland Habitat (WET) and Riparian Fringe Habitat (RIP) Sensitive and endangered bird species may use the island for stopover areas during migratory periods. The nearness to the Willamette/Columbia confluence provides a mixing of different water quality and nutrient regimes that can be a productive area for bird species. The scarcity of these habitat types that function with integrity and regularity (regular floodplain connectivity) gives the WHI WET and RIP importance. Low-elevation wetlands that are near shoreline areas can be connected during flood stages and provide important refuge habitat that is lacking in this stretch of the river. However, nearby Kelly Point Park provides similar shoreline features (slough feature on Willamette River side and forested banks) which make up the desired conditions needed for connecting shoreline habitats through the corridor, in particular hydrologically connected wetlands and RIP. **Importance Rating: HIGH**

FOREST/WOODLAND HABITAT (FW), SHRUBLAND HABITAT (SHR), AND GRASSLAND/HERBACEOUS HABITAT (GRA)

Sensitive and endangered wildlife species lack abundant access to aquatic/riparian upland corridor connectivity in the study area. WHI locale provides connection to these habitats from the Columbia River, and is an important access point to food resources for sensitive wildlife species. WHI's contributes to the

migratory corridor as a diverse vegetation community. The size of the FW in relation to the scarcity of other FW in the region is one of the main reasons these habitats have high importance. Breeding and migratory bird densities in these cottonwood habitats are generally the highest of all habitat types in North America. Large trees provide quality nesting habitat for larger birds that need big trees for their nests such as bald eagles, great-horned owls, and a number of colonial nesters including great blue herons. **Importance Rating: HIGH**

5.1.3 Habitat-Level Importance Rating Summary

WHI contains a small component of each habitat type represented in the study area. Loss of these particular habitats would only represent a small percentage of the habitats in the study area. The baseline conditions of these habitats in the study area indicate drastic losses from historic conditions.[37] Small reductions of habitat in an increasingly small habitat inventory have greater ecological significance. Resource use becomes concentrated in these shrinking habitats, magnifying the importance of maintaining larger tracts of habitat, particularly for river and watershed corridors.[38]

Due to these considerations, as well as regional habitat conservation guidance documents, all WHI habitat types are rated as high importance. Regional habitat conservation guidance documents indicate that WHI habitat types are considered to be of high importance (ODFW Conservation strategy). For example, Oregon Department of Fish and Wildlife has identified the following strategy habitats within the Willamette Valley and West Cascades: grasslands, wetlands, freshwater aquatic habitats, oak woodlands, late successional conifer forests, and riparian habitats (including cottonwood galleries). Of these habitats, all are present on WHI with the exception of oak woodlands and late successional conifer forests. These strategy habitats were identified based on habitat loss since 1850 and based on historical importance at the ecoregional scale, ecological similarity, amount of remaining habitat managed for conservation value, limiting factors, and importance to strategy species.

5.2 ISLAND HABITAT TYPES LEVEL OF IMPORTANCE

The previous section evaluated the importance of each WHI habitat type independently. WHI functioning as one habitat area, however, provides important features that contribute to habitat and species diversity, life history diversity, conservation, and protection that are often not provided by "mainland" habitats. Unlike a landscape that may be part of an extensive block of land that animals may avoid if not suitable, organisms from a broad area utilize island resources in a transient manner. Providing quality habitat continuity is an important, often critical factor in the long-term health and survival of populations that depend on these types of aquatic and terrestrial links for survival.

Four criteria are used to rate the island-level importance of each WHI habitat: relative size of the WHI habitat patch, importance of WHI to other natural areas, connectivity of WHI to water, and spatial location of WHI.

5.2.1 Island-Level Criterion 1: Relative Size/Quantity of WHI Habitat Patch Size

There is a total of 1,045 acres of habitat provided by WHI, including SWH and UBC. In particular, WHI provides significant forested acreage in relation to other natural areas. Within the Portland and Vancouver metropolitan areas, natural areas are generally smaller with the exception of Forest Park and vicinity. The large habitat patch size of WHI coupled with relatively minimal human impact and diverse habitat types, results in conditions that support high species diversity. Intact WHI forest habitats provide good riparian

[37] Oregon Department of Fish and Wildlife. 2006. The Oregon Conservation Strategy. Oregon Department of Fish and Wildlife. Portland, OR.
[38] USDA NRCS. 1999. Conservation Corridor Planning at the Landscape Level: Managing for Wildlife Habitat.

function and create opportunities for nesting, roosting, and perching. Downed large woody debris, either as whole trees or through breakage, is present in the woodlands and dead trees/snags provide potential cavity nesting sites. The downed large woody debris also combines with understory vegetation to create cover habitat and thermal refuge from warm open areas for small wildlife species (e. g. red-legged frog, salamander, and vole) and provides important nutrients for plants to absorb.

However, WHI is one of a series of island complexes in the Columbia River (nearby Government Island, Lemon Island, McGuire Island). The islands are part of a larger network of natural resource areas in the lower Columbia River as a corridor[39] and are positioned to be used by wildlife moving upstream-downstream along the corridor. Muskrat, river otter, and deer can cross large channel areas of the Columbia River to access these island resources. **Importance Rating: MEDIUM**

5.2.2 Island Level Criterion 2: Importance of WHI for Functioning in Association with other Natural Areas

WHI habitats are part of a large network of natural areas that provide habitat for migrating birds and many other species. These natural areas include Smith and Bybee Lakes, Sauvie Island, Ridgefield National Wildlife Refuge, Kelley Point Park, and Vancouver Lake Lowlands. **Table 5-1** summarizes these habitat areas, and does not include open water habitat in the Willamette and Columbia Rivers. WHI sits at the intersection of two major wildlife corridors and is used by wildlife moving north-south between Smith and Bybee Lakes and Ridgefield National Wildlife Refuge, and east-west between Sauvie Island and the Sandy River Delta.

At a larger scale, the study area is at the core of Pacific Flyway primary and secondary routes (see **Map 12**). Although the entire North American continent is essentially a flyway, there are principal routes traditionally mapped including valleys and wetlands typically used by shorebirds and waterfowl. One general east-southwesterly route connects northwestern Montana through the panhandle of Idaho and continues through the Snake and Columbia River valleys. While most species predominantly then turn southward across central Oregon to the interior valleys of California, some continue through the Columbia corridor merging with coastal or coastal - interior routes. The other principal route is the predominant north-south migration originating in Alaska and maintaining a coastal route which includes the confluence of the Willamette and Columbia Rivers and the Willamette Valley.

Table 5-1 Undeveloped Natural Areas in the Study Area

Site	Approximate Acres	Features
Sauvie Island	2400	Oak groves, cottonwood forests, pastures, fields
Smith – Bybee Lakes	1300	Oregon ash, cottonwood, willow forests; open water, wetlands, meadows
Government Island	1900	Riverine floodplain habitat, cottonwood forests, Oregon ash, willow forests, wetlands; meadows
Columbia Corridor (south shore)	1744	Riparian forests, beach habitat, shallow water habitat
Columbia Slough	266	Tidally-influenced riverine channel; wetlands, marsh, riparian, corridor Sandy River Delta to lower Willamette River
Sandy River Delta	1832	Cottonwood forests, river bottomland, meadows beach habitat, shallow water habitat
Vancouver Lake	2600	Open water, wetlands, riparian, meadow
Post Office Lake egress channels	4000	Open water, deciduous riparian, flood water retention
Ross Island Complex (Ross, Hardtack, East and Toe Islands)	325	Open water, deciduous uplands

[39] USDA NRCS. 1999. Conservation Corridor Planning at the Landscape Level: Managing for Wildlife Habitat.

Site	Approximate Acres	Features
Oaks Bottom Wildlife Refuge	163	Shrub habitat, open water, restoration
Sand Island	78	Riparian forest, beach habitat, shallow water habitat
Lady Island	500	Deciduous riparian forest and woodland, beach habitat, shallow water habitat
McGuire Island	228	Riparian forest; miscellaneous wildlife, beach habitat, shallow water habitat
Lemon Island	149	Grassland, shrubland, riparian forest, beach habitat, shallow water habitat;
Sand Island	75	Cottonwood forests, grasslands
Ridgefield National Wildlife Refuge	5217	Riverine flood plain habitat, seasonal and permanent wetlands, agricultural lands.
WHI	827	Riverine flood plain habitat, seasonal and permanent wetlands, bottomland forest and woodlands, grasslands, beach habitat, shallow water habitat

Natural areas near WHI are unevenly distributed and within the Portland metropolitan area urbanization has fragmented remaining limited natural areas. Remaining areas are concentrated in several large parks and low impacted neighborhood recreation areas. Kelly Point, Greenway, Whipple Creek, Forest, Holman, Macleay and Washington Parks, and Balch Creek are west of the planning area. Tryon Creek State Park, Smith and Bybee Wetlands, the headwater areas of Tryon and Fanno watersheds, Tualatin Mountains and McCarthy Creek, sloughs and wetlands of the Columbia Corridor, Johnson Creek watershed, and the upland east side buttes are the most notable natural areas within the Portland metropolitan area.

Despite the past and ongoing development in the Willamette/Columbia River confluence area, there are several areas of contiguous or lowly impacted acres of undeveloped land (including agriculture) from Sauvie Island to the mouth of the Sandy River and the lower Willamette River.

Many parts of Portland metropolitan area are devoid of the larger forested or vegetated resource areas, wetlands, and stream corridors featured in the Natural Resource Inventory. Large industrial and commercial areas along the Willamette Corridor, and in the Columbia Corridor, downtown Portland, and throughout much of the central-east portions of the city are densely developed. Parks, street trees and neighborhood groves provide essential watershed functions downtown and in many developed neighborhoods; however, anchor habitat areas and surface streams have been largely eliminated. Most of the resources identified in the inventory are degraded, at least somewhat, by the effects of urbanization which include: removal of vegetation, reduction and fragmentation of habitat patches and corridors, industrial contamination, stream channel down-cutting due to increased stormwater runoff rates, and invasion of non-native plant and animal species. **Importance Rating: MEDIUM**

5.2.3 Island Level Criterion 3: Level of Connectivity to Water

WHI has extensive overland and wetland connection opportunities during flood stage. Several similar island habitats and sloughs exist throughout the study area but do not provide as much habitat area. Larger wetland-lake areas such as Vancouver Lake or Smith and Bybee Lakes offer more extensive wetted area but may have difficult access, may be inaccessible, or may be undetected by migratory fish in the mainstem river. Therefore these small, cumulative habitats of WHI that are more readily accessible can have a relatively higher importance for particular species due to their connectivity. **Importance Rating: MEDIUM**

5.2.4 Island Level Criterion 4: Spatial Location of WHI Habitat

The distinctive characteristics of WHI habitat location in relation to other natural areas in the study area are due to its location near: 1) confluence of two major rivers, 2) intertidal influence in freshwater system, 3) dense metropolitan area, 4) central corridor of federally-designated Critical Habitat, 4) migratory bird

corridors, and 5) adjacent to highly developed area (Jantzen Beach – East Hayden Island). The location of this habitat provides a natural area linkage through a section of the Columbia River that has been impacted. In particular, the resources of riparian, connected wetland and upper beach habitat on WHI contribute to migratory and foraging success of fishes and birds.

WHI is a significant link in a chain of river islands starting near Sandy River Delta and continuing through the lower Columbia estuary. WHI shoreline is important in the face of lost functional shoreline due to Columbia River bank hardening. Migratory and resident species may depend on the terrestrial and aquatic link that WHI provides through the fragmented study area. **Importance Rating: HIGH**

5.3 CONCLUSIONS

WHI is positioned at both an aquatic and terrestrial intersection at the Columbia River/Willamette River confluence habitat and floodplain area. It is a large undeveloped tract amidst a fragmented urban landscape that provides nesting and stopover opportunities for migratory birds using the Pacific Flyway. Findings in this chapter include:

- All habitat types on WHI are of high importance. Wetlands (due primarily to their small sizes and known contributions to sensitive species) and shallow water habitat (due to their importance in large rivers and estuarine ecosystems as well as contributions to sensitive species) are potentially the habitats with the highest importance on WHI.
- The WHI habitat area viewed at the island-level as an assemblage of habitat types is of medium to high importance due to its diverse habitat types in close proximity, its relatively large size in the context of the Portland metropolitan area, its location at the center of migratory routes, and its connectivity through its wetlands and shoreline areas to water.

SECTION 6

Limiting Factors

The purpose of this section is to identify potential limits to maintaining natural resource function in the face of development. The section draws from preceding sections to identify and evaluate limiting factors to a mix of uses on WHI, including habitat conservation, marine-related economic development, and recreation. There are four subsections of this analysis of limiting factors. **Section 6.1** summarizes the mix of uses that may occur on WHI and provides an overview of potential impacts of these uses on WHI natural resource function. **Section 6.2** identifies and describes the six key limiting factors to natural resource function and their sensitivity to development. **Section 6.3** summarizes available information on how species use of WHI may be influenced by development-induced changes in the limiting factors. **Section 6.4** concludes with a brief discussion of these limiting factors in the context of larger cumulative land use change in the Lower Columbia River.

6.1 PROPOSED MULTIPLE USES AND LAND USE CHANGE

As noted in **Section 1**, WHI has been designated by Metro as a Regionally Significant Industrial Area, a high value riparian area, and a Moderate Habitat Conservation Area. Additionally, the site has significant recreation potential. The CWG is considering the viability of a mix of uses on WHI consisting of marine-related economic development, recreation, and habitat conservation. As described in the Economic Foundation Study, marine-related economic development would likely consist of marine terminals and potentially other marine industrial facilities. Recreation development would vary based on the activities and facilities provided, but would likely include beach access and boat docks or ramps. Hereafter, mixed use development refers to recreation and marine-related industrial uses in conjunction with habitat preservation.

Details of the type, size and location of recreation or marine-related economic development of WHI are not available at this time. However, the likely developments of commercial infrastructure, marine terminal(s) and/or recreational facilities may be on the order of 200 to 500 acres. There may be some combination of buildings of various sizes and configurations, lighting and communications structures, parking lots, roads, rail spurs, hiking/biking trails, maintained greenways, marine terminals; shoreline bulkheads, river channel dredging, and other infrastructure. Associated with these facilities and activities may be noise, vibration, artificial lighting, human activity, changes in surface and ground water hydrology, and other non-natural disturbances, any or all of which may limit natural resource function on WHI. These "limiting factors" are the subject of this section.

6.1.1 Overview of Potential Changes in Natural Resource Function from Land Use Change

The potential impacts of development on WHI wildlife habitat and overall natural resource function will vary depending on (a) the size, type, duration, magnitude, and location of development, and (b) the degree that mitigation measures or best management practices are implemented during construction and operation. For a given level of development, effects on each key fish and wildlife species will vary based on the habitat requirements and sensitivity of each species to changes.

Potential effects of marine terminal or recreation development on WHI could affect habitat and associated wildlife in the following general ways:

- Overall reduction of habitat area resulting from presence of buildings, roadways, parking lots, and other impervious surfaces will reduce the habitat available to support species. Land areas directly adjacent to a development footprint are more exposed to non-native invasive species and native generalist species during the post-construction period. Mitigation requirements during and after construction will typically mitigate for overland runoff and hydrologic issues associated with the development, however, the effects of direct habitat loss could be difficult or impractical to compensate for in the remaining undeveloped area. Some species require large habitat areas, and the resulting smaller habitat availability may reduce the number, or change the composition of, species on WHI.

- Fragmentation of the habitat will occur with development. Habitat fragmentation affects plant and animal populations at several scales. The fragmented landscape (e.g., smaller patches of physically undisturbed habitat, increase in non-native vegetation, buildings located in riparian areas) can create isolated habitat patches that are too small and/or are disconnected leading to reduction in utilization by some species and even local extirpation of some species population(s).

- Edge habitat relative to interior habitat on WHI will be increased by development. As habitat becomes fragmented into smaller patches, more habitats will become edge habitat located next to developed areas. Decreasing the amount of interior habitat areas[40] may result in a reduction of species diversity and/or of utilization by some species. For marine terminal developments, necessary infrastructure such as truck, vehicle and rail transportation, utilities, and operational effects such as noise, vibration, and lighting, can decrease edge habitat quality. These are not necessarily physical degradations or conversion of habitats, but are effects that may make habitats less suitable or even unsuitable for certain species.

- Simplification of habitat (e.g., introduction of non-native and/or early successional native vegetation, landscaping, tree pruning) can occur by creating intensively-managed areas (e.g., conventional landscaping or stormwater/runoff retention ponds) that offer minimal habitat diversity. Simplification, or the reduced diversity, of habitat reduces foraging and nest sites for ground- and shrub-dependent wildlife. Eventually, natural succession may diversify the habitats but the recovery time can vary depending on the initial vegetation type. Habitats that are scarcer than others, such as wetlands, are most vulnerable to simplification. Their functions are only replaceable by other equally functional wetlands.

- Water quality can be degraded by runoff from impervious surfaces. Water quality impacts could degrade existing wetland conditions or function even if the wetlands are left physically intact. Altered hydrology can affect the length of time wetlands maintain surface water, having implications for amphibian or aquatic reptile life history schedule and/or success.

- Barriers to wildlife movement could be created by infrastructure (including roadways, culverts, elevated levees, buildings, pier piles, and artificial lighting). Animal fatality by vehicles or trains may increase if wildlife movement is not accommodated in the project design and operation. Expansion of road and trail networks could require wider rights-of-way, increased elevation, and/or impervious surfacing. Bank, shoreline and in-water structures such as docks, wharves, or artificial bank stabilization may impact habitat quality and may inhibit wildlife travel between water and upland (e.g., grassland, riparian) areas.

- General disturbance by concentrated industrial development or recreation can adversely impact habitats or their use by:

  - Artificial lighting that may lengthen the photoperiod for some species and provide an attraction for other species, especially birds, that results in collisions with building and structures;

[40] Interior habitat is defined as habitat farther than 200 feet from developed areas.

- Increasing predation, especially from feral cats, dogs (domesticated and feral), and other visual predators, with particular adverse effects on ground nesters and feeders,
- Regular foot and vehicle traffic, pet use, and beach access by boating activities that could affect breeding success for several species of birds as well as reptiles.
- Increasing noise throughout WHI; and
- Introduce vibration from industrial machinery and traffic.

These potential changes in physical conditions can in turn affect the physiological, behavioral, and life history of WHI wildlife. In general, the following biological impacts should be considered in determining the type, location, spatial extent, and potential impacts of development:

- Increased predation of and disturbance to resident, native species;
- Increased winter residency in areas formerly used only for stopovers;
- Loss of stopover habitats for migratory or transiting species;
- Changes in feeding and foraging behavior;
- Prolonged breeding season and/or multiple clutches during the breeding season;
- Change in nesting habits such as using areas with increased densities, use of non-preferred tree or branch configurations for nest construction, or other alternatives from loss of cavity habitat;
- Reduced reproductive success as a result of stressors in the environment such as noise, lighting, or limited habitat space;
- Smaller population size because of decreased food and space resources;
- Tolerance of humans that could influence changes in feeding behavior and risks to traffic encounters; and
- Change in species composition and diversity as a result of reduced habitat area and changes in habitat characteristics, especially related to vegetation and /or hydrology.

Loss of habitat area would be expected to result in an overall decrease in the population size and diversity of animals and plants on WHI. With greater loss of any particular habitat type, a decline in use by species adapted to that habitat would be expected. The magnitude, time frame, and sequence of these population-level impacts are difficult to quantify without comprehensive baseline information about WHI population abundance and distribution and their seasonal use of adjacent habitats such as mainland, other island, and open water areas. In general though, the development of WHI is expected to lead to a decline in size, location, and diversity of habitats and thus to a decline in species use, abundance and diversity on WHI.

6.2 LIMITING FACTORS TO NATURAL RESOURCE FUNCTION WITH MIXED USES

The "principle of limiting factors" in ecology is related to the controlling factors for ecological processes. It suggests that, at any particular time, the productivity of a species, habitat, community, or ecosystem is limited by a single essential factor, the one that is present in the smallest supply relative to the potential biological demand. Limiting factors may be different among species or communities and can also vary depending on the location (for example, the size of available spawning habitat in the upper part of a particular tributary may be limiting the size of a fish population). For the purposes of this study, we define the limiting factors as those natural resource attributes that may be affected by development and therefore may limit the viability of one or more species of concern when the present habitat-species composition is compared to the expected composition with mixed use development. Many of these limiting factors are the criteria used to score habitat types and natural resource function in the quality/quantity rating (see **Section 2** and **Section 4**).

6.2.1 Identification and Description of Key Limiting Factors

This section identifies the key limiting factors that may constrain natural resource function and species use due to development on WHI. Six key limiting factors are identified: hydrodynamics and shallow water habitat function, habitat patch size and configuration, riparian function, wetland function, wildlife movement and island habitat diversity, and disturbance associated with human activity. Of the types of changes outlined in **Section 6.1.1**, these six factors are likely to be the most critical, or most limiting, to natural resource function and species utilization on WHI in the face of development.

Table 6-1 summarizes the six limiting factors, describes the habitat structural change that may occur due to mixed use development, and notes the general predicted change in natural resource function and species utilization of WHI in response to these structural changes.

Table 6-1 Effects of WHI Mixed Use Development By Limiting Factor

Limiting Factor	Structural Change to Limiting Factor due to Development	Effect on Natural Resource Function / Species Utilization
Hydrodynamics And Shallow Water Habitat	Altered flow dynamics Floodplain disconnect Physical structures and development may harden shoreline	Establishment of floodplain, disturbance-dependent vegetation communities inhibited Non-native shrub/grass communities may become predominant Fishery resource use of stream-adjacent wetlands, which historically had more frequent flooding and access from river, may be limited to high flood stages Inundation of season wetlands reduced, which affects the wetland function and the species that use the wetlands Effects of structures within SWH could affect use in several ways for a variety of species Impacts on forest succession due to altered hydrology could inhibit long-term forest succession
Habitat Patch Size, Configuration, and Continuity	Direct loss of wildlife habitat Loss of standing and down wood Increased edge and reduced interior habitat	Fragmented forests may not provide the size and/or continuity for maximizing use by some native wildlife species Increase in utilization and dominance for non-native invasive as well as native colonizing species Reduced species population size and diversity; potential of certain habitat size-dependant species to forgo use of WHI
Riparian Function	Reduced riparian vegetation abundance and diversity Bank hardening Steepening of banks	Reduced shading and microclimate affects, nutrient cycling, soil development, overland flow control, and pollutant filtering and sediment trapping Reduced vegetation diversity and wildlife species populations and diversity Reduced wildlife access between upland and aquatic habitats Increase in utilization and dominance for non-native invasive as well as native colonizing species Potential highly restricted corridor habitat
Wetland Function	Filling and subsequent development Edge effects including loss of surrounding vegetation, distance to development Hydraulic isolation from water sources and/or within a wetland	Direct Habitat loss or fragmentation of partially filled wetland areas Partial isolation due to linear features such as trail, rail or road loops

Wildlife Movement and Habitat Diversity and Structure	Large habitat patches fragmented, separated and/or isolated Loss of habitat type due to infrastructure	Wildlife population becomes fragmented, movement is restricted or eliminated and disruption of breeding success for terrestrial wildlife Reduction or elimination of habitat/wildlife abundance in project area Lack of substitute habitats in the region that could be utilized by migrating species could lead to reductions in regional species populations
Disturbance	Noise (People, Machinery) Artificial light Air and water pollution Human and pet presence	Animals may alter behavior to avoid areas of disturbance Reproductive success reduced by disturbance of breeding and nesting. Artificial light may interrupt natural behaviors, expose individuals to higher predation levels, or disrupt navigational abilities. Human and pet presence and air and water pollution can deter habitat use or cause avoidance behaviors of animals.

6.2.1.1 Hydrodynamics and Shallow Water Habitat

The quality/quantity evaluation in **Section 4** finds that WHI maintains relatively high quality habitat. WHI shoreline areas and island elevation in some areas have been altered by dredge material placement; however several habitat types, including man-made habitats, are used by many native species. The quality ratings for Upper Beach and Shallow Water Habitat were influenced by the non-developed shoreline that includes several low-energy sandy beaches. These low energy areas contain some embayment properties and adjacent forested riparian areas, and are important high value areas in the lower Columbia River.

Irregular connectivity of WHI floodplain areas to flood events has hindered bottomland hardwood forest development. Development on WHI could lead to further loss of connectivity between the Columbia River and WHI floodplain areas and thus reduced function and quality of existing forest/woodland habitat. Less frequent flooding may also lead to replacement of the cottonwood/ash mixed communities by shrub habitat as the existing cottonwood/ash community matures and dies.

Altered hydrology due to dam-regulated flows has limited the development and maintenance of shallow water habitats in the Lower Columbia River including WHI. Natural expansion and man-made creation of shallow water habitat in recent years has increased in the lower estuary. The quality of shallow water habitat has some dependence on nearshore vegetation type and upper beach habitat. The shallow water areas are utilized more frequently and more abundantly by fish and wildlife species. Further validation of the local importance of these areas would be necessary and could potentially include identifying areas with embayments, complex upper beach, and overhead canopy in the riparian area providing relatively high productive shallow water habitats.

On WHI, the effect of a development on shallow water habitat may be substantial but would likely be more related to disturbance from construction and operation activities than from physical habitat loss (especially if appropriate mitigation measures are implemented). Terminal designs could include dock extensions into deeper-water. The effects of such structures could create low flow refuge in the deeper water around the piles but also may induce scour of shallow water habitat substrate. Overwater structures can have negative impacts on the aquatic environment; e.g., aquatic vegetation may be shaded and wood piles may provide refuge for predators. Hydrodynamic features and shoreline features that fish are known to use could be altered by shoreline development or overwater structures, which could reduce habitat quality and potentially result in less use by species. Since shallow water habitat surrounds WHI, development contained in one area of the island would have a limited impact on the overall amount of shallow water habitat on WHI.

Impacts to riverine aquatic habitats will mostly be determined by intensity of land use, and by final designs and operations related to overwater structures. The limiting factor may be mitigated to some extent by the placement of ramps, docks and extensions in the siting of structures. More extensive analysis and

development design details are necessary to understand if channel maintenance or artificial bank stabilization techniques would be required.

6.2.1.2 Habitat Patch Size, Configuration, and Continuity

WHI supports a mostly contiguous, species-diverse natural area composed of several vegetation communities with a diverse representation of vagile species (species able to move freely about such as songbirds) and less vagile species (such as small mammals or resident reptiles). There is no evidence to suggest WHI has either more or less species diversity than historic conditions. McGarigal and McComb[41] conducted a regional study in coastal Oregon landscapes that found that changes in bird abundance among landscapes was more strongly related to changes in habitat area than configuration (layout) of the habitats. Therefore, loss of habitat through development on WHI, regardless of where it may occur, may reduce quality of WHI resources for wildlife use.

McGarigal and McComb found no evidence of a specific threshold at which bird population(s) dramatically changed due to the amount of habitat and/or configuration. Andren[42] reviewed studies of bird and mammal population dynamics in habitat patches that had varying proportions of suitable habitat. He found that patch size and isolation of habitat patches compounds the effect of habitat loss when habitat is 30 percent or less of the total landscape area. WHI is located in a metropolitan landscape that, as a whole area, is less than 30 percent habitat. Therefore, habitat patch size and configuration is expected to be a stronger influence in habitat quality within a metro area compared to a landscape surrounded by natural areas. In a metropolitan area, such as the greater Portland-Vancouver area, the effect of habitat loss may be a potential loss of species from the area.

6.2.1.3 Riparian Function

Riparian areas are a necessary component in many aquatic and terrestrial species lifecycles. All of WHI functions as a riparian area due to its location in the Columbia River floodplain. In general, the closer a riparian area is to a river or stream, the more influence it has on the both the adjacent upland and aquatic habitats. Riparian areas may have less influence on the aquatic functions of larger rivers than on smaller streams, but the importance of their health remains since many species are dependent on the riparian habitat for portions of their life history.

The influence of riparian zones upon certain aquatic characteristics, such as water temperature and hydrologic effects, are difficult to directly relate to riparian conditions in large rivers such as the Lower Columbia River. Most functional thresholds for determining riparian protection were developed through observations in forested upland areas adjacent to much smaller streams/rivers than the Columbia River. Large river estuaries and mainstem channels are predominantly influenced by the cumulative effects from upstream habitat. In the lower reaches of large rivers, floodplain interactions and the hyporheic (underground) flow affect water temperature and flow characteristics to a larger degree than do vegetation characteristics. The Lower Columbia River is a very large river, so the relative contribution of WHI riparian habitat to water temperature and flow characteristics are localized and limited.

However, forested riparian areas on WHI can significantly enhance riparian function and contribute to the success of wildlife species such as pond-breeding amphibians and turtles that depend on riparian areas to complete portions of their life history. Forested riparian areas on WHI provide habitat to many wildlife

41 McGarigal, K., and W. C. McComb. 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. Ecological Monographs 65(3):235- 260.

42 Andren, H. 1995. Effects of landscape composition on predation rates at habitat edges. p. 225–255. In L. Hansson, L. Farhig, and G. Merriam (eds.) Mosaic Landscapes and Ecological Processes. Chapman and Hall, London, UK.

species, particularly in the context of the significant decline in bottomland hardwood forests in the Lower Columbia River. In the study area, riparian habitat along the large rivers (Willamette and Columbia) has been greatly diminished and WHI is one of a diminishing number of intact riparian habitats.

Significant ecological functions, such as nutrient input, litterfall, and habitat structure, will be lost upon removal of riparian vegetation even in a river such as the Columbia. WHI's north shoreline contains expanses of sparse vegetation and has generally lower habitat quality than the south bank. Removing even sparse vegetation on either shore through development would result in a loss of riparian functions. Removing mature forested/woodland riparian vegetation that provides complex forest structure, vegetation diversity, and species diversity, would result in a loss of riparian functions that would be difficult to replace through mitigation.

6.2.1.4 Wetland Function

WHI contains predominantly sandy soil characteristics that provide for good hyporheic connectivity and percolation during river flood stages and heavy rainfall. The WHI emergent wetland habitat adjacent to the Columbia River includes litterfall and floodplain deposits, both of which serve as nutrient resources. The wetlands provide for absorption of surface water into the groundwater aquifer. These wetlands also provide habitat for a variety of plant, insect, fish, bird, and other wildlife species, some of which may be largely or wholly dependent on wetlands for their existence on WHI.

WHI development could result in direct wetland habitat loss or fragmentation if wetland areas are partially filled due to development. Loss of these wetlands in conjunction with paved areas would likely affect the rate and amount of absorption of surface water into the groundwater aquifer. Loss of wetlands can have highly deleterious effects on wildlife species such as reptiles and amphibians that depend on this habitat to complete portions of their life history. If adjacent riparian and/or wetland vegetation is removed for development purposes, the surface water and water retained in wetlands through the summer could experience adverse effects such as elevated temperature, reduced dissolved oxygen and adverse chemical concentrations.

Several regional strategies indicate wetland habitat is scarce and essential for threatened and endangered species recovery. Mitigation requirements for wetlands or surface water runoff limitations could affect siting of facilities on WHI.

6.2.1.5 Wildlife Movement and Habitat Diversity

Unimpeded wildlife movement is crucial to healthy wildlife populations, and as it occurs, it creates a synergistic effect that increases the overall quality of the habitat. Movement across landscapes allows wildlife to access diverse habitats needed for various life stages, such as calving or nesting, and for daily migrations between different areas used for foraging, breeding, nesting, denning or bedding. Maintenance of transmission line rights of way and the necessity of additional road easements can impact connectivity and productivity of habitats by isolating habitats and hindering movement of some terrestrial species. Apart from potential building strikes, birds would not be hindered by building structures but foraging behaviors or habitat use may be changed from reduced habitat area and adjacent development. Species that may have migrated between the Columbia River and aquatic or upland habitats may use riparian corridors less if transportation or operational effects are near.

Perhaps one of the strongest contributions of WHI contribution to the ecoregion is its diversity of functional habitat types. Although much of the habitat diversity is due to past management, such as the grassland area resulting from dredge material management, or the shallow water habitat and embayment areas formed near sediment dikes from sand deposition, the sites are functional. Loss of significant portions of any one habitat type will reduce habitat diversity. Development on the north shore of WHI would likely have the greatest

impact on grassland habitat, with this habitat persisting in small patches, potentially below the amounts needed by many species to be viable.

With the combination of having diverse habitats and its mid-channel location, WHI serves as a key link in the upstream-downstream corridor migration of the Columbia River. Maintaining such wildlife corridors and habitat diversity is a means to moderate some of the adverse effects on wildlife species of habitat fragmentation. More riverside development occurring elsewhere will increase species use of WHI as foraging or stopover habitat in addition to use by resident wildlife populations.

6.2.1.6 Disturbance (Light, Noise, Pollution, Human Activity)

Direct and indirect effects from WHI development are likely to limit reproductive success and population size of species in adjacent habitats. Infrastructure such as truck, vehicle and rail transportation, and utilities and operational effects such as noise and lighting, can decrease adjacent habitat quality through edge effects. Such disturbances are not necessarily physical degradations or conversion of habitats, but are effects that may make habitats less suitable for some species or cause species behavioral modifications. Shoreline development structures such as docks, wharves, or artificial bank stabilization may adversely impact habitat quality and use.

6.2.2 General Responsiveness of Limiting Factors to Mixed Use

This section provides a brief discussion of how some of the principal habitats and limiting factors could be affected by mixed use development. Development may affect natural resource function, and associated limiting factors, directly and indirectly.

Figure 6-1 illustrates, at a conceptual level, the response of habitat-based limiting factors to reduction or loss of habitat. The general shape and slope of the response curve for each limiting factor is based on general trends observed in the region. The steepness of the curve (sensitivity) is influenced by the general elasticity of the limiting factor; that is, how resilient or not the factor is to maintaining its function in the presence of disturbance. The response curve of each limiting factor to development will depend on the type and size of development, and its location on WHI. The response curves would be shaped differently (not illustrated in **Figure 6-1**) with effective mitigation that could restore function towards baseline conditions and minimize the effect of development. Setbacks, seasonal use restrictions, constructed habitats, enhancement of existing conditions are examples of such practices.

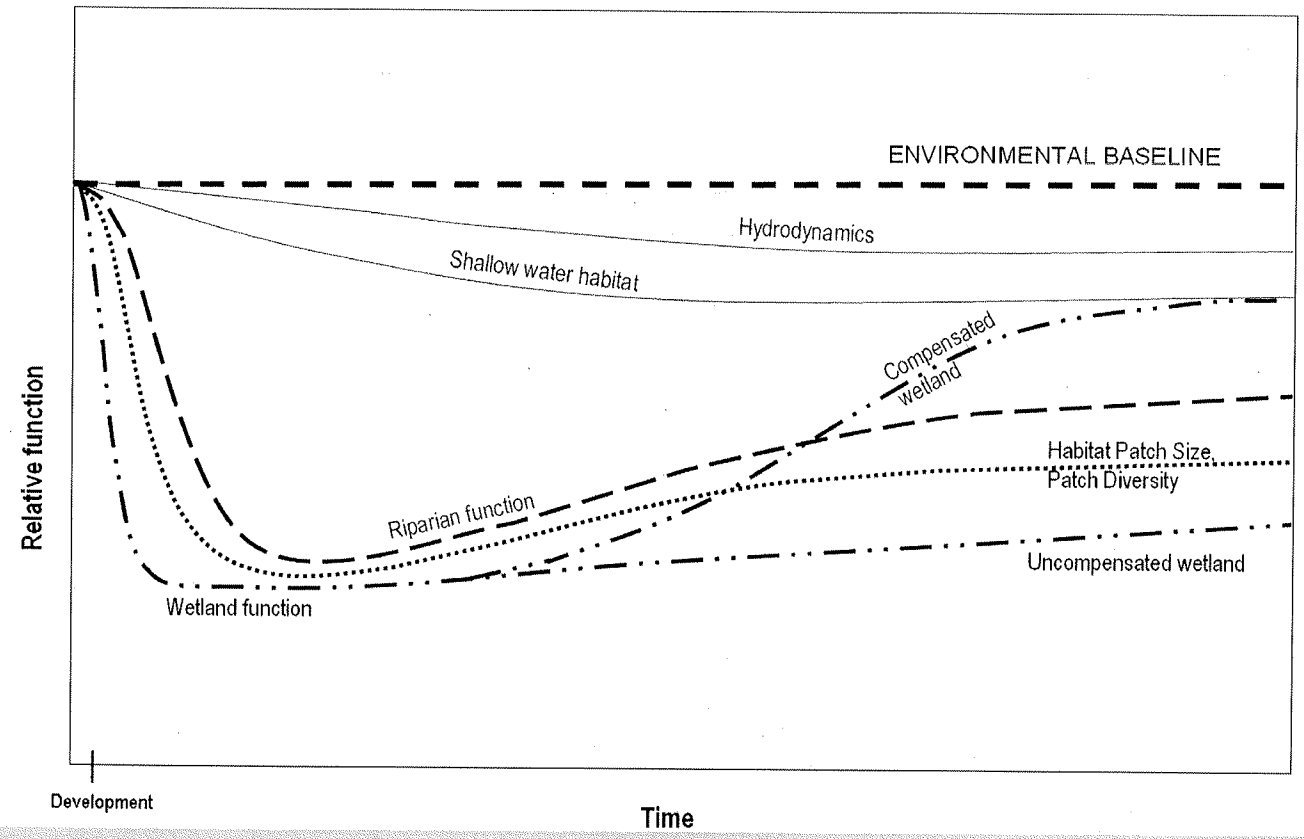

Figure 6-1 Conceptual Effect of Development on Habitat-based Limiting Factors

The wetland function curve illustrates the conceptual response to functional recovery. Filling or excavating the wetland results in a substantial and almost immediate loss of function. Wetland function is not likely to recover much without effective mitigation.

Hydrodynamics and shallow water habitat are expected to be moderately influenced by development and operation, as permanent fixtures in the shallow water habitat and effects on wildlife use through operation would reduce function. Habitat patch size would be directly impacted by development. There may be slight recovery of habitat use by wildlife adaption to development, but developed acreage would permanently reduce overall habitat abundance. Habitat patch size altered through construction or in the center of a track loop could potentially recover. Migration by terrestrial wildlife across the island and to mainland areas would be altered by development. Some connectivity could be recovered by culverts or green belts but would be limited to permanent and static locations.

Riparian function effects are immediate and directly related to habitat loss in interior areas adjacent to wetlands. Some improved functionality could be gained island-wide by forest succession or by post-development site reclamation. Reduced wetland habitat acreage is the affected habitat type due to its island-wide scarcity and concentrated presence in the development footprints. Wetland functionality recovery can be slow if reliant on natural succession of remaining wetlands. Compensatory wetland mitigation can hasten recovery of function to existing levels. The time period required for constructed or enhanced wetlands to fully function is unpredictable, as function can be constrained by new site conditions.

In general, the sensitivity of these limiting factors to development can be a combination of many influences such as how large the habitat patch sizes are, seasonal differences, resiliency of the habitat type, and the location of the habitat and how it contributes to the functionality of adjacent habitats. **Table 6-2** provides a general overview of the relative sensitivity of limiting factors within and outside of a mixed use footprint.

Table 6-2 Overview of Relative Sensitivity of Limiting Factors to WHI Mixed Land Use

Limiting Factor	Estimated Response to Development	Rationale for Influence Level of Limiting Factor	Sensitivity within Mixed Use Footprint	Sensitivity Outside of Mixed Use Footprint
Hydrodynamics and Shallow Water Habitat	Nearshore flow modifications Generally low impact with non-obtrusive design and limited bank hardening	With appropriate setbacks, development may avoid or minimize shore hydrodynamics Minimal impacts from development could occur if overwater structures are located closer to navigation channel than shoreline; operations may have more significant impact.	Moderate to High	Low to Moderate Downstream effects may occur
Habitat Patch Size, Configuration, and Continuity	Loss of habitat and habitat fragmentation Reduced patch size	Development footprint is direct habitat loss Rail spur development could inhibit wildlife access between habitats Aquatic habitat patch size may be minimally affected; terrestrial habitats patch size may be substantially reduced	Moderate (aquatic habitat) High (terrestrial habitat)	Moderate Remaining habitat patch size is smaller.
Riparian Function	Loss of riparian vegetation adjacent to wetlands would reduce function	With a 300 foot setback, riparian area on the river could be fairly maintained. However, the footprint could include wetland and interior riparian areas.	Moderate	Low Riparian function is a likely limited to footprint
Wetland Function	Immediate impacts due to construction and partial impacts of remaining wetlands. Curve slowly recovers with compensatory or wetland mitigation program	Limited wetland acreage, long duration needed for constructed/mitigate ponds to function	High	Moderate Hydraulic influence and microclimate can still be impacted
Wildlife Movement & Island Habitat Diversity	Structures may disconnect habitat corridors used by wildlife; this is particularly relevant for spur development unless mitigated Diversity will be maintained unless complete loss of a particular habitat	For animals to be productive on island ecosystems they need access to limited food resources. Birds would be are minimally affected by linear infrastructure. Remnant (small patches) of habitats may not fully function	Moderate to High	Moderate Effects can still be island wide because of island-wide use by some species
Disturbance	Modified behaviors, avoidance of construction area, underutilization of habitat	Species adaption to noise levels, there will be more subdued noise levels after construction	High	Low to Moderate Noise and light disturbance can have a large range

6.3 THRESHOLDS AND IMPACTS OF MULTIPLE USE ON SPECIES

Every species has factors that limit its population size, health and range. Size of a landscape and the types of habitat present are key factors that may limit species diversity and abundance. The limiting factors described previously in **Section 6.2** are general habitat and ecological considerations but will vary in influence depending on the scale of the analysis area. In an acre-by-acre comparison, an impact on a relatively small natural area such as WHI would have greater response sensitivity than the same impact on a much larger natural area. Landscape planners use the concepts of thresholds and guidelines to facilitate effective planning.

A thorough description of thresholds is typically based on a comprehensive and systematic literature review, but often still results in qualitative estimates because of the diversity of study scenarios and applications. For this exercise, we first briefly evaluate WHI indicator species that use particular WHI habitat types or sensitive habitat areas. Typically, minimum patch area by species type, proportions of suitable habitat, size of edge effects and riparian buffer width are evaluated in synergy, but we will consider size thresholds as a proxy to overall habitat area needs. The difficulty in accurately representing "rules of thumb" for thresholds in planning is that animals can adapt and be resilient to some habitat change, and have often been observed in disturbed ecosystems. There may also be instances of anomalous observations (such as species observed in unlikely habitats or exhibiting abnormal behavior), but such observations may also indicate that some elements of species' behavior or life history is poorly understood.

The section concludes with a qualitative discussion of the potential effects on species with different levels of development. The primary resource for this discussion is based on Hennings and Soll[43] and habitat-species relationships described in Johnson and O'Neil.[44]

6.3.1 Identification and Effects of Limiting Factors on Indicator Species

Ecosystem status is often described by the presence, absence, or abundance of an indicator species in a particular habitat type. An indicator species is one that has such a narrow range of ecological tolerance to one or more limiting factors that their presence or absence is a good indication of environmental conditions. Their presence does not provide an indication of ecosystem health but a rough indication that the basic ecosystem components necessary to support the species in question are present and that those same ecosystem components support other more tolerant native wildlife species. Fish, amphibians, reptiles, birds, and mammals represent the spectrum of wildlife potentially using WHI. From these animal types, we have selected species that have some sensitivity to patch size, are important in the region's conservation strategies, or are sensitive to other limiting factors. Note that macroinvertebrates including insects were not included as indicator species, but could provide additional information on limiting factors on WHI.

The limiting factors have varying effects on the indicator species. Some species may be more sensitive to a limiting factor; for example, species with small home ranges that complete their entire life cycle on WHI will be more sensitive compared to a species with a large home range such as an eagles or raptors that can utilize adjacent areas when/if WHI habitat falls below their threshold tolerance level. Habitat quality will also affect a limiting factor's influence on an indicator species. For instance diverse and high quality habitats in a smaller area may support higher bird diversity than a much larger area with simple and low quality habitat. These considerations make it difficult to provide quantitative acreage and functional thresholds for maintaining species, in particular for WHI because of its island geography. **Table 6-3** is a summary of the expected relative sensitivity between indicator species and the limiting factors for WHI. Following the table, a summary description is provided for each species group regarding species requirements and their sensitivity to the limiting factors.

The relative sensitivity is based on Pacific Northwest ecology and species-habitat relationships. The ratings relate to their influence on WHI in the context of proposed mixed use development. A high sensitivity indicates that the limiting factor is a primary influence of the habitat on the abundance, productivity, survival, or other measure(s) for a particular species or species group. A medium sensitivity indicates influence on these same population factors but to a lesser degree, possibly because the species could complete life history needs with some reductions in habitat or are known to adapt to local changes. A low sensitivity suggests a minor response to the influence of known limiting factors.

[43] Hennings, L., and J. Soll. 2010. Wildlife corridors and permeability: a literature review. Metro Sustainability Center, Portland, OR. 96 pp.

[44] Johnson, D.H., and T.A. O'Neil, eds. 2001. Wildlife-habitat relationships in Oregon and Washington. 1 ed. Corvallis, OR: Oregon State University Press.

Table 6-3 Summary of Relative Sensitivity of Limiting Factors on WHI Indicator Species

		Relative Influence of Limiting Factors					
Species Group	Species	Patch Size/ Configuration/ Continuity	Hydrodynamics/ Shallow Water Habitat	Riparian Function	Wetland Function	Wildlife Movement /Habitat Diversity	Disturbance from Light, Noise, Human Presence
Fish	Chinook	Medium Habitat continuum; shoreline connectivity every ¼ mile	High	Medium	High May utilize connected pond for short time periods as outmigrants	Low	Medium
	chum	Medium Habitat continuum; shoreline connectivity every ¼ mile	High	Medium	Medium	Low	Low
Amphibians	Red-legged frog	High Averages 20 acres per breeding pair	Medium May not utilize large river margin as much as wetland	High	High	High Potentially distant migration	Low
	Northwestern salamander	Medium Wet habitats and adjacent forest required	Low	High	High	High	Low
Reptiles	Western pond and western painted turtles	High 56 acres per breeding pair	Medium	High	High	High Although able to navigate somewhat across culvert barriers	High
Birds	Forest breeding songbirds	Very high 5-50 acres per breeding pair	Low	Medium	Medium	High	High
	Pileated woodpecker	High 650+ acres	Low	Medium	Medium	High	Medium
	White breasted nuthatch	High Up to 98 acres	Low	Medium	Medium	High	Medium
	Streak horned lark	Very High Up to 12.6 acres	Low	Medium	Medium	High	High
	Swainson's thrush	High Up to 12 acres average. Average is 1 to 5 acres.	Low	Medium	Medium	High Needs interior habitat, not edge	Medium
Mammals	Yuma myotis Yuma bat	Medium Unknown, most limited by stand type	Low	High	Medium	Medium	High
	Small mammals	Medium 25 acres	Low	High	Medium	High	Medium Can elude disturbances, nocturnal behavior modifications
Comparative Sensitivity to Limiting Factors		Most sensitive Birds, mammals Least sensitive	Most sensitive Fish Least sensitive	Most sensitive Birds, mammals Least sensitive	Most sensitive Fish, reptiles, amphibians,	Most sensitive Mammals, Birds Least sensitive	Most sensitive Birds, mammals Least sensitive

		Relative Influence of Limiting Factors					
Species Group	Species	Patch Size/ Configuration/ Continuity	Hydrodynamics/ Shallow Water Habitat	Riparian Function	Wetland Function	Wildlife Movement /Habitat Diversity	Disturbance from Light, Noise, Human Presence
		Fish	Reptiles	None	Least sensitive Mammals	Fish	Fish, amphibians

a Hayes et al. (2002) observed 100 adults in 2,800 acre industrial area with natural corridors.

b A large range of recommended minimum habitat use is reviewed by Hennings and Soll (2010).

6.3.1.1 Fish

Although there are many species of freshwater fish using mainstem Columbia River habitats, Pacific salmon, especially juveniles, are one of the more sensitive genera to water quality and quantity, and physically diverse and complex habitats. In the freshwater environment, Pacific salmon are dependent on the following elements: healthy upland and riparian conditions (e.g., litter fall, shade, erosion control) that influence water quality, healthy aquatic food web, complex instream and shoreline habitats, and the distribution of those habitats throughout their migration path. On habitats associated with WHI, these effects are mostly related to food web dynamics and use of sheltered (i.e., low current energy) shoreline areas for refuge during extended outmigration periods. The highly migratory salmon do not necessarily have a threshold limitation at the scale of WHI habitat (considered in the context of their overall Columbia River habitat) but the presence of WHI shallow water habitat components are beneficial to their freshwater survival. The needs of juvenile Chinook and chum salmon, with their dependence on shallow water habitat for resting and foraging, are an indicator of the requirements for functioning shallow water habitat on WHI.

In smaller tributaries, access to habitat and habitat area can be the most direct limiting factors that determine size of populations within a watershed. In larger rivers that serve as migratory corridors, the continuity of habitats along shoreline will contribute more towards survival factors of individuals than capacity of a watershed. WHI shoreline areas provide this very important component of survival particularly for downstream migrants. The functionality curve of shallow water habitats will be most directly influenced by the presence or absence of complex habitats, embayments, or connected wetland habitats and a reasonable goal is to have these features occur every one-quarter mile along the migration corridor.

6.3.1.2 Amphibians

Amphibian populations are dependent on a variety of habitat types to meet the annual requirements of their various life history stages. In particular, amphibians thrive in the moist terrestrial and aquatic environments that WHI offers. The loss of any one of these habitats or the impairment of movement between habitat types could result in the extirpation of the local population. The combination of large river access, wetlands, and adjacent forested and shrub areas provide habitats for complete life history of several amphibian species.

Amphibian populations are highly sensitive to patch size and configuration of habitat, riparian and wetland function, and the maintenance of wildlife corridors to assist in their distribution. Relative to many other amphibians, this requirement for a seasonal mosaic of habitat types makes northern red-legged frogs particularly vulnerable to habitat loss or alteration. The northern red-legged frog attaches its eggs in vegetated shallows of wetlands and tadpoles use warm water shallows for development leading to adults that are known to move upwards of 300 meters from breeding pools into forested riparian areas.[45] Maintaining 20 acres of the

[45] Nussbaum, R.A., E.D. Brodie Jr. and R.M. Storm. 1983. Amphibians and Reptiles of the Pacific Northwest. University Press of Idaho, Moscow, Idaho; Licht, L.E. 1986. Food and feeding behavior of sympatric red-legged frogs, Rana aurora, and spotted frogs, Rana pretiosa, in southwestern British Columbia. Canadian Field-Naturalist 100:22–31; Gomez, D.M. and R.G. Anthony. 1996. Amphibian and reptile abundance in riparian and upslope areas of five forest types in western Oregon. Northwest Science 70:109–119; Hayes, M. P., S. G. Beilke, S. M. Boczkiewicz, P. B.

combined habitats per breeding pair of red-legged frog should allow populations to be maintained. Northwestern salamanders have strict aquatic breeding requirements with egg attachment occurring below the water line. Similar to red-legged frogs, NW salamanders use terrestrial habitats. There is very limited information available however, on the extent of their terrestrial use.

On a regional basis, many amphibian populations exist as meta-populations, represented by a set of linked but geographically discrete local populations occupying suitable habitats. Local populations will fluctuate because of environmental factors and natural stochastic mechanisms. But regionally, populations will be maintained through dispersal of individuals between populations and re-colonization of vacant habitat. However, habitat loss can result in populations becoming isolated or separated by greater distances. Impacted island habitats in particular are particularly vulnerable to population losses since they are not connected to extensive overland areas that could recruit individuals from surrounding areas. This can limit immigration from neighboring populations, which can lead to a decrease in the fitness of individuals in the isolated population because of reduced gene flow and increase the likelihood that the isolated population will become extinct because of random population fluctuations.

Reptiles

Reptiles are most sensitive to factors concerning patch size, wetland and riparian function, movement corridors and human disturbance. A 56-acre area can be a suitable area requirement for a breeding pair of turtles. One main consideration for the extent of this acreage is the importance of visual screening from disturbances and predator avoidance.

The Western painted turtle is a sensitive species requiring terrestrial and slow-moving shallow water habitats. Their nesting habitat is typically within 50-100 meters of aquatic habitats. Western pond turtles use similar habitats but the western painted turtle seems to have a greater dependence on aquatic habitats for over-wintering and selection of slower, more stagnant waters.[46] In the Portland metropolitan area, turtles have been observed making short-distance movements of at least 1 km around wetland complexes, but movement can be much longer given aquatic connectivity and lengthy aquatic corridors.[47]

In addition to the key limiting factors, the populations of western painted turtles are limited by predation by bullfrog and non-native predatory fishes (bass). Loss of wetland and adjacent upland habitat, including the degradation of nest areas from invasive plants that increase cover, particularly Himalayan blackberry, are also influential factors. Potential road infrastructure could contribute to road mortality and since western painted turtles are easily disturbed while basking, recreational activities could disrupt behaviors. Rights-of-way of either de-vegetated areas or roadways can hinder migration or cause road mortality, particularly for female turtles seeking nest sites. Provision of nesting habitat that is free of human disturbance and close to water is important.

6.3.1.3 Birds

The most abundant and diverse terrestrial wildlife group using WHI is birds. WHI provides protective characteristics of an island habitat for many species. Habitat patch size, habitat diversity, and disturbance from human activity are the key limiting factors for bird species. Riparian function is a limiting factor, though to a lesser extent, as all of WHI can function as riparian habitat. Even with some impacts to habitat, riparian-obligate species such as belted kingfisher, great blue heron, and mallards are likely to sustain a

Hendrix, P. I. Ritson, and C. J. Rombough. 2002. The western painted turtle (Chrysemys picta bellii) at the Rivergate Industrial District: management options and opportunities. Unpublished report.

46 Ibid.

47 Ibid.

population on WHI, provided that adequate habitat patch size and connectivity between forests and aquatic habitats are maintained.

Different bird species require different amounts of habitats to remain viable. Generally there are broad ranges of core habitat acreage needed for species and the forest characteristic (age, structure) affects the required patch size. Minimum habitat requirements are often measured at the patch scale and it is important to identify the factors that affect these habitat requirements. In considering minimum habitat requirements for reproductive success, Vance et al. (2003) demonstrated a clear negative relationship between a forest bird species' innate reproductive rate and the amount of habitat required for a certain probability of presence in the landscape; that is, species with low reproductive potential are more prone to extinction due to habitat loss than species with high reproductive potential. WHI, with its high bird species diversity, hosts some species whose reproductive success could be limited by loss of extensive forest/woodland or shrub habitat.

For example, a small population of the streaked horned lark breeds and winters near the Portland area of the Columbia River. This species requires large patch sizes of habitat several hundreds of acres in size but have been observed in areas as small as 100 acres. The grasslands formed by the dredge materials management area, although not a naturally-formed habitat, could be habitat for streaked horned lark. The protected American bittern's life history is dependent on wetland habitats and population size is strongly related to wetland sizes.

Forest breeding bird species such as black-capped chickadee, pileated woodpecker, red-eyed vireo and Swainson's thrush, are but a few of the species using forested habitat that may be sensitive to reduced patch size. For example, some forest species require extensive home ranges:

- Pileated woodpecker: 659 to 2608 acres
- Short-eared owl: 50 to 300 acres.

Similarly grassland and forest species can require extensive patch sizes:

- Western meadowlark (Grassland species, typically less than 19 acres, may use up to100 acres).
- Streaked horned lark (100 acres to several hundred acres)
- White-breasted nuthatch (forest species, 25 to 98 acres).

Travel across fragmented habitat can also have physiological effects on individuals and thus can affect breeding success.

6.3.1.4 Mammals

Mammalian species are a diverse group, but in large part their successful productivity depends on complex habitat structure, landscape connectivity, and access to water. Because these features are often associated with riparian areas, riparian habitats may have more abundant small mammal populations than upland areas.[48] Mammals are thus most sensitive to the reduction in patch size and lack of diverse, adjacent habitats, so development occurring in areas of greatest habitat diversity such as riparian areas would likely have the most impact on these species.

[48] Doyle, A.T. 1990. Use of riparian and upland habitats by small mammals. Journal of Mammology. 71:14-23; Bellows AS, Mitchell JC: Small mammal communities in riparian and upland habitats on the upper coastal plain of Virginia. Virginia Journal of Science 2000; 51:171-186.

Although there is limited regional information on patch size requirements for small mammals, Murphy[49] suggests that small mammals such as short-tail weasel, Oregon vole, Northern flying squirrel, shrews and chipmunks may need 25 acres of habitat patch to persist. Estimates per breeding pair of small mammals are not available and the island geography will influence estimates that have been made on larger landscapes. On an island biogeography, species often adapt to fulfilling life history requirements in smaller areas than the regional population would on larger landscapes.

Bats are dependent on forest type availability and it is known that clear-cut edges support increased levels of bat activity. [50]However, little is known about the foraging ecology of bats associated with remnant patches. Edges may create concentrated feeding areas by provide a wind barrier that aids bats in capturing insects, but the tradeoff is exposure of bats to predation by raptors and owls. Another factor in limiting bat productivity and survival is the presence of artificial light which can alter their feeding timing.

6.4 CONCLUSIONS

As described in this section, it is difficult to qualitatively, much less quantitatively, describe the effects of varying levels of mixed use on natural resource function and species use of WHI. Furthermore, it is important to recognize WHI as one habitat area within a larger ecological area. A relatively small change in a particular area of specific habitat on WHI due to development may result in a negligible to minor impact, but the accumulation of the individual changes at multiple habitat locations over time may constitute a major impact. The Lower Columbia River habitats have experienced extensive cumulative impacts mostly measured as habitat loss or alteration. Amidst extensive land-use impacts, intact natural areas increase in their overall importance because less area now must function to support more species and individuals. Some species may be capable of adapting to the changes in space requirements, may utilize alternative or secondary food resources, and may alter their breeding behavior, but without mitigation, long–term impacts at the population level are occurring for many species.

There are many environmental considerations in analyzing the viability of a mix of land uses. Several of these factors may limit the viability of mixed-use unless appropriate mitigation can be conducted. Mixed use development on WHI is likely to reduce acreage of high quality habitats, with particularly large impacts on grassland/herbaceous and wetland habitats if development occurs on the northeastern area of WHI. WHI is currently a large area of contiguous habitat with connections between aquatic and terrestrial habitats. WHI's capability to host the diversity of species currently observed is likely due not only to the expanse of the island (825+ acres) but also to the diversity of habitats on the island. By reducing overall acreage and increasing edge effects, mixed use development would affect the quality of the remaining habitat and possibly affect behaviors of species that use multiple habitat types. Some habitat functions are expected to be affected immediately upon development. Some may recover a certain portion of the baseline function but the loss of overall habitat area may make it difficult for some functions to fully recover.

[49] Murphy M. 2005. Determinants of vertebrate species richness in an urban landscape. Report No.1448-13420-01-J145, Portland State University. 16 p.

[50] Crampton L. H., and Barclay, R. M. R. Barclay. 1996. Habitat selection by bats in fragmented and unfragmented aspen mixedwood stands of different ages. Pp. 238–259, in Bats and Forest Symposium (R. M. R. Barclay and R. M. Brigham, eds.). British Columbia Ministry of Forests, Victoria, B.C., 292 pp; Grindal, S. D., and R. M. Brigham. 1998. Short term effects of small-scale habitat disturbance on activity by insectivorous bats. Journal of Wildlife Management, 62: 996–1003; Verboom, B, and K. Spoelstra. 1999. Effects of food abundance and wind on the use of tree lines by an insectivorous bat, Pipistrellus pipistrellus. Canadian Journal of Zoology, 77: 1393–1401.

SECTION 7

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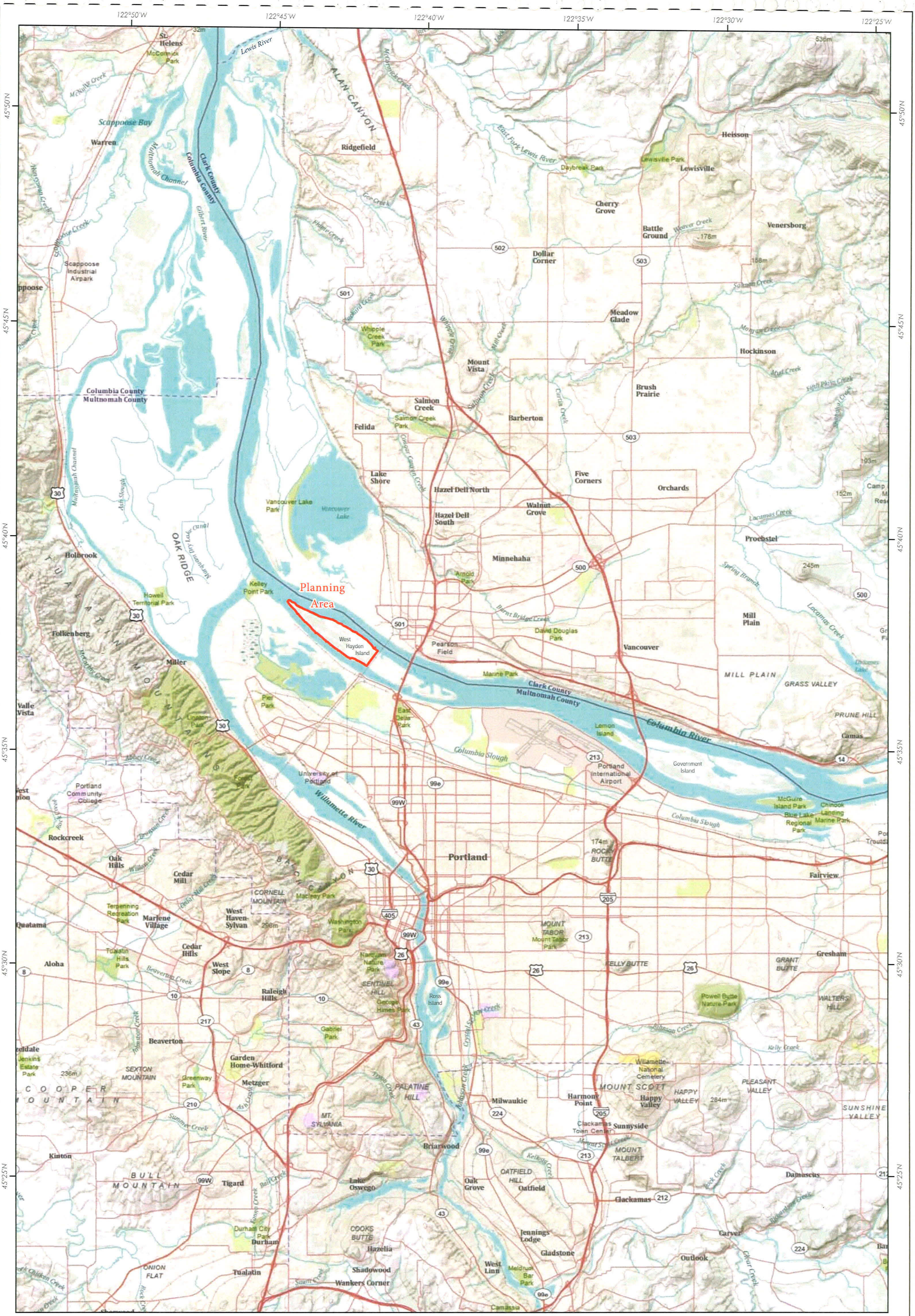
Maps

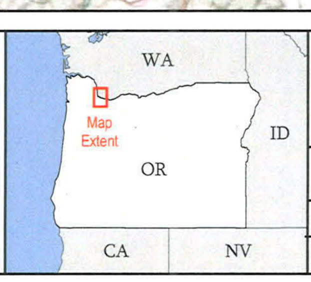


1:210,000
1 inch = 17,500 feet

0 2 4 6 8 Miles
0 3 6 9 12 Kilometers

Map 1
Study Area

West Hayden Island
Environmental Foundation Study



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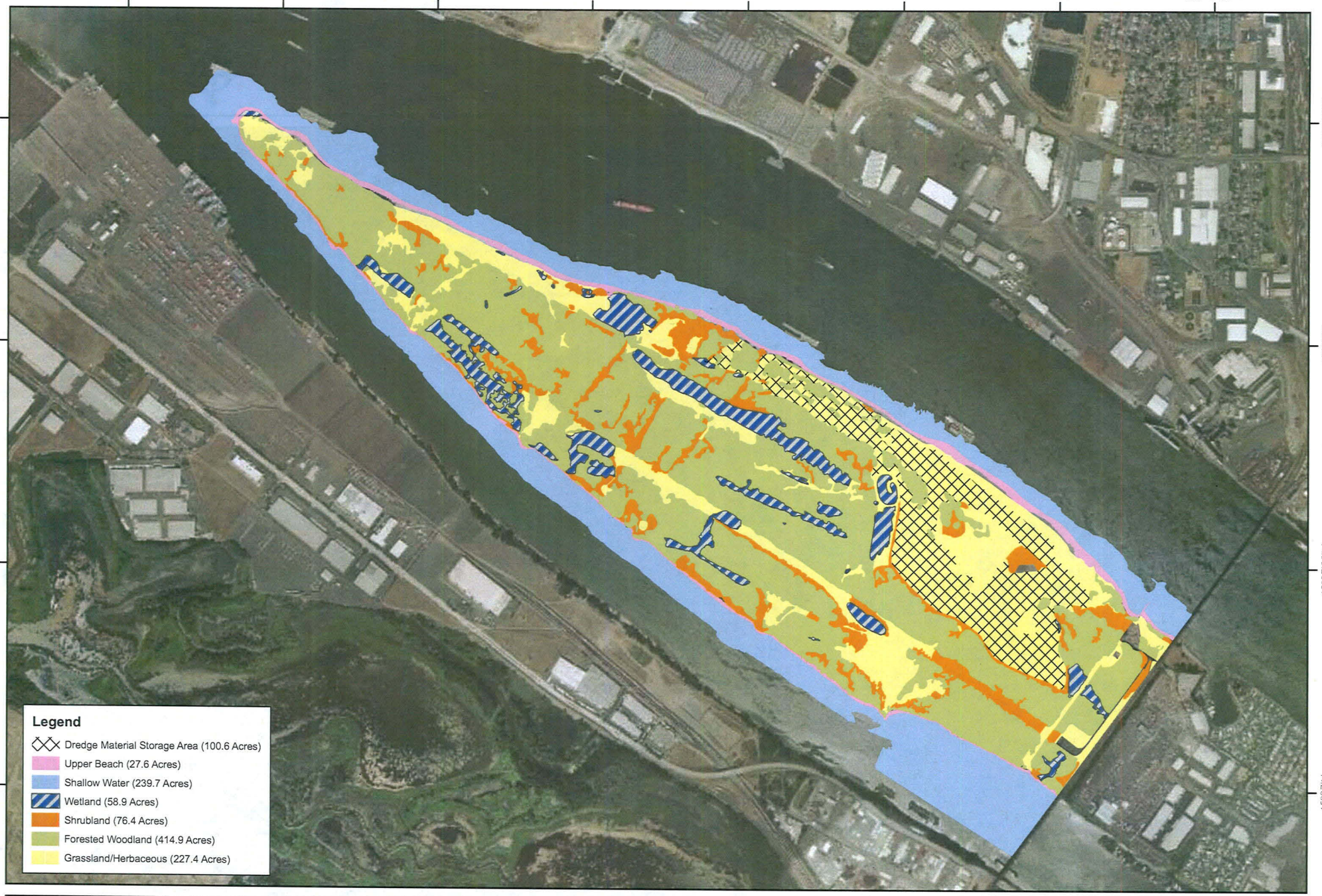
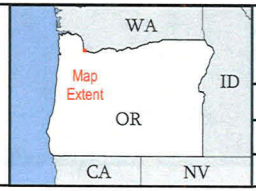


Scale = 1:30,000
1 inch = 2,500 feet

0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Map 2
Habitat Classification Map
West Hayden Island
Environmental Foundation Study



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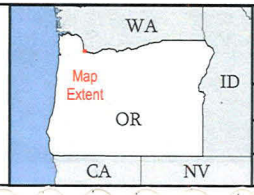
Scale = 1:30,000
1 inch = 2,500 feet

0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	
0.51 - 1.00	2.01 - 2.25
1.01 - 1.50	2.26 - 2.50
1.51 - 1.75	2.51 - 2.75
1.76 - 2.00	2.76 - 3.00

Map 3
Shallow Water Habitat
West Hayden Island
Environmental Foundation Study



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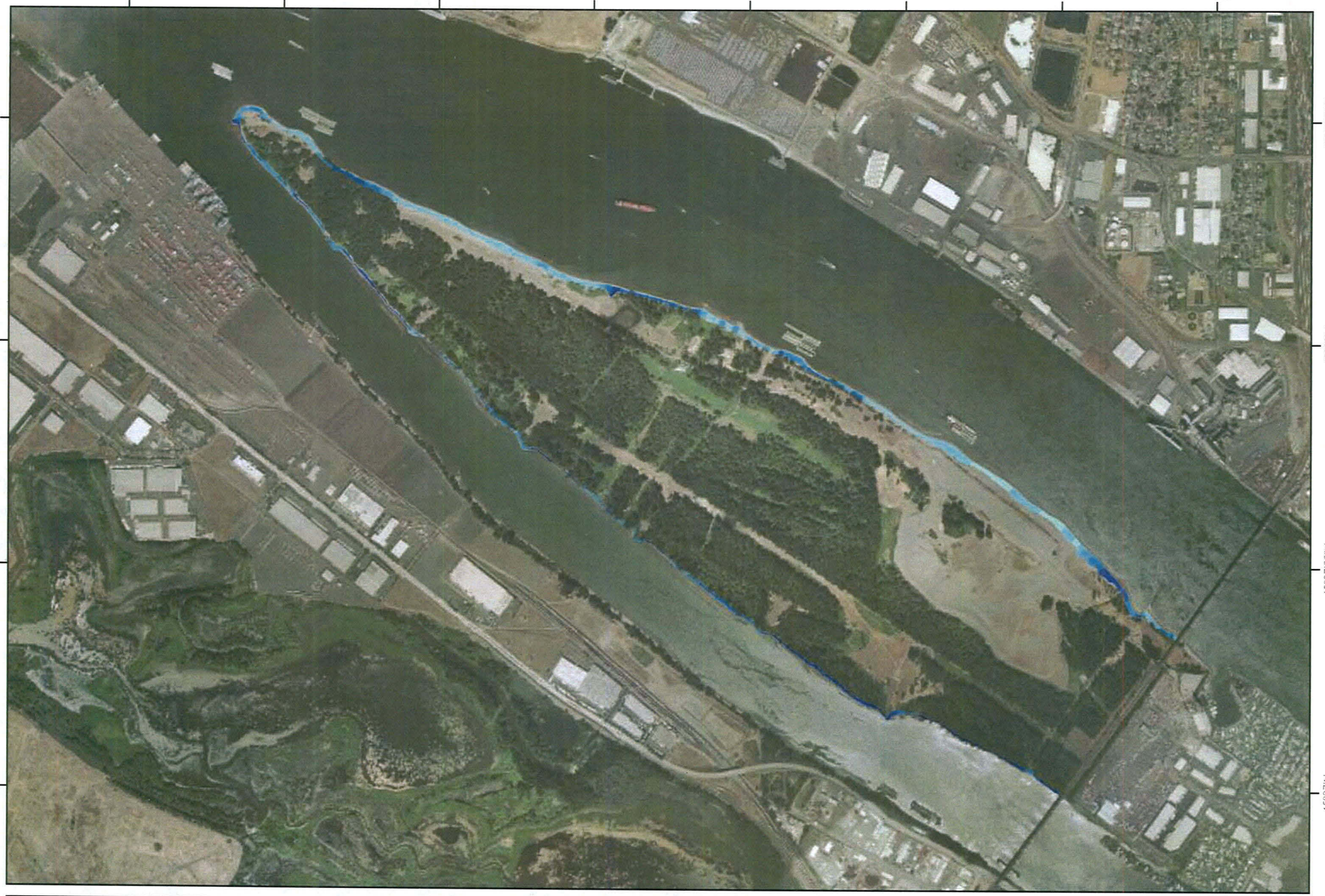

Scale = 1:30,000
1 inch = 2,500 feet

0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	
0.51 - 1.00	2.01 - 2.25
1.01 - 1.50	2.26 - 2.50
1.51 - 1.75	2.51 - 2.75
1.76 - 2.00	2.76 - 3.00

Map 4
Upper Beach Habitat
West Hayden Island
Environmental Foundation Study

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Scale = 1:30,000
1 inch = 2,500 feet

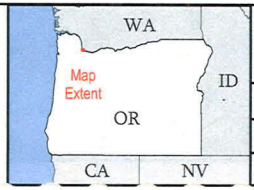
0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	
0.51 - 1.00	2.01 - 2.25
1.01 - 1.50	2.26 - 2.50
1.51 - 1.75	2.51 - 2.75
1.76 - 2.00	2.76 - 3.00

Map 5
Wetland Habitat

West Hayden Island
Environmental Foundation Study



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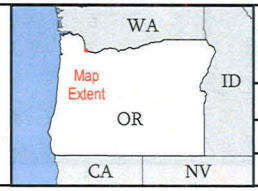
Scale = 1:30,000
1 inch = 2,500 feet

0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	
0.51 - 1.00	2.01 - 2.25
1.01 - 1.50	2.26 - 2.50
1.51 - 1.75	2.51 - 2.75
1.76 - 2.00	2.76 - 3.00

Map 6
Riparian Fringe Habitat
West Hayden Island
Environmental Foundation Study



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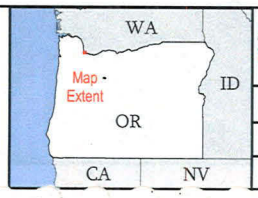
Scale = 1:30,000
1 inch = 2,500 feet

0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	
0.51 - 1.00	2.01 - 2.25
1.01 - 1.50	2.26 - 2.50
1.51 - 1.75	2.51 - 2.75
1.76 - 2.00	2.76 - 3.00

Map 7
Forest/Woodland Habitat
West Hayden Island
Environmental Foundation Study



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Scale = 1:30,000
1 inch = 2,500 feet

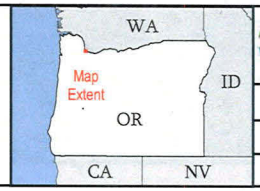
N

0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	
0.51 - 1.00	2.01 - 2.25
1.01 - 1.50	2.26 - 2.50
1.51 - 1.75	2.51 - 2.75
1.76 - 2.00	2.76 - 3.00

Map 8
Shrubland Habitat
West Hayden Island
Environmental Foundation Study



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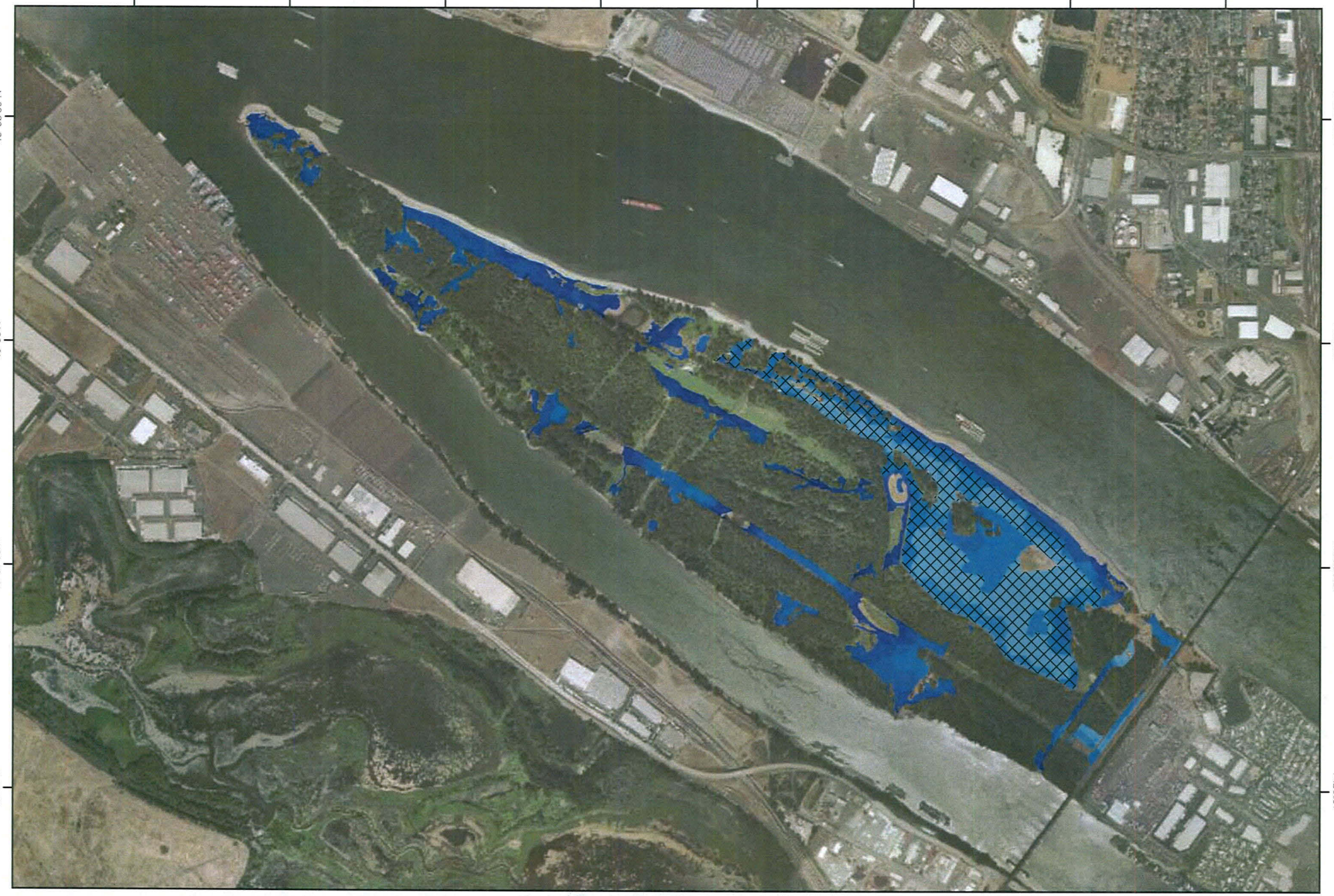


Scale = 1:30,000
1 inch = 2,500 feet

N

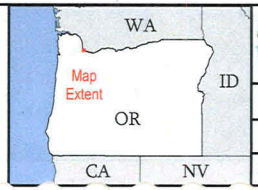
0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	2.01 - 2.25
0.51 - 1.00	2.26 - 2.50
1.01 - 1.50	2.51 - 2.75
1.51 - 1.75	2.76 - 3.00
1.76 - 2.00	Dredge Material Storage Area

Map 9
Grassland/Herbaceous Habitat

West Hayden Island
Environmental Foundation Study



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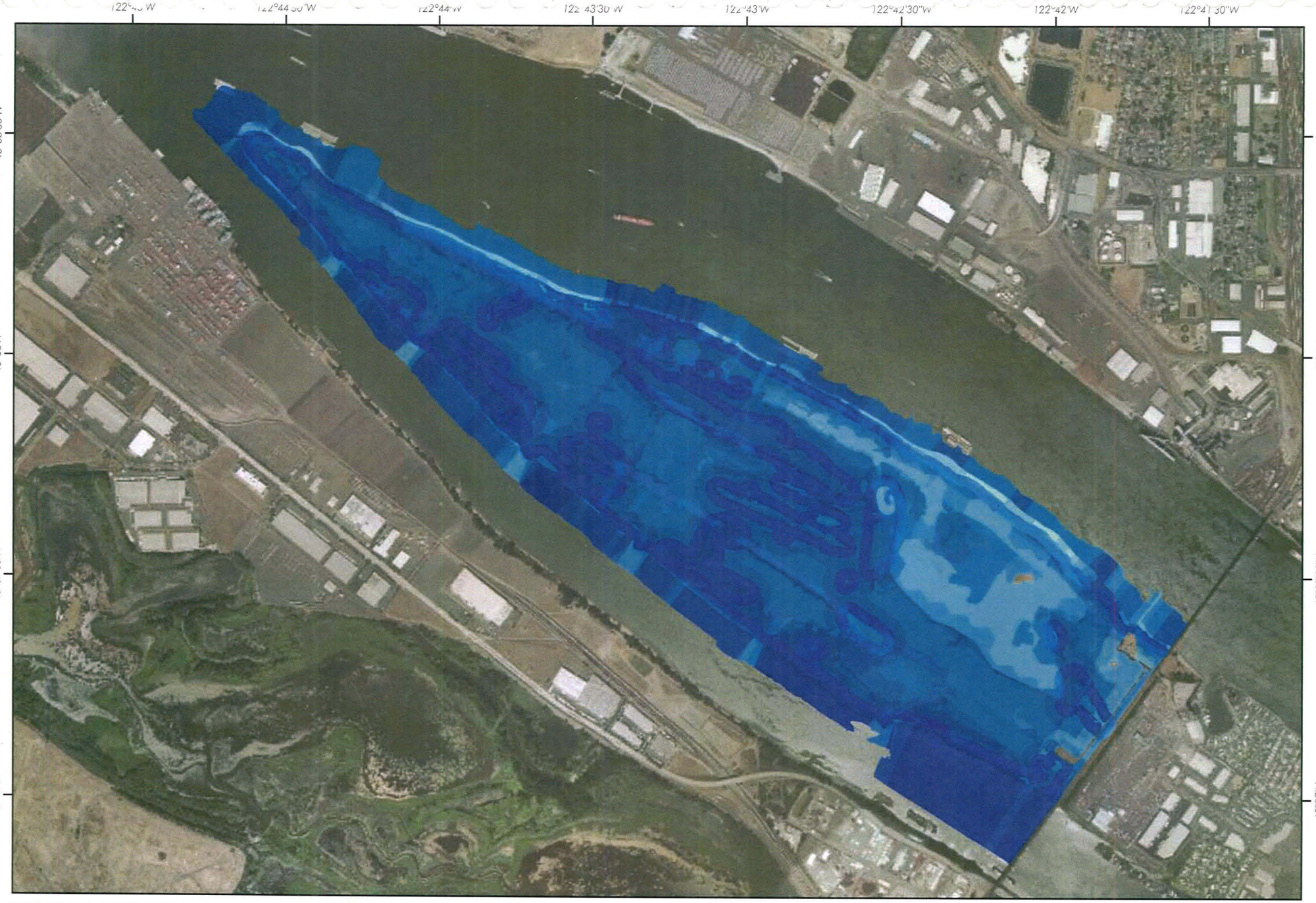
Map Projection: Mercator WGS84



Scale = 1:30,000
1 inch = 2,500 feet

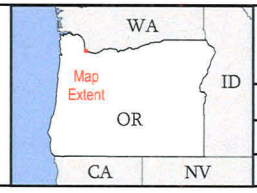
0 0.2 0.4 0.6 0.8 1 Miles
0 0.5 1 1.5 Kilometers

Score

< 0.50	
0.51 - 1.00	2.01 - 2.25
1.01 - 1.50	2.26 - 2.50
1.51 - 1.75	2.51 - 2.75
1.76 - 2.00	2.76 - 3.00

Map 10
Composite Habitat Map

West Hayden Island
Environmental Foundation Study



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122°50'W
122°45'W
122°40'W
122°35'W
122°30'W
122°25'W
45°50'N
45°45'N
45°40'N
45°35'N
45°30'N
45°25'N
Planning Area
West Hayden Island
St. Helens
McCormick Park
Lewis River
Scappoose Bay
Warren
Multnomah Channel
Columbia County
Gilbert River
Scappoose Industrial Airpark
Columbia County
Multnomah County
Ridgefield
Whipple Creek Park
Mount Vista
Salmon Creek
Felida
Lake Shore
Hazel Dell North
Hazel Dell South
Vancouver Lake Park
Vancouver Lake
OAK RIDGE
Holbrook
Howell Territorial Park
Kelley Point Park
Folkenberg
Miller
Pier Park
Pearson Field
Heisson
Lewisville Park
Lewisville
Daybreak Park
Cherry Grove
Battle Ground
Venersborg
Dollar Corner
Meadow Glade
Hockinson
Brush Prairie
Barberton
Five Corners
Orchards
Walnut Grove
Minnehaha
Proebstel
Mill Plain
David Douglas Park
Vancouver
MILL PLAIN
GRASS VALLEY
PRUNE HILL
Camas
Marine Park
Clark County
Multnomah County
Columbia River
Lemon Island
Government Island
Portland International Airport
Columbia Slough
McGuire Island Park
Blue Lake Regional Park
Chinook Landing Marine Park
East Delta Park
University of Portland
Willamette River
Portland
ROCKY BUTTE
Fairview
MOUNT TABOR
Mount Tabor Park
KELLY BUTTE
GRANT BUTTE
Gresham
Powell Butte Nature Park
WALTERS HILL
Forest Park
Linnton Park
Valle Vista
Portland Community College
Rockcreek
Oak Hills
Cedar Mill
CORNELL MOUNTAIN
Macleay Park
Washington Park
Terpenning Recreation Park
Marlene Village
West Haven-Sylvan
Quatama
Aloha
Tualatin Hills Park
Cedar Hills
West Slope
Raleigh Hills
SENTINEL HILL
George Himes Park
Ross Island
Gabriel Park
Beaverton
Garden Home-Whitford
Metzger
Greenway Park
SEXTON MOUNTAIN
COOPER MOUNTAIN
Jenkins Estate Park
PALATINE HILL
MT. SYLVANIA
Milwaukie
Harmony Point
Willamette National Cemetery
MOUNT SCOTT
Happy Valley
HAPPY VALLEY
PLEASANT VALLEY
SUNSHINE VALLEY
Clackamas Town Center
Sunnyside
MOUNT TALBERT
Kinton
BULL MOUNTAIN
Tigard
Briarwood
Lake Oswego
Oak Grove
OATFIELD HILL
Oatfield
Clackamas
Damascus
Jennings Lodge
Gladstone
Outlook
Carver
Durham City Park
Durham
COOKS BUTTE
Hazelia
Shadowood
Wankers Corner
ONION FLAT
Tualatin
West Linn
Meldrum Bar Park
Camassia

Map 11
Critical Habitat of Study Area

West Hayden Island
Environmental Foundation Study

Data Source: Northwest Regional Office NOAA Fisheries (2005 designations)

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130°W 128°W 126°W 124°W 122°W 120°W 118°W 116°W 114°W 112°W

54°N 52°N 50°N 48°N 46°N 44°N 42°N 40°N 38°N

British Columbia

Alberta

Edmonton

Calgary

Tweedsmuir Provincial Park

Queen Charlotte Sound

Pacific Ocean

ROCKY MOUNTAIN TRENCH

SELKIRK MOUNTAINS

GREAT PLAINS

Bellingham

Marysville

Seattle

OLYMPIA

Washington

Wenatchee National Forest

Spokane

Kootenai National Forest

Flathead National Forest

Flathead R.

Clark Fork

Yakima

Nez Perce National Forest

Salmon River

BITTERROOT

Vancouver

Columbia River

Portland

SALEM

Willamette River

Deschutes River

Eugene

Oregon

BLUE MOUNTAINS

Boise National Forest

RANGE

Idaho

BOISE

Idaho Falls

Pocatello

Snake River

Rogue River

Medford

Klamath River

Trinity River

Weaverville

Redding

Sacramento River

SIERRA NEVADA MOUNTAINS

GREAT BASIN

Nevada

Reno

CARSON CITY

Santa Rosa

Napa

SACRAMENTO

Vacaville

Lodi

Vallejo

Oakland

Stockton

San Francisco

Modesto

Turlock

Major Flyway

Principal Routes

Merging Routes (with other routes)

Data Sources: *pacificflyway.gov, www.birdnature.com*

1:8,000,000

0 75 150 225 300 Miles

0 75 150 225 300 375 450 Kilometers

Map 12
Pacific Northwest Zone of Pacific Flyway

West Hayden Island
Environmental Foundation Study

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