APPENDIX A

Natural Resource Restoration Potential on WHI

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TECHNICAL MEMORANDUM

Date: June 29, 2010
To: Mike Rosen
From: Paul Manson
Subject: West Hayden Island Ecosystem Services Restoration Concept Plan
cc:
Project Number: 283-2177-027
Project Name:

SUMMARY

This memorandum documents a potential restoration and preservation scenario for West Hayden Island (WHI) that is intended to maximize the provision of ecosystem services. This conceptual plan is based on managing the site solely for natural resource opportunities and maximizing benefits to the region's communities. It should be noted that optimizing ecosystem services values on this site is unlikely to be feasible if passive restoration actions are the only solution proposed. Restoration actions discussed in this report require more involved construction, engineering, and maintenance than is often ideal, but these actions are included to explore the upper range of restoration potential on the site.

The evaluation of the current conditions and future 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. In alignment with the scope of work for this project, current and potential ecosystem services levels are estimated with a qualitative measure. A detailed analysis of the benefits and the feasibility of the potential restoration actions are not fully studied here and would require further analysis in order to quantify ecosystem services opportunities.[1]

The initial review of potential restoration scenarios involved examining the Natural Resource Inventory Update (NRIU) assessment and the scoring incorporated therein, based on the WHI criteria presented in recent assessments of the site (Entrix 2010). The scoring criteria on WHI focused on seven key habitat types and their level of functions performed by that habitat type. The WHI scores indicated that much of the island's habitat was in or near the top 25 percent of value or function. For example, aquatic functions include channel margin dynamics, food web and nutrient cycling, large wood and channel dynamics, water storage, and fish refuge. For terrestrial habitats, connectivity for movement, patch size, habitat diversity, and similar functions are scored. These examples are not exhaustive, but are a selected set. The high scores were in part driven by the large patch

[1] Project team expertise and judgment contributed to the evaluation. Project team included Paul Manson, project manager, Mark Vlahakis, wetland and restoration ecologist, Michelle (Kenna) Halsey, ecologist, Mike Parton, fisheries biologist, Ann Radil, climatologist and landscape ecologist, and Kevin Benck, geographer.

sizes and the proximity to other resources on the island, such as proximity to water or distance from developed surfaces. These factors in the scoring tended towards the higher values, limiting the ability to measure new benefits on site. This also did not provide an immediate basis for identifying an approach to a preferred future condition.

To develop a preferred restoration scenario, the approach taken for this scope of work involved using an ecosystem services enhancement approach to focus restoration actions on those historic ecological processes that are still appropriate in the current-day context, as well as on new opportunities that reflect site changes over time. The ecosystem services approach seeks to increase the goods, services and benefits the natural functions on the site provide as much as possible. Based on the review of available information and data, it is estimated that modest ecosystem service gains are possible through restoration actions. Primarily biodiversity support, natural hazard protection through flood management and climate regulation are expected through restoration actions. Biodiversity improvements provide the greatest opportunity for change 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. The restoration scenario supports ongoing regional and watershed efforts to recover and restore the health of the river and species that depend on it.

The restoration actions proposed here 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 spoil site 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, similar to a historic channel previously present on the island. 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. Additional grassland and wetland restoration actions are proposed for current dredge spoil disposal areas. These actions are shown on Figure 1 (attached). The following sections of this report discuss the opportunities to address ecosystem services across WHI, and the management area descriptions follow providing detailed description of actions and benefits.

ECOSYSTEM SERVICES AND RESTORATION PLANNING

Ecosystem services are the goods and services that human communities depend upon for health, safety, and economic prosperity. These goods and services are often grouped into the general categories of provisioning, regulating, cultural, or supporting services (Daily et al. 2009). Provisioning services include more common conceptions of goods from the natural world such as food, fiber, and fuels. Regulating services include the natural features and functions that protect communities from flood, fires, and storms. Cultural services are those aspects of the natural environment which contribute to our spiritual, recreational, or educational values. In addition to these three categories of ecosystem services is a fourth, supporting services. Supporting services are the natural functions that provide the foundation for all other services. These services include biodiversity, primary production and nutrient and water cycling, which can be difficult to quantify (Millennium Ecosystem Assessment [MEA] 2005.) Biodiversity is traditionally a challenging value to include in ecosystem services because of this supporting role, and the fact that direct consumption does not occur.[2]

The approach taken for this project is a departure from more commonly used traditional ecosystem services evaluation techniques that are based on economic valuation. Instead of assigning a particular monetary value to

[2] Biodiversity support promotes many species that are then included in the provisioning type services such as food, fuel and fiber production. (MEA 2005)

the services on the site, this approach estimates approximate performance levels for key ecosystem services.[3] This provides a starting point for addressing tradeoffs in ecosystem services and other uses in policy decision making. Further research and analysis may provide quantitative measures of percent of performance by service, but that level of data was not available for this analysis.

This approach is an effort to address concerns raised about the use of ecosystem services in conservation planning. For example, research suggests that managing for ecosystem services alone fails to adequately protect biodiversity by focusing environmental policy attention on services with more easily measured values (Vira et al. 2009 and Kremen 2005). The concern stems from the way services are defined. Because their value is tied to human use and consumption, some natural functions necessary to support biodiversity are lost or undervalued because it is difficult to link them directly to human use. Research on the correlation between services and biodiversity has only recently begun, but initial studies indicate that while protecting ecosystem services does protect biodiversity to a degree, it may only capture half the benefits associated with biodiversity (Benyas et al. 2009).

To address these concerns, the methodology for reviewing the potential restoration options on West Hayden Island includes biodiversity support directly, alongside the more obvious ecosystem services. Internationally, this approach has been included in global assessments of ecosystem services (Millennium Ecosystem Assessment 2005) as well as in a regional assessment for the Willamette Valley (Nelson et al. 2009).

In accordance with the scope for this project, this report identifies the conceptual restoration scenario by using three primary guides, rather than evaluating tradeoffs of financial implications. First, all restoration actions need to be self sustaining as much as possible. To judge this, the historical ecological processes from pre-settlement conditions were used to provide important contextual information. Recognizing that the Columbia River Basin and the landscape surrounding the site have been drastically altered by human activity requires acknowledging that not all historic processes or functions can, or should, be replicated. Second, this approach looks for opportunities to create the most benefit across multiple ecosystem services. Some restoration actions will provide multiple benefits and these are preferred over actions with a singular focus on one service. Finally, the restoration scenario is informed by a review of other similar ecosystem services evaluations and restoration plans that have been developed in the region. This provides a target and context for opportunities on WHI, based on other successful projects such as the Sandy River Delta restoration project.

HISTORIC AND CURRENT CONDITIONS

The WHI site is the 827-acre portion of Hayden Island west of the railroad crossing. The site is a natural area that has experienced extensive human alteration primarily from historic grazing and dredge spoil disposal. The ecological functions and processes on West Hayden Island are altered by the historic development of the Columbia River Basin. Many studies have documented the loss of natural flood regimes, the loss of connectivity due to surrounding development, on-site impacts from dredge disposal, and the spread of invasive plant species (Entrix 2010, SWCA 2009). The current condition of the site is driven by four main factors:

- Changes to the Flood Regime and Hydrograph
- Loss of Habitat Diversity
- Introduction of Invasive Plants
- Loss of Connectivity

[3] The Entrix team currently assisting in the developing economic valuation for the site.

These four factors combine and interact to create the primary challenges restoration must address. Addressing these four factors guide the restoration proposal presented in this document. As the restoration actions were identified, they were further refined to maximize ecosystem services on site.

Changes to the Flood Regime and Hydrograph

Historically, the Columbia River at WHI experienced higher flows and earlier in the year compared to present conditions. Development of the Columbia basin hydroelectric dam system has lessened these peak flows and reduced the frequency and duration of inundation on WHI (Entrix 2010, SWCA 2009.) The loss of the flooding regimes and the deposition of dredge spoils have removed the historic presence of off-channel connections. The General Land Office (GLO) survey indicates the island was historically bisected from southeast to northwest by a channel, and elevation data along with wetland data suggest areas of annual inundation with connections to the main channels (Christy et al. 2009). The loss of annual flooding also affects habitat diversity and invasive plant species control. Flooding is likely to have contoured portions of the island and contributed large wood to the shorelines and shallow water areas. The loss of the flooding has also resulted in modern conditions on site that are drier, less dynamic and more prone to the spread and establishment of invasive plant species.

Loss of Habitat Diversity

Habitat diversity has been lost on the island over the past century, in both terrestrial and aquatic habitats. Terrestrial habitat has been reduced to primarily forested areas, several wetlands, and dredge spoil dominated grasslands. Historic data suggests the island was a mix of forested areas, wetlands, channels, and low areas of frequent inundation. With the change in the flood regime, the periodic disturbance that flooded the island has been removed. The extensive spoil deposits have also reduced habitat diversity by replacing native vegetation with sand deposits that do not support dense vegetation.

Aquatic habitat has also been simplified with the loss of natural wood recruitment for structure and through channel management or alteration activities to meet navigational needs. Use of the river by marine traffic has also contributed light and sound stresses to these nearby habitats.

Invasive Plant Introduction

The current cottonwood forest areas are dominated by older stands that lack a middle story and there is limited recruitment of new trees. The lower story in these forests is dominated by invasive species, though not uniformly. Some lower and wetter areas that are under the full canopy are less overcome by Himalayan blackberry or reed canarygrass. In these areas, natural recruitment maybe more successful than in other areas, though enough time has not yet passed since grazing was terminated on the island to see a change yet.

Loss of Connectivity

In addition to the on-site impacts, the island is affected by the general loss of habitat diversity and functions throughout the region. Development on the eastern portion of the island, along with port development to the north and south, limits the opportunities for species to use the site due to a lack of structure and food sources on the island. Development has reduced the immediate upstream nutrient and large wood inputs for WHI. This is particularly true for migratory birds as well as herptiles. Adequate habitat and connectivity to other regional naturally managed areas such as Ridgefield National Wildlife Refuge and Smith and Bybee Lakes are important to these species.

These four factors guide the restoration proposal presented here. As the restoration actions were identified, they were further refined to maximize ecosystem services provisioning on site.

ECOSYSTEM SERVICES RESTORATION OPPORTUNITIES

The survey of West Hayden Island has identified three ecosystem services that can be improved through restoration actions. These three services are the most likely to be increased and conceptually appear feasible as goals. The key ecosystem services are:

- Biodiversity Support
- Climate Regulation
- Natural Hazard Management

The three key ecosystem services include two regulating services and biodiversity support, a supporting service. These three services are heavily interconnected on the site.

Biodiversity Support Opportunities

Biodiversity support on WHI is best improved by addressing the loss of habitat diversity from historic conditions. Figure 2 (attached) presents the recently digitized GLO land cover types present in 1852 (Christy et al. 2009.) The spatial accuracy of the data is likely not precise, but the mix of habitat types and the structure of the waterways gives clues about the historic ecological processes. These clues suggest that a mix of forested, wetland and prairie habitats, along with improved connectivity to the Columbia River may be appropriate, where feasible given the site's current context. 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. However, it is important to note that no restoration scenario at this scale can provide a species population response that can easily be measured.

The proposed aquatic and inundation areas are expected to provide direct benefits for salmon and other aquatic species. The needs of salmonids in the lower Columbia River have been documented in the National Marine Fisheries Service (NMFS) recovery planning process. Salmonid use at West Hayden Island is not solely for migration. Juvenile salmonid have been found utilizing the site for rearing and foraging. They are smaller in size and weight than would be expected, which may be caused by conditions upstream or on the island. Despite the conditions, the use is still important and that there is a clear opportunity to improve habitat conditions (Sol, et al. 2009, Sol, et al. 2008.). Key issues that are known for all salmonids in the area of West Hayden Island include the need to replicate natural functions lost through the construction and operation of the hydroelectric dam system on the Columbia River (ODFW 2009), and the historic loss of floodplain connectivity, which provides nutrient and detritus inputs as well as refuge during high flows. This restoration concept will address these issues through the development of off channel connections and new areas of seasonal inundation.

Additional benefits associated with the proposed concept will be provided for herptiles and water birds. Grassland and forest revegetation will benefit song birds, raptors, and mammals on the site. These activities also tie into larger regional connectivity needs for these species.

Climate Regulation Opportunities

Climate regulation-related ecosystem services opportunities 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).[4] The VCS protocols define the accepted measures to produce carbon offset credits.

For forested areas, the VCS Afforestation, Reforestation and Revegetation (ARR) methodology best applies. This methodology covers restoration activities including "woody vegetation to increase carbon stocks in woody biomass and, in certain cases, soils" (VCS 2007). The methodology also permits selected thinning to help manage invasive species. Currently, there are nearly 414 acres of forest/woodland habitat on WHI, of which 158 acres is located within a riparian fringe habitat (Entrix, 2010). Table 1 summarizes potential carbon sequestration that may be realized through afforestation, reforestation, and revegetation using two scenarios depending on the feasibility of managing riparian forests for carbon sequestration.

The first scenario estimates carbon sequestration across all 414 acres of forest/woodland habitat including the riparian fringe habitat; the second scenario estimates carbon sequestration across 256 acres of forest/woodland habitat, not including the riparian fringe habitat. The two scenarios are designed to provide low and high-estimates of total carbon sequestration potential in metric tons of carbon dioxide equivalent per acre per year ($MTCO_2e/yr$), since the hydrology of riparian forest/woodland habitat may limit the accumulation of woody biomass, or reduce carbon sequestration potential. Given the site characteristics, revegetation is the most likely mechanism for generating carbon offsets. The revegetation numbers present the conservative estimate. The other categories, afforestation and reforestation, may be possible if further research on site indicates these methods are applicable for WHI. These rates of carbon sequestration are also included for comparison to the revegetation option. Average carbon sequestration rates are based on research conducted by the U.S. Environmental Protection Agency (EPA).

Table 1. Modeled Carbon Sequestration in Forest/Woodland Habitats

Activity	Representative Carbon Sequestration Rates in U.S. ($MtCO_2e/yr$)	Average Carbon Sequestration Rates based on EPA Estimates ($MtCO_2e/yr$)	Time Over Which Sequestration May Occur Before Saturating (Assumes no disturbance, harvest or interruption of practice)	Scenario 1: 414 Acre Project Area ($MtCO_2e/yr$)	Scenario 2: 256 Acre Project Area $MtCO_2e/yr$)	References
Afforestation [a]	0.6 – 2.6 [b]	1.6	90 – 120+ years	662	410	Birdsey 1996
Reforestation [c]	0.3 – 2.1 [d]	1.2	90 – 120+ years	497	307	Birdsey 1996
Revegetation	0.6 – 0.8 [e]	0.7	If wood products are included in accounting, saturation does not necessarily occur.	290	179	Row 1996
	0.2 [f]			83	51	IPCC 2000

a. Values are for average management of forest after being established on previous croplands or pasture.
b. Values calculated over 120-year period. Low value is for spruce-fir forest type in Lake States; high value for Douglas fir on Pacific Coast. Soil carbon accumulation included in estimate.
c. Values are for average management of forest established after clear-cut harvest.
d. Values calculated over 120-year period. Low value is for Douglas fir in Rocky Mountains; high value for Douglas fir on Pacific Coast. No accumulation in soil carbon is assumed.
e. Select examples, calculated over 100 years. Low value represents change from 25-year to 50-year rotation for loblolly pines in Southeast; high value is change in management regime for Douglas fir in Pacific Northwest. Carbon in wood products included.
f. Forest management here encompasses regeneration, fertilization, choice of species and reduced forest degradation. Average estimate here is not specific to U.S., but averaged over developed countries.

[4] http://www.v-c-s.org/about.html.

In addition to the carbon sequestration that it may be possible to achieve in the forested areas, a separate estimate is possible for grassland areas. There are 152 acres of grassland/herbaceous habitat on WHI, of which 67 acres is located within a riparian fringe habitat (Entrix 2010). Table 2 summarizes potential carbon sequestration rates, based on estimates of carbon sequestration reported by researchers at Oregon State University (Conant 2001). The first scenario estimates carbon sequestration across all 152 acres of grassland/herbaceous habitat including the riparian forest, the second scenario includes the 85 acres of grassland/herbaceous habitat outside of the riparian area. As in the forest/woodland evaluation, the two scenarios are designed to provide low and high-estimates of total carbon sequestration potential in metric tons of carbon dioxide equivalent per acre per year ($MTCO_2e/yr$). A range of sequestration potential is provided because the hydrology in the riparian area may limit carbon sequestration potential.

Table 2. Modeled Carbon Sequestration in Grassland/Herbaceous Habitats

Activity	Representative Carbon Sequestration Rates in U.S. ($MtCO_2e/yr$)	Average Carbon Sequestration Rates ($MtCO_2e/yr$)	Time Over Which Sequestration May Occur Before Saturating	Scenario 1: 152 Acre Project Area ($MtCO_2e/yr$)	Scenario 2: 85 Acre Project Area ($MtCO_2e/yr$)	References
Restoration of native grassland species	0.5 – 1.4	0.95	40 years	144	81	Conant 2001

These initial results indicate a wide range of possible carbon sequestration rates based on the underlying assumptions about current conditions and restoration success. The low end of the estimate for the combined forest and grassland areas is approximately 132 $MtCO_2e/yr$ and ranges up to 434 $MtCO_2e/yr$.

If considered in the carbon market context, private-sector carbon offset project developers typically seek to generate carbon credits from a project that produces a net reduction of 500 $MTCO_2e$ annually; this is the "rule of thumb" threshold for determining when the income generated by the sale of credits justifies the expenses associated with permitting and registering a carbon offset project. Based on this litmus test, this initial assessment indicates that neither the carbon credits generated from revegetation nor the restoration of native grassland species will produce revenue in excess of the permitting costs over the life of the project. However, land management activities that enhance carbon sequestration generate co-benefits, such as increased biodiversity and soil conservation, that support the goal of the WHI restoration program and contribute to overall increased ecosystem services performance on the island.

Natural Hazard Management Opportunities

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 (Thorp et al. 2010). 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. Figure 3 (attached) shows the shaded relief and contours for the island based on LiDAR data.[5]

The proposed restoration actions would reintroduce channels and increase floodplain connections, ideally leading to the reduction of flood energy and an increase in water storage during storm events. Restoration actions to increase flood protection will also add biodiversity benefits through reintroducing historic flood patterns and benefits for aquatic species. Increased inundation will also contribute to controlling the spread of invasive species on the site and will support forest management goals for WHI. The reconnection of floodplain areas and the increase in off-channel areas also addresses a regional increase in filled floodplains. The island presents a rare opportunity to address the regional cut-fill balance if fill in the floodplain is removed. These opportunities are specifically associated with increasing the amount of open water and floodplains, particularly through the proposed off channel area in the dredge spoil site and through the creation of a channel to connect the interior wetland through Meyer Pond.

Table 3. Opportunities to Increase Ecosystem Services by Management Area

Management Area	Biodiversity Support	Climate Regulation	Natural Hazard Management
MA-1	High	Low	High
MA-2	Medium	Medium	N/A
MA-3	High	Low	N/A
MA-4	Medium	Low	N/A
MA-5	High	Low	High
MA-6	Medium	Low	Medium
MA-7	Medium	Medium	N/A
MA-8	Medium	Low	High
MA-9	See Note	N/A	N/A
MA-10	See Note	N/A	N/A

Note: Management Areas 9 and 10 will largely be improved by increased ecosystem services functions on adjacent management areas. These benefits are discussed in the management area section below.

Other Ecosystem Services

In addition to these services, the island provides a number of other ecosystem services that are important but not easily improved upon, based on the existing condition of the site. These secondary services are no less important, but their levels of performance are either not changed greatly by proposed actions or they are highly dependent on the regional context and difficult to measure without broadening the study area. These secondary services include:

- Air Quality Regulation
- Education
- Natural Pollination
- Primary Production
- Recreation

[5] Review of elevation data is preliminary at this stage. No hydraulic modeling was performed, and error in vertical accuracy in the LiDAR data may change conclusions on further investigation.

- Sense of Place
- Water Regulation (Quality and Quantity, including hyporheic flows)

As mentioned, several of these services are tied to the biodiversity benefits developed in the restoration plan. These include air quality regulation, natural pollination and water regulation. These three services are not directly targeted by the restoration actions, so large increases in the level of service are not anticipated. However, maintaining their service level is important because the site represents one of the larger undeveloped natural areas in the region and the site provides cumulative benefits when considered in a landscape context:

- Air quality regulation is primarily provided by the forested areas through trapping and filtering airborne particulates. Maintaining and increasing the forest health on the site will further improve the provision of this service on the island.
- The educational services of the island will likely increase greatly with the proposed restoration scenario. The restoration will provide an opportunity to study the processes and options in lower Columbia River restoration. However, quantifying these benefits is not possible at this time. A final and equally challenging service to value is the sense of place. There is no clear methodology for measuring this for the island at this time. But it is important to keep in mind that the island may provide a defining landscape or sense of place to residents both locally and regionally.
- The natural pollination service refers to a site's ability to provide habitat for native insects and birds that pollinate natural and cultivated areas. The habitat requirements for these species are a mix of structure and ground cover types. No assessment of pollinator support on the island is available without more detailed site information, but it is assumed support is present.
- Cultural services on the island include education, recreation and a sense of place. These services are tied to the passive recreation and other low-impact uses of the island. The valuation of these services is influenced heavily by the neighboring land uses. If recreational management opportunities are pursued, it must occur with recognition of the impacts from adjacent marine and industrial uses.
- Water regulation is normally interpreted as the ability of a site to help improve the quantities of clean water available for human use. The location of island in the middle of the Columbia River makes it unlikely that surrounding communities will soon chose to use this source. The island does provide benefits through rain water interception and infiltration, as well as through hyporheic flow.

These secondary services may prove to have a greater role in the value of the island with further site investigations and with development of a more thorough understanding of their contribution in the landscape context.

RESTORATION PROPOSAL BY MANAGEMENT AREA

The proposed restoration actions have been divided up into management areas on the island with similar current conditions and management activities. In all, 10 separate areas have been developed as shown in Figure 1 (attached). These management areas are based on available habitat data and a brief field visit to verify some current conditions.

Management Area 1 – Dredge spoil site restoration

Description and Actions

This management area is proposed to be excavated to create shallow water off-channel habitat and native grasslands. The site currently supports very sparse vegetative cover and low diversity due to excessive drainage and poor soil chemistry. The degraded nature of the area, caused by dredge spoil disposal, and its large size and proximity to the river makes this area a priority for achieving multiple restoration goals. The surface elevation of the existing forested area to the south and that of the wetland located to the west provide reference elevations that may guide fill removal when attempting to reach native soils below the disposed sands. It may be necessary to conduct a series of borings throughout dredge sand area to determine native substrate elevation. It is possible that the dredge sands that need to be removed can be disposed of at other sites in the region.

The new shoreline and littoral zone resulting from the excavation could be further improved by the addition of structures such as large wood or boulders. This management area provides an opportunity to develop numerous habitats including open water, wetlands and grasslands. The desirable proportion of habitat types will depend on further investigation of the site and construction feasibility. The proportion of new shallow water habitat to wetland and grassland habitats needs to be determined based on elevation data, but both habitat types are suggested priorities for the management area. In previous planning efforts, this type of an excavation project has been proposed (Cogan and Associates 1979).

Potential Issues of Concern for this Management Area

- Need for wave barrier facing river to counter erosive forces from river traffic.
- Potential for fish entrapment associated with grading.
- Need to remove and dispose of large quantities of dredge sands.

Impact on Ecosystem Services

These restoration actions would benefit biodiversity support and natural hazard management. Biodiversity support will have the greatest increase due to improved natural features proposed in this area. These new features will provide functions that contribute to biodiversity. Channel margin dynamics will be improved by shifting from existing steep sand beach to gradual sand beach with structures. Food web and nutrient cycling will benefit due to proximity of new off-channel area to existing forests and proposed grassland areas. Large wood and channel dynamics will be improved via connectivity to adjacent forested areas. Wildlife movement will benefit from removing artificial impediments and connecting forest and woodlands to shoreline. The shallow water areas will provide fish refuge during high flows and new foraging areas for water birds.

Natural Hazard Management is anticipated to increase moderately and primarily through providing a new off-channel area to hold flood waters and to absorb energy from flood events. Some water quality improvements are possible, if shading is provided for off-channel areas on southern banks.

Management Area 2 – Interplant native evergreens within existing cottonwood forest

Description and Actions

Management Area 2 encompasses most of the forested interior of the island. This area is characterized primarily by older cottonwood stands with some small interior wetlands present. Existing cottonwoods are at or near the end of the species' typical life span and recruitment ability suffers from lack of seasonal flooding and invasive understory plant species, both of which negatively impact germination and establishment. The proposed restoration action is to enhance the forest with long-lived evergreen species, primarily western red cedar. Cedar is

appropriate for the island due to the dam-modified annual flooding regime. The recommendation to add conifer cover is to provide year-round shade to help control the spread of invasive understory species. There are a number of locations throughout the island's cottonwood forest where introducing conifers is feasible. Breaks in the canopy that are dominated by Himalayan blackberry would be the first locations targeted for treatment. The specific sites for conifer planting will be dependant upon a more detailed suitability analysis that focuses on hydrology and exposure. This management activity can be conducted in either a phased approach or in a single, large planting effort. A phased approach may be preferable as it would provide opportunities to evaluate survival success before a full planting effort is instigated.

An additional opportunity in this management area is to remove roadways or improve roadway crossings over wetlands and seasonally inundated areas. A number of the roadways do not include culverts and provide a barrier to natural inundation in the wetland areas, notably the larger wetland in Management Area 5.

Potential Issues of Concern for this Management Area

- Need to preserve roadways for access or other island uses.

Impact on Ecosystem Services

Biodiversity support and climate regulation are the two services most affected by the proposed actions. Benefits to biodiversity support are limited, but important. Biodiversity support will be improved by furthering the forest's natural ability to recruit new trees. The preservation of the forest and the introduction of conifer species will also contribute to climate regulation by providing new growth and carbon sequestration opportunities.

Management Area 3 – Enhance/enlarge grassland/pasture into grasslands dominated by native species

Description and Actions

This area includes the non-native and native grasslands on the southern side of the island on the eastern boundary of the study area, near the railroad. Soils in the area are sandy and the vegetation shows the impacts from historic grazing. The area provides the opportunity to develop a native species dominated grassland. The rolling topography in this area may allow for a mix of grassland communities. It is anticipated that standard prairie restoration methods can successfully return the site to a native species dominated area. This would likely require one to two years of site preparation, seeding and maintenance. Ongoing site maintenance would also be needed and would primarily be to prevent colonization by woody and invasive species.

Potential Issues of Concern for this Management Area

- Management restrictions under power line rights-of-way.
- Removal or management of sandy soils that presently limit grass communities.

Impact on Ecosystem Services

Biodiversity is the primary ecosystem service to be improved in this area. The reintroduction of native grasses will support songbirds and raptors. Some limited climate regulation is also possible through grassland regeneration, but it is not as effective as forest-based strategies.

Management Area 4 – Grade out existing blackberry ridges in central portion of island

Description and Actions

Running from north to south in the interior of the island is a series of berms that are dominated by Himalayan blackberry. Several of these berms are also located underneath the north-to-south power transmission lines. The areas are not large, but left unmanaged, they will continue to provide a source of invasive species on the island. The proposed restoration action includes grading the berms to the surrounding elevation and replanting with native trees and shrubs.

Potential Issues of Concern for this Management Area

- Management restrictions under power line rights-of-way.

Impact on Ecosystem Services

Biodiversity is the primary ecosystem service to be improved in this area through the reduction in invasive plant species.

Management Area 5 – Construct new off-channel connections with emergent wetland swale

Description and Actions

Management Area 5 includes Benson Pond on the north shore of the island, the central emergent wetland and a proposed new connection to North Portland Harbor to the southeast. The connection between Meyer's Pond and the interior wetland is currently broken by roadways that lack culverts or other openings for hydraulic connection. Similar roadway crossings exist within the wetland area. The proposed connection to the southeast would approximate historic channels across the island, but further study will be required to determine feasibility and likelihood of success.

The outline of Area 5 on Figure 1 (attached) shows a conceptual route for the proposed channel. The elevations in the area suggest a seasonally inundated channel is possible. Approximately 75 percent of the proposed route is currently within ordinary high water (OHW), with the remaining portion within several feet of the OHW elevation. Figure 4 below presents the elevation profile of the proposed route; OHW is currently approximately 21 feet (USACE 2004). Connections would be made through a combination of roadway removal or replacement and excavation of low-lying areas to connect the features. At approximately 1 mile upstream along the proposed route the channel crosses over to the south side of the dredge spoil site where more excavation would be necessary to connect the channel to the river. Historic examinations of the site have indicated the water table is close to surface elevations, though driven primarily by river levels (Cogan and Associates 1982, Entrix 2010).

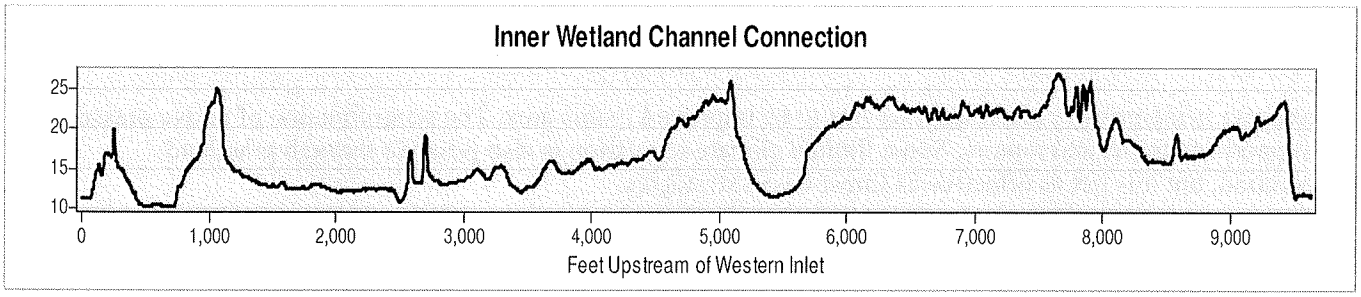

Figure 4. Elevation Profile of Cross-Island Channel (NAVD88 Datum)

The feasibility of constructing the entire channel is difficult to assess at this time. A second option for constructing a connection may be possible by only connecting the main channel of the Columbia River through Meyer's Pond to the interior wetland and not going further east.

Potential Issues of Concern for this Management Area

- Uncertain hydrology and elevation requirements to prevent sedimentation of channel.
- Engineering and hydrologic feasibility of creating and maintaining the connection.
- Construction may encounter cultural resources with excavation below spoil deposits (SWCA 2009).
- Access issues with roadway removal.

Impact on Ecosystem Services

Biodiversity support and natural hazard management are the primary ecosystem services to be improved in this area. The biodiversity support will be greatly increased through the added flooding opportunities in the interior of the island. Flooding actions will stress the invasive species and partially mimic the flood regimes that supported regeneration of the cottonwood forests. Flooding and ponding would also bring nutrients and detritus back into the shallow water areas and the mainstem, a benefit for salmonid species. The seasonal inundation would provide habitat for herptiles including turtle species. If new elevations effectively support longer periods of ponding, the site would better support migratory birds and water birds, providing a connection between regional habitat resources for these species at Ridgefield National Wildlife Refuge, Sauvie Island, and Smith and Bybee Lakes.

Management Area 6 – Connect existing PSS/PFO wetlands on southwest side to channel

Description and Actions

Wetland areas on the southwest portion of the island appear to have historic connections to the North Portland Harbor that have since been blocked by sedimentation, spoil deposits and the construction of massive rocky groins. These are visible on Figure 3 in the five higher elevation features on the south of the island. These wetland areas currently contain excellent examples of older willow and Oregon ash communities. However, the other wetlands in this area are dominated by reed canarygrass. The reconnection to the river would provide a beneficial stressor for the reed canarygrass if elevations are appropriate. Areas at or below OHW may provide high flow refugia for aquatic species. After the connections to the river are excavated, minimal additional construction is anticipated to be needed.

Potential Issues of Concern for this Management Area

- Uncertain hydrology and elevation requirements needed to reestablish historic connections and maintain them over time.

Impact on Ecosystem Services

Biodiversity support is the primary improvement in this area, though natural hazard protection will have modest improvements. Similar to the biodiversity benefits in Area 5, the reconnection will mimic historic flooding, although less frequently. The flooding benefits will stress the invasive species and create a better opportunity for natural recruitment in the existing forested and shrub wetlands. Flooding and ponding will also bring nutrients and detritus back into the shallow water areas and the mainstem of the Columbia River, thus providing a benefit for salmonid species. The seasonal inundation would provide habitat for herptiles, including turtle species, which are also known to be present across North Portland Harbor and in the Smith and Bybee Lakes area.

Management Area 7 – Remove blackberry and replace with native trees/shrubs dominated by evergreens

Description and Actions

This management area is similar to Management Area 2, but the southern shore of the island along the North Portland Harbor includes an opportunity to increase benefits for shallow water habitats though improved connectivity and large wood recruitment. With a natural regeneration pattern in the cottonwood forested areas, naturally felled trees will contribute structure to nearshore areas. Existing cottonwoods are at or near the peak of their typical life span and recruitment suffers from lack of seasonal flooding and invasive understory plant species (both negatively impact germination/establishment). The proposed restoration action is to enhance the forest with long-lived evergreen species targeting western red cedar. The conifer cover will provide year-round shade to help control the spread of invasive understory species. Several areas along river bank area are well suited for replacement of standing cottonwood with new conifer plantings. Wood felled during restoration can provide direct nearshore benefits (e.g., large wood recruitment, shade, organic inputs).

Potential Issues of Concern for this Management Area

- None identified.

Impact on Ecosystem Services

Biodiversity support and climate regulation are the two services most affected by the proposed actions. Biodiversity will be improved by furthering the forest's natural ability to recruit trees. The preservation of the forest and the introduction of conifer species will also contribute to climate regulation by providing new growth and carbon sequestration. It will also further carbon storage by maintaining the regeneration of the forested areas and preventing the loss of forest cover to invasive under stories.

Management Area 8 – Grade down sand bench to connect hydrologically with river high flows

Description and Actions

Historic beach nourishment deposits and dredge spoils are above the beach throughout this management area. The deposits have left the area largely deforested with sparse herbaceous cover. The proposed action includes excavating sands from the high bench between the river and cottonwood forest and restoring or creating a scrub/shrub wetland community with willow or dogwood. The elevation target is to provide connectivity with the high river flows, near OHW. It is assumed that with this elevation, the area will provide hydrology for wetland restoration and provide new connections to the river during high water events. The beach will need to be sloped to prevent damage from wave erosion.

Potential Issues of Concern for this Management Area

- Uncertain hydrology and elevation requirements to establish connections and maintain them over time.
- Wave energy or flood energy may modify the site greatly.
- Uncertain substrates below spoil deposits.

Impact on Ecosystem Services

Similar to Areas 1, 5, and 6, the restoration or creation of wetland areas with OHW will provide biodiversity support and natural hazard mitigation service improvements. The reconnection will mimic historic flooding, providing off-channel refuge during high water events and providing nutrient and detritus inputs for adjacent aquatic habitats.

Management Area 9 – Maintain upper beach areas

Description and Actions

No prescribed activities are included specifically within this management area, although improved forest management and floodplain connectivity in adjacent management areas will greatly benefit this area through increase nutrient and structure inputs.

Potential Issues of Concern for this Management Area

- Wave energy or flood energy may modify the site based on changes in adjacent management areas.
- Uncertainty about the role of salmonid juvenile stranding by wake from marine traffic and how this affects design.

Impact on Ecosystem Services

Biodiversity support is the primary service from this management area and it is highly dependent on adjacent management areas.

Management Area 10 – Preserve and maintain shallow water habitat areas

Description and Actions

No prescribed activities are included specifically within this management area, although improved forest management and floodplain connectivity in adjacent management areas will greatly benefit this area through increased nutrient and structure inputs.

Pile and dolphin removal may be a future improvement opportunity; however, the benefits to biodiversity are uncertain. The in-water structures provide hydraulic relief and nutrient inputs for both salmonid juveniles and their predators. At this time, it is unclear what the net benefit is and whether to pursue removal.

Potential Issues of Concern for this Management Area

- Continued or expanded in water structure use by marine traffic.

Impact on Ecosystem Services

Biodiversity support is the primary service from this management area and it is highly dependent on adjacent management areas.

CONCLUSION: ALTERNATIVE SCENARIOS AND THE LANDSCAPE CONTEXT

West Hayden Island'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 spoil disposal has occurred. Some further forest improvements are possible, but these areas are currently providing services at higher level 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 cottonwood forest regeneration capability. 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 (SWCA 2009) 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 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 be lost, and in fact, the loss of the forest 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.

The island also represents a problem that faces the entire lower Columbia River. No single site provides an opportunity to make a major improvement in the health of the river system and the species that rely upon it. Instead, it is part of a cumulative degradation of habitats and ecosystem services. While large uplift cannot be expected at any given site, it is just as important to recognize that a collective series of restoration actions are underway and planned in the region. Managing the island natural values will support these regional efforts. If restoration is possible on the island it will contribute to these efforts as well, all of which are necessary to meet recovery and watershed health goals for the region.

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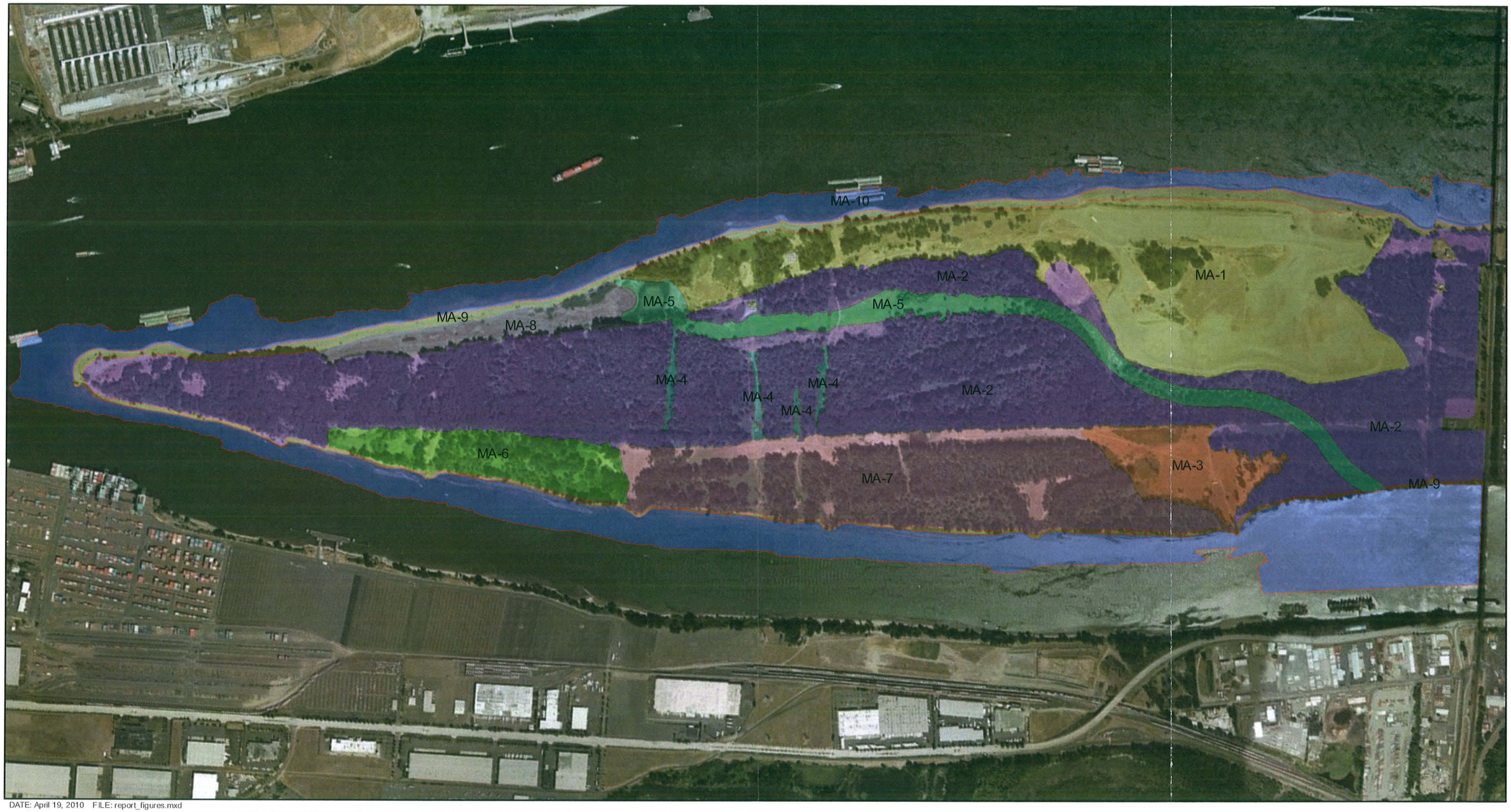

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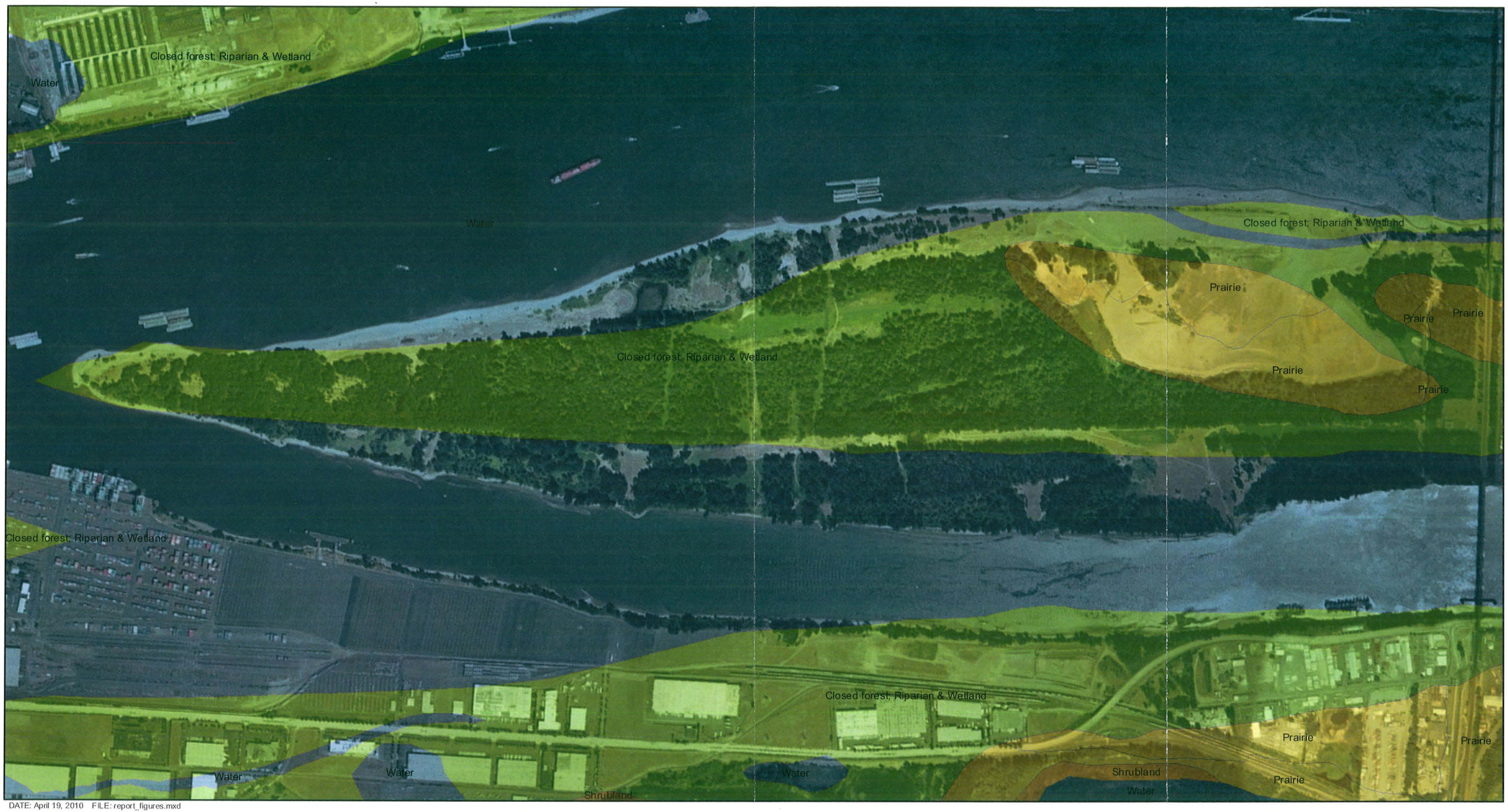
West Hayden Island
Ecosystem Services Restoration Concept Plan:
Figure 1: Management Areas

Parametrix

0 0.25 0.5 0.75 1
Miles

MA-1 MA-5 MA-9
MA-2 MA-6 MA-10
MA-3 MA-7
MA-4 MA-8



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West Hayden Island
Ecosystem Services Restoration Concept Plan:
Figure 2: GLO Vegetation Classes (1852)

Parametrix

0 0.25 0.5 0.75 1
Miles

- Closed forest; Riparian & Wetland
- Closed forest; Upland
- Composition unknown
- Emergent wetlands
- Herbaceous Upland Communities
- Prairie
- Savanna
- Shrubland
- Unvegetated
- Water
- Woodland

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West Hayden Island
Ecosystem Services Restoration Concept Plan:
Figure 3: Elevation Data (NAV88)

Parametrix

0 0.25 0.5 0.75 1
Miles

Note:
Elevation data is derived from LiDAR with some gaps in bare earth interpretation over open water. The elevation contour colors are approximations of river stage levels. Blue countours are within the mean monthly stage, light green contours represent the mean monthly to OHW levels. Brown shades are above OHW. All elevations in feet (NAVD88).

LiDAR Derived Contours
Feet (NAVD88)
- 8 - 11
- 12 - 16
- 17 - 21
- 22 - 28
- 29 - 40