U.S. Fish & Wildlife Service

Willapa National Wildlife Refuge

Comprehensive Conservation Plan

Volume 2

A Vision of Conservation

Within this beautiful coastal and bay setting, incoming tides mix with nutrient laden freshwaters to create one of the most pristine and productive estuarine environments along the Pacific coastline.

The distinctive habitats found within the Refuge include coastal dunes, salt marshes, mudflats, open water with eelgrass beds, grasslands, and old growth western red cedar forest.

Visitors explore and enjoy a variety of wildlife from Roosevelt elk and the Pacific giant salamanders on Long Island to flocks of birds containing tens of thousands of shorebirds along the beach at Leadbetter Point.

Refuge management activities focus on protecting and restoring historic habitat conditions: second growth forests to healthy old growth forests, managed manmade freshwater wetlands to historic salt marsh habitat, threatened and endangered species to healthy sustained wildlife populations.

Success with these management activities is attained through partnerships with the Shoalwater Bay Tribe, local, state, and federal agencies, local organizations, communities, and individuals.

Community stewardship for these natural resources helps to sustain the healthy naturally functioning ecosystems of the Willapa Bay region for current and future generations to enjoy.

Comprehensive Conservation Plans provide long-term guidance for management decisions and set forth goals, objectives, and strategies needed to accomplish refuge purposes and identify the U.S. Fish and Wildlife Service's best estimates of future needs. These plans detail program planning levels that are sometimes substantially above current budget allocations, and as such, are primarily used for strategic planning and program prioritization purposes. The plans do not constitute a commitment for staffing increases, operational and maintenance increases, or funding for future land acquisition.

Dunlin and sanderlings
© Rudy Schuver

Table of Contents
Volume 2

Appendices

Appendix G.	Wilderness Inventory for the Willapa National Wildlife Refuge	G-1
Appendix H.	Integrated Pest Management Program	H-1
Appendix I.	Statement of Compliance	I-1
Appendix J.	Acronyms and Glossary	J-1
Appendix K.	South Willapa Bay Conservation Area Draft Forest Landscape Restoration Plan	K-1
Appendix L.	Predator Management Plan	L-1
Appendix M.	Hunt Plan	M-1
Appendix N.	Literature Cited	N-1
Appendix O.	Estuarine Restoration Plan	O-1
Appendix P.	Willapa National Wildlife Refuge Headquarters Draft Site Plan	P-1
Appendix Q.	Wildlife and Plant List for Willapa National Wildlife Refuge	Q-1
Appendix R.	Economic Effects of Willapa National Wildlife Refuge’s Comprehensive Conservation Plan	R-1

Appendices G-R

Pink sand verbena
USFWS

Appendices

Appendix G. Wilderness Inventory for the Willapa National Wildlife Refuge

G.1 Policy and Direction for Wilderness Reviews

Wilderness review is the process used to determine whether to recommend lands or waters in the National Wildlife Refuge System (System) to the U.S. Congress for designation as wilderness. Planning policy for the System (602 FW 3) mandates conducting wilderness reviews every 15 years through the comprehensive conservation planning (CCP) process.

The wilderness review process has three phases: wilderness inventory, wilderness study, and wilderness recommendation. After first identifying lands and waters that meet the minimum criteria for wilderness (inventory phase), the resulting wilderness study areas (WSAs) are further studied to determine if they merit recommendation from the Service to the Secretary of the Interior for inclusion in the National Wilderness Preservation System (NWPS). Areas recommended for designation are managed to maintain wilderness. A brief discussion of the wilderness inventory and recommendation follows.

During the study phase, a WSA is analyzed for all values (ecological, recreational, cultural), resources (wildlife, water, vegetation, minerals, soils), and uses (management and public) within the WSA. The purpose of the study is to determine each WSA's suitability for management as wilderness in light of its primary purpose as a refuge. The findings of the study determine whether the WSA merits recommendation for inclusion in the NWPS or should be managed under an alternate set of goals, objectives, and strategies/actions that do not involve wilderness designation.

If the wilderness study determines that a WSA meets the requirements for inclusion in the NWPS, a wilderness study report that presents the results of the wilderness review, accompanied by a Legislative Environmental Impact Statement (LEIS), is prepared. The wilderness study report and LEIS that support wilderness designation are then transmitted through the Secretary of the Interior to the President of United States, and ultimately to the U.S. Congress for action.

If it is determined during the inventory that no areas qualify as WSAs or if it is concluded from the study that we should not recommend any areas as wilderness, we prepare a brief report that documents the unsuitability of the lands and waters for wilderness study or recommendation. That report is submitted to the Director of the Fish and Wildlife Service.

G.1.2 Previous Wilderness Reviews

There have been no previous wilderness reviews conducted on this Refuge.

G.1.3 Lands Considered Under This Wilderness Review

All Service-owned lands and waters inside the approved boundary were considered during the inventory for wilderness. This is consistent with current Service policy.

G.2 Wilderness Inventory Criteria

The Wilderness Act of 1964, as amended (16 U.S.C. 1131-1136), provides the following description of wilderness: "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." In this Act, an area of wilderness is further defined to mean "an area of undeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions."

The following criteria for identifying areas as wilderness are described further in Section 2(c) of the Act and are elaborated upon in the Service Wilderness Management Policy (610 FW 1-5). We inventory Refuge System lands and waters to identify areas that meet the definition of wilderness in Section 2(c) of the Wilderness Act.

(1) Size—an area meets the size criteria if it:

- has no permanent roads and is 5,000 contiguous acres or more,
- has no permanent roads and is of sufficient size as to make practicable its preservation and use in an unimpaired condition, or
- is a roadless island

(2) Naturalness—an area meets the naturalness criteria if it:

- would look fairly natural to the average visitor who would not realize that historic conditions of the ecosystem had been modified by humans

(3) Opportunities for solitude or primitive and unconfined recreation—an area meets this criterion if it offers:

- outstanding opportunities for solitude—visitors can experience nature essentially free of the reminders of society, or
- outstanding opportunities for primitive and unconfined recreation—dispersed, undeveloped recreation not requiring prohibited uses.

Outstanding opportunities do not have to be present on every acre and the area does not have to be open to public entry and use.

At the end of the inventory, we may have identified none, one, or several WSAs based on the above criteria.

G.2.1 Process of Analysis

The CCP team began the inventory phase of the wilderness review and recognized that the only unit meeting the above basic criteria was the Long Island Unit of the Refuge. The team completed a preliminary assessment of the island and documenting the findings.

The following evaluation process was used in identifying suitability for wilderness designation:

- Determination of Refuge unit sizes.
- For any areas that met the size/island criterion, an assessment was made of its naturalness.
- For any areas that met the size/island criterion, an assessment was made of its capacity to provide opportunities for solitude or primitive and unconfined recreation.
- For any areas that met the size/island criterion, an assessment was made of its features of scientific, educational, scenic, or historical value.

More detail on the actual factors considered and used for each assessment step follows.

Identification of Roadless Areas and Roadless Islands

Identification of roadless areas and roadless islands required gathering land status maps, land use and road inventory data, and aerial photographs of existing Refuge mainland tracts and islands. "Roadless" refers to the absence of improved roads suitable and maintained for public travel by means of motorized vehicles primarily intended for highway use. Only lands currently owned by the Service in fee title were evaluated.

The roads on Long Island are visible and used routinely by staff and partners for necessary Refuge management purposes. This includes use of heavy equipment, tractors, ATVs, and trucks to conduct forest restoration activities, fire management activities, monitor wildlife, control invasive plants, and maintain roads and other infrastructure.

Unit Size: Roadless Areas that Meet the Size Criterion If Any of the Following Standards is Applied

- An area with at least 5,000 contiguous acres. Lands owned by states, local governments, and private parties are not included in making this acreage determination.
- A roadless island of any size. A roadless island is defined as an area surrounded by permanent waters or an area that is markedly distinguished from the surrounding lands by topographical or ecological features.
- An area of less than 5,000 contiguous federal acres that is of sufficient size as to make practicable its preservation and use in an unimpaired condition, and of a size suitable for wilderness management.
- An area of less than 5,000 contiguous federal acres that is contiguous with a designated wilderness, recommended wilderness, or area under wilderness review by another federal wilderness managing agency such as the Forest Service, National Park Service, or Bureau of Land Management.

As stated previously none of the current Refuge units other than the Long Island Unit meet the 5,000-acre size criterion. Currently, Refuge roads on the island are frequently used for management and restoration activities by the Refuge staff and their partners. Long Island has 5,451 acres owned by the Service, and it has over 7 miles of roads, which were created for logging operations and are currently maintained for Refuge management purposes. Once the planned forest restoration and road decommissioning activities have been completed, this island should be considered and further studied as a WSA.

Solitude or Primitive and Unconfined Recreation

A wilderness area must provide outstanding opportunities for solitude or primitive recreation. The area does not have to possess outstanding opportunities for both solitude and primitive and unconfined recreation, and it does not need to have outstanding opportunities on every acre. Further, an area does not have to be open to public use and access to qualify under these criteria; the U.S. Congress has designated a number of wilderness areas in the Refuge System that are closed to public access to protect natural resource values.

"Opportunities for solitude" refers to the ability of a visitor to be alone and secluded from other visitors in the area. "Primitive and unconfined recreation" means nonmotorized, dispersed outdoor recreational activities that are compatible and do not require developed facilities or mechanical transport. These primitive recreational activities may provide opportunities to experience challenge, risk, self-reliance, and adventure.

These two elements are not well-defined by the Wilderness Act. In some cases, they occur together. However, an outstanding opportunity for solitude may be present in an area offering only limited primitive recreation potential. Conversely, an area may be so attractive for recreational use that experiencing solitude is not an option.

In the wilderness inventory for roadless islands, the following factors were the primary considerations in evaluating the availability of outstanding opportunities for solitude or primitive and unconfined recreation on Long Island:

- Island size and
- Availability of vegetative screening

Opportunities for solitude and primitive recreation were judged to be outstanding on Long Island. The young, second-growth forest cover contains dense vegetative undergrowth and vegetative screening, providing a sense of solitude. The size of the island (5,451 acres) and five dispersed primitive camping areas (a total of 21 camp sites) is large enough to provide individuals an opportunity for solitude. Hunting and camping opportunities are provided on the island and offer a quality primitive recreation activity. Hiking on the island can be accomplished along the maintained roadways and one developed trail (Cedar Grove Trail). Access to the island can be via motorized or nonmotorized watercraft.

Naturalness and Wildness

In addition to being roadless, a wilderness area must meet the naturalness and wildness criteria. Section 2(c) defines wilderness as an area that "generally appears to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable." If not pristine, an area must at least appear natural to the average visitor. The presence of historical landscape conditions is not required. An area may include some human impacts, provided they are substantially unnoticeable in the unit as a whole. Significant human-caused hazards, such as the presence of unexploded ordnance from military activity, and the physical impacts of Refuge management facilities and activities are also considered in evaluation of the naturalness criteria. An area may not be considered unnatural in appearance solely on the basis of the "sights and sounds" of human impacts and activities outside the boundary of the unit.

In this wilderness inventory, the following factors were primary considerations in evaluating the naturalness of Long Island:

- presence of buildings and roads/vehicles,
- presence of forest harvest/thinning activities, and
- presence of other management activities

Opportunities for naturalness are currently judged to be poor on the Long Island Unit. The second-growth forest is actively managed by mechanical means to improve forest health.

Forest management activities currently require Refuge staff to use a variety of heavy equipment, helicopters, trucks, and ATVs. The island has over 7 miles of roads with maintained water culverts, an equipment barn, and a boat dock facility. Wildlife-dependent public recreation activities (wildlife observation, hunting) are available on the island. To facilitate these activities there are five campgrounds (with a total of 21 camp sites), which require active management using vehicles to maintain the facilities.

This island currently does not have the appearance of a pristine natural island due to the former forest harvest and clearcutting activities on approximately 75 percent of the overall island. The activities of the past are reinforced by the ongoing resource and forest management activities. The presence and sounds of forest management activities include power boats, air boats, heavy equipment, and vehicles, all of which would impact that sense of naturalness and wildness on a seasonal basis as Refuge management and forest restoration activities are implemented.

Based on the preceding discussion, this island does not meet the minimum standards for a wilderness study. This island should be re-evaluated for wilderness study once the forest management activities and the plans for future road decommissioning have been completed as part of this 15-year CCP.

Supplemental Values or Features

Supplemental values have been determined to occur on Long Island. The values include 270 acres of old-growth western red cedar forest, including the wide variety of wildlife species that occur on the island. Both wildlife habitat and historical Native American cultural values occur as a result of protection and management of this island.

Inventory Findings

Based on this inventory, Long Island appears to possess the best opportunities for future consideration as a WSA. Currently, the scars of past commercial timber harvest activities are visible across the island's landscape. Management activities include routine use of island roads for aggressive forest habitat restoration and future road decommissioning (track hoes, chainsaws, and helicopters), fire protection activities, and continued implementation of the forest management plan. There is a large barn located on the island, which is used for storage of necessary mechanical and fire equipment.

The team recommends re-evaluation of the Long Island Unit for a wilderness study in 15 years.

Results of the Willapa NWR Wilderness Inventory.

Area	Unit Acres	Meets Island and/or Size Criterion	Meets Naturalness Criterion	Meets Solitude/ Primitive Recreation Criterion	Meets Supplemental Values Criterion (Optional)	Preliminary Conclusion: Suitable for Further Consideration in Wilderness Study
Long Island Unit	5,451	Yes	No	Yes	Yes	No

Appendix H. Integrated Pest Management Program

H.1 Background

Integrated Pest Management (IPM) is an interdisciplinary approach using methods to prevent, eliminate, contain, and/or control pest species in concert with other management activities on Refuge lands and waters to achieve wildlife and habitat management goals and objectives. IPM is also a scientifically based, adaptive management process where available scientific information and best professional judgment of the Refuge staff as well as other resource experts would be used to identify and implement appropriate management strategies that can be modified and/or changed over time to ensure effective, site-specific management of pest species to achieve desired outcomes. In accordance with 43 C.F.R. 46.145, adaptive management would be particularly relevant where long-term impacts may be uncertain and future monitoring would be needed to make adjustments in subsequent implementation decisions. After a tolerable pest population (threshold) is determined considering achievement of Refuge resource objectives and the ecology of pest species, one or more methods, or combinations thereof, would be selected that are feasible, efficacious, and most protective of non-target resources, including native species (fish, wildlife, and plants), and Service personnel, Service authorized agents, volunteers, and the public. Staff time and available funding would be considered when determining feasibility/practicality of various treatments.

IPM techniques to address pests are presented as CCP strategies (see Section H.2 of this CCP) in an adaptive management context to achieve Refuge resource objectives. In order to satisfy requirements for IPM planning as identified in the Director's Memo (dated September 9, 2004) entitled "Integrated Pest Management Plans and Pesticide Use Proposals: Updates, Guidance, and an Online Database," the following elements of an IPM program have been incorporated into this CCP:

- Habitat and/or wildlife objectives that identify pest species and appropriate thresholds to indicate the need for and successful implementation of IPM techniques; and
- Monitoring before and/or after treatment to assess progress toward achieving objectives including pest thresholds.

Where pesticides would be necessary to address pests, this appendix provides a structured procedure to evaluate potential effects of planned uses involving ground-based applications to Refuge biological resources. Only pesticide uses that likely would cause minor, temporary, or localized effects to Refuge biological resources and environmental quality with appropriate best management practices (BMPs), where necessary, would be allowed for use on the Refuge.

This appendix does not describe the more detailed process to evaluate potential effects associated with aerial applications of pesticides. Moreover, it does not address effects of mosquito control with pesticides (larvicides, pupacides, or adulticides) based upon identified human health threats and presence of disease-carrying mosquitoes in sufficient numbers from monitoring conducted on a Refuge. However, the basic framework to assess potential effects to Refuge biological resources and environmental quality from aerial application of pesticides or use of insecticides for mosquito management would be similar to the process described in this appendix for ground-based treatments of other pesticides.

H.2 Pest Management Laws and Policies

In accordance with Service policy 7 RM 14 (Pest Control), wildlife and plant pests on units of the National Wildlife Refuge System can be controlled to ensure balanced wildlife and fish populations in support of Refuge-specific wildlife and habitat management objectives. Pest control on federal (Refuge) lands and waters also is authorized under the following legal mandates:

- National Wildlife Refuge System Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee);
- Plant Protection Act of 2000 (7 U.S.C. 7701 et seq.);
- Noxious Weed Control and Eradication Act of 2004 (7 U.S.C. 7781-7786, Subtitle E);
- Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (7 U.S.C. 136-136y);
- National Invasive Species Act of 1996 (16 U.S.C. 4701);
- Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 U.S.C. 4701);
- Food Quality Protection Act of 1996 (7 U.S.C. 136);
- Executive Order 13148, Section 601(a);
- Executive Order 13112; and
- Animal Damage Control Act of 1931 (7 U.S.C. 426-426c, 46 Stat. 1468).

Pests are defined as “living organisms that may interfere with the site-specific purposes, operations, or management objectives or that jeopardize human health or safety” from Department policy 517 DM 1 (Integrated Pest Management Policy). Similarly, 7 RM 14 defines pests as “Any terrestrial or aquatic plant or animal which interferes, or threatens to interfere, at an unacceptable level, with the attainment of Refuge objectives or which poses a threat to human health.” 517 DM 1 also defines an invasive species as “a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.” Throughout the remainder of this appendix, the terms *pest* and *invasive species* are used interchangeably because both can prevent/impede achievement of Refuge wildlife and habitat objectives and/or degrade environmental quality.

In general, control of pests (vertebrate or invertebrate) on the Refuge would conserve and protect the nation’s fish, wildlife, and plant resources as well as maintain environmental quality. From 7 RM 14, animal or plant species, which are considered pests, may be managed if the following criteria are met:

- Threat to human health and well-being or private property, the acceptable level of damage by the pest has been exceeded, or state or local government has designated the pest as noxious;
- Detrimental to resource objectives as specified in a Refuge resource management plan (e.g., comprehensive conservation plan, habitat management plan), if available; and
- Control would not conflict with attainment of resource objectives or the purposes for which the Refuge was established.

From 7 RM 14, the specific justifications for pest management activities on the Refuge are the following:

- Protect human health and well-being;
- Prevent substantial damage to important to Refuge resources;

- Protect newly introduced or re-establish native species;
- Control non-native (exotic) species in order to support existence for populations of native species;
- Prevent damage to private property; and
- Provide the public with quality, compatible wildlife-dependent recreational opportunities.

In accordance with Service policy 620 FW 1 (Habitat Management Plans), there are additional management directives regarding invasive species found on the Refuge:

- "We are prohibited by Executive Order, law, and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere."
- "Manage invasive species to improve or stabilize biotic communities to minimize unacceptable change to ecosystem structure and function and prevent new and expanded infestations of invasive species. Conduct Refuge habitat management activities to prevent, control, or eradicate invasive species."

Animal species damaging/destroying Federal property and/or detrimental to the management program of a Refuge may be controlled as described in 50 C.F.R. 31.14 (Official Animal Control Operations)**.** Based upon 7 RM 14.7E, a pest control proposal is required, in some cases, to initiate a control program on Refuge lands. The required elements of a pest control proposal are described in 7 RM 14.7A-E. However, a pest control proposal is not required under the following scenarios:

- Routine protection of Refuge buildings, structures (e.g., dikes, water control structures), and facilities not involving prohibited chemicals.
- Incidental control of exotics (e.g., non-native rats, non-native rabbits) or feral animals on Refuge lands that are not protected by either federal or state laws, except where chemicals may be used.
- The use of routine habitat management techniques, selective trapping, on-Refuge transfer, and physical and mechanical protection such as barriers and fences (including electric fences).

For example, the incidental removal of beaver damaging Refuge infrastructure (e.g., clogging with subsequent damaging of water control structures) and/or negatively affecting habitats (e.g., removing woody species from existing or restored riparian) managed on Refuge lands may be conducted without a pest control proposal. We recognize beavers are native species and most of their activities or Refuge lands represent a natural process beneficial for maintaining wetland habitats. Exotic nutria, whose denning and burrowing activities in wetland dikes causes cave-ins and breaches, can be controlled using the most effective techniques considering site-specific factors without a pest control proposal. Along with the loss of quality wetland habitats associated with breaching of impoundments, the safety of Refuge staff and public (e.g., auto tour routes) driving on structurally compromised dikes can be threaten by sudden and unexpected cave-ins.

Trespass and feral animals also may be controlled on Refuge lands. In accordance with 7 RM 14.9B(1), animals trespassing on Refuge lands may be captured and returned to their owners or transferred to humane societies or local animal shelters, where feasible. Based upon 50 C.F.R. 28.43 (Destruction of Dogs and Cats), dogs and cats running at large on a national wildlife Refuge and observed in the act of killing, injuring, harassing, or molesting humans or wildlife may be disposed of in the interest of public safety and protection of the wildlife. In accordance with 7 RM 14.9B(2), feral animals should be disposed by the most humane method(s) available and in accordance with relevant Service directives (including Executive Order 11643).

Disposed wildlife specimens may be donated or loaned to public institutions. Donation or loans of resident wildlife species will only be made after securing state approval (50 C.F.R. 30.11 [Donation and Loan of Wildlife Specimens]**).** Surplus wildlife specimens may be sold alive or butchered, dressed, and processed subject to federal and state laws and regulations (50 C.F.R. 30.12 [Sale of Wildlife Specimens]).

As previously stated, for controlling animals damaging/destroying federal property and/or detrimental to the management program of a Refuge, incidentally removing such animals from Refuge lands does not require a pest control proposal.

H.3 Strategies

To fully embrace IPM, the following strategies, where applicable, would be carefully considered on the Refuge for each pest species:

- **Prevention.** This would be the most effective and least expensive long-term management option for pests. It encompasses methods to prevent new introductions or the spread of the established pests to uninfested areas. It requires identifying potential routes of invasion to reduce the likelihood of infestation. Hazard Analysis and Critical Control Points (HACCP) planning can be used determine if current management activities on a refuge may introduce and/or spread invasive species in order to identify appropriate BMPs for prevention. See http://www.haccp-nrm.org/ for more information about HACCP planning.

  Prevention may include source reduction, using pathogen-free or weed-free seeds or fill; exclusion methods (e.g., barriers) and/or sanitation methods (e.g., wash stations) to prevent re-introductions by various mechanisms including vehicles, personnel, livestock, and horses. Because invasive species are frequently the first to establish newly disturbed sites, prevention would require a reporting mechanism for early detection of new pest occurrences with quick response to eliminate any new satellite pest populations. Prevention would require consideration of the scale and scope of land management activities that may promote pest establishment within uninfested areas or promote reproduction and spread of existing populations. Along with preventing initial introduction, prevention would involve halting the spread of existing infestations to new sites (Mullin et al. 2000). The primary reason for prevention would be to keep pest-free lands or waters from becoming infested. Executive Order 11312 emphasizes the priority for prevention with respect to managing pests.

  The following would be methods to prevent the introduction and/or spread of pests on Refuge lands:

  - Before beginning ground-disturbing activities (e.g., disking, scraping), inventory and prioritize pest infestations in project operating areas and along access routes. Refuge staff would identify pest species on-site or within reasonably expected potential invasion vicinity. Where possible, the Refuge staff would begin project activities in uninfested areas before working in pest-infested areas.

- The Refuge staff would locate and use pest-free project staging areas. They would avoid or minimize travel through pest-infested areas, or restrict to those periods when spread of seed or propagules of invasive plants would be least likely.
- The Refuge staff would determine the need for, and when appropriate, identify sanitation sites where equipment can be cleaned of pests. Where possible, the Refuge staff would clean equipment before entering lands at on-Refuge approved cleaning site(s). This practice does not pertain to vehicles traveling frequently in and out of the project area that will remain on roadways. Seeds and plant parts of pest plants would need to be collected, where practical. The Refuge staff would remove mud, dirt, and plant parts from project equipment before moving it into a project area.
- The Refuge staff would clean all equipment, before leaving the project site, if operating in areas infested with pests. The Refuge staff would determine the need for, and when appropriate, identify sanitation sites where equipment can be cleaned.
- Refuge staffs, their authorized agents, and Refuge volunteers would, where possible, inspect, remove, and properly dispose of seed and parts of invasive plants found on their clothing and equipment. Proper disposal means bagging the seeds and plant parts and then properly discarding of them (e.g., incinerating).
- The Refuge staff would evaluate options, including closure, to restrict the traffic on sites with ongoing restoration of desired vegetation. The Refuge staff would revegetate disturbed soil (except travel ways on surfaced projects) to optimize plant establishment for each specific site. Revegetation may include topsoil replacement, planting, seeding, fertilization, liming, and weed-free mulching as necessary. The Refuge staff would use native material, where appropriate and feasible. The Refuge staff would use certified weed-free or weed-seed-free hay or straw where certified materials are reasonably available.
- The Refuge staff would provide information, training, and appropriate pest identification materials to other Refuge staff members, permit holders, and recreational visitors. The Refuge staff would educate them about pest identification, biology, impacts, and effective prevention measures.
- The Refuge staff would require grazing permittees to utilize preventative measures for their livestock while on refuge lands.
- The Refuge staff would inspect borrow material for invasive plants prior to use and transport onto and/or within refuge lands.
- The Refuge staff would consider invasive plants in planning for road maintenance activities.
- The Refuge staff would restrict off-road travel to designated routes.

The following would be methods to prevent the introduction and/or spread of pests into Refuge waters:

- The Refuge staff would inspect boats (including air boats), trailers, and other boating equipment. Where possible, the Refuge staff would remove any visible plants, animals, or mud before leaving any waters or boat launching facilities. Where possible, the Refuge staff would drain water from motor, live well, bilge, and transom wells while on land before leaving the site. If possible, the Refuge staff would wash and dry boats, downriggers, anchors, nets, floors of boats,

propellers, axles, trailers, and other boating equipment to kill pests not visible at the boat launch.
- Where feasible, the Refuge staff would maintain a 100-foot buffer of aquatic pest-free clearance around boat launches and docks or quarantine areas when cleaning around culverts, canals, or irrigation sites. Where possible, the Refuge staff would inspect and clean equipment before moving to new sites or one project area to another.

These prevention methods to minimize/eliminate the introduction and/or spread of pests were taken verbatim or slightly modified from Appendix E of U.S. Forest Service (2005).

- **Mechanical/Physical Methods.** These methods would remove and destroy, disrupt the growth of, or interfere with the reproduction of pest species. For plants species, these treatments can be accomplished by hand, hand tool (manual), or power tools (mechanical) and include pulling, grubbing, digging, tilling/disking, cutting, swathing, grinding, sheering, girdling, mowing, and mulching of the pest plants.

  For animal species, Service employees or their authorized agents could use mechanical/ physical methods (including trapping) to control pests as a Refuge management activity. Based upon 50 C.F.R. 31.2, trapping can be used on a refuge to reduce surplus wildlife populations for a "balanced conservation program" in accordance with federal or state laws and regulations. In some cases, non-lethally trapped animals would be relocated to off-Refuge sites with prior approval from the state. A pest control proposal (see 7 RM 14.7A-D for required elements) is needed before initiation of trapping activities, except those operations identified in 7 RM 14.7E. In addition, a separate pest control proposal is not necessary if the required information can be incorporated into an EA (or other appropriate NEPA document).

  Each of these tools would be efficacious to some degree and applicable to specific situations. In general, mechanical controls can effectively control annual and biennial pest plants. However, to control perennial plants, the root system has to be destroyed or it would resprout and continue to grow and develop. Mechanical controls are typically not capable of destroying a perennial plant's root system. Although some mechanical tools (e.g., disking, plowing) may damage root systems, they may stimulate regrowth producing a denser plant population that may aid in the spread depending upon the target species (e.g., Canada thistle). In addition, steep terrain and soil conditions would be major factors that can limit the use of many mechanical control methods.

  Some mechanical control methods (e.g., mowing), which would be used in combination with herbicides, can be a very effective technique to control perennial species. For example, mowing perennial plants followed sequentially by treating the plant regrowth with a systemic herbicide often would improve the efficacy of the herbicide compared to herbicide treatment only.

- **Cultural Methods.** These methods would involve manipulating habitat to increase pest mortality by reducing its suitability to the pest. Cultural methods would include water-level manipulation, mulching, winter cover crops, changing planting dates to minimize pest impact, prescribed burning (facilitate revegetation, increase herbicide efficacy, and remove litter to assist in emergence of desirable species), flaming with propane torches, trap crops, crop rotations that would include non-susceptible crops, moisture management, addition of beneficial insect habitat, reducing clutter, proper trash disposal, planting or seeding desirable species to shade or out-compete invasive plants, applying fertilizer to enhance desirable vegetation, prescriptive grazing, and other habitat alterations.

- **Biological Control Agents.** Classical biological control would involve the deliberate introduction and management of natural enemies (parasites, predators, or pathogens) to reduce pest populations. Many of the most ecologically or economically damaging pest species in the United States originated in foreign countries. These newly introduced pests, which are free from natural enemies found in their country or region of origin, may have a competitive advantage over cultivated and native species. This competitive advantage often allows introduced species to flourish, and they may cause widespread economic damage to crops or out compete and displace native vegetation. Once the introduced pest species population reaches a certain level, traditional methods of pest management may be cost prohibitive or impractical. Biological controls typically are used when these pest populations have become so widespread that eradication or effective control would be difficult or no longer practical.

  Biological control has advantages as well as disadvantages. Benefits would include reducing pesticide usage, host specificity for target pests, long-term self-perpetuating control, low cost/acre, capacity for searching and locating hosts, synchronizing biological control agents to hosts' life cycles, and the unlikelihood that hosts will develop resistance to agents. Disadvantages would include the following: limited availability of agents from their native lands, the dependence of control on target species density, slow rate at which control occurs, biotype matching, the difficulty and expense of conflicts over control of the target pest, and host specificity when host populations are low.

  A reduction in target species populations from biological controls is typically a slow process, and efficacy can be highly variable. It may not work well in a particular area although it does work well in other areas. Biological control agents would require specific environmental conditions to survive over time. Some of these conditions are understood, whereas others are only partially understood or not at all.

  Biological control agents would not eradicate a target pest. When using biological control agents, residual levels of the target pest typically are expected; the agent population level or survival would be dependent upon the density of its host. After the pest population decreases, the population of the biological control agent would decrease correspondingly. This is a natural cycle. Some pest populations (e.g., invasive plants) would tend to persist for several years after a biological control agent becomes established due to seed reserves in the soil, inefficiencies in the agents search behavior, and the natural lag in population buildup of the agent.

  The full range of pest groups potentially found on Refuge lands and waters would include diseases, invertebrates (insects, mollusks), vertebrates, and invasive plants (the most common group). Often it is assumed that biological control would address many if not most of these pest problems. There are several well-documented success stories of biological control of invasive weed species in the Pacific Northwest including Mediterranean sage, St. Johnswort (Klamath weed), and tansy ragwort. Emerging success stories include Dalmatian toadflax, diffuse knapweed, leafy spurge, purple loosestrife, and yellow star thistle. However, historically, each new introduction of a biological control agent in the United States has only about a 30% success rate (Coombs et al. 2004). Refer to Coombs et al. (2004) for the status of biological control agents for invasive plants in the Pacific Northwest.

Introduced species without desirable close relatives in the United States would generally be selected as biological controls. Natural enemies that are restricted to one or a few closely related plants in their country of origin are targeted as biological controls (Center et al. 1997; Hasan and Ayres 1990).

The Refuge staff would ensure introduced agents are approved by the applicable authorities. Except for a small number of formulated biological control products registered by the U.S. Environmental Protection Agency (USEPA) under the Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (FIFRA), most biological control agents are regulated by the U.S. Department of Agriculture (USDA)-Animal Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ). State departments of agriculture and, in some cases, county agricultural commissioners or weed districts, have additional approval authority.

Federal permits (USDA-APHIS-PPQ Form 526) are required to import biocontrol agents from another state. Form 526 may be obtained by writing:

USDA-APHIS-PPQ
Biological Assessment and Taxonomic Support
4700 River Road, Unit 113
Riverdale, MD 20737

or

through the internet at:
http://www.aphis.usda.gov/ppq/permits/bioligical/weedbio.html

The Service strongly supports the development, and legal and responsible use of appropriate, safe, and effective biological control agents for nuisance and non-indigenous or pest species.

State and county agriculture departments may also be sources for biological control agents or they may have information about where biological control agents may be obtained. Commercial sources should have an Application and Permit to Move Live Plant Pests and Noxious Weeds (USDA-PPQ Form 226 USDA-APHIS-PPQ, Biological Assessment and Taxonomic Support, 4700 River Road, Unit 113, Riverdale, MD 20737) to release specific biological control agents in a state and/or county. Furthermore, certification regarding the biological control agent's identity (genus, specific epithet, sub-species and variety) and purity (e.g., parasite free, pathogen free, and biotic and abiotic contaminants) should be specified in purchase orders.

Biological control agents are subject to 7 RM 8 (Exotic Species Introduction and Management). In addition, the Refuge staff would follow the International Code of Best Practice for Classical Biological Control of Weeds (http://sric.ucdavis.edu/exotic /exotic.htm) as ratified by delegates to the X International Symposium on Biological Control of Weeds, Bozeman, Montana, July 9, 1999. This code identifies the following:

- Release only approved biological control agents,
- Use the most effective agents,

- o Document releases, and
- o Monitor for impact to the target pest, non-target species, and the environment.

Biological control agents formulated as pesticide products and registered by the USEPA (e.g., *Bti*) are also subject to PUP review and approval (see below).

A record of all releases would be maintained with date(s), location(s), and environmental conditions of the release site(s); the identity, quantity, and condition of the biological control agents released; and other relevant data and comments such as weather conditions. Systematic monitoring to determine the establishment and effectiveness of the release is also recommended.

NEPA documents regarding biological and other environmental effects of biological control agents prepared by another federal agency, where the scope is relevant to evaluation of releases on Refuge lands, would be reviewed. Possible source agencies for such NEPA documents include the Bureau of Land Management, U.S. Forest Service, National Park Service, U.S. Department of Agriculture-Animal and Plant Health Inspection Service, and the military services. It might be appropriate to incorporate by reference parts or all of existing document(s) from the review. Incorporating by reference (43 C.F.R. 46.135) is a technique used to avoid redundancies in analysis. It also can reduce the bulk of a Service NEPA document, which only must identify the documents that are incorporated by reference. In addition, relevant portions must be summarized in the Service NEPA document to the extent necessary to provide the decision maker and public with an understanding of relevance of the referenced material to the current analysis.

- **Pesticides.** The selective use of pesticides would be based upon pest ecology (including mode of reproduction), the size and distribution of its populations, site-specific conditions (e.g., soils, topography), known efficacy under similar site conditions, and the capability to utilize BMPs to reduce/eliminate potential effects to non-target species, sensitive habitats, and potential to contaminate surface and groundwater. All pesticide usage (pesticide, target species, application rate, and method of application) would comply with the applicable federal (FIFRA) and state regulations pertaining to pesticide use, safety, storage, disposal, and reporting. Before pesticides can be used to eradicate, control, or contain pests on Refuge lands and waters, pesticide use proposals (PUPs) would be prepared and approved in accordance with 7 RM 14. PUP records would provide a detailed, time-, site-, and target-specific description of the proposed use of pesticides on the Refuge. All PUPs would be created, approved or disapproved, and stored in the Pesticide Use Proposal System (PUPS), which is a centralized database only accessible on the Service's intranet (https://systems.fws.gov/pups). Only Service employees would be authorized to access PUP records for a Refuge in this database.

  Application equipment would be selected to provide site-specific delivery to target pests while minimizing/eliminating direct or indirect (e.g., drift) exposure to non-target areas and degradation of surface and groundwater quality. Where possible, target-specific equipment (e.g., backpack sprayer, wiper) would be used to treat target pests. Other target-specific equipment to apply pesticides would include soaked wicks or paint brushes for wiping vegetation and lances, hatchets, or syringes for direct injection into stems. Granular pesticides may be applied using seeders or other specialized dispensers. In contrast, aerial spraying (e.g., fixed wing or helicopter) would only be used where access is difficult (remoteness) and/or the size/distribution of infestations precludes practical use of ground-based methods.

Because repeated use of one pesticide may allow resistant organisms to survive and reproduce, multiple pesticides with variable modes of action would be considered for treatments on Refuge lands and waters. This is especially important if multiple applications within years and/or over a growing season likely would be necessary for habitat maintenance and restoration activities to achieve resource objectives. Integrated chemical and non-chemical controls also are highly effective, where practical, because pesticide-resistant organisms can be removed from the site.

Cost may not be the primary factor in selecting a pesticide for use on a Refuge. If the least expensive pesticide would potentially harm natural resources or people, then a different product would be selected, if available. The most efficacious pesticide available with the least potential to degrade environment quality (soils, surface water, and groundwater) as well as least potential effect to native species and communities of fish, wildlife, plants, and their habitats would be acceptable for use on Refuge lands in the context of an IPM approach.

- **Habitat restoration/maintenance.** Restoration and/or proper maintenance of Refuge habitats associated with achieving wildlife and habitat objectives would be essential for long-term prevention, eradication, or control (at or below threshold levels) of pests. Promoting desirable plant communities through the manipulation of species composition, plant density, and growth rate is an essential component of invasive plant management (Brooks et al. 2004; Masters and Sheley 2001; Masters et al. 1996). The following three components of succession could be manipulated through habitat maintenance and restoration: site availability, species availability, and species performance (Cox and Anderson 2004). Although a single method (e.g., herbicide treatment) may eliminate or suppress pest species in the short term, the resulting gaps and bare soil create niches that are conducive to further invasion by the species and/or other invasive plants. On degraded sites where desirable species are absent or in low abundance, revegetation with native/desirable grasses, forbs, and legumes may be necessary to direct and accelerate plant community recovery, and achieve site-specific objectives in a reasonable time frame. The selection of appropriate species for revegetation would be dependent on a number of factors including resource objectives and site-specific, abiotic factors (e.g., soil texture, precipitation/temperature regimes, and shade conditions). Seed availability and cost, ease of establishment, seed production, and competitive ability also would be important considerations.

H.4 Priorities for Treatments

For many refuges, the magnitude (number, distribution, and sizes of infestations) of pest problems is too extensive and beyond the available capital resources to effectively address during any single field season. To manage pests in the Refuge, it would be essential to prioritize treatment of infestations. Highest priority treatments would be focused on early detection and rapid response to eliminate infestations of new pests, if possible. This would be especially important for aggressive pests potentially impacting species, species groups, communities, and/or habitats associated Refuge purpose(s), NWRS resources of concern (federally listed species, migratory birds, selected marine mammals, and interjurisdictional fish), and native species for maintaining/restoring biological integrity, diversity, and environmental health.

The next priority would be treating established pests that appear in one or more previously uninfested areas. Moody and Mack (1988) demonstrated through modeling that small, new outbreaks of invasive plants eventually would infest an area larger than the established, source population. They also found that control efforts focusing on the large, main infestation rather than the new, small satellites reduced the chances of overall success. The lowest priority would be treating large infestations (sometimes monotypic stands) of well-established pests. In this case, initial efforts would focus upon containment of the perimeter followed by work to control/eradicate the established infested area. If containment and/or control of a large infestation is not effective, then efforts would focus upon halting pest reproduction or managing source populations. Maxwell et al. (2009) found treating fewer populations that are sources represents an effective long-term strategy to reduce of total number of invasive populations and decreasing meta-population growth rates.

Although state-listed noxious weeds would always of high priority for management, other pest species known to cause substantial ecological impact would also be considered. For example, cheatgrass may not be listed by a state as noxious, but it can greatly alter fire regimes in shrub steppe habitats resulting in large monotypic stands that displace native bunch grasses, forbs, and shrubs. Pest control would likely require a multi-year commitment from the Refuge staff. Essential to the long-term success of pest management would be pre- and post-treatment monitoring, assessment of the successes and failures of treatments, and development of new approaches when proposed methods do not achieve desired outcomes.

H.5 Best Management Practices

BMPs can minimize or eliminate possible effects associated with pesticide usage to non-target species and/or sensitive habitats as well as degradation of water quality from drift, surface runoff, or leaching. Based upon the Department of Interior Pesticide Use Policy (517 DM 1) and the Service Pest Management Policy and Responsibilities (30 AM 12), the use of applicable BMPs (where feasible) also would likely ensure that pesticide uses may not adversely affect federally listed species and/or their critical habitats through determinations made using the process described in 50 C.F.R. part 402.

The following are BMPs pertaining to mixing/handling and applying pesticides for all ground-based treatments of pesticides, which would be considered and utilized, where feasible, based upon target- and site-specific factors and time-specific environmental conditions. Although not listed below, the most important BMP to eliminate/reduce potential impacts to non-target resources would be an IPM approach to prevent, control, eradicate, and contain pests.

H.5.1 Pesticide Handling and Mixing

- As a precaution against spilling, spray tanks would not be left unattended during filling.
- All pesticide containers would be triple rinsed, and the rinsate would be used as water in the sprayer tank and applied to treatment areas.
- All pesticide spray equipment would be properly cleaned. Where possible, rinsate would be used as part of the make-up water in the sprayer tank and applied to treatment areas.
- The Refuge staff would empty and triple rinse all pesticide containers that can be recycled at local herbicide container collections.
- All unused pesticides would be properly discarded at a local “safe send” collection.

- Pesticides and pesticide containers would be lawfully stored, handled, and disposed of in accordance with the label and in a manner safeguarding human health, fish, and wildlife and prevent soil and water contaminant.
- The Refuge staff would consider the water quality parameters (e.g., pH, hardness) that are important to ensure greatest efficacy where specified on the pesticide label.
- All pesticide spills would be addressed immediately using procedures identified in the Refuge spill response plan.

H.5.2 Applying Pesticides

- Pesticide treatments would only be conducted by or under the supervision of Service personnel and non-Service applicators with the appropriate, state or BLM certification to safely and effectively conduct these activities on Refuge lands and waters.
- The Refuge staff would comply with all federal, state, and local pesticide use laws and regulations as well as Departmental, Service, and NWRS pesticide-related policies. For example, the Refuge staff would use application equipment and apply rates for the specific pest(s) identified on the pesticide label as required under FIFRA.
- Before each treatment season and prior to mixing or applying any product for the first time each season, all applicators would review the labels, material safety data sheets (MSDSs), and PUPs for each pesticide, determining the target pest, appropriate mix rate(s), personal protective equipment (PPE), and other requirements listed on the pesticide label.
- A 1-foot no-spray buffer from the water’s edge would be used, where applicable and where it does not detrimentally influence effective control of pest species.
- Use low-impact herbicide application techniques (e.g., spot treatment, cut stump, oil basal, Thinvert system applications) rather than broadcast foliar applications (e.g., boom sprayer, other larger tank wand applications), where practical.
- Use low-volume rather than high-volume foliar applications where low-impact methods above are not feasible or practical, to maximize herbicide effectiveness and ensure correct and uniform application rates.
- Applicators would use and adjust spray equipment to apply the coarsest droplet size spectrum with optimal coverage of the target species while reducing drift.
- Applicators would use the largest droplet size that results in uniform coverage.
- Applicators would use drift reduction technologies such as low-drift nozzles, where possible.
- Where possible, spraying would occur during low (average<7 mph and preferably 3 to 5 mph) and consistent direction wind conditions with moderate temperatures (typically <85^{o}F).
- Where possible, applicators would avoid spraying during inversion conditions (often associated with calm and very low wind conditions) that can cause large-scale herbicide drift to non-target areas.
- Equipment would be calibrated regularly to ensure that the proper rate of pesticide is applied to the target area or species.
- Spray applications would be made at the lowest height for uniform coverage of target pests to minimize/eliminate potential drift.
- If windy conditions frequently occur during afternoons, spraying (especially boom treatments) would typically be conducted during early morning hours.
- Spray applications would not be conducted on days with >30% forecast for rain within 6 hours, except for pesticides that are rapidly rain fast (e.g., glyphosate in 1 hour) to minimize/eliminate potential runoff.

- Where possible, applicators would use drift retardant adjuvants during spray applications, especially adjacent to sensitive areas.
- Where possible, applicators would use a nontoxic dye to aid in identifying target area treated as well as potential over spray or drift. A dye can also aid in detecting equipment leaks. If a leak is discovered, the application would be stopped until repairs can be made to the sprayer.
- For pesticide uses associated with cropland and facilities management, buffers, as appropriate, would be used to protect sensitive habitats, especially wetlands and other aquatic habitats.
- When drift cannot be sufficiently reduced through altering equipment set up and application techniques, buffer zones may be identified to protect sensitive areas downwind of applications. The refuge staff would only apply adjacent to sensitive areas when the wind is blowing the opposite direction.
- Applicators would utilize scouting for early detection of pests to eliminate unnecessary pesticide applications.
- The refuge staff would consider timing of application so native plants are protected (e.g., senescence) while effectively treating invasive plants.
- Rinsate from cleaning spray equipment after application would be recaptured and reused or applied to an appropriate pest plant infestation.
- Application equipment (e.g., sprayer, ATV, tractor) would be thoroughly cleaned and PPE would be removed/disposed of on-site by applicators after treatments to eliminate the potential spread of pests to uninfested areas.

H.6 Safety

H.6.1 Personal Protective Equipment

All applicators would wear the specific PPE identified on the pesticide label. The appropriate PPE will be worn at all times during handling, mixing, and applying. PPE can include the following: disposable (e.g., Tyvek) or laundered coveralls; gloves (latex, rubber, or nitrile); rubber boots; and/or an NIOSH-approved respirator. Because exposure to concentrated product is usually greatest during mixing, extra care should be taken while preparing pesticide solutions. Persons mixing these solutions can be best protected if they wear long gloves, an apron, footwear, and a face shield.

Coveralls and other protective clothing used during an application would be laundered separately from other laundry items. Transporting, storing, handling, mixing and disposing of pesticide containers will be consistent with label requirements, USEPA and Occupational Safety and Health Administration (OSHA) requirements, and Service policy.

If a respirator is necessary for a pesticide use, then the following requirements would be met in accordance with Service safety policy: a written respirator program, fit testing, physical examination (including pulmonary function and blood work for contaminants), and proper storage of the respirator.

H.6.2 Notification

The restricted entry interval is the time period required after the application at which point someone may safely enter a treated area without PPE. Refuge staff, authorized management agents of the Service, volunteers, and members of the public who could be in or near a pesticide treated area within the stated re-entry time period on the label would be notified about treatment areas. Posting would occur at any site where individuals might inadvertently become exposed to a pesticide during other activities on the Refuge. Where required by the label and/or state-specific regulations, sites would also be posted on its perimeter and at other likely locations of entry. The Refuge staff would also notify appropriate private property owners of an intended application, including any private individuals who have requested notification. Special efforts would be made to contact nearby individuals who are beekeepers or who have expressed chemical sensitivities.

H.6.3 Medical Surveillance

Medical surveillance may be required for Service personnel and approved volunteers who mix, apply, and/or monitor use of pesticides (see 242 FW 7 [Pesticide Users] and 242 FW 4 [Medical Surveillance]). In accordance with 242 FW 7.12A, Service personnel would be medically monitoring if one or more of the following criteria is met: exposed or may be exposed to concentrations at or above the published permissible exposure limits or threshold limit values (see 242 FW 4); use pesticides in a manner considered "frequent pesticide use"; or use pesticides in a manner that requires a respirator (see 242 FW 14 for respirator use requirements). In 242 FW 7.7A, "Frequent Pesticide Use means when a person applying pesticide handles, mixes, or applies pesticides, with a Health Hazard rating of 3 or higher, for 8 or more hours in any week or 16 or more hours in any 30-day period." Under some circumstances, individuals may be medically monitored who use pesticides infrequently (see Section H.7.7), experience an acute exposure (sudden, short term), or use pesticides with a health hazard ranking of 1 or 2. This decision would consider the individual's health and fitness level, the pesticide's specific health risks, and the potential risks from other pesticide-related activities. Refuge cooperators (e.g., cooperative farmers) and other authorized agents (e.g., state and county employees) would be responsible for their own medical monitoring needs and costs.

Standard examinations (at Refuge expense) of appropriate Refuge staff would be provided by the nearest certified occupational health and safety physician as determined by Federal Occupational Health.

H.6.4 Certification and Supervision of Pesticide Applicators

Appropriate Refuge staff or approved volunteers handling, mixing, and/or applying or directly supervising others engaged in pesticide use activities would be trained and state or federally (BLM) licensed to apply pesticides to Refuge lands or waters. In accordance with 242 FW 7.18A, certification is required to apply restricted use pesticides based upon USEPA regulations. For safety reasons, all individuals participating in pest management activities with general use pesticides also are encouraged to attend appropriate training or acquire pesticide applicator certification. The certification requirement would be for a commercial or private applicator depending upon the state. New staff unfamiliar with proper procedures for storing, mixing, handling, applying, and disposing of herbicides and containers would receive orientation and training before handling or using any products. Documentation of training would be kept in the files at the Refuge office.

H.6.5 Record Keeping

H.6.5.1 Labels and material safety data sheets

Pesticide labels and MSDSs would be maintained at the Refuge shop and laminated copies in the mixing area. These documents also would be carried by field applicators, where possible. A written reference (e.g., note pad, chalk board, dry erase board) for each tank to be mixed would be kept in the mixing area for quick reference while mixing is in progress. In addition, approved PUPs stored in the PUPS database typically contain website links (URLs) to pesticide labels and MSDSs.

H.6.5.2 Pesticide use proposals (PUPs)

A PUP would be prepared for each proposed pesticide use associated with annual pest management on Refuge lands and waters. A PUP would include specific information about the proposed pesticide use including the common and chemical names of the pesticide(s), target pest species, size and location of treatment site(s), application rate(s) and method(s), and federally listed species determinations, where applicable.

In accordance with 30 AM 12 and 7 RM 14, PUPs would be required for the following:

- Uses of pesticides on lands and facilities owned or managed by the Service, including properties managed by Service personnel as a result of the Food Security Act of 1985;
- Service projects by non-Service personnel on Service owned or controlled lands and facilities and other pest management activities that would be conducted by Service personnel; and
- Where the Service would be responsible or provides funds for pest management identified in protective covenants, easements, contracts, or agreements off Service lands.

In accordance with Service guidelines (Director's memo [December 12, 2007]), Refuge staff may receive up to five-year approvals for Washington Office and field reviewed proposed pesticide uses based upon meeting identified criteria including an approved IPM plan, where necessary (see http://www.fws.gov/contaminants/Issues/IPM.cfm). For a Refuge, an IPM plan (requirements described herein) can be completed independently or in association with a CCP or a habitat management plan if IPM strategies and potential environmental effects are adequately addressed within appropriate NEPA documentation.

PUPs would be created, approved or disapproved, and stored as records in the Pesticide Use Proposal System (PUPS), which is centralized database on the Service's intranet (https://systems.fws.gov/pups). Only Service employees can access PUP records in this database.

H.6.5.3 Pesticide usage

In accordance with 30 AM 12 and 7 RM 14, the Refuge Project Leader would be required to maintain records of all pesticides annually applied on lands or waters under Refuge jurisdiction. This would encompass pesticides applied by other federal agencies, state and county governments, nongovernment applicators including cooperators and their pest management service providers with Service permission. For clarification, pesticide means all insecticides, insect and plant growth regulators, desiccants, herbicides, fungicides, rodenticides, acaricides, nematicides, fumigants, avicides, and piscicides.

The following usage information can be reported for approved PUPs in the PUPS database:

- Pesticide trade name(s)
- Active ingredient(s)
- Total acres treated
- Total amount of pesticides used (lbs or gallons)

- Total amount of active ingredient(s) used (lbs)
- Target pest(s)
- Efficacy (% control)

To determine whether treatments are efficacious (eradicating, controlling, or containing the target pest) and achieving resource objectives, habitat and/or wildlife response would be monitored both pre- and post-treatment, where possible. Considering available annual funding and staffing, appropriate monitoring data regarding characteristics (attributes) of pest infestations (e.g., area, perimeter, degree of infestation-density, % cover, density) as well as habitat and/or wildlife response to treatments may be collected and stored in a relational database (e.g., Refuge Habitat Management Database), preferably a geo-referenced data management system (e.g., Refuge Lands GIS) to facilitate data analyses and subsequent reporting. In accordance with adaptive management, data analysis and interpretation would allow treatments to be modified or changed over time, as necessary, to achieve resource objectives considering site-specific conditions in conjunction with habitat and/or wildlife responses. Monitoring could also identify short- and long-term impacts to natural resources and environmental quality associated with IPM treatments in accordance with adaptive management principles identified in 43 C.F.R. 46.145.

H.7 Evaluating Pesticide Use Proposals

Pesticides would only be used on Refuge lands for habitat management as well as croplands/facilities maintenance after approval of a PUP. In general, proposed pesticide uses on Refuge lands would only be approved where there would likely be minor, temporary, or localized effects to fish and wildlife species as well as minimal potential to degrade environmental quality. Potential effects to listed and nonlisted species would be evaluated with quantitative ecological risk assessments and other screening measures. Potential effects to environmental quality would be based upon pesticide characteristics of environmental fate (water solubility, soil mobility, soil persistence, and volatilization) and other quantitative screening tools. Ecological risk assessments as well as characteristics of environmental fate and potential to degrade environmental quality for pesticides would be documented in Chemical Profiles (see Section H.7.5). These profiles would include threshold values for quantitative measures of ecological risk assessments and screening tools for environmental fate that represent minimal potential effects to species and environmental quality. In general, only pesticide uses with appropriate BMPs (see Section H.4) for habitat management and cropland/facilities maintenance on Refuge lands that would potentially have minor, temporary, or localized effects on Refuge biological and environmental quality (threshold values not exceeded) would be approved.

H.7.1 Overview of Ecological Risk Assessment

An ecological risk assessment process would be used to evaluate potential adverse effects to biological resources as a result of a pesticide(s) proposed for use on Refuge lands. It is an established quantitative and qualitative methodology for comparing and prioritizing risks of pesticides and conveying an estimate of the potential risk for an adverse effect. This quantitative methodology provides an efficient mechanism to integrate best available scientific information regarding hazard, patterns of use (exposure), and dose-response relationships in a manner that is useful for ecological risk decision-making. It would provide an effective way to evaluate potential effects where there is missing or unavailable scientific information (data gaps) to address reasonable, foreseeable adverse effects in the field as required under 40 C.F.R. Part 1502.22. Protocols for ecological risk assessment of pesticide uses on the Refuge were developed through research and established by the USEPA (2004). Assumptions for these risk assessments are presented in Section H.6.2.3.

The toxicological data used in ecological risk assessments are typically results of standardized laboratory studies provided by pesticide registrants to the USEPA to meet regulatory requirements under FIFRA. These studies assess the acute (lethality) and chronic (reproductive) effects associated with short- and long-term exposure to pesticides on representative species of birds, mammals, freshwater fish, aquatic invertebrates, and terrestrial and aquatic plants. Other effects data publicly available would also be utilized for risk assessment protocols described herein. Toxicity endpoint and environmental fate data are available from a variety of resources. Some of the more useful resources can be found in Section H.7.5.

Table H-1. Ecotoxicity Tests Used to Evaluate Potential Effects to Birds, Fish, and Mammals to Establish Toxicity Endpoints for Risk Quotient Calculations.

Species Group	Exposure	Measurement endpoint
Bird	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[1]
Fish	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[2]
Mammal	Acute	Oral Lethal Dose (LD_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[3]

[1] Measurement endpoints typically include a variety of reproductive parameters (e.g., number of eggs, number of offspring, eggshell thickness, and number of cracked eggs).
[2] Measurement endpoints for early life stage/life cycle typically include embryo hatch rates, time to hatch, growth, and time to swim-up.
[3] Measurement endpoints include maternal toxicity, teratogenic effects, or developmental anomalies, evidence of mutagenicity or genotoxicity, and interference with cellular mechanisms such as DNA synthesis and DNA repair.

H.7.2 Determining Ecological Risk to Fish and Wildlife

The potential for pesticides used on the Refuge to cause direct adverse effects to fish and wildlife would be evaluated using USEPA's Ecological Risk Assessment Process (USEPA 2004). This deterministic approach, which is based upon a two-phase process involving estimation of environmental concentrations and then characterization of risk, would be used for ecological risk assessments. This method integrates exposure estimates (estimated environmental concentration [EEC] and toxicological endpoints [e.g., LC_{50} and oral LD_{50}]) to evaluate the potential for adverse effects to species groups (birds, mammals, and fish) representative of legal mandates for managing units of the NWRS. This integration is achieved through risk quotients (RQs) calculated by dividing the EEC by acute and chronic toxicity values selected from standardized toxicological endpoints or published effect (Table H-1).

RQ = EEC/Toxicological Endpoint

The level of risk associated with direct effects of pesticide use would be characterized by comparing calculated RQs to the appropriate Level of Concern (LOC) established by the USEPA (1998 [Table 2]). The LOC represents a quantitative threshold value for screening potential adverse effects to fish and wildlife resources associated with pesticide use. The following are four exposure-species group scenarios that would be used to characterize ecological risk to fish and wildlife on the Refuge: acute-listed species, acute-nonlisted species, chronic-listed species, and chronic-nonlisted species.

Acute risk would indicate the potential for mortality associated with short-term dietary exposure to pesticides immediately after an application. For characterization of acute risks, median values from LC_{50} and LD_{50} tests would be used as toxicological endpoints for RQ calculations. In contrast, chronic risks would indicate the potential for adverse effects associated with long-term dietary exposure to pesticides from a single application or multiple applications over time (within a season and over years). For characterization of chronic risks, the no observed concentration (NOAEC) or no observed effect concentration (NOEC) for reproduction would be used as toxicological endpoints for RQ calculations. Where available, the NOAEC would be preferred over a NOEC value.

Listed species are those federally designated as threatened, endangered, or proposed in accordance with the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884, as amended-Public Law 93-205). For listed species, potential adverse effects would be assessed at the individual level because loss of individuals from a population could detrimentally impact a species. In contrast, risks to nonlisted species would consider effects at the population level. An RQ<LOC would indicate the proposed pesticide use "may affect, not likely to adversely affect" individuals (listed species) and it would not pose an unacceptable risk for adverse effects to populations (nonlisted species) for each taxonomic group (Table H-2). In contrast, an RQ>LOC would indicate a "may affect, likely to adversely affect" for listed species and it would also pose unacceptable ecological risk for adverse effects to nonlisted species.

Table H-2. Presumption of Unacceptable Risk for Birds, Fish, and Mammals (USEPA 1998).

Risk Presumption		Level of Concern	
		Listed Species	Nonlisted Species
Acute	Birds	0.1	0.5
	Fish	0.05	0.5
	Mammals	0.1	0.5
Chronic	Birds	1.0	1.0
	Fish	1.0	1.0
	Mammals	1.0	1.0

H.7.2.1 Environmental exposure

Following release into the environment through application, pesticides would experience several different routes of environmental fate. Pesticides which would be sprayed can move through the air (e.g., particle or vapor drift) and may eventually end up in other parts of the environment such as non-target vegetation, soil, or water. Pesticides applied directly to the soil may be washed off the soil into nearby bodies of surface water (e.g., surface runoff) or may percolate through the soil to lower soil layers and groundwater (e.g., leaching) (Baker and Miller 1999; Butler et al. 1998; EXTOXNET 1993; Pope et al. 1999; Ramsay et al. 1995). Pesticides which would be injected into the soil may also be subject to the latter two fates.

The aforementioned possibilities are by no means complete, but it does indicate movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together, but it also may involve transportation of pesticides over long distances (Barry 2004; Woods 2004).

H.7.2.1.1 Terrestrial exposure

The EEC for exposure to terrestrial wildlife would be quantified using an USEPA screening-level approach (USEPA 2004). This screening-level approach is not affected by product formulation because it evaluates pesticide active ingredient(s). This approach would vary depending upon the proposed pesticide application method: spray or granular.

H.7.2.1.1.1 Terrestrial-spray application

For spray applications, exposure would be determined using the Kanaga nomogram method (Pfleeger et al. 1996; USEPA 2004, 2005a) through the USEPA's Terrestrial Residue Exposure model (T-REX) version 1.2.3 (USEPA 2005b). To estimate the maximum (initial) pesticide residue on short grass (<20 cm tall) as a general food item category for terrestrial vertebrate species, T-REX input variables would include the following from the pesticide label: maximum pesticide application rate (pounds active ingredient [acid equivalent]/acre) and pesticide half-life (days) in soil. Although there are other food item categories (tall grasses; broadleaf plants and small insects; and fruits, pods, seeds and large insects), short grass was selected because it would yield maximum EECs (240 ppm per lb. ai/acre) for worst-case risk assessments. Short grass is not representative of forage for carnivorous species (e.g., raptors), but it would characterize the maximum potential exposure through the diet of avian and mammalian prey items. Consequently, this approach would provide a conservative screening tool for pesticides that do not biomagnify.

For RQ calculations in T-REX, the model would require the weight of surrogate species and Mineau scaling factors (Mineau et al. 1996). Body weights of bobwhite quail and mallard are included in T-REX by default, but body weights of other organisms (Table H-3) would be entered manually. The Mineau scaling factor accounts for small-bodied bird species that may be more sensitive to pesticide exposure than would be predicted only by body weight. Mineau scaling factors would be entered manually with values ranging from 1 to 1.55 that are unique to a particular pesticide or group of pesticides. If specific information to select a scaling factor is not available, then a value of 1.15 would be used as a default. Alternatively, zero would be entered if it is known that body weight does not influence toxicity of pesticide(s) being assessed. The upper bound estimate output from the T-REX Kanaga nomogram would be used as an EEC for calculation of RQs. This approach would yield a conservative estimate of ecological risk.

Table H-3. Average Body Weight of Selected Terrestrial Wildlife Species Frequently Used in Research to Establish Toxicological Endpoints (Dunning 1984).

Species	Body Weight (kg)
Mammal (15 g)	0.015
House sparrow	0.0277
Mammal (35 g)	0.035
Starling	0.0823
Red-winged blackbird	0.0526
Common grackle	0.114
Japanese quail	0.178
Bobwhite quail	0.178
Rat	0.200
Rock dove (aka pigeon)	0.542
Mammal (1,000 g)	1.000
Mallard	1.082
Ring-necked pheasant	1.135

H.7.2.1.1.2 Terrestrial—granular application

Granular pesticide formulations and pesticide-treated seed would pose a unique route of exposure for avian and mammalian species. The pesticide is applied in discrete units which birds or mammals might ingest accidentally with food items or intentionally as in the case of some bird species actively seeking and picking up gravel or grit to aid digestion or seed as a food source. Granules may also be consumed by wildlife foraging on earthworms, slugs or other soft-bodied soil organisms to which the granules may adhere.

Terrestrial wildlife RQs for granular formulations or seed treatments would be calculated by dividing the maximum milligrams of active ingredient (a.i.) exposed (e.g., EEC) on the surface of an area equal to 1 square foot by the appropriate LD_{50} value multiplied by the surrogate's body weight (Table H-3). An adjustment to surface area calculations would be made for broadcast, banded, and in-furrow applications. An adjustment also would be made for applications with and without incorporation of the granules. Without incorporation, it would be assumed that 100% of the granules remain on the soil surface available to foraging birds and mammals. Press wheels push granules flat with the soil surface, but they are not incorporated into the soil. If granules are incorporated in the soil during band or T-band applications or after broadcast applications, it would be assumed only 15% of the applied granules remain available to wildlife. It would be assumed that only 1% of the granules are available on the soil surface following in-furrow applications.

EECs for pesticides applied in granular form and as seed treatments would be determined considering potential ingestion rates of avian or mammalian species (e.g., 10%-30% body weight/day). This would provide an estimate of maximum exposure that may occur as a result of granule or seed treatment spills such as those that commonly occur at end rows during application and planting. The availability of granules and seed treatments to terrestrial vertebrates would also be considered by calculating the loading per unit area (LD_{50}/ft^2) for comparison to USEPA Level of Concerns (USEPA 1998). The T-REX version 1.2.3 (USEPA 2005b) contains a submodel which automates Kanaga exposure calculations for granular pesticides and treated seed.

The following formulas will be used to calculate EECs depending upon the type of granular pesticide application:

- In-furrow applications assume a typical value of 1% granules, bait, or seed remain unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}580\ mg/lb.)(1\%\ exposed))] / \{[(43{,}560\ ft.^2/acre)/(row\ spacing\ (ft.))] / (row\ spacing\ (ft.)\}$$

or

$$mg\ a.i./ft^2 = [(lbs\ product/1{,}000\ ft.\ row)(\%\ a.i.)(1{,}000\ ft.\ row)(453{,}580\ mg/lb.)(1\%\ exposed)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Incorporated banded treatments assume that 15% of granules, bait, and seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/1{,}000\ row\ ft.)(\%\ a.i.)(453{,}580\ mg/lb.)(1\text{-}\%\ incorporated)] / (1{,}000\ ft.)(band\ width\ (ft.))$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Broadcast treatment without incorporation assumes 100% of granules, bait, seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}590\ mg/lb.)] / (43{,}560\ ft.^2/acre)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

Where:

- % of pesticide biologically available = 100% without species specific ingestion rates
- Conversion for calculating mg a.i./ft.^{2} using ounces: 453,580 mg/lb. /16 = 28,349 mg/oz.

The following equation would be used to calculate an RQ based on the EEC calculated by one of the above equations. The EEC would divided by the surrogate LD_{50} toxicological endpoint multiplied by the body weight (Table H-3) of the surrogate.

$$RQ = EEC / [LD_{50}\ (mg/kg) * body\ weight\ (kg)]$$

As with other risk assessments, an RQ>LOC would be a presumption of unacceptable ecological risk. An RQ<LOC would be a presumption of acceptable risk with only minor, temporary, or localized effects to species.

H.7.2.1.2 Aquatic exposure

Exposures to aquatic habitats (e.g., wetlands, meadows, ephemeral pools, water delivery ditches) would be evaluated separately for ground-based pesticide treatments of habitats managed for fish and wildlife compared with cropland/facilities maintenance. The primary exposure pathway for aquatic organisms from any ground-based treatments likely would be particle drift during the pesticide application. However, different exposure scenarios would be necessary as a result of contrasting application equipment and techniques as well as pesticides used to control pests on agricultural lands (especially those cultivated by cooperative farmers for economic return from crop yields) and facilities maintenance (e.g., roadsides, parking lots, trails) compared with other managed habitats on the Refuge. In addition, pesticide applications may be done <25 feet of the high water mark of aquatic habitats for habitat management treatments, whereas no-spray buffers (≥25 feet) would be used for croplands/facilities maintenance treatments.

H.7.2.1.2.1 Habitat treatments

For the worst-case exposure scenario to non-target aquatic habitats, EECs (Table H-4) would be would be derived from Urban and Cook (1986) that assumes an intentional overspray to an entire, non-target water body (1-foot depth) from a treatment <25 feet from the high water mark using the max application rate (acid basis [see above]). However, use of BMPs for applying pesticides (see Section H.4.2) would likely minimize/eliminate potential drift to non-target aquatic habitats during actual treatments. If there would be unacceptable (acute or chronic) risk to fish and wildlife with the simulated 100% overspray (RQ>LOC), then the proposed pesticide use may be disapproved or the

PUP would be approved at a lower application rate to minimize/eliminate unacceptable risk to aquatic organisms (RQ=LOC).

Table H-4. Estimated Environmental Concentrations (ppb) of Pesticides in Aquatic Habitats (1-foot depth) Immediately after Direct Application (Urban and Cook 1986).

Lbs/acre	EEC (ppb)
0.10	36.7
0.20	73.5
0.25	91.9
0.30	110.2
0.40	147.0
0.50	183.7
0.75	275.6
1.00	367.5
1.25	459.7
1.50	551.6
1.75	643.5
2.00	735.7
2.25	827.6
2.50	919.4
3.00	1,103.5
4.00	1,471.4
5.00	1,839
6.00	2,207
7.00	2,575
8.00	2,943
9.00	3,311
10.00	3,678

H.7.2.1.2.2 Cropland/facilities maintenance treatments

Field drift studies conducted by the Spray Drift Task Force, which is a joint project of several agricultural chemical businesses, were used to develop a generic spray drift database. From this database, the AgDRIFT computer model was created to satisfy USEPA pesticide registration spray drift data requirements and as a scientific basis to evaluate off-target movement of pesticides from particle drift and assess potential effects of exposure to wildlife. Several versions of the computer model have been developed (i.e., v2.01 through v2.10). The Spray Drift Task Force AgDRIFT® model version 2.01 (AgDRIFT 2001; SDTF 2003) would be used to derive EECs resulting from drift of pesticides to Refuge aquatic resources from ground-based pesticide applications >25 feet from the high water mark. The Spray Drift Task Force AgDRIFT model is publicly available at http://www.agdrift.com. At this website, click “AgDRIFT 2.0” and then click “Download Now” and follow the instructions to obtain the computer model.

The AgDRIFT model is composed of submodels called tiers. Tier I Ground submodel would be used to assess ground-based applications of pesticides. Tier outputs (EECs) would be calculated with AgDRIFT using the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium droplet size, EPA-defined wetland, and a ≥25-foot distance (buffer) from treated area to water.

H.7.2.2 Use of information on effects of biological control agents, pesticides, degradates, and adjuvants

NEPA documents regarding biological and other environmental effects of biological control agents, pesticides, degradates, and adjuvants prepared by another federal agency, where the scope would be relevant to evaluation of effects from pesticide uses on Refuge lands, would be reviewed. Possible source agencies for such NEPA documents would include the Bureau of Land Management, U.S. Forest Service, National Park Service, U.S. Department of Agriculture-Animal and Plant Health Inspection Service, and the military services. It might be appropriate to incorporate by reference parts or all of existing document(s). Incorporating by reference (40 C.F.R. 1502.21) is a technique used to avoid redundancies in analysis. It also would reduce the bulk of a Service NEPA document, which only would identify the documents that are incorporated by reference. In addition, relevant portions would be summarized in the Service NEPA document to the extent necessary to provide the decision maker and public with an understanding of relevance of the referenced material to the current analysis.

In accordance with the requirements set forth in 43 C.F.R. 46.135, the Service would specifically incorporate through reference ecological risk assessments prepared by the U.S. Forest Service (http://www.fs.fed.us/r6/invasiveplant-eis/Risk-Assessments/Herbicides-Analyzed-InvPlant-EIS.htm) and Bureau of Land Management (http://www.blm.gov/wo/st/en/prog/more/veg_eis.html). These risk assessments and associated documentation also are available in total with the administrative record for the Final Environmental Impact Statement entitled *Pacific Northwest Region Invasive Plant Program – Preventing and Managing Invasive Plants* (U.S. Forest Service 2005) and *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS (PEIS)* (Bureau of Land Management 2007). In accordance with 43 C.F.R. 46.120(d), use of existing NEPA documents by supplementing, tiering to, incorporating by reference, or adopting previous NEPA environmental analyses would avoid redundancy and unnecessary paperwork.

As a basis for completing "Chemical Profiles" for approving or disapproving Refuge PUPs, ecological risk assessments for the following herbicide and adjuvant uses prepared by the U.S. Forest Service would be incorporated by reference:

- 2,4-D
- Chlorosulfuron
- Clopyralid
- Dicamba
- Glyphosate
- Imazapic
- Imazapyr
- Metsulfuron methyl
- Picloram
- Sethoxydim
- Sulfometuron methyl
- Triclopyr
- Nonylphenol polyethylate (NPE) based surfactants

As a basis for completing "Chemical Profiles" for approving or disapproving Refuge PUPs, ecological risk assessments for the following herbicide uses as well as evaluation of risks associated with pesticide degradates and adjuvants prepared by the Bureau of Land Management would be incorporated by reference:

- Bromacil
- Chlorsulfuron
- Diflufenzopyr
- Diquat
- Diuron
- Fluridone
- Imazapic
- Overdrive (diflufenzopyr and dicamba)
- Sulfometuron methyl
- Tebuthiuron
- Pesticide degradates and adjuvants (Appendix D – Evaluation of risks from degradates, polyoxyethylene-amine (POEA) and R-11, and endocrine disrupting chemicals)

H.7.2.3 Assumptions for ecological risk assessments

There are a number of assumptions involved with the ecological risk assessment process for terrestrial and aquatic organisms associated with utilization of the USEPA's (2004) process. These assumptions may be risk neutral or may lead to an over- or under-estimation of risk from pesticide exposure depending upon site-specific conditions. The following describes these assumptions, their application to the conditions typically encountered, and whether or not they may lead to recommendations that are risk neutral, underestimate, or overestimate ecological risk from potential pesticide exposure.

- Indirect effects would not be evaluated by ecological risk assessments. These effects include the mechanisms of indirect exposure to pesticides: consuming prey items (fish, birds, or small mammals), reductions in the availability of prey items, and disturbance associated with pesticide application activities.
- Exposure to a pesticide product can be assessed based upon the active ingredient. However, exposure to a chemical mixture (pesticide formulation) may result in effects that are similar or substantially different compared to only the active ingredient. Non-target organisms may be exposed directly to the pesticide formulation or only various constituents of the formulation as they dissipate and partition in the environment. If toxicological information for both the active ingredient and formulated product are available, then data representing the greatest potential toxicity would be selected for use in the risk assessment process (USEPA 2004). As a result, this conservative approach may lead to an overestimation of risk characterization from pesticide exposure.
- Because toxicity tests with listed or candidate species or closely related species are not available, data for surrogate species would be most often used for risk assessments. Specifically, bobwhite quail and mallard duck are the most frequently used surrogates for evaluating potential toxicity to federally listed avian species. Bluegill sunfish, rainbow trout, and fathead minnow are the most common surrogates for evaluating toxicity for freshwater fishes. However, sheep's head minnow can be an appropriate surrogate marine species for

coastal environments. Rats and mice are the most common surrogates for evaluating toxicity for mammals. Interspecies sensitivity is a major source of uncertainty in pesticide assessments. As a result of this uncertainty, data is selected for the most sensitive species tested within a taxonomic group (birds, fish, and mammals) given the quality of the data is acceptable. If additional toxicity data for more species of organisms in a particular group are available, the selected data will not be limited to the species previously listed as common surrogates.

- The Kanaga nomogram outputs maximum EEC values that may be used to calculate an average daily concentration over a specified interval of time, which is referred to as a time-weighted-average (TWA). The maximum EEC would be selected as the exposure input for both acute and chronic risk assessments in the screening-level evaluations. The initial or maximum EEC derived from the Kanaga nomogram represents the maximum expected instantaneous or acute exposure to a pesticide. Acute toxicity endpoints are determined using a single exposure to a known pesticide concentration typically for 48 to 96 hours. This value is assumed to represent ecological risk from acute exposure to a pesticide. On the other hand, chronic risk to pesticide exposure is a function of pesticide concentration and duration of exposure to the pesticide. An organism's response to chronic pesticide exposure may result from either the concentration of the pesticide, length of exposure, or some combination of both factors. Standardized tests for chronic toxicity typically involve exposing an organism to several different pesticide concentrations for a specified length of time (days, weeks, months, years or generations). For example, avian reproduction tests include a 10-week exposure phase. Because a single length of time is used in the test, time response data is usually not available for inclusion into risk assessments. Without time response data it is difficult to determine the concentration which elicited a toxicological response.
- Using maximum EECs for chronic risk estimates may result in an overestimate of risk, particularly for compounds that dissipate rapidly. Conversely, using TWAs for chronic risk estimates may underestimate risk if it is the concentration rather than the duration of exposure that is primarily responsible for the observed adverse effect. The maximum EEC would be used for chronic risk assessments although it may result in an overestimate of risk. TWAs may be used for chronic risk assessments, but they will be applied judiciously considering the potential for an underestimate or overestimate of risk. For example, the number of days exposure exceeds a Level of Concern may influence the suitability of a pesticide use. The greater the number of days the EEC exceeds the Level of Concern translates into greater the ecological risk. This is a qualitative assessment and is subject to reviewer's expertise in ecological risk assessment and tolerance for risk.
- The length of time used to calculate the TWA can have a substantial effect on the exposure estimates and there is no standard method for determining the appropriate duration for this estimate. The T-REX model assumes a 21-week exposure period, which is equivalent to avian reproductive studies designed to establish a steady-state concentration for bioaccumulative compounds. However, this does not necessarily define the true exposure duration needed to elicit a toxicological response. Pesticides, which do not bioaccumulate, may achieve a steady-state concentration earlier than 21 weeks. The duration of time for calculating TWAs will require justification and it will not exceed the duration of exposure in the chronic toxicity test (approximately 70 days for the standard avian reproduction study). An alternative to using the duration of the chronic toxicity study is to base the TWA on the application interval. In this case, increasing the application interval would suppress both the estimated peak pesticide concentration and the TWA. Another alternative to using TWAs would be to consider the number of days that a chemical is predicted to exceed the LOC.

- Pesticide dissipation is assumed to be first-order in the absence of data suggesting alternative dissipation patterns such as bi-phasic. Field dissipation data would generally be the most pertinent for assessing exposure in terrestrial species that forage on vegetation. However, these data are often not available and it can be misleading particularly if the compound is prone to "wash-off." Soil half-life is the most common degradation data available. Dissipation or degradation data that would reflect the environmental conditions typical of Refuge lands would be utilized, if available.
- For species found in the water column, it would be assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column.
- Actual habitat requirements of any particular terrestrial species are not considered, and it is assumed that species exclusively and permanently occupy the treated area, or adjacent areas receiving pesticide at rates commensurate with the treatment rate. This assumption would produce a maximum estimate of exposure for risk characterization. This assumption would likely lead to an overestimation of exposure for species that do not permanently and exclusively occupy the treated area (USEPA 2004).
- Exposure through incidental ingestion of pesticide contaminated soil is not considered in the USEPA risk assessment protocols. Research suggests <15% of the diet can consist of incidentally ingested soil depending upon species and feeding strategy (Beyer et al. 1994). An assessment of pesticide concentrations in soil compared to food item categories in the Kanaga nomogram indicates incidental soil ingestion will not likely increase dietary exposure to pesticides. Inclusion of soil in the diet would effectively reduce the overall dietary concentration compared to the present assumption that the entire diet consists a contaminated food source (Fletcher et al. 1994). An exception to this may be soil-applied pesticides in which exposure from incidental ingestion of soil may increase. Potential for pesticide exposure under this assumption may be underestimated for soil-applied pesticides and overestimated for foliar-applied pesticides. The concentration of a pesticide in soil would likely be less than predicted on food items.
- Exposure through inhalation of pesticides is not considered in the USEPA risk assessment protocols. Such exposure may occur through three potential sources: spray material in droplet form at time of application, vapor phase with the pesticide volatilizing from treated surfaces, and airborne particulates (soil, vegetative matter, and pesticide dusts). The USEPA (1990) reported exposure from inhaling spray droplets at the time of application is not an appreciable route of exposure for birds. According to research on mallards and bobwhite quail, respirable particle size (particles reaching the lung) in birds is limited to maximum diameter of 2 to 5 microns. The spray droplet spectra covering the majority of pesticide application scenarios indicate that less than 1% of the applied material is within the respirable particle size. This route of exposure is further limited because the permissible spray drop size distribution for ground pesticide applications is restricted to ASAE medium or coarser drop size distribution.
- Inhalation of a pesticide in the vapor phase may be another source of exposure for some pesticides under certain conditions. This mechanism of exposure to pesticides occurs post application, and it would pertain to those pesticides with a high vapor pressure. The USEPA is currently evaluating protocols for modeling inhalation exposure from pesticides including near-field and near-ground air concentrations based upon equilibrium and kinetics-based models. Risk characterization for exposure with this mechanism is unavailable.

- The effect from exposure to dusts contaminated with the pesticide cannot be assessed generically as partitioning issues related to application site soils and chemical properties of the applied pesticides render the exposure potential from this route highly situation specific.
- Dermal exposure may occur through three potential sources: direct application of spray to terrestrial wildlife in the treated area or within the drift footprint, incidental contact with contaminated vegetation, or contact with contaminated water or soil. Interception of spray and incidental contact with treated substrates may pose risk to avian wildlife (Driver et al. 1991). However, available research related to wildlife dermal contact with pesticides is extremely limited, except dermal toxicity values are common for some mammals used as human surrogates (rats and mice). The USEPA is currently evaluating protocols for modeling dermal exposure. Risk characterization may be underestimated for this route of exposure, particularly with high risk pesticides such as some organophosphates or carbamate insecticides. If protocols are established by the USEPA for assessing dermal exposure to pesticides, they will be considered for incorporation into pesticide assessment protocols.
- Exposure to a pesticide may occur from consuming surface water, dew, or other water on treated surfaces. Water soluble pesticides have the potential to dissolve in surface runoff and puddles in a treated area may contain pesticide residues. Similarly, pesticides with lower organic carbon partitioning characteristics and higher solubility in water have a greater potential to dissolve in dew and other water associated with plant surfaces. Estimating the extent to which such pesticide loadings to drinking water occurs is complex and would depend upon the partitioning characteristics of the active ingredient, soils types in the treatment area, and the meteorology of the treatment area. In addition, the use of various water sources by wildlife is highly species-specific. Currently, risk characterization for this exposure mechanism is not available. The USEPA is actively developing protocols to quantify drinking water exposures from puddles and dew. If and when protocols are formally established by the USEPA for assessing exposure to pesticides through drinking water, these protocols will be incorporated into pesticide risk assessment protocols.
- Risk assessments are based upon the assumption that the entire treatment area would be subject to pesticide application at the rates specified on the label. In most cases, there is potential for uneven application of pesticides through such plausible incidents such as changes in calibration of application equipment, spillage, and localized releases at specific areas in or near the treated field that are associated with mixing and handling and application equipment as well as applicator skill. Inappropriate use of pesticides and the occurrence of spills represent a potential underestimate of risk. It is likely not an important factor for risk characterization. All pesticide applicators are required to be certified by the state in which they apply pesticides. Certification training includes the safe storage, transport, handling, and mixing of pesticides; equipment calibration; and proper application with annual continuing education.
- The USEPA relies on Fletcher et al. (1994) for setting the assumed pesticide residues in wildlife dietary items. The USEPA (2004) "believes that these residue assumptions reflect a realistic upper-bound residue estimate, although the degree to which this assumption reflects a specific percentile estimate is difficult to quantify." Fletcher et al.'s (1994) research suggests that the pesticide active ingredient residue assumptions used by the USEPA represent a 95th percentile estimate. However, research conducted by Pfleeger et al. (1996) indicates USEPA residue assumptions for short grass was not exceeded. Baehr and Habig (2000) compared USEPA residue assumptions with distributions of measured pesticide residues for the USEPA's UTAB database. Overall residue selection level will tend to overestimate risk characterization. This is particularly evident when wildlife individuals are

likely to have selected a variety of food items acquired from multiple locations. Some food items may be contaminated with pesticide residues whereas others are not contaminated. However, it is important to recognize differences in species feeding behavior. Some species may consume whole aboveground plant material, but others will preferentially select different plant structures. Also, species may preferentially select a food item although multiple food items may be present. Without species specific knowledge regarding foraging behavior characterizing ecological risk other than in general terms is not possible.

- Acute and chronic risk assessments rely on comparisons of wildlife dietary residues with LC_{50} or NOEC values expressed as concentrations of pesticides in laboratory feed. These comparisons assume that ingestion of food items in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh-weight wildlife food intake estimates, it does not allow for gross energy and assimilative efficiency differences between wildlife food items and laboratory feed. Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods are not accounting for a potentially important aspect of food requirements.
- There are several other assumptions that can affect non-target species not considered in the risk assessment process. These include possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic and biotic factors) and behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are usually characterized in the published literature in only a general manner limiting their value in the risk assessment process.
- It is assumed that aquatic species exclusively and permanently occupy the water body being assessed. Actual habitat requirements of aquatic species are not considered. With the possible exception of scenarios where pesticides are directly applied to water, it is assumed that no habitat use considerations specific for any species would place the organisms in closer proximity to pesticide use sites. This assumption produces a maximum estimate of exposure or risk characterization. It would likely be realistic for many aquatic species that may be found in aquatic habitats within or in close proximity to treated terrestrial habitats. However, the spatial distribution of wildlife is usually not random because wildlife distributions are often related to habitat requirements of species. Clumped distributions of wildlife may result in an under- or over-estimation of risk depending upon where the initial pesticide concentration occurs relative to the species or species habitat.
- For species found in the water column, it would be assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column. Additional chemical exposure from materials associated with suspended solids or food items is not considered because partitioning onto sediments likely is minimal. Adsorption and bioconcentration occurs at lower levels for many newer pesticides compared with older more persistent bioaccumulative compounds. Pesticides with RQs close to the listed species level of concern, the potential for additional exposure from these routes may be a limitation of risk assessments, where potential pesticide exposure or risk may be underestimated.
- Mass transport losses of pesticide from a water body (except for losses by volatilization, degradation, and sediment partitioning) would not be considered for ecological risk assessment. The water body would be assumed to capture all pesticide active ingredients

entering as runoff, drift, and adsorbed to eroded soil particles. It would also be assumed that pesticide active ingredient is not lost from the water body by overtopping or flow-through, nor is concentration reduced by dilution. In total, these assumptions would lead to a near maximum possible water-borne concentration. However, this assumption would not account for the potential to concentrate pesticide through the evaporative loss. This limitation may have the greatest impact on water bodies with high surface-to-volume ratios such as ephemeral wetlands, where evaporative losses are accentuated and applied pesticides have low rates of degradation and volatilization.

- For acute risk assessments, there would be no averaging time for exposure. An instantaneous peak concentration would be assumed, where instantaneous exposure is sufficient in duration to elicit acute effects comparable to those observed over more protracted exposure periods (typically 48 to 96 hours) tested in the laboratory. In the absence of data regarding time-to-toxic event, analyses, and latent responses to instantaneous exposure, risk would likely be overestimated.
- For chronic exposure risk assessments, the averaging times considered for exposure are commensurate with the duration of invertebrate life-cycle or fish-early life stage tests (e.g., 21-28 days and 56-60 days, respectively). Response profiles (time to effect and latency of effect) to pesticides likely vary widely with mode of action and species and should be evaluated on a case-by-case basis as available data allow. Nevertheless, because the USEPA relies on chronic exposure toxicity endpoints based on a finding of no observed effect, the potential for any latent toxicity effects or averaging time assumptions to alter the results of an acceptable chronic risk assessment prediction is limited. The extent to which duration of exposure from water-borne concentrations overestimate or underestimate actual exposure depends on several factors. These include the following: localized meteorological conditions, runoff characteristics of the watershed (e.g., soils, topography), the hydrological characteristics of receiving waters, environmental fate of the pesticide active ingredient, and the method of pesticide application. It should also be understood that chronic effects studies are performed using a method that holds water concentration in a steady state. This method is not likely to reflect conditions associated with pesticide runoff. Pesticide concentrations in the field increase and decrease in surface water on a cycle influenced by rainfall, pesticide use patterns, and degradation rates. As a result of the dependency of this assumption on several undefined variables, risk associated with chronic exposure may in some situations underestimate risk and overestimate risk in others.
- There are several other factors that can affect non-target species not considered in the risk assessment process. These would include the following: possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic [not pesticides] and biotic factors), and sublethal effects such as behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are not routinely assessed by regulatory agencies. Therefore, information on the factors is not extensive limiting their value for the risk assessment process. As this type of information becomes available, it would be included, either quantitatively or qualitatively, in this risk assessment process.
- USEPA is required by the Food Quality Protection Act to assess the cumulative risks of pesticides that share common mechanisms of toxicity, or act the same within an organism. Currently, USEPA has identified four groups of pesticides that have a common mechanism of toxicity requiring cumulative risk assessments. These four groups are: the organophosphate

insecticides, N-methyl carbamate insecticides, triazine herbicides, and chloroacetanilide herbicides.

H.7.3 Pesticide Mixtures and Degradates

Pesticide products are usually a formulation of several components generally categorized as active ingredients and inert or other ingredients. The term active ingredient is defined by the FIFRA as preventing, destroying, repelling, or mitigating the effects of a pest, or it is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. In accordance with FIFRA, the active ingredient(s) must be identified by name(s) on the pesticide label along with its relative composition expressed in percentage(s) by weight. In contrast, inert ingredient(s) are not intended to affect a target pest. Their role in the pesticide formulation is to act as a solvent (keep the active ingredient is a liquid phase), an emulsifying or suspending agent (keep the active ingredient from separating out of solution), or a carrier (such as clay in which the active ingredient is impregnated on the clay particle in dry formulations). For example, if isopropyl alcohol would be used as a solvent in a pesticide formulation, then it would be considered an inert ingredient. FIFRA only requires that inert ingredients identified as hazardous and associated percent composition, and the total percentage of all inert ingredients must be declared on a product label. Inert ingredients that are not classified as hazardous are not required to be identified.

The USEPA (September 1997) issued Pesticide Regulation Notice 97-6, which encouraged manufacturers, formulators, producers, and registrants of pesticide products to voluntarily substitute the term “other ingredients” for “inert ingredients” in the ingredient statement. This change recognized that all components in a pesticide formulation potentially could elicit or contribute to an adverse effect on non-target organisms and, therefore, are not necessarily inert. Whether referred to as “inerts” or “other ingredients,” these constituents within a pesticide product have the potential to affect species or environmental quality. The USEPA categorizes regulated inert ingredients into the following four lists (http://www.epa.gov/opprd001/inerts/index.html):

- List 1—Inert Ingredients of Toxicological Concern
- List 2—Potentially Toxic Inert Ingredients
- List 3—Inerts of Unknown Toxicity
- List 4—Inerts of Minimal Toxicity

Several of the List 4 compounds are naturally occurring earthen materials (e.g., clay materials, simple salts) that would not elicit toxicological response at applied concentrations. However, some of the inerts (particularly the List 3 compounds and unlisted compounds) may have moderate to high potential toxicity to aquatic species based on MSDSs or published data.

Comprehensively assessing potential effects to non-target fish, wildlife, plants, and/or their habitats from pesticide use is a complex task. It would be preferable to assess the cumulative effects from exposure to the active ingredient, its degradates, and inert ingredients as well as other active ingredients in the spray mixture. However, it would only be feasible to conduct deterministic risk assessments for each component in the spray mixture singly. Limited scientific information is available regarding ecological effects (additive or synergistic) from chemical mixtures that typically rely upon broadly encompassing assumptions. For example, the U.S. Forest Service (2005) found that mixtures of pesticides used in land (forest) management likely would not cause additive or synergistic effects to non-target species based upon a review of scientific literature regarding toxicological effects and interactions of agricultural chemicals (ATSDR 2004). Moreover, information on inert ingredients, adjuvants, and degradates is often limited by the availability of and access to reliable toxicological data for these constituents.

Toxicological information regarding "other ingredients" may be available from sources such as the following:

- TOMES (a proprietary toxicological database including USEPA's IRIS, the Hazardous Substance Data Bank, the Registry of Toxic Effects of Chemical Substances [RTECS]).
- USEPA's ECOTOX database, which includes AQUIRE (a database containing scientific papers published on the toxic effects of chemicals to aquatic organisms).
- TOXLINE (a literature searching tool).
- MSDSs from pesticide suppliers.
- Other sources such as the Farm Chemicals Handbook.

Because there is a lack of specific inert toxicological data, inert(s) in a pesticide may cause adverse ecological effects. However, inert ingredients typically represent only a small percentage of the pesticide spray mixture, and it would be assumed that negligible effects would be expected to result from inert ingredient(s).

Although the potential effects of degradates should be considered when selecting a pesticide, it is beyond the scope of this assessment process to consider all possible breakdown chemicals of the various product formulations containing an active ingredient. Degradates may be more or less mobile and more or less hazardous in the environment than their parent pesticides (Battaglin et al. 2003). Differences in environmental behavior (e.g., mobility) and toxicity between parent pesticides and degradates would make assessing potential degradate effects extremely difficult. For example, a less toxic and more mobile, bioaccumulative, or persistent degradate may have potentially greater effects on species and/or degrade environmental quality. The lack of data on the toxicity of degradates for many pesticides would represent a source of uncertainty for assessing risk.

A USEPA-approved label specifies whether a product can be mixed with one or more pesticides. Without product-specific toxicological data, it would not possible to quantify the potential effects of these mixtures. In addition, a quantitative analysis could only be conducted if reliable scientific information allowed a determination of whether the joint action of a mixture would be additive, synergistic, or antagonistic. Such information would not likely exist unless the mode of action would be common among the chemicals and receptors. Moreover, the composition of and exposure to mixtures would be highly site- and/or time-specific and, therefore, it would be nearly impossible to assess potential effects to species and environmental quality.

To minimize or eliminate potential negative effects associated with applying two or more pesticides as a mixture, the use would be conducted in accordance with the labeling requirements. Labels for two or more pesticides applied as a mixture should be completely reviewed, where products with the least potential for negative effects would be selected for use on the Refuge. This is especially relevant when a mixture would be applied in a manner that may already have the potential for an effect(s) associated with an individual pesticide (e.g., runoff to ponds in sandy watersheds). Use of a tank mix under these conditions would increase the level of uncertainty in terms of risk to species or potential to degrade environmental quality.

Adjuvants generally function to enhance or prolong the activity of pesticide. For terrestrial herbicides, adjuvants aid in the absorption into plant tissue. Adjuvant is a broad term that generally applies to surfactants, selected oils, anti-foaming agents, buffering compounds, drift control agents, compatibility agents, stickers, and spreaders. Adjuvants are not under the same registration requirements as pesticides and the USEPA does not register or approve the labeling of spray adjuvants. Individual pesticide labels identify types of adjuvants approved for use with it. In general, adjuvants compose a relatively small portion of the volume of pesticides applied. Selection of adjuvants with limited toxicity and low volumes would be recommended to reduce the potential for the adjuvant to influence the toxicity of the pesticide.

H.7.4 Determining Effects to Soil and Water Quality

The approval process for pesticide uses would consider potential to degrade water quality on and off Refuge lands. A pesticide can only affect water quality through movement away from the treatment site. After application, pesticide mobilization can be characterized by one or more of the following (Kerle et al. 1996):

- Attach (sorb) to soil, vegetation, or other surfaces and remain at or near the treated area;
- Attach to soil and move off-site through erosion from runoff or wind;
- Dissolve in water that can be subjected to runoff or leaching.

As an initial screening tool, selected chemical characteristics and rating criteria for a pesticide can be evaluated to assess potential to enter ground and/or surface waters. These would include the following: persistence, sorption coefficient (K_{oc}), groundwater ubiquity score (GUS), and solubility.

Persistence, which is expressed as half-life ($t_{½}$), represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially). Persistence in the soil can be categorized as the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996). Half-life data is usually available for aquatic and terrestrial environments.

Another measure of pesticide persistence is dissipation time (DT_{50}). It represents the time required for 50% of the deposited pesticide to degrade and move from a treated site, whereas half-life describes the rate for degradation only. As for half-life, units of dissipation time are usually expressed in days. Field or foliar dissipation time is the preferred data for use to estimate pesticide concentrations in the environment. However, soil half-life is the most common persistence data cited in published literature. If field or foliar dissipation data is not available, soil half-life data may be used. The average or representative half-life value of most important degradation mechanism will be selected for quantitative analysis for both terrestrial and aquatic environments.

Mobility of a pesticide is a function of how strongly it is adsorbed to soil particles and organic matter, its solubility in water, and its persistence in the environment. Pesticides strongly adsorbed to soil particles, relatively insoluble in water, and not environmentally persistent would be less likely to move across the soil surface into surface waters or to leach through the soil profile and contaminate groundwater. Conversely, pesticides that are not strongly adsorbed to soil particles, are highly water soluble, and are persistent in the environment would have greater potential to move from the application site (off-site movement).

The degree of pesticide adsorption to soil particles and organic matter (Kerle et al. 1996) is expressed as the soil adsorption coefficient (K_{oc}). The soil adsorption coefficient is measured as micrograms of pesticide per gram of soil (µg/g) that can range from near zero to the thousands. Pesticides with higher K_{oc} values are strongly sorbed to soil and, therefore, would be less subject to movement.

Water solubility describes the amount of pesticide that will dissolve in a known quantity of water. The water solubility of a pesticide is expressed as milligrams of pesticide dissolved in a liter of water (mg/L or parts per million [ppm]). Pesticide with solubility <0.1 ppm are virtually insoluble in water, 100-1,000 ppm are moderately soluble, and >10,000 ppm highly soluble (U.S. Geological Survey 2000). As pesticide solubility increases, there would be greater potential for off-site movement.

The groundwater ubiquity score (GUS) is a quantitative screening tool to estimate a pesticide's potential to move in the environment. It utilizes soil persistence and adsorption coefficients in the following formula.

$$GUS = \log_{10}(t_{½}) \times [4 - \log_{10}(K_{oc})]$$

The potential pesticide movement rating would be based upon its GUS value. Pesticides with a GUS <0.1 would considered to have an extremely low potential to move toward groundwater. Values of 1.0-2.0 would be low, 2.0-3.0 would be moderate, 3.0-4.0 would be high, and >4.0 would have a very high potential to move toward groundwater.

Water solubility describes the amount of pesticide dissolving in a specific quantity of water, where it is usually measured as mg/L or ppm. Solubility is useful as a comparative measure because pesticides with higher values are more likely to move by runoff or leaching. GUS, water solubility, $t_{½}$, and K_{oc} values are available for selected pesticides from the Oregon State University Extension Pesticide Properties Database at http://npic.orst.edu/ppdmove.htm. Many of the values in this database were derived from the SCS/ARS/CES Pesticide Properties Database for Environmental Decision Making (Wauchope et al. 1992).

Soil properties influence the fate of pesticides in the environment. The following six properties are mostly likely to affect pesticide degradation and the potential for pesticides to move off-site by leaching (vertical movement through the soil) or runoff (lateral movement across the soil surface).

- Permeability is the rate of water movement vertically through the soil. It is affected by soil texture and structure. Coarse textured soils (e.g., high sand content) have a larger pore size and they are generally more permeable than fine textured soils (i.e., high clay content). The more permeable soils would have a greater potential for pesticides to move vertically down through the soil profile. Soil permeability rates (inches/hour) are usually available in county soil survey reports.
- Soil texture describes the relative percentage of sand, silt, and clay. In general, greater clay content with smaller the pore size would lower the likelihood and rate water that would move through the soil profile. Clay also serves to adsorb (bind) pesticides to soil particles. Soils with high clay content would adsorb more pesticide than soils with relatively low clay content. In contrast, sandy soils with coarser texture and lower water holding capacity would have a greater potential for water to leach through them.
- Soil structure describes soil aggregation. Soils with a well-developed soil structure have looser, more aggregated, structure that would be less likely to be compacted. Both characteristics would allow for less restricted flow of water through the soil profile resulting in greater infiltration.

- Organic matter would be the single most important factor affecting pesticide adsorption in soils. Many pesticides are adsorbed to organic matter which would reduce their rate of downward movement through the soil profile. Also, soils high in organic matter would tend to hold more water, which may make less water available for leaching.
- Soil moisture affects how fast water would move through the soil. If soils are already wet or saturated before rainfall or irrigation, excess moisture would runoff rather than infiltrate into the soil profile. Soil moisture also would influence microbial and chemical activity in soil, which effects pesticide degradation.
- Soil pH would influence chemical reactions that occur in the soil which in turn determines whether or not a pesticide will degrade, rate of degradation, and, in some instances, which degradation products are produced.

Based upon the aforementioned properties, soils most vulnerable to groundwater contamination would be sandy soils with low organic matter. In contrast, the least vulnerable soils would be well-drained clayey soils with high organic matter. Consequently, pesticides with the lowest potential for movement in conjunction with appropriate best management practices (see below) would be used in an IPM framework to treat pests while minimizing effects to non-target biota and protecting environmental quality.

Along with soil properties, the potential for a pesticide to affect water quality through runoff and leaching would consider site-specific environmental and abiotic conditions including rainfall, water table conditions, and topography (Huddleston 1996).

- Water is necessary to separate pesticides from soil. This can occur in two basic ways. Pesticides that are soluble move easily with runoff water. Pesticide-laden soil particles can be dislodged and transported from the application site in runoff. The concentration of pesticides in the surface runoff would be greatest for the first runoff event following treatment. The rainfall intensity and route of water infiltration into soil, to a large extent, determine pesticide concentrations and losses in surface runoff. The timing of the rainfall after application also would have an effect. Rainfall interacts with pesticides at a shallow soil depth (¼ to ½ inch), which is called the mixing zone (Baker and Miller 1999). The pesticide/water mixture in the mixing zone would tend to leach down into the soil or runoff depending upon how quickly the soil surface becomes saturated and how rapidly water can infiltrate into the soil. Leaching would decrease the amount of pesticide available near the soil surface (mixing zone) to runoff during the initial rainfall event following application and subsequent rainfall events.
- Terrain slope would affect the potential for surface runoff and the intensity of runoff. Steeper slopes would have greater potential for runoff following a rainfall event. In contrast, soils that are relatively flat would have little potential for runoff, except during intense rainfall events. In addition, soils in lower areas would be more susceptible to leaching as a result of receiving excessive water from surrounding higher elevations.
- Depth to groundwater would be an important factor affecting the potential for pesticides to leach into groundwater. If the distance from the soil surface to the top of the water table is shallow, pesticides would have less distance to travel to reach groundwater. Shallower water tables that persist for longer periods would be more likely to experience groundwater contamination. Soil survey reports are available for individual counties. These reports provide data in tabular format regarding the water table depths and the months during which

it is persists. In some situations, a hard pan exists above the water table that would prevent pesticide contamination from leaching.

H.7.5 Determining Effects to Air Quality

Pesticides may volatilize from soil and plant surfaces and move from the treated area into the atmosphere. The potential for a pesticide to volatilize is determined by the pesticide's vapor pressure which would be affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these numbers easier to compare, vapor pressure may be expressed in exponent form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with I<10 would have a low potential to volatilize, whereas pesticides with I>1,000 would have a high potential to volatilize (Oregon State University 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database.

H.7.6 Preparing a Chemical Profile

The following instructions would be used by Service personnel to complete Chemical Profiles for pesticides. Specifically, profiles would be prepared for pesticide active ingredients (e.g., glyphosate, imazapic) that would be contained in one or more trade name products that are registered and labeled with USEPA. All information fields under each category (e.g., Toxicological Endpoints, Environmental Fate) would be completed for a Chemical Profile. If no information is available for a specific field, then "No data is available in references" would be recorded in the profile. Available scientific information would be used to complete Chemical Profiles. Each entry of scientific information would be shown with applicable references.

Completed Chemical Profiles would provide a structured decision-making process utilizing quantitative assessment/screening tools with threshold values (where appropriate) that would be used to evaluate potential biological and other environmental effects to Refuge resources. For ecological risk assessments presented in these profiles, the "worst-case scenario" would be evaluated to determine whether a pesticide could be approved for use considering the maximum single application rate specified on pesticide labels for habitat management and croplands/facilities maintenance treatments pertaining to refuges. Where the "worst-case scenario" likely would only result in minor, temporary, and localized effects to listed and nonlisted species with appropriate BMPs (see Section H.5), the proposed pesticide's use in a PUP would have a scientific basis for approval under any application rate specified on the label that is at or below rates evaluated in a Chemical Profile. In some cases, the Chemical Profile would include a lower application rate than the maximum labeled rate in order to protect Refuge resources. As necessary, Chemical Profiles would be periodically updated with new scientific information or as pesticides with the same active ingredient are proposed for use on the Refuge in PUPs.

Throughout this section, threshold values (to prevent or minimize potential biological and environmental effects) would be clearly identified for specific information presented in a completed Chemical Profile. Comparison with these threshold values provides an explicit scientific basis to approve or disapprove PUPs for habitat management and cropland/facilities maintenance on Refuge lands. In general, PUPs would be approved for pesticides with Chemical Profiles where there would be no exceedances of threshold values. However, BMPs are identified for some screening tools that would minimize/eliminate potential effects (exceedance of the threshold value) as a basis for approving PUPs.

Date: Service personnel would record the date when the Chemical Profile is completed or updated. Chemical Profiles (e.g., currently approved pesticide use patterns) would be periodically reviewed and updated, as necessary. The most recent review date would be recorded on a profile to document when it was last updated.

Trade Name(s): Service personnel would accurately and completely record the trade name(s) from the pesticide label, which includes a suffix that describes the formulation (e.g., WP, DG, EC, L, SP, I, II or 64). The suffix often distinguishes a specific product among several pesticides with the same active ingredient. Service personnel would record a trade name for each pesticide product with the same active ingredient.

Common chemical name(s): Service personnel would record the common name(s) listed on the pesticide label or MSDS for an active ingredient. The common name of a pesticide is listed as the active ingredient on the title page of the product label immediately following the trade name, and the MSDS, Section 2: Composition/ Information on Ingredients. A Chemical Profile is completed for each active ingredient.

Pesticide Type: Service personnel would record the type of pesticide for an active ingredient as one of the following: herbicide, desiccant, fungicide, fumigant, growth regulator, insecticide, piscicide, or rodenticide.

EPA Registration Number(s): This number (EPA Reg. No.) appears on the title page of the label and MSDS, Section 1: Chemical Product and Company Description. It is not the EPA Establishment Number that is usually located near it. Service personnel would record the EPA Reg. No. for each trade name product with an active ingredient based upon PUPs.

Pesticide Class: Service personnel would list the general chemical class for the pesticide (active ingredient). For example, malathion is an organophosphate and carbaryl is a carbamate.

CAS (Chemical Abstract Service) Number: This number is often located in the second section (Composition/Information on Ingredients) of the MSDS. The MSDS table listing components usually contains this number immediately prior to or following the % composition.

Other Ingredients: From the most recent MSDS for the proposed pesticide product(s), Service personnel would include any chemicals in the pesticide formulation not listed as an active ingredient that are described as toxic or hazardous, or regulated under the Superfund Amendments and Reauthorization Act, Comprehensive Environmental Response, Compensation, and Liability Act, Toxic Substances Control Act, OSHA, State Right-to-Know, or other listed authorities. These are usually found in MSDS sections titled "Hazardous Identifications", "Exposure Control/Personal Protection", and "Regulatory Information". If concentrations of other ingredients are available for any compounds identified as toxic or hazardous, then Service personnel would record this information in the Chemical Profile by trade name. MSDS(s) may be obtained from the manufacturer, manufacturer's website, or from an on-line database maintained by Crop Data Management Systems, Inc. (see list below).

H.7.6.1 Toxicological Endpoints

Toxicological endpoint data would be collected for acute and chronic tests with mammals, birds, and fish. Data would be recorded for species available in the scientific literature. If no data are found for a particular taxonomic group, then "No data available is references" would be recorded as the data entry. Throughout the Chemical Profile, references (including toxicological endpoint data) would be cited using parentheses (#) following the recorded data.

Mammalian LD_{50}: For test species in the scientific literature, Service personnel would record available data for oral lethal dose (LD_{50}) in mg/kg-bw (body weight) or ppm-bw. Most common test species in scientific literature are the rat and mouse. The lowest LD_{50} value found for a rat would be used as a toxicological endpoint for dose-based RQ calculations to assess acute risk to mammals (see Table H-1 in Section H.7.1).

Mammalian LC_{50}: For test species in the scientific literature, Service personnel would record available data for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species in scientific literature are the rat and mouse. The lowest LC_{50} value found for a rat would be used as a toxicological endpoint for diet-based RQ calculations to assess acute risk (see Table H-1 in Section H.7.1).

Mammalian Reproduction: For test species listed in the scientific literature, Service personnel would record the test results (e.g., Lowest Observed Effect Concentration [LOEC], Lowest Observed Effect Level [LOEL], No Observed Adverse Effect Level [NOAEL], No Observed Adverse Effect Concentration [NOAEC]) in mg/kg-bw or mg/kg-diet for reproductive test procedure(s) (e.g., generational studies [preferred], fertility, new born weight). Most common test species available in scientific literature are rats and mice. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for a rat would be used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table H-1 in Section H.7.1).

Avian LD_{50}: For test species available in the scientific literature, Service personnel would record values for oral lethal dose (LD_{50}) in mg/kg-bw or ppm-bw. Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LD_{50} value found for an avian species would be used as a toxicological endpoint for dose-based RQ calculations to assess acute risk (see Table H-1 in Section H.7.1).

Avian LC_{50}: For test species available in the scientific literature, Service personnel would record values for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LC_{50} value found for an avian species would be used as a toxicological endpoint for dietary-based RQ calculations to assess acute risk (see Table H-1 in Section H.7.1).

Avian Reproduction: For test species available in the scientific literature, Service personnel would record test results (e.g., LOEC, LOEL, NOAEC, NOAEL) in mg/kg-bw or mg/kg-diet consumed for reproductive test procedure(s) (e.g., early life cycle, reproductive). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for an avian species would be used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table H-1 in Section H.7.1).

Fish LC_{50}: For test freshwater or marine species listed in the scientific literature, Service personnel would record a LC_{50} in ppm or mg/L. Most common test species available in the scientific literature are the bluegill, rainbow trout, and fathead minnow (marine). Test results for many game species may also be available. The lowest LC_{50} value found for a freshwater fish species would be used as a toxicological endpoint for RQ calculations to assess acute risk (see Table H-1 in Section H.7.1).

Fish Early Life Stage (ELS)/Life Cycle: For test freshwater or marine species available in the scientific literature, Service personnel would record test results (e.g., LOEC, NOAEL, NOAEC, LOAEC) in ppm for test procedure(s) (e.g., early life cycle, life cycle). Most common test species available in the scientific literature are bluegill, rainbow trout, and fathead minnow. Test results for other game species may also be available. The lowest test value found for a fish species (preferably freshwater) would be used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table H-1 in Section H.7.1).

Other: For test invertebrate as well as non-vascular and vascular plant species available in the scientific literature, Service personnel would record $LC_{50,}$ $LD_{50,}$ LOEC, LOEL, NOAEC, NOAEL, or EC_{50} (environmental concentration) values in ppm or mg/L. Most common test invertebrate species available in scientific literature are the honey bee and the water flea. Green algae and pondweed are frequently available test species for aquatic non-vascular and vascular plants, respectively.

Ecological Incident Reports: After a site has been treated with pesticide(s), wildlife may be exposed to these chemical(s). When exposure is high relative to the toxicity of the pesticides, wildlife may be killed or visibly harmed (incapacitated). Such events are called ecological incidents. The USEPA maintains a database (Ecological Incident Information System) of ecological incidents. This database stores information extracted from incident reports submitted by various federal and state agencies and nongovernment organizations. Information included in an incident report is date and location of the incident, type and magnitude of effects observed in various species, use(s) of pesticides known or suspected of contributing to the incident, and results of any chemical residue and cholinesterase activity analyses conducted during the investigation.

Incident reports can play an important role in evaluating the effects of pesticides by supplementing quantitative risk assessments. All incident reports for pesticide(s) with the active ingredient and associated information would be recorded.

H.7.6.2 Environmental Fate

Water Solubility: Service personnel would record values for water solubility (S_w), which describes the amount of pesticide that dissolves in a known quantity of water. S_w is expressed as mg/L (ppm). Pesticide S_w values would be categorized as one of the following: insoluble <0.1 ppm, moderately soluble = 100 to 1,000 ppm, highly soluble >10,000 ppm (U.S. Geological Survey 2000). As pesticide S_w increases, there would be greater potential to degrade water quality through runoff and leaching.

S_w would be used to evaluate potential for bioaccumulation in aquatic species [see Octanol-Water Partition Coefficient (K_{ow}) below].

Soil Mobility: Service personnel would record available values for soil adsorption coefficient (K_{oc} [μg/g]). It provides a measure of a chemical's mobility and leaching potential in soil. K_{oc} values are directly proportional to organic content, clay content, and surface area of the soil. K_{oc} data for a pesticide may be available for a variety of soil types (e.g., clay, loam, sand).

K_{oc} values would be used in evaluating the potential to degrade groundwater by leaching (see Potential to Move to Groundwater below).

Soil Persistence: Service personnel would record values for soil half-life ($t_{½}$), which represents the length of time (days) required for 50% of the deposited pesticide to degrade (completely or partially) in the soil. Based upon the $t_{½}$ value, soil persistence would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996).

Threshold for approving PUPs:

- *If soil t½ ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.*
- *If soil t½ >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface runoff and leaching that can degrade water quality:*
    - Do not exceed one application per site per year.
    - Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
    - Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Along with K_{oc}, soil $t_{½}$ values would be used in evaluating the potential to degrade groundwater by leaching (see Potential to Move to Groundwater below).

Soil Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade and move from a treated site, whereas soil $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Field dissipation time would be the preferred data for use to estimate pesticide concentrations in the environment because it is based upon field studies compared to soil $t_{½}$, which is derived in a laboratory. However, soil $t_{½}$ is the most common persistence data available in the published literature. If field dissipation data is not available, soil half-life data would be used in a Chemical Profile. The average or representative half-life value of most important degradation mechanism would be selected for quantitative analysis for both terrestrial and aquatic environments.

Based upon the DT_{50} value, environmental persistence in the soil also would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for approving PUPs:

- *If soil DT_{50} ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.*
- *If soil DT_{50} >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface runoff and leaching that can degrade water quality:*
    - Do not exceed one application per site per year.
    - Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.

- Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Along with K_{oc}, soil DT_{50} values (preferred over soil $t_{½}$) would be used in evaluating the potential to degrade groundwater by leaching (see Potential to Move to Groundwater below), if available.

Aquatic Persistence: Service personnel would record values for aquatic $t_{½}$, which represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially) in water. Based upon the $t_{½}$ value, aquatic persistence would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996).

Threshold for approving PUPs:

- *If aquatic t½ ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.*
- *If aquatic t½ >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface runoff and leaching that can degrade water quality:*
    - Do not exceed one application per site per year.
    - Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
    - Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Aquatic Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade or move (dissipate), whereas aquatic $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Based upon the DT_{50} value, environmental persistence in aquatic habitats also would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for approving PUPs:

- *If aquatic DT_{50} ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.*
- *If aquatic DT_{50} >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface runoff and leaching that can degrade water quality:*
    - Do not exceed one application per site per year.
    - Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
    - Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Potential to Move to Groundwater: Groundwater ubiquity score (GUS) = $\log_{10}(\text{soil } t_{½}) \times [4 - \log_{10}(K_{oc})]$. If a DT_{50} value is available, it would be used rather than a $t_{½}$ value to calculate a GUS score. Based upon the GUS value, the potential to move toward groundwater would be recorded as one of the following categories: extremely low potential <1.0, low 1.0 to 2.0, moderate 2.0 to 3.0, high 3.0 to 4.0, or very high >4.0.

Threshold for approving PUPs:

- *If GUS ≤4.0, then a PUP would be approved without additional BMPs to protect water quality.*
- *If GUS >4.0, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface runoff and leaching that can degrade water quality:*
  - Do not exceed one application per site per year.
  - Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
  - Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Volatilization: Pesticides may volatilize (evaporate) from soil and plant surfaces and move off-target into the atmosphere. The potential for a pesticide to volatilize is a function of its vapor pressure that is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these values easier to compare, vapor pressure would be recorded by Service personnel in exponential form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with I<10 would have low potential to volatilize, whereas pesticides with I >1,000 would have a high potential to volatilize (Oregon State University 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA ARS pesticide database (see References).

Threshold for approving PUPs:

- *If I ≤,1,000, then a PUP would be approved without additional BMPs to minimize drift and protect air quality.*
- *If I >1,000, then a PUP would only be approved with additional BMPs specifically to minimize drift and protect air quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to reduce volatilization and potential to drift and degrade air quality:*
  - Do not treat when wind velocities are <2 or >10 mph with existing or potential inversion conditions.
  - Apply the large-diameter droplets possible for spray treatments.
  - Avoid spraying when air temperatures >85ºF.
  - Use the lowest spray height possible above target canopy.
  - Where identified on the pesticide label, soil incorporate pesticide as soon as possible during or after application.

Octanol-Water Partition Coefficient (K_{ow}): The octanol-water partition coefficient (K_{ow}) is the concentration of a pesticide in octanol and water at equilibrium at a specific temperature. Because octanol is an organic solvent, it is considered a surrogate for natural organic matter. Therefore, K_{ow} would be used to assess potential for a pesticide to bioaccumulate in tissues of aquatic species (e.g., fish). If K_{ow} >1,000 or S_w<1 mg/L and soil $t_{½}$>30 days, then there would be high potential for a pesticide to bioaccumulate in aquatic species such as fish (U.S. Geological Survey 2000).

Threshold for approving PUPs:

- *If there is not a high potential for a pesticide to bioaccumulate in aquatic species, then the PUP would be approved.*
- If there is a high potential to bioaccumulate in aquatic species (K_{ow}>1,000 or S_w<1 mg/L and soil t½>30 days), then the PUP would not approved, except under unusual circumstances where approval would only be granted by the Washington Office.

Bioaccumulation/Bioconcentration: The physiological process where pesticide concentrations in tissue would increase in biota because they are taken and stored at a faster rate than they are metabolized or excreted. The potential for bioaccumulation would be evaluated through bioaccumulation factors (BAFs) or bioconcentration factors (BCFs). Based upon BAF or BCF values, the potential to bioaccumulate would be recorded as one of the following: low 0 to 300, moderate 300 to 1,000, or high >1,000 (Calabrese and Baldwin 1993).

Threshold for approving PUPs:

- *If BAF or BCF≤1,000, then a PUP would be approved without additional BMPs.*
- If BAF or BCF>1,000, then a PUP would not approved, except under unusual circumstances where approval would only be granted by the Washington Office.

H.7.6.3 Worst-case Ecological Risk Assessment

Max Application Rates (acid equivalent): Service personnel would record the highest application rate of an active ingredient (ae basis) for habitat management and cropland/facilities maintenance treatments in this data field of a Chemical Profile. These rates can be found in Table CP.1 under the column heading "Max Product Rate – Single Application (lbs/acre – AI on acid equiv basis)". This table would be prepared for a Chemical Profile from information specified in labels for trade name products identified in PUPs. If these data are not available in pesticide labels, then write "NS" for "not specified on label" in this table.

EECs: An estimated environmental concentration (EEC) represents potential exposure to fish and wildlife (birds and mammals) from using a pesticide. EECs would be derived by Service personnel using an USEPA screening-level approach (USEPA 2004). For each max application rate [see description under Max Application Rates (acid equivalent)], Service personnel would record 2 EEC values in a Chemical Profile; these would represent the worst-case terrestrial and aquatic exposures for habitat management and croplands/facilities maintenance treatments. For terrestrial and aquatic EEC calculations, see description for data entry under Presumption of Unacceptable Risk/Risk Quotients, which is the next field for a Chemical Profile.

Presumption of Unacceptable Risk/Risk Quotients: Service personnel would calculate and record acute and chronic RQs for birds, mammals, and fish using the provided tabular formats for habitat management and/or cropland/facilities maintenance treatments. RQs recorded in a Chemical Profile would represent the worst-case assessment for ecological risk. See Section H.7.2 for discussion regarding the calculations of RQs.

For aquatic assessments associated with habitat management treatments, RQ calculations would be based upon selected acute and chronic toxicological endpoints for fish and the EEC would be derived from Urban and Cook (1986) assuming 100% overspray to an entire 1-foot deep water body using the max application rate (ae basis [see above]).

For aquatic assessments associated with cropland/facilities maintenance treatments, RQ calculations would be done by Service personnel based upon selected acute and chronic toxicological endpoints for fish and an EEC would be derived from the aquatic assessment in AgDRIFT® model version 2.01 under Tier I ground-based application with the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium/coarse droplet size, 20 swaths, EPA-defined wetland, and 25-foot distance (buffer) from treated area to water.

See Section H.7.2.1.2 for more details regarding the calculation of EECs for aquatic habitats for habitat management and cropland/facilities maintenance treatments.

For terrestrial avian and mammalian assessments, RQ calculations would be done by Service personnel based upon dietary exposure, where the "short grass" food item category would represent the worst-case scenario. For terrestrial spray applications associated with habitat management and cropland/facilities maintenance treatments, exposure (EECs and RQs) would be determined using the Kanaga nomogram method through the USEPA's T-REX version 1.2.3. T-REX input variables would include the following: max application rate (acid basis [see above]) and pesticide half-life (days) in soil to estimate the initial, maximum pesticide residue concentration on general food items for terrestrial vertebrate species in short (<20 cm tall) grass.

For granular pesticide formulations and pesticide-treated seed with a unique route of exposure for terrestrial avian and mammalian wildlife, see Section H.7.2.1.1.2 for the procedure that would be used to calculate RQs.

All calculated RQs in both tables would be compared with LOCs established by USEPA (see Table H-2 in Section H.7.2). If a calculated RQ exceeds an established LOC value (in brackets inside the table), then there would be a potential for an acute or chronic effect (unacceptable risk) to federally listed (threatened and endangered [T&E]) species and nonlisted species. See Section H.7.2 for detailed descriptions of acute and chronic RQ calculations and comparison to LOCs to assess risk.

Threshold for approving PUPs:

- *If RQs≤LOCs, then a PUP would be approved without additional BMPs.*
- *If RQs>LOCs, then a PUP would only be approved with additional BMPs specifically to minimize exposure (ecological risk) to bird, mammal, and/or fish species. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to reduce potential risk to nonlisted or listed species:*
    - Lower application rate and/or fewer number of applications so RQs≤LOCs
    - For aquatic assessments (fish) associated with cropland/facilities maintenance, increase the buffer distance beyond 25 feet so RQs≤LOCs.

Justification for Use: Service personnel would describe the reason for using the pesticide based control of specific pests or groups of pests. In most cases, the pesticide label will provide the appropriate information regarding control of pests to describe in the section.

Specific Best Management Practices (BMPs): Service personnel would record specific BMPs necessary to minimize or eliminate potential effects to non-target species and/or degradation of environmental quality from drift, surface runoff, or leaching. These BMPs would be based upon scientific information documented in previous data fields of a Chemical Profile. Where necessary and feasible, these specific practices would be included in PUPs as a basis for approval.

If there are no specific BMPs that are appropriate, then Service personnel would describe why the potential effects to Refuge resources and/or degradation of environmental quality is outweighed by the overall resource benefit(s) from the proposed pesticide use in the BMP section of the PUP. See Section H.4 of this document for a complete list of BMPs associated with mixing and applying pesticides appropriate for all PUPs with ground-based treatments that would be additive to any necessary, chemical-specific BMPs.

References: Service personnel would record scientific resources used to provide data/information for a chemical profile. Use the number sequence to uniquely reference data in a chemical profile.

The following online data resources are readily available for toxicological endpoint and environmental fate data for pesticides:

1. California Product/Label Database. Department of Pesticide Regulation, California Environmental Protection Agency. (http://www.cdpr.ca.gov/docs/label/labelque.htm#regprods)

2. ECOTOX database. Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, D.C. (http://cfpub.epa.gov/ecotox/)

3. Extension Toxicology Network (EXTOXNET) Pesticide Information Profiles. Cooperative effort of University of California-Davis, Oregon State University, Michigan State University, Cornell University and University of Idaho through Oregon State University, Corvallis, Oregon. (http://extoxnet.orst.edu/pips/ghindex.html)

4. FAO specifications and evaluations for plant protection products. Pesticide Management Unit, Plant Protection Services, Food and Agriculture Organization, United Nations. (http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/)

5. Human health and ecological risk assessments. Pesticide Management and Coordination, Forest Health Protection, U.S. Department of Agriculture, U.S. Forest Service. (http://www.fs.fed.us/foresthealth/pesticide/risk.htm)

6. Pesticide Chemical Fact Sheets. Clemson University Pesticide Information Center. (http://entweb.clemson.edu/pesticid/Document/Labels/factshee.htm)

7. Pesticide Fact Sheets. Published by Information Ventures, Inc. for Bureau of Land Management, Department of Interior; Bonneville Power Administration, U.S. Department of Energy; and Forest Service, U.S. Department of Agriculture. (http://infoventures.com/e-hlth/pesticide/pest-fac.html)

8. Pesticide Fact Sheets. National Pesticide Information Center. (http://npic.orst.edu/npicfact.htm)

9. Pesticide Fate Database. U.S. Environmental Protection Agency, Washington, D.C. (http://cfpub.epa.gov/pfate/home.cfm).

10. Pesticide product labels and material safety data sheets. Crop Data Management Systems, Inc. (CDMS) (http://www.cdms.net/pfa/LUpdateMsg.asp) or multiple websites maintained by agrichemical companies.

11. Registered Pesticide Products (Oregon database). Oregon Department of Agriculture. (http://www.oda.state.or.us/dbs/pest_products/search.lasso)

12. Regulatory notes. Pest Management Regulatory Agency, Health Canada, Ontario, Canada. (http://www.hc-sc.gc.ca/pmra-arla/)

13. Reptile and Amphibian Toxicology Literature. Canadian Wildlife Service, Environment Canada, Ontario, Canada. (http://www.cws-scf.ec.gc.ca/nwrc-cnrf/ratl/index_e.cfm)

14. Specific Chemical Fact Sheet – New Active Ingredients, Biopesticide Fact Sheet and Registration Fact Sheet. U.S. Environmental Protection Agency, Washington, D.C. (http://www.epa.gov/pestidides/factsheets/chemical_fs.htm)

15. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. The Invasive Species Initiative. The Nature Conservancy. (http://tnsweeds.ucdavis.edu/handbook.html)

16. Wildlife Contaminants Online. U.S. Geological Survey, Department of Interior, Washington, D.C. (http://www.pwrc.usgs.gov/contaminants-online/)

17. One-liner database. 2000. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, D.C.

Chemical Profile

Date:			
Trade Name(s):		**Common Chemical Name(s):**	
Pesticide Type:		**EPA Registration Number:**	
Pesticide Class:		**CAS Number:**	
Other Ingredients:			

Toxicological Endpoints

Mammalian LD_{50}:	
Mammalian LC_{50}:	
Mammalian Reproduction:	
Avian LD_{50}:	
Avian LC_{50}:	
Avian Reproduction:	
Fish LC_{50}:	
Fish ELS/Life Cycle:	
Other:	

Ecological Incident Reports

Environmental Fate

Water solubility (S_w):	
Soil Mobility (K_{oc}):	
Soil Persistence ($t_{½}$):	
Soil Dissipation (DT_{50}):	
Aquatic Persistence ($t_{½}$):	
Aquatic Dissipation (DT_{50}):	
Potential to Move to Groundwater (GUS score):	
Volatilization (mm Hg):	
Octanol-Water Partition Coefficient (K_{ow}):	
Bioaccumulation/Biocentration:	**BAF:`** **BCF:**

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** **Croplands/Facilities Maintenance:**
EECs	**Terrestrial (Habitat Management):** **Terrestrial (Croplands/Facilities Maintenance):** **Aquatic (Habitat Management):** **Aquatic (Croplands/Facilities Maintenance):**

Habitat Management Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Cropland/Facilities Maintenance Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Justification for Use:	
Specific Best Management Practices (BMPs):	
References:	

Table CP.1 Pesticide Name

Trade Name[a]	Treatment Type[b]	Max Product Rate – Single Application (lbs/acre or gal/acre)	Max Product Rate -Single Application (lbs/acre - AI on acid equiv basis)	Max Number of Applications Per Season	Max Product Rate Per Season (lbs/acre/season or gal/acre/season)	Minimum Time Between Applications (Days)

[a] From each label for a pesticide identified in pesticide use proposals (PUPs), Service personnel would record application information associated with possible/known uses on Service lands.
[b] Treatment type: H – habitat management or CF – cropland/facilities maintenance. If a pesticide is labeled for both types of treatments (uses), then record separate data for H and CF applications.

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Appendix I. Statement of Compliance

The following executive orders and legislative acts have been reviewed as they apply to the implementation of the Comprehensive Conservation Plan (CCP) for Willapa National Wildlife Refuge (NWR), located in Washington State.

National Environmental Policy Act (1969). (42 U.S.C. 4321 et seq.). The planning process has been conducted in accordance with National Environmental Policy Act Implementing Procedures, with Department of Interior and Fish and Wildlife Service procedures, and in coordination with the affected public. The requirements of the National Environmental Policy Act (42 U.S.C. §4321 et seq.) and its implementing regulations in 40 C.F.R. Parts 1500-1508 have been satisfied in the procedures used to reach this decision. These procedures included the development of a range of alternatives for the Willapa NWR CCP; analysis of the likely effects of each alternative; and public involvement throughout the planning process. The Draft CCP/EIS was released for a minimum 45-day public comment period. The affected public was notified of the availability of these documents through a Federal Register notice, news releases to local newspapers, the Service's refuge planning website, and a planning update. Copies of the Draft CCP/EIS and/or planning updates were distributed to an extensive mailing list. In addition, the Service hosted two public open houses in 2008. The CCP was revised based on public comment received on the draft documents.

National Historic Preservation Act (1966). (16 U.S. C.470 et seq.). The management of the archaeological and cultural resources of Willapa NWR will comply with the regulations of Section 106 of the National Historic Preservation Act. No historic properties are known to be affected by the proposed action based on the criteria of an effect or adverse effect as an undertaking defined in 36 C.F.R. 800.9 and Service Manual 614 FW 2; however, determining whether a particular action has the potential to affect cultural resources is an ongoing process that occurs as step-down and site-specific project plans are developed. Should historic properties be identified or acquired in the future, the Service will comply with the National Historic Preservation Act if any management actions have the potential to affect any these properties.

Endangered Species Act. (16 U.S.C. 1531-1544). This Act provides for the conservation of threatened and endangered species of fish, wildlife, and plants by federal action and by encouraging the establishment of state programs. Documentation is required under Section 7 of the Act. Refuge policy requires the Refuge Manager to document issues that affect or may affect endangered species before initiating projects such as the restoration project (Appendix O).

Executive Order 12372. Intergovernmental Review. Coordination and consultation with affected tribal, local, and state governments, other federal agencies, and local interested persons has been completed through personal contact by Refuge staff and Refuge Supervisors.

Executive Order 11988. Floodplain Management. Under this order, federal agencies "shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains."

Wilderness Preservation Act of 1964. The Service has evaluated the suitability of the Refuge for wilderness designation (Appendix G) and has found there are no areas that are currently suitable for wilderness designation.

Executive Order 11990. Protection of Wetlands. The CCP is consistent with Executive Order 11990 because CCP implementation would potentially enhance and restore wetland resources on the Refuge.

National Wildlife Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-668ee). The National Wildlife Refuge System Improvement Act (Public Law 105-57, Improvement Act) requires the Service to develop and implement a comprehensive conservation plan for each refuge. The CCP identifies and describes Refuge purposes; Refuge vision and goals; fish, wildlife, and plant populations and related habitats in the Refuge; archaeological and cultural values of the Refuge; issues that may affect populations and habitats of fish, wildlife, and plants; actions necessary to restore and improve biological diversity on the Refuge; and opportunities for wildlife-dependent recreation, as required by the Act.

During the CCP process, the Refuge Manager evaluated all existing and proposed Refuge uses at Willapa NWR. Priority wildlife-dependent uses (hunting, fishing, wildlife observation and photography, environmental education and interpretation) are considered automatically appropriate under Service policy and thus exempt from appropriate uses review. The following use was found to be appropriate: camping.

Compatibility determinations have been prepared for the following uses: waterfowl hunting, big game hunting, sport fishing, environmental education, wildlife observation, interpretation, and photography, and camping.

Executive Order 12898. Federal Actions to Address Environmental Justice in Minority and Low-Income Populations. All federal actions must address and identify, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations, low-income populations, and Indian Tribes in the United States. The CCP was evaluated and no adverse human health or environmental effects were identified for minority or low-income populations, Indian tribes, or anyone else.

Executive Order 13186. Responsibilities of Federal Agencies to Protect Migratory Birds. This Order directs agencies to take certain actions to further implement the Migratory Bird Treaty Act. A provision of the Order directs federal agencies to consider the impacts of their activities, especially in reference to birds on the Fish and Wildlife Service's list of Birds of Conservation Concern. It also directs agencies to incorporate conservation recommendations and objectives in the North American Waterbird Conservation Plan and bird conservation plans developed by Partners in Flight into agency planning as described in Chapter 1.

Executive Order 13175. Consultation and Coordination with Indian Tribal Governments. As required under the Secretary of the Interior Order 3206—American Indian Tribal Rights, Federal-Tribal Responsibilities, and the Endangered Species Act—the Project Leader notified and consulted interested tribes. The Service consulted with the Shoalwater Bay Tribe throughout the Service's planning process.

Americans with Disabilities Act of 1990. This Act requires access to federal facilities for people with disabilities.

Integrated Pest Management (IPM), 517 DM 1 and 7 RM 14. In accordance with 517 DM 1 and 7 RM 14, an integrated pest management (IPM) approach has been adopted to eradicate, control, or contain pest and invasive species on the Refuge. In accordance with 517 DM 1, only pesticides registered with the U.S. Environmental Protection Agency (USEPA) in full compliance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and as provided in regulations, orders, or permits issued by USEPA may be applied on lands and waters under Refuge jurisdiction.

Acting Scott McCarty 9/20/11

Chief, Division of Planning, Visitor Services, and Transportation

Date

Appendix J. Acronyms and Glossary

Acronyms

a.i.	Active Ingredient
ABC	American Bird Conservancy
ADA	Americans with Disabilities Act
AHM	Adaptive Harvest Management
AM	Adaptive Management
APHIS-PPQ	U.S. Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine
APHIS-WS	U.S. Department of Agriculture, Animal Plant Health Inspection Service, Wildlife Services
ARS	U.S. Department of Agriculture Agricultural Research Service
BAF	Bioaccumulation Factor
BCC	Birds of Conservation Concern
BCF	Bioconcentration Factor
BIDEH	Biological Integrity Diversity and Environmental Health
BMC	Birds of Management Concern
BMP	Best Management Practice
BPA	Bonneville Power Administration
CD	Compatability Determination
C.F.R.	Code of Federal Regulations
CARL	Pacific County Critical Areas and Resources Land Ordinance No. 147
CAS	Chemical Abstract Service
CCP	Comprehensive Conservation Plan
CEQ	Council on Environmental Quality
CLMA	Cooperative Land Management Agreement
CWCS	Comprehensive Wildlife Conservation Strategy
dbh	Diameter at Breast Height
DM	Departmental Manual
DPS	Distinct Population Segment
EA	Environmental Assessment
EE	Environmental Education
EEC	Estimated Environmental Concentration
EIS	Environmental Impact Statement
ENSO	El Niño–Southern Oscillation
ESA	Endangered Species Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FMP	Fire Management Plan
FONSI	Finding of No Significant Impact
FR	Federal Register
GAP	Gap Analysis Program
GIS	Geographic Information System
GMU	Game Management Units
GUS	Groundwater Ubiquity Score
HACCP	Hazard Analysis and Critical Control Points
IAC	Interagency Committee for Outdoor Recreation (Washington State)

IBA	Important Bird Area
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
LEED	Leadership in Energy and Environmental Design
LEIS	Legislative Environmental Impact Statement
LOC	Level of Concern
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observed Effect Level
LWD	Large Woody Debris
MBCC	Migratory Bird Conservation Commission
MBTA	Migratory Bird Treaty Act
MHW	Mean High Water
MHHW	Mean Higher High Water
MIS	Management Information System
MLLW	Mean Lower Low Water
mm/yr	Millimeters Per Year
MMS	Maintenance Management System
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPA	Marine Protected Area
mph	Miles Per Hour
MSDS	Material Safety Data Sheet
NAWCA	North American Wetlands Conservation Act
NAWCP	North American Waterbird Conservation Plan
NAWMP	North American Waterfowl Management Plan
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No Observed Adverse Effect Concentration
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NPCRSCP	Northern Pacific Coast Region Shorebird Conservation Plan
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSRE	National Survey on Recreation and the Environment
NWPS	National Wilderness Preservation System
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
OMB	U.S. Office of Management and Budget
ONRC	Olympic Natural Resources Center
ORS	Washington Outdoor Recreation Survey
OSHA	Occupational Safety and Health Administration
PJV	Pacific Joint Venture
PIF	Partners in Flight
PPE	Personal Protective Equipment
ppm	Parts Per Million
PUD	Pacific County Public Utilities District

PUP	Pesticide Use Proposal
PUPS	Pesticide Use Proposal System
RCO	Washington State Recreation and Conservation Office
RCW	Revised Code of Washington
RM	Refuge Manual
RNA	Research Natural Area
RONS	Refuge Operating Needs System
RQ	Risk Quotient
SAMMS	Service Asset Management System
SCORP	Statewide Comprehensive Outdoor Recreation Plan
Service	U.S. Fish and Wildlife Service (also USFWS)
SLAMM 5.0	Sea Level Affecting Marshes Model Version 5.0
SWBCA	South Willapa Bay Conservation Area
T&E	Threatened and Endangered
TNC	The Nature Conservancy
T-REX	Terrestrial Residue Exposure model
TWA	Time-Weighted-Average
U.S.C.	U.S. Code
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service (also Service)
UWCIG	University of Washington Climate Impacts Group
WAC	Washington Administrative Code
WAP	Wildlife Action Plan
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WFPB	Washington Forest Practices Board
WRP	Wetland Reserve Program
WSDA	Washington State Department of Agriculture
WSPHRA	Western Snowy Plover Habitat Restoration Area
WSPRC	Washington State Parks and Recreation Commission

Glossary

Adaptive Management. Refers to a process in which policy decisions are implemented within a framework of scientifically driven experiments to test predictions and assumptions inherent in management planning. Analysis of results helps managers determine whether current management should continue as is or whether it should be modified to achieve desired conditions.

Anadromous. Migratory fishes that spend most of their lives in the sea and migrate to fresh water to breed.

Approved Acquisition Boundary. A National Wildlife Refuge boundary approved by the National or Regional Fish and Wildlife Service Director for potential acquisition of lands by the Service.

Archaeology. The scientific study of material evidence remaining from past human life and culture.

Biological Diversity (also Biodiversity). The variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur (Service Manual 601 FW 3). The System's focus is on indigenous species, biotic communities, and ecological processes.

Biological Integrity. Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities (Service Manual 601 FW 3).

Birds of Conservation Concern. Species, subspecies, and populations of migratory nongame birds identified by the U.S. Fish and Wildlife Service as likely to become candidates for listing under the Endangered Species Act unless additional conservation actions are taken.

Blockage. When used in reference to anadromous fish habitat, a "complete blockage" occurs when conditions fully block all life stages of all salmonid fish species to upstream migration. A "partial blockage" occurs when conditions prevent species or life stages of a species of salmon from completing its upstream migration. See WDFW website http//wdfw.wa.gov/mapping/salmonscape.

Candidate Species (Federal). Fish, wildlife, and plant species that the U.S. Fish and Wildlife Service will review for possible listing as federally endangered or threatened. A species will be considered for designation as a federal candidate if sufficient evidence suggests that its status may meet the listing criteria defined for federally endangered or threatened.

Candidate Species (State). Fish, wildlife, and plant species that a state will review for possible listing as state endangered, threatened, or sensitive species. A species will be considered for designation as a state candidate if sufficient evidence suggests that its status may meet the listing criteria defined for state endangered, threatened, or sensitive.

Categorical Exclusion. A category of actions that do not individually or cumulatively have a significant effect on the human environment and have been found to have no such effect in procedures adopted by a federal agency pursuant to the National Environmental Policy Act (40 C.F.R. 1508.4).

Colonial Nesting Birds. Birds that nest in groups. At this refuge, most of the colonial nesting birds are waterbirds, such as gulls, terns, cormorants, and herons.

Columbia River Estuary. The area where the fresh water of a river meets the salt water of an ocean. The boundary of the Columbia River Estuary is considered the lower 46 miles (Lower Columbia River Estuary Partnership).

Compatibility Determination. A written determination signed and dated by the refuge manager and Regional Chief signifying that a proposed or existing use of a national wildlife refuge is a compatible use or is not a compatible use. The Director makes this delegation through the Regional Director. (Service Manual 603 FW 2).

Compatible Use. A wildlife-dependent recreational use or any other use of a refuge that, in the sound professional judgment of the Director, will not materially interfere with or detract from the fulfillment of the mission of the System or the purposes of the refuge (Service Manual 603 FW 3). A compatibility determination supports the selection of compatible uses and identifies stipulations or limits necessary to ensure compatibility.

Comprehensive Conservation Plan. A document that describes the desired future conditions of the refuge, and provides long-range guidance and management direction for the refuge manager to accomplish the purposes of the refuge, contribute to the mission of the System, and to meet other relevant mandates (Service Manual 602 FW 1.5).

Connectivity. The arrangement of habitats that allows organisms and ecological processes to move across the landscape; patches of similar habitats are either close together or linked by corridors of appropriate vegetation. The opposite of fragmentation.

Conservation Target. A set of features or elements of biological diversity that are the focus of conservation within a system of conservation areas.

Consumptive Use. Recreational activities, such as hunting and fishing, that involve harvest or removal of wildlife or fish, generally to be used as food by humans.

Contaminants or Environmental Contaminants. Chemicals present at levels greater than those naturally occurring in the environment resulting from anthropogenic or natural processes that potentially result in changes to biota at any ecological level. Pollutants that degrade other resources upon contact or mixing. Pollutants that degrade other resources upon contact or mixing (Adapted from Webster's II.)

Cooperative Agreement. This is a simple habitat protection action, and no property rights are acquired. An agreement is usually long term but can be modified by either party. They are most effective in establishing multiple use management of land.

Cover Type. The present vegetation of an area.

Cultural Resources. The physical remains, objects, historic records, and traditional lifeways that connect us to our nation's past. (USFWS, Considering Cultural Resources).

Cultural Resource Inventory. A professionally conducted study designed to locate and evaluate evidence of cultural resources present within a defined geographic area. Inventories may involve various levels, including background literature search, comprehensive field examination to identify all exposed physical manifestations of cultural resources, or sample inventory to project site distribution and density over a larger area. Evaluation of identified cultural resources to determine eligibility for the National Register follows the criteria found in 36 C.F.R. 60.4 (Service Manual 614 FW 1.7).

Deciduous. Describes trees and shrubs which shed all of their leaves each year.

Disturbance. Significant alteration of habitat structure or composition. May be natural (e.g., fire) or human-caused events (e.g., aircraft overflight).

Draw-down. The controlled reduction of water in managed wetlands.

Ecological Attribute. A characteristic or condition required to support the life history, habitat, physical processes, or community interaction of conservation targets.

Ecosystem. A dynamic and interrelating complex of plant and animal communities and their associated non-living environment.

Ecosystem Management. Management of natural resources using system-wide concepts to ensure that all plants and animals in ecosystems are maintained at viable levels in native habitats and basic ecosystem processes are perpetuated indefinitely.

Ecotone. A transitional zone between two communities containing the characteristic species of each.

Emergent Vegetation. Herbaceous plants that require a water environment to grow for at least part of their life cycle; stem structure is rigid and self-supporting; and vegetative growth continues above the waterline.

Environmental Assessment. A concise public document, prepared in compliance with the National Environmental Policy Act, that briefly discusses the purpose and need for an action, alternatives to such action, and provides sufficient evidence and analysis of impacts to determine whether to prepare an environmental impact statement or finding of no significant impact (40 C.F.R. 1508.9).

Environmental Impact Statement. A detailed written statement required by Section 102(2) (C) of the National Environmental Policy Act, analyzing the environmental impacts of a proposed action, adverse effects of the project that cannot be avoided, alternative courses of action, short-term uses of the environment versus the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitment of resources (40 C.F.R. 1508.11).

Endangered Species (Federal). A plant or animal species listed under the Endangered Species Act that is in danger of extinction throughout all or a significant portion of its range.

Endangered Species (State). A plant or animal species in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. Populations of these species are at critically low levels or their habitats have been degraded or depleted to a significant degree.

Environmental Education Facility. A building with one or more classrooms and environmental education materials to accommodate groups of students.

Environmental Education Field Sites. Outdoor locations where groups of students receive hands-on environmental education.

Environmental Health. Composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment (Service Manual 601 FW 3).

Enhancement. Improvement, especially for the benefit of habitats and/or species.

Estuarine. Deepwater tidal habitats and adjacent tidal wetlands that are usually partly enclosed by land but have some access to the open ocean and are diluted by fresh water.

Estuary. The area where the fresh water of a river meets the salt water of an ocean. In the National Estuary Program, this definition is extended to include the tidally influenced waters of a river.

Exotic Species. A species from another part of the world. A non-native species.

Extirpated. Species no longer inhabiting an area that it historically occupied.

Finding of No Significant Impact. A document prepared in compliance with the National Environmental Policy Act, supported by an environmental assessment, that briefly presents why a federal action will have no significant effect on the human environment and for which an environmental impact statement, therefore, will not be prepared (40 C.F.R. 1508.13).

Focal Conservation Target. A suite of conservation targets that for purposes of planning are sorted and condensed to represent threats to biological integrity, diversity, and environmental health at the refuge level.

GAP Analysis. Analysis done to identify and map elements of biodiversity that are not adequately represented in the nation's network of reserves. It provides an overview of the distribution and conservation status of several components of biodiversity, with an emphasis on vegetation and terrestrial vertebrates.

Goal. Descriptive, open-ended, and often broad statement of desired future conditions that conveys a purpose but does not define measurable units (Service Manual 602 FW 1.5).

Habitat. Suite of existing environmental conditions required by an organism for survival and reproduction. The place where an organism typically lives.

Habitat Connectivity (also Landscape Connectivity). The arrangement of habitats that allows organisms and ecological processes to move across the landscape; patches of similar habitats are either close together or linked by corridors of appropriate vegetation. The opposite of fragmentation.

Habitat Management Plan. A plan that guides refuge activities related to the maintenance, restoration, and enhancement of habitats for the benefit of wildlife, fish, and plant populations.

Habitat Restoration. Management emphasis designed to move ecosystems to desired conditions and processes, and/or to healthy ecosystems.

Headquarters. An administrative center.

Historic Conditions. Composition, structure, and functioning of ecosystems resulting from natural processes that we believe, based on sound professional judgment, were present prior to substantial human related changes to the landscape (Service Manual 601 FW 3).

Hydrology. A science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

Hydrograph. A graph of water flows in a river or stream. A hydrograph provides a way of seeing seasonal and yearly changes in the flow or discharge of a waterway.

Hydroperiod. A segment of a hydrograph for a specific timeframe.

Indicator. Something that serves as a sign or symptom.

Inholding. Refers to lands within a refuge's approved acquisition boundary that are not owned by the U.S. Fish and Wildlife Service. These can be private lands or lands owned by city, county, state, or other federal agencies.

Interpretation. A teaching technique that combines factual information with stimulating explanation. Frequently used to help people understand natural and cultural resources.

Interpretive Trail. A trail with informative signs, numbered posts that refer to information in a brochure, or where guided talks are conducted for the purpose of providing factual information and stimulating explanations of what visitors see, hear, feel, or otherwise experience while on the trail.

Invasive Species. Species of plants and animals that have the potential to rapidly colonize and dominate an area.

Issue. Any unsettled matter that requires a management decision (e.g., a Service initiative, opportunity, resource management problem, a threat to the resources of the unit, conflict in uses, public concern, or the presence of an undesirable resource condition) (Service Manual 602 FW 1.5).

Land Protection. The acquisition of fee-title, easement, or lease of a given land parcel to protect important natural resource values on the land from incompatible land uses.

Landform. A natural feature of a land surface.

Maintenance. The upkeep of constructed facilities, structure and capitalized equipment necessary to realize the originally anticipated useful life of a fixed asset. Maintenance includes preventative maintenance; cyclic maintenance; repairs; replacement of parts, components, or items of equipment, periodic condition assessment; periodic inspections, adjustment, lubrication and cleaning (non-janitorial) of equipment; painting, resurfacing, rehabilitation; special safety inspections; and other actions to ensure continuing service and to prevent breakdown.

Maintenance Management System. A national database of refuge maintenance needs and deficiencies. It serves as a management tool for prioritizing, planning, and budgeting purposes.

Managed Field. Refuge grasslands maintained for winter goose forage by mowing, haying, grazing, or burning.

Mean High Water. The average level of the surface of the river, used as a standard in determining land elevation or sea depths.

Mean Higher High Water. The average of the two high waters of any tidal day.

Migration. The seasonal movement from one area to another and back.

Migratory Birds. Those species of birds listed under 50 C.F.R. 10.13, Chapter 1-USFWS, DOI.

Monitoring. The process of collecting information to track changes of selected parameters over time.

Monoculture. Vegetation composed primarily of a single species, such as in areas dominated by invasive weeds.

Native Species. With respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem. (Service Manual 601 FW 3).

National Wildlife Refuge. A designated area of land, water, or an interest in land or water within the National Wildlife Refuge System.

National Wildlife Refuge System. Various categories of areas administered by the Secretary of the Interior for the conservation of fish and wildlife, including species threatened with extinction; all lands, waters, and interests therein administered by the Secretary as wildlife refuges; areas for the protection and conservation of fish and wildlife that are threatened with extinction; wildlife ranges; games ranges; wildlife management areas; or waterfowl production areas.

Neotropical Migrant. A bird that winters in southern Mexico, Central and South America, or the West Indies and migrates northward to breed in North America.

Non-native Species. An introduced species that did not naturally occur in an area. See also exotic species.

Nonpoint Source. Coming from more than one location. Frequently refers to pollution or erosion that comes from a widespread area and accumulates in streams and rivers.

Noxious Weed. A plant species designated by federal or state law as generally possessing one or more of the following characteristics: aggressive or difficult to manage; parasitic; a carrier or host of serious insect or disease; or non-native, new, or not common to the United States, according to the federal Noxious Weed Act (PL 93-639), a noxious weed is one that causes disease or had adverse effects on humans or their environment and therefore is detrimental to the agriculture and commerce of the United States and to the public health.

Objective. An objective is a concise target statement of what will be achieved, how much will be achieved, when and where it will be achieved, and who is responsible for the work. Objectives are derived from goals and provide the basis for determining management strategies. Objectives should be attainable and time-specific and should be stated quantitatively to the extent possible. If objectives cannot be stated quantitatively, they may be stated qualitatively (Service Manual 602 FW 1.5).

Old Field. Refuge grasslands left relatively unmanaged to provide food and cover for a variety of native wildlife. Control of noxious weeds does occur on old fields.

Operations. Activities related to the normal performance of the functions for which a facility or item of equipment is intended to be used. Costs such as utilities (electricity, water, sewage) fuel, janitorial services, window cleaning, rodent and pest control, upkeep of grounds, vehicle rentals, waste management, and personnel costs for operating staff are generally included within the scope of operations.

Outreach. The process of providing information to the public on a specific issue through the use of the media, printed materials, and presentations.

Pacific Flyway. One of several major north-south travel corridors for migratory birds. The Pacific Flyway is west of the Rocky Mountains.

Palustrine. Freshwater wetlands that are less than 2 meters deep at low water. They do not include areas regularly impacted by waves or part of a bedrock shoreline. They are familiarly known as marshes, swamps, bogs, wet meadows, prairies, and small shallow ponds.

Plant Association. A classification of plant communities based on the similarity in dominants of all layers of vascular species in a climax community.

Plant Community. An assemblage of plant species unique in its composition; occurs in particular locations under particular influences; a reflection or integration of the environmental influences on the site such as soils, temperature, elevation, solar radiation, slope, aspect, and rainfall; denotes a general kind of climax plant community (e.g., ponderosa pine).

Preplanning. The first phase of comprehensive conservation planning process. It includes identifying the planning area and data needs; establishing the planning team and planning schedule; reviewing available information; preparing a public involvement plan and conducting internal scoping.

Priority Public Uses. Hunting, fishing, wildlife observation and photography, environmental education and interpretation were identified by the National Wildlife Refuge System Improvement Act of 1997 as the six priority public uses of the National Wildlife Refuge System.

Priority Species. Fish and wildlife species that the Washington Department of Fish and Wildlife believe require protective measures and/or management guidelines to ensure their perpetuation. Priority species include the following: 1) state-listed and candidate species; 2) species or groups of animals susceptible to significant population declines within a specific area or statewide by virtue of their inclination to aggregate (e.g., seabird colonies); and 3) species of recreation, commercial, and/or Tribal importance.

Public. Individuals, organizations, and groups; officials of federal, state, and local government agencies; Indian Tribes; and foreign nations. It may include anyone outside the core planning team. It includes those who may or may not have indicated an interest in Service issues and those who do or do not realize Service decisions may affect them.

Public Use Area. A designated area within the Willapa NWR that is open to the public.

Raptor. A category of carnivorous birds, most of which have heavy, sharp beaks and strong talons, and take live prey (e.g., peregrine falcon, bald eagle).

Refuge Operating Needs System. A national database of unfunded refuge operating needs required to meet and/or implement station goals, objectives, management plans, and legal mandates. It is used as a planning, budgeting, and communication tool describing funding and staffing needs of the Refuge System.

Refuge Purpose(s). The purpose(s) specified in or derived from the law, proclamation, executive order, agreement, public land order, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, a refuge unit, or refuge subunit (Service Manual 602 FW 1.5).

Research Natural Area. A federal land designation that establishes areas with predominantly natural conditions and processes for research and educational purposes.

Restoration. The act of bringing back to a former or original condition.

Revenue Sharing. Service payments (government lands are exempt from taxation) made to counties in which national wildlife refuges reside. These payments may be used by the counties for any governmental purpose such as, but not limited to, roads and schools.

Riparian. Refers to an area or habitat that is transitional from terrestrial to aquatic ecosystems; including streams, lakes, wet areas, and adjacent plant communities and their associated soils which have free water at or near the surface; an area whose components are directly or indirectly attributed to the influence of water; of or relating to a river; specifically applied to ecology, “riparian” describes the land immediately adjoining and directly influenced by streams. For example, riparian vegetation includes any and all plant life growing on the land adjoining a stream and directly influenced by the stream.

Riverine. Flowing perennial to intermittent waters bounded by a channel. This habitat encompasses a river or stream, its channel, and the associated aquatic vegetation.

Salmonid. A category of fish that includes salmon, steelhead, and trout.

Scoping. Using news releases, and other appropriate media to notify the public of the opportunity to participate in the planning process and to help identify issues, concerns, and opportunities related to the project.

Seral. Of or relating to an ecological sere; a seral stage.

Songbirds (also Passerines). A category of birds that are medium to small, perching landbirds. Most are territorial singers and migratory.

Special Status Species. Fish, wildlife and plant species that have special conservation status because they have been listed under one or more authorities such as Endangered Species Act, state-listed species, Birds of Conservation Concern, and others.

Step-down Plan. A step-down plan provide the details necessary to implement management strategies identified in the comprehensive conservation plan (Service Manual 602 FW 1.5).

Strategy. A specific action, tool, or technique or combination of actions, tools, and techniques used to meet unit objectives (Service Manual 602 FW 1.5).

Threatened Species (Federal). Species listed under the Endangered Species Act that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Threatened Species (State). A plant or animal species likely to become endangered in Washington within the near future if factors contributing to population decline or habitat degradation or loss continue.

Threshold. The lowest level or intensity at which a stimulus is perceptible or can produce an effect. This term is sometimes used in connection with monitoring the effects of public uses on natural resources.

Turbidity. A measurement of clarity of water based on particles suspended in the water. It is measured with a nephelometer, which indicates the amount of light that passes through (or is scattered by) a column of water.

Vegetation Type (also Habitat Type, Forest Cover Type). A land classification system based upon the concept of distinct plant associations.

Vision Statement. A concise statement of the desired future condition of the planning unit, based primarily upon the System mission, specific refuge purposes, and other relevant mandates (Draft Service Manual 602 FW 1.5).

Watershed. The region or area drained by a river system or other body of water (Webster's II).

Wetlands. Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water at some time during the growing season of each year (Service Manual 660 FW 2).

Wildlife-dependent Recreation. Hunting, fishing, wildlife observation and photography, environmental education and interpretation. These are also referred to as priority public uses of the National Wildlife Refuge System.

Appendix K. South Willapa Bay Conservation Area Draft Forest Landscape Restoration Plan

SOUTH WILLAPA BAY CONSERVATION AREA

A joint project of The Nature Conservancy and Willapa National Wildlife Refuge

FOREST LANDSCAPE RESTORATION PLAN

Final – July 10, 2007

South Willapa Bay Conservation Area Forest Landscape Restoration Plan

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This project was envisioned and completed in partnership with the Willapa National Wildlife Refuge and their contributions were indispensable in this cooperative effort. Refuge biologists, Marie Fernandez and Kirsten Brennan, imparted critical insight into refuge specific forest management goals and past research and data availability, and also provided review of the plan. The support and guidance of the refuge Project Leader, Charlie Stenvall was vital to ensuring that the plan is scientifically rigorous, yet useful for operational planning purposes.

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The Nature Conservancy would like to thank Derek Churchill, Andrew Larson, and Kevin Cedar for the rigor and detail they applied to considering the central question that this plan aims to answer; how do we restore ecological function to young overstocked coastal forests? Their deep personal interest in the finer points of coastal forest ecology is clearly evident in this plan.

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS .... **V**

INTRODUCTION 1
1. *Purpose and Need* 1
2. *Management Philosophy and Goals* 3

OVERVIEW OF THE SOUTH WILLAPA BAY CONSERVATION AREA **5**

A. PHYSIOGRAPHIC SETTING 6
1. *Climate and Climatic Variation* 6
2. *Geology & Soils* 6

B. CONSERVATION SIGNIFICANCE 10
1. *Ecological Systems and Natural Communities* 10
2. *Rare plants* 11
3. *Fish & Wildlife Populations* 11
4. *Potential Threats to Conservation Value* 14

C. SITE HISTORY AND MANAGEMENT 16
1. *Pre-settlement Forest Composition* 16
2. *Human Use* 18
3. *Forest Management History* 18
4. *Current Land Use and Surrounding Ownership* 20
5. *Recreation and Public Access* 20
6. *Bonneville Powerlines* 20

LANDSCAPE RESOURCE ASSESSMENT **22**

A. FOREST VEGETATION 23
1. *Forest Inventory and Key Structural Metrics* 23
2. *Forest Stand Types* 24
3. *Forest Health* 32

B. FRESHWATER STREAM SYSTEMS 35

C. FOREST ROADS AND OTHER INFRASTRUCTURE 38
1. *Forest Roads* 38
2. *Rock Pits* 39
3. *Building Infrastructure and Other Resources* 39

MANAGEMENT CONSIDERATIONS **40**

A. DESIRED FUTURE CONDITIONS 41
1. *Ecosystem Resistance and Resilience to Perturbation at Multiple Scales* 41
2. *Landscape Composition and Pattern: Spatial and Temporal Heterogeneity* 43
3. *Functional Landscape Linkages* 44
4. *Habitat for Late-successional Dependent Species* 44
5. *Desired Future Conditions: Synthesis* 45

B. SCIENTIFIC JUSTIFICATION 46
1. *Scientific Basis for Restoration Silviculture in Spruce-Hemlock Forests* 46
2. *Scientific Basis for Road Removal* 50
3. *Risks associated with Active vs. Passive Management* 53

C. OPERATIONAL CONSTRAINTS 58
1. *Staff Capacity* 58
2. *Financial Resources & Considerations* 58
3. *Applicable forest practice laws and policies* 61
4. *Access, road network, and logging systems* 61
5. *Community & stakeholder context and desires* 62

RESTORATION PROGRAM AND SCHEDULE **63**

A. MANAGEMENT APPROACH 64
1. Silvicultural System *64*
2. Determining and Prioritizing Forest Treatments *68*
3. Determining and Prioritizing Road Treatments *72*
4. Generalized Forest Treatment Scenarios *73*
5. Sale and collection of non-timber forest products *76*
6. Development and use of onsite rock resources *76*
7. Use of chemicals *77*
8. Local access and hunting *77*
9. Use of revenue generated from timber sales *77*
B. IMPLEMENTATION SCHEDULE 79
1. Restoration Thinning and Road Treatment Schedule *79*
2. Landscape Simulation of Treatments *80*
3. Projected Volume and Revenue Outputs *86*
C. MONITORING 89
1. Adaptive Management *89*

REFERENCES .... **A**

APPENDIX A: ECOLOGY OF SPRUCE-HEMLOCK FORESTS **1**

BY: ANDREW LARSEN AND DEREK CHURCHILL 1
Natural Disturbances *1*
Forest Development Pathways *2*
Stream Geomorphology, Disturbances, and Habitat, including Riparian Areas *7*
References *7*

APPENDIX B: PROCESS AND GUIDELINES FOR DEVELOPING STAND LEVEL PRESCRIPTIONS **1**

BY: DEREK CHURCHILL, ANDREW LARSON, & KEVIN CEDAR 1

List of Acronyms and Abbreviations

B-IBI -- Benthic Index of Biotic Integrity
BPA -- Bonneville Power Administration
BR -- Biomass removal thinning treatments
CCI --- Cooperative Conservation Initiative
CWD --- Coarse Woody Debris
DBH--- Diameter at Basal Height
DFC -- Desired Future Condition
ENSO -- El Nino/Southern Oscillation
FSC --- Forest Stewardship Council
FVS --- Forest Vegetation Simulator
HD(R) -- Height to Diameter Ratio
IRM-- Integrated Resource Management
LCR-- Live crown ratio
LMS -- Landscape Management System
MDL -------------------------------- Mature drop and leave thinning treatments
MOGI -- Modified Old-Growth Index
MOU -- Memorandum of Understanding
NCC -- Nature Conservancy of Canada
PCT--- Pre-commercial thinning treatments
PDO-- Pacific Decadal Oscillation
QMD-- Quadratic Mean Diameter
RNA-- Research Natural Area
SDI --- Stand Density Index
SVS -- Stand Visualization System
SWBCA ------------------------------------ South Willapa Bay Conservation Area
TIMO --------------------------- Timber Investment Management Organization
TNC --- The Nature Conservancy
TPA -- Trees per Acre
UM ------ Understory, variable density thinning treatments and management
USFWS ---------------------------------- United States Fish and Wildlife Service
VDT-- Variable Density Thinning
WADNR------------------------ Washington Department of Natural Resources
WADOE ---------------------------------- Washington Department of Ecology
WDFW -------------------------- Washington Department of Fish and Wildlife
WNWR --- Willapa National Wildlife Refuge
YDL ---------------------------------- Young drop and leave thinning treatments

Introduction

1. *Purpose and Need*

In July of 2003, The Nature Conservancy ("the Conservancy") and U.S. Fish and Wildlife Service signed a Memorandum of Understanding for the purpose of "collaborating to accomplish forest management goals and objectives" on properties managed by both parties in Pacific County, Washington. Thus began a partnership to restore young-managed forestlands at a landscape scale across the Conservancy's Ellsworth Creek Preserve the neighboring Willapa National Wildlife Refuge (the "Refuge"). Financial resources to support this work have been secured, in part, through the U. S. Fish and Wildlife Service's Jobs In The Woods Program (FWS Agreement #134103J007), the Department of Interior's Cooperative Conservation Initiative (Cooperative Agreement 135524J115), Nestucca Oil Spill Revised Restoration Plan (USFWS 2004), and private funds from individuals and foundations. The following management plan was prepared to provide specific goals and management guidance over the next 20 years for this restoration effort within the Refuge and Conservancy's terrestrial ownership, hereafter referred to as the "South Willapa Bay Conservation Area" (SWBCA), (Figure 1 – South Willapa Bay Conservation Area).

Old-growth western redcedar at Teal Slough

Forests within the SWBCA have been managed for timber production over most of the last century. Today, less than 5% of the area remains as unmanaged or old-growth forest habitat. Extensive forest management has profoundly changed ecological conditions within the landscape. The dominant, simplified young-managed forests do not support several species that are dependent on complex old-growth forests including the federally listed marbled murrelet (*Brachyramphus marmoratus*) and Northern spotted owl (*Strix occidentalis caurina*). Streams are altered from high sediment loads and scouring, and extensive forest road systems fragment habitat and modify hydrological processes. Low-elevation coastal old-growth forests in South Willapa Bay, however, provide habitat for an especially diverse array of species while also supporting natural ecological processes that maintain healthy freshwater stream systems and adjacent estuarine habitats. Because of the rarity and biological significance of old-growth forest ecosystems in the Willapa Hills of Washington, the Conservancy and Refuge are working together to restore a forested landscape that is representative of past, unmanaged, landscape conditions.

Restoration actions, or active management, will primarily include (1) carefully designed density management (ie. thinning) within young-managed forest stands (< 90 years old) to promote forest growth and the development of habitat complexity, (2) the removal, or repair of high risk forest roads, and (3) improvement to the existing forest road network to minimize impacts to water quality. This landscape restoration plan outlines the management direction and implementation schedule for specific restoration actions that are anticipated over the following 20 year period. The plan provides detail on management goals, conservation significance, existing natural and cultural resources, desired future conditions, planning considerations, management approach, implementation schedule, and monitoring. While the Conservancy and Refuge recognize that restoration of forest ecosystems within the SWBCA will play out over the next century or longer, we anticipate that the next 10-20 years are critical for altering the ecological trajectory of this important landscape toward a trend that supports the recovery of our mutual conservation values.

The Nature Conservancy

South Willapa Bay Conservation Area

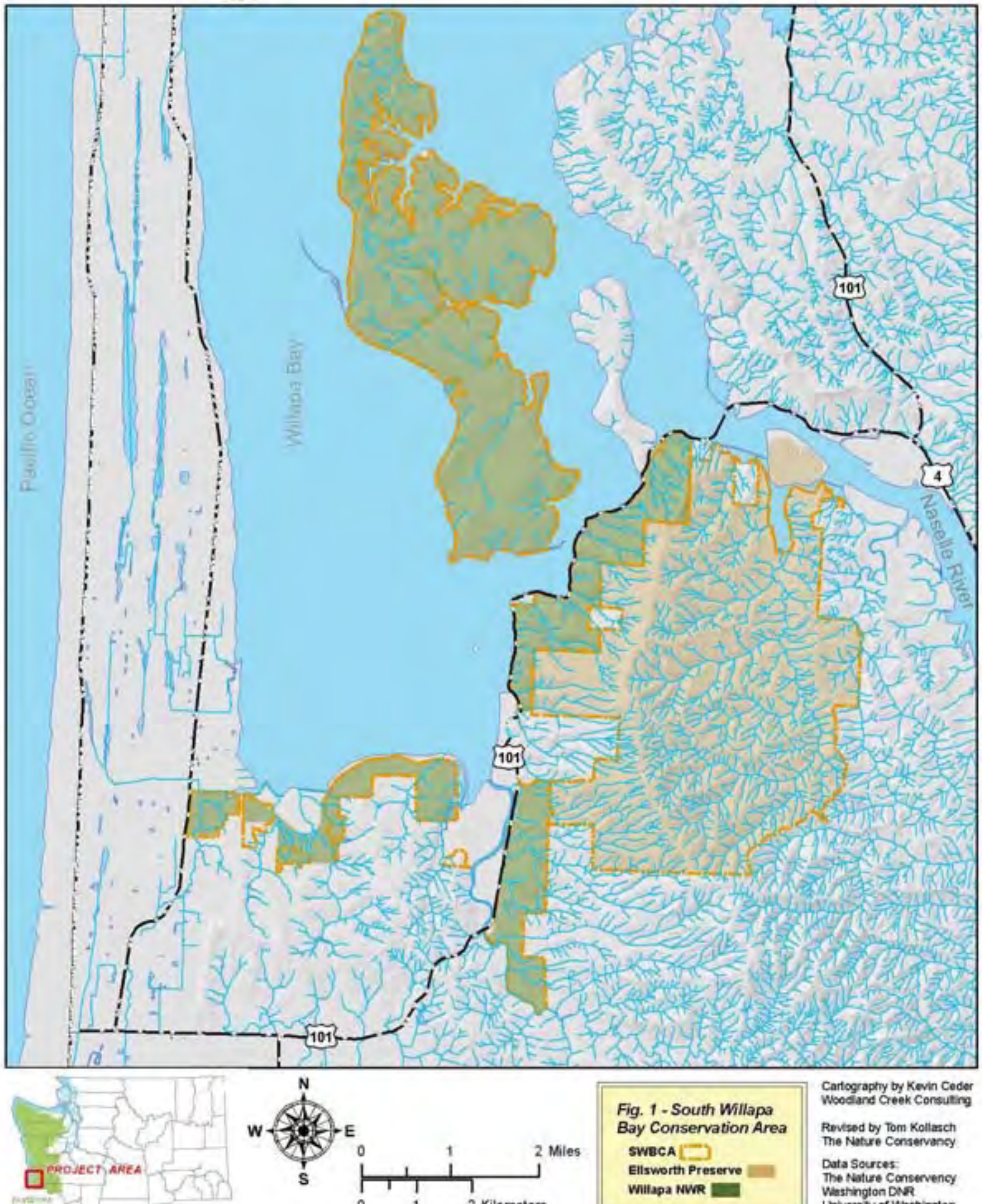


Fig. 1 - South Willapa Bay Conservation Area

2. ***Management Philosophy and Goals***

The intent of management within the SWBCA is to restore self sustaining, natural, ecological processes and healthy forest and stream systems, as opposed to engineering or manipulating habitats to meet specific structural or compositional targets. The Conservancy and Refuge propose to do this by abating threats to the landscape and/or sources of habitat degradation. The major identified threats include extensive forest road systems, simplified forest and stream habitats, increased sediment loads in stream systems, and invasive species. Restoration and management practices will be based upon the best science available with the level of active management varying across the landscape. Monitoring and refinement of management practices will occur as a key component of the restoration process.

A core assumption of this landscape restoration project is that young-managed forest landscapes can, over long time periods, develop ecological conditions that are comparable to unmanaged or late-successional forest landscapes found within the same physiographic province. The Conservancy and Refuge recognize that existing unmanaged forest landscapes developed under unique environmental conditions and that those histories cannot be replicated (Spies et al. 2002b). Remaining unmanaged stands represent only a small proportion of the representative habitat diversity that once existed on the landscape. Thus, metrics from the remaining remnant forests will only be used as an initial template for comparison, not as an ultimate target to reach and maintain throughout the landscape. The goal is to restore a dynamic and resilient, naturally functioning forest system, not to artificially hold the landscape in a defined old-growth state (i.e., to balance the affects of continued logging in the surrounding region). The Conservancy and Refuge believe that significant portions of the SWBCA should develop complex forest canopy and understory structures, high levels of standing and downed wood, dynamic and complex stream habitats, diverse species communities, and resilience to natural disturbances that are typical of unmanaged late-successional forest landscapes in the Pacific Northwest (Franklin J.F. and Spies 1991, Naiman et al. 2000).

Specific goals for each partner are outlined below.

The Nature Conservancy

The Conservancy is an international nonprofit conservation organization whose mission is to preserve plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. Since its establishment in 1951, the Conservancy has been responsible for protecting more than 15 million acres in the United States and more than 102 million acres in Latin America, the Caribbean, Asia and the Pacific. The Conservancy works in all 50 states and 28 countries. The Nature Conservancy of Washington was established in 1979 and began acquiring properties as part of the Ellsworth Creek Preserve in 1998. Currently, the Ellsworth Creek Preserve is approximately 7,436 acres in size, encompassing almost the entire Ellsworth Creek watershed, and includes upland forest and estuarine habitats, and freshwater stream systems.

Primary goals for the Ellsworth Creek Preserve include:

1. Restore ecologically functional estuarine, freshwater, and upland forest habitats that support species and ecological processes representative of those found within unmanaged late-successional forest landscapes of the Pacific Northwest coast.
2. Develop and implement restoration strategies that accomplish ecological goals in a cost effective and financially replicable manner.
3. Maximize opportunities for learning how coastal forest landscapes respond to restoration treatments and export those lessons to other forest resource managers.
4. Manage the preserve with exemplary stewardship that earns respect and builds productive relationships within the local community and amongst resource management partners.
5. Attain and maintain Forest Stewardship Council (FSC) certification.
6. Serve as a contributor to positive carbon sequestration.

The Conservancy has been a member of the Forest Stewardship Council (FSC) since 2001 and holds a certificate as a certified forest manager for over 250,000 acres. The Conservancy intends to pursue FSC certification at its Ellsworth Creek Preserve and believes certification is an important forest conservation tool because it can:

- Integrate socio-economic values/concerns into forest management activities;
- Ensure that any active management on Conservancy owned and managed lands is consistent and meets an internationally recognized standard of management;
- Provide independent verification and monitoring of forest management and chain of custody practices that help reduce illegal logging; and,
- Create incentives for sound forest management by providing some landowners with better access to certain markets and price premiums for certified product.

Willapa National Wildlife Refuge

The Refuge was established in 1937 as a refuge and breeding ground for migratory birds and other wildlife in and around Willapa Bay (Executive Order 7541, dated Jan. 22, 1937). The Refuge currently manages approximately 15,000 acres including coastal dunes and beaches, intertidal mudflats, saltwater and freshwater marshes, grasslands and forestlands. The terrestrial portion of the Refuge is approximately 7,726 acres, including 362 acres designated as a Research Natural Area (RNA).

Refuge goals related to forest management include:

1. To preserve and protect unique ecosystems associated with Willapa Bay
2. To manage for the conservation and recovery of threatened and endangered animals in their natural ecosystems.

Under these goals the Refuge has developed specific objectives related to the forest management program.

1. Restore ecological function to Refuge forests by creating a natural distribution of stand structure, composition, and successional stages while promoting old-growth/late successional characteristics to benefit forest dependent wildlife – especially the marbled murrelet.
2. Decommission unnecessary forest roads to reduce/eliminate stream impacts and fragmentation of forest habitat.
3. Adopt forest management practices designed to change fire prone thickets of western hemlock over a period of time to something that structurally resembles old-growth and reduces fuel loads.
4. Protect, and where appropriate, restore associated stream habitat to prevent further declines of anadromous fish stocks and enhance native amphibian populations and other stream dependent wildlife species.
5. Reduce risk from insects and disease where endemics are likely.

Research Natural Areas

The Diamond Point (88 acres) (Dyrness 1972) and Cedar Grove Research Natural Areas (274 acres) (Atkinson 1987)are both located within the SWBCA, on Long Island. Research natural areas are established on federal lands: (1) to preserve examples of all significant natural ecosystems for comparison with those influenced by humans; (2) to provide educational and research areas for ecological and environmental studies; (3) to preserve gene pools of typical and endangered plants and animals (WADNR 2005). Activities on Research Natural Areas are limited to research, study, observation, monitoring, and educational activities that are non-destructive, non-manipulative, and maintain unmodified natural conditions. These areas were designated due to the high quality vegetation communities found at each site and no active management is proposed at either site within this plan.

Overview of the South Willapa Bay Conservation Area

Late-successional forest at Ellsworth Creek

A. PHYSIOGRAPHIC SETTING

1. *Climate and Climatic Variation*

The SWBCA has a mild, maritime climate. Annual precipitation at nearby Long Beach, WA and Naselle, WA averaged 80" for the period 1967-2005 and 114" for the period 1948-2005, respectively (NOAA 2007). Precipitation is lowest during July and August, however the summer drought is moderated by low clouds and fog (Franklin J. F. and Dyrness 1988). Fog condensation on tree crowns and subsequent fog drip is an additional source of precipitation (Ruth and Harris 1979), which may be of ecological significance during summer months (Dawson 1998). Temperatures are moderate; temperatures at Long Beach, WA range from a mean high of 66.8 F in August and September to a mean low of 36.0 F in January (NOAA 2007).

Climatic conditions are variable at both long (millennial) and short (annual-decadal) time scales. The primary forcing of long-term climate variation in this region is changing patterns of seasonal insolation, which is in turn controlled by variation in the Earth's tilt and orbital pattern (Berger 1991, Heusser C.J., L.E. Heusser, D.M. Peteet. 1985). Long-term climatic variation of this nature has led to substantial changes in the vegetation composition throughout the Pacific Northwest (Whitlock 1992). At the annual and decadal scales, El Nino/Southern Oscillation (ENSO) (Diaz and Markgraf 2000) and Pacific Decadal Oscillation (PDO) (Biondi 2001, Mantua 1997), respectively, and interactions between these two climatic oscillations (Newman 2003) are important sources of climatic variation, influencing both temperature and precipitation. Individual tree growth and forest ecosystem productivity in the PNW respond to annual and decadal climate variation (Peterson David W. and Peterson 2001). Particularly relevant to the SWBCA site management are the recent findings that summer temperature and PDO influence growth in coastal low elevation forests in western Washington (Nakawatase and Peterson 2006). Sitka spruce (*Picea sitchensis*) forests exhibit very high sensitivity to environmental variation, with potential for extreme growth response to climate variation (Holman 2006).

2. *Geology & Soils*

The Ellsworth creek drainage and the lands with the Willapa National Wildlife Refuge are located in the southwestern portion of the Willapa Hills subprovince of the Coast Range physiographic province. All waters drain into Willapa Bay. Ellsworth creek lies within the lower Naselle River watershed, while Conservancy and Refuge lands to the south and west of Bear River Ridge are part of the Bear River watershed unit. Long Island comprises its own watershed unit. Elevation ranges from sea level along Willapa Bay to 1,715 feet along Bear River Ridge. The area covered by this plan can be divided into 2 physiographic zones with distinct geological, topographic, and soil characteristics (Table 1): Coastal hills, and Long Island, alluvial zones and former sand dunes.

Coastal hills

The coastal hills have rounded topography and deep weathering profiles. The landscape is highly dissected, and the drainage network is dendritic. Marine sedimentary rock from the late Eocene through early Miocene (60 to 20 million year old) underlies most of this zone and consists of thin-bedded, laminated tuffaceous siltstones and lesser amounts of sandstone (Wells 1989). Middle Miocene intrusions of basalt also exist and are much more resistant than the surrounding sedimentary rocks. This contrast in rock hardness has resulted in the development of locally steeper slopes and higher relief, as evidenced by Bear River Ridge (Wells, 1989). Due to lack of glaciation during the last 2 million years, soils and exposed bedrock are highly weathered. Thick soils have developed on stable upland surfaces and slopes range from very gentle to over 200%.

Three major geologic formations exist that have corresponding geomorphic features (Map – SWBCA Landforms). The Lincoln Creek formation consists of steep, dissected hill slopes west of the Bear River

Ridge divide and west of Ellsworth Creek (Wegmann 2004) where soils are primarily from the Palix and Narel Series (Map – SWBCA Soils). These deep, well drained soils were generally formed in mixed slope deposits derived from sandstone and siltstone consisting of silt loams and silty clay loams with 10-30% pebble sized rock fragments. Depth to partly consolidated sandstone ranges from 40 to 60 inches. Available water capacity is high and water moves readily through these soils.

The Grand Ronde Basalt formation contains steep escarpments of Bear River Ridge associated with resistant invasive Columbia River basalt flows. Soils are highly weathered basalts from the Vesta series on ridge tops and the Knappton series on side slopes. These deep, well drained soils consist of silt loams and gravelly, silty clay loams with 0-30% pebble sized rock fragments. Depth to weathered, fractured basalt ranges from 40 to 60 inches. Available water capacity is high and water moves readily through these soils.

Figure 2. Landslide risk is generally moderate within the SWBCA although higher risks are associated with roads.

The Shoalwater Bay formation consists of moderately-to-low dissected hill slopes and bluffs west and north of Bear River Ridge that slope gently towards Willapa bay. Soils are weathered sandstones and siltstones from the Palix, Illwaco, Leban, and Treham series, with some intrusions of Knappton soils. The Illwaco and Leban series are similar to the Palix series, while the Treham series is similar to Knappton. Intrusion of basalt and more recent estuarine deposits mixed in and make for complex geology.

All of the soils in coastal hills of the SWBCA are medial, mesic Andic Haplumbrepts (Pringle 1986). These fine textured soils, in combination with the abundant rainfall, give the area high soil productivity. King (1966) 50 year Douglas-fir (*Psuedotsuga menzesii*)site index taken from Cambell Group cruise data ranges from 107-145, and is site class 2 in most places with some site 1 and site 3. Barnes (1962) 50 year western hemlock site index ranges from 90-128 (Map – SWBCA Site Index: 50 year Western Hemlock), and maximum annual volume increment for a fully stocked 50 year old western hemlock (*Tsuga heterophylla*) stand ranges from 214-272 cubic feet per acre per year or 1170 – 1486 board feet per acre per year (Pringle 1986).

The combination of steep slopes, susceptible bedrock types, and significant precipitation makes the area susceptible to landslides. Wegmann (2004) conducted a historical review of landslide activity and an analysis of landslide risk in the lower Naselle watershed. Using data from Powell et al. (2003) he rated overall landslide potential as moderate when compared to other drainage basins in the Olympic and Cascade mountain ranges. He also found that over 90% of past landslides occurred on concave-to-planar slopes of bedrock hollows, inner gorges, and convergent headwalls, especially on slopes greater than 70% in the Grande Ronde Basalt and Lincoln Creek Formations. Based on these factors, mass wasting risk was evaluated for areas within the Ellsworth watershed (Map – Ellsworth Creek Unstable Landforms). The 2000 Washington State DNR slope stability ratings based on the SLPSTAB model (Washington State Department of Natural Resources 2006) are also included in a landslide susceptibility model for both ownerships (Map – SWBCA Slope Stability Hazard).

While most landslides have been shallow rapid slides or debris flows, there have been some deep seated landslides that affect much larger areas and consist of poorly sorted colluvium and bedrock slump blocks. While the risk of further shallow, subsidiary landslides within these previous events is minimal, steep headscarps and over-steepened toes of some of the deep-seated slides are susceptible to increased shallow landslide activity, especially if forest roads are constructed across them. In general, Wegmann's (2004) analysis found that forestry activities have greatly hastened landslide activity and roughly 85% of the 319 landslides since 1958 were related to forestry activities (Wegmann 2004). In a separate analysis of the Ellsworth creek drainage, Powell et. al (2003) found that of the 86 landslides that have occurred since 1946, 52 were road related and 34 were related to clear cut harvests. Approximately 110 acres were affected and 87% of slides resulted in disturbance and or sediment delivery to stream channels.

Long Island, alluvial zones, and former sand dunes
Long Island and other marine terraces bordering Willapa Bay are comprised of estuarine terraces and alluvial deposits that are generally flat to gently sloped (Wells 1989). They consist of unconsolidated to semi-consolidated mud and silt with sand lenses. Terrace surfaces occur up to 260 feet above the modern sea level. Dissection of terrace surfaces increases with increasing elevation above sea level, yet, the overall dissection of these deposits is minimal, likely owing to their relatively young age and minimal topographic gradient (Wegmann 2004).

The marine terraces consist of uplifted and wave cut terraces of highly stratified Willapa Bay esturiane sediments that were laid down over the last 2 million years (Quaternary) as sea levels fluctuated. These terraces occur on Long Island and parts of the mainland shoreline areas and often overlay older, consolidated sandstone that can be seen on Long Island cliffs. Basalt intrusions are also present. Due to rapid weathering, geological history is not well known in many cases. Soils are primarily from the Willapa and Ilwaco series and are deep, moderately drained soils that consist of silt loam in the 8-20 inch surface horizons and mottled, silty clay loams below (Pringle 1986). Available water capacity is high. A small portion of these terraces have Newskaw soils, which are loams in the surface horizons and fine sand below. These soils are medial, mesic Andic Haplumbrepts.

In estuaries, floodplains, and low terraces of the major streams entering Willapa Bay, soils are derived from recent alluvial sediments. Soils from the Ocosta series are the most prevalent (Pringle 1986). This very deep, poorly drained soil occurs in flood plains and deltas of coastal bays ands consists of silty clay loam and silty clay. Other similar, minor soil series include Nuby and Montesa. These soils are mesic Typic Fluvaquents. The Aabab series occurs in terraces along streams and is a silt loam. The small area of the Wildlife Refuge on the Willapa Spit consists of former sand dunes where soils are from the Netarts and Yaquina series.

Soil productivity of marine terrace areas tends to be a little lower than in the coastal hills, but is still quite high on most soil types. Risk of mass wasting is generally low, except on steep slopes along the edge of the Willapa Bay Estuary that have a history of landsliding in response to forest management activities. Both shallow-rapid and small deep-seated failures have occurred here on slopes averaging 34%, indicating a lower slope threshold for landslide risk than in the coastal hills (Wegmann 2004).

Table 1: Proportion of area within each soil series and the corresponding site index.

Soil ID #	Series Name	WNWF % Cover	TNC % Cover	WH Site Index[1]	RA Site Index[2]
111-116	Palix	18%	39%	111	
155-160	Willapa	36%	0%	108	
89	Narel	0%	28%	104	
49-54	Ilwaco	24%	1%	103	
59-61	Knapton	2%	16%	104	
149-150	Vesta	1%	12%	112	
104	Ocosta	10%	0%		94
1	Aabab	0%	3%		100
95-96	Newskah	3%	0%	105	
65-66	Lebam	1%	1%	112	
162	Yaquina	2%	0%		90
102	Nuby	1%	0%		103
79	Montesa	1%	0%		102
144	Traham	1%	0%	92	
108	Orcas	1%	0%		
92	Netarts	1%	0%	107	

[1] Western Hemlock site index is 50yr from Barnes 1962.
[2] Red Alder site index is from Chambers (1974)
Soil Series are from Pringle (1986).

B. CONSERVATION SIGNIFICANCE

From a local to global perspective the SWBCA is an area of particularly high conservation significance. While the large estuarine ecosystem of Willapa Bay is renowned for the ecological and economic value of its marine resources and its shorebird migrations of hemispheric importance (Wolf 1993),populations (Wolf 1993) the forest and freshwater systems also harbor a rich diversity of species and habitats. Low elevation coastal rainforest habitats, such as those found in the conservation area, only occur in a few disparate regions of the world and are typified by high productivity. The forests of the SWBCA provide habitat for diverse assemblages of species, from familiar vertebrate species and abundant salmon to the less know, like fungi, lichens, bryophytes, and many groups of invertebrates such as mollusks and millipedes. These species, and others, all play key roles in functional pathways within the forest, such as decomposition and nutrient cycling. Amphibians are another important group of species within these forests and surveys by the Conservancy have shown the area to have some of the highest species richness in the Pacific Northwest.

Regional conservation assessments for the marbled murrelet and the Pacific Northwest Coast Ecoregional Assessment (The Nature Conservancy et al. 2006) have further substantiated the significance of this conservation area. Over the last several years, the Conservancy has worked with key partners to develop scientifically-rigorous conservation assessments for every North American ecoregion. These comprehensive assessments evaluate the full spectrum of biodiversity within a given ecoregion, identifying areas of biological significance where conservation efforts have the greatest value and potential success. The recently completed Pacific Northwest Coast Ecoregional Assessment(Vander Schaaf et al. 2006) was the product of a partnership initiated in 2001 to identify priority conservation areas in this ecoregion. The Conservancy, the Nature Conservancy of Canada (NCC), and the Washington Department of Fish and Wildlife (WDFW) were the primary partners in this project. The stated goal for the Pacific Northwest Coast Ecoregional Conservation Assessment was to "identify the suite of conservation areas that promote the long-term survival of all native plant and animal species and natural communities in the ecoregion." The SWBCA, and surrounding estuarine and freshwater systems, were all identified in this assessment as sites of high priority for conservation.

1. *Ecological Systems and Natural Communities*

Forests of the SWBCA are located entirely within the Sitka spruce zone of Franklin and Dyrness (1988) while the Natural Heritage Program's classification describes two major ecological systems for this area of the Pacific Coast – the North Pacific hypermaritime Sitka spruce forest, and the North Pacific hypermaritime western redcedar *(Thuja plicata*)-western hemlock (*Tsuga heterophylla*) forest ((http://www.natureserve.org/getData/USecologyData.jsp) (Comer et al. 2003)). Both of these ecological systems are restricted to areas within 40 miles of the coast at low elevation (typically less than 2,000 ft) where the climate is hypermaritime, with cool summers, very wet winters, abundant fog, and without a major winter snowpack. The natural disturbance regime is mostly small-scale windthrow or other gap mortality processes, occasional widespread intense windstorms, and very few fires (a detailed description and analysis of disturbance regimes and forest development pathways in these forest types is provided in Appendix A).

Sitka spruce forests are generally found in more productive micro-sites along valley bottoms or riparian terraces. Stands are typically dominated or codominated by Sitka spruce but often have a mixture of other conifers present, such as western hemlock (often a codominant), and western redcedar. The understory is rich with shade-tolerant shrubs and ferns, including salal (*Gaultheria shallon*), evergreen huckleberry

(*Vaccinium ovatum*), swordfern (*Polystichum munitum*), *Dryopteris* spp., and deer fern (*Blechnum spicant*), as well as a high diversity of mosses and lichens.

Western red cedar- western hemlock forests often contain nearly pure stands of hemlock and thrive in this environment where they are exposed to intense windstorms. The abundance of western red cedar in relation to other conifers is one of the diagnostic characters of this forest system, as is the low abundance of Douglas-fir (*Pseudotsuga menziesii*) and Sitka spruce. A shrub layer of salal, oval-leaf huckleberry (*Vaccinium ovalifolium*), and fool's huckleberry (*Menziesia ferruginea*) is usually well-developed. The prominence of deer fern is typical of hypermaritime conditions. Oregon oxalis (*Oxalis oregano*) is also important in the understory of particularly moist microsites.

Natural plant communities of these two ecological systems are limited to forest stands that have not been harvested or where limited entry has occurred. Specific plant communities identified within the Cedar Grove Research Natural Area include the western redcedar-western hemlock/evergreen huckleberry forest (Atkinson 1987). Forests at Ellsworth Creek and within the adjacent Ellsworth Creek Natural Resource Conservation Area include the Sitka spruce/Oregon oxalis forest, Sitka spruce/salal forest, western hemlock/Oregon oxalis forest, western hemlock/salal/deerfern forest, western hemlock/swordfern forest plant communities (Chappell 1997). Because forests at the Diamond Point Research Natural Area have been harvested they are not considered natural communities by the Washington Natural Heritage Program.

2. ***Rare plants***

Two rare plants are known from the vicinity of the SWBCA (Table 2), although neither is found in upland forest habitats covered by this plan.

Table 2: Rare plants known from the South Willapa Bay Conservation Area.

Scientific Name	Common Name	Ranking	Habitat	Location
Abronia umbellate ssp. a*cutalata**	Pink sandverbena	G4G5T1QSX Species was rediscovered in Washington in 2005	Shifting sands and dunes	Leadbetter Point
Hydrocotyle ranunculoides	Floating water pennywort	GS 5	Freshwater ponds, lakes, and streams.	Ellsworth Cr. estuary

* species is under review to determine whether it is distinctive or a northern population of *Abronia umbellate* ssp. *breviflora*.

3. ***Fish & Wildlife Populations***

The forest, riparian, marsh, and tidal habitats within the SWBCA provide habitat for a large number of species. An estimated 233 species of birds, 51 species of mammals, and 17 species of amphibians and reptiles are known to occur on the Refuge (USFWS 1999). The cool, wet climate of the Willapa area makes it a "hot spot" of amphibian diversity in Washington. Habitats on the Refuge and the Conservancy's lands may support up to 13 of the 24 native amphibians that occur in the state, including several regionally endemic species (USFWS 1999).

Several species of state and federal concern occur within the SWBCA (Table 3), including the marbled murrelet, bald eagle (*Haliaeetus leucocephalus*), and a number of invertebrate (e.g., mollusks and millipedes), lichen, and fungi species. Northern spotted owls (*Strix occidentalis caurina)* were known to inhabit the old-growth forest stands on Long Island in the 1980's, but have been replaced by barred owls (*Strix varia)* (USFWS 1987). Although spotted owl vocalizations were detected in the Ellsworth Creek and Teal Slough areas in the 1990's (USFWS 1999), they are now considered extirpated from the SWBCA. Habitat restoration may improve opportunities for spotted owl recovery in the future.

Table 3: Federal and state species of concern that are known from the Ellsworth Creek Preserve. FT = federal threatened, FCo = federal species of concern, ST = State threatened, SC = State candidate

Common Name	Scientific Name	Federal/State Endangered Species Status
Marbled Murrelet	*Brachyramphus marmoratus*	FT/ST
Bald eagle	*Haliaeetus leucocephalus*	FT/ST
Aleutian Canada Goose	*Branta canadensis leucopareia*	FCo/ST
River Lamprey	*Lampetra ayresi*	FCo/SC
Columbia torrent salamander	*Rhyacotriton kezeri*	FCo/SC
Cope's giant salamander	*Dicamptodon copei*	None/SM
Red-legged frog	*Rana aurora*	FC/None
Tailed frog	*Ascaphus truei*	FCo/SM
Van Dyke's salamander	*Plethodon vandykei*	FCo/SC
Dunn's salamander	*Plethodon dunni*	None/SC
Pileated woodpecker	*Dryocopus pileatus*	None/SC
Vaux's swift	*Chaetura vauxi*	None/SC
Sea-run Cutthroat trout - Southwest WA/Lower Columbia River ESU	*Oncorhynchus clarki clarki*	FC/None
Coho Salmon - Southwest WA/Lower Columbia River ESU	*Oncorhynchus kisutch*	FC/None

Marbled Murrelet

Marbled murrelets rely on coastal mature and old-growth forests for nesting and their populations have declined along with the loss of habitat to the point where today they are listed as a federally threatened species (USFWS 1997). Existing murrelet habitat and populations in the Willapa Bay area are important to the long-term viability of the species since the area is otherwise largely devoid of nesting habitat and forms a significant distributional gap in the range of the species. The federal recovery plan for the murrelet specifically identifies the protection of existing habitat, and "increasing the amount, quality, and distribution of suitable nesting habitat" in southwest Washington, as important recovery strategies (USFWS 1997). With some of the largest remaining stands of suitable nesting habitat in the Willapa Bay region, and a goal to restore additional, functional, late-successional forest systems, the SWBCA is clearly a crucial landscape for promoting the recovery of this marine bird species.

Significant federal grants have been awarded to both the Conservancy and the Refuge for habitat acquisition specifically aimed at supporting the recovery of marbled murrelet populations. Conservation of occupied murrelet habitat is a critical first step; however, effective restoration will be important in the procurement of the additional habitat necessary to recover the species within reasonable timeframes. Therefore, landscape restoration is a specific focus of this plan. The Conservancy has developed a robust, long-term forest restoration research program at Ellsworth Creek designed to provide guidance for restoring forest complexity in formerly managed coastal forests. Lessons learned through this research will be applied more broadly within the Preserve, on the Refuge, and hopefully on other federal and private lands in the coastal region. Recognizing this significant contribution to murrelet recovery, the U.S. Fish and Wildlife Service (USFWS) has proposed excluding both ownerships from designation as critical habitat for the marbled murrelet under section 4(b)(2) of the Federal Endangered Species Act (USFWS 2006). Justification for this exclusion is based on documentation that provides:

1. A management plan that is complete and demonstrates a conservation benefit to the species.
2. Reasonable assurances that the conservation management strategies and actions will be implemented.
3. Reasonable assurances that the conservation strategies and measures will be effective.

The USFWS is expected to review this restoration and management plan to ensure that these conditions are met. Elements of our approach to marbled murrelet conservation and habitat restoration/development are described throughout the management plan. Sections of particular note include …….

Portions of stands that are known to be occupied by nesting murrelets will not be targeted for biomass removal treatments. Young-managed forest stands of unsuitable habitat with simplified forest structures and dense stocking may, however, be actively managed, following the criteria and restrictions outlined in this plan, so they develop older forest structures more quickly that are suitable for meeting suitable murrelet nesting habitat.

Salmonids

Ellsworth creek contains one of the highest spawning densities of chum salmon (*Oncorhynchus keta*) in the Willapa Bay watershed with close to 8,000 fish reported over a 0.8 mile index reach in 2002 (Washington Department of Fish and Wildlife data). Although abundant populations of coho salmon (*Oncorhynchus kisutch*) and coastal cutthroat trout (*Oncorhynchus clarki*) are reported in the Ellsworth Creek drainage, systematic inventories of most fish species have not been conductedcompleted (scheduled for summer 2007). Stream surveys conducted on the Refuge (Barndt et al. 2000, Yoshinaka and Stone 2004) have observed coho and chum salmon, cutthroat trout, riffle sculpin (*Cottus gulosus),* and threespined stickleback (*Gasterosteus aculeatus)* in varying levels in different streams and note that spawning populations are likely. Therefore, theseEach of the Refuge streams and Ellsworth Creek are classified as being strongly heterotrophic (require complex organic chemicals for metabolic synthesis). Management actions proposed in this plan are expected to improve habitat for salmonids and other anadromous fish over time; however, short term effects of active forest restoration and road removal are unknown.

Figure 3: Amphibian diversity is extremely high within the SWBCA. Here a Van Dyke's salamander is followed by a Dunn's salamander with a western red-backed salamander in the background.salamanders.

Amphibians

The SWBCA is known to have some of the highest diversity of amphibian species is Washington state. In particular, surveys have found abundant populations of stream-associated amphibians in headwater tributary habitats. Species found here include Cope's giant salamander (*Dicamptodon copei*), Columbia torrent salamander (*Rhyacotriton kezeri*), Dunn's salamander (*Plethodon dunni*), Van Dyke's salamander (*Plethodon vandykei*), and the tailed frog (*Ascaphus truei*). Populations of these species have been in decline with research suggesting a relationship between intensive timber management practices and the degradation of habitat (Corn and Bury 1989). The distribution and population levels of these species are not fully known within the SWBCA. Recently initiated monitoring surveys within the Ellsworth Creek watershed should lead to a better understanding of population densities for this group of species.

Management actions proposed in this plan are expected to improve amphibian habitat over time; however, short term effects of active forest restoration and road removal are unknown.

4. ***Potential Threats to Conservation Value***

Throughout the SWBCA lingering threats to biological diversity remain from decades of logging activity, including habitat fragmentation, invasive species, sedimentation and altered hydrology related to extensive forest road systems. Climate change may also cause significant future changes in forest community composition.

When placed in the context of surrounding industrial ownerships, where intensive forest management with short rotations continues to prevail, the Conservancy and Refuge ownerships will provide an increasingly important refugia of mature and old forest habitat for fish and wildlife species within the coastal region of northern Oregon and southern Washington.

High Risk Invasive Species

Invasive species are considered by many to be one of the top two threats to the decline of biological diversity, together with habitat loss. While invasive species are thought to be uncommon within the SWBCA quantitative information on the distribution of most species is lacking. For this plan the focus is on invasive species that are found in upland forest, riparian forest and freshwater habitats. Exotic invasive species are spreading through forest and freshwater ecosystems in the Pacific Northwest at rates that are alarming ecologists. Species such as English ivy (*Hedera helix*), holly (*Illex aquifolium*), and Japanese knotweed (*Polygonum cuspidatum*) have become well established in some areas of Pacific County and are being targeted for eradication. Others like West-nile virus, sudden oak death (*Phytophthora ramorum*), and citrus long-horned beetle *(Anoplophera chinensis*) pose an enormous future threat to the region as they spread in nearby areas and are being closely monitored. The spread of these and other exotic species and even native pathogens have benefited from climatic changes and human manipulations of habitat. Interstate and international commerce, extensive road systems that fragment habitat, and the modification of natural ecological processes such as fire have all contributed to the globalization of ecosystems (Duncan 2001). For example, it is thought that the impacts of Swiss needle cast (*Phaeocryptopus gaeumannii*), a native foliage pathogen that affects Douglas-fir in coastal areas, has intensified with the large-scale adoption of uniform silvicultural practices favoring Douglas-fir production across the ecoregion (Thies and Goheen 2002). Given current patterns and conditions, we can only expect the list of exotic species and their breadth of distribution to increase over time.

Invasive species have the potential to alter the structure, composition, and function of ecological communities and are known to directly eliminate species from an ecosystem. Although the long-term ecological impact of many invasive species is unknown, there is growing concern with the increased number and distribution of species in this region. Moreover, the SWBCA is close to several ports of entry for these invasive species, which increases the likelihood of further introductions and infestations in the future. While non-native invasive species are relatively uncommon in the forested areas, they are slowly increasing in abundance, especially in proximity to roads. Species of particular concern in the SWBCA include English ivy (spreading along highway US 101) and English holly (which is seen scattered throughout the forest in low to moderate abundamce). While not specifically addressed in this plan, managers within the SWBCA should develop weed management plans in the near future to limit the spread of these and other habitat altering species.

Table 4: Major invasive weeds found within the South Willapa Bay Conservation Area and general ranking of abundance and distibution.

Common Name	Scientific Name	Abundance	Distribution	Potential Impact[1]
bull thistle	*Cirsium vulgare*	Low	Local	Low
common gorse	*Ulex europaeus*	Low	Local	Low
cutleaf blackberry	*Rubus laciniatus*	Moderate	Wide	Moderate
English ivy	*Hedera helix*	Low	Local	High
English (cherry) laurel	*Prunus laurocerasus*	Low	Local	Moderate
English holly	*Ilex aquifolium*	Moderate	Wide	High
hairy catsear	*Hypochaeris radicata*	High	Wide	Low
Himalayan blackberry	*Rubus discolor*	High	Wide	Moderate
giant knotweed	*Polygonum sachalinense*	Absent[2]	Absent	High
Japanese knotweed	*Polygonum cuspidatum*	Absent[2]	Absent	High
old-man-in-the-Spring	*Senecio vulgaris*	Moderate	Wide	Low
reed canarygrass	*Phalaris arundinacea*	Moderate	Local	Moderate
Scotchbroom	*Cytisus scoparius*	Moderate	Wide	Moderate
stinking willie	*Senecio jacobaea*	High	Wide	Low

1 Species with high impact could significantly alter forest habitat composition and structure - those with low potential are common in open or disturbed areas, but are not expected to persist as forest canopies develop.

2 Both knotweed species are not currently known from the SWBCA, however they are found nearby in the Naselle River drainage and have a high potential impact if populations are discovered in the future.

C. SITE HISTORY AND MANAGEMENT

1. *Pre-settlement Forest Composition*

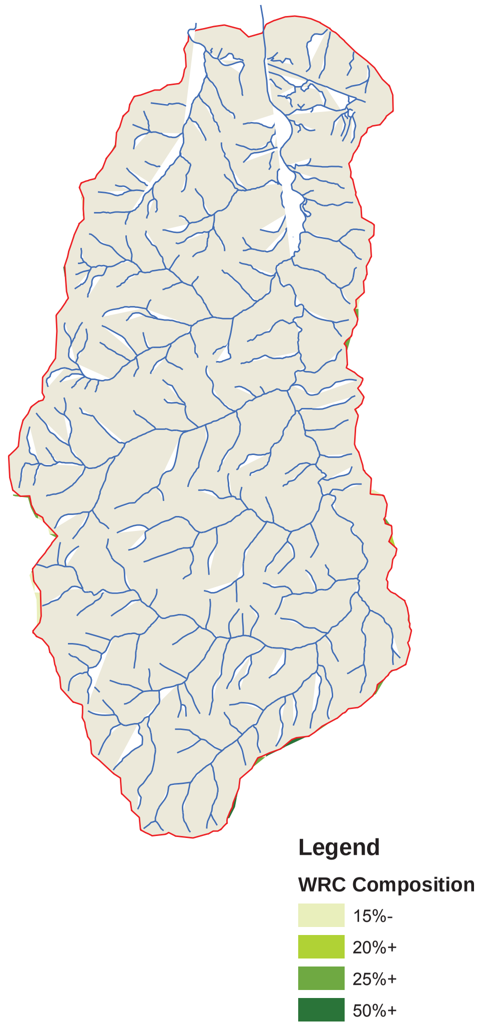
Holocene Vegetation

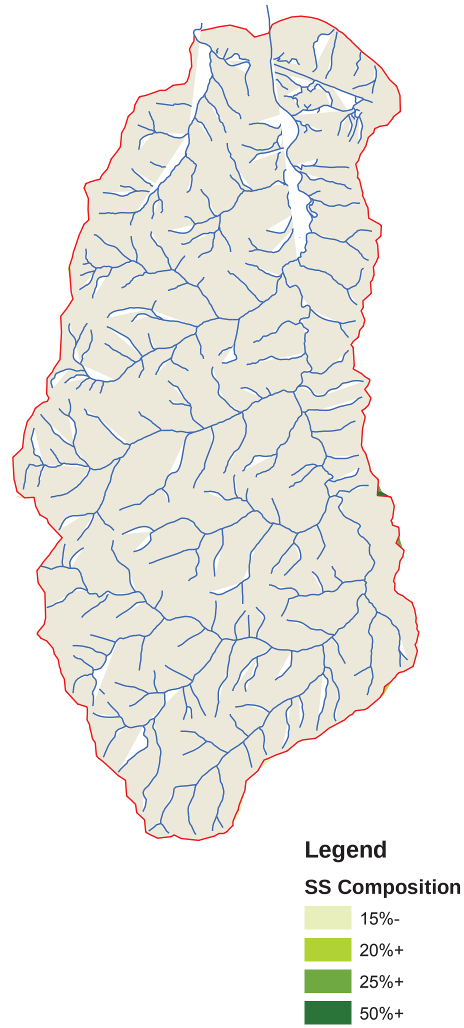
Vegetation assemblages in the maritime PNW have changed in response to climatic variation during the Holocene (10,000 yrs Before Present [BP] to current time). In the early Holocene, forest vegetation on the western Olympic Peninsula—which we assume to be representative of the planning area—transitioned from a pine-spruce-mountain hemlock-fir (*Pinus-Picea-Tsuga mertensiana-Abies*) community to an alder-Douglas-fir-bracken fern (*Alnus-Pseudotsuga-Pteridium*) community (Heusser C.J. 1977). This shift in species composition was apparently brought about by increasing temperatures coupled with a relatively droughty precipitation regime. Warming continued, apparently reaching a maximum during the Hypsithermal at approximately 7,000-8,000 BP (Heusser C.J. 1977). Modern vegetation assemblages developed about 5,000-6,000 years BP, concurrent with decreasing temperatures and increasing precipitation. Perhaps the most noticeable change in vegetation composition is the arrival and proliferation of western redcedar. In western Washington western hemlock and Sitka spruce increased in abundance simultaneous with the arrival of western redcedar (Whitlock 1992).

Sediment cores taken from a small lake in northern coastal Oregon just south of the mouth of the Columbia River provide a proxy record of fire and vegetation history for the planning area (Long C.J. and Whitlock 2002). Throughout the 4,600 year record the pollen (and spore) assemblage is dominated by red alder (*Alnus rubra*), western hemlock, Sitka spruce, western redcedar and sword fern —the characteristic modern flora of the locale. Charcoal and magnetic susceptibility data indicate that fire episodes occurred during the period 4,600-2,700 years B.P. more frequently (140 +/- 30 years) than the period 2,700 B.P. to present (240 +/- 30 years). The earlier of these two periods is characterized by a relatively greater abundance of alder and sword fern pollen, indicating that burned areas may have been occupied by a seral community analogous to the red alder/sword fern formation—a closed canopy community—described by Bailey and Poulton (1968) on the Tillamook Burn. Overall, fire appears to have been a significant disturbance agent over the last 4,600 years in these coastal forests.

Forests of the Early 20th Century

Powell et al. (2003) examined bearing tree records from section corners of the 1908 public lands survey, and estimated composition of the forests in the Ellsworth creek watershed at that time. While this method does not provide a complete picture of forest composition, it has been used by a number of authors to get an idea of pre-settlement conditions in other areas in Washington (Collins et al. 2002). Western hemlock was the dominant species in terms of total volume in almost every plot. From Powell's data, the maps were produced displaying the location and abundance of Sitka spruce, western redcedar, and Douglas-fir (Figure 4 – Historical Forest Composition). Sitka spruce appeared along the mainstem of Ellsworth Creek and in valley bottoms, while western redcedar was very abundant overall and generally missing where spruce is prevalent. Douglas-fir was present in minor amounts and red alder seemed to be very uncommon (Powell et al. 2003). Because close to 98 % of the watershed was identified as being in an old-growth structural condition (Powell et al. 2003), one can infer that stand replacing disturbance at stand to landscape scales were infrequent.





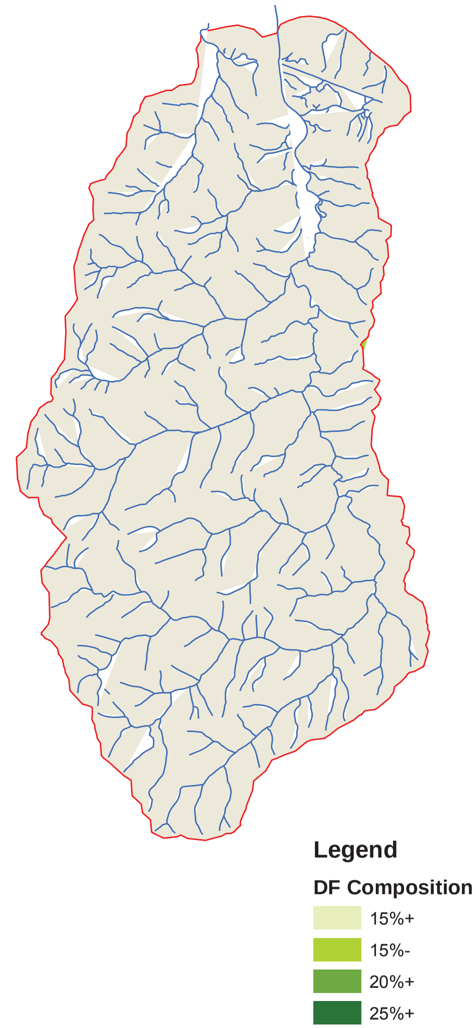


Figure 4: Historical Forest Composition - Sitka spruce, western redcedar, and Douglas-fir abundance in 1908 in Ellsworth Creek as percent of total plot volume (data from Powell et al. 2003)

2. *Human Use*

Native American History and Use

Prior to western settlement, the Willapa Bay region was inhabited by Native Americans for thousands, perhaps tens of thousands of years. The Chinook people were a widespread group of linguistically similar people who lived along the Columbia river upriver to present day The Dalles, OR and twenty miles up and down the Pacific coast from the Columbia's mouth. The Shoalwater tribe of the Chinook spent summers along the mouth of the Columbia River and lived along the protected shores of Willapa Bay, formerly called Shoalwater Bay, primarily during the winter. There are several known archaeological sites on Long Island which are remains of Indian Villages and middens (USFWS 1979).

The Chinook fished for salmon, sturgeon and eulachon (smelt), and gathered clams, oysters, seaweeds and other inter-tidal foods. They also harvested cranberries, wapato and other plants from local wetlands. The Chinook were prolific traders; occupying a strategic location at the mouth of the Columbia where they controlled trade of a wide variety of goods and staples between inland tribes and tribes up and down the Pacific coast (USFWS 1979).

Chinook use of the forested uplands appears to have been minimal and infrequent, and there is little information about how the Athabascan tribes may have used the inland forest areas. Western redcedar was highly valued by the Chinook. They used cedar bark to make clothing, baskets and other woven goods. Certain cedar trees or stands are known to have been favored for bark gathering by the Chinook, but no such sites have been documented within the planning area. Cedar was relatively easy to split into planks for use in building their rectangular longhouses for communal living and storage. The Chinook were renowned for their craftsmanship in building cedar dugout canoes and for their skill in open water navigation, but the cedar they used for canoe building came from the forest margins or beaches in the form of driftwood. The Shoalwater people used large canoes for fishing and transporting trade goods and small canoes on local streams to facilitate portage between the Columbia River and Willapa Bay until ship-based trading began with the Chinook after Captain Robert Gray first navigated the Columbia River in 1792.

Settlement History

Anglo American settlement of the region began shortly after the historic journey of Lewis and Clark to the lower Columbia during the winter of 1805-1806. The first permanent settlements in the area were established as outposts for fur trading companies such as the Hudson's Bay Company and the Pacific Fur Company. The settlements that followed focused on salmon harvest with logging increasing from local procurement to volume production over time.

The Naselle River valley was first settled, predominantly by Finnish immigrants, in the 1850's. The growing community coalesced around agriculture, especially dairying, with fishing and timber production also providing significant employment. Other settlements in the area fared less well in the long run. Diamond City was established in 1867 at the north end of Long Island, primarily to harvest and sell the area's oysters. By 1878, the area's oysters were depleted and the town was abandoned. Speculative development led to the platting of a town on the eastern margin of Ellsworth creek. As discussed in a report by Bryan Penttila (2002), a hotel was built during the early history of the Ellsworth Creek area which was used by passing boating traffic. The town however never became a reality.

3. *Forest Management History*

Like much of coastal Washington, forest management began slowly in the beginning of the 20th century. As recently as 1942, nearly 87% of Ellsworth Creek's forestlands remained as unmanaged old-growth (Powell et. al. 2003). Aside from some minor logging at the mouth of Ellsworth Creek by the Ellsworth family, logging in the watershed began during World War I. The United State Spruce Production Division set up camp in 1918 and built several kilometers of narrow-gauge railway into the watershed (Penttila 2002).

Although this effort only lasted 6 months, a surprising number of large Sitka spruce were selectively logged, mainly in the middle portion of the main stem of Ellsworth Creek. With the advent of chainsaws and the Caterpillar bulldozer, the Brix Logging Company began extensive road building and timber harvesting in the watershed in 1943 (Penttila 2002). By 1950, Brix had relocated and in 1960 the Weyerhaeuser Timber Company took control of the forests and began logging operations. Weyerhaeuser rapidly expanded the road network and introduced high yield, even-aged silvicultural systems (clearcutting) throughout the basin. In the 1980's, John Hancock Insurance Company and the Campbell Group purchased Ellsworth and continued to log extensively. By 2001, when the Conservancy acquired the basin, only 7%, or approx. 350 acres, of the original old-growth forests remained (Figure 5 – Historical Forest Age Class Distribution). Over 16% of the basin has been cut twice and is now in its third rotation (Powell et. al. 2003). Although historical information for the Conservancy or mainland Refuge forests outside of the Ellsworth Creek basin is not known, the logging history is presumed to be similar to what is known from Ellsworth Creek.

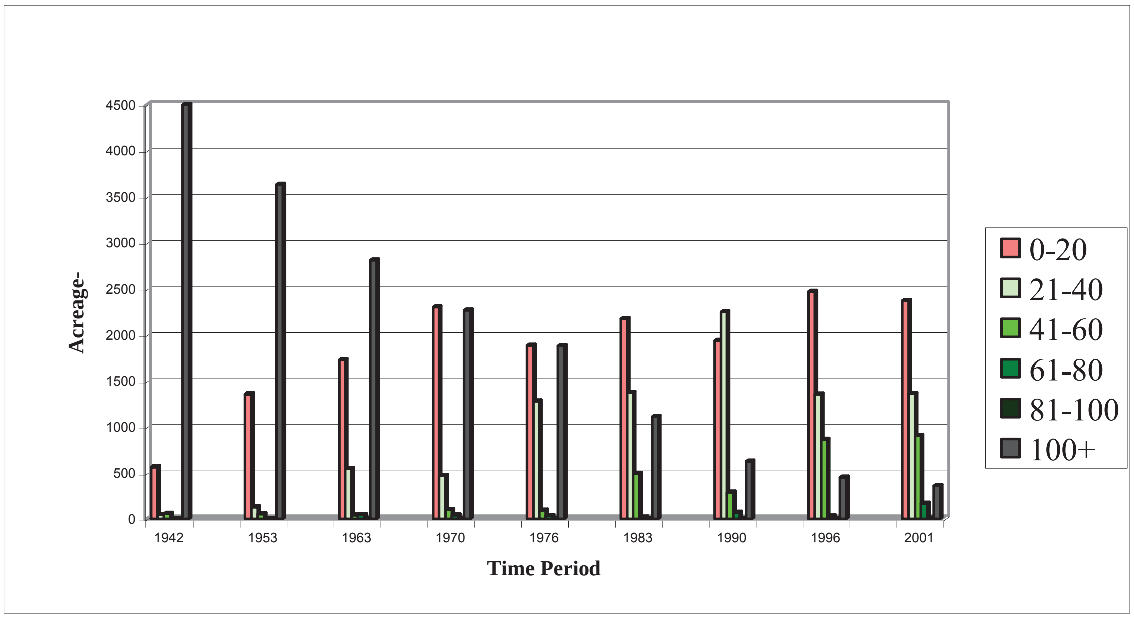


Figure 5: Historical changes in forest age class distribution from harvest activities in the Ellsworth creek basin (From Powell et. al. 2003)

Logging on Long Island began in the late 1800's and most of the island was logged by private timber companies with a focus on old-growth western red cedar and Sitka spruce – as western hemlock was then considered unmarketable. Regeneration was mostly natural and little thinning was done over the years. The Refuge began acquiring land on the island from the Weyerhaeuser Company in 1940 and consolidated its holding with two Land for Timber Exchange Agreements in the 1950's.

In the early 1950's, an outbreak of the Hemlock Looper occurred in Northwest Oregon, from the Astoria Area to the Tillamook Burn Area within the Spruce/Hemlock Zone. Stands of old hemlock (>200 years old) were defoliated. Extensive salvage operations took place by industrial timber land owners, to capture the mortality. Natural regeneration of dense hemlock followed. It was also reported by a local resident, that the South Willapa Bay Area (including Long Island) was aerial sprayed with DDT to prevent the potential threat to the older hemlock stands in the area.

Between 1960 and 1968 the Refuge harvested timber on its own lands following a plan developed in 1960. Following a large windstorm in 1962, both the Refuge and Weyerhaeuser Company increased harvest around salvage operations. A review of the Refuge's harvest practices in 1968, however, resulted in a halt of logging operations until 1975 when the Refuge entered into a memorandum of understanding with the

Weyerhaeuser Company to acquire the remainder of the companies lands (at that time 1,622 acres) on the island. The agreement stated that both parties would develop a cooperative resource management plan for the island. As part of the plan Weyerhaeuser agreed to exchange its lands to the Refuge for the value of the timber on the island. At the time it was felt that harvesting of this timber resource was consistent with the Refuge's goals for wildlife management (USFWS 1979). Most of the harvestable forest stands were even-aged stands dominated by western hemlock and less than 100 years old, having regenerated after logging and wildfire before the turn of the century. Weyerhaeuser proceeded to harvest 1,009 acres in total (USFWS 689 acres, Weyerhaeuser 320 acres) and transfer its entire ownership to the Refuge until the program was completed in 1987.

4. ***Current Land Use and Surrounding Ownership***

Naselle is currently an unincorporated town of approximately 400 residents and perhaps 1400 people living within the school district. Primary economic activity centers on timber production and commercial fishing and decreasingly on farming. Following the completion of the Megler Bridge across the Columbia River in 1966, tourist traffic through the area has increased as has development

Land use patterns in this largely rural county (Pacific) are dominated by private forest land dedicated to commercial timber production. Large lot residences are scattered along major highways and secondary county roads. This pattern is consistent within the immediate vicinity of the SWBCA. That is, neighboring lands are, by and large, commercial timber holdings with limited numbers of home sites adjacent to county roads. The commercial timberlands directly adjacent to the SWBCA are largely owned by investment groups and managed by timber investment management organizations (TIMO's). Two TIMO's, Campbell Group and Hancock Investments, manage adjacent forestland for investment return purposes.

5. ***Recreation and Public Access***

The Ellsworth Creek Preserve is open to public access though vehicle traffic is restricted behind locked gates. Walk in access is permitted inside gated areas; however, no formal trails are maintained for public use. Hunting and fishing activities are allowed within the preserve as permitted by state regulations. Fires and camping are not allowed.

The Refuge offers a variety of public access and recreational activities. Campgrounds, hiking trails, hunting, boating and wildlife viewing are all provided at various locations around the Refuge. The Refuge has an active public recreation program that maintains and develops appropriate public infrastructure and interpretation.

Long Island is a main focus of boating and hiking activities, and the only area on the Refuge where camping is permitted. Access to the Island is strictly by boat. The Refuge provides a public boat launch at the headquarters location. There is a boat ramp on Long Island just south of there. Five campgrounds, all accessible from the water, are spread across Long Island. Former logging roads or trails currently link all but one campground to the main road system. Another trail loops through the "cedar grove", a stand of ancient western redcedar located at the center of the south end of the island. Modern firearm hunting is not permitted on the island, however, archery hunting is allowed.

6. ***Bonneville Powerlines***

Two electrical transmission lines, owned and managed by the Bonneville Power Administration, traverse the Ellsworth Preserve and Refuge property. This line emanates from the power substation located in

Naselle and supplies power to local public utility districts in the Ilwaco and Long Beach Area. It is a 6-line system, generally contained on one large transmission structure but sometimes splits into two 3-line transmission structures. It runs westerly along the south side of the Naselle River estuary and continues inland along the north boundary of the DNR's Ellsworth NRCA. The line then heads north along Pellervo ridge before turning southwest and crossing the Ellsworth estuary. It then continues westerly and southerly through the Ellsworth Preserve for several miles, then continues in a southerly manner for several miles through the Ellsworth Preserve, then leaves the Willapa Forest continuing westerly across Highway 101 near Greenhead Slough, and finally splitting into two lines—one continuing westerly across the South Willapa Bay Estuary and one continuing southerly through the Refuge's North Bear river unit towards Seaview.

The BPA transmission line right-of-ways run for 3.6 miles through TNC property and 1.9 miles through Refuge property. In addition, a number of roads are associated with maintaining the transmission lines and rights-of-way. Many are rudimentary (narrow and unrocked) roads. These access roads can be a source of erosion, sedimentation, and water quality degradation particularly on the Ellsworth Preserve.

The areas underneath the transmission lines are maintained in a manner that precludes trees from growing taller than 10 feet. Thus, the transmission line right-of-ways significantly influence and impact operational activities and landscape level forest restoration goals. These barriers are an operational and restoration challenge and will have to be factored in to annual operation plans.

Landscape Resource Assessment

Long Island and Willapa Bay looking northwest from Bear River Ridge

A. Forest Vegetation

1. *Forest Inventory and Key Structural Metrics*

Stand structure and species composition varies considerably in particular stands due to differences in age and management history. To gain a thorough picture of existing conditions, a detailed forest inventory was conducted by Integrated Resource Management (IRM) on both the Conservancy and Refuge ownerships in 2004 (Stringer 2005). Over half of the total acreage and a representative sample of age classes were inventoried (Table 5). The inventory was based on field protocols developed under the Oregon Department of Forestry's Stand Level Inventory Protocol (ODF 2002). Basic forest structure attributes were sampled along with understory plant cover, downed wood, snags, and forest health concerns. An average of 15 plots were installed within each stand. While not complete for the entire ownerships, the information is sufficient for long term planning efforts. Additional inventory work will be conducted during management activities in specific stands and through an ongoing effort to re-sample approximately 10% of the forest stands within the SWBCA each year.

Table 5: Distribution of stand types and acres inventoried in 2002-2004 by IRM and un-inventoried stands (includes additional data from the 2006 Rogers addition to the Ellsworth Creek Preserve).

Stand Type	TNC		WNWR		All
	Inventoried acres & (stands)	*Un-invent. acres & (stands)*	*Inventoried acres & (stands)*	*Un-invent. acres & (stands)*	*Total Number of acres & (stands)*
WH-SS-RC-1 (0-15yr)	614 (12)	256 (5)	13 (1)	837 (15)	1,719 (33)
WH-SS-RC-2 (15-30)	1,171 (14)	521 (15)	77 (1)	50 (4)	1,818 (34)
WH-SS-RC-3 (30-60)	1,388 (15)	124 (7)	2,194 (19)	303 (11)	4,009 (52)
WH-SS-RC-4 (60-100)	292 (9)	128 (8)	1,063 (16)	564 (18)	2,048 (51)
WH-SS-RC-5 (100+)	269 (2)	23 (3)	500 (5)	34 (3)	826 (13)
Douglas-fir-1 (0-15yr)	60 (2)	388 (8)	35 (1)	80 (1)	564 (12)
Douglas-fir-2 (15-30)	607 (4)	821 (14)	103 (1)	351 (2)	1,882 (21)
Red Alder-1 (0-15yr)	73 (4)	0 (0)	0 (0)	77 (1)	150 (5)
Red Alder-2 (15-30)	0 (0)	2 (1)	0 (0)	221 (5)	222 (6)
Red Alder-3 (30-60)	12 (1)	106 (7)	103 (3)	33 (5)	253 (16)
Red Alder-4 (60-100)	0 (0)	0 (0)	200 (3)	20 (3)	220 (6)
Non-forest	0 (0)	76 (4)	0 (0)	382 (7)	458 (11)
Totals	4,486 (63)	2,444 (72)	4,288 (50)	2,952 (75)	14,170 (260)

This baseline inventory information was used to calculate common structural metrics for each inventoried stand (Appendix B). Inventory data was also input into the Landscape Management System (LMS) (McCarter et al. 1998) to facilitate many types of stand and landscape level analyses. To quantify stand structure, guide management decisions and gauge progress towards desired future conditions, two key metrics were chosen - Stand Density Index (Long J.N. 1985, Reineke 1933) and Weighted Old-growth Index.

The Stand Density Index (SDI) was selected to measure degree of site occupancy and level of tree competition, or relative density. While Curtis' Relative Density (Curtis 1982) is commonly used for Douglas-fir and Relative Density Index (Drew and Flewelling 1979) can be used for both Douglas-fir and western hemlock stands, SDI is the most broadly used across different species (Woodall et al. 2006) and is the only metric that has been used by numerous researchers in multi-species and multi-cohort stands (Amoroso 2004, Long J.N. 1996, O'Hara 1996, Puettmann et al. 1993, Woodall et al. 2005). This is done by calculating SDI for each species, cohort, or diameter class and then adding them together (Long J.N. 1995, Shaw 2000). As SDI was designed for use with single cohort and single species plantations, there are significant challenges to using it in complex stands (O'Hara and Gersonde 2004, Woodall et al. 2005). Yet it is the most versatile density metric that is still practical for management applications.

The Weighted Old-growth Index was developed by Franklin et al. (2005) to assess old growth structure on Washington State DNR lands across western Washington. For the SWBCA landscape, a Modified Old-growth Index (MOGI) was used that does not include stand age (Franklin J.F. et al. 2005). The MOGI is based on for structural variables associated with old-growth forests:

1. Large trees (number per acre > 100 cm dbh [40 inches])
2. Large snags (number per hectare > 50 cm dbh and > 15 m tall [20 inches dbh; 49 feet tall])
3. Volume of down woody debris (cubic meters per hectare)
4. Tree size diversity: (# of trees in the following 4 diameter classes: 2-9.9", 10-19.9", 20-39.9", 40"+)

The MOGI ranks old-growth structure for each stand on a scale of 0-100, with 75 representing the median of the old-growth dataset used by Franklin et al. (2005). The four structural variables can be weighted to increase or decrease the importance of a particular structural variable; variables were equally weighted in the analysis of SWBCA stands. MOGI has been successfully used to identify old-growth stands from inventory data in coastal spruce-hemlock-cedar forests (Franklin et al. 2005). However, old-growth stands will not necessarily attain perfect scores (i.e. 100). In general, MOGI scores increase with stand age (Map – SWBCA Modified Old-Growth Index). Old-growth SWBCA stands averaged 62 with a 90% confidence interval of 22-72. The highest MOGI scored was the main cedar grove stand on Long Island with a score of 73 (stand #30026).

2. ***Forest Stand Types***

The IRM inventory information was used to classify stands into stand types (Map – SWBCA Stand Types). For un-inventoried stands, inventory data from past owners, aerial photos, and field verification was used. In order to make this classification simple and practical for management purposes, typing was based on dominant species (over 50% of basal area) and age class using age at breast height. When needed for landscape level analysis, stands can be further classified according to attributes such as developmental stage, SDI, MOGI, presence of residual old-growth legacy features, or relative species composition. Averages for each stand type of these attributes, along with other forest structural variables, are presented in Table 6.

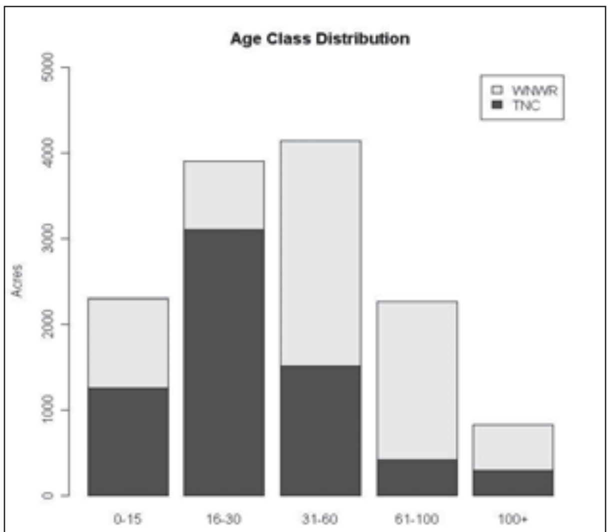


Figure 6: Age class distribution of forests in the Refuge and Conservancy ownerships in 2006.

Overall, both ownerships are dominated by structurally simple managed forests younger than 60 years of age since harvest (Figure 6 – Age Class Distribution) . The old-growth index values also proved to be fairly well correlated with age class with scores being relatively low for most of the inventoried stands as would be expected given the SWBCA's management history.

South Willapa Bay Conservation Area
Stand Types

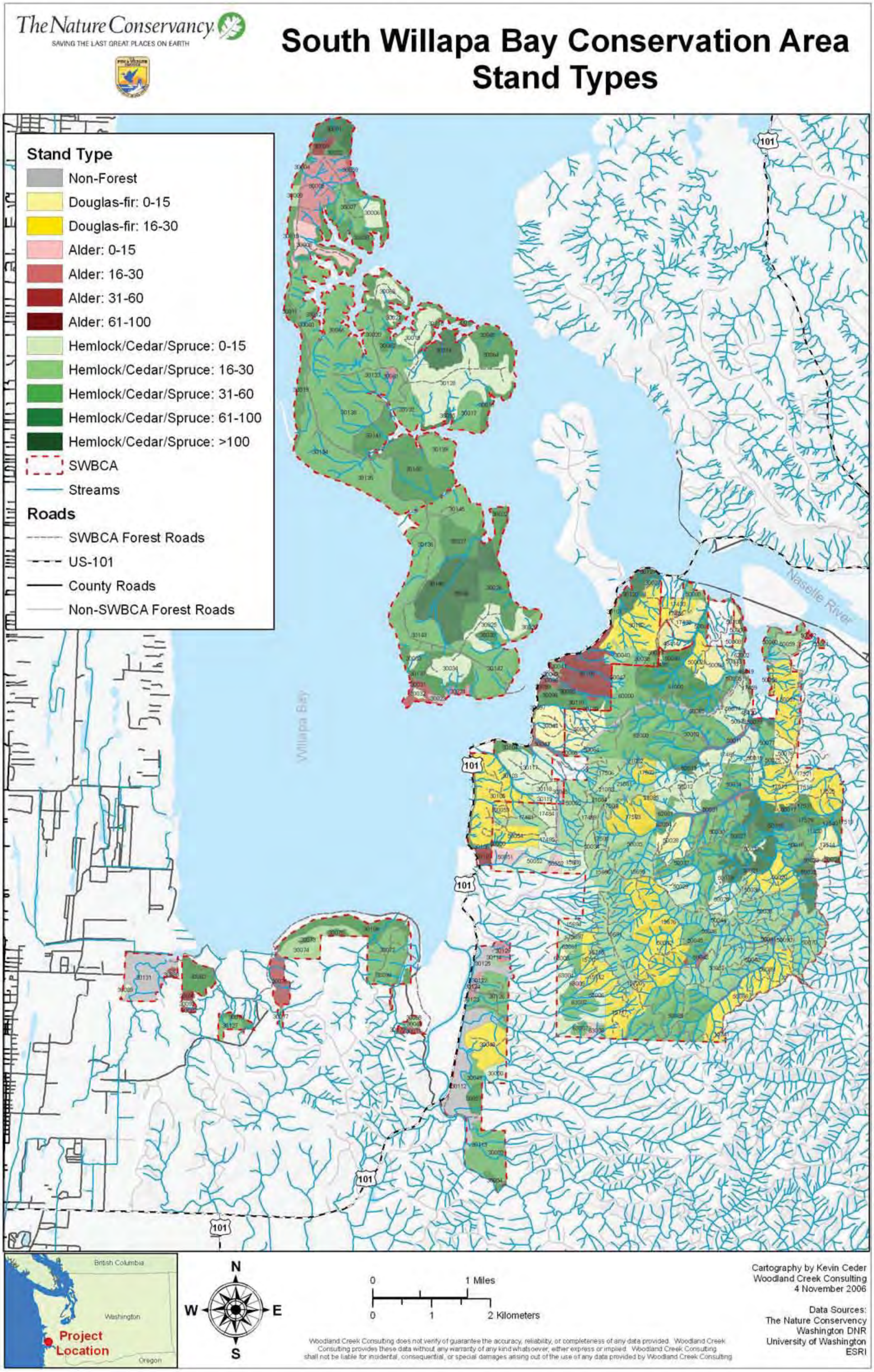


Table 6: Average stand metrics and 90% confidence limits *(Italics)* for stands inventoried by IRM. NF = attribute not found. *NA* = insufficient data for confidence interval.

		Live Trees									Snags and Downed Logs				
Stand Type	**N**	**BA**	**TPA**	**TPA > 10**	**TPA > 18**	**TPA > 30**	**AVG DBH**	**QMD**	**RD**	**TREE VOL**	**SPA**	**AVG DBH**	**LPA**	**LOG VOL**	**MOGI**
DF-1	3	11 *(5)*	1910 *(2975)*	1 *(NA)*	NF *(NA)*	NF *(NA)*	1 *(1)*	1 *(1)*	11 *(7)*	0 *(0)*	1 *(NA)*	11 *(NA)*	326 *(366)*	97 *(20)*	15 *(8)*
DF-2	6	164 *(25)*	597 *(224)*	60 *(51)*	3 *(2)*	NF *(NA)*	6 *(1)*	7 *(1)*	61 *(8)*	20 *(5)*	60 *(51)*	12 *(1)*	241 *(135)*	92 *(40)*	32 *(7)*
RA-1	4	104 *(214)*	694 *(996)*	96 *(59)*	21 *(22)*	4 *(NA)*	4 *(8)*	5 *(10)*	33 *(69)*	18 *(38)*	96 *(59)*	17 *(2)*	291 *(513)*	90 *(100)*	25 *(14)*
RA-3	2	118 *(21)*	642 *(4117)*	56 *(106)*	3 *(21)*	NF *(NA)*	5 *(24)*	6 *(22)*	48 *(90)*	13 *(5)*	56 *(106)*	13 *(2)*	194 *(2347)*	84 *(858)*	28 *(101)*
RA-4	2	233 *(1183)*	720 *(1375)*	135 *(800)*	24 *(132)*	2 *(9)*	5 *(32)*	8 *(27)*	81 *(282)*	39 *(171)*	135 *(800)*	16 *(8)*	127 *(567)*	60 *(6)*	32 *(183)*
WH/SS/RC-1	9	63 *(66)*	2026 *(897)*	24 *(33)*	21 *(23)*	6 *(6)*	2 *(2)*	3 *(3)*	30 *(20)*	8 *(16)*	24 *(33)*	17 *(4)*	277 *(89)*	107 *(31)*	25 *(11)*
WH/SS/RC-2	17	160 *(23)*	874 *(233)*	64 *(25)*	6 *(5)*	3 *(2)*	5 *(1)*	6 *(1)*	64 *(7)*	17 *(5)*	64 *(25)*	13 *(1)*	243 *(62)*	103 *(30)*	31 *(6)*
WH/SS/RC-3	41	253 *(24)*	760 *(146)*	150 *(18)*	18 *(5)*	2 *(1)*	6 *(1)*	8 *(1)*	87 *(8)*	43 *(6)*	150 *(18)*	15 *(0)*	283 *(51)*	104 *(18)*	38 *(3)*
WH/SS/RC-4	27	277 *(27)*	822 *(242)*	113 *(16)*	30 *(6)*	7 *(2)*	6 *(1)*	9 *(1)*	94 *(8)*	60 *(8)*	113 *(16)*	18 *(1)*	179 *(42)*	94 *(20)*	48 *(4)*
WH/SS/RC-5	5	313 *(70)*	469 *(353)*	72 *(23)*	45 *(9)*	16 *(3)*	7 *(6)*	13 *(6)*	91 *(26)*	91 *(19)*	72 *(23)*	24 *(2)*	105 *(57)*	123 *(72)*	62 *(10)*

Definitions
Species: DF = Douglas-fir, RA = red alder, WH/SS/RC = western hemlock, Sitka spruce or western redcedar
Age class (yrs): 1 = < 15, 2 = 15 – 30, 3 = 30 – 60, 4 = 60 – 100, 5 = > 100
N: Number of stands within each Stand Type inventoried in 2004 by IRM.
Live Tree Metrics: BA: Total basal area in square feet. TPA: Total trees per acre. TPA > 10: Trees per acre with DBH > 10”. TPA > 18: Trees per acre with DBH > 18”. AVG DBH: Arithmetic average DBH in inches. QMD: Quadratic Mean Diameter in inches. RD: Curtis’s Relative Density. TREE VOL: Scribner board-feet volume per acre in thousands of board-feet per acre.
Snags and Logs: SPA: Total number of snags per acre. AVG DBH: Average DBH of snags in inches. LPA: Total number of logs per acre. LOG VOL: Total cubic foot volume of logs in thousand cubic feet.
MOGI: Modified Old-Growth Index

Western hemlock/Sitka Spruce/Western Redcedar types

This is by far the most prevalent type on both ownerships and was dominant throughout most of the landscape in the pre-settlement times. While western hemlock typically dominates these stands in terms of trees per acre and basal area, Sitka spruce and western redcedar make up significant portions of these stands and in a few cases are the dominant species. Red alder is abundant in riparian areas and along roads and landings, and a minor to moderate component in upland areas. Douglas-fir is relatively rare, but present in varying degrees due to management history. Images generated by the Stand Visualization System (SVS) using inventory information from specific stands are provided for each age class in (Figure 7 – SVS stand types).

The 100 yr+ age class is either unmanaged old growth or stands that were selectively logged by the U.S. Spruce Production Division or early settlers. While this partial harvesting altered some of these current old growth stands, it is not clear to what extent and what the impact on current stand structure is. Approximately 825 acres of this age class exist across the SWBCA. Three major types of remnant old-growth stands exist in the SWBCA landscape – spruce-hemlock, cedar-hemlock, and pure hemlock.

Spruce-hemlock stands typify the old-growth remnants in along the lower reaches of Ellsworth Creek. This stand type is analogous to the Sitka Spruce-Western Hemlock Plant Association Group (PAG) of Franklin et al. (2005) and the Sitka spruce Zone of Franklin and Dryness (1988). Large diameter spruce are the dominant feature in these stands while hemlock dominate the understory and midstory. Spruce is moderately shade tolerant and long-term coexistence with hemlock is thought to be mediated by canopy gap formation (Taylor A.H. 1990). Spruce-hemlock stands were historically distributed along the lower reaches of the Ellsworth Creek and major tributaries.

Cedar-hemlock stands historically dominated the uplands of the Ellsworth Creek watershed and most of Long Island. These stands most closely resemble the Western Redcedar Coastal Plain PAG of Franklin et al. (2005). They do not seem to be an exact match however; the regeneration difficulties typical of the Western Redcedar Coastal Plain PAG are not apparent anywhere in the SWBCA landscape. Very large cedars are the dominant feature in these stands; individuals up to 15' dbh can be found in the SWBCA landscape. Woody debris loads can be extremely large due to the decay resistance of cedar wood. These forests appear to be maintained by chronic, low to moderate severity wind disturbance which primarily affects hemlock and not the decay and wind resistant cedar. Understory vegetation is dominated by dense thickets of salal, fool's huckleberry and evergreen huckleberry.

A few residual old-growth stands, particularly in the Ellsworth Creek Watershed, appear to be a mixture of the two former types. All three major species, spruce, hemlock and cedar can occur in relatively even mixture. This mixed type was most likely more common in historical conditions than is suggested by the composition of present day remnant old-growth stands.

Pure or nearly pure hemlock stands comprise the third old-growth forest type. Classical old-growth structures—large diameter trees, snags and logs—are relatively scarce in these stands due to the relatively short lifespan of hemlock. Understories can be poorly developed, particularly when the overstory is intact. The origin and developmental history of these stands is not clear. The most likely explanation is that they established as high density hemlock stands following periodic disease/insect outbreaks, high severity wind disturbances, and prolific stress seed production. Throughout remnant old-growth stands on the mainland, and less so on Long Island, occasional Douglas-fir individuals add structural and compositional diversity.

The 30-60 and 60-100 year age classes are mostly a result of the Brix company operations and early Weyerhaeuser logging that was focused on removing high value trees. Natural regeneration was relied on, and abundant legacies such as decadent old-growth hemlock, mid and understory trees, non-merchantable downed logs, and snags were typically left following harvest. These stands tend to have higher levels of structural complexity and are mostly naturally regenerated hemlock, some Sitka spruce, and little western redcedar. Some of these stands appear to have been pre-commercially thinned to densenarrow spacing (e.g., 8 x 8' to 10x10'), in anticipation of future clearcut harvesting at around age 45-50 years old8 feet to 10x10 feet). In general, these stands are very dense, have little understory development, and are in the competitive exclusion stage. Some older stands in the 60-100 year age class are more complex, however, and are in an understory re-initiation stage of development.

The 15-30 year age class is marked by changes in management practices. In 1967, Weyerhaeuser introduced High Yield Forestry and began planting Douglas-fir seedlings immediately following timber harvest (Pentilla 2002). However, natural western hemlock regeneration often overtook planted seedlings. In addition, it was a routine practice to aerial spray the young conifer plantations to eliminate competing hardwood trees and shrubs. A shift toward much more intensive site prep began that included snag felling, slash removal, and broadcast burning. By the mid 1970s thorough site prep and planting were standard practice and pre-commercial thinning became common. While a portion of this age class has been pre-commercially thinned and has densities of approximately 350 trees per acre (TPA), many stands have not and are extremely dense. Few, if any, legacies exist, and stands are simplified conifer plantations in the canopy closure or early competitive exclusion stage. They have varying degrees of species diversity, and a few stands dominated by Sitka spruce exist. Where western redcedar is found, it is generally in the lower crown classes due its slower early height growth (Oliver and Larson 1996, Ruth and Harris 1979) and is commonly dying out from competition induced mortality.

The 0-15 year age class is comprised of recent clear-cuts, usually of second-growth stands. Broadcast burning fell out of favor in the late 1980's and 1990's and site prep and control of competing vegetation was typically not as thorough in these stands. Small numbers of snags, live trees, and 25-50' riparian buffer strips were left due to changes in forest practice regulations, although a few stands contain large number of legacy old growth snags. Western hemlock and Sitka spruce were either planted or have outgrown Douglas-fir affected by Swiss Needle Cast. Red alder and western redcedar are moderately abundant. These stands are in the cohort establishment or canopy closure stage, and typically have higher levels of tree species diversity, shrubs and forbs, and patchiness than the 15-30 year age class. They are still structurally simple plantation stands, however, and competitive exclusion will eliminate much of the diversity and complexity in the next 10-30 years if left alone.

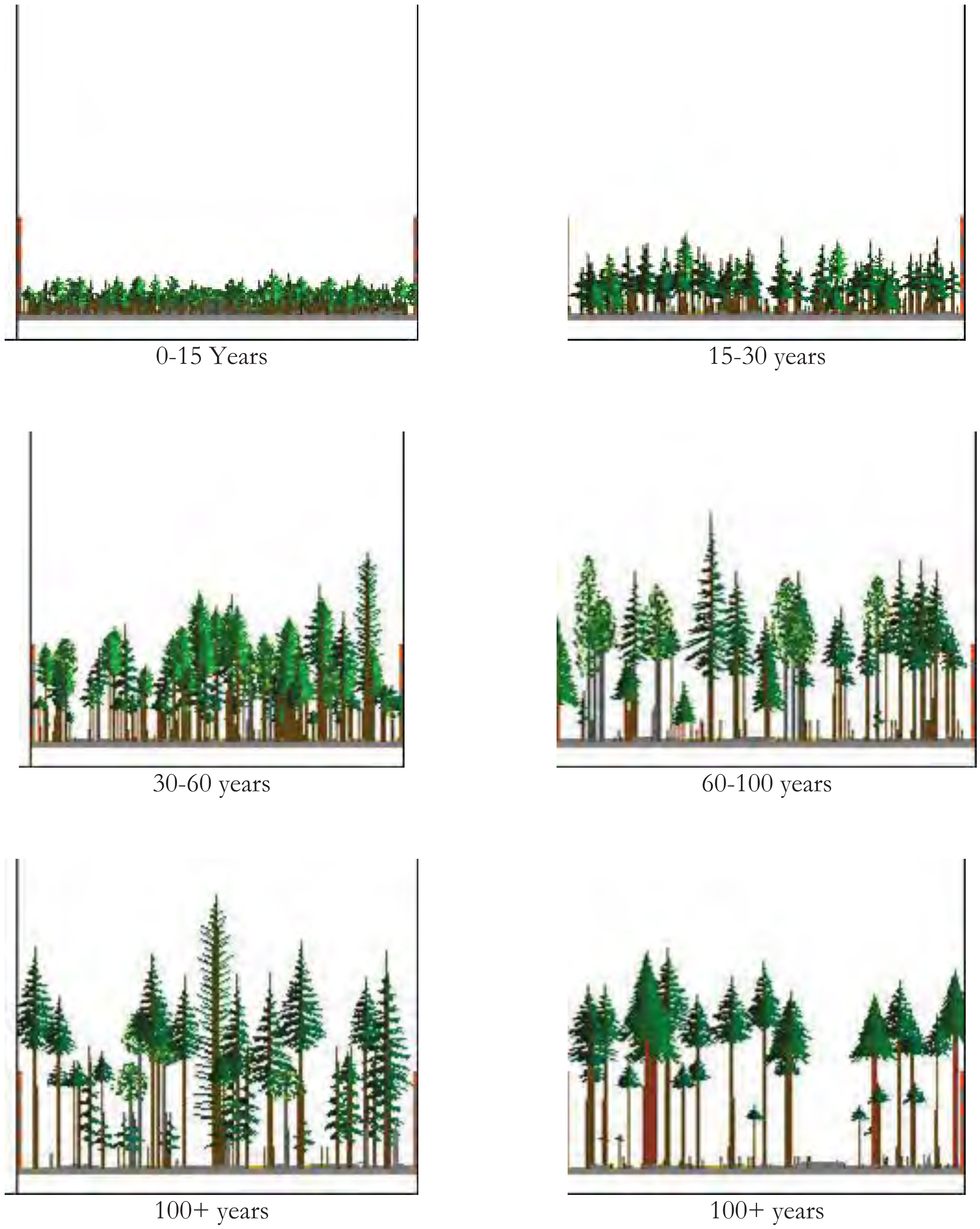


Figure 7: SVS images of different age classes of western hemlock, Sitka spruce, western redcedar stand type. Two 100 year + stands are provided to demonstrate differences in old-growth structure.

Douglas-fir types

The two age classes of Douglas-fir, 0-15 and 15-30 years, resulted from planting Douglas-fir after intensive site prep and control of competing vegetation. The oldest stands are approximately 30 years old. Establishing Douglas-fir in this region proved to be a challenging task and often failed (Tappeiner et al. 2002). Except for stands that were pre-commercially thinned to heavily favor Douglas-fir, stands have significant amounts of other trees species. While the Douglas-fir appears to be growing well in most places, Swiss Needle Cast is prevalent and has reduced foliage density in many stands. Except for the dominance of Douglas-fir, these stands are similar in structure to corresponding age classes in the western hemlock type as described above.

Red alder types

Red alder stands established in areas where naturally regenerated red alder was not controlled and was able to outgrow planted or naturally regenerated conifers. While alder is the dominant species, these are typically mixed stands with significant amounts of conifers in both the overstory and understory (Figure 8 – SVS alder stand types). In the younger age classes, 0-15 and 15-30 years, density tends to be high and crown competition between alders and conifers is intense. The older age classes, 30-60 and 60-100 years, are relatively complex with lush, well developed understories, mid-story conifers, and large spruce, hemlock, or cedar emergents that rise above the alder canopy. Alder snags are becoming abundant in the older stands. Patches of pure alder do exist within stands, but they are relatively uncommon. Evidence of browse from deer and elk is quite common in these stands.

Figure 8: SVS images of different age classes within the red alder stand type.

Riparian Forests

Riparian forests are typically the most floristically diverse and structurally complex parts of forested landscapes in the Pacific Northwest (Pollock 1998). While this is the case in much of the SWBCA, harvesting and increases in mass wasting events related to forest management have simplified many riparian stands and shifted species composition towards red alder. Rentmeester's (2004) assessment of forests within 160 feet (50 meters) of the fish bearing segments of Ellsworth Creek creates a foundation for our understanding of this forest type within the SWBCA (Figure 9 – Riparian Forests).

Similar to upland stands, management history plays a significant role in determining age and composition in riparian forests. The old growth riparian stands in Ellsworth creek tend to be dominated by 2-4' diameter western hemlock with a significant component of larger Sitka spruce. A surprising number of spruce stumps are present from the World War I era Spruce Division (Rentmeester 2004), and corroborate the public land survey data from 1908 showing that that spruce was abundant along much of the mainstem (Figure 4 – Historical Composition). Sitka spruce also dominate the old-growth riparian stands along the small creeks on the mainland portion of the Refuge (USFWS 1999). The large western redcedar that characterize other old-growth stands in the mainland portions of the SWBCA are relatively rare, possibly due to the productive soils and lower frequency of blow down events in the protected valley bottoms, which both favor hemlock dominance. In contrast, the old growth riparian areas on Long Island have a much high component of western redcedar.

In 25-50 year old riparian forest stands, Rentmeester (2004) found that: "while structural aspects (basal area, density, and QMD) were not significantly different between stands of the same age, stand composition was notably different between confined and unconfined reaches". Riparian forests located along unconfined stream reaches have wide valleys and tend to be located entirely on floodplain and terrace landforms. Mixed conifer/hardwood stands are prevalent and tend to have a gradual transition from red alder dominance in the inner riparian zone to conifer dominance on outer zone and side slopes. These areas are similar to the red alder stand types described above, although conifer abundance is often lower and generally consists of understory and midstory western hemlock and Sitka spruce. Black cottonwood (*Populus tricocarpa*) is also present in some areas. In narrower, confined channels, a much sharper transition exists between alder dominance along the stream channel and terraces, and conifer dominance on the steep side slopes. This sharp transition is very clear in low order, non-fish bearing streams throughout the Ellsworth Creek basin. Conifer dominance is especially prevalent in plantation stands 20-40 years old that have been intensively managed. Stands less than 20 years old typically have narrow buffer strips of older, mixed forest in the inner riparian area that were left due to the implementation of riparian buffers under the Washington Forest Practice Rules.

Rentmeester (2004) also found typical patterns of plantation stand development in terms of forest structure. Basal area increased with stand age, and ranged from 107 ft^2/acre in 15 year-old stands to 305 ft^2/acre in stands more than 200 years old. Quadratic mean diameter also increased from an average of 5.7 inches in 15 year old stands to 17.3 inches in 200 plus years old areas. Average trees per acre decreased, and ranged from 283 to 2004 tpa in young transects and from 57-405 tpa in older stands. Snag abundance decreased with age, with 38 stems/acre at age 25, 32 stems/acre at age 50, and 28 stems/acre at age 200. Mean diameter of snags, however, increased from 6 inches at age 25 to approximately 16 inches at age 200. Decay class was generally higher in younger stands, reflecting the process of competition induced mortality early in stand development. In 25 year old age classes, 68% of snags were conifers. The portion of hardwood snags gradually increased to age 75, where 83% of snags were hardwoods. In the 200 plus age class, only 10% of snags were hardwood.

In the smaller watersheds outside of the Ellsworth Creek watershed - that drain west and north of Bear River Ridge on both the Conservancy and Refuge ownerships - studies on stream conditions (Barndt et al. 2000, Wright W. and Callaghan 2002, Yoshinaka and Stone 2004) and field reconnaissance indicate that the pattern of hardwood dominance in the inner riparian zone and greater conifer abundance in the outer zone is generally the same as described above. A notable difference is the presence of big leaf maple (*Acer macrophyllum*), which is not found within the Ellsworth Creek Preserve. On Long Island, the short, low gradient streams tend to be dominated by red alder in managed areas, while the older unmanaged riparian stands are mostly composed of conifers.

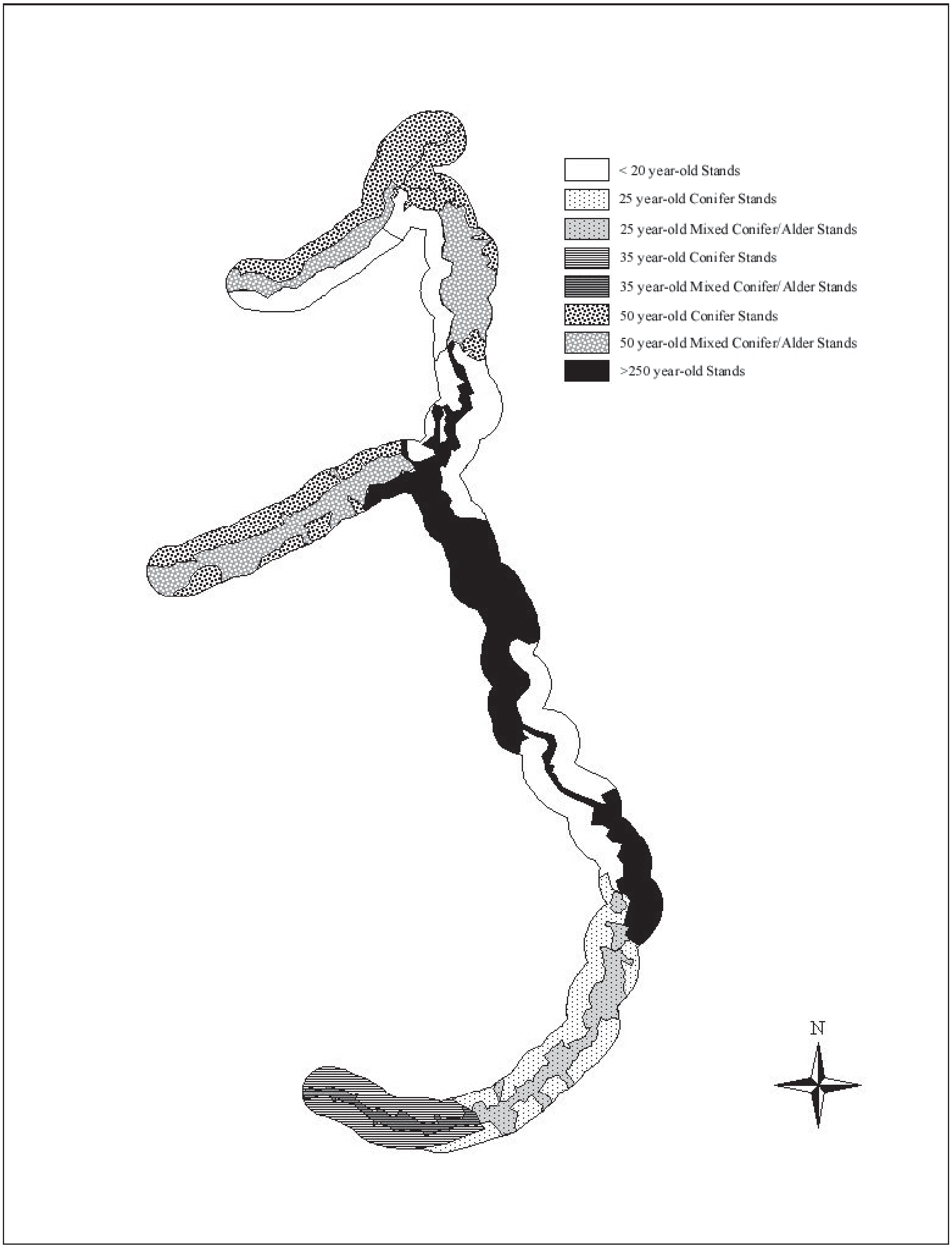


Figure 9: Riparian forest types along fish bearing channels of Ellsworth Creek (Rentmeester 2004)

3. ***Forest Health***

The interactions between fungi, insects, animals, and abiotic disturbance agents play critical roles in shaping forest structure and creating complex, diverse ecosystems (Edmonds et al. 2000). In order to achieve the given management objectives within the SWBCA, it is essential to understand these agents and work with them, as opposed to viewing them as threats. While these agents result in significant losses to timber value in spruce/hemlock forests (Ruth and Harris 1979), their patterns and influences do not appear to have been dramatically altered by forest management within the SWBCA in most cases. Insects and diseases are not likely to dramatically affect forest management over the next few decades (Hildebrand and Hostetler 2003) although climate change may lead to major shifts in their dynamics.

Swiss needle cast, caused by the fungus *Phaeocrytopus gaeumannii*, is native to Pacific Coast forests and while long considered innocuous, it has become a major concern in Douglas-fir plantations within approximately 18 miles of the coast in Oregon and Washington in the last few decades (Thies and Goheen 2002). During wet springs when adequate moisture is present, the fungus germinates, infects needles on Douglas-fir trees, and causes them to yellow and drop prematurely. Although it rarely kills trees outright, Swiss needle cast can reduce growth rates by up to 35% and make trees more susceptible to other agents of mortality (Holmberg et. al. 2006). While the causes of the recent increase are not fully known, the large-scale replacement of spruce-hemlock forests with pure Douglas-fir plantations is thought to be a chief factor (Thies and Goheen 2002). The 5-30 year old, Douglas-fir dominated stands on the Conservancy ownership have moderate to high levels of infection that appears more pronounced on upper ridges and west aspects (IRM 2005). In young plantations with more western hemlock, infection levels are generally lower and tend to vary more from tree to tree. On the Refuge, 10 infected stands totaling 1,041 acres were identified, with infection levels again highest in Douglas-fir dominated stands (IRM 2005). While crowns often appear sparse, height and diameter growth on dominant and co-dominant trees in most stands appears to be within expected ranges of site class. Its long terms effects are uncertain, however.

Gap development is often influenced by the action of forest pathogens.

Annosus root rot, caused by the fungus *Heterobasidion annosum,* is a common pathogen in western hemlock and Sitka spruce. It produces a dark brown conk and brown-heart rot that weakens the bole of trees and typically leads to stem breakage or mortality from bark beetles or other agents. It spreads through root graft and pervasive aerial spores that germinate readily on live bare wood, such as fresh stump surfaces, bole exposure from logging damage, or top or major branch breakage. It grows slowly, however, and effects are usually not noticeable until trees reach at least 120 years old (Thies and Goheen 2002). Combined with wind, it is probably the largest cause of tree mortality and snag recruitment for mature western hemlock in this forest type and a major limiting factor on the development of large, old hemlocks and to a lesser extent Sitka Spruce. Thinning has been shown to significantly increase infection levels as spores germinate on cut stumps and spread through root grafts to live trees (Edmonds et al. 2000). This has not proven to be a serious concern in plantations that are harvested well before age 120 (Edmonds et. al. 2000). As none of the managed stands on the Conservancy and Refuge ownerships are over 100 years old, mortality from annosus appears to be confined to the old growth stands and legacy hemlocks in younger stands (Hildebrand & Hostetler 2003). However, it is likely that the fungus is present in many trees and that thinning will increase infection levels. In stands heavily dominated by hemlock, this poses a challenge to the long-term goal of developing old growth structure (Thies and Goheen 2002).

Hemlock dwarf mistletoe (*Arceuthobium tsugense*) is a vascular, parasitic plant that affects western hemlock, and occasionally Sitka Spruce and Douglas-fir, in this forest type. Mature female plants forcibly discharge seeds an average of 15 feet, and the sticky seeds adhere to branches and stems of new hosts. The flowers, fruits, and seeds are a source of food for several invertebrates and bird species, and birds can spread the seeds. Seeds then germinate and the roots mechanically enter host tissues to extract water, nutrients, and sugars. Host branches usually respond with swelling and by producing a "witches broom" that may grow to weigh several hundred pounds in older trees and provide preferred nesting platforms for marbled murrelets and other species (Thies & Goheen 2002). Young western hemlock trees that are lightly infected (less than 1/3 of branches infected), and that are free to grow in the open, can outgrow dwarf mistletoe infection and leave the dwarf mistletoe in the lower crown. Severe infestations cause growth loss, reduction in wood quality, and an increase in mortality. Damage is more serious in stands over 100 years of age than in younger stands. Dwarf mistletoe is prevalent in the old growth stands and on legacy hemlocks in younger stands across the SWBCA. Forty to sixty year old trees that are adjacent to infected legacy trees are beginning to show signs of infection in many stands.

Sitka spruce is susceptible to the white pine weevil (previously known as the Sitka spruce weevil *Pissodes strobi)*. The weevil lays its eggs on the terminal shoot, and larvae then mine the phloem and girdle the leader, causing it to die and curl. Damaged trees are often overtopped and suppressed by other species. Surviving spruce may have forked and crooked tops and a bushy appearance. Weevil infection is highest in warmer, drier areas, while areas immediately adjacent to the coast are low hazard due to cool climate (Holmberg et al. 2006). Weevil populations and attack rates typically stabilize and begin to decline as trees reach heights of 30 feet. Incidence of spruce weevil appears to be low within the SWBCA, although it does contribute to overtopping of spruce by other species in many stands. It should not be much of a long-term concern, however, as trees will be greater than 30 feet relatively soon in most stands.

Laminated root rot pockets, caused by the fungus *Phellinus weirii,* were noted in several stands on the Conservancy's ownership during the IRM inventory. Although western hemlock is susceptible, this fungus is typically rare in spruce-hemlock forests and commonly found in natural and planted Douglas-fir stands (Thies and Sturrock 1995). It spreads through ectotrophic mycelium in roots and root grafts and moves outwards from infections centers at a rate of approximately 30cm per year, slowly creating an expanding pocket of mortality. Spread by spores is thought to be unimportant compared to vegetative spread, but little is known about how new infection centers get started in stands without previous history of the fungus (Thies and Sturrock 1995). While its effects are currently small in the SWBCA, it could become a larger factor in Douglas-fir plantations in the future.

Mature western hemlock stands are susceptible to epidemics of the hemlock looper (*Lambdina fiscellaria lugubrosa*), a defoliating caterpillar. Outbreaks typically occur in old hemlock stands, but recently have occurred in 60 year old second growth (Holmberg et al. 2006). Outbreaks last 3-4 years and can kill large areas of stands dominated by western hemlock (Edmonds et al. 2002). Other conifers within these stands are also heavily fed upon and can die as well. Recent anecdotal observations indicate that stands whose vigor has been enhanced by thinning are relatively resistant to surrounding epidemics (Holmberg et al. 2006). Pentilla (2002) states, "a section of timber was decimated by a hemlock looper infestation in 1931", according to Pentilla (2002). Also, it has been reported that a large scale looper infestation occurred in Northwest Oregon, stretching from Astoria south to the Tillamook Burn Area. In addition, a conversation with a local resident revealed that vicinity of the forested stands on Long Island were sprayed with DDT around the same time period, to address a hemlock looper infestation. SWBCA. As mature hemlock stands in this region have been almost entirely been converted to younger plantations and are likely to be managed under short rotations for the foreseeable future, it is unlikely that major outbreaks will reach the SWBCA. However, as the hemlock dominated forests mature, an outbreak is possible and could result in large-scale mortality. It is also unknown what the effects of climate change will be on the lifecycle dynamics of the looper and other invertebrates that cause tree mortality.

Bear damage largely occurs in the spring when the sap is running and other food sources are scarce.

Animal damage to trees from black bears, porcupines, mountain beavers, beavers, and rubbing from ungulates appears to be a persistent, but low-level source of tree wounding and mortality. Bear damage to western redcedar has been noted throughout the SWBCA. It is not a concern it terms of affecting the long-term goal of developing late seral structure, however, unless bear populations increased significantly from present levels. The only exception is the significant effect of elk and deer browse on conifer regeneration, especially in riparian corridors. Efforts to underplant western redcedar will need to address this fact or risk failure.

B. FRESHWATER STREAM SYSTEMS

Based on the Washington State DNR hydrography GIS layers the SWBCA contains approximately 46 miles of fish bearing streams and 115 miles of non-fish bearing perennial and seasonal streams. The streams have been classified according to the Washington State DNR stream classification system (WADNR WAC 222-16-031) and are shown in Map – SWBCA WADNR Stream Types. Stream types include fish bearing (F), shoreline (S), non-fish bearing (N), and (U) for unknown. These coastal streams are all rain fed, have their highest flows during the winter months, and flow regimes that are highly sensitive to rain storms. Most of these streams have been surveyed and overall stream condition in terms of salmonid fish habitat and biotic integrity ranges from fair to good (Table 7). However, road building, forest harvesting, diversion dams, and diking have increased sediment inputs, blocked fish passage, decreased abundance and recruitment of large woody debris, and exacerbated peak flows due to the expansion of the stream network.

Ellsworth Creek

Ellsworth Creek is by far the largest watershed and drains approximately 5,000 acres. Rentmeester (2004) conducted a thorough inventory of large wood debris (LWD) loading and stream geomorphology. He divided the watershed into headwater channels that drain less than 500 acres, and mainstem channels that drain more than 500acres and have an average slope of less than 3%. Headwater channels matched or exceeded LWD loading levels found in unmanaged streams in western Washington (Fox 2001), while mainstem channels were generally deficient in total volume and especially in large, key pieces. He attributed this to the fact that headwater channels receive the majority of their LWD inputs from debris flows (Bilby R. E. and Bisson 1998a) which have increased due to forest management (Powell et al. 2003). Mainstem channels, on the other hand, depend on bank erosion, stand mortality, and transport from upstream. Harvesting has thus depleted recruitment rates and piece size. Without the large, key pieces that form pools and debris jams smaller wood that is transported from upstream tends to get flushed out much faster. Increased recruitment of large pieces in mainstem channels will take many decades, if not centuries, as most inner riparian zones along mainstem channels are dominated by red alder, which breaks easily and does not persist nearly as long as large conifer logs (Cederholm et al. 1997).

The Washington Department of Ecology selected Ellsworth Creek as 1 of 10 statewide core reference sites for their stream biological monitoring program (WA DOE 2004). Using the River Invertebrate Prediction and Classification System (Plotnikoff and Wiseman 2001), biotic integrity was found to be very high (Table 7).

Table 7: Stream conditions for the SWBCA. Streams type classifications are displayed on Map – SWBCA WADNR Stream Types.

Stream Name	Drainage Area:km^2	B-IBI [a] RIVPAC [b]	LWD Rating	Channel Complexity[c]	Substrate Suitability[d]
Ellsworth[e]	20	1.03[2]	Good: headwater Poor: Mainstem		
Headquarters[f]	0.7	42	Adequate: above dam Poor : below dam	Poor: above dam Moderate: below dam	Moderate
Long Island Cedar Grove[f]	1.9	40	Adequate	Moderate	Good
WDFW #0674[g]	2		Adequate	Good	Good
WDFW #0675[g]	1.3		Poor	Poor	Poor
WDFW #0677[g]	2.6		Adequate	Moderate	Moderate
North Creek[h]	1.9	46	Poor	Moderate-good	Good – moderate
Middle Creek[h]	2.6	42	Poor	Moderate-poor	Good – moderate
South Creek[h]	2.1	38	Poor	Moderate	Poor
Lewis 1[f]	2.5	36	Poor - adequate	Moderate - high	Good
Porter[f]	1.7		Poor - adequate	Poor	Poor
Riekkola[f]	3.0				None: above dam

Notes:
a: River Invertebrate Prediction and Classification System (RIVPACS) score. A score of 1 means that 100% of expected invertebrates were present (Plotnikoff & Wiseman 2001).
b: Benthic Index of Biotic Integrity (Kerans & Karr 1994). A composite measure of invertebrate community composition. A score of 50 is the highest score
c: Channel complexity is a general evaluation of the ratio, quality, and quantity of pools, riffles, and off channel habitats.
d: Rating of suitability of substrate for spawning of salmonids.
e. Source: Rentemeester 2004, WA DOE 2004
f. Source: Barndt et. al. 2000
g. Source: Wright & Callaghan 2002
h. Source: Yoshinaka & Stone 2004, Conklin (2003)

A series of much smaller creeks drain the watersheds on the north and west sides of Bear River ridge and to the west of Bear River (Table 7). They flow directly into Willapa Bay or into Bear River. The headwaters of some of these creeks are owned by the Conservancy while others are owned and managed by the Washington Department of Natural Resources or other private landowners for most of these creeks. Long Island also supports a number of small creeks. Most of these creeks have adequate levels of overall LWD, although a few are noticeably deficient. Similar to Ellsworth, large pieces are much less common, and future recruitment is limited by the dominance of red alder along inner riparian zones as well as the young age of many of the conifers in riparian areas. Macro-invertebrate communities have been sampled in many of these creeks, and B-IBI scores (Benthic Index of Biological Integrity; Karr et al 1986) range from fair to good or 32-42 out of 50 (Yoshinaka & Stone 2004, Conklin 2003). Channel complexity, including pool ratios and volume, riffles, and off channel habitats, are variable between streams, as is substrate suitability for spawning by salmonids. Beaver ponds were observed in many of these streams as well as log jams that form potential fish barriers. Human created barriers such as high gradient or disconnected culverts and dams are also present on several creeks. In general, stream surveys (see references in Table 7) found that habitat quality for salmonids varied from poor to good, with most of the streams rated moderate to good. There are also two small artificial ponds on Long Island, but neither have suitable fish habitat.

C. FOREST ROADS AND OTHER INFRASTRUCTURE

1. *Forest Roads*

Assessments of forest road conditions were completed for the Ellsworth Creek Preserve in 2001 (CWC 2001) and the Refuge in 2005 (Stringer 2005) following consistent methods and field protocols. The Ellsworth Creek inventory describes conditions, at the time, for 72 miles of forest road across 7,900 contiguous acres. Some of this land has since been transferred to the Refuge and additional lands have been acquired. However, the general conclusions and site specific assessments remain valid regardless of current ownership. The Refuge inventory describes conditions for 28 miles of forest road across 7,800 noncontiguous acres (Stringer 2005).

Although the road systems for the Refuge and Ellsworth Creek Preserve are often contiguous, they nonetheless differ in the density of roads present (6.3 mi/mi^2 on Ellsworth vs. 2.3 mi/mi^2 on Refuge) and in the general condition of those roads (poor condition at Ellsworth vs. fair condition at Refuge). These differences can often be attributed to differing topography and geology, but also to road age, and previous ownership patterns. Ellsworth Creek Preserve lands are typically steep and deeply dissected whereas Refuge lands are generally less steep. Roads at Ellsworth Creek were frequently built across steep landslide prone terrain that is less common on Refuge lands. However, roads on both properties have not been well maintained in recent years, due to changing ownership and the relative remoteness of sections of the road system (e.g., Long Island). This has led to a general reduction in the condition of forest roads throughout the planning area.

A variety of mass wasting hazards exist on road systems across the SWBCA. An analysis of forest history chronology that maps road building, logging and landslides was conducted and found a strong correlation between road building and the incidence of landslides (CWC 2003). Fill slope failures have resulted from overloading of fill slopes with sidecast material, especially on roads cut into steep mid-slope terrain. This type of road is quite common on Ellsworth Creek though less so on the Refuge; thus significant failure risks remain. Secondly, stream crossings are susceptible to mass failure when poorly constructed (i.e., some at Ellsworth Creek that were built without culverts) or poorly maintained. Risks can increase with age as old galvanized culverts rust through. These conditions have been exacerbated or triggered by insufficient or poorly designed drainage from the road surface and ditches.

Running surface erosion caused by poorly designed or maintained road surface drainage has resulted in degradation of road conditions, particularly in areas where grades are steep and roads are graded flat. Also, improperly placed cross drain culverts have caused major erosion of the outboard slope in places.

Some roads within the planning area are shared through easement with other neighboring landowners. These easements may affect the nature and timing of maintenance actions on these roads. Easement holders have specific access rights and maintenance responsibilities that are described in the legal title documents for those properties. Similarly, access to some areas can only be gained through neighboring land and roads (e.g., the new Rodgers addition to the Ellsworth Creek Preserve). A Bonneville Power Administration (BPA) high voltage power line runs through the Ellsworth Preserve and portions of the refuge. BPA has broad authority to access the power infrastructure through both properties by roads that roughly parallel the power corridor.

2. ***Rock Pits***

Eleven rock pits exist within the Ellsworth Creek Preserve. None are known inside the Refuge. These rock pits were quarried to build and maintain the existing road system. The pits vary in size and condition from approximately 2,500 ft^2 to perhaps 25,000 ft^2 and from overgrown to open and functional. Rock quality has been informally assessed at the sites that are strategically located and likely to produce good quality road rock. Hard crushed rock is also available for purchased from Weyerhaeuser's Templin pit which is enclosed by Preserve and Refuge lands. The Refuge will continue to procure rock materials from commercial sources such as this.

The Conservancy will develop rock from its own pits for use on roads within the Preserve, or where road easements exist outside the Preserve, to upgrade and maintain the road system with the goal of reducing road related impacts to aquatic habitat. Development of rock resources will occur following the guidelines and commitments discussed below in the Management Approach section.

3. ***Building Infrastructure and Other Resources***

A number of structures exist at various locations across the Refuge for administrative and maintenance purposes. The Refuge headquarters is located along US Hwy 101 across from the south end of Long Island. Administrative functions for the Willapa refuge complex are located in a remodeled residence with two neighboring shop buildings, fuel storage and equipment parking. Public parking, interpretive signage, a pit toilet and a boat ramp are located along the highway at the headquarters. The Refuge manager quarters are located near the south end of the north Bear River unit. A small shop is located on the south end of Long Island, near the boat ramp access. The Refuge's main heavy equipment storage and maintenance shop is located at the Reikkola unit at the south end of Willapa Bay. Access is from the west off Sandridge Road.

One structure, a small cabin acquired in 2008 on the Larwick property, exists within the Ellsworth Creek Preserve. Although it generally removes structures from the lands it acquires, the Conservancy chose to retain this structure for the potential utility it provides. The Conservancy intends to chiefly use the cabin as lodging for out of area researchers, volunteers or other work crews directly engaged in stewardship activities on the Preserve. Occasional small events, meetings or retreats may also occur.

The cabin is constructed almost entirely of Sitka spruce lumber milled from the surrounding property. It has full kitchen and bathroom facilities, two small bedrooms and a loft. Water is supplied via rain collection from the metal roof. Sewage is treated in a septic drain field. Power consists of a 12 volt battery system, recharged by a small solar panel, which supplies a few lights.

The Conservancy recognizes the long term potential for human disturbance this type of development presents, especially in the context of marbled murrelet recovery. Currently, the cabin is located within a young forest stand, less than 20 years old. The nearest suitable murrelet nesting habitat is about ¾ miles away. Although this is too far to cause concern, the potential for disturbance will increase in the future as stands near the cabin mature. Therefore, the Conservancy commits to removing the cabin and reforesting the site in 2038, 30 years from its date of purchase. In the interim, the Conservancy will conduct necessary repairs to maintain the cabin in usable condition. Should the cabin fall into disuse or disrepair and become unusable the Conservancy will remove it at that time.

MANAGEMENT CONSIDERATIONS

Old-growth western red cedar at Teal Slough

A. Desired Future Conditions

On 23 June 2006 a joint workshop between the Conservancy and the Refuge and facilitated by Stewardship Forestry Alternatives was held to identify the desired future ecological conditions for the SWBCA. Several themes for desired future conditions emerged from the discussion during the workshop, some of which are already captured by the goals listed in the introduction to this plan. In this section we describe the major elements of the desired future conditions for the SWBCA: ecosystem resistance to environmental perturbation at multiple scales, spatial and temporal heterogeneity, functional landscape linkages, and provision of habitat for late-successional species and species of concern.

1. *Ecosystem Resistance and Resilience to Perturbation at Multiple Scales*

Ecosystem resistance and resilience to perturbation—disturbances and environmental change—emerged as a major component of the DFC for the SWBCA landscape. Resistance is the capacity of an ecosystem to withstand perturbation, while resilience is defined as the degree to which an ecosystem is able to return to initial conditions following perturbation (Halpern 1988). We define perturbation here to include both punctuated events such as windstorms, fires and floods, as well as the protracted process of large-scale climate change. Perturbations are a critical and unavoidable component of any ecosystem.

Wind Disturbance

Managed landscapes, such as the SWBCA, have been altered such that the response to typical perturbations is different from that of unmanaged landscapes. For example, past harvest has created forest stands with hard edges, decreasing forest ecosystem resistance to wind disturbance (Ruth and Harris 1979). Across the SWBCA landscape, stands historically contained relatively high densities of large, old, wind firm western redcedar, indicating the prevalence of a chronic, low severity disturbance regime and not a high severity, catastrophic regime. Past harvesting, regeneration, and thinning practices have dramatically reduced both large and young western redcedar in most of the SWBCA landscape. Dense, even-aged western hemlock and Douglas fir dominated stands are now the dominant stand type and are much more susceptible to catastrophic blow down (Beese 2001). The high stand density causes trees to have high height:diameter ratios, with stand stability reaching a minimum in the mature (*sensu* Franklin et al. 2002) stage. During early maturity, where natural single cohort stands are just beginning to transition into multi-cohort structure and composition, the likelihood of high severity wind disturbance is greatest (Acker et al. 2000, Greene 1992, Harcombe P.A. et al. 2004, Harcombe P.A., Harmon, M.E., Greene, S.E. 1990, Harris 1989, Jane 1986, Rebertus et al. 1997, Wimberly and Spies 2001). A likely outcome for these single cohort western hemlock dominated stands originating from catastrophic disturbance (timber harvest) is to move into a high-severity wind disturbance regime, in contrast to the historical low severity wind disturbance regime that maintained the landscape in a high proportion of old-growth (Figure 10 – Stand Structure-Mediated Wind Disturbance). High severity disturbance is undesirable in this scenario because the affected area is returned to the early stages of stand structural development, which is at odds with another DFC for the SWBCA landscape (see *Provision of Habitat for Late-successional Dependent Species* below). Consequently, a major DFC for the SWBCA landscape is to return the system to a state where wind and other disturbance results in low to moderate severity tree mortality or breakage and further development of old-growth forest structure, and away from a state that is susceptible to catastrophic, high severity events that restart forest development.

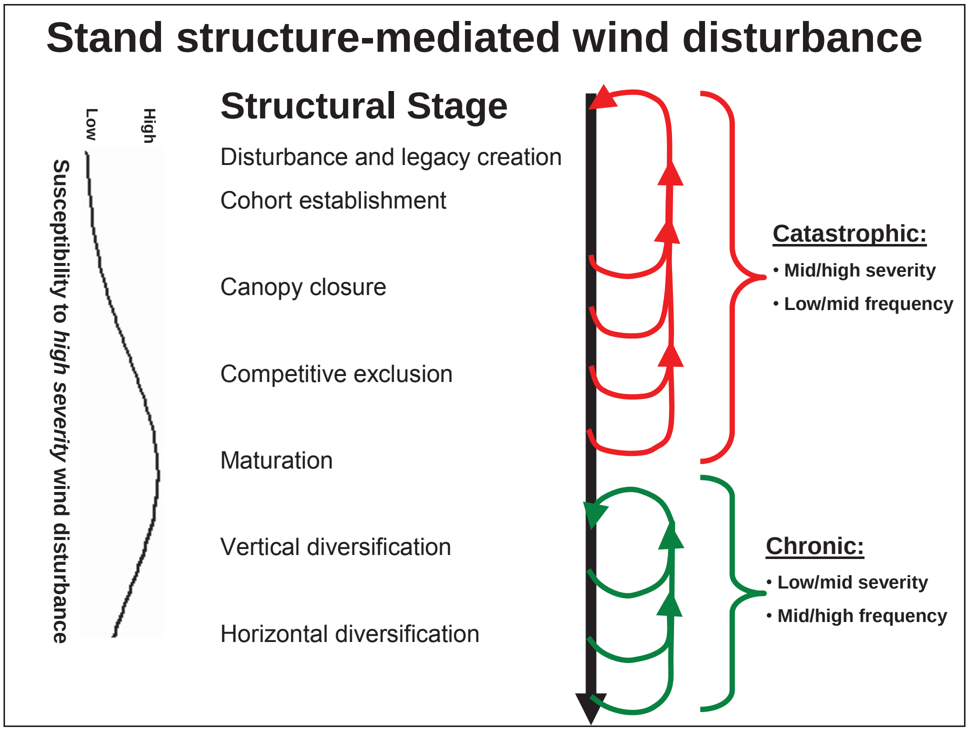


Figure 10: Stand structure-mediated wind disturbance

Fire Disturbance

In light of the old (750+ year old) red cedar still extant upon the landscape, suggest that the stand replacement fire regime interval for this area is 750 years or more. With the roading and harvesting of the area over the past 60 years, there are significant fuel breaks across the landscape—such as forest roads and young plantations. Consequently, the opportunity for a stand replacement level fire on a landscape level will be remote until the area reaches the desired future condition when the landscape simulates an old-growth regime.

On the other hand, smaller sized natural fire evens will periodically occur resulting in gaps throughout the forest. These may be man caused and/or lightning caused events. With the existing road network and State fire protection infrastructure in the area, these smaller fire events will be kept to relatively small acreages. These periodic events will be replanted with cedar and spruce to introduce these species across the landscape.

Insect Disturbance

As detailed earlier, observations of the extant old growth stands reveal that hemlock cohorts appear to be cycling at a different periodic rate than the cedar. The cedar appears to be cycling at a 750+ year interval; whereas, the hemlock appears to be cycling at a 200-300 year interval. It appears that the affect of periodic hemlock looper outbreaks, followed by a break down of the hemlock within the stand, followed by prolific seeding, followed by periodic wind events shape the uneven aged, species mosaic within old growth stands. This type of uneven aged natural cycling within these stands will likely continue across this coastal landscape.

Climate Change

Creating conditions across the SWBCA landscape that will facilitate resistance to climate change also surfaced as a DFC during the workshop. This objective is particularly difficult, as forecasting climate change and the accompanying consequences for the SWBCA landscape is an inexact, uncertain proposition. A cautious approach to management will be necessary, as attempts to "engineer" the SWBCA ecosystem in anticipation of climate change could easily result in undesirable (and dysfunctional) ecosystems. Returning the landscape to a resilient state requires the fewest assumptions, and likely carries the lowest level of risk of any anticipating-climate-change management action. This conservative approach will entail maintaining the suite of naturally occurring species. It may be desirable to manage for a relatively greater proportion of Douglas-fir, a naturally occurring tree species in the SWBCA landscape, than existed historically. Because Douglas-fir is able to occupy a broad range of biophysical conditions (McKenzie et al. 2003), maintaining a substantial Douglas-fir component may provide increased resistance to some climate change scenarios. However, the range of Douglas-fir is expected to remain stable or contract in the SWBCA landscape (Whitlock Cathy, Sarah L. Shafer and Jennifer Marlon 2003) (Shafer et al. 2001) suggesting that dramatically increasing Douglas-fir abundance may be unwarranted.

2. ***Landscape Composition and Pattern: Spatial and Temporal Heterogeneity***

Ecosystems are dynamic biophysical constructs, changing through time and across space. Natural disturbance events alter developmental processes and create a mosaic of compositionally and structurally complex conditions across the landscape (Turner et al. 2001). This disturbance mosaic is overlaid on the underlying physical template, adding even further heterogeneity to the landscape (e.g., Harcombe et al. 2004). With respect to stewardship of the SWBCA landscape it is important to recognize that the functioning "natural" landscape will almost never be entirely maintained in late-successional conditions. Late-successional conditions may dominate, and by all indications did dominate in recent pre-settlement times in the Ellsworth drainage (Powell 2003). Pre-settlement conditions on Willapa NWR lands are less well known. Based on landscape position—relatively greater exposure to winter storms—Long Island probably supported relatively lower levels of old-growth and a relatively greater proportion of successional stands originating from high severity wind disturbance. In addition, the large contiguous patches of old-growth forest that characterized historical landscapes had high within-patch heterogeneity (Franklin J.F. and Van Pelt 2004, Spies et al. 2002) described in section B, 3 different types of old growth forest exist within the SWBCA landscape that have different degrees of vertical and horizontal complexity. This complexity at multiple spatial scales is thought to be a key element of supporting biological diversity.

Current landscape pattern and composition is entirely the product of forest management (Powell et al. 2003). The SWBCA landscape is a mosaic of different aged stands, most characterized by a single cohort age structure (*sensu* Oliver and Larson 1996) with patches separated by linear, hard edges formed by clearcutting. Using the 1908 conditions as a reference and knowledge of natural disturbance regimes, the desired future condition, with respect to landscape composition and pattern, is a state characterized by a high proportion of structurally complex forest at multiple scales. Over time, much of the landscape will likely develop into late-successional forest. At the stand scale, a future condition of multiple types of old-growth with their respective degrees and patterns of complexity is desired. Some patches of old growth should have a high level of patchiness, understory development, vertical canopy layering, species diversity, and tree size distribution, while others should be relatively uniform with more of a single-storied, closed canopy. At the landscape scale, however, disturbance agents will create patches of younger age classes through time. Thus rather than a DFC of certain proportion of late successional forest, the landscape level DFC is maintenance of spatial and temporal heterogeneity by natural disturbance processes, except for fire which will be actively suppressed.

3. ***Functional Landscape Linkages***

The different ecosystem types (e.g., estuaries, streams and terrestrial uplands) contained in the greater SWBCA do not exist as independent units with discrete, impermeable boundaries. At the most basic level, the nature of these cross-system linkages is characterized by the transfer of material and energy across system boundaries. This transfer can be mediated by both physical and biological agents. For example, geomorphic events and processes (e.g., landslides, debris flows, hill slope hydrology) deliver the basic habitat constituents (sediment, woody debris and fine allotochonous organic inputs, and water) from terrestrial ecosystems into streams (Benda et al. 1998, Benda et al. 2004, Bilby R.E. and Bisson 1998a, Naiman et al. 2000) Further physical processing within the stream ecosystem, for example by flood events, transfers these materials (and new materials originating from within the stream ecosystem) to estuaries, and ultimately, the marine environment.

Biotic agents also transfer materials across ecosystem boundaries. Beavers (*Castor canadensis*) are a classic example of a biotic agent mediating entry of terrestrial organic materials into aquatic ecosystems (Naiman et al. 1998). Beaver activity also influences rates of material processing within the stream ecosystem (e.g., sediment and water retention behind dams). An important attribute of biotic-mediated transfer of material across ecosystem boundaries is the potential to move material against physical/energy gradients. Perhaps the best known example from the Pacific Coastal Ecoregion is the movement of marine derived nutrients (MDN) from the ocean through estuaries and into streams by anadramous fish (McClain 1998). The MDN contained in the salmon carcasses can then be further translocated by a secondary biotic agent (i.e. carnivorous mammals) from the stream ecosystem into terrestrial habitats, where the MDN are ultimately incorporated into the terrestrial vegetation (Helfield and Naiman 2006). Both beavers and anadromous fish are present in the SWBCA.

A DFC for the SWBCA is to restore and maintain functional landscape linkages for the movement of material across ecosystem boundaries, such that the functioning of each component ecosystem is maintained. Implicit within this objective is the restoration and maintenance of material pools that have been depleted by past management, such as the distribution of large live trees and woody debris across the landscape. Also subsumed within this broad desired future condition is constraining the rate of delivery of materials within the bounds of a “natural” range of variability —e.g., poorly designed, constructed or maintained road networks alter patterns of delivery of sediment and water from uplands into streams, inhibiting stream functioning and degrading habitat.

4. ***Habitat for Late-successional Dependent Species***

Late-successional habitats are extremely rare in the low elevation forests of southwestern Washington. The SWBCA plays a key role in the regional landscape since the Refuge and Preserve host some of the last old-growth forests in the area, and are some of the only locations where late-successional forests will be promoted and allowed to develop, assuming the current management regime of private forest land in southwest Washington does not drastically change. Of particular interest is the marbled murrelet, a seabird that requires large branches for nesting, typically of sizes found only on old-growth trees. Silvicultural intervention is thought to be a means to accelerate the development of late successional forest attributes in previously harvested forests. Long term restoration research at Ellsworth Creek will explore coastal forest restoration pathways at a landscape scale. These studies will provide valuable insight into effective strategies to accelerate the development of old-growth structure to provide habitat for late-successional dependent species. To be clear, the goal is habitat for late-successional species in general, rather than specific habitat elements, as in many single species restoration plans (Carey 2003a). It is assumed that returning the SWBCA to a condition where natural, as opposed to anthropogenic processes, are allowed to operate will result in the development and maintenance of late-successional habitats that provide suitable habitat for multiple late successional dependant species (see Spatial and Temporal Heterogeneity).

5. *Desired Future Conditions: Synthesis*

The desired future condition for the SWBCA is one characterized by resilient, functioning terrestrial, aquatic and estuarine ecosystems. This condition necessitates that landscape level linkages be intact, and that rates and quantities of materials flowing through system linkages are consistent with those that produce desired functionality. Recognizing that natural disturbance events will stochastically (randomly) occur, the DFC for SWBCA, in terms of landscape and stand level pattern and content, is also characterized by a spatially and temporally heterogeneous distribution of patches at various stages of response to (i.e. time since) disturbance. In contrast to current conditions, the desired future structure of the landscape will primarily be controlled by natural process, as opposed to human disturbances such as the recent management regime of timber harvest. It is assumed that the amount of late-successional forest habitat will increase substantially from the current level as the DFCs are realized.

B. SCIENTIFIC JUSTIFICATION

1. *Scientific Basis for Restoration Silviculture in* Spruce-Hemlock Forests

Since the implementation of the Northwest Forest Plan restoration of young, previously harvested forest to late-successional structure, composition and function—particularly habitat function—has emerged as a management objective for many public, and increasingly, private forest lands. Large scale silvicultural experiments, as well as reconstructions of the developmental history of old-growth forests have been undertaken in an effort to inform silvicultural interventions in young previously harvested forests designed to accelerate the development of old-growth characteristics (Carey 2003b, Carey et al. 1999c, Harrington et al. 2005, Hunter 2001, Muir et al. 2002, Poage and Tappeiner 2002, Tappeiner et al. 1997, Winter et al. 2002a, Winter et al. 2002b, Zenner 2005). These studies have identified manipulation of forest stand density and species composition as a primary strategy for restoring late-successional characteristics in previously harvested young stands.

Truncating or completely bypassing the competitive exclusion stage of forest structural development is the core idea underlying the theoretical basis for restoration of late successional characteristics in young-managed conifer forests along the Pacific Northwest Coastal Region. With this direction in restoration, competitive exclusion is abbreviated via stand density management, and typically accomplished silviculturally with thinning (DeBell et al. 1997) - although planting at low densities following harvest may also minimize the competitive exclusion stage if natural regeneration is not abundant. Thinning reduces stand density, thereby increasing the relative amount of resources (light, water, nutrients) available to the residual stems left following thinning (Oliver and Larson 1996, Smith D.M. et al. 1997). Decreasing overstory density also increases the amount of resources available to understory herb and shrub species because the residual trees left following thinning cannot capture all of the available resources on the site. Understory vegetation in thinned stands has been shown to be more similar to old-growth than unthinned young stands (Bailey J.D. and Tappeiner 1998, Garman et al. 2003, Lindh and Muir 2004, Thysell and Carey 2001). Thinning stimulates establishment and development of understory shade tolerant conifers (Alaback and Herman 1988, Bailey J.D. and Tappeiner 1998, Curtis et al. 1998, Harrington et al. 2005, Ruth and Harris 1979). A vertically continuous understory and midstory shade tolerant canopy is a defining characteristic of old-growth forests (Franklin J.F. and Van Pelt 2004, Franklin J.F. et al. 2002). Recruitment of shade-tolerant trees is a rate-limiting factor in the development of old-growth structure (Acker et al. 1998, Keeton and Franklin 2005). The rate of understory development in natural stands is also related to overstory composition; understory plant community development proceeds particularly slowly in stands with a strong dominance of western hemlock in the overstory (Stewart 1988). Therefore, thinning provides a mechanism to accelerate the rate of development of old-growth canopy structure in young, single cohort stands, particularly in coastal stands dominated by western hemlock.

Responses of forest biota, in terms of both direction and magnitude, to thinning are variable across species. Abundance and development of understory vegetation including shade tolerant trees appears to increase in most cases (Bailey and Tappeiner 1998, Alaback and Herman 1988, Harrington et al. 2005, Ruth 1979, Lindh and Muir 2004, Bailey and Tappeiner 1998, Garman et al. 2003, Curtis et al. 2000, Thysell and Carey 2001). In contrast, thinning tends to adversely affect macrofungi species richness and biomass, at least in the short-term, and thinned stands tend to have less evenly proportioned species composition (Colgan et al. 1999, Durall et al. 1999, Fogarty et al. 2001, Norvell and Exeter 2004). . Thinning appears to have little or no effect, however, on lichen diversity (Curtis et al. 2000, Peterson E.B. 2002, Peterson E.B and McCune 2001). Because lichen diversity and abundance are positively related to stand age, development of the lichen communities in forests is thought to be a dispersal limited process (Curtis et al. 2000, Sillett et al. 2000). Hardwood patches have been identified as "hot spots" for epiphytic lichen diversity in young-managed western coniferous forests (Neitlich and McCune 1997), suggesting thinning entries should conserve hardwood tree species if maintenance of lichen diversity is an objective. Initial results have found little effect of thinning on invertebrate communities (Schowalter 2003); although additional time since treatment may reveal a treatment effect. Similar to lichens, hardwood trees are associated with increased diversity of arthropods in young conifer dominated stands (Muir et al. 2002, Schultz and De Santo 2006), suggesting that thinning treatments should maintain tree species diversity if arthropod diversity is a management objective. Thinning dense young conifer stands improved conditions for several bird species and heterogeneous thinning treatments including substantial unthinned "skip" areas within the thinned matrix appear to provide the greatest benefit to songbirds (Hagar et al. 2004, Hayes et al. 2003). Thinning effects on small mammals are quite variable across species, making generalizations difficult (Suzuki and Hayes 2003). Based on habitat associations and thinning effects on vegetation it is thought that thinning could have positive effects on small mammal populations (Carey 2000, Hayes et al. 1997). However, conclusive results linking thinning treatments to changes in small mammal populations remain elusive.

Studies of the habitat requirements of the northern spotted owl and its primary prey species (Carey 2000, Hayes et al. 1997) provide insight into the desired future forest structure and composition conditions and suggest pathways for managing young forests towards these specific late-successional characteristics. However, views differ about the types and scales of spatial patterning that should be introduced in restoration thinning treatments—termed variable density thinning (VDT) (Carey and Johnson 1995, Carey et al. 1992, Carey et al. 1999c), especially in regards to managing for listed species. Spatial heterogeneity, a defining characteristic in VDT prescriptions, is conspicuously lacking from restoration silviculture recommendations designed specifically to maximize marbled murrelet habitat development in coast redwood stands to identify in greater detail the DFC (in terms of forest structure and composition) for young forests being managed for late-successional characteristics. Data from these studies form the basis of arguments about the types and scales of spatial patterning that should be introduced in restoration thinning treatments—termed variable density thinning (VDT) (Carey 2003b, Carey et al. 1999a). Silvicultural strategies for developing murrelet habitat are forced to balance the tension that arises due to two conflicting objectives: 1) promoting the development of nesting habitat (i.e. large tree and branch size, multi-layered canopies) while 2) minimizing understory plant response to stand density reductions (which can have the effect of increasing local populations of murrelet nest predators (Carey et al. 2003)).

Partial harvest for timber production objectives in spruce-hemlock forests of southeast Alaska resulted in complex stands with old-growth attributes (Deal et al. 2002). Similarly, understory plant communities in partially cut stands did not differ from understory plant communities in uncut old-growth forests (Deal and Tappeiner 2002). These results suggest that silvicultural systems can be designed to produce economic benefit and timber products while simultaneously maintaining stand structural diversity and old-growth conditions (Deal et al. 2002). With respect to restoration silviculture in spruce-hemlock-cedar forests, these results provide circumstantial evidence in support of the idea that woody biomass can be removed during restoration silviculture treatments without compromising the objective of enhancing the development of old-growth structure. Additionally, biomass removal in thinning is not expected to adversely affect management objectives related to woody debris because stems removed in thinning entries will be from small size classes and primarily western hemlock, which decomposes rapidly (Edmonds et al. 2000, Hennon and Loopstra 1991). Woody debris loads are primarily limited by piece size, not total amount. Thinning treatments, even with biomass removal, will accelerate the rate of production of large woody debris by increasing residual tree diameter growth rates. However, the long term effect of removing biomass early on in stand development is one of the key uncertainties in restoration silviculture and will be examined as part of the experiment being installed within the Ellsworth Creek Adaptive Management area.

Results from research and current scientific thinking support the notion that thinning can be used successfully to direct and accelerate the development of forest vegetation structure and composition towards old-growth conditions, although results characterizing effects of thinning on some populations of forest biota are not yet available or able to be generalized. However, to the best of our knowledge restoration silviculture has not been attempted in coastal spruce-hemlock-cedar forests. One exception might be the "Fresca" block of the Olympic Habitat Development Study (Harrington et al. 2005) which is located in a spruce-hemlock stand. Most of the studies cited above share one condition: they were conducted in Douglas-fir forests. With respect to restoration silviculture, spruce-hemlock-cedar forests differ from Douglas-fir forests in several critical ways, including different environmental regime, species composition and relative abundance, and especially the dominant disturbance regime. One of the central underpinnings of restoration silviculture in Douglas-fir forests is that anthropogenic suppression of low and moderate severity fire has removed the key intermediate, natural disturbance agent that reduces stand density and creates spatial complexity (Spies et al. 2002a). Thinning is thus needed to take the place of fire. Conversely, wind, the primary driver of spatial complexity in Sitka spruce forests, remains very much part of the system. Thus, the available restoration literature (primarily studies in Douglas-fir forests) must be transferred to coastal forests with great care, with restoration prescriptions formulated as working hypotheses.

Applying principles of stand dynamics and disturbance ecology to achieve DFCs

The preponderance of silviculture studies in the Pacific Northwest have been conducted in Douglas-fir forests and thus don't necessarily translate directly to spruce-hemlock-cedar forests. However, a complimentary approach to transferring inferences about restoration is reasonable, if we begin by understanding where differences occur in spruce-hemlock-cedar stand dynamics and disturbance ecology principles. Thus, in the remainder of this section we further develop the scientific basis for restoration silviculture in spruce-hemlock-cedar forests by considering the relevant silviculture and stand dynamics literature with respect to the DFC's for the SWBCA.

- *Increasing forest stand resistance to wind disturbance:* Stands with a relatively high component of western redcedar tend to be more resistant to wind disturbance (Weetman and Prescott 2001). Historical upland forests in the Ellsworth Creek watershed appear to be dominated by western redcedar (Figure 4 – Historical Forest Composition), and current residual old-growth stands on Long Island are also characterized by large, old western redcedar. As described above, past management has shifted the current landscape to dense, even-aged western hemlock dominated stands that are much more susceptible to high severity, catastrophic blow down. In the absence of future management, structurally complex old-growth spruce-hemlock-cedar forest will take many centuries to develop. Abundance of western redcedar will slowly increase as it preferentially survives wind disturbance events, and will have colonization opportunities following wind disturbance. However, its slower growth early in stand development compared with western hemlock and Sitka spruce puts it at a major disadvantage in the dense single cohort stands that currently dominate the SWBCA. Increasing western redcedar dominance in current young stands via thinning and planting is expected to accelerate the development of large western red cedar, thereby increasing the resistance of SWBCA forests to wind disturbance, and helping to shift the landscape back toward a low-severity disturbance regime.

  A second strategy to increase forest stand resistance to wind disturbance is by decreasing tree height-to-diameter ratios via thinning. Evidence from several studies indicate that single cohort stands become increasingly unstable—less resistant to wind disturbance—as they reach the maturation stage of forest structural development (Harcombe et al. 2004, Harris 1989, Jane 1986, Rebertus et al. 1997). Trees growing in dense, maturing stands reduce their crown depth (Oliver and Larson 1996, Smith et al. 1997). As a result, stems reduce the degree to which they taper and height-to-diameter ratios increase, ultimately leading to less stable trees. Reducing stand density with thinning can decrease height:diameter ratio and increase crown depths, particularly if implemented early in stand development before crowns have been greatly reduced (Ruel 1995, Wilson and Oliver 2000, Wonn and O'Hara 2001). Sitka-spruce and western hemlock are known to increase diameter growth and decrease height-to-diameter ratios in response to thinning (de Montigny and de Jong 1998, Mitchell 2000, Ruth and Harris 1979)

Multi-cohort stands may be more resistant to wind disturbance due to lower height-to-diameter ratios (Mason 2002, Weetman and Prescott 2001). In addition to being more wind resistant, multicohort stands will be more resilient to wind disturbance. Because understory and midstory trees are already established in multicohort stands, overstory canopy gaps created by wind disturbance are likely to be already filled by understory and midstory trees (Winter et al. 2002b). Seedlings establish following thinning in coastal spruce-hemlock-cedar stands at high densities (Alaback and Herman 1988, Harrington et al. 2005, Ruth & Harris 1979), indicating that thinning is a mechanism to begin to transition stands from a single cohort to multicohort condition. Multi-cohort, multi-species stands are also typically more resistant to insect and pathogen outbreaks (Edmonds et al. 2000, Thies and Goheen 2002) and higher in overall biodiversity.

- *Developing late-successional habitat characteristics:* Large individual trees are a defining characteristic of old-growth forests (Franklin et al. 2002, Acker et al. 1998, Franklin et al. 2005), and are a prerequisite to large diameter snags and downed logs. Lack of large trees is the primary component lowering MOGI scores in maturing stands within the SWBCA. Additionally large, complex tree crowns provide habitat for a range of epiphytes, lichens, other plants, and cavity dependent wildlife species which is not afforded by structurally simple young tree crowns. Marbled murrelets also use large diameter branches as nesting platforms (Carey et al. 2003). Ongoing research is drawing increasing attention to the role of large horizontal structures and reiterated stems as drivers of crown level habitat complexity and epiphyte community development. Density management through thinning increases tree diameter growth (Marshall and Curtis 2002, Mitchell 2000, Ruth and Harris 1979) which then sets the stage for the development of larger trees, snags, and downed logs. In addition, increasing the growing space of individual trees slows crown recession (Ruth and Harris 1979, Smith et al. 1997) and enhances the development of large diameter branches (Maguire et al. 1991). Thinning can also stimulate epicormic branch development, particularly on Douglas-fir. Manipulations within crowns of individual trees to promote the formation of trunk reiterations may also be useful for developing murrelet nesting platforms (Berg et al. 1996, Carey et al. 2003). Given the DFCs and the significant lack of late-successional habitat in the regional landscape, accelerating the growth rate of trees, and formation of complex branch systems in young previously harvested stands throughout the SWBCA is desirable.

- *Enhancing spatial heterogeneity***:** The spatial uniformity of managed plantations, especially those that underwent extensive site preparation and pre-commercial thinning, is one of the key factors limiting biodiversity. Silvicultural treatments can be used to restore and accelerate the development of heterogeneity at multiple scales and is one of the main objectives of many forest restoration treatments, particularly VDT (Carey et al. 1999a, Carey et al. 2003). In contrast to VDT, which was initially developed around the habitat needs of spotted owls, recommendations for treatments designed to specifically enhance development of marbled murrelet nesting habitat call for more spatially uniform thinning in order to prevent conditions attractive to murrelet nest predators (Carey et al. 2003). A landscape approach for the provision of habitat for listed species must use multiple approaches to provide murrelet nesting habitat and spotted owl habitat simultaneously. Thus, the type, extent and degree of spatial patterning introduced with thinning treatments should reflect the current stand conditions, landscape context, and specific management goals for the particular stand being managed. Some thinning treatments may be relatively uniform, while others more heterogeneous.

- *Restoring landscape linkages:* In many riparian areas dominated by red alder, accelerating the transition to conifer dominated forests and increasing tree diameter growth will increase the availability of large wood. In intensively harvested basins such as the Ellsworth Creek watershed, large diameter woody debris are lacking in streams (Bilby R. E. and Bisson 1998a, Rentmeester 2004). If large woody debris loads of large diameter pieces are below desired levels, it may be desirable to release suppressed conifers from overstory red alder competition with thinning (Deal et al. 2004, Emmingham et al. 2000); particularly in stream reaches where woody debris is delivered primarily from adjacent riparian stands. Thinning in riparian areas to increase the diameter growth of conifers should not eliminate overstory hardwoods however. Hardwoods are a source of diversity of arthropod (Muir et al. 2002, Schultz and De Santo 2006) and lichen species (Neitlich and McCune 1997) and provide qualitatively different allotochonous organic inputs into aquatic systems compared to conifers. Planting may also be required if conifer establishment in riparian stands is seed limited (Beach and Halpern 2001, Emmingham et al. 2000). Thinning dense, conifer dominated young riparian stands can also lead to faster development and recruitment of large wood, although in smaller streams, thinning can reduce recruitment of functional, small diameter logs from competition related mortality (Beechie et al. 2000, Roni et al. 2002). Streams need both large and small diameter logs and thus a mix of riparian thinning and no cut buffers are generally recommended in dense, conifer riparian stands (Naiman et al. 2005), P. Bisson pers. comm. 2006). Thinning to increase the availability of large wood in mass wasting zones is another consideration. Many of these areas are currently densely stocked with young trees and will be able to deliver large wood to the stream network for many decades.

In conclusion, decades of ecological and silvicultural research provide a strong scientific basis for forest restoration in the SWBCA. A treatment regime of density management and manipulating species composition with planting and thinning—tailored to individual stand conditions—will likely achieve the objectives of increasing forest stand resistance to wind disturbance, increasing tree diameter growth rates, restoring functional landscape linkages, and promoting the development of large diameter branches suitable for marbled murrelet nesting platforms. However, the ability of restoration silviculture to accelerate the development of old growth forests remains uncertain, particularly given the tremendous complexity of these forests, climatic variability, the long timeframes involved, and the lack of precedent in coastal spruce-hemlock-cedar forests. It will be necessary to formulate silvicultural prescriptions designed to meet the DFCs and associated silvicultural objectives as working hypotheses to be evaluated within an adaptive management framework.

2. *Scientific Basis for Road Removal*

The ecological effects of forest roads have been extensively researched in the Pacific Northwest. They alter hydrology by reducing soil infiltration, converting subsurface flow to surface flow, concentrating water through road drainage structures, and increasing peak flows (Jones et al. 2000, Luce 2002). They can result in geomorphic changes, including chronic erosion and elevated sediment delivery into streams (Gucinski et al. 2000, Megahan and Kidd 1972), extension of channel networks (Wemple et al. 1996), and increased risk and rates of mass wasting (Montgomery 1994, Swanson and Dyrness 1975). Roads also influence the ecology of terrestrial and aquatic ecosystems through direct habitat degradation and fragmentation, loss of soil productivity, spread of exotic, non-native species, and associated human impacts as a result of increased access (Gucinski et al. 2000, Newcombe and MacDonald 1991). Individual road segments differ greatly in their ecological impact, however, due to site specific factors such as construction techniques, road grade, hillslope position, climate, basin hydrology, soil properties, and underlying geology (Gucinski et al. 2000, Switalski et al. 2004).

Types of Decommissioning

In order to address the negative effects caused by roads and restore natural hydrologic processes, road decommissioning has become an important management consideration on public and private forestland in the US and Canada. Many different interpretations of the term "road decommissioning" are used by different agencies, however. Depending on management objectives, access needs, road condition, relative risk, and budgets, several techniques or levels of road decommissioning exist. Below is a summary of the basic approaches and terms defined as they will be used the SWBCA.

- *Obliteration:* The goal of obliteration is to remove the road and its associated impacts from the landscape and set the stage for vegetation to re-colonize the site. All culverts are removed and stream crossings are restored by excavating the fill down to the original land surface, re-contouring the stream banks, and installing channel stabilization structures, sediment traps, and re-vegetating where necessary. Compacted road surfaces are ripped, then side cast and other fill material is moved to partially or fully re-contour to the natural hill-slope. Some combination of slash, woody debris, and mulch is typically used to cover the re-contoured slope. Seeding or re-planting is often a final step. Recovering the original topsoil may also aid in re-vegetative success and limit the spread of non-native species on the site (Walder and Bagley 1998). Ideally, following obliteration, subsurface water flow is no longer interrupted; peak flows, sedimentation, and mass wasting rates return to pre-road levels; vegetation recovers; and fragmented habitat is reconnected., This technique is generally restricted to roads that will be permanently removed from the road network, as re-opening an obliterated road costs the same as construction of a new road.

- *Putting to Bed*: The goal of stabilization, or "putting roads to bed", is to eliminate or minimize the hydrological and geological effects of a road, while leaving much of the road prism intact. Culverts and stream crossings are removed, water bars and cross-road drains are installed, and problem sidecast (soil cast aside during road construction) or cutslope areas (areas upslope from the road where soil was removed) are stabilized by removing material and bringing slopes to a stable gradient. In some instances, inboard ditches are removed and the road is out-sloped to restore sheet flow. The road bed may be ripped or left intact, and can be covered with slash, woody debris, or mulch. Putting roads to bed accomplishes three important mitigation goals: it stabilizes unstable fill and sidecast; it removes ongoing hydrologic hazards, allowing streams to run unimpeded; and dispersing concentrated water, surface water to the ground (Walder and Bagley 1998). Once put to bed roads can be left to re-vegetate and fill in through natural processes and subsequently re-constructed for future management entries if and when they are needed.

- *Conversion to Trail:* The goal is to reduce the impacts of the road, while converting it to a motorized or non-motorized trail. High impact stream crossings are typically removed, unstable fill, side cast, or cutslopes are treated, and cross-road drains or gentle waterbars are installed to disperse concentrated water. Lower risk culverts are often left in place and the road is generally not ripped, although some treatment may be done on the sides of the road to reduce the width. Roads can be easily re-constructed for future use. Ongoing monitoring and maintenance of these converted roads are typically necessary to prevent culverts from plugging and erosion and rutting of the trail surface.

- *Road Closure:* Roads are closed with gates, berms, or deep ditches (tank traps) to prevent un-authorized use. The rest of the road is left untreated. In some instances, the first quarter mile or the immediately visible part of a road is re-contoured and re-vegetated to camouflage the road and therefore discourage vehicular travel. Road closures, when effective, can help mitigate road impacts on road-averse species such as bears and elk (Walder and Bagley 1998). Closed roads can be easily re-opened for future use. If abandoned or not maintained, however, culverts may fail when plugged by debris or if they are insufficiently sized to convey peak stream discharges and the road will continue to alter hydrologic processes, and culverts will continue to act as barriers to fish passage (Walder and Bagley 1998).

- *Road Abandonment:* This is the same as road closure except that access is left open. These roads usually remain drivable until re-vegetation or erosion closes them in.

Effectiveness of Decommissioning

Although research into the effects of road decommissioning is relatively new, results indicate an overall positive effect. In Redwood National Park, where full obliteration was first introduced, a major storm in 1997 provided the opportunity to measure the effectiveness of two decades of road removal. Most treated roads produced very little sediment and 80% of the road reaches had no detectable landslides following treatment (Madej et al. 2001). In contrast, untreated roads produced four times the level of sediment delivery as treated roads, mostly in the form of landslides (Bloom 1998, Madej et al. 2001). Full obliteration has also been shown to greatly reduce landslide occurance in western Washington (Harr and Nichols 1993), coastal Oregon (Cloyd and Musser 1997), and north-central Idaho (USFS 2003). Results suggest that hillslope position and slope gradient are important factor in determining treatment success. Although treatments dramatically reduced landslide occurrence and sediment delivery from upper- and mid-slope roads, steep lower-slope roads continued to have high failure rates in some landscapes, no matter what treatments were used (Bloom 1998, Madej et al. 2001) .

Madej (2001) examined 207 stream crossings treated between 1980 and 1997 in Redwood National Park, and found that: "The greater the stream power and the larger the excavation, the more the channel eroded following treatment. Deeply incised channels that required more fill to be excavated were more vulnerable to post-treatment erosion than shallow crossings with less road fill because the reshaped stream banks were steeper and more likely to fail. Erosion following treatment is highly variable, and many site-specific conditions (such as the presence of bedrock, springs, poorly drained soils, incomplete excavations, and use of sediment control measures) can influence post-treatment erosion as well." In general, both Madej (2001) and Bloom (1998) found that most treated crossings produced very little sediment and none triggered landslides or debris torrents. Five to 20 years after culvert removals, Madej et al. (2001) found that pool habitat in excavated streams had only partially recovered but a riparian zone of young red alder was providing a closed canopy and shade over the streams.

The effectiveness of road decommissioning at reducing chronic erosion and sediment delivery has also been examined. A short-term problem with decommissioning occurs following treatment when bare re-contoured slopes or ripped road surfaces are most susceptible to erosion (Switalski et al. 2004). While erosion has been shown to increase post-treatment, rates typically decline within one growing season and eventually mimic natural slope conditions as vegetation returns (Gucinski et al. 2000, Luce 1997, Switalski et al. 2004, USFS 2003).The key to reducing chronic erosion is re-vegetation. Adding soil amendments, including sidecast topsoil, slash, mulches, biosolids (residual materials from wastewater treatment), and fertilizers to ripped road surfaces or re-contoured slopes has been shown to effectively increase infiltration and re-vegetation rates (Bergeron 2003, Bradley 1997, Luce 1997, Switalski et al. 2004). In regions where rapid natural revegetation occurs, such as coastal areas like the SWBCA, little to no mulching or replanting may be necessary.

Overall, results suggest that while road decommissioning creates short-term disturbances that can temporarily increase sediment delivery, it can reduce chronic erosion and the risk of landslides over the long term (Switalski et al. 2004). However, these conclusions are far from settled and site specific factors have a large influence on results (Luce 2002, Switalski et al. 2004). Also, the larger question of how effective road decommissioning is at restoring functional landscape linkages of stream and terrestrial ecosystems is only beginning to be addressed. The experiment being conducted in the

Ellsworth Creek Adaptive Management Area is expected to provide importation contributions to these questions.

3. ***Risks associated with Active vs. Passive Management***

While a solid scientific basis for active restoration of the SWBCA exists, there are risks and impacts that must be weighed and analyzed. Natural processes created existing old growth forests over hundreds of years, and some authors argue that managed forests are likely to eventually develop into old growth on their own (Spies et al 2002, Winter 2002a), although climate change is a major wild card. In addition, thinning and removing wood can have numerous negative impacts that may set landscapes back ecologically. These may include elevated risk of annosum root rot, soil compaction, loss of nutrients and organic matter, invasive species, loss of habitat features (snags, tall shrubs, rare plants), detrimental disturbance to sensitive wildlife, and negative impacts of forest road systems such as chronic, elevated sediment delivery to aquatic systems and habitat fragmentation. If stands are thinned heavily, the open canopy can cause excessive understory shrub response or western hemlock regeneration that can reduce habitat value for some species. Moreover, thinning to promote ecological objectives is relatively new and more complex than traditional thinning for spacing. There is always risk of misguided prescriptions and poor implementation that can homogenize or over-thin stands. Current research indicates that the fine scale spatial patterns of trees left following typical thinning treatments are different from those of overstory trees in old-growth forests (Larson, unpublished data). Specifically, thinning can result in residual trees being spaced some minimum distance apart, and this minimum spacing is greater than that observed for some overstory trees in old-growth forests. Thinning treatments , therefore, have the potential to eliminate a fine-scale spatial pattern characteristic of old-growth forests: closely spaced pairs and clumps of overstory trees as well as dense thickets of midstory trees.

Conversely, there is also a risk in walking away and letting nature runs its course. A number of researchers contend that plantations will not develop into old growth due to the suppression of diameter growth and increased windthrow risk from developing at high densities (Andrews et al. 2005, Poage and Tappeiner 2002, Spies et al. 2002a). Forests within the SWBCA are structurally and functionally very different from landscapes dominated by old growth forest, both at the stand and landscape scales. Stands also lack the legacies, species composition, and spatial complexity of a young forest recovering from a natural blowdown event (Kohm and Franklin 1997, Lindenmeyer and Franklin 2002). As described above, the whole system is likely to shift from a chronic, low-moderate severity disturbance regime to a high severity, catastrophic regime if left alone. Population declines in numerous terrestrial and aquatic species are unlikely to be reversed under such a scenario. Given the tremendous reduction of old growth habitat in the region, the recovery of these species may depend on actively restoring functional landscape linkages and encouraging specific structures and habitats.

Windthrow Risk

Stability of trees on wind prone sites is related to individual tree characteristics such as height, species, diameter, crown size, crown density and root or stem rots as well as site characteristics such as rooting depth, soil moisture, rooting substrate and topographic exposure and stand density (Edmonds 2002). In dense competitive exclusion stands, trees tend have high height to diameter ratios with small crowns and narrow rooting zones resulting in trees that are susceptible to complete blowdown or stem breakage when they are exposed to strong winds. Western hemlock, with its shallow roots and structurally weaker stems, is especially susceptible (Holmberg et al. 2006). In these dense stands, however, the neighboring trees provide shelter and support, thus reducing the potential for windthrow. Forest management can affect many of the tree and stand characteristics that drive the likelihood of windthrow. On one hand, thinning can lead to more stable trees with lower height to diameter ratios, especially if done early in stand development. On the other hand, opening up dense stands with tall, windthrow-prone trees can increase windthrow risk. Careful analysis of these two factors is critical in successful use of silviculture to achieve old growth structure.

A windthrow probability model developed by Scott and Mitchell (2005) for Vancouver Island was built into LMS to assess the current winthrow potential of stands and potential changes caused by treatments on the SWBCA. Parameters used by the model are height to diameter ratio, percent live crown, crown density, rooting substrate, post-thinning density and variable retention fetch, which is a measure of the level exposure of a tree to winds. These parameters for trees with a DBH of >4" are used to estimate the probability of windthrow for each tree in a unit after harvest. These probabilities are averaged for the entire stand for an overall windthrow probability. The current conditions of the SWBCA have a generally low probability of windthrow (Map – SWBCA Average Windthrow Probability) because many of the stands are dense providing shelter and support for reduced probability of windthrow. If not done carefully, active management could alter the current stability and increase the probability of windthrow within treated stands.

Topographic exposure is an important aspect of windthrow that was not used in this model. Scott and Mitchell (2005) compared their stand level model with a more complex model that incorporated topographic position and storm patterns with structural variables. Based on field verification, they found that the stand level model predicted windthrow risk as well or better than the more complex model. Nevertheless, topographic position must also be taken into account in evaluating windthrow risk. As winter storms that affect the SWBCA generally come from the southwest, areas with a south and western exposure, especially along Bear River Ridge and the west side of Long Island, would be expected to have a higher potential for windthrow. Ridge tops are also areas of high exposure to winds and windthrow of trees. Evidence of this is seen in the SWBCA where there are areas on ridges with a higher proportion of wind-firm western redcedar and less windthrow-prone western hemlock.

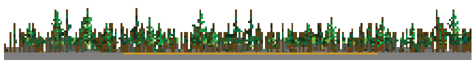
Modeling thinning treatments

To analyze the potential benefits and risks from thinning, the Pacific Northwest Coast variant of the Forest Vegetation Simulator (FVS) (Donnelley 1997) growth model was used within LMS to model several basic treatment scenarios on 2 stands within the SWBCA (#17484 and #30027). FVS tends to grow stands that have a lower height to diameter ratio and lower density than those found in the real world. Fortunately growth in FVS can be adjusted. For this model FVS was calibrated by setting a maximum SDI of 800 for all species other than Douglas-fir, which was set to 600, and then reducing the basal area increment for the stand incrementally as it approaches the maximum SDI value. These adjustments result in QMD increments that approximate those Curtis and Marshall (1986) found in the LOGS studies as sites in SW Washington. As FVS is a not a spatially explicit model, it cannot model horizontal spatial variability. It also does not model natural understory regeneration, but understory trees can be added in. The simulators utility lies in modeling growth rates, mortality, changes in stand density, height to diameter ratios, and crown development. In terms of old growth structure, it can thus predict the development of large trees, snags, downed logs, and shifts in species composition and diameter distribution. The Modified Old Growth Index (MOGI) was incorporated into LMS to measure these output variables. A snag to downed wood algorithm and a decay function that accounts for differences in decay rates by species and log sizes were both built into the LMS MOGI output. This approach is similar to other simulation studies that have used growth models to test the effects of thinning on development of old growth structure (Acker et al. 1998, Andrews et al. 2005, Garman et al. 2003)

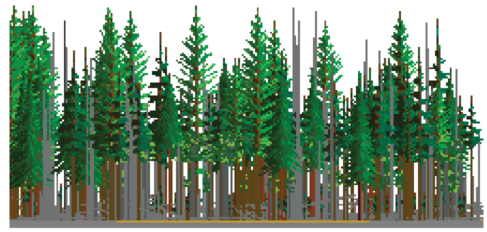
The first stand, #17484 is a dense 13 year old plantation, but young enough where tree competition has not become intense. Three treatment scenarios were run: 1) a no-thin, 2) 2 light thinning entries (L-L) in 2010 and 2035 to increase diameter growth while favoring western redcedar and Sitka spruce, and 3) a heavier initial thinning (H-T) to encourage Douglas-fir growth followed by a second thinning where nearly all Douglas-fir are removed. The stands were grown out 50 years. Both the thinning treatments moved the stand from hemlock dominance to redcedar and Sitka spruce dominance and result in significantly higher diameter growth than the no-thin. The H-L treatment results in larger number of big trees (20-40" dbh). The MOGI value is higher in L-L because of a higher number of large snags (20"+dbh) and more downed wood. The All MOGI values are heavily influenced by the presence of large volumes of dead wood. Mortality from self-thinning within FVS is known to be excessively high and thus it is likely that actual snag TPA and CWD volumes will be lower in all scenarios, but especially in the no-thin. The excessive mortality also reduces diameter growth suppression in dense stands and number of large trees and snags may be even lower in the no-thin scenario. L-L may provide the best trajectory to move the stand to a higher MOGI as it balances diameter growth with snag and downed wood generation. However, a large input of dead wood could easily be created by a windthrow event in the H-L scenario. This dead wood would likely be larger than in the other two scenarios and thus persist for longer. Both L-L and H-T have a SDI of 333 at year 2055 and may need to be thinned in the future to maintain tree growth. Finally, windthrow risk was not affected by thinning.

The second stand #30027 is a 76 year old, dense western hemlock stand on Long Island. Its current MOGI score is low due to a lack of snags over 20" dbh and low downed wood levels. Three treatment scenarios were also run: 1) no-thin, 2) a single mid-story thin (H) to encourage development of trees over 40 inches dbh, and 3) 2 lighter thins (L-L) to remove trees in the 6-20 inches dbh classes to reduce competition and encourage overall tree growth. Both the thinning options increase MOGI over the no-thin alternative due to a higher number of trees over 40" dbh. Downed wood is lower in both the thinning treatments, while large snags remain the same. The relatively small increase in diameter growth from thinning is due to the stands older age and the fact that competition has reduced crown lengths. In general, once conifers in this region start slowing down in height growth around age 70, their ability to build crown and accelerate growth rates in response to thinning decreases (Oliver and Larson 1996, Tappeiner et al. 2002). Older trees still respond to thinning, however, and growth responses are generally observed over time (Latham and Tappeiner 2002). The same issues with the FVS as discussed above are likely reducing the difference in diameter as well. Of the two thinning treatments H has a slight decrease in windthrow probability over no-thin because average height:diameter ratio improves as many of the small diameter trees are removed with little change in the amount of exposure to the overstory trees. In contrast, L-L does increase windthrow potential by further exposing the overstory trees to wind by reducing the density of the overstory in the second thinning.

The two treatment scenarios are provided as a modeling exercise and do not represent actual prescriptions that will be implemented. The results of these treatment scenarios are presented in SVS visualizations in Figures 11 and 12. The images are caricatures and do not represent the actual location of trees in the stand. These scenarios do show, however, that opportunities do exist for accelerating the development of large trees and snags, and shifting species composition, without dramatically affecting the amount of live and dead biomass on the site. Thinning treatments can also be designed to minimize a future increase in windthrow probability. Having the windthrow model implemented within LMS allows assessment of treatments in a gaming context to assess changes in windthrow to guide the development of prescriptions. More than anything, the scenarios clearly show that thinning early in stand development produces much greater differences in diameter growth over later thinning.



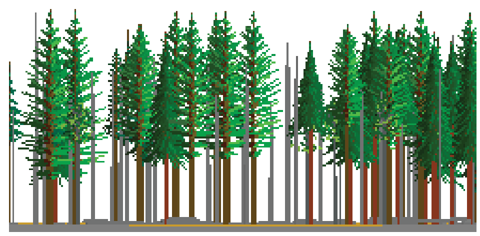
Current, Age 12



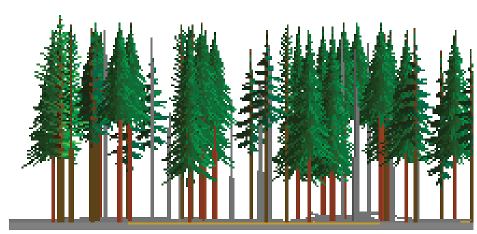
Age 52 No-Thin

		No Thin	L-L	H-L
Year	**2005**	**2055**	**2055**	**2055**
Age	12	52	52	52
TPA	2,328	1,035	126	133
DBHq	1.1	6.9	18.4	17.8
Avg. Ht	8	54	105	110
SDI	66	574	334	333
Vol/Ac	0	34,215	50,083	37,278
Wind Pb	0.00	0.00	0.01	0.01
MOGI	11	43	56	45
10-19.9"	0	123	72	84
20-39.9"	0	11	39	48
40"+	0	0	0	0
L Snags	0	2	14	5
CWDVol	1087	5581	4960	3688
DDI	10	42	51	50

DBHq: Quadratic mean diameter (inches)
Avg Ht: Avg height (feet)
LCR: Live crown ratio
SDI: Stand density index
Vol/Ac: Scribner bf volume/acre (mbf)
Wind Pb: Windthrow probability
MOGI: Modified old growth index
10-19.9”: Trees per acre of trees 10-19.9” dbh
L snags: Snags per acre over 20” dbh
CWD vol: Cubic volume of CWD; ft^3/ac
DDI: Diameter diversity index

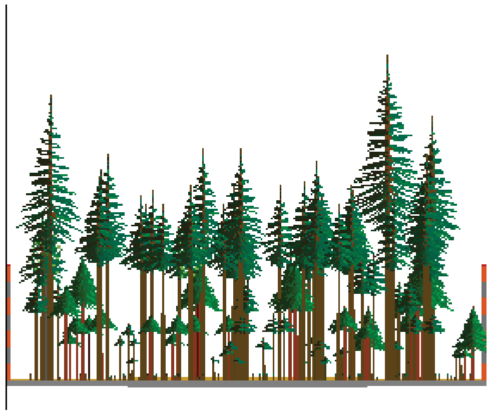


Age 52: 2 Light Thins (L-L)

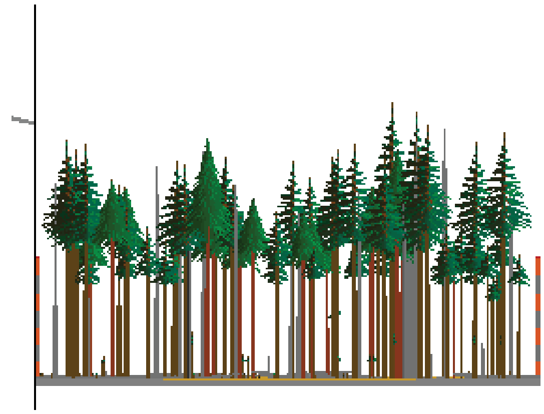


Age 52: 1 Heavy, 1 Light Thin (H-L)

Figure 11: Treatment scenarios and results for stand # 17484.



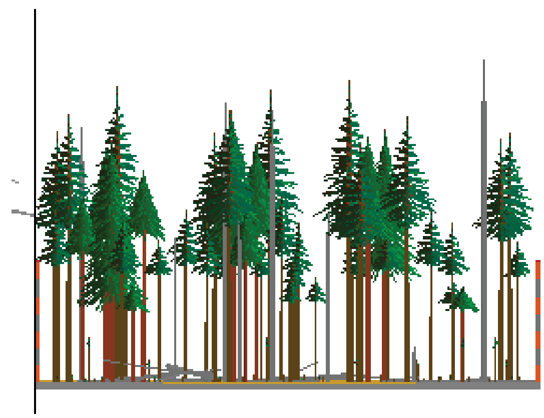
Current, Age 76



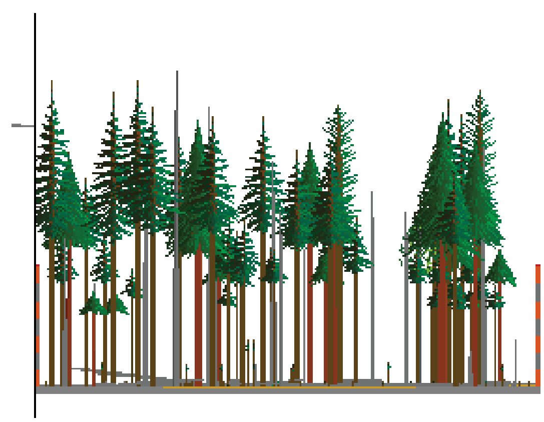
Age 126 No-Thin

		No Thin	H	L-L
Year	**2005**	**2055**	**2055**	**2055**
Age	76	126	126	126
TPA	590	428	285	223
DBHq	10.4	12.37	13.46	13.48
Avg Ht	46	66	52	52
SDI	628	602	459	440
Vol/Ac	69.0	87.1	84.6	81.5
Wind Pb	0.01	0.13	0.12	0.19
MOGI	29	64	71	69
10-19.9"	148	115	49	26
20-39.9"	42	50	40	46
40"+	1	2	5	4
L Snags	0	14	13	15
CWDVol	1003	7379	6009	6586
DDI	65	65	71	65

DBHq: Quadratic mean diameter (inches)
Avg Ht: Avg height (feet)
LCR: Live crown ratio
SDI: Stand density index
Vol/Ac: Scribner bf volume/acre (mbf)
Wind Pb: Windthrow probability
MOGI: Modified old growth index
10-19.9": Trees per acre of trees 10-19.9" dbh
L snags: Snags per acre over 20" dbh
CWD vol: Cubic volume of CWD; ft^3/ac
DDI: Diameter diversity index



Age 126: 1 Heavier Thin (H)



Age 126: 2 Light Thins (L-L)

Figure 12: Treatment scenarios and results for stand # 30027

C. Operational Constraints

1. *Staff Capacity*

The Refuge and the Conservancy have limited resources devoted to management and restoration of the forested landscape. Existing staff resources for the Refuge include a Refuge Manager and Wildlife Biologist, while the Conservancy's staff includes a Program Director, and Project Ecologist. Both managers are responsible for all stewardship, managerial, and administrative issues on their respective ownerships while the biologist and ecologist lead research and monitoring activities. A Forester and Forest Technician are also employed by the Conservancy to meet obligations under existing federal grants for implementing restoration actions across the SWBCA landscape. These two positions are largely dedicated to scoping and supervising contract work associated with road removal and forest thinning projects. Additional support for road removal comes from a small staff of heavy equipment operators at the Refuge who can be assigned to restoration projects as time allows.

2. *Financial Resources & Considerations*

Financial resources to cover the expenses of restoration come from internal operating funds, public and private grants, and other private fundraising activities. As of 2006, two federal grants comprise the majority of all funds used for restoration – a U.S. Fish and Wildlife Service Community Conservation Initiative (CCI) grant ($750,000) and a grant from the Nestucca Oil Spill Mitigation Fund ($215,000). The five-year (2005-2009) CCI grant is administered by the Conservancy specifically to remove or repair 15 miles of forest road and ecologically thin 1,500 acres of young-managed forest across the SWBCA. Nestucca mitigation funds are administered by the Refuge primarily for road removal, forest restoration, and monitoring of marbled murrelet populations on the Refuge. Given the existing staff capacity, these grant resources are expected to cover the on-the-ground costs of restoration activities through 2008. It is expected that approximately 3-5 miles of forest road and 500 acres of young-managed forest can be treated on an annual basis during that time period. Beyond 2008, additional funds must be raised through some combination of new grant sources, fundraising efforts, or the sale of timber from restoration thinning to sustain restoration activity within the SWBCA.

While producing revenue is not the primary management objective, the ability of the Conservancy and Refuge to fund road decommissioning, road maintenance, and forest and stream restoration activities will be significantly affected by the revenue that can be produced from forest thinning. Even though the decision of when and how to treat stands will be driven by ecological criteria, the costs and potential revenues from alternative treatments must be factored in as they will determine what is economically feasible. The following assumptions and considerations will be used to assist managers in being as efficient as possible while allowing for the generation of revenues within the boundaries of the overall ecological objectives.

Management Costs

The costs of management activities will always be highly dependant upon regional rates within the forest industry in southwest Washington and northwest Oregon (Table 8). Fortunately, this region has a high likelihood of maintaining its forest management infrastructure over time and so costs should stay relatively low compared to other geographic areas. Ranges for average costs for different activities were researched relative to the local area. These numbers are only contractor costs and do not include administration costs. They also will change over time.

Table 8: Average range of contractor costs for management activities in 2006 in southwest Washington - administration costs are not included. Costs are expected to change constantly over time.

Management Activity	Contract cost range
Ground based thinning (less than 35% slopes)	$125-175/ mbf (1000 board feet)
Cable thinning (uphill) (greater than 35% slopes)	$200-250/ mbf
Cable thinning (downhill)	$300-350/ mbf
Helicopter Yarding	$350-450/ mbf
Hauling	$30-65/ mbf
Pre-commercial thinning	$100-150/ acre
Falling and leaving selected trees. (MDL treatments)	$40-50/ hour
Vegetation Control (Manual slashing)	$0.50 per seedling
Vegetation Control (Spot spraying)	$0.40 per seedling
Planting & Browse Control	$150/acre (100 tpa)
Road Obliteration	$15,000-100,000/ mile
Putting roads to bed	$5,000-50,000/ mile

Reducing harvest costs is dependent on a number of factors.

- Projects must be large enough to absorb a contractors mobilization costs (moving equipment in and out) and keep the equipment and crews busy for as long as possible.
- Projects should aim to be at least 50 acres in size for any single type of yarding, and over 100 acres for combined operations (e.g., cable/ ground).
- Several stands may make up one project, but stands should be as close together as possible.
- Thinning should be combined with road decommissioning in one contract to increase project size and get better bids as many logging contractors have excavators and bulldozers and are happy to have more work for their machines.

Another major factor in reducing yarding costs for forest thinning is production rates (Kellog et al. 2002). As logging contractors base their bids on the estimated number of truck loads they can produce per day, average yarding distances, volumes removed per acre, and log size will largely determine yarding costs. For ground base yarding, average yarding distances should be no more than 600 feet with a maximum yarding distance of 1,200-1,500 feet, depending on whether yarding is uphill or downhill. Distances can be longer, but it is general ecologically less damaging and economically advantageous to build temporary spur roads to avoid longer distances. For uphill cable yarding, 1,000-1,200 feet average distance is ideal with a maximum of 1,600-1,800 feet. Downhill cable yarding is much slower and damaging, and distances should be no more than 500 feet. For helicopter yarding, average distance should be no more than 1 mile, and ideally 0.5 miles. In terms of log size, the larger the logs that will be removed, the higher production rates will be. As the planned thinning in the Refuge and Conservancy ownerships will involve thinning primarily small trees (7-14 inches dbh), production rates will be slower and costs higher. Finally, production rates are highly dependent on the volumes per acre removed. In general, removing less than 10 mbf (thousand board feet) per acre of small diameter, low value logs with cable yarding is not economically viable. This level can be lower if higher value species such as red alder are removed or ground based yarding is being used. Overall, it is unlikely that it will be economically desirable to remove wood in stands younger than 25 years of age, or in stands with total volumes less than 20 mbf/acre. However, there are no magic numbers in terms of age, standing volume, or tree size for when wood should be removed during a thin. Site specific conditions, prescription objectives, contractor rates, log prices, thinning history, and many other factors play into these stand by stand decisions.

Due to the relatively low economic value of western hemlock (which will be the primary species removed within the SWBCA), the removal of small diameter trees, and the amount of steep ground that will require cable yarding, it will be a challenge to ensure that thinning projects are economically viable. To address this reality, managers should creatively factor in logging system requirements into prescriptions and work constructively with contractors. For example, heavier thin areas and gaps can be placed in areas that are closer to landings and easy to yard from, while lightly thinned areas and skips can be left to the logging contractor to place in areas that are difficult to yard from. If done with care, this approach can reduce costs without sacrificing any of the desired ecological objectives.

Costs for pre-commercial thinning (young drop-and-leave), planting, and vegetation control are also driven by production rates. Dense stands with larger trees will be more expensive to pre-commercial thin. Also, complex prescriptions that are hard to understand and implement will increase costs. Yet, with creativity and through trial and error, prescriptions that achieve the desired ecological objectives can be made simple enough for most contractors to implement at competitive rates. SWBCA managers have already begun to work closely with contractors to make this happen. Costs for road decommissioning are determined by the level of re-contouring desired, topographic position, grade, road width, the amount of fill or side cast material to be removed, the number of culverts and stream crossings, and how the final surfaces will be treated (mulched, covered with slash, seeded, etc). In general, managers must weigh the ecological gains of full vs. partial contouring against the exponentially higher cost of full re-contouring.

Revenues

Gross revenues from thinning projects will depend on the prices of the species and log sizes that are removed. The primary species to be harvested will be western hemlock, Douglas-fir, and red alder, in that order. Small diameter Sitka spruce and western redcedar may occasionally be removed from stands dominated by those species. Log prices from local mills as of October, 2006 are provided in Table 9, for the three primary species. Although log prices will fluctuate significantly through time, it is likely that the relative order of value for different species will remain the same over the next 10-15 years. Markets for FSC certified logs or logs with unique qualities should be periodically explored as higher prices may be found.

The basic log sizes, or "sorts" currently used by mills are based on inside bark, top diameters, but typical dbh values are also presented using a log length of 30 feet (Table 9). These sorts are likely to change through time as markets and mill technologies evolve. Minimum top diameters are currently 4.5 or 5 inches, which translates into a minimum 7 inches dbh tree. Logs with a top diameter smaller than 4.5 inches may be removed and sold as pulp, but pulp prices are currently too low to make this economical.

Table 9: Average log prices in southwest Washington for Oct 2006. Prices are per thousand board feet (mbf). Tonnage prices for chip and saw logs were converted using 6.9 tons/mbf for Douglas-fir and 7 tons/mbf for western hemlock. Source (Log lines, Oct 2006)

Sort	Western Hemlock	Douglas-fir	Red Alder
Chip & Saw (#4 saw) 5-7" top (7-12" dbh)	$315	$445	$625
Small Sawlogs (#3 saw) 8"-11" top (12-15" dbh)	$410	$500	$730
Large Sawlogs (#1-2 saw) 12"+ top (15-22" dbh)	$440	$575	$830

3. ***Applicable forest practice laws and policies***

The Refuge and the Conservancy must comply with similar but somewhat different set of state and federal laws and regulations when conducting forest management activities. The Conservancy, as a private forest owner, must comply with Washington State Forest Practice Act (FPA) and water quality laws. This requires the Conservancy to apply for permits under FPA regulations for forest management actions that may affect the resources of the state. The Refuge, as a federal agency, is not required to obtain state permits for similar work (the Refuge nonetheless strives to conduct work at or above these standards). The Refuge is required, however, through the National Environmental Policy Act (NEPA), to conduct a review of significant management actions. NEPA also requires the Conservancy to consult with federal natural resource management agencies prior to using federal dollars to conduct management actions.

Riparian Areas, Shorelines, and Wetlands

Based on the current FPA, the approximately 45 miles of fish bearing (type F) streams within the SWBCA are required to have a 170 foot buffer for site class 2 areas and a 140 foot buffer for site class 3 areas on both sides of the stream. Shorelines have the same buffer requirements. Partial harvesting can take place outside of an inner, 50 foot no cut buffer. Non-fish bearing, perennial streams (type N) are required to have a 50 foot no cut buffer on each side, on half of the entire stream length. Harvest machinery is not allowed in forested wetlands, but trees may be removed via skyline or ground based cable yarding.

Topography and Unstable Landforms

As described previously, the steep terrain, heavy precipitation, and susceptible bedrock types make soils in the SWBCA prone to mass wasting events. The Map – Ellsworth Creek Unstable Landforms displays the watershed contains a large number of convergent headwalls, bed rock hollows, inner gorges, and unstable sections of former deep-seated landslides (Map – SWBCA Slope Stability Hazard). These features will need to be carefully identified on the ground when managers plan forest thinning and road removal projects. In order to remove wood from these areas, FPA rules require a Class 4 Special permit. This involves obtaining a geotechnical design and report that describes how the risk of mass wasting and damage to streams, shorelines, and public safety will not be increased.

State and Federal Listed species

The Conservancy and Refuge must follow all applicable laws and regulations pertaining to active management which could impact endangered species. As stated above, a particular emphasis will be placed on avoiding disturbance to listed species. All forest management activities will be aimed at increasing suitable habitat over time.

The principal operational constraints on forest management activities pertaining to listed species occur in relation to marbled murrelets and, to a lesser degree, spotted owls. Both species have specific protection measures codified within FPA regulations. These regulations are largely intended to control the level of impact from industrial scale forest practices, such as clearcut harvesting, where listed species are present. Since forest restoration is the primary goal within the SWBCA, alternative practices may be appropriate. The Conservancy will consult with the appropriate State and Federal regulators prior to implementing alternative practices.

4. ***Access, road network, and logging systems***

The extensive road network in the SWBCA provides sufficient and often redundant access for wood removal for almost every part of the landscape. Recent and planned road obliteration has and will remove access to some areas, although a significant number of road segments can be removed from the system without reducing the number of acres that can be accessed. Maintaining roads on the steep terrain of Bear River Ridge will require significant time and resources. Fully putting road segments in steep terrain to bed between treatments is possible in most cases, but may not be much more economically advantageous than obliteration. The roads on gentle topography to the west and south of Bear River Ridge and on Long Island, however, will be much easier to put to bed between treatments.

On terrain with slopes below 35%, ground based yarding is possible in most cases (Kellog et al. 2002) whereas on steeper ground cable yarding will be necessary. Forwarders can operate on slopes as high as 45%, but they can only move downhill when loaded and must have a gentler path to get to the top of the slope. In stands that are mostly below 35% slope, but have occasional steeper pitches, ground based machinery can pull logs in with a winch when necessary. Landings appear sufficiently close together, in most stands throughout the SWBCA, to avoid the need for temporary spur roads. As the road system is mainly on ridgetops, most stands are well positioned for uphill cable yarding with maximum yarding distances of around 1,200-1.800 feet. Yarding corridors for cable thinning are typically 100-150 feet apart and are 6-12 feet wide. Several contractors in the region have small, light, and mobile yarders that are well designed for thinning small diameter trees and have experience implementing ecologically oriented prescriptions.

5. *Community & stakeholder context and desires*

Various people, communities and organizations have interest in the Refuge for a variety of reasons and purposes, and must be considered in making management decisions. Local individuals and tourists have common interests in the Refuge as a place that provides hiking, boating, hunting, camping, wildlife viewing, bird watching and interpretation of the natural world. The Refuge is also valued for its role in protecting and enhancing wildlife and natural habitats, apart from these recreational offerings. Local communities use the Refuge as a place to conduct educational field trips. The Refuge is also valued for the aesthetic beauty it imparts to the area and the effect that has on quality of life for residents and for the draw it imparts on tourists.

Local individuals have mixed feelings about the Ellsworth Creek Preserve's value considering its recent history as commercial timberland and the importance of logging jobs and revenue to the local economy. However continuing uses such as hiking and hunting mean that the land is valued for similar purposes under the Conservancy's ownership. Camping is not permitted on the Preserve, and nature interpretation is not currently presented in any regularly organized fashion. The limited drive-in access is valued because most private forestland roads in the area are gated.

Restoration Program and Schedule

Excavator recontouring at a stream crossing road removal site

A. MANAGEMENT APPROACH

1. *Silvicultural System*

A silvicultural system is a progression of treatments during the life of a stand designed to achieve the desired stand level structural objectives (Smith D.M. et al. 1997). The set of treatments is heavily influenced by the ecosystem characteristics, landowner goals, and management constraints of a particular ownership. The system outlined here for the SWBCA reflects the over-aching goal of restoring resilient old-growth forests and habitat for threatened species, the desire to generate revenue to help defray the costs of landscape restoration, and the ecological dynamics of spruce-cedar-hemlock forests. The system combines silvicultural treatments with natural stand development processes and disturbance agents to shift stands onto development trajectories that meet the DFCs (Figure 13 – Conceptual Harvest Systems). A key principal of the system is to restore the species diversity, spatial complexity, and decadence that exist in natural young stands recovering from disturbance but are not present due to past management. A second key principle is to accelerate the development of large trees, future large snag and CWD recruitment, and vertical canopy layering. A third principal is that while natural processes serve as an important guide, actively manipulating developmental processes to achieve the DFCs may move stands through an unnatural pathway for a period of time.

Response to Disturbances and Forest Health Issues

Unlike traditional silvicultural systems, the system for the SWBCA does not view natural disturbances and forest health issues as factors that must be controlled and stopped to reduce losses to timber value. Instead, disturbances are viewed as key architects of the complexity inherent in old growth forest (Franklin et al. 2002). Dwarf mistletoe, for example, plays a key role in developing murrelet nesting platforms in western hemlock and will generally be promoted in treatments. Wind and annosum root rot act together as major drivers of overstory mortality, decadence creation, and horizontal diversification. Salvage operations to remove wood in blow down patches will not likely occur, as downed logs are a key habitat feature and substrate for tree species colonization. Animal damage often creates decadence in trees that lead to cavity formation in live trees. Decadence in live or dead trees provides critical nesting, hiding, and foraging habitat for suites of wildlife, fungal, and insect species.

While most disturbances are "natural", they may or may not push the stand towards the DFC's. Thus, when disturbances threaten to move stands away from key structural goals, they will be managed or contained as much as is practical. Fire, while a historic disturbance agent, will be actively suppressed, given the small amount of old growth forest left with the regional landscape. Too much annosum root rot can lead to early mortality of the overstory and preclude the development of large diameter trees. It will not be encouraged and stumps will be cut at least 12 inches high to avoid spread. Planted seedlings will be protected from browse to improve their chance of survival. Salvage may occur in cases of severe blow down where subsequent outbreaks of Douglas-fir beetle (*Dendroctonus pseudotsuage)* or other beetles threaten remaining stands. Most importantly, stands will be managed to promote species and structural diversity that will act as a buffer against epidemic outbreaks of hemlock looper, spread of Swiss Needle cast, or catastrophic blow down (Edmonds et al. 2000, Thies and Goheen 2002).

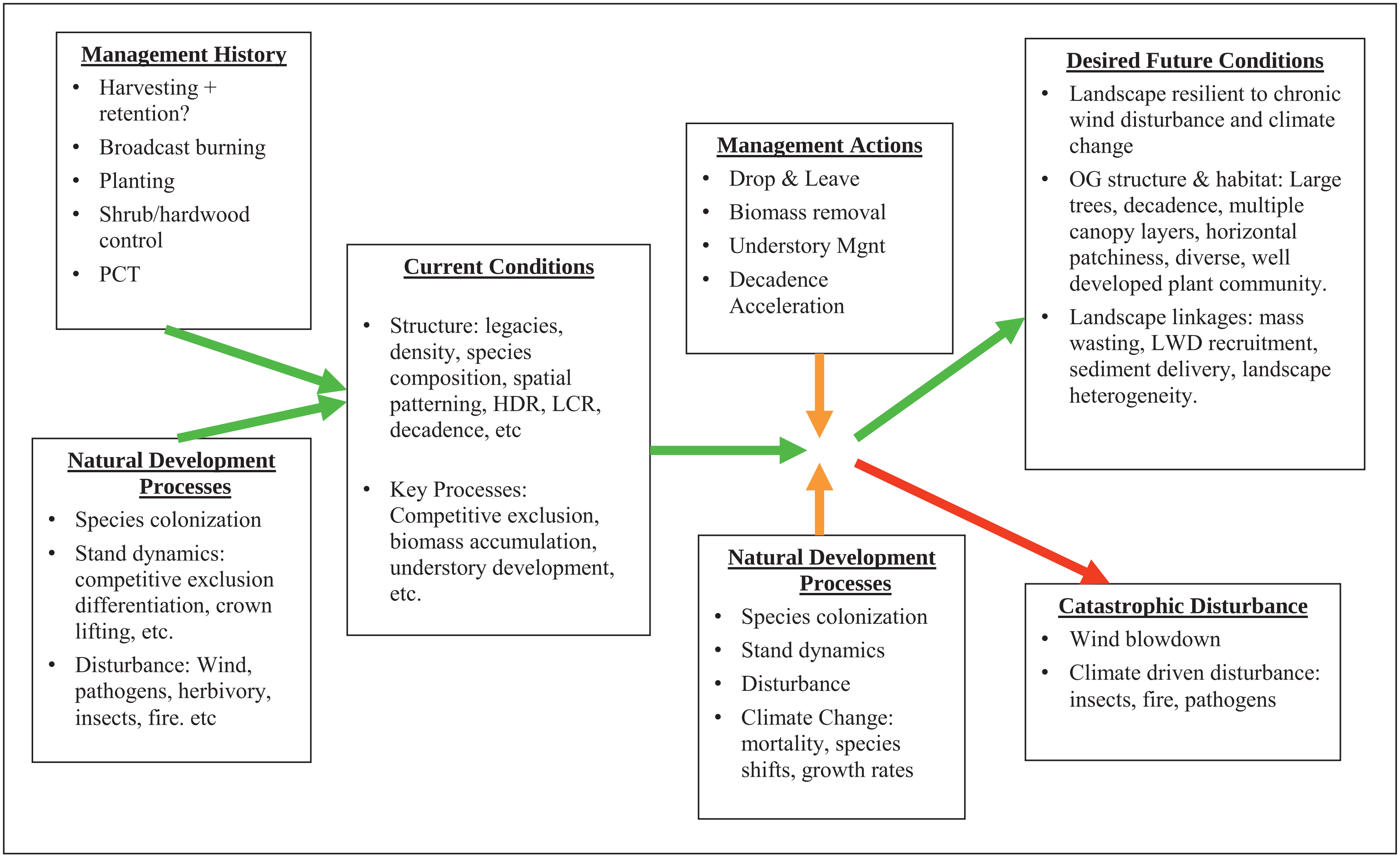


Figure 13: Conceptual diagram of silvicultural system designed for the Refuge and Conservancy ownerships.

New Terminology:

In an effort to distinguish ecologically oriented silvicultural systems from traditional wood production forestry, other ownerships and authors have coined many new terms such as "Thinning for diversity" (Hunter 2001), "Ecological thinning", "Restoration thinning" (Erckmamn and others 2000), "New forestry" (Holmberg et al. 2006), and "Biodiversity pathways" (Carey et al. 1999b). These terms are often vague descriptions of approaches that involve a mix of truly new restoration techniques and traditional silvicultural tools applied to non-traditional objectives. They have generated confusion among stakeholders and the forestry community and skepticism among some older foresters. To avoid confusion, terms from traditional silviculture are used in this plan where possible. However, the silvicultural system defined here is fundamentally different from traditional even or uneven-aged systems where the primary reason to grow and harvest trees is wood production and revenue generation. In this system, the primary reason to cut, remove or plant trees is to achieve ecological objectives. In many cases, the felled trees will be left on the ground. In other cases, the wood will be removed to generate income for other restoration when it can be done without compromising long term ecological objectives. Thus new terms were created for this system to where it is necessary to capture this fundamental difference and also to use terms that more precisely reflect their meaning.

Treatments

The silvicultural system consists of 4 different treatment categories that are described below, each containing multiple treatment types (Table 10). Treatments will be done at various stages of stand development with an end goal of an old growth dominated, self-sustaining forest ecosystem that is not dependent on perpetual management intervention. Unlike even-aged or uneven-aged silvicultural systems, it does not have a regeneration harvest component.

Table 10: Categories and treatment types for the Conservancy/NWR

Category	Treatment Type	Acronym
Drop and Leave	1. Young: Variable Density Thin 2. Mature: Individual Tree Selection	YDL MDL
Biomass Removal	1. Variable Density Thin 2. Individual Tree Selection 3. Group Selection	BR
Understory Management	1. Planting 2. Shrub Control (around seedlings) 3. Browse Protection (seedlings) 4. Understory, Variable Density Thin 5. Invasive Species Control	UT
Decadence Acceleration	1. Snag or Wildlife Tree Creation 2. Course Wood Creation 3. Fungal/Mistletoe Inoculation	DA

a. *Drop and Leave*

This category applies to all treatments where trees are felled and left on the ground to decompose. Such treatments will be used in both young and older stands when it is not ecologically appropriate and/or economically viable to remove wood from a stand. In dense, young stands (typically 12-25 years old) with small diameter trees that are not merchantable, young drop and leave treatments (YDL) will be used. While these are similar in many respects to "pre-commercial thinning" (PCT) and PCT crews will be contracted to get the work done, they will not be designed to set stands up for commercial harvest, and thus a different name is warranted. Instead of thinning for spacing as in traditional PCT treatments, "variable density thinning" (VDT) (Public Forestry Foundation 2001) will be used. Variable density thinning is similar to traditional thinning in that it seeks to reduce stand density to increase diameter growth and crown development on residual trees throughout a stand. It differs, however, in that it also seeks to create varying densities in a stand to promote horizontal patchiness, species diversity, and multiple canopy layers (Carey 2003b, Lindenmeyer and Franklin 2002). This patchiness is achieved in prescriptions by a combination of favoring certain tree species; varying spacing targets; leaving pairs or clumps of dominant trees, and by adding in "skips" or no thin areas, and heavy thin areas, or gaps.

In older stands, drop and leave treatments will be generally be targeted at fostering specific, individual tree attributes in certain parts of a stand, and not involve treating entire stands to achieve a specific density reduction goal. Examples include increasing habitat suitability near large trees with murrelet nesting platforms, releasing understory conifers in red alder dominated stands, accelerating diameter growth of a selected number of dominant conifers on unstable slopes or riparian areas for future LWD recruitment, and creating small gaps where conifers can be planted. The best term for this approach is "Individual Tree Selection" (Smith D.M. et al. 1997), which is used in uneven-age management systems to target individual trees or small groups of trees for release or removal. This approach has also been called "Individual Tree Culturing" or "Crop Tree Management" – here we use the term mature individual tree selection or just mature drop-and-leave (MDL). In some cases, girdling may be used to kill trees instead of falling them. This is cheaper and usually effective as girdled western hemlock trees tend to fall over quickly (Hennon and Loopstra 1991).

b. ***Biomass Removal***

This category applies to treatments where felled trees can be removed from stands without compromising long term ecological objectives. Treatment types used will generally be variable density thinning, individual tree selection, or a combination of the two. Group selection may also be used to transition some mature red alder stands to conifer dominated stands by creating larger gaps or patch cuts, or to treat extremely dense conifer stands that will not respond well to thinning and are likely to experience significant windthrow. Generally, biomass removal (BR) treatments will occur in 30-80 year old stands were net positive revenue generation is possible, or at least where projects are revenue neutral. While biomass removal treatments are similar to "commercial thinning", they are not "commercial" in that they are not designed to be intermediate treatments that set stands up for a final regeneration harvest where revenue generation is a major goal. Instead, they are designed to accelerate or reduce specific stand development processes to create complexity and develop old growth structure. What distinguishes them ecologically from drop and leave treatments is that the logs or "biomass" created from felling targeted trees will be removed from the system. Hence, the term "Biomass Removal". Where necessary or more appropriate, areas of drop and leave treatments may be embedded within an overall biomass removal treatment for a specific stand (i.e. shoreline buffers, unstable slopes, etc).

c. ***Understory Management***

While natural regeneration will be relied on as the main source of understory colonization in stand development, trees may be planted in some circumstances at various stages of stand development. To accelerate the development of a large western redcedar component, it may be planted in stands where it is poorly represented and few overstory trees exist to provide seed source. In stands heavily dominated by red alder, a mix of conifers may be planted in gaps to prevent shrubs from dominating the site and making natural regeneration very difficult (Tappeiner et al. 2002). In general, planted seedlings, along with some natural seedlings of desired species, will be protected from the heavy browse and intense shrub competition that exist in this area until they are "free to grow". Without such follow-up management, survival and growth of planted seedlings is typically poor (Emmingham et al. 2000). Non-native species will also be controlled as needed, especially highly invasive species that can overwhelm native plant communities. Manual and chemical means will be used.

In older stands where the understory tree layer is uniformly dense throughout a stand and is shading out other understory plants, variable density thinning of the understory layer (UM) may be used to create patchy understory and midstory canopy layers. This may be necessary in stands where dense western hemlock regeneration results from heavy overstory thinning or has already occurred in small fragments of mature or old growth forests adjacent to clearcuts. While this type of thinning is similar to young drop and leave treatments, it is specific to managing the understory. In general, understory management will typically be done in conjunction with overstory treatments, but may occur on its own in certain cases.

d. *Decadence Acceleration*

Downed logs, snags, or wildlife trees (e.g., live trees with broken tops, cavities, large branch platforms, or other decadence) may be created in stands deficient in these critical habitat structures. Inoculation of trees with specific fungi or mistletoe may also be pursued where deemed necessary. These treatments may be done in conjunction with other treatments, but may also occur on their own.

2. *Determining and Prioritizing Forest Treatments*

Landscape Scale Management Designations

The first step in determining which parts of the Conservancy and Refuge ownerships should be treated, and which treatment method was appropriate, was done at the landscape scale. Areas of high value to landscape processes, areas high in biodiversity, or other unique or sensitive areas were first identified and the appropriate type of management determined. The experimental treatment (control, road removal, or thin) designations for each basin within the Ellsworth Creek Adaptive Management area was then incorporated. Next, the remaining portions of the landscape were analyzed to determine what categories of treatments were appropriate, given stand conditions and landscape scale considerations (Figure 14 – Decision Model).

As both ownerships had been previously partitioned into defined stands based on past timber management, the final step was to place each stand into a specific management designation based on the above analysis (Map – SWBCA Management Designations). In most cases, designations were clearly prescribed by the management objectives, legal requirements, or practical considerations such as road access or social factors. As new knowledge is gained, forest conditions change, and roads are removed through time changes in designations may occur and boundaries are expected to shift. The designations are described below:

- *Reserves*. These include the existing blocks of old growth larger than 5 acres and the Research Natural Areas. The only management intervention that may take place is fire suppression and removal of invasive non-native species. The area in this category is 965 acres.
- *Control Areas:* These are areas where silvicultural treatments will not take place, for at least the next 10 years, in order to have an experimental control to evaluate the effects of restoration silviculture in other parts of the landscape. They also provide for landscape heterogeneity by ensuring that a portion of young stands remains in an untreated condition. They include the no-thin and road removal basins within the Ellsworth Creek Adaptive Management area, as well as a control area on the north end of Long Island. The total area in this category is 2,418 acres.
- *Limited Management Areas:* These are areas where biomass removal treatments are rarely appropriate given regulatory requirements or organizational management constraints. Other silvicultural

treatments such as drop and leave, decadence acceleration, or understory management treatments may be more appropriate to achieve ecological objectives. Limited management areas include shoreline, wetland, and stream buffers; 300 ft. murrelet buffers around existing old growth stands and occupied habitat; unstable landforms; and a visual buffer around the Refuge headquarters complex. The approximate area in this category is 3,961 acres, although this number is likely to rise as additional unstable slopes or other sensitive areas may be identified and reclassified in the future.

- *Unreserved Management Areas:* This is the remaining part of the landscape where restoration silviculture may be fully applied. The types of treatment used in specific areas will be driven by the process outlined in the decision model (Figure 14– Decision Model). In areas where wood can be economically removed without compromising long term ecological objectives, biomass removal treatments will be done. In other areas, young or mature drop and leave, decadence acceleration, or understory management treatments may be done as needed to achieve ecological objectives. Areas that are not appropriate, or are not expected to benefit from active management, will not be entered (i.e., estuarine forested wetlands, no cut “skips” embedded within other treatments, etc). The total area in this category is 6,828 acres. However, as additional unstable slopes and other sensitive areas may be designated, the total acreage in this category is likely to decrease.

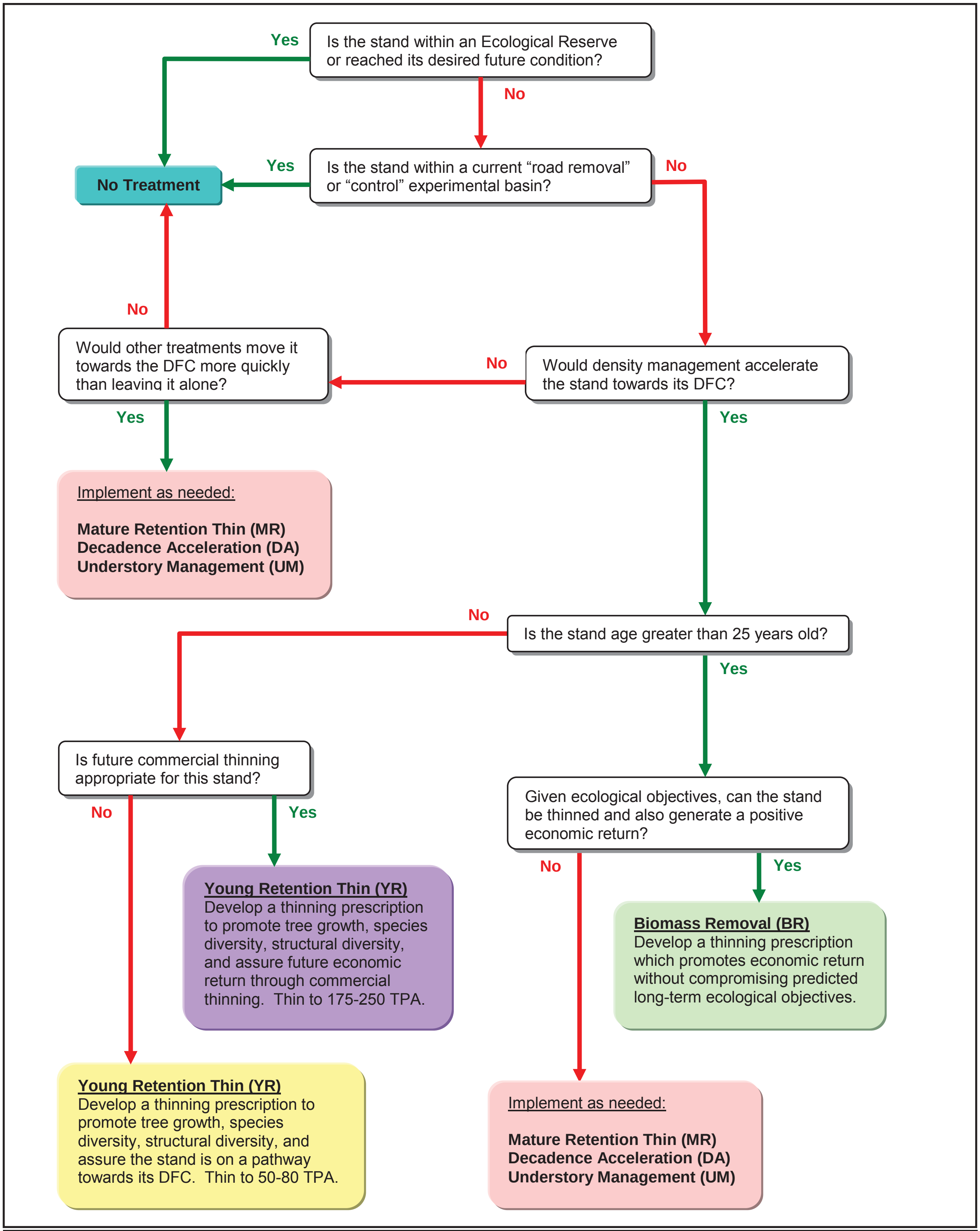


Figure 14: Decision Model for designating treatments on the Ellsworth Creek Preserve and Willapa National Wildlife Refuge.

Prioritization Framework for Scheduling Treatments

Prioritization is rarely a linear, formulaic process. Instead, it involves considering and balancing a number of overlapping, conflicting, or interconnected factors that operate on multiple scales. In order to prioritize treatments for this plan within the given management designations, the following set of considerations were used. The framework provides guidelines for future planning and scheduling efforts and is summarized in Table 11.

Table 11: Prioritization framework for scheduling treatments

Factors	Components
Contribution to Major Landscape Goals	• Expand and connect blocks of late-seral forest • Stream Network Function (LWD & sediment) • Murrelet Habitat • Landscape Windthrow Dynamics (restoring landscape level disturbance resiliency)
Coordinating treatments with road system needs	• Grouping stands for treatment within a road system • Putting road systems "to bed" after area is treated • Treating stands were road removal is a high priority
Stand Level Structural Conditions	• Stand density • Windthrow susceptibility: Topographic position and HDR • Response to thinning: Live crown ratio & diameter growth • Thinning window: projected loss of crown & stability • Species loss: competitive Exclusion of WRC
Economic Factors	• Markets, harvest costs, revenue potential • Revenue potential now vs. later weigh against structural tradeoffs
Management Needs:	• Experimental design needs • Regular and manageable work flow • Stable revenue stream

The contribution of individual stands to landscape processes and the timeline in which they can provide key functions were the first considerations that were evaluated. Stands that could expand marbled murrelet nesting habitat, increase availability of large woody debris to the stream network, or enlarge and connect existing blocks of old growth habitat in the short to medium term (5-50 years) were given high priority. Examples include mature drop and leave or biomass removal treatments in 60-80 year old stands to promote trees with large branch platforms, or mature drop and leave treatments in riparian areas where midstory conifers are suppressed by mature red alders. The potential for a particular stand to improve its contribution to functional landscape linkages through treatments should always be the first consideration in restoration silviculture as the major goals are generally landscape based. In contrast, focusing first on the stand level makes sense when wood production is the driving goal.

Coordinating treatments with road system needs was another major factor. In most cases, groups of stands that are accessed by the same road system will be treated in the same time period. Roads will be opened or re-constructed to access a particular area and then those that are not critical to the overall road network will be obliterated, put to bed, or converted to trails once the treatments are completed. Roads that are put to bed can then be re-opened to access stands that will receive another biomass removal treatment in 15-30 years and subsequently obliterated. This will allow for operational efficiencies and reduce the number of road system miles that have to be kept open and maintained. Groups of stands accessed by roads that are a high priority for removal were given extra priority in the near term.

Stand level structural conditions such as stand density, wind firmness, crown ratios, and competitive exclusion of key species were also factored in. Stands that are nearing the end of their "thinning window", the period when response to thinning will be high and the risks of post-thinning windthrow the lowest, were given high priority. Key thresholds used were height to diameter ratios (HDR) that are approaching 80 (measured at dbh) (Mustard and Harper 1998, Newton and Comeau 1990, Wonn and O'Hara 2001) and live crown ratios (LCR) approaching 40% (Emmingham et al. 2000, Holmberg et al. 2006, Oliver and Larson 1996) in the dominant and co-dominant trees. An HDR threshold of 60 was used for stands in topographic positions that are subject to high winds. The wind model was also used to evaluate the windthrow risks of thinning vs. not thinning. Trees can recover from high height to diameter ratio and low live crown ratio, but as trees exceed the levels described above the risk of windthrow increases significantly and response to thinning will take a long time (Deisenhofer 2000, Kneeshaw et al. 2002, Wright E.F. et al. 2000). In general, if even-aged stands in this forest type are kept below an overstory Stand Density Index of 350-400 they will not miss their thinning window (Holmberg et al. 2006). Stands that have exceeded these levels and are well past their window were given a lower priority and may be more suitable for a group selection treatment. Another factor included was increased competitive exclusion of understory plants as canopies close and shade out the understory with time. In particular, the likelihood of losing western redcedar if thinning was delayed and the opportunity to promote its growth and presence within the overstory was examined.

Structural conditions were also weighed against economic considerations. For some 25-60 year old stands, waiting 5-10 years before thinning will not make much difference structurally, but will have a big impact on the revenue side. For example, in some young stands that missed an early young drop and leave treatment waiting until a revenue positive biomass removal treatment was feasible made sense as increases in heigh to diameter ratios, declines in live crown ratios, and effects on long term diameter growth were minimal. On the other hand, implementing a drop and leave treatment in the next few years sends other stands on a faster track to achieving old growth structure and created an opportunity for a net positive second thinning entry in 10-20 years. High and low prices for particular species were also considered in cases where ecological factors were roughly equal. Staying attuned to market changes in the future will likely have a significant impact on revenue generation without compromising ecological objectives.

Growth models, economic analysis tools, and wind models within LMS were used to evaluate the ecological and economic tradeoffs between treating stands under alternative treatment scenarios. While these must be balanced with field evaluation and human judgment, they provide powerful analytical tools for managers to use in future planning efforts provided that their limitations are fully understood.

A final set of considerations used in prioritizing stands were management needs. The "vegetation manipulation" basins within the Ellsworth Creek Adaptive Management Area were prioritized for early treatment in the same year to begin the experiment and minimize treatment differences. The other management need was a regular work flow that fit within staffing and budgetary constraints and produced a stable revenue stream. As a good portion of the young plantation stands in the SWBCA have not been thinned, there is backlog of thinning needs. Not all stands will be able to be thinned at their ideal time, however, due to the practical limits of management resources.

3. ***Determining and Prioritizing Road Treatments***

Forest roads within the SWBCA were built with commercial timber hauling as the main purpose. Purchase for the purpose of conservation has changed that rationale. Although timber hauling for restoration purposes will remain a priority for some time, ecological considerations have become equally or more important. The Ellsworth road inventory ranked mass wasting hazards by severity and imminence, each on a scale of 1 to 10. Approximately three miles of the higher combined ranking roads have been removed already. The Refuge road inventory identified hazard sites and highlighted the most urgent. One mile of road including multiple urgent hazards has already been removed at Teal Slough.

On the Ellsworth Creek Preserve, roads located within experimental basins were randomly assigned a fate. All roads will be removed from road removal basins (although roads skirting the edges along the ridge top between two basins may be kept to avoid creating a highly inefficient road system). Roads within the control basins and thinning basins will be maintained to standards that reduce threats to the forest and aquatic ecosystems. Some roads in these basins will be removed if that is the most appropriate threat reduction strategy. Roads completely outside the experimental basins will be upgraded to similar high standards or decommissioned depending upon the access need and the inventoried condition and risk, as well as timing considerations and available budget.

On the refuge, experimental considerations do not apply. Forest road upgrade and removal decisions on the refuge were made with the following considerations: In general, in order to reduce forest fragmentation, roads will be removed as soon as access is no longer required. Mainline roads required for emergency access will be maintained. Other roads may be kept as or converted to hiking trails. Where near-term hazards are minimal roads will be kept until forest restoration activities can take place.

4. *Generalized Forest Treatment Scenarios*

The generalized prescription concepts that follow focus on the main, stand level processes at play. Site specific factors such as protection and special management for sensitive habitats, legacy features, unstable slopes, riparian areas, etc are implicit and not described here. Actual stand-level prescriptions are not presented in this plan as they cannot be developed without a forester completing a detailed assessment of the forest inventory data and evaluating site specific field conditions (see Appendix B for a more detailed process to follow in developing actual stand-level prescriptions).

Young Stands: Cohort establishment (0-10 years)

The key developmental process occurring in these stands are cohort establishment and canopy closure. If canopy closure has not set it and openings in the young canopy are still present, the opportunity to impact the long term species composition of the overstory by planting exists. Once canopy closure sets in, introducing new species that will occupy the overstory will be practically impossible for many decades. Also, western redcedar is unlikely to naturally colonize the understory until much later in stand development. In several very young stands that were clearcut and planted just prior to being acquired by the Conservancy or Refuge, abundance of western redcedar and Sitka spruce is quite low. Thus planting 20-50 trees per acre is recommended, and some shrub control and removal of western hemlock around the seedlings will likely be necessary as part of the planting effort. Browse control will also be necessary.

Young Stands: Canopy Closure (10-30 years)

In stands where canopy closure is just occurring, an early young drop and leave treatment combined with planting can achieve the twin goals of increasing the abundance of western redcedar and Sitka spruce where necessary and maintaining rapid diameter growth throughout early stand development by delaying the onset of crown recession. Seedlings should be planted in small gaps. Depending on the height of the existing trees, the seedlings may not grow into the overstory over time, but will form a midstory layer.

Once canopy closure sets in, the main processes that will shape long term vertical and horizontal complexity at this stage of stand development are crown class differentiation and early stratification. Young drop and leave treatments should seek to prevent a portion of intermediate western redcedar and Sitka-spruce from being overtopped and relegated to the midstory by having wide spacing targets around select trees of those species. In the rest of the stand, trees of all species that are at lower end of the height distribution and clearly in the midstory should be left to form a future mid-story. This can be accomplished with a minimum height threshold. Care should also be taken to not eliminate fine scale heterogeneity: clusters or pairs of dominant trees. Upper diameter targets, or specifying that trees within a certain distance of each other be left, can achieve this.

In terms of density reduction targets, the projected timing of the next entry and the landscape level need for early-seral habitat are key factors. The heavier the thinning, the longer crown closure, the onset of increasing height to diameter ratios, and competitive exclusion of shrubs and slower growing western redcedar will be delayed. The thinning window for future thinning entries will also be prolonged. If thinning is very heavy (below 150 tpa), however, a second wave of cohort establishment may occur that will set back the density reduction goals of the treatment and possibly create a need for another young drop and leave treatment. Also, opportunities for future, revenue generating biomass removal treatments will be reduced.

To introduce additional spatial complexity in young drop and leave treatments, some areas of the stand should be left un-thinned or lightly thinned to allow for the onset of competitive exclusion and all the habitats and subsequent processes associated with it. For example, understory tree colonization later in stand development is greatly facilitated by an understory with few no shrubs and other plants. This in turn is one of the key processes of vertical canopy development and horizontal complexity. Unless there is a landscape level need to maintain early-seral shrub communities throughout stand development, gaps are generally unnecessary. Likewise, introducing additional variation in spacing is typically not necessary unless further treatments are not likely for the particular stand. In that case, 20-50 dominant trees per acre should be thinned to a wider spacing so they can maintain rapid diameter growth and avoid intense competition for many decades. This can be done with a diameter and species rule, where trees of a certain species and/or above a certain diameter receive a wider spacing target. Uniform, heavy thinning (below 150 tpa) should be avoided as it tends to homogenize stands and sets back the natural processes that set stands up for later development of horizontal and vertical complexity. In general, multiple thinning entries are preferable to a single entry as unintended consequences are not as severe and mid-course corrections are possible. The option of follow-up mature drop and leave treatments should be maintained if possible where future biomass removal treatments are unlikely.

In stands with high proportions of Douglas-fir or red alder in the dominant and co-dominant crown classes and where future biomass removal treatments are likely, young drop and leave treatments should seek to keep a significant proportion of these two species while maintaining a component of intermediate or suppressed western hemlock, Sitka spruce, and western redcedar that will be overtopped by the dominant trees and move into the midstory. Eventually, much of the Douglas-fir and red alder can be "thinned from above" to produce revenue and release the remaining trees. As long as the other species do not have too much side competition from other trees in their cohort, they should retain enough crown to maintain their release potential (Deisenhofer 2000, Emmingham et al. 2000, Kneeshaw et al. 2002, Miller and Emmingham 2001, Wright E.F. et al. 2000).

Finally, within older stands in this category, where competitive exclusion has been the dominant process for some time, the thinning window may have passed. In such cases, the understory is typically completely shaded out, crowns have lifted beyond 40% live crown ratio, and midstory trees (often western redcedar) have very high height-to-diameter ratios and low live crown ratios leading to low vigor and imminent mortality. In these cases, a moderate to light young drop and leave treatment, with heavier release of dominant trees and any western redcedar that has a lower height-to-diameter ratio and higher live crown ratio is advised. Gaps that open the stand to excessive windthrow risk should be avoided. Once the stand has recovered live crown and height-to-diameter ratios, another entry will likely be necessary to keep excessive competition from returning to the stand.

Mid-age stands: Competitive exclusion and biomass accumulation (30-60) years

Once the process of competitive exclusion is well underway, opportunities to shape species composition, manipulate stratification to encourage midstory development, build stem stability, slow crown recession, and maintain diameter growth begin to decrease exponentially with time in dense stands. If a stand received a prior young drop and leave treatment, densities are not too high, understory shrub communities are still present, and height to diameter ratios of the overstory trees are below 60, a similar approach as described above for young drop and leave treatments should be taken.

Several key differences exist, however. Selecting 20-50 dominant trees per acre for heavy release should be given high priority. These are the "golden years" of height and diameter growth and the opportunity to influence the development of large trees with long full crown is greatest at this stage. Understory tree and shrub colonization will likely be stimulated in these areas. Depending on how much past PCT treatments homogenized the stand in terms of spacing and species composition, small gaps and planting may be necessary to add trees species diversity. For stands dominated by Douglas-fir or red alder, a large portion of these species can be removed from the overstory at this time. If any midstory western redcedar exist and have good stem form, they should be released. Skips are still necessary for the reasons stated above, and to allow for intense competition to create areas with unstable trees in parts of the stand. If a whole stand consists of large, stable trees, the ability of wind to create heterogeneity later in stand development may be reduced. Skips will also be necessary to protect sensitive habitats, critical habitat features, and provide refugia for fungal mats that can be damaged by ground based thinning (Colgan et al. 1999, Smith J.E. et al. 2002). In general, the more complex these stands are, the less additional heterogeneity will need to be introduced. Creating or greatly expanding gaps to promote early-seral habitat is likely to be low priority at this phase as maintaining these early-seral habitats can be accomplished with greater success in younger or older stands. Likewise, accelerating decadence through snag or CWD creation at this stage is not likely to be a high priority. Protecting existing snags and wildlife trees, relying on natural decadence formation processes, and waiting until trees are larger is advisable. Habitat needed at the landscape must be taken into account, however.

In stands where competition has been intense for many years, height to diameter ratios are high, and live crown ratios are low, several critical questions must be addressed: Do the dominant and co-dominant trees have sufficient live crown to respond to thinning? Is the stand heavily dominated by hemlock, or is a significant Sitka-spruce, western redcedar, and Douglas-fir component present? How much will thinning increase the risk of major windthrow? Given the answers to these questions, is shifting the stand away from a catastrophic windthrow trajectory possible? If it is, then several light, relatively uniform thinning entries with skips and attention to fine scale heterogeneity should be pursued. If not, and the stand is important at the landscape scale for marbled murrelet habitat, it should be left alone or given a light MDL treatment targeted at enhancing branch structures on specific trees to create better marbled murrelet nesting platforms. If the stand is not important for marbled murrelets, a group selection approach can be taken to create large gaps or expand existing ones. This will accelerate the process of re-initiating the stand through gap-phase development as wind will expand the gaps over time. If natural regeneration of western redcedar and Sitka spruce is not sufficient, they will need to be planted in the gaps to ensure that relatively species composition shifts away from hemlock. Group selection can also be used in red alder stands to transition large patches of pure red alder towards mixed conifer stands. A significant portion of the alder should be left however.

Mature stands (60-100 years)

Similar to the previous category, the stability, risk of windthrow, and existing complexity of these stands will determine what treatments are appropriate. As height growth is peaking and beginning to slow at this stage, opportunities to build crown, significantly increase diameter growth, and build stem stability by thinning are declining. Wind and other exogenous mortality agents are likely to start breaking these stands up and thus gap creation, understory tree colonization, mid-story development, and decadence creation will slowly become the dominant processes as competitive exclusion wanes.

In stands with a high ratio of trees with long crowns and a balanced composition of species, opportunities to prolong the period of rapid diameter growth and crown development still exist. A mix of heavier release of dominant and midstory trees, small gap creation or expansion to stimulate understory development, light to moderate thinning in the rest of the stand, and significant areas in skips should be pursued. Individual tree selection approaches to target specific species and trees for release and to promote large branches or epicormic branching should be included. In areas where murrelet habitat is a high priority, lighter, more uniform thinning and avoiding heavy stimulation of the understory is preferable. Decadence acceleration through snag creation or drop and leave treatments should be considered in stands where windthrow or other agents are not creating these structures.

In stands in this category where competition has been intense for many years and height-to-diameter ratios are high, the same questions and choices must be faced as stands in this condition in the last category. Thinning these stands too heavily will significantly increase their risk of windthrow. Group selection treatments combined with planting are likely to be preferable to thinning. Either way, treatments must be designed with a higher level of stand examination and analysis.

5. ***Sale and collection of non-timber forest products***

Many current non-timber forest products exist on SWBCA ownership such as: cedar shake/shingle logs, salal, ferns, moss, and hard rock with the potential to generate revenue. However, the expected revenues from these non-timber forest products, when compared to expected timber sale revenue, would generate less than 1% of projected revenues for the Conservancy and/or Refuge lands. The level of ecological risk associated with these activities likely ranges from minor to severe. In addition, a program to sell and administer contracts to remove these minor forest products is very labor intensive and difficult to monitor and control.

Since cedar logs and trees are recognized as being valuable for their contribution to LWD, long-term snag retention, and other ecological processes, it would be counter-productive to have it removed as shake or shingle bolts. Therefore, it will be the policy of SWBCA to not engage in marketing commercial cedar bolt sales.

The removal of salal, fern, moss, and other minor forest products may impact the long-term ecological recovery of SWBCA forests. Furthermore, a program to sell, monitor and administer contracts for these products would likely exceed the revenue that would be generated. Therefore, it will be the policy of SWBCA to not engage in marketing commercial minor forest products.

6. ***Development and use of onsite rock resources***

Within the local area, hard rock is a limit resource and in high demand. Because the supply of hard rock on the ownership is scarce and can be quite costly to purchase, even from neighboring Templin Pit, it is not advisable to sell hard rock if only to preserve it for long term use within the ownership. It will be the policy of SWBCA to not engage in marketing its limited rock supply.

The Conservancy is committed to developing and using its hard rock resources in a manner that limits the disruption of natural systems. All rock development activities will be conducted following a written Pit Development and Reclamation plan. These plans will identify the limits of mining and present the intended methods and sequence of development and reclamation. Methods to minimize the delivery of sediment to the aquatic ecosystem are by nature, very site specific and will be addressed on a site by site basis within the Pit Development and Reclamation plan for each rock source.

Disturbance potential from loud rock development activities, especially blasting, on nesting murrelets and their chicks is of particular concern. Fortunately, because none of the available rock pits occur near suitable murrelet habitat, the likelihood of disturbance is minimal in the near term. As adjacent forests mature, disturbance potential could rise. To minimize potential for disturbance, where rock pits occur within ¼ mile of suitable marbled murrelet nesting habitat, the Conservancy will not conduct blasting or mechanical crushing activities during the breeding season, from April 1 to September 15. Less noisy activities like loading and hauling at these rock pits will not occur during the "daily peak activity period" of one hour before to two hours after sunrise, and one hour before to two hours after sunset during the breeding season. Where pits occur more than ¼ mile from suitable habitat blasting will normally be restricted to dates outside the breeding season, but loading and hauling will not be limited by the daily peak activity period.

7. *Use of chemicals*

Forest management on the SWBCA will employ silvicultural systems, integrated pest management, and strategies for controlling pests or invasive species that minimize the need for the use of chemicals. Specifically, chemicals should only be used where less environmentally hazardous techniques have been shown through research or empirical experience to be ineffective. Chemical use may be necessary to control invasive weed species that have the potential for altering forest habitat function and in some cases where invasive or native species are aggressively encroaching on active forest roads. When chemicals are applied, the least environmentally hazardous option will be used to minimize effects on non-target organisms or ecological systems. Furthermore, where chemical use is deemed necessary, trained applicators will follow all applicable safety precautions and chemicals will be stored and disposed of in a safe and environmentally appropriate manner.

8. *Local access and hunting*

Both the Refuge and the Conservancy are committed to continue providing access for hunting, hiking and other hike-in recreational activities. Hunters and hikers may be affected by the removal of roads, but sufficient active roads and trails will remain to provide reasonable access. Vehicular access is likely to remain restricted to the existing open roads.

Vehicular access is to remain restricted to the existing open roads. Use of off road vehicles (i.e. motorcycles, ATV's, 4-wheel drive trucks, etc.) often cause unacceptable impacts to soil and water resources, and are difficult to monitor and control. Therefore, it will be the policy of SWBCA to not allow these motorized vehicles in the forest, unless specifically granted to conduct authorized research, monitoring activities, and directly related Conservancy and/or Refuge business.

Although it generally does not allow hunting on its preserves, the Conservancy recognizes the importance of the long-valued local tradition of hunting in the Ellsworth Creek/Bear River to the community. Therefore, hunting for Roosevelt elk, Black-tailed deer, and black bear in accordance with State laws and regulation is allowed on Ellsworth Preserve. Incidental take of cougar and coyotes is known to occur but is not condoned. Refuge forestlands are also generally open to hunting activities.

9. *Use of revenue generated from timber sales*

As discussed above, revenue generation is expected when thinning commercial aged forests to reach ecological targets. These revenues will be solely used to fund additional restoration work within the project area in accordance with all applicable state and federal regulations and guidelines, and policies of the Conservancy and Refuge System. Accounting mechanisms have been put in place to ensure detailed tracking of these restoration revenues.

B. Implementation Schedule

1. *Restoration Thinning and Road Treatment Schedule*

Based on the landscape level management designations, the generalized treatment scenarios described above, and other factors outlined in this plan, forest stands throughout the SWBCA were placed in a treatment category (i.e., biomass removal, drop and leave, etc). Stands where active management will occur were then scheduled for treatment at least once in the 20 year planning horizon considered in this plan. Five time periods used for scheduling were used (Table 12); an annual basis for the first three years (2007-2009), the subsequent 7 year period (2010-2016), and concluding with a final 10 year period (2017-2026), (see corresponding Treatment Maps for these periods). The first three years were planned out in greater detail to give managers a concrete action plan for the immediate future. It is likely, however, that minor changes will be made in these first three years due to more detailed site specific analysis, market changes, and management practicalities. The forth (2010-2016) and fifth (2017-2026) time periods should be considered pools of stands in which treatment will likely be appropriate, based on current data and growth modeling. The fifth period includes approximately 2,900 acres of stands treated in the first 4 periods that are likely to be ready for a second entry. In this plan, a special effort was also made to optimize the timing and extent of management activities so road improvements and thinning are coordinated to reduce road system impacts and achieve operational and cost efficiencies.

Managers will need to continually re-assess the thinning pool and establish concrete management schedules in 2-3 year annual increments. It is likely that not all the acres identified in a single time period will actually be treated as some will be deferred or deemed not necessary to achieve the overall ecological objectives. What is important is that all of the stands within each pool are assessed at the beginning of the time period to determine when a treatment is appropriate. New information from adaptive management, natural disturbances, changing markets, and evolving management approaches will affect management direction over time, and thus more concrete plans for the forth and fifth time periods were not made at this time.

Table 12: Restoration thinning treatment types and acres per time period for each ownership.

Treatment	Owner	2007	2008	2009	2010-2016	2017-2026	Totals
Young Drop & Leave	TNC	405	674	544	762	188	2573
	WNWR	163	0	108	671	45	987
	Total	567	674	652	1433	233	3561
Mature Drop & Leave	TNC	0	0	26	59	0	85
	WNWR	8	98	169	13	0	288
	Total	8	98	195	72	0	373
Biomass Removal[1]	TNC	0	261	345	871	3238	4715
	WNWR	0	148	0	2673[2]	519	3339
	Total	0	409	345	3545	3756[3]	8054[1&3]

[1] Not all the acres in this category will be treated as up to 1/3rd of the total acreage in individual stands may be left in buffers or skips for streams, sensitive areas, or stand level variability. A portion of these buffers may be treated with MDL treatments where appropriate.
[2] Some of the BR treatments in years 2010-2016 may pushed off until 2017-2026
[3] This includes acres that receive YDL and BR treatments in years 2007-2016 and will likely be ready for a second treatment in years 2017-2026.

It should be noted that wood will not be removed from all the acres within the biomass removal category. In each stand, up to 1/3rd of the total acreage may be left in buffers or skips for streams, unstable slopes, sensitive areas, or stand level variability. A portion of these buffers or skips may be treated with mature drop and leave treatments where appropriate. For example, many stands on Long Island slated for a biomass removal treatment will contain shoreline buffers where mature drop and leave treatments or no treatment will occur. In addition, the 8,054 total acres in the biomass removal category (Table 12) includes 3,000 acres of 2nd entries into stands that were treated with young drop and leave or biomass removal treatments in the first four time periods years. Subtracting these 3,000 acres and assuming 20% of the remaining acres will be left in buffers or skips, an approximate total of 4,000 acres of the SWBCA will be treated with biomass removal treatments. This equates to roughly 30% of the 14,170 acre of forested habitat in the SWBCA.

From 2007 through 2016, the active road system will be reduced by a projected total of 53.8 miles (Table 13) or roughly half of the current total for the total landscape. This is in addition to the 4.5 miles of road that have already been obliterated. Roughly 5.7 miles of new road will be built, primarily to move the road system to ridge top locations and away from mid and lower slope positions. Following treatments, the road density will decline significantly from the current level throughout the SWBCA. The road treatments listed in table 13 and shown in the Treatment Maps do not include the re-opening of previously put-to-bed roads for 2nd entries in the 2017-2026 time period. As the need for 2nd entries for specific stands is not certain at this time, it is difficult to predict which roads will be re-opened and when. After the 2nd entry, these roads may be obliterated or put to bed again, depending on the likelihood of future entries.

Table 13: Road treatment types per time period and ownership

Treatment	Owner	2007	2008	2009	2010-2016	Totals
Obliterate	TNC	2.8	6.6	8.9	0.3	19.3
	WNWR	0.3	0.0	0.0	9.5	9.8
	Total	3.1	6.6	8.9	9.7	29.1
Put to Bed	TNC	7.2	1.5	2.3	3.0	15.8
	WNWR	0.0	1.4	0.0	1.3	2.7
	Total	7.2	2.9	2.3	4.2	18.5
Convert to Trail	TNC	0.1	0.0	0.8	0.2	1.1
	WNWR	0.0	0.0	0.0	5.1	5.1
	Total	0.1	0.0	0.8	5.3	6.2
Build	TNC	2.1	1.3	2.1	0.0	5.7
	WNWR	0.0	0.0	0.0	0.0	0.0
	Total	2.1	1.3	2.1	0.0	5.7

2. ***Landscape Simulation of Treatments***

The Landscape Management System (LMS) was used to model the effects of restoration thinning. Stands were grown out 50 years in 5 year increments and treated according to their scheduled timeframe and type of treatment young drop and leave, biomass removal, mature drop and leave, or no entry. Only treatments in the first 20 years, as covered by this plan, were included. A no-treatment scenario was also run as a baseline to compare to the effects of thinning. The Pacific Northwest Coast variant of FVS was used in the model and was calibrated based on data from the LOGS Studies (Curtis and Marshall 1986, Hoyer et al.

1996). As complete inventory data was not available for all stands, average stand metrics were used to create a "sample" stand for each stand type. These "sample" stands were used to model stands for which stand data was not available. Treatments were not designed to exactly mimic the individualized treatments for each stand that will occur in reality. Instead generalized treatments were used for each treatment type. Also, FVS and LMS cannot model variable density thinning or group selection treatments. Thus the rationale for the modeling scenario is not to predict the exact consequences of treatments, but rather to examine the relative effects of thinning vs. no-thinning on different components of forest structure and explore the hypothesis that thinning will accelerate the development of late-seral structure. While modeling cannot provide an answer to this hypothesis, it can provide important insights and help frame questions for monitoring and experimentation over time. The treatments incorporated into the landscape model were as follows:

- *Young drop and leave* : Thin trees over 5 inches dbh from below to 100 SDI, thin trees under 5 inches to 150 TPA, then plant 75 tpa of western red cedar and 75 tpa of Sitka spruce. The stands that are slated for follow-up biomass removal treatment in years 2017-2026 in the plan were then thinned back down to 100 SDI in from below, but leaving all trees under 8 inches dbh. This follow-up treatment was done in year 2025.

- *Biomass removal*: Stands were thinned to 50 tpa from below in the 6-12 inch dbh range and 25 tpa from below in 12-20inch dbh range. All trees less than 6 inches dbh and larger than 20 inches dbh were retained. This thinning from the middle approach was derived from the rules in the WA DNR Forest Practices Regulations for buffers adjacent to marbled murrelet habitat (WAC 222-16, 2006) While this treatment removed too many large trees in some stands, it was a good generalized prescription that thinned stands heavy enough to see significant effects from thinning 50 years in the future. Actual prescriptions for older conifer stands will generally be lighter and may involve multiple entries. Red alder stands were thinned with this same prescription as it removed most of the alder and left behind the smaller conifers.

- *Mature drop and leave*: Reduce BA of all trees in the 8-20 inch dbh range by 50%, leaving all trees less than 8 inches and greater than 20 inches dbh.

- *No entry*: Approximately half the stands in the SWBCA are within reserves, control areas, or limited management areas.

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The Modified Old Growth Index (MOGI), as described previously, was used as the primary metric to evaluate the results of the modeling exercise. The MOGI scores for all the stands in the entire SWBCA landscape were calculated at 5 year intervals for both the thinning and no-treatment scenarios (Figure 15). The box plots reveal very little difference in MOGI scores between the treatment and no-treatment scenarios. Further analysis of the data showed no statistical differences. This result should be viewed with caution due to a number of factors. First, roughly half of the stands in the SWBCA landscape will not be entered and thus have the same MOGI scores in both scenarios. This suppresses the effect of thinning vs. not thinning. Second, an examination of the 4 different components of the MOGI shows that thinning increases some components while depressing others. Third, thinning effects on MOGI scores vary considerably for different stand types and age classes.

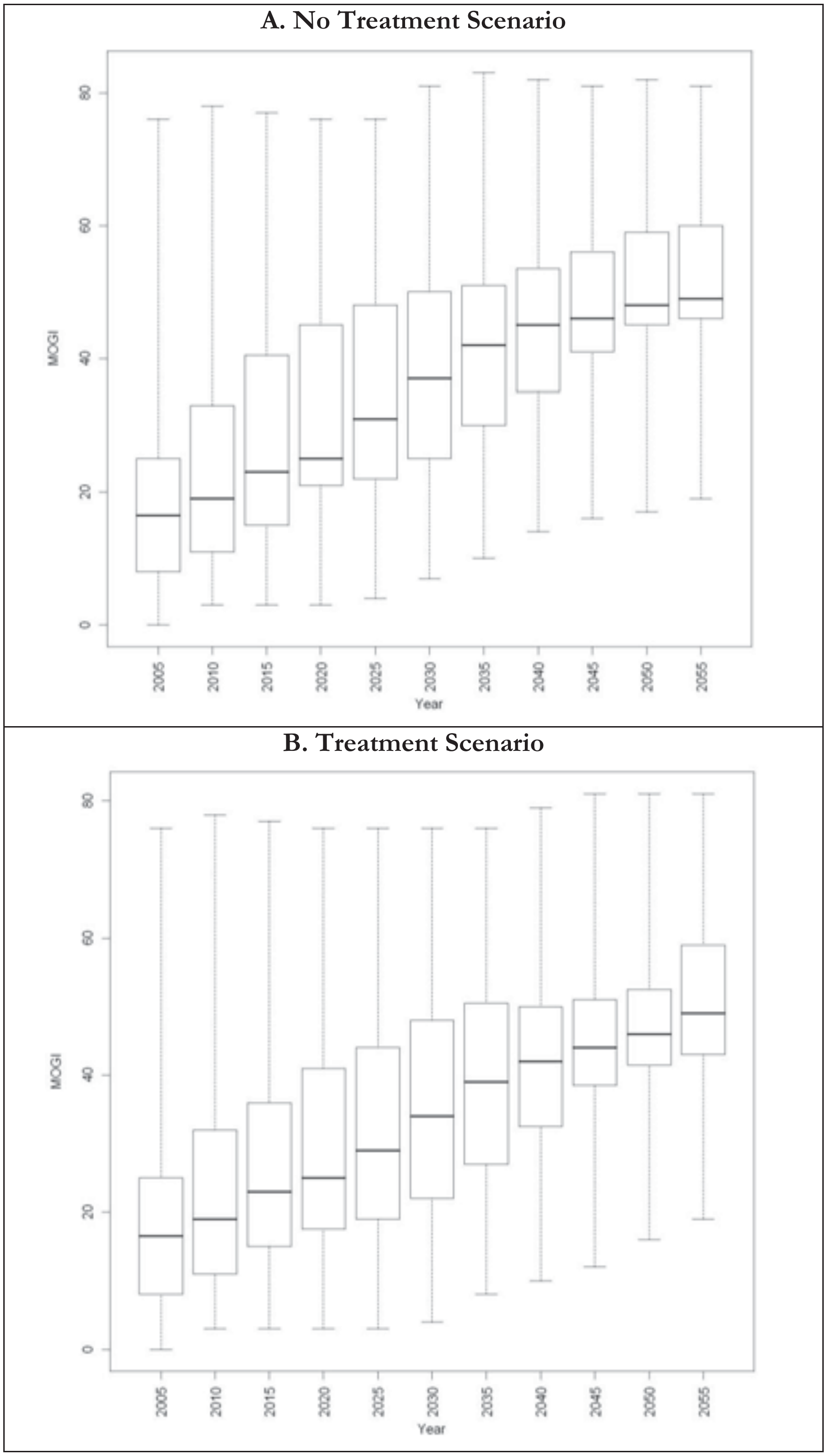
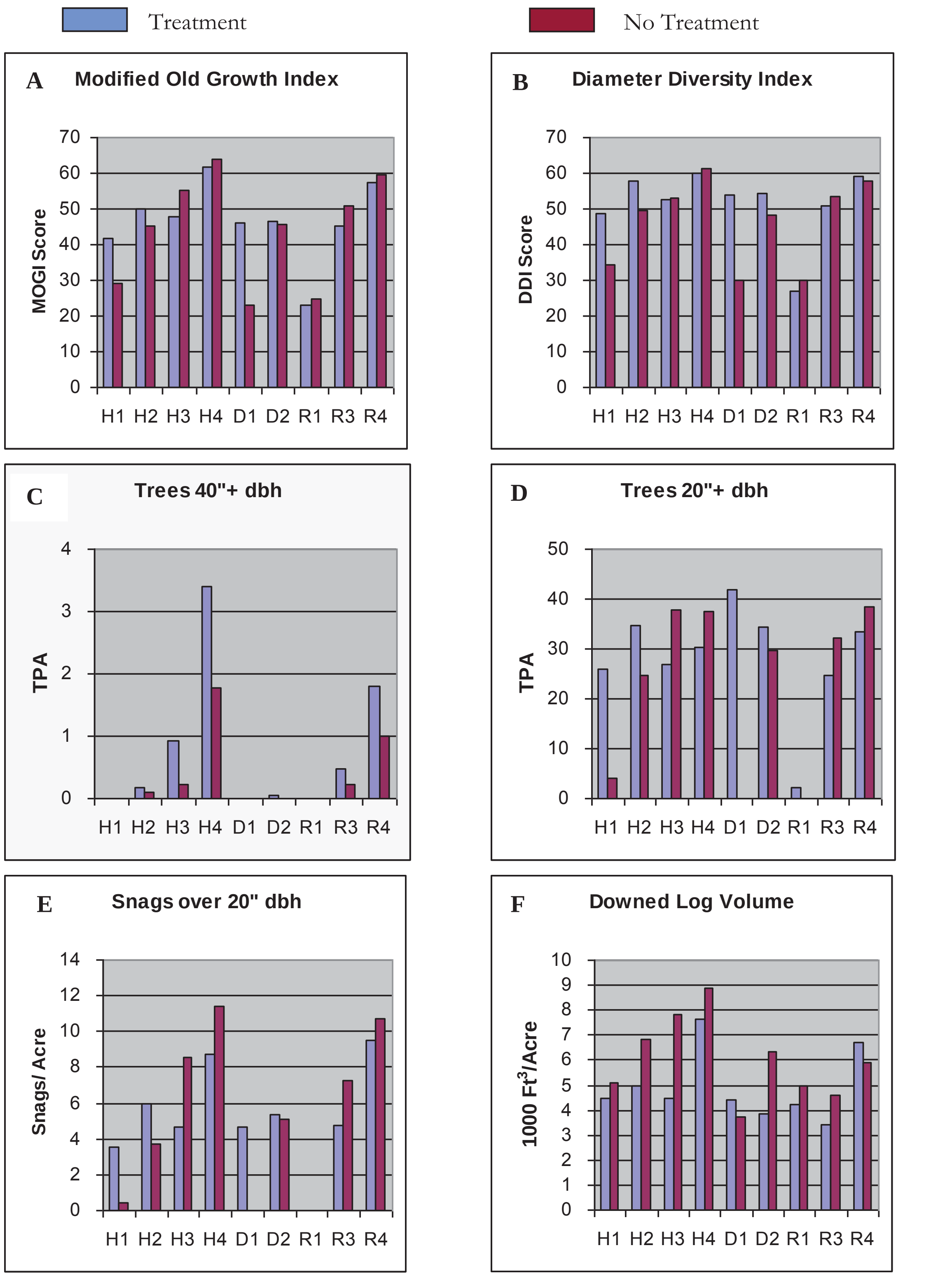


Figure 15: Modified Old Growth Index Scores (MOGI) for all stands within the SWBCA landscape for both no-thinning and thinning scenarios. The median value is represented by the solid line in each box and the upper and lower edges of the boxes are the 25% and 75% percentile values. The top and bottom of each "whisker" or vertical line show the upper and lower quartile of the data and the end of each whisker is the maximum and minimum value.



Notes: H1: WH/SS/RC 1-14 yrs; H2: WH/SS/RC 15-30 yrs; H3: WH/SS/RC 30-60 yrs; H4 WH/SS/RC 60-100 yrs; D1: DF 1-14 yrs; D2 15-30 yrs; R1: RA 1-14 yrs; R3 RA 30-60 yrs; R4 60-100 yrs

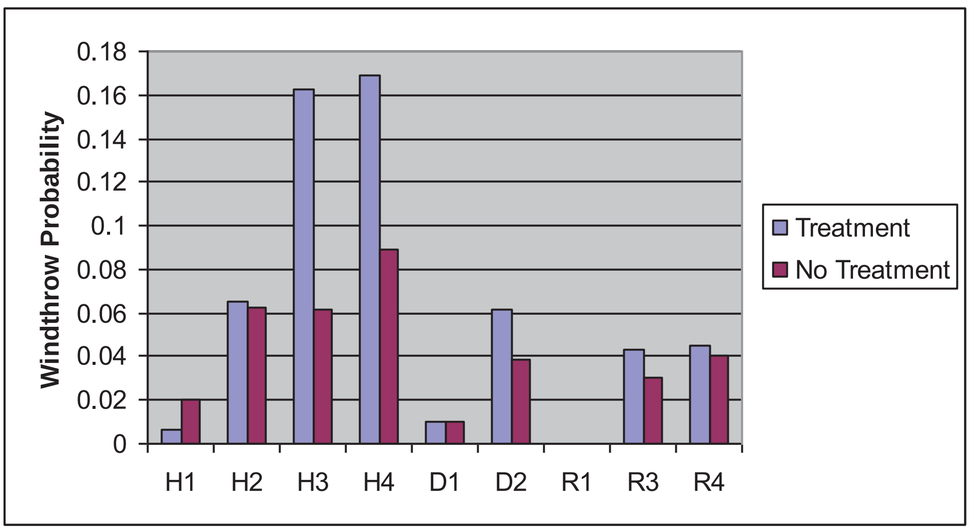
Figure 16: Overall Modified Old Growth Index scores (MOGI) and different MOGI components in 2055 by stand type. Data is from 87 stands that have full inventory data and are slated to receive treatment entries.

In order to tease out these factors, MOGI scores in the year 2055 were analyzed for stands that receive treatment entries and have actual inventory data (Figures 16). When overall MOGI scores are broken down by stand type (Figure 16A), it becomes clear that stands treated at a young age (under 15 yrs: H1, D1) show the biggest gains from thinning treatments in the model. This is due to the fact that increased diameter growth following thinning sends the number of trees per acre over 20 inches dbh significantly higher. While the tpa of trees over 20 inchesdbh is not one of the 4 main components of the MOGI, it improves the diameter diversity index component (Figure 16B) and the number of snags over 20 inches dbh per acre component (Figure 16E). As more live trees over 20 inches dbh exist, more are available to become snags. In addition to a greater number of trees over 20 inches dbh, the diameter diversity index was improved by additions to the lower diameter classes from planting and faster movement of trees through all diameter classes. The downed log volume component is not significantly affected by thinning at this early age (Figure 16F). Similar to the large snags, the increase in tree size leads to larger downed wood that decays more slowly. This offsets the higher total amount of dead wood recruitment in the untreated stands that is smaller in diameter and thus decays more quickly. Also, additional 2nd entry biomass removal treatments are light thinnings from below that do not remove many trees in the co-dominant and dominant crown classes. The number of trees over 40 inches dbh is not affected in these younger stands as the dominant trees do not reach this size in the 50 year modeling timeframe. While FVS was calibrated based on field data to model diameter growth increases from thinning for this model run, it likely is still underestimating diameter growth. It is possible that at least some dominant trees in stands on high productivity sites will be over 40 inches dbh when they reach ages 60-65.

Stands in the 15-30 year age class showed slight increases in overall MOGI scores. Similar to the very young stands, increased diameter growth in treated stands pushed up the diameter diversity index, tpa of trees over 40 inches dbh, and snags/acre over 20 inches dbh. However, roughly half of these stands received the marbled murrelet biomass removal treatment that removed a significant portion of trees in the co-dominant and dominant crown classes, leading to a significant decline in downed wood volume compared to the no-treatment scenario. Despite the calibration of FVS to address its typical overestimation of mortality, especially in un-thinned stands, it is likely that downed log recruitment is still being over-estimated in un-thinned stands. Also, while competition mortality kills the most trees in young stands, exogenous mortality (windthrow, pathogens, insects, etc) is often responsible for a majority of the total volume of downed wood as it typically kills larger trees in a stand (Lutz and Halpern 2006). Predicting mortality from stochastic events such as windthrow is very challenging and is not well modeled in FVS mortality functions. As thinning increases both windthrow and spread of annosum root rot, treated stands will likely experience significant recruitment of larger downed wood that is not accounted for in this modeling scenario. Also, the downed wood component of the MOGI does not distinguish between different sizes of logs. While many wildlife species use smaller down logs, large logs are critical for many species (Marcot et al. 2002) and a defining element of old growth forests (Harmon et al. 1986). Thus in terms of habitat value, the loss of smaller diameter dead wood from thinning vs. no-treatment may be offset by higher recruitment levels of large dead wood in thinned stands that results from increased diameter growth and elevated exogenous mortality of large trees.

The older conifer stands (H3, H4) and all the red alder stands experienced small declines in MOGI scores following treatment. While the increased diameter growth from treatment pushes up the tpa of trees over 40 inches dbh, the removal of a significant portion of trees in the co-dominant and dominant crown classes depresses all the other MOGI components relative to the no-treatment scenario. The diameter diversity index is also lower in the treated scenario as thinning moves trees out of the lower diameter classes faster than under the no-treatment scenario. Natural regeneration, which is stimulated by thinning, is not accounted for in FVS and thus replenishment of trees in the lower diameter classes is not occurring in the model. Similar to 15-30 year old stands, the large difference in downed log levels between treated and untreated stands is likely overestimated. However, the model clearly demonstrates that relatively heavy thinning from the "middle" and the resulting removal of dominant and co-dominant trees reduces the pool of mid and larger sized trees from which snags and downed logs can be recruited. While windthrow will likely create more snags and downed logs in thinned stands over time, it will also reduce the pool of live trees that will develop into large, old growth trees. In stands where windthrow is not too high, the total amount of dead wood recruitment is likely to be lower in treated stands in the medium term (50-100 yrs). Where high windthrow leads to high mortality and dead wood recruitment, stands may not have sufficient overstory canopy left to meet late seral canopy cover thresholds (50-70% canopy cover from the overstory). Downed wood could also be created by dropping, girdling, or topping trees, although one of the goals of management in the SWBCA is to restore natural processes of decadence formation.

In order to gauge the effects of thinning on windthrow , treated and untreated stands were run through the windthrow probability model that was built into LMS (Scott and Mitchell 2005) (Figure 17). While the effect of treatment is negligible in most stand types, it roughly doubles in the older conifer stand types (H3 & H4). This is the result of the relatively heavy biomass removal treatment in these mostly dense stands that have high height to diameter ratios. It confirms that recruitment of larger dead wood is likely in thinned stands. Also, the model assumes that stands remain closed throughout the 50 year period and does not factor in creation and expansion of windthrow pockets over time and the resulting exponential increase in pocket area. As heavy thinning will significantly open up these older stands, it is likely to accelerate the break up of stands compared to the no-treatment scenario, especially on exposed sites. The group selection approach to high risk stands was not included as FVS cannot model group selection. Group selection leaves most of a stand intact and thus windthrow is likely to be lower overall and concentrated on the edges of gaps. In younger stands, the decreases in height to diameter ratios and increases in crown ratios from thinning appear to make up for the lower density and inter-tree sheltering. The higher resilience of western red cedar to windthrow is not accounted for by the model.



Notes: H1: WH/SS/RC 1-14 yrs; H2: WH/SS/RC 15-30 yrs; H3: WH/SS/RC 30-60 yrs; H4 WH/SS/RC 60-100 yrs; D1: DF 1-14 yrs; D2 15-30 yrs; R1: RA 1-14 yrs; R3 RA 30-60 yrs; R4 60-100 yrs

Figure 17: Windthrow probability in 2055 by stand type. Data is from 87 stands that have full inventory data and are slated to received treatment entries.

Overall, the modeling exercise illustrates the key tradeoffs from thinning vs. no-treatment. Thinning increases diameter growth of residual trees which leads to earlier recruitment of larger dead wood as well as "bigger trees faster". It also moves small and medium sized trees through the diameter class distribution faster, which translates into accelerated development of mid-story layers. However, by reducing overall stand biomass it may reduce overall dead wood recruitment, at least in a 50 year time horizon. If prescriptions are heavy and remove significant number of trees in the upper half of the diameter distribution, numbers of medium to large sized live trees will be reduced which will shrink the recruitment pool for similar sized snags and downed logs. Exogenous disturbance agents, primarily wind in this case, are likely to compensate for the reduction in competition mortality driven dead wood recruitment. Heavy thinning, however, is likely to result in high levels of windthrow in a short timeframe that may reduce overstory canopy cover beyond levels typically associated with late seral forests for a significant period of time.

These tradeoffs explain why MOGI scores were essentially unchanged across the SWBCA landscape by the treatment scenario compared to no-treatment. In 50 years, the model shows that roughly half of the landscape will have a MOGI score above 50, with the older managed stands nearing 60, compared to the current average old growth score of 62. This does not mean that the managed stands will be fully functional old growth, however. The overestimation of downed wood recruitment by LMS is likely inflating scores. There is also a large degree of variance in FVS's predictions of stand conditions 50 years in the future, especially in older stands. Most important, the MOGI only considers 4 variables, whereas the structure of old growth forests is much more complex. What the high MOGI scores do suggest, however, is that these stands will begin displaying many of the components of current old growth forests within 50 years and, therefore, may also begin to support some old growth dependent species.

Modeling results also suggest that thinning can generate an economic return without compromising desired structural development objectives. Beyond this minimum threshold, results indicate that thinning can accelerate the development of at least some components of old growth structure, especially when thinning is done early in stand development. Thinning prescriptions must be light enough to ensure than sufficient biomass remains for dead wood recruitment and to avoid excessive windthrow, yet heavy enough to promote diameter growth, under and midstory development, and encourage some windthrow. The individualized LMS prescriptions created for a 70 year old stand earlier in this document came close to achieving this balance and increased the overall MOGI score relative to no-treatment. Similar individualized prescriptions could be designed and re-run through the LMS model for all stands and would likely increase the treatment effect on landscape level MOGI scores.

The objective of this modeling exercise, however, was to examine the relative effects of thinning vs. no-thinning on different components of forest structure, not to show that thinning could achieve higher MOGI scores. This type of modeling exercise cannot incorporate all of the real-world details required to develop site-specific prescriptions. These modeling results do provide a preliminary test of the use of thinning to accelerate the development of late-successional forest conditions, and offer a foundation from which site specific prescriptions can be developed. Creating such prescriptions will take time, careful thought, and trial and error. Over time, they will provide an opportunity to empirically test the hypothesis that thinning can accelerate the development of late-seral structure and refine our understanding and models of forest development.

3. ***Projected Volume and Revenue Outputs***

A preliminary economic analysis of the planned treatments over the next 20 years was performed to obtain a crude estimate of volume production and revenue flow. The TNC and WNWR ownerships within the SWBCA were grouped together for this analysis. In order to provide an accurate estimate that accounts for different log sort and species prices, volume per acre outputs for different stand types, and ground based vs. cable yarding costs, a forecasting spreadsheet was designed. The spreadsheet can be adjusted over time as prices and costs change. Log prices were based on October 2006 prices (Table 9). Logging costs were assumed to be $225/mbf for cable yarding, $175/mbf for ground based yarding (processer/forwarder combination), and $40/mbf for hauling. Each stand slated for a biomass removal treatment was evaluated to determine the extent of ground based vs. cable yarding required. The number of ground based and cable acres of each forest type for each time period where biomass removal treatments will occur was then calculated. The total acreage for each stand was reduced by 20% to account for buffers and skips. Volume produced per acre for different stand types was determined in LMS by growing them forward until their planned thinning date, running several different thinning treatments, and then adjusting for overestimation of volume by LMS. Adjustments were based on stand volumes from actual forest inventory data vs. LMS volume, and professional experience from thinning similar stands. The values are conservative by design and range from 7 mbf/acre for thinning in 25-35 year old stands to 13 mbf/acre for 60+ year old stands. Actual volume per acre outputs may be higher, especially within older stands.

The total volumes by species, sort, and time period were then calculated (Table 14 – also see Table 12 for acreage figures) for the analysis. The estimated total harvest volume is 65 million board feet over 20 years, which equates to an average of 3.25 million board feet per year; however, annual volume production will fluctuate over this time period. As the ecological need and economic viability of planned 2nd entries in years 2017-2026 will be not known for some time, thinning acreages and volume production may be lower than projected, especially towards the end of the planning period..

While logging costs are subtracted for this analysis, estimated revenue generation by species, sort and time period (Table 15) do not reflect the costs of forest or road management. To account for inflation, totals for each time period were discounted by 5%. For time periods 2010-2016 and 2017-2026, midpoint years were used for discounting. The total net present value is $6.5 million, which equates to an annual revenue stream of $325,000. This number will of course fluctuate based on prices, costs, and annual volume production.

Table 14: Volume production by species, sort, and time period. All numbers are Scribner volumes in thousand board feet (mbf).

Species	Sort	2007	2008	2009	2010-2016	2017-2026	Total
WH-SS	#4	0	1896	1630	15208	11461	30195
	#3	0	1437	1158	9873	4550	17019
	#1-2	0	392	303	2446	1471	4612
DF	#4	0	262	249	2828	4819	8157
	#3	0	0	0	891	3225	4117
	#1-2	0	0	0	0	0	0
RA	#4	0	0	0	217	67	284
	#3	0	0	0	433	134	567
	#1-2	0	0	0	325	100	425
Total		0	3,987	3,341	32,221	25,828	65,376
Annual Volume Production		0	3,987	3,341	4,603	2,583	
Total Thinning Acres[1]		0	327	276	2836	3005	6443
Average Mbf/Acre		0	12.2	12.1	11.4	8.6	10.1

[1:] This total assumes that 20% of the Biomass removal acres listed in table 12 will be left in skips or buffer.

Table 15: Revenue generation by species, sort, and time period.

Species	Sort	Price/ mbf	2007	2008	2009	2010-2016	2017-2026
WH	#4	$315	$0	$597,258	$513,402	$4,790,470	$3,610,251
	#3	$410	$0	$589,151	$474,960	$4,048,129	$1,865,396
	#1-2	$440	$0	$172,330	$133,358	$1,076,335	$647,424
DF	#4	$445	$0	$116,578	$110,885	$1,258,313	$2,144,258
	#3	$500	$0	$0	$0	$445,566	$1,612,746
	#1-2	$575	$0	$0	$0	$0	$0
RA	#4	$625	$0	$0	$0	$135,364	$41,835
	#3	$730	$0	$0	$0	$316,210	$97,727
	#1-2	$830	$0	$0	$0	$269,645	$83,335
Gross Total			$0	$1,475,318	$1,232,606	$12,340,034	$10,102,973
Total Logging Costs			$0	$983,761	$838,530	$7,279,661	$6,194,767
Net Revenue			$0	$491,557	$394,076	$5,060,372	$3,908,206
Net Revenue per Acre			$0	$1,504	$1,427	$1,785	$1,301
Net Present Value (5% Discount Rate)			$0	$468,150	$357,438	$3,776,128	$1,879,914
Total Net Present Value			$6,481,630				
Annualized NPV Revenue Stream			$324,082				

C. MONITORING

Monitoring the success of restoration treatments and recovery of late-successional forest species is an important component of the management plan for the SWBCA; however, resources for monitoring are limited. Compliance and validation monitoring of specific road and forest management treatments is expected to occur as a regular component of such actions. Effectiveness monitoring of fish and wildlife populations, and habitat responses to management actions will occur as funding and resources allow. The Refuge is planning to continue limited breeding season surveys of marbled murrelets in select forest stands following standard protocols (Evans et al. 2003). Other ongoing monitoring includes chum salmon spawning counts along a reference stream reach in the Ellsworth Creek drainage conducted annually by the WDFW. The foundation for monitoring the effectiveness of forest management and restoration within the SWBCA, however, will rely on an extensive experimental adaptive management study within the Ellsworth Creek watershed. This adaptive management study is one of the most extensive studies concerning forest restoration at a landscape scale in the Pacific Northwest.

Taking measurements at one of 224 permanent forest plots.

1. Adaptive Management

A considerable amount of research has taken place in the Pacific Northwest concerning old-growth forest ecology, growth and yield in young-managed forests, stream ecology, and wildlife-habitat relationships and other topics; however, as outlined in this plan, debate continues over how young-managed forest landscapes should be managed for restoration (e.g., Young Stand Management Forum, Olympia Washington, April 2003). Hot topics in this debate concern the economic motives of forest thinning, within stand damage caused by thinning treatments, impacts of forest roads, and effects on aesthetic or spiritual values in forest landscapes. Findings from ongoing research do not resolve these issues, and leave managers with several management alternatives – many of which are equally scientifically and socially justifiable. Managing these forest landscapes through an adaptive management process (Walters and Holling 1990) offers a method to test alternative management practices simultaneously and improve our understanding of how these systems respond to various forms of management intervention. In the Siuslaw National Forest, the Five Rivers Landscape Management Project (USFS 2001) has recently been implemented specifically to address these management questions. In the SWBCA, the Ellsworth Creek watershed offers an additional site, time within the Sitka spruce Zone (Franklin and Dyrness 1988), where these questions can be addressed at a landscape scale.

To meet the mutual goals of restoring the Ellsworth Creek Preserve, and addressing the key scientific uncertainties that remain regarding restoration treatments, the Conservancy will follow an active adaptive management process. Furthermore, the Conservancy will work toward linking this project with other landscape restoration efforts throughout the Pacific Northwest to promote synergistic mechanisms for increasing our collective knowledge of ecosystem recovery within young-managed forest landscapes.

An active adaptive management system offers the best chance to rapidly increase our management knowledge because it takes an experimental approach to simultaneously testing multiple restoration treatments - all of which have equal validity given our current state of knowledge (Bormann et al. 1999, Taylor B. et al. 1997, Walters and Holling 1990). In contrast, more commonly applied reactive and passive adaptive management systems (Figure 18) inhibit rapid learning because they apply only a single management regime to a problem (reactive and passive), or do not include monitoring as a key element of the design (reactive) (Bormann et al. 1996). Due to its landscape-scale size, topographical and geomorphological layout (i.e., multiple westward flowing tributary basins), single ownership, and the Conservancy's flexibility toward implementing a range of management regimes, the Ellsworth Creek watershed is an ideal setting to implement an active adaptive approach to restoration.

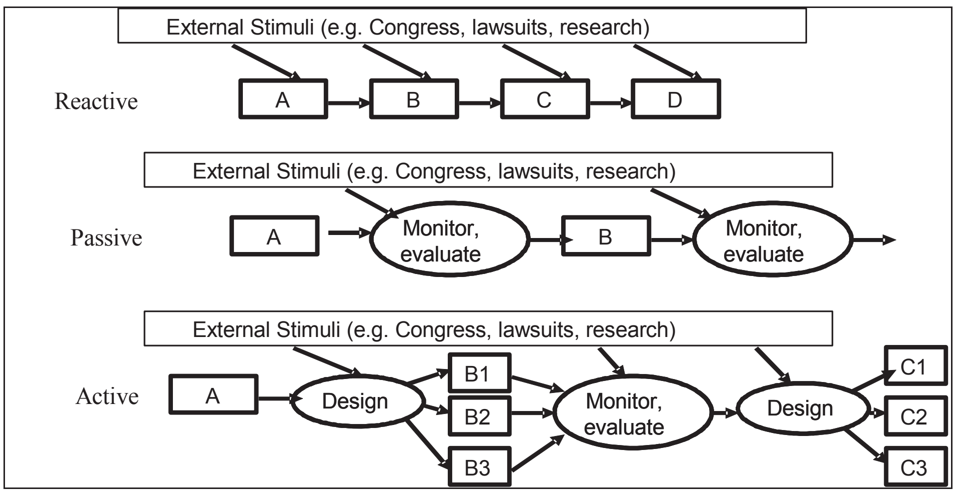


Figure 18. The flow of knowledge and modification of management regimes (A, B, C, D) under reactive, passive, and active adaptive management strategies. In an active adaptive management strategy, equally appropriate management treatments (B_1, B_2, B_3) are simultaneously applied and tested using an experimental design (*Adapted from*: Bormann et al. 1996).

The Conservancy worked with an external science review panel to develop a study design (Rolph and Beggs 2006) (that will simultaneously test rates of ecosystem recovery and cost effectiveness using three different restoration pathways (Map – Ellsworth Creek Experimental Basins). Each pathway is equally justifiable given our current understanding of forest restoration.

1. *Road Removal* – forest stands will be left to develop without management intervention and all roads will be permanently abandoned (unless constrained by management or legal restrictions).
   - Advantages – very low cost of forest management, quickly eliminates signs of human management (e.g., roads, new stumps), forest stands may develop different characteristics than thinned stands, reduces forest fragmentation and sediment delivery from roads.
   - Disadvantages – high initial financial costs for road abandonment, forest growth models predict stagnation within the stem exclusion stage, windthrow may be high due to increasing stem-diameter ratios, lack of access for management.
2. *Vegetation Management* – forest stands will be actively thinned during the initial treatment period (first 10 years) and at recurring intervals to promote forest growth and the development of structural complexity. Roads will be maintained to allow for harvest and other management operations.
   - Advantages – the time period for forest stands to obtain characteristics typical of late-successional forests should shorten: tree growth rates should increase, stands should quickly develop structural and compositional complexity, understory vegetation diversity should increase, large wood delivery

should increase in shorter timeframe. Some revenue generation from sale of commercially thinned trees.
- Disadvantages – increased ground disturbance and potential for invasive species introductions, higher sediment production and delivery to streams, higher forest fragmentation from roads, windthrow may be high in areas with high stem/diameter ratios and along road corridors, continued cost of road maintenance, signs of human management will be evident.

3. *Control* – forest stands will remain unthinned during the initial treatment period (first 10 years) and all roads will be maintained or repaired as needed. This management pathway will be re-evaluated in 10 years in an adaptive management context.
   - Advantages –lowest initial cost of management, sign of human management is reduced within forest stands, forest stands may develop different characteristics than thinned forests over time.
   - Disadvantages – moderate potential for introduction of invasive species along road corridors, continuing threat of sediment delivery from roads, ongoing costs of road maintenance, ongoing stand fragmentation from roads, future management options within forest stands may decline as young stands develop with high stem densities.

The Conservancy began implementing the experimental adaptive management study in 2005. Baseline data is currently being collected on a variety of indicator variables and will continue through the winter of 2007-2008. Indicator variables include:

- Stream hydrology
- Physical stream habitat
- Hydrologic connectivity of roads and streams
- Forest structure and composition
- Forest bird abundance
- Headwater stream amphibians abundance
- Spawning populations of coho salmon
- Stream macroinvertebrate composition
- LiDAR data

In general, no active management will occur within the adaptive management study area during the baseline data collection period. Two exceptions to this rule include: a) roads rated as high hazards for failure or showing imminent signs of failure will be treated uniformly throughout the study area, and b) thinning for restoration purposes within young-managed forest stands (less than 20 yrs of age) may occur within the study area, but only outside of the 8 designated experimental tributary basins.

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<u>APPENDIX A: ECOLOGY OF SPRUCE-HEMLOCK FORESTS</u>

By: Andrew Larsen and Derek Churchill

<u>Natural Disturbances</u>

Disturbances play important roles in structuring the coniferous forests of western North America (Agee 1993, Franklin et al. 2002, Veblen et al. 1994). Their variation in type, extent, intensity and frequency lead to unique post-disturbance conditions and forest developmental pathways. Stand replacing disturbances initiate the forest development sequence while chronic, small-scale disturbances are important agents of tree mortality and pattern formation within the development sequence. Wind is the primary disturbance in coastal Sitka spruce Zone forests. Storms with hurricane force winds—potential stand replacing events—have swept the western Washington coast approximately once every 20 years in the last 200 years (Henderson et al. 1989). Of these events, the "21 Blow" of 1921 and the Columbus Day Storm of 1962 were the most significant, with estimated 7 and 11 billion board feet of timber volume blow down in the storms, respectively. In addition, smaller windstorms blow down or damage individual trees or groups of trees on a much more frequent basis. Additional complexity is introduced by feedbacks between wind-created edges along canopy gaps and blowdown areas, which expose additional trees to wind disturbance (Greene et al. 1992). As a consequence, wind disturbance become chronic, and blowdown patches can be seen to grow and migrate across coastal forest landscapes at annual to decadal time scales in complex wave and partial wave patterns (Harcombe et al. 2004). The net effect of this variable-intensity wind disturbance regime is a complex landscape mosaic of different patch types and sizes, often with high within-patch heterogeneity.

Fires, while rare, also perturb coastal Sitka spruce Zone forests. The incidence of fire in these forests is low because ignition sources are infrequent and ignitions rarely coincide with fuel moisture levels conducive to carrying wildfire. The limited available fire history data for Sitka spruce forests indicates that stand replacement fires occur only during extreme weather conditions associated with dry east winds (Agee 1993). Long and Whitlock (2002) estimated a fire return interval of 240 ± 30 years over the past 2700 years at a site just south of the project area in northwest Oregon. In the Sitka spruce Zone forests of the Olympic Peninsula fires have burned with a return interval of approximately 900 years (Henderson et al. 1989). A major stand-replacing fire event—the Nestucca Fire— burned Sitka spruce Zone forests at what is now the Cascade Head Experimental Forest in northwest Oregon sometime between 1845 and 1849 (Morris 1934, Munger 1944). The Nestucca fire started in the Willamette Valley and was pushed over the Coast Range by strong east winds. It is unknown if this significant fire was of natural or human origin. In any case, stand replacement fire events are certainly possible in the Sitka spruce Zone, although the probability of occurrence is quite low.

Reconnaissance in the largest old-growth patch on Long Island revealed occasional isolated fire-scarred western redcedar snags, confirming that fire has been present to some degree in recent centuries. As the old-growth patch has no evidence of a recent stand-replacement event, these solitary fire-scarred snags likely represent trees that were struck by lightening and subsequently smoldered and charred, with the fire remaining small in extent. Recent lightening strikes in 2005 on Long Island and within the Ellsworth Creek watershed provide circumstantial evidence in support of this idea.

Landslides are another major disturbance type that affects coastal forests, (Powell et al. 2003, Skaugset et al. 2002, Wegmann 2004). Shallow, rapid translational landslides appear to comprise the bulk of soil mass movements in the Ellsworth Creek watershed, although deep-seated landslides are also apparent (Wegmann 2004). They can be categorized as either debris slides, where the debris is deposited at the foot of the failure scarp, or debris flows, in which material has a high water content, is mobilized down slope, and enters the stream channel network (Skaugset et al. 2002). By creating sites with exposed mineral soil in the terrestrial uplands, landslides create opportunities for early successional species to establish and thus maintain diversity in upland forest plant communities. Another important function of landslides, specifically debris flows, is to transport sediment and large woody debris from terrestrial uplands to the stream network. They reconfigure aquatic ecosystems (Montgomery D.R. and Buffington 1998) and deliver pulses of the basic habitat elements required for streams to develop optimal habitat function (Reeves et al. 1995).

Forest Development Pathways

Old-growth Sitka spruce Zone forests are structurally similar to old-growth Douglas-fir forests (Franklin et al. 2005). The well studied structural development of Douglas-fir forests (Franklin et al. 2002, Zenner 2005) is helpful in understanding structural development in Sitka spruce forests, especially in managed stands as historic clear-cutting was typically a high severity disturbance that placed new stands on an even-aged trajectory similar to Douglas-fir stands after a high severity fire. However, the dominant disturbance in natural Sitka spruce Zone forests—wind—differs from that of Douglas-fir forests, which are influenced relatively more by fire. The silvics of the major species are also different. Thus, while reviewing the developmental sequence of Douglas-fir forests, we will also identify the key differences of Sitka spruce Zone forests.

Franklin et al. (2002) present an eight stage conceptual model for Douglas-fir forest development following stand-replacing disturbance. Each structural stage is named for the dominant structural development processes at that point in development. Many developmental processes operate at any one time in stand structural development, however; forests do not develop in an orderly fashion. General trends are certainly identifiable, but high variability in natural forests is the rule rather than the exception.

The developmental sequence is initiated in the disturbance and legacy creation stage. The type and intensity of the stand replacing disturbance create the substrate and biological legacies (living organisms, dead organic matter, and biologically-derived spatial patterns that persist following a disturbance) that set the stage for stand development. Stand replacement windstorms create a complex substrate of overturned rootwads with depressions of exposed mineral soil, downed logs, and intact pre-disturbance forest soils that is very different from the predominance of exposed mineral soil after a high intensity fire. In addition a larger number of live trees tend to persist through windstorms as opposed to high intensity fire. Much recent research on biological legacies has focused on residual live green trees, including their distribution (Keeton and Franklin 2004, Keeton and Franklin 2005) affects on stand volume growth (Acker et al. 1998, Zenner et al. 1998), influence on spatial patterns of regenerating trees (Goslin 1997), contribution to stand structural complexity (Zenner 2000), and influence on rates of forest succession (Keeton and Franklin 2005). In all these examples, the influence of the stand-initiating disturbance, and especially the biological legacies, is apparent decades or even centuries later in stand development.

Following disturbance and legacy creation, stands enter the cohort establishment stage. This stage is characterized by the establishment of a new cohort of conifer tree seedlings that is highly variable in time and space. The establishment of tree populations is limited or facilitated by five broad factors: seed availability and dispersal; environmental conditions; competition with non-tree vegetation; seed and seedling loss to herbivory and pathogens; and repeat disturbance prior to the sexual maturity of the new cohort. The first three factors operate in serial progression. Environmental conditions only limit tree regeneration after viable seed reaches the site, and competing non-tree vegetation only becomes limiting after tree species germinants have survived the initial environmental filter. The last two factors operate more-or-less throughout the tree establishment process.

In the moderate, moist Sitka spruce Zone cohort establishment is typically a relatively rapid process. Both spruce and hemlock are prolific seed producers (Ruth and Harris 1979) and seedlings typically establish at very high densities. Western redcedar also establishes, but at lower densities. The growing conditions are also quite favorable for competing non-tree vegetation however; if seed source is limiting immediately following fire a dense shrub layer may establish, limiting further tree seedling recruitment (Tappeiner et al.

2002). Because the dominant disturbance in the Sitka spruce Zone is wind, advanced regeneration often survives in its relatively sheltered position in the understory and can dominate the new cohort. Cohort establishment thus precedes the disturbance and legacy creation stage.

The next structural development stage following cohort establishment is distinguished by closure of the tree canopy. Canopy closure brings about extremely rapid shifts in the environmental conditions at the site. Understory light levels shift from nearly full sun to quite dark. Temperature and moisture regimes become moderated by the tree canopy, as well as understory wind speeds. Community composition begins to change following canopy closure. Shade intolerant, early successional herb and shrub species begin to be excluded from the site and successful establishment of additional tree seedlings ceases.

With the development of a closed, interlocking canopy forest development enters a developmental period marked by intense competition and biomass accumulation. At extreme levels, competition results in the mortality of those plants unable to capture enough resources to compensate for respiration costs. Competition in the moist Sitka spruce Zone forests is assumed to be primarily competition for light, which is generally thought of as a one-sided process (Cannell and Grace 1993, Cannell et al. 1984, Ford 1975, Ford and Diggle 1981) . In one-sided (asymmetrical) competition for light, a tall plant does not compete with a short plant, at least not above the level of the highest foliage on the shorter plant, while short plants compete directly with adjacent taller plants.. Alternately, two-sided or symmetrical competition occurs when plants share scarce resources in proportion to their size. If symmetrical competition is occurring even small plants will adversely affect the growth of large plants, as in the ponderosa pine/grand fir (*Pinus ponderosa/Abies grandis*) stands studied by McDowell and colleagues (2003), where water use by young grand fir limited growth of old-growth ponderosa pine. Competition for belowground resources is generally thought of as a two-sided process; the ability of a plant to extract limited belowground resources is proportional to the size of its root system. In reality, both one-sided and two-sided competition likely occurs in Sitka spruce Zone forests. However, stand structural development is likely influenced more strongly by one-sided competition for light than by two-sided below ground competition.

Competition related tree mortality prevails during the competitive exclusion/biomass accumulation stage. Growth rates and early canopy differentiation determine the "winners". Slower growing species such as western redcedar are often out-competed and decline in relative abundance. The spatial outcome of competitive tree mortality is an overall homogenization of the forest stand structure. Subordinate trees and plants die, and recruitment of additional tree seedlings is excluded (Harcombe 1986) resulting in a canopy structure characterized by a single uniform layer of foliage (Van Pelt and Nadkarni 2004). Dense clumps of trees self-thin, reducing within-stand variation in tree density. Trees surviving competitive mortality tend to be distributed in a spatially regular pattern (Kenkel 1988). While competition related mortality dominates tree demography, ecologically significant competition-independent tree mortality due to disturbance typically occurs during the competitive exclusion/biomass accumulation stage. For example, in a young Cascadian Douglas-fir-hemlock forest (Lutz and Halpern 2006) found that while the frequency of suppression mortality of trees was 2.5 times greater than that of mortality due to disturbance, nearly four times more biomass was lost to disturbance mortality.

Gradually, the developing stand transitions from the competitive exclusion/biomass accumulation stage into the maturation stage. Maturation is marked by the attainment of maximum height and crown spread. As overstory trees slow their crown expansion the intensity of competition for light lessens. Consequently, the dominant agents of tree mortality shift from competition related processes to density-independent processes, such as small scale disturbance, pathogens and insects. Understory light levels increase, allowing the development and re-establishment of understory plants and shade-tolerant tree species in the lower canopy. However, this process can be very slow in mature stands with a strong western hemlock component—a common scenario in the Sitka spruce Zone. Working in mid-elevation forests in the Oregon Cascades Stewart (1986, 1988) found that shade tolerant tree regeneration was delayed and understory plant community development was limited in stands with hemlock-dominated overstories , relative to Douglas-fir dominated stands. The denser hemlock canopy likely transmits less light, restricting understory development. By extension, Sitka spruce Zone forests that established with a high initial western hemlock overstory component my experience delays in maturation relative to stands that established with a relatively large Sitka spruce overstory component.

Once understory trees have established, further small-scale canopy disturbances create opportunities for growth of shade-tolerant trees into the middle and overstory strata (Winter et al. 2002), resulting in a vertically continuous canopy and a diversity of live tree sizes. This stage is termed vertical diversification. As overstory trees which have grown to substantial size at this developmental stage succumb to mortality, woody debris loads increase from the low levels typical of the early maturation stage to those typical of old-growth forests. In coastal forests, much of the overstory tree mortality at this stage arises due to interactions between pathogens (root and butt rots) and wind. Large branch systems develop during vertical diversification, as does decadence in live trees (e.g. stem rot, cavities, bark scarring, broken tops, etc.), creating diverse canopy habitat for animals and epiphytes.

The horizontal diversification stage follows vertical diversification and describes the process by which a forest stand develops a spatially heterogeneous structure in a horizontal plane. Horizontal diversification subsumes many tree birth, death and growth processes, of which the net effect is to transform the homogenous young stand (i.e. a stand in the competitive exclusion/biomass accumulation stage) into a spatially heterogeneous forest. Horizontal heterogeneity, defined as the presence of multiple patches within a forest stand which together form a fine scale structural mosaic, is considered an emergent property of old-growth forests (Franklin and Van Pelt 2004) and is thought to originate primarily from a combination of spatially-aggregated tree mortality and competitive interactions between different subpopulations of trees (Franklin et al. 2002, Larson and Franklin 2006).

The final developmental stage identified by Franklin et al (2002) is pioneer cohort loss, which is simply the loss of the last members of the original stand initiation cohort. In the Douglas-fir forests described by Franklin et al. (2002) this represents a potential loss of forest structure and function since Douglas-fir generally does not regenerate in canopy gaps. The analogue for Sitka spruce Zone forests would be the loss of large, dominant spruce. However, in spruce forests the pioneer cohort loss stage does not have the same consequences for forest structure, composition and function as in Douglas-fir forests because spruce is capable of regenerating in canopy gaps (Taylor 1990), thereby maintaining a spruce component over time spans greater than the longevity of the original spruce cohort.

Two major stand development pathways exist in coastal spruce-hemlock-cedar forests and arise from variation in severity of the dominant disturbance, wind (Figure: 1). Sites with greater exposure to wind tend to experience high severity disturbance and stand development follows a catastrophic pathway (i.e., Franklin et al. 2002). Due to their prolific seed production and rapid early growth, western hemlock, and to much a lesser extent, Sitka spruce tend to be the dominant species in this pathway. Relatively less exposed sites experience chronic, low severity wind disturbance, which manifests as small scale, canopy-thinning disturbances (Winter et al. 2002). The chronic disturbance pathway tends to select for wind resistant, western redcedar and leads to relatively open, cedar dominated stands that are increasingly resistant to wind disturbance over time (Weetman and Prescott 2001). At the landscape scale, topographic heterogeneity create a mosaic of young, even aged stands developing along the catastrophic pathway following high severity wind disturbance and old-growth, all aged stands maintained by low and moderate severity wind disturbance (Kramer et al. 2001, Weetman and Prescott 2001).

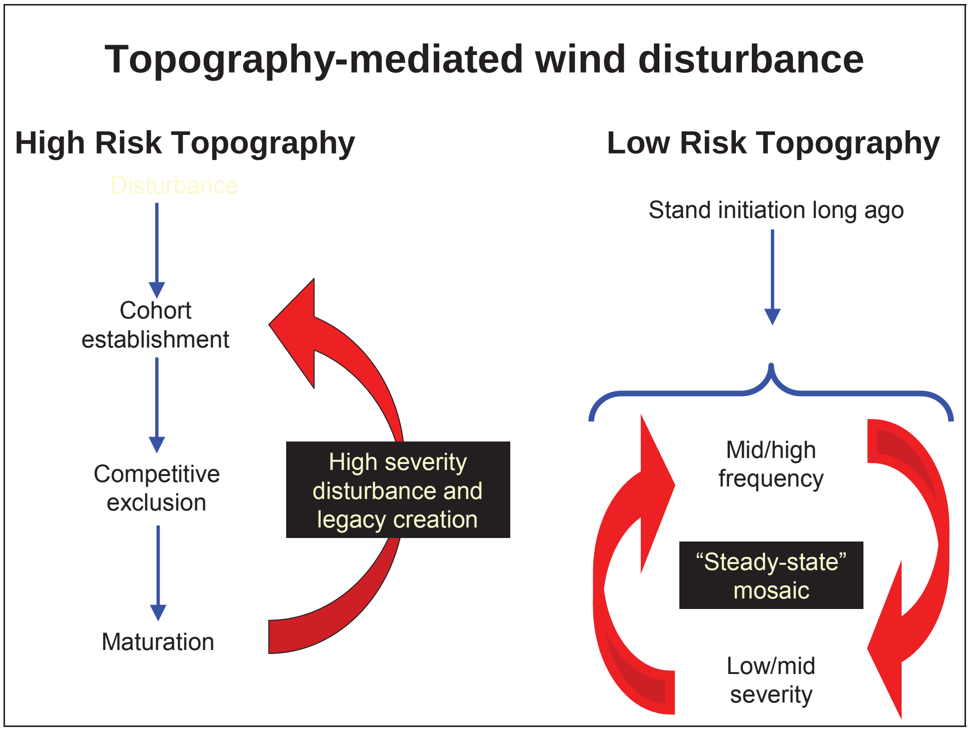

Figure 1: The effects of topography on wind disturbance and forest development

Long term studies of forest development following stand replacement fire at Cascade Head Experimental Forest provide additional insight into forest structural development in the Sitka spruce Zone. Stand replacement fire burned the Northern Oregon Coast Range in circa 1845 (Morris 1934, Munger 1944), including the area now designated as the Cascade Head Experimental Forest. Following fire, stand structural development proceeded along the sequence described by Franklin et al. (2002) up to the end of the competitive exclusion stage and beginning of the maturation stage (Harcombe 1986). Permanent plot studies then demonstrate accelerating mortality and biomass loss in maturing forests (Acker et al. 2000, Greene et al. 1992, Harcombe et al. 1990) from a complex pattern of wind disturbance (blowdown). Harcombe et al. (2004) used aerial photographs to characterize this wave like pattern as it advanced through Cascade Head over a 40 year period.

Susceptibility of a forest stand to windthrow increases with stand age in coastal forests (Harmon et al. 2004, Harris 1989, Jane 1986, Rebertus et al. 1997, Wimberly and Spies 2001) (Figure 2). As trees grow taller they become less able to withstand the physical forces of high velocity winds, leading to increases incidence of mechanical failure either by uprooting or stem breakage. Stem, butt and root rots in older (larger) trees also increase the likelihood of windthrow (Edmonds et al. 2000). Also, once gaps in the canopy have been created, the remaining trees are more exposed and susceptible. Topography interacts with prevailing wind directions (storm tracks) such that different locations will have greater or lower susceptibility to windthrow (Kramer et al. 2001). On sites predisposed to catastrophic windthrow by the local topographic context, forest structural development will be truncated, seldom reaching the later stages (i.e. vertical and horizontal diversification) of forest structural development.

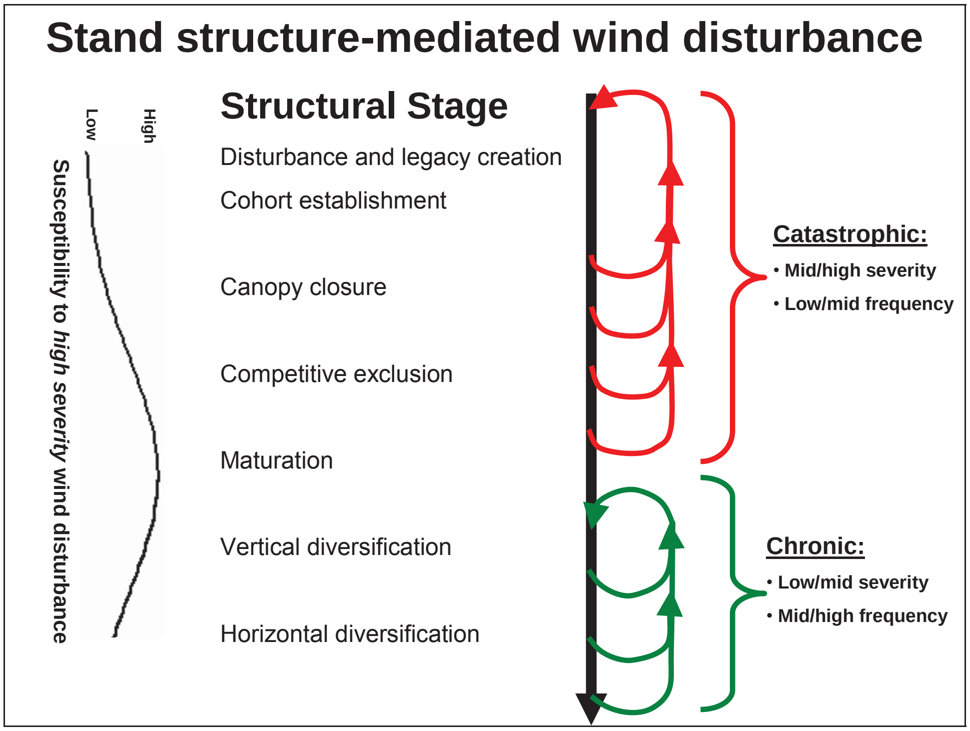

Figure 2: The influence of stand structure and wind disturbance on forest developmental pathways.

In the case of the Cascade Head, both topographic position and decreased resistance to wind disturbance due to unstable, single cohort stand structure dominated by tall, slender trees have contributed to the observed pattern of partial blowdown waves (Harcombe et al. 2004). These waves initiated from discreet canopy gaps that have slowly spread and coalesced through time. A similar phenomenon has been observed in other coastal, wind-disturbed forests (Rebertus and Veblen 1993, Rebertus et al. 1997). Thus, the implication is that conversion of wind resistant cedar dominated old-growth stands (*sensu* Weetman and Prescott 2001) to even aged hemlock dominated stands has decreased the resistance to wind disturbance, particularly on sites with only moderate topographic protection from storm tracks.

Red alder aggressively invades many sites in the Sitka spruce Zone following disturbances. Consequently, pure stands of red alder, or mixed alder - conifer stands often develop following logging or natural disturbance (Deal et al. 2004). Red alder is a short lived species; two major successional pathways are possible in maturing alder stands. Spruce, hemlock and cedar are all able to persist in the understory of alder stands. Thus, a common successional sequence is a gradual transition from alder to conifer dominance. Beach and Halpern (2001) found that distance to seed source was the most important explanatory variable for patterns of conifer seedling abundance in alder dominated riparian forests. Substrate (woody debris) was positively related to hemlock and spruce seedling abundance, while conifer seedling abundance declined with increasing herb and shrub cover. The same study found no relationship between conifer seedling abundance and overstory cover, suggesting that alder does not competitively exclude conifer seedlings from the understory. If conifer seed is not available, or if conifer seedling establishment is otherwise limited (e.g. by competition with understory plants or herbivory), shrubs may increase in dominance as the alder component senesces, further excluding conifer establishment and maintaining a stable shrub community (Spies et al. 2002). Having some portion of the landscape maintained in brushfields is not necessarily undesirable; the condition likely occurred naturally. However, management action (e.g. planting conifer seedlings) may need to be taken on some sites if past harvesting has removed local conifer seed sources.

Mixed alder - conifer stands have the potential to develop heterogeneous stand structures with multiple canopy layers and large diameter conifers (Deal et al. 2004). Rapid initial height growth by alder leads to canopy stratification, with understory conifers persisting under an overstory of alder. Alder is a short lived species however and mortality of overstory trees facilitates the eventual recruitment of suppressed conifers into the overstory of mixed alder – conifer stands. Sitka spruce appears to be particularly adept at responding to release from overstory alder competition (Deal et al. 2004).

Stream Geomorphology, Disturbances, and Habitat, including Riparian Areas

Stream geomorphology can be characterized at multiple spatial scales ranging from geomorphic provinces to channel reaches. Three basic types of channel reaches exist: (Montgomery D.R. and Buffington 1998).

- Colluvial reaches: These are typified by low volume, ephemeral flows and poor sediment sorting, as debris flows are the primary sediment transport process in colluvial reaches.
- Bedrock reaches: These occur where sediment transport capacity exceeds sediment supply, preventing the accumulation an alluvial sediment bed.
- Alluvial reaches: These occur where alluvial sediments accumulate and assume several different morphologies (cascade, step-pool, plane-bed, pool-riffle, and dune-ripple) depending on the ratio of sediment supply to transport capacity. These five types tend to arrange themselves within the channel network according to stream gradient, with cascades morphologies typically found in steeper areas and pool-riffle and dune-ripple reaches occupying low gradient locations. However, in-channel large woody debris alters sediment delivery-transport relationships, forcing channel reaches to assume different morphologies than would be expected in the absence of large wood in the stream channel. In-channel woody debris can create suitable aquatic habitat in stream reaches that would otherwise be of low habitat quality.

Disturbance regimes and processes change throughout the stream network (Montgomery D. R. 1999). As stream channels increase in size, dominant disturbance processes transition from landslides and debris flows to floods and channel migration/avulsion events. The frequency and magnitude of stream disturbance regimes shifts from infrequent and high magnitude disturbances in small streams to higher frequency and more moderate intensity in larger channels. Debris flows are primarily responsible for delivery of large woody debris in high gradient headwater channels; while downstream transport, bank erosion, and stand mortality are the primary causes of recruitment in low gradient, larger channels. Also, habitat heterogeneity within channel networks is hypothesized to be strongly influenced by large deposits of large woody debris in tributary junctions (Benda et al. 2004).

Riparian vegetation influences instream microenvironmental conditions, nutrient inputs and the quality and quantity of allotochonous organic inputs (Naiman et al. 2000, Naiman et al. 1998, Spies et al. 2002). Aquatic biota respond to changes in the quantity and quality of allotochonous inputs from riparian forests (Bisson and Bilby 1998). Riparian forests represent an important habitat resource in their own right: 29% of wildlife

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APPENDIX B: PROCESS AND GUIDELINES FOR DEVELOPING STAND LEVEL PRESCRIPTIONS

By: Derek Churchill, Andrew Larson, & Kevin Cedar

Numerous land management agencies in western Washington such as the Washington State DNR (Holmberg et al. 2006), the Olympic National Forest (Shoal 2002), the Cedar River Watershed (Erckmamn and others 2000), Fort Lewis Military Reservation (Public Forestry Foundation 2001), and the Pinchot Partners (Churchill et al. 2005) have translated the theoretical ideas of accelerating the development of old growth structure into operational thinning prescriptions. Various scientists have also provided operational level recommendations (Carey, pers. comm., Franklin pers. comm.). However, these recommendations are geared towards creating old growth structure suitable for spotted owl habitat in mostly Douglas-fir dominated forests. They also do not clearly articulate a thought process for determining the amount, scale, and distribution of variability that should be introduced at different stages of stand development in different forest types.

Applying these concepts and implementation strategies to the Sitka spruce forests of Willapa Bay, where wind disturbance and prolific hemlock regeneration are defining attributes, is likely to lead to unintended consequences. The following process was thus developed to guide managers in developing site-specific prescriptions that have a clearly defined rationale of how to meet distinct objectives for particular stands. It is an attempt to articulate and define the complete set of factors and thought processes that should be addressed when designing prescriptions for a mix of objectives. Many of the steps will be obvious to any land manager, while others may not be. It may seem at first glance to be overly complex, yet it is basically what experienced foresters do intuitively. By ensuring that the prescription development is done in a conscious, systematic fashion with a clear rationale can be explained, unintended consequences from cookie-cutter prescriptions that can develop over time are more likely to be avoided. Most of the information needed in the process has already been gathered, is presented in this plan, and can be further analyzed using the multiple GIS layers, inventory data, and LMS tools collected and developed for these ownerships. While this process is laid out in a linear fashion, prescription development is by nature an iterative process and will involve going back and forth between steps.

1. *Clearly Articulate Management Goals & Constraints*

While the overall management objectives and landscape level, desired future conditions for the Refuge and Conservancy ownerships have been laid out in this plan, it is critical that they be clearly fleshed out for the specific stand in question. Getting clear and being upfront about the balance of ecological, economic, and social needs and constraints of each particular project will continually refresh and allow for evolution of overall management goals, avoid overuse of boilerplate language, and guard against loss of public trust. Although this is an obvious and often repeated step, many land management agencies have been slow to change their goals, thinking, and strategies as social values, ecological conditions, and scientific knowledge have changed.

2. *Assess Stand*

- Landscape context: Several questions should be examined to get a clear picture of how the stand is connected with the surrounding landscape. What is the condition of the landscape around this stand in terms of stand structure, age class distribution, landscape heterogeneity, and habitat connectivity? What functions does this stand provide at the watershed and landscape scales? Are there riparian areas, streams, wetlands, unstable slopes, special habitats, rare species, or other features that are part of important landscape level processes or habitat for key wildlife species? If so, assess the condition of these areas relative to providing key functions. If treating several stands that are close together, much of this step can be done for multiple stands at once.

- Site characteristics: The key physical factors that affect the vegetation and potential vegetation on the site must be clearly understood by identifying the geological history, landform, topographic position, soil characteristics, site productivity, and susceptibility to disturbance (primarily wind) of the site where the stand is located. Also, identify the plant association group, its defining physiological and ecological characteristics (i.e. low or high drought and frost tolerance, light vs. moisture limited, etc), and the silvics of the tree species present (regeneration strategies, shade tolerance, lifespan, growth potential, etc).

- Stand development history: Summarize how the stand developed by listing all past management activities (i.e. clear cut harvest, broadcast burning, planting, pre-commercial thinning, etc) and key natural processes that also played a role (i.e. species colonization, windthrow, competitive interactions, disease, etc). Next, using the explanation of natural stand development for this forest type provided in appendix A, identify key differences between the developmental pathway of this stand and a theoretical natural stand of a similar age developing after natural disturbance on this particular site. While the natural pathway is not necessarily the ideal or target pathway, it is critical to understand what structures and processes are different because of past management (i.e. lack of legacy live trees, snags, and CWD; high proportion of Douglas-fir, reduced horizontal patchiness early in stand development, low crown class differentiation, low species diversity, etc). Finally, attempt to determine the fine scale distinctions in old growth development that exist in the specific plant association and topographic position of the particular stand. For example, sites on drier soils on exposed ridge tops appear more conducive to western redcedar dominated stands while protected riparian corridors favor Sitka spruce and western hemlock.

- Structure and composition of stand: Through both inventory data and thoroughly walking the stand, managers should have a firm grasp of the following items:
    - Stand density, diameter and height distribution, and species composition.
    - Live crown and height to diameter ratios
    - Live legacies
    - Size, decay class, and expected longevity of snags, CWD, and wildlife trees:
    - Horizontal patterning: patchiness
    - Understory plant community composition
    - Ongoing disturbances

- Developmental processes: As described in appendix A, Franklin et. al. (2002) built on the work of earlier efforts (Carey and Curtis 1996, Oliver and Larson 1996) to develop a series of structural stages that describe the development of old growth forests. Most land management agencies use these or similar systems to classify stands into structural stages and to prescribe treatment regimes. However, stand development is rarely a linear path and stands often have processes from multiple stages happening at once (Franklin et al. 2002). This is especially true in systems with chronic disturbance regimes. When designing prescriptions, it is much more important to understand the specific processes occurring in a stand and their relation to the development of the desired future conditions, than it is to define the specific structural stage. From a synthesis of the above authors and several others (Carey 2003, Spies and Franklin 1990, Spies et al. 2002a, Spies et al. 2002b), the 5 overarching components that lead to the development of old growth structure in westside Pacific Northwest forests have been broken down into the processes that drive them (table 1). These five overarching components are inherently interconnected and many of the processes are thus listed more than once. The processes are somewhat sequential, but not necessarily so. In order to better understand where the stand is at and where it is headed, the status of the overarching components should be observed in the field and analyzed. To do this, processes that are either in full swing, ramping up, declining, or about to begin should be identified using table 1.

Table 1: Stand development processes that lead to development of old growth structure in west side old growth forests in the Pacific Northwest.

Stand Development Processes
a). Overstory canopy development • Cohort establishment & early mortality from weather, herbivory, and shrub competition • Canopy closure • Crown class differentiation: • Competitive exclusion & mortality • Biomass accumulation: height growth, diameter growth, and stem form • Vertical crown development: height growth, crown lifting, & epicormic re-building • Horizontal crown expansion
b). Horizontal spatial patterning • Live and dead legacy carry over from previous stand • Early cohort establishment & mortality weather, herbivory, and shrub competition • Horizontal packing: canopy closure and competitive exclusion that leads to more homogenous spatial pattern. • Small and large gap creation • Patchy development of multiple canopy layers that creates "anti-gaps" (patches of dense mid and understory trees).
c). Vertical canopy development • Cohort establishment (early tree species colonization) • Competitive exclusion • Stratification • Understory tree species colonization • Recruitment and decomposition of dead wood: substrate for colonization. • Development of midstory • Patchy development of multiple canopy layers. Bottom loaded canopy where majority of foliage is in mid and understory tree layers.
d). Decadence formation • Legacy carry over from previous stand • Biomass accumulation • Competitive mortality • Exogenous mortality (pathogens, inserts, wind, fire, etc). • Damage to live trees: bole damage and crown damage • Decomposition: fungi, invertebrates, vertebrates, abiotic, etc.
e). Plant community development (shrubs, herbs, epiphytes, lichens, etc) • Live legacy carry over from previous stand • Early species colonization & mortality • Competitive exclusion & suppression. • Understory re-initiation: species colonization & growth • Gap formation • Recruitment and decomposition of dead wood: substrate for colonization. • Patchy development of multiple canopy layers where mid-understory tree layers create complex understory light environment • Crown colonization: epiphytes, lichens, etc.

Operational assessment: A rough assessment of the operational needs of different management options should be done (access, logging systems, landings, skid trails, etc) and the potential costs, revenues, and impacts estimated. The likelihood of a future entry and what type of future entry (MDL vs. BR) should also be determined as it will be a critical factor. Key potential impacts to be assessed include:
Soil compaction
Erosion and sediment delivery to aquatic systems
Invasive species
Loss of key ecological features: snags, tall shrubs, rare plant species.
Disturbance to sensitive wildlife & plant species.
Excessive shrub response or western hemlock regeneration
Social impacts: recreation, cultural sites, scenic value, etc.

3. *Design Prescription:*

- Process analysis: The information gathered the stand assessment should be used to answer the following questions:
    - Which processes are currently moving the stand towards DFC and which are moving the stand away from it?
    - Without any management intervention, what processes and structures will be missing or slow to develop with respect to DFC?
    - What processes could be manipulated to move the stand towards DFC?
    - What processes could be set back by a management entry?
    - Will stand benefit from treatment, factoring in the potential impacts? If not, consider alternative treatments or do not enter stand.

- Specific treatment objectives: While the management goals provide guidance, more detailed quantitative structural targets and a timeline should be clearly articulated for the particular stand given all of its site-specific conditions and landscape context. The general goal of developing late-seral structure should be broken down into the type of old growth forest that is desired and possible on the site. For example, some sites may be conducive to patchy, cathedral like, cedar-dominated old growth stands. On other sites, a more uniform, smaller diameter hemlock-spruce old growth forest may be the best option given habitat needs for Marbled Murrelets, the site, and the current structure of the stand. The intermediate structural stages should be spelled out by establishing quantitative targets of dominant tree size, height to diameter ratios, snag abundance, relative species composition, shrub cover, and spatial patterning within a 20-50 fifty year timeframe. The short to medium term effects of treating the stand should be balanced against the long term goals. Careful analysis of the stand inventory data and experimentation with different treatment scenarios in LMS will likely be necessary. The level of precision possible will vary for different metrics and a good deal of silvicultural judgement will be required. Maintaining future management options should also be factored in.

- Sensitive areas and biodiversity hotspots: From the stand assessment, identify what features and areas will need special management or protection. These may include large snags, legacy trees, hardwood patches, wildlife trees, midstory trees, riparian areas, wetlands, unstable slopes, rare plants, and habitat for endangered wildlife species. Based on landscape and stand level ecological conditions and regulatory requirements, determine if they should be managed with a no entry buffer, a drop and leave release treatment, or protected through specific marking or contract language protection.

- Operational design: If a biomass removal treatment is being considered, a logging systems analysis should be done at this stage. Costs and operational requirements should be calculated. The sensitive areas listed above will likely be a major factor to work with. For YDL, MDL, understory management, or decadence acceleration treatments, costs and opportunities for operational efficiencies should also be examined.

- Desired species composition: Determine what species will be retained and which will be targeted for removal.

- Understory management & decadence acceleration: Given the current species composition, snag and CWD levels, and what natural regeneration and blowdown is likely after a BR or MDL treatment, determine if these treatments are necessary and when.

- Baseline density and diameter targets: (for YDL, BR, and MDL treatments) The baseline density target can be considered the "average" or background thinning intensity that can be used to establish the range of variability desired in VDT treatments. Decades of silvicultural research provide guidance as to expected responses from different intensities of thinning (Marshall and Curtis 2002, Oliver and Larson 1996). While this research was conducted on plantations managed for wood production, it offers important knowledge and tools to achieve ecologically oriented structural goals.

  Density targets should be set in Stand Density Index (SDI) and can then be translated into trees per acre or basal area if necessary. The "Lower Management Zone" in stand density diagrams (Curtis 1982, Drew and Flewelling 1979, Long 1985, Reineke 1933) can be used as a starting point. This is 35% of maximum SDI or 50% of full stocking. It is the point where enough growing space is opened to allow residual trees to grow vigorously for a sustained period of time without losing excessive stand level volume growth (DeMars 2000, Drew and Flewelling 1979, Oliver and Larson 1996). Ecologically, it is a balance between growing large individual trees and maintaining biomass accumulation for future snag and CWD recruitment. It will typically result in a small to moderate pulse of understory development and tree regeneration that will slow down as the canopy re-closes. If additional understory or midstory development is desired or growing large trees is a primary goal, the density target should be lower, 25-35% of max SDI. In dense stands with high HD ratios or on wind prone sites, density targets may need to be set higher to avoid increasing windthrow risk. A general rule for these dense hemlock stands is to not lower density by more than 20% of max SDI (Holmberg et al. 2006). If a stand is at 70% of max SDI, then it should only be taken down to 50% of max SDI.

  Maximum SDI levels are 790 for western hemlock, 750 for Sitka Spruce and western redcedar, 590 for Douglas-fir, and 270 for red alder (Drew and Flewelling 1979, Farnden 2006, Hibbs and Carlton 1989, Long 1985, Puettmann et al. 1993, Smith N.J. 1989). Methods for determining maximum SDI levels for mixed species, multi-strata stands have only recently been developed (Woodall et al. 2005) and are still experimental. However, these stands are able to carry more stocking as different species and strata capture growing spacing differently and intra-specific competition is not as intense (Amoroso 2004, Long 1995, O'Hara and Gersonde 2004, Shaw 2000, Woodall et al. 2005). Thus maximum SDI levels in stands without a clearly dominant species (more than 60% of basal area) should use the highest SDI level of all the species in the stand, which will be 790 for western hemlock in most cases. Max SDI in stands dominated by Douglas-fir or red alder will need to be lower, and can be calculated using a weighted average based on the relative composition of the different species post-thinning. Field testing and experimentation through time will be needed to determine site specific maximum SDI levels for different mixtures of species and corresponding thinning targets. Also, in stands where individual tree or group selection approaches will be used to target specific features or areas of a stand, simple trees per acre targets may be more appropriate than using the SDI framework. Likewise, young drop and leave treatments are generally done in trees per acre targets. However, the same principles of stand density apply.

  In addition to the baseline density target, the decision as to what diameter classes to thin from must also be addressed. While thinning from below (removing the smallest diameter classes until the density target is reached) is the most common approach in thinning, it can reduce crown class differentiation, set back vertical canopy development, reduce species diversity, and generally simplify stand structure.

Given the goals of accelerating old growth development processes, removing some dominants and co-dominants is generally necessary and desirable. A proportional thin with lower and upper diameter caps can be used to achieve this. A stand table should be used to establish diameter caps

Finally, determining density and diameter targets requires clearly assessing a number of considerations. LMS can be used to experiment with different thinning intensities and to assess trade-offs. Density targets should then be field tested to ensure they make sense. Considerations include:

- Desired growth response of residual trees and time until canopy closure
- Post-thinning susceptibility to blow-down
- Effects on understory and midstory development
- Likelihood of future entries
- Volume removal and revenue potential
- Future snag and CWD recruitment potential

- <u>Introducing patchiness:</u> The amount, patch size, and distribution of horizontal patchiness to be introduced should be specified and supported by a clear rationale. Structural objectives, answers from the process analysis above, and existing patchiness, species composition, midstory condition, logging system requirements, access, topographical features, and special management areas should be all factored be in. Spatial information from nearby old growth stands can be used as a reference if it is available, although natural stand development processes that will shape the young stand over time must be factored in. The following items can be used to introduce patchiness and vary understory light levels.
    - No entry skips (in addition to those around sensitive features) to maintain dark areas in the understory, maintain snag creation from competitive mortality, provide refugia for soil fungi that can be negatively impacted from ground based thinning (Colgan et al. 1999, Smith J.E. et al. 2002), and set pockets up for future blowdown by maintaining high HD ratios.
    - Heavy release areas to release certain species or trees to achieve high growth rates and large crowns, as well as promoting understory development. Heavy release is generally 15-30% of max SDI. These can involve releasing single trees, clusters, or extend over multiple acres.
    - Gaps to promote understory development. Some trees can be left in larger gaps to either grow into large diameter trees or blow down to create snags and CWD. Often wind will create gaps naturally over time or expand ones that are created.
    - Varying the baseline density target in different parts of the stand to achieve the same goals as the first three items, but to a lesser degree.
    - Retain clustered or paired dominant trees, thickets of small trees, preserving fine scale heterogeneity. These features often are often lost in thinning treatments and are prominent features in old growth stands.
    - Retain all trees of a certain species, trees above or below specific diameter targets, or trees with specific features such as broken or forked tops. While this is an imprecise tool to create variability, it is easy to implement and can be effective at creating patchy stand structure post thinning or accelerating the development of a patchy midstory, which will create a variable understory light environment in the future.

There are no set maximum or minimum levels for these items. Objectives and site specific conditions must drive prescriptions. In stands that are already high in complexity, preserving and working with existing complexity when thinning may be all that is necessary. For example, in stands with a patchy component of midstory conifers, thinning the overstory more heavily around some midstory patches, leave some skips around areas with no midstory, and thinning the rest of the stand in a relatively even fashion will promote the patchy development of multiple canopy layers and lead to a range of small-scale vegetation patch types over time (dark sparse thickets, intermediate patches with low shrubs, “parked out” patches with large trees and a lush understory, and open shrubby gaps). On the other hand, in 60-80 year old stands where marbled murrelet habitat is a major goal or where post thinning blowdown is likely, a single density target, contract language to preserve fine scale heterogeneity, and a few skips may be all that is desired. In uniform 40 year old stands where growing large trees is a major goal and a future entry is likely, 20% of the stand in skips, heavy release in 30% of the stand favoring western redcedar where it exists, and a lighter thin around the rest of the residual trees may achieve the desired results. In 15-20 year old stands, a few areas of light thinning, retaining fine scale heterogeneity, and thinning the rest of the stand to a relatively even spacing while focusing on shifting relatively species composition may be all that is needed when future entries are likely. If maintaining early-seral habitat is a landscape scale need for certain species, then creating several large gaps in young stands where canopy closure has not excluded early-seral plant communities should be considered.

- Treatment Type: Make final decisions on what treatment or combinations of treatments to use in the stand: YDL, BR, MDL, UT, etc. For BR and MDL treatments, decide whether variable density thinning, individual tree selection, or group selection should be used. A combination of treatment approaches may often be used. At the operational level, these different approaches often blend together.

- Implementation and operational prescription: The final step is this process is to translate the management of sensitive sites, species selections, logging systems, desired variability, and density targets into an operational prescription that is simple and practical enough to be understood and implemented by marking crews and/or contractors in a cost effective manner. A number of implementation approaches have been used by other agencies implanting these types of prescriptions:
    - Marking: this is the most straightforward method and the easiest to fine tune. It can be costly, however, especially in young stands with high densities.
    - Designation by Description (DxD): This is a method of designating the specific trees that will be removed without actually marking. Any person following the prescription will select the same trees. It is simple and efficient to implement and can be adjusted with species and diameter targets. However, it can be challenging to achieve the desired level and type of variability with this method and it can overly homogenize stands.
    - Designation by Prescription (DxP): Known also as "operator's choice", the contractor selects which trees are actually removed using clear guidelines and spacing or basal area targets. It offers considerable options and flexibility when designing complex prescriptions and incorporates the knowledge and experience of the contractor, which can often reduce stand damage and create efficiencies. It requires skilled operators and an experienced sale administrator who knows how to work with contractors to avoid miscommunication and get the desired results.

  The method used will depend on the stand, treatment type, prescription, management resources, and available contractors. In many cases, a combination of some marking with a DxD or DxP prescription is ideal.

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Appendix L. Predator Management Plan

Predator Management Plan
Willapa National Wildlife Refuge
Leadbetter Point Unit

2011

TABLE OF CONTENTS

L.1 Purpose and Need for Action L-3
L.1.1 Overview L-3
L.1.2 Purpose L-3
L.1.3 Background L-4
L.1.4 Relevance to Refuge Purpose and Need for Action L-5
L.1.5 Existing Snowy Plover Conservation and Predator Management Efforts L-6
L.1.6 Authority and Compliance L-6
L.1.7 Cooperators L-9
L.2 Comprehensive Predator Management Plan L-9
L.2.1 Comprehensive Predator Management Strategy L-9
L.2.2 Predator Damage Management Methods L-13
L.2.3 Direct Control of Predators—Species-Specific Protocols L-20
L.3 Literature Cited L-25

L.1 Purpose and Need for Action

L.1.1 Overview

Pursuant to its endangered species management responsibilities and in conjunction with other wildlife and habitat management activities, the U.S. Fish and Wildlife Service (Service) will implement, per available funding, a predator management program on the Willapa National Wildlife Refuge (Willapa NWR or Refuge). The species expected to directly benefit from this action is the federally threatened western snowy plover (*Charadrius alexandrinus nivosis*). The Federal candidate streaked horned lark (*Eremophila alpestris strigata*) would also benefit from these activities because they inhabit the sparsely vegetated sand beaches and dunes used by breeding plovers on the Refuge. Implementation of this program would maximize adult survival and juvenile recruitment of Western snowy plover as identified in the Western Snowy Plover Recovery Plan by reducing the threat posed by certain problem avian and mammalian predators. Predator management is identified in Objective 6.1 in Section 2.5 of the Willapa National Wildlife Refuge comprehensive conservation plan (CCP) as one of several actions to be implemented in support of listed species occurring on the Refuge.

This predator management plan has been developed as a comprehensive conservation strategy that addresses a range of management actions, from vegetation control and nesting habitat enhancement to non-lethal and lethal control, when necessary. The most effective, selective, and humane techniques available to deter or remove individual predators or species that threaten nesting, breeding, or foraging snowy plovers or horned larks will be implemented. Existing predator management plans for the conservation of plovers provided the framework for this document and form the basis for methods used in this proposed plan (USDA 2002, 2005; USFWS 2002, 2006).

A number of species recognized as potential predators of snowy plover eggs, chicks, and adults are likely target predator species under this plan. They include crows, ravens, hawks, falcons, owls, coyote, fox, weasel, and mice (Liebezeit and George 2002; Powell et al. 2002; USFWS 2002, 2007). American and northwestern crows, common raven, northern harrier, merlin, American kestrel, peregrine falcon, coyote, and mice are currently suspected to be potential predators for Western snowy plovers and streaked horned larks at the Leadbetter Point Unit of the Refuge. Elk are also implicated as having an impact on ground nesting birds at Leadbetter Point. (Refer to Objective 6.1, Section 2.5 of the Willapa National Wildlife Refuge CCP for the proposed elk management strategy.) Those wildlife species requiring management because of conflicts with the recovery of listed species could be impacted by removal of a few problem individuals. The adverse effects of predator management on the local and range-wide population of the affected predator species would be insignificant.

L.1.2 Purpose

The Willapa NWR predator management program would aid the Refuge in accomplishing the following recovery actions:

- Maintain a 5-year average population of 40 breeding pairs of Western snowy plover on the Refuge.
- Maintain a five-year average productivity of at least 1.0 fledged Western snowy plover chick per male on the Refuge.
- Fledge at least one young per Western snowy plover pair per year on the Refuge.

- Reduce the number of problem predators using the Leadbetter Point Unit. Problem predators are defined as individual wildlife of species that are known to prey on Western snowy plover and streaked horned lark and that are exhibiting hunting behavior in plover and lark nesting areas.

The predator plan is being developed to support the Refuge's CCP management objectives of recovering and maintaining stable snowy plover populations. The 2009 Washington statewide Western snowy plover nesting population as reported by Pearson et al. (2009) was 35 (95% CI = 26-44), and the 2009 Oregon nesting population was 145 (Lauten et al. 2009), for a total of 181 (CI = 171-190) nesting adult plovers in Recovery Unit 1. The Federal recovery population objective is 250 breeding adults in Recovery Unit 1. The Willapa NWR predator management program is designed to integrate with existing Refuge management efforts, including the Leadbetter Coastal Dune Habitat Restoration Project.

Developing a metapopulation model for streaked horned larks, determining the prevalence of site fidelity, and quantifying movement patterns between sites used for breeding and wintering are currently underway. These are precursors to preparing a regional streaked horned lark conservation strategy. The streaked horned lark population is currently estimated at approximately 750 birds. However, this estimate was derived from data collected from different survey efforts, using differing methods, over a period of several years (Pearson and Altman 2005). The 2004 Washington State breeding population was reported by Stinson (2005) to be 330 birds. A conservative 2009 estimate of 9 or 10 breeding pairs on the Refuge is based on available data. Pearson et al. (2008) predicted Washington's streaked horned lark population to be declining rapidly at an annual rate approaching 40 percent. Because predation is identified as a leading cause of streaked horned lark nest failure, minimizing predation will be an important component of any future conservation strategy (Altman 1999; Pearson and Altman 2005; Pearson and Hopey 2005; Pearson et al. 2008). A regional and Refuge-based conservation strategy would include criteria necessary to attain viable populations, similar to recovery actions for listed species.

L.1.3 Background

Predation is one of many mortality factors that influence wildlife populations. Predators often play critical roles in the composition and function of wildlife populations in ecosystems (Witmer et al. 1996). Normally, predation would be considered part of the function of a healthy ecosystem. However, major changes have occurred in the ecosystems of the Pacific coastal region. The effects of predation on birds can be detrimental to local populations or islands, especially when predator densities are high or when predators gain access to areas not historically occupied (Bailey 1993; Stoudt 1982). In general, ground-nesting birds suffer the highest predation rates, followed by cliff/burrow nesters. Tree nesters experience the lowest rates of depredation (DeVos and Smith 1995).

Predator removal has been conducted to increase survival of fledglings and to increase breeding populations of threatened or endangered wildlife, rare species, and species not traditionally hunted (Reynolds and Tapper 1996). Numerous studies have shown that nest predation accounts for the largest share of nest failures of neotropical migratory songbirds and contributes to low recruitment rates (Heske et al. 2001; Nelson 2001). Increased rates of nest predation are believed to be largely related to habitat fragmentation, habitat degradation, and other changes in related landscape features (Heske et al. 2001; Nelson 2001; Sovada et al. 2001). The impacts of predation vary geographically because of habitat composition and structure, and species composition of predator communities

(Nelson 2001; Sovada et al. 2001). Also, when implemented, the effectiveness of predator removal to protect these non-game species has varied due to compensatory mortality (predator species composition), predator removal strategies and methodologies used (i.e., human bias), and geographic location.

Predation by native and introduced species has been identified as a leading cause of reproductive failure for the Western snowy plover (USFWS 2007). Pearson et al. (2009) reported that predation was the primary source (58 percent) of plover nest failure in Washington in 2009. Crows and ravens are recognized as important predators of eggs and juvenile plovers and larks (Liebezeit and George 2002; Powell et al. 2002; USFWS 2002; Wilson-Jacobs and Dorsey 1985). Based on studies in Oregon between 1990 and 2000, corvids (ravens and crows) caused at least 64 plover nest failures (USDA 2002). Predation was also the most frequent cause of streaked horned lark nest failure (69 percent) in Washington at sites in south Puget Sound in 2002-2004; predation also caused 46 percent of failures at two coastal sites and one river island site in 2004 (Pearson and Hopey 2005). Liebezeit and George (2002) provide a detailed review of corvids' importance as predators. The Western Snowy Plover Recovery Plan and annual survey and population monitoring reports offer additional data on plover predation (Lauten et al. 2009; Pearson et al. 2009; USFWS 2007).

L.1.4 Relevance to Refuge Purpose and Need for Action

The USFWS mission is to conserve natural resources for future generations, the goal being to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Willapa NWR was established in 1937 to protect migrating and wintering populations of brant, waterfowl, shorebirds, and other migratory birds. The Refuge preserves a number of unique ecosystems including diverse salt marshes, rich tideflats, rain-drenched old-growth forest, and dynamic coastal dunes.

The Leadbetter Point Unit of Willapa NWR is 705 hectares (1,742 acres) or about 7.05 square kilometers (2.72 mi^2) in size. Despite the success in attracting Western snowy plovers and streaked horned larks to the Refuge's Leadbetter Point habitat restoration area, the relationship between the size of the restoration area and the number of plover nests discovered within this area suggests that plovers are not currently habitat-limited at Leadbetter Point. The number of nests within the restoration area initially increased in 2005 as the size of the area increased, but has quickly reached a peak at around 20 nests (Pearson et al. 2009) despite the continued enlargement of the restoration area. This conclusion is further emphasized by the lack of use of the State habitat restoration areas by plovers in 2008 or 2009.

By taking no actions related to predator management, mammalian and avian predators would not be harassed or specifically deterred from traveling or flying through the Refuge or entering the nesting areas. Based on previously documented losses of listed species to predation elsewhere in Oregon and California (Lauten et al. 2009; USDA 2002; USFWS 2002, 2006, 2007), it is likely that the Refuge's population of Western snowy plovers and streaked horned larks would not be able to achieve sustainability objectives for adult breeding population levels and fledging success. In addition, a dramatic reduction in nest productivity could cause snowy plovers and streaked horned larks to abandon the existing nesting areas on the Refuge. Because the Leadbetter Point site is one of only two currently active breeding sites in Washington State, a management strategy that excludes any form of predator management would place the viability of the Refuge's listed species at risk of extirpation, and would likely make it impossible to achieve the Recovery Unit and step-down, Refuge-specific objectives. After implementing predator management in Oregon, the state's plover population has experienced an increasing population trend for the first time, and unlike the years prior to predator management, fledging success has been above 1.0 chicks fledged per male for each year (Lauten et al. 2006, 2007, 2009; Pearson et al. 2009).

The management direction in the CCP includes plover predator management beyond nest exclosures that are currently being used to protect nests. If Willapa NWR implements predator management at Leadbetter Point and the plover population increases, then the restored suitable habitat at Leadbetter would likely be needed by the growing population.

L.1.5 Existing Snowy Plover Conservation and Predator Management Efforts

Existing snowy plover conservation and predator management efforts at Willapa NWR will continue or be expanded through the proposed action. The Refuge and its cooperators will continue to monitor snowy plovers to determine hatch and fledge rates as well as adult survivorship and population size. A discussion of how impacts of this plan would be monitored can be found on page L-14. See Pearson et al. (2009) for details on plover population and demographic monitoring. Current management and conservation practices also include seasonal use of nest exclosures on some snowy plover and streaked horned lark nests, spreading of oystershell in the snowy plover habitat restoration area, invasive tree and beachgrass removal in and/or adjacent to nesting areas, and installation of perching deterrents in and around known nest locations.

L.1.6 Authority and Compliance

Based on agency mission and legislative mandates, the USFWS is the "lead agency" and "decision maker" for this CCP, and is therefore responsible for the CCP's scope, content, and outcome. As cooperating agencies, the Washington Department of Fish and Wildlife (WDFW), Washington State Parks and Recreation Commission (WSPRC), and U.S. Department of Agriculture, Animal Plant Health Inspection Service-Wildlife Services (APHIS-WS) provided input to this CCP and will provide advice and recommendations to the lead agency on when, where, and how predator damage management could be conducted. APHIS-WS would be the Service's authorized agent for implementing removal actions on the Refuge.

Agency Authority for Endangered Species Management and Conservation

USFWS. The USFWS is the scientific and management authority for implementation and enforcement of the Endangered Species Act of 1973 (ESA), as amended, and for developing recovery plans for many federally listed species. The USFWS cooperated with the WDFW, APHIS-WS, and WSPRC by recommending measures to promote the recovery of threatened and endangered species. The USFWS also makes recommendations to avoid or minimize take of threatened and endangered species. The term "take" is defined by the ESA (Section 3(19)) as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct." The terms "harass" and "harm" have been further defined by USFWS regulations (50 C.F.R. Section 17.3) as (1) "harass" is the intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering; (2) "harm" is an act which actually kills or injures wildlife. Such acts may include significant habitat modification or degradation when it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering.

APHIS-WS. APHIS-WS is subject to the ESA, which requires Federal agencies to use their authorities to conserve threatened and endangered species. The primary statutory authorities for the APHIS-WS program are the Animal Damage Control Act of 1931 and the Rural Development, Agriculture, and Related Agencies Appropriations Act of 1988, which authorize APHIS-WS to reduce damage caused by wildlife, in cooperation with other agencies.

WDFW. The WDFW has the responsibility to manage all protected and classified wildlife in Washington, regardless of the land class on which the animals are found (Revised Code of Washington [RCW] 77.12.020). The Washington State Department of Agriculture (WSDA) is authorized to cooperate with APHIS-WS and WDFW for controlling predatory birds (RCW 15.04.110). Washington State law authorizes the removal or killing of wildlife that is destroying or injuring property, or when it is necessary for wildlife management or research (RCW 77.12.240). The law, however, does require the person trapping or killing the wildlife to notify WDFW immediately. The department shall dispose of wildlife so taken within three days of receiving such a notification and in a manner determined by the director to be in the best interest of the state.

Compliance with Federal Regulations

Several Federal laws regulate wildlife damage management. The USFWS and APHIS-WS comply with these laws, and consult and cooperate with other agencies as appropriate. The following Federal laws are relevant to the actions considered in the CCP for this plan:

50 C.F.R. 31.14 Official Animal Control Operations.

(a) Animal species which are surplus or detrimental to the management program of a wildlife refuge area may be taken in accordance with Federal and State laws and regulations by Federal or State personnel or by permit issued to private individuals.

(b) Animal species which are damaging or destroying Federal property within a wildlife refuge area may be taken or destroyed by Federal personnel.

50 C.F.R. 31.2 Methods of surplus wildlife population control and disposal. Upon a determination that wildlife are surplus to a balanced conservation program on any wildlife refuge area, the surplus may be reduced or utilized in accordance with Federal and State law and regulation by:

(a) Donation or loan to public agencies and institutions.
(b) Sale to public or private agencies and institutions.
(c) Commercial harvest of fishery resources.
(d) Official wildlife control operations.
(e) Public hunting or fishing.
(f) Trapping.

42 U.S.C. 4321-4347 National Environmental Policy Act (NEPA). Environmental documents pursuant to NEPA must be completed before actions can be implemented. NEPA requires that Federal actions be evaluated for environmental impacts, that these impacts be considered by the decision maker(s) prior to implementation, and that the public be informed. This EIS has been prepared in compliance with NEPA (42 U.S.C. Section 4231, et seq.); the Council on Environmental Quality Regulations (40 C.F.R. Section 1500-1508); Department of the Interior regulations (43

C.F.R. 46); and Fish and Wildlife Service NEPA procedures found in the Departmental Manual (DM) (516 DM 8).

16 U.S.C. 1531-1544 Endangered Species Act (ESA). It is Federal policy, under the ESA, that all Federal agencies shall seek to conserve endangered and threatened species and shall use their authorities in furtherance of the purposes of the ESA (Section 2(c)). Section 7 consultations with the USFWS are conducted to use the expertise of the USFWS to ensure that "any action authorized, funded, or carried out by such an agency … is not likely to jeopardize the continued existence of any endangered or threatened species. Each agency shall use the best scientific and commercial data available" (Section 7(a)(2)). The USFWS will complete consultation pursuant to Section 7 of the ESA regarding the effects of predator damage management on the Pacific coast population of the Western snowy plover and other federally listed species in the area.

7 U.S.C. 136-136y Federal Environmental Pesticide Control Act of 1972 (FIFRA). FIFRA requires the registration, classification, and regulation of all pesticides used in the United States. The Environmental Protection Agency (EPA) is responsible for implementing and enforcing FIFRA. All chemical methods integrated into any selected program as implemented by APHIS-WS or other cooperating agencies must be registered with and regulated by the EPA and the Oregon Department of Agriculture, and used in compliance with labeling procedures and requirements.

16 U.S.C. 703-712 Migratory Bird Treaty Act (MBTA). The Migratory Bird Treaty Act provides the USFWS with regulatory authority to protect species of birds that migrate outside the United States. Individuals of these species that do not migrate outside of the United States are also protected. All cooperating agencies coordinate with the USFWS on migratory bird issues. If migratory birds are found to be preying on plovers, the agencies would request a permit from USFWS under the MBTA to "take" these species, if lethal control is determined to be necessary. A depredation permit for crows "when found committing or about to commit depredations upon ornamental or shade trees, agricultural crops, livestock, or wildlife, or when concentrated in a manner as to constitute a health hazard" is not required (50 C.F.R. 21.43). The USFWS Office of Migratory Bird Management, Pacific Regional Office, requires notification prior to use of chemical substances for control of migratory birds that are not covered by the depredation order.

7 U.S.C. 426-426c Animal Damage Control Act and the Rural Development, Agriculture, and Related Agencies Appropriations Act. The Acts authorize and direct APHIS-WS to reduce damage caused by wildlife in cooperation with other agencies.

16 U.S.C. 1451-1464 Coastal Zone Management Act of 1972. All federally conducted or supported activities directly affecting the coastal zone must be undertaken in a manner consistent to the maximum extent practicable with approved State coastal management programs.

EO 13045 Protection of Children from Environmental Health and Safety Risks. Children may suffer disproportionately from environmental health and safety risks for many reasons. Predator damage management as proposed in this CCP would only involve legally available and approved damage management methods in situations or under circumstances where it is highly unlikely that children would be adversely affected. Therefore, implementation of the proposed action would not increase environmental health or safety risks to children.

EO 13112 Invasive Species. The Invasive Species Executive Order directs Federal agencies to use their programs and authorities to prevent the spread or to control populations of invasive species that cause economic or environmental harm, or harm to human health.

EO 13186 Migratory Birds. Executive Order 13186 directs Federal agencies to use their programs and authorities to enter into a Memorandum of Understanding with the USFWS outlining how the agency will promote conservation of migratory birds. Other activities called for include incorporating bird conservation considerations into agency planning, including NEPA analyses, reporting annually on the level of take of migratory birds, and generally promoting the conservation of migratory birds without compromising the agency mission.

Relevant Washington State Regulations

RCW 77.12.240 Authority to take wildlife—Disposition. Authorizes the removal or killing of wildlife that is destroying or injuring property, or when it is necessary for wildlife management or research.

RCW 15.04.110 Control of predatory birds. The director of the State Department of Agriculture may control birds which he determines to be injurious to agriculture, and for this purpose enter into written agreements with the Federal and State governments, political subdivisions and agencies of such governments, political subdivisions and agencies of this state, including counties, municipal corporations and associations, and individuals, when such cooperation will implement the control of predatory birds injurious to agriculture.

L.1.7 Cooperators

The proposed predator management plan will be implemented in cooperation with the following agencies:

- Washington Department of Fish and Wildlife
- Washington State Parks and Recreation Commission
- U.S. Department of Agriculture, Animal Plant Health Inspection Service-Wildlife Services

L.2 Comprehensive Predator Management Plan

L.2.1 Comprehensive Predator Management Strategy

This plan will implement integrated predator management strategies on Western snowy plover and streaked horned lark nesting habitats of the Willapa NWR. Before implementing control actions, the initial step involves identifying individuals or groups of snowy plover and streaked horned lark predators. After identification, the most effective, selective, and humane tools available would be used to deter or remove the species that impact nesting, breeding, or foraging adult and young snowy plovers and streaked horned larks within breeding areas. When plover and lark numbers increase and their populations stabilize, native wildlife would be allowed a more natural interaction with the local species of concern and active predator management would be de-emphasized.

Predator management is based on interagency relationships, which require close coordination and cooperation because of overlapping authorities and legal mandates. The Refuge, in consultation with

WDFW, may request that APHIS-WS conduct direct predator management actions to protect the snowy plovers. The Refuge may also take action itself. Under the predator management plan, the Refuge and its cooperators will continue to monitor snowy plovers to determine hatch and fledge rates as well as adult survivorship and population size. In addition, avian predators on the Refuge and adjacent lands will be monitored; information recorded will include species observed and their behavior and habits.

Based on monitoring to identify specific predators impacting nesting birds, agency personnel will evaluate the feasibility of particular strategies and methods to reach the desired goal in the context of their availability (legal and administrative) and suitability based on biological, economic, and social considerations. Following this evaluation, the methods deemed to be practical, effective, and most humane for the situation based upon professional judgment will form the basis of a management strategy. Monitoring will continue during and after the management strategy has been implemented; monitoring is conducted to assess the effectiveness of the strategy and to determine reproductive success. Records will be kept and data reported to the appropriate wildlife management agencies. This proposal would implement safe and practical methods for the prevention and control of damage caused by predators, based on local problem analysis, environmental and social factors, and the informed judgment of trained personnel.

An effective program requires that site-specific consideration of the many variables listed above be given to allow the wildlife specialist to select and implement the most appropriate technique to resolve each unique damage situation. Flexibility in the management approach is important because of the high variability found in the natural environment. An adaptive management approach will be used by the Refuge in implementing and refining this plan. In order to determine when to initiate as well as select management techniques for specific damage situations, consideration would be given to:

- **Western Snowy Plover:** Achieving breeding population (40 breeding pairs of snowy plover) of adults and production of chicks (greater than 1 chick/adult male) as identified in Western Snowy Plover Recovery Plan (see Objective 2.4.6.1 in the CCP).
  Streaked Horned Lark: A Refuge-specific population objective is being developed by streaked horned lark working group.
- Geographic extent of threat
- Time of year
- Life cycle of the snowy plover or streaked horned lark
- Vulnerability to each predator species
- Other land uses (such as proximity to recreational areas)
- Feasibility of implementation of the various techniques
- Movement patterns and life cycle of the predator
- Status of target and non-target species (such as protected or endangered)
- Local environmental conditions such as terrain, vegetation, and weather
- Presence of Refuge visitors and Refuge staff
- Presence of trash that could attract predators
- Potential legal restrictions such as availability of tools or management methods
- Humaneness of the available options[1]

[1] The lead and cooperating agencies regard humane methods of predator damage management (including the use of lethal methods where allowed) to be those that cause the least pain, suffering, or injury to individual animals under

- Cost of control options (the cost of control in this proposal may be a secondary concern because of overriding environmental and legal considerations)

Visual and auditory repellants are limited by several factors, including (1) unintentional hazing of protected species while attempting to haze predatory species; (2) reduced effectiveness over time as some predatory species become accustomed to particular stimuli and begin to ignore them; (3) difficulties in effectively deploying such repellents in the field; and (4) limited effectiveness of repellents on particular species. Predator management priorities will take the following general approach:

1) Non-native and feral species before native species
2) Target offending individuals before predator species as a group
3) Target family groups (e.g., corvids)
4) Primary concern is addressing nest predation for increased hatch rates; predation of chicks is second in importance to increasing fledge rates, and minimizing predation on plover adults is the third priority

Although typically adult survival is one of the most important demographic parameters to consider, adult predation is not currently thought to be a significant factor at Leadbetter Point. Upon positive determination of the predator species that threaten plovers in each case, the following tools would be available:

Non-lethal Control: Non-lethal control of predators involves implementing measures such as visual and auditory repellents and physical barriers. Increased or improved trash management to reduce the amount of available garbage is another form of non-lethal control. Current management and conservation practices at Willapa NWR include seasonal use of nest exclosures on some snowy plover and streaked horned lark nests, spreading of oystershell in the snowy plover habitat restoration area, and invasive tree removal adjacent to nesting areas. An inventory and mapping project of perching and nesting structures will be completed for the Leadbetter Unit of the Refuge. Complete removal of nonessential structures will be implemented to minimize perches available to avian predators in and adjacent to nesting habitat. Installation of perching deterrents will be undertaken on all necessary structures in and around known nest locations. Beachgrass removal to improve plover habitat on the Refuge and increase the area available for nesting habitat should reduce predation pressure over time. Habitat restoration actions are discussed under Objectives 4.1 and 4.2 in Chapter 2 of the CCP.

Predator management tools could include any or all of the following depending upon the circumstances: nest or decoy trapping; relocation of live trapped animals; aversive methods that deter, harass, or condition the behaviors of predators such as foul-tasting eggs, pyrotechnics, electronic calls, repellants, or effigies; or electrified or non-electrified exclusionary nest site fencing and electric wired perches.

Use of physical barriers would be implemented, which should reduce the need for control of some mammals including feral dogs and cats and domestic, free-roaming pets. Increased enforcement of pet violations on Refuge lands will also reduce some disturbance. However, physical barriers in the absence of the ability to remove a predator are ineffective in controlling avian predation, as well as

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the circumstances. Predator damage management would be accomplished only to the extent necessary to meet defined objectives, such as, aiding plover recovery by reducing predation.

some mammalian predation. The use of exclosures over nesting plovers has been effective in protecting eggs, but once the chicks leave the exclosure, they are once again vulnerable to predation. Although predation could be reduced to some extent through indirect control, the potential for loss, particularly from avian predators would remain high; therefore, this form of control alone is not considered adequate to achieve the goals and objectives of the Refuge for listed species.

Predator management that relies on the control of all predators using only non-lethal methods would not be adequate and could result in devastating impacts on the Refuge's snowy plover and streaked horned lark populations. This is particularly true in situations in which an avian predator learns to prey on the eggs or young of a listed species. Past experience elsewhere has demonstrated that once an individual predator successfully begins to forage within a nesting colony, significant losses to the colony can occur before the individual is successfully trapped or otherwise discouraged from returning to the colony. In the case of predation of breeding adults, the losses have an even greater effect on productivity because losses of breeding adults can have adverse effects on populations for several generations. Without the option to implement lethal control when deemed necessary to protect listed species, it may not be possible to support the recovery plan and achieve the Refuge goals and objectives for the protection of endangered and threatened species.

Lethal Control: Lethal control could include any or all of the following depending upon field circumstances: shooting; euthanasia in conjunction with cage traps; padded-jaw leg-hold traps; nets; snares; gas cartridges; DRC-1339 (avicide); nest removal and egg destruction; snap traps; or zinc phosphide bait (rodenticide).

Service employees or their authorized agents could use mechanical/physical methods (including trapping) to control pests as a Refuge management activity. Based on 50 C.F.R. 31.2, trapping can be used on a refuge to reduce surplus wildlife populations for a "balanced conservation program" in accordance with Federal or State laws and regulations. In some cases, non-lethally trapped animals would be relocated to off-Refuge sites with prior approval from the State. A pest control proposal (see 7 RM 14.7A-D for required elements) is needed before initiation of trapping activities, except for those operations identified in 7 RM 14.7E. In addition, a separate pest control proposal is not necessary if the required information can be incorporated into an environmental impact statement (or other appropriate NEPA document).

Targeted animals that are live-trapped are euthanized by lethal injection (sodium phenobarbital), shot, or gassed using carbon monoxide or carbon dioxide gas. It is not likely that all methods will be used because site conditions would render some tools more appropriate than others. APHIS-WS and Refuge personnel can pre-determine what method or combination of methods is most practical and effective for each unique situation using the APHIS-WS Decision Model.

Monitoring: Since 2006, the Refuge and WDFW have completed intensive surveys for snowy plovers at nesting areas on the Long Beach Peninsula. The Refuge in coordination with the cooperating agencies will monitor any program that results from the CCP and report those results annually. Direct observation and still or video photography will be employed as methods to obtain information about the particular species of potential predators. Data on evidence or sign of potential predators adjacent to nesting areas will also be collected.

The impacts discussed in this plan will be monitored and used in two ways:

(1) Determine if any additional information that arises subsequent to the NEPA decision would trigger the need for additional NEPA analysis compliance or possibly trigger other compliance requirements. The lead agency would review program results annually, or as needed, to ensure that the need for action, issues identified, alternatives, regulatory framework, and environmental consequences are consistent with the CCP.

(2) If work plans need modification based on the findings of the program's effects on plover or other environmental issues, APHIS-WS, in coordination with the Refuge and WDFW, would monitor impacts on target predator populations through its Management Information System (MIS) database when APHIS-WS is involved in direct damage management. The MIS information would be used to assess the localized and cumulative impacts of the program on predator populations. Monitoring the effectiveness of the actions would be done by the Refuge in coordination with WDFW and APHIS-WS to determine if the program is benefitting plovers or if changes are needed. The Refuge would use the results of monitoring to develop site-specific work plans (annually or as needed) for the Leadbetter Point plover sites, in cooperation with WDFW and APHIS-WS.

L.2.2 Predator Damage Management Methods

A variety of methods are used by APHIS-WS personnel in predator damage management. APHIS-WS employs three general strategies to reduce wildlife damage: resource management, physical exclusion, and wildlife management. Each of these approaches is a general strategy or recommendation for addressing predator damage situations. Most predator damage management methods have recognized strengths and weaknesses relative to each damage situation. APHIS-WS personnel can determine for each unique situation what method or combination of methods is most appropriate and effective using the WS Decision Model (Slate et al. 1992).

All predator damage management methods have limitations that are defined by the circumstances associated with individual wildlife damage problems. APHIS-WS considers a wide range of limitations as they apply the decision-making process to determine what method(s) to use to resolve each damage problem (USDA 1997). Examples of limitations that must be considered and criteria to evaluate various methods are presented in USDA (1997) and in the following discussion.

Resource Management. Resource management includes a variety of practices that may be used by resource managers or owners to reduce the potential for predator damage. Implementation of these practices is appropriate when the potential for or actual damage can be reduced without significantly increasing a resource manager owner's costs or diminishing a person's ability to manage resources pursuant to their goals.

Habitat Management. Just as habitat management is an integral part of other wildlife management programs, it also plays an important role in predator damage management. The type, quality, and quantity of habitats are directly related to the animals attracted to an area and what the habitat can support. Therefore, habitat can be managed so that it does not produce or attract certain species or it repels them. Limitations of habitat management as a method of controlling wildlife damage are determined by the characteristics of the species involved, the nature of the damage, economic feasibility, and other factors.

Physical Exclusion. Physical exclusion methods restrict the access of wildlife to resources. Nest exclosures are used to protect nesting plovers from predation. The exclosures must encompass the sides and top of the structure, and be buried into the sand to help prevent burrowing, climbing, and flying predators from entering the exclosures. These methods provide a means of appropriate and effective prevention of damage in some situations.

Wildlife Management. Reducing wildlife damage is achieved with many different techniques. The objective of this approach is to alter the behavior or population of the target animal, thereby eliminating or reducing the potential for loss or damage.

Frightening Devices. Frightening devices include distress calls, pyrotechnics, propane cannons, flags, and reflective tape. The success of frightening methods depends on the animal's fear of and subsequent aversion to the stimuli. Once animals become habituated to a stimulus, they often resume their damaging activities. Persistent efforts are usually required to consistently apply frightening techniques and to vary them sufficiently to prolong their effectiveness. In many situations, animals frightened from one location become a problem at another. Some frightening devices may have negative effects on non-target wildlife, including threatened and endangered species. Frightening devices will probably have severe limitations in protecting plovers since they may affect plovers as much as the target species. The use of some frightening devices and techniques in urban and suburban environments may be considered aesthetically displeasing, such as netting over trees, or a nuisance by some persons, such as the noise from propane cannons. The continued success of these methods frequently requires reinforcement by limited shooting (see Shooting).

Pyrotechnics. Pyrotechnics consist of a variety of noise-making devices in the form of fireworks. Double shotgun shells, known as shell-crackers or scare cartridges, are 12-gauge shotgun shells containing a fire cracker that is projected up to 75 yards before exploding. Noise bombs, whistle bombs, racket bombs, and rocket bombs are fired from 15-millimeter flare pistols. They are used similarly to shell-crackers, but are projected for shorter distances. Noise bombs (also called bird bombs) are firecrackers that travel about 75 feet before exploding. Whistle bombs are similar to noise bombs, but whistle in flight and do not explode. They produce a noticeable response because of the trail of smoke and fire, as well as the whistling sound. Racket bombs make a screaming noise in flight and do not explode. Rocket bombs are similar to noise bombs but may travel up to 150 yards before exploding. These pyrotechnics are often used to frighten birds away from crops, roosting locations, or runways. The shells are fired so that they explode in front of, or underneath, flocks of birds attempting to enter crop fields, roosts, or the air operating area at an airport. The purpose is to produce an explosion between the birds and their objective. Birds already in a crop field or at an airport can be frightened away, but it is extremely difficult to disperse birds that have already settled in a roost.

A variety of other pyrotechnic devices, including firecrackers, rockets, and Roman candles, are used for dispersing animals. The discharge of pyrotechnics may be inappropriate and prohibited in some area such as urban and suburban communities. Pyrotechnic projectiles can start fires, ricochet off buildings, pose traffic hazards, cause some dogs to bark incessantly, and injure and annoy people. Pyrotechnics may cause fear or alarm in urban areas as the sound of discharge sometimes resembles gunfire.

Propane Exploders. Propane exploders operate on propane gas and are designed to produce loud explosions at controlled intervals. They are strategically located (elevated above the vegetation, if possible, and hidden) in areas of high wildlife use to frighten wildlife from the problem site. Because animals are known to habituate to sounds, exploders must be moved frequently and used in conjunction with other scare devices or reinforced with lethal methods. Exploders can be left in an area after dispersal is complete to discourage animals from returning. However, propane exploders are generally inappropriate for use in urban areas due to the repeated loud explosions, which many people consider an unacceptable nuisance.

Scarecrows or Effigies. Since personnel are often limited, the use of scarecrows can be effective when people are not present at a field. The human effigy is still one of the best scarecrows available. These work best with eyes on both sides of the head and dressed in clothes similar to those worn by people that are harassing the birds. Other scarecrows are available such as “scare-eye” balloons. As with other techniques, scarecrows work best when the number is varied, a variety of scarecrows are used, and they are moved often.

Flagging. Flags may have limited effectiveness in frightening birds. Anecdotal reports indicate black flagging may be effective at repelling some birds.

Bioacoustics. Distress and alarm calls of various animals have been used singly and in conjunction with other scarring devices to successfully scare or harass animals. Many of these sounds are available on records and tapes. Calls should be played back to the animals from either fixed or mobile equipment in the immediate or surrounding area of the problem. Animals react differently to distress calls; their use depends on the species and the problem. Calls may be played for short (few second) bursts, for longer periods, or even continually, depending on the severity of damage and relative effectiveness of different treatments or “playing” times.

Chemical Repellents. Chemical repellents are compounds that prevent the consumption of food items or use of an area. They operate by producing an undesirable taste, odor, feel, or behavior pattern. Effective and practical chemical repellents should be nonhazardous to wildlife; nontoxic to plants, seeds, and humans; resistant to weathering; easily applied; reasonably priced; and capable of providing good repellent qualities. The reaction of different animals to a single chemical formulation varies, and for any species there may be variations in repellency between different habitat types. Development of chemical repellents is expensive and cost prohibitive in many situations. Chemical repellents are strictly regulated, and suitable repellents are not available for many wildlife species or wildlife damage situations. Naphthalene (moth balls) has proven to be ineffective as a bird repellent (Dolbeer et al. 1988).

Aversive Agents. Methiocarb, active ingredient in Mesurol, can be useful as an aversive conditioning agent, used in eggs, in reducing raven predation of colonial waterbirds (Avery et al. 1995). Mesurol is an aversive conditioning egg treatment registered with the EPA to reduce predation on the eggs of protected, threatened, or endangered species. Mesurol is only available for use under APHIS-WS program supervision. After pre-baiting, a limited number of treated eggs would be distributed within the nesting colony. To reduce risk to humans, non-target animals, and pets, a blind would be established during treated egg-baiting periods so treated egg sites can be observed. In addition, eggs would be wired to the ground so they cannot be removed from the site, and thus would be consumed on-site. Treated eggs would be removed from bait sites when the observer is not present. When used according to label directions, methiocarb will not pose unreasonable risks or adverse effects to humans or the environment (USEPA 1994, see product label).

Relocation. Most damaging species are common and numerous throughout Washington, so they are rarely, if ever, relocated because habitats in other areas are generally already occupied. Relocation of damaging species to other areas following live capture generally would not be biologically sound, effective, or cost-effective. Relocation of wildlife often involves stress to the relocated animal, poor survival rates, and difficulties in adapting to new locations or habitats. Relocation of target predator animals of breeding Western snowy plovers and streaked horned larks is usually not recommended according to State wildlife policy

Lethal Control Methods

Chemical Immobilizing and Euthanizing Agents. Most APHIS-WS specialists in Washington are trained and certified to use drugs for capturing or euthanizing wildlife. Drugs such as sodium phenobarbital derivatives are used for euthanasia. Most drugs (an exception is alpha-chloralose) fall under restricted-use categories and must be used under the appropriate license from the U.S. Department of Justice, Drug Enforcement Agency. The drugs used by APHIS-WS are approved by a Drug Committee panel.

Euthanasia. Captured animals may be euthanized. The euthanasia method used is dependent on whether the animal is going to be processed for human consumption. Animals that are not going to be consumed can be euthanized with a sodium phenobarbital solution such as Beuthanasia-D® or other appropriate method such as cervical dislocation, decapitation, a shot to the brain, or asphyxiation. Carbon dioxide (CO_2) is sometimes used to euthanize animals that are captured in live traps and when relocation is not a feasible option.

Leg-hold Traps. These are used to capture animals such as coyotes, bobcats, fox, mink, raccoon, and skunk. These traps are the most effective, versatile, and widely used tool available to APHIS-WS for capturing many species. Traps placed in the travel lanes of the target animal, using location rather than attractants, are known as “blind sets.” More frequently, traps are placed as “baited” or “scented” sets. These trap sets use an attractant consisting of the animal’s preferred food or some other lure such as fetid meat, urine, or musk to attract the animal into the trap.

In some situations, a carcass or large piece of meat (i.e., a draw station) may be used to attract target animals to an area where traps are set. In this approach, single or multiple trap sets are placed at least 30 feet from the draw station. APHIS-WS program policy prohibits placement of traps or snares within 30 feet of a draw station to prevent the capture of non-target scavenging birds. There are only two exceptions to this policy. One is when setting leg-hold traps to capture cougars returning to a kill. In these cases the weight of the target animal allows pan-tension adjustments that preclude the taking of small, non-target animals. The second exception is when leg-hold traps are set next to carcasses used to capture raptors under permit with the USFWS.

Two primary advantages of the leg-hold trap are that they can be set under a wide variety of conditions, and that pan-tension devices can be used to prevent smaller animals from springing the trap, thus allowing a degree of selectivity not available with many other methods. Effective trap placement by trained personnel greatly contributes to the leg-hold trap’s selectivity. Another advantage of leg-hold traps is that the live-capture of animals permits release if warranted.

Disadvantages of using leg-hold traps include the difficulty of keeping them in operation during rain, snow, or freezing weather. In addition, they lack selectivity where non-target species are of similar size to target species and are abundant. The selectivity of leg-hold traps is an important issue and has been shown to be a function of how they are used. The type of set and attractant used significantly influences both capture efficiency and the risk of catching non-target animals. The use of leg-hold traps in the APHIS-WS program is costly due to the amount of manpower and time involved; however, the technique is indispensable in selectively resolving many animal damage situations. APHIS-WS program guidelines require warning signs to be posted in the vicinity of control operations. Placement is generally confined to areas not visible to or frequently visited by the public. APHIS-WS personnel are the most vulnerable to hazard exposures (USDA 1997).

Snares. Snares made of cable are among the oldest existing wildlife damage management tools. Snares can be used to catch most species. They are used wherever a target animal moves through a restricted lane of travel (i.e., "crawls" under fences, trails through vegetation, den entrances, and so on). When an animal moves forward into the snare loop, the noose tightens and the animal is held. Snares offer the advantage of being much lighter than leg-hold traps and are not as affected by inclement weather.

Snares can be set as either lethal or live-capture devices. Snares set to capture an animal around the neck can be a lethal use of the device, whereas snares positioned to capture the animal around the body or leg can be a live-capture method. Careful attention to details in placement of snares and the use of slide stops can also allow for the live capture of neck-snared animals.

The catch pole snare is used to capture or handle problem animals. Catch poles are primarily used to remove live animals from traps without injury to the animal or danger to the APHIS-WS Specialist. Human safety hazards associated with snares are similar to leg-hold traps. Risks are minimized by limiting or avoiding use where the public may be exposed, and by program guidelines that require warning signs to be posted in the vicinity of control operations (USDA 1997).

Cage Traps. Cage traps are frequently used to capture skunks, raccoons, cougars, and black bears. Cage traps can also be used to capture coyote pups, fox, and dogs. Cage traps capture the animal by mechanical closure of the entry way via the animal's actuation of a triggering device. Cage traps commonly used or recommended by APHIS-WS to capture skunks and raccoons are drop-door wire box traps. Live traps are generally baited with food items as attractants.

The use of cage traps allows the release of captured non-target animals or target animals that are to be relocated. Cage traps are frequently recommended to private individuals for capturing skunks and raccoons or used operationally by APHIS-WS personnel in situations where other methods may not be as safe. These devices pose minimal risk to the humans, pets, or non-target animals, and are easily monitored and maintained. Some animals fight to escape from cage traps and become injured. However, live traps, as applied and used by APHIS-WS pose no danger to pets or the public and if a pet is accidentally captured in such traps, it can be released unharmed.

Shooting Birds. Shooting is more effective as a dispersal technique than as a way to reduce bird densities when large numbers of birds are present. Shooting is a very individual-specific method and is normally used to remove a single offending bird. Shooting to supplement harassment typically enhances the effectiveness of harassment techniques and can help prevent bird habituation to hazing methods (Kadlec 1968). In situations where the feeding instinct is strong, most birds quickly adapt to scaring and harassment efforts unless the control program is periodically supplemented by shooting.

Shooting can be relatively expensive because of the staff hours sometimes required (USDA 1997). It is selective for target species and may be used in conjunction with decoys and calling. Shooting with shotguns, air rifles, or rim and center fire rifles is sometimes used to manage bird damage when lethal methods are determined to be appropriate. The birds are killed as quickly and humanely as possible. APHIS-WS personnel follow all firearm safety precautions when conducting bird damage management and comply with all laws and regulations governing firearms use. (Also see "Shooting Mammals" for human safety considerations.)

Firearm use is very sensitive and a public concern from general safety issues relating to misuse. To ensure safe use and awareness, APHIS-WS employees who use firearms to conduct official duties are required to attend an approved firearms safety and use training program within three months of their appointment and a refresher course every three years afterwards (WS Directive 2.615). WS employees who carry firearms as a condition of employment are required to sign a form certifying that they meet the criteria as stated in the *Lautenberg Amendment*, which prohibits firearm possession by anyone who has been convicted of a misdemeanor crime of domestic violence.

Shooting Mammals. Shooting is selective for the target species but is relatively expensive due to the staff hours required. Shooting is, nevertheless, an essential wildlife damage management method. Removal of one or two problem animals can quickly stop extensive damage. Predator calling is an integral part of ground hunting. Even difficult-to-catch, trap-wise predators are vulnerable to calling. Shooting can be selective for offending individuals and has the advantage that it can be applied in specific damage situations.

The primary human health and safety hazard associated with shooting is related to firearm handling by the user, making APHIS-WS personnel the most vulnerable. Human health and safety risks are minimized by program safety practices that include extensive training and experience in safe and effective firearms use; frequent employee evaluations; and use of firearms only at safe distances from human habitations or other activities, and in safe directions only (USDA 1997).

Egg, Nest, and Hatchling Removal and Destruction. Egg and nest destruction is used mainly to reduce or limit the growth of a nesting population in a specific area through limiting reproduction of offspring or removal of nest to other locations. Egg and nest destruction is practiced by manual removal of the eggs or nest. This method is practical only during a relatively short time interval and requires skill to properly identify the eggs and hatchlings of target species.

Chemical Toxicants. All chemicals used by APHIS-WS are registered under FIFRA (administered by EPA and WSDA) or by the Food and Drug Administration. APHIS-WS personnel that use chemical methods are certified as pesticide applicators by WSDA and are required to adhere to all certification requirements set forth in FIFRA and Washington pesticide regulations. Chemicals are only used on private, public, or tribal property sites with authorization from the property owner or manager.

Denning. Denning is the practice of seeking out the dens of depredating coyotes or red fox and eliminating the young, adults, or both to stop ongoing predation or prevent further depredations. The usefulness of denning as a damage management method is proven; however, since locating dens is difficult and time consuming, and den usage is restricted to about two to three months of the year, its use is limited to specific, appropriate situations that must be determined by a specialist.

Coyote and red fox depredations often increase in the spring and early summer due to the increased food requirements of rearing and feeding young. Removal of pups will often stop depredations even when the adults are not removed. When the adults are removed and the den site is known, the pups are killed to prevent their starvation. The pups are euthanized in the den with a registered fumigant. Denning is highly selective for the target species responsible for damage. Den hunting for adult coyotes and fox is often combined with other activities (such as calling and shooting)

Den fumigants, also called gas cartridges, are fumigants or gases used to manage wildlife. They are highly effective but are expensive and labor-intensive to use. In the APHIS-WS program, fumigants are only used in predator dens. The APHIS-WS program manufactures and uses den cartridges specifically formulated for this purpose. These cartridges are hand placed in the active den, and the entrance is tightly sealed with soil. The burning cartridge causes death from a combination of oxygen depletion and carbon monoxide poisoning.

DRC-1339. DRC-1339 is a slow acting avicide that is registered with the EPA for use on a number of species (e.g., ravens, crows, pigeons, gulls, blackbirds, and starlings), and on various bait carriers, such as grain, meat baits, sandwich bread, and cull French fries. DRC-1339 is only available for use under APHIS-WS program supervision. Under project conditions, DRC-1339 is available for authorized for use on corvids and gulls (see product label). DRC-1339 was marketed as an avicide because of its differential toxicity to mammals. DRC-1339 is highly toxic to sensitive species but only slightly toxic to non-sensitive birds, predatory birds, and mammals. Most bird species that are responsible for damage, including starlings, blackbirds, pigeons, crows, magpies, and ravens are highly sensitive to DRC-1339. Many other bird species such as raptors, sparrows, and eagles are classified as non-sensitive. Numerous studies show that DRC-1339 poses minimal risk of primary poisoning to non-target and threatened and endangered species (USDA 1997). Secondary poisoning has not been observed with DRC-1339–treated baits. This can be attributed to relatively low toxicity to species that might scavenge on birds killed by DRC-1339 and its tendency to be almost completely metabolized in the target birds, which leaves little residue to be ingested by scavengers. Secondary hazards of DRC-1339 are almost non-existent. DRC-1339 acts in a humane manner, producing a quiet and apparently painless death.

DRC-1339 is unstable in the environment and degrades rapidly when exposed to sunlight, heat, or ultraviolet radiation. DRC-1339 is highly soluble in water but does not hydrolyze, and degradation occurs rapidly in water. DRC-1339 tightly binds to soil and has low mobility. The half-life is about 25 hours, which means it is nearly 100 percent broken down within a week, and identified metabolites (i.e., degradation chemicals) have low toxicity. Aquatic and invertebrate toxicity is low (USDA 1997). USDA (1997) contains a thorough discussion and risk assessment of DRC-1339. That assessment concluded that no adverse effects are expected from use of DRC-1339.

Zinc Phosphide. Zinc phosphide pellets (2%) may be used only by certified applicators, or persons under their direct supervision, for Norway rats, roof rats, and house mice (see product label). In the project area, the bait must be placed in tamper-resistant bait stations or in burrows because non-target hazards exist to any granivorous birds or mammals that occur in areas where zinc phosphide grain bait is applied (USDA 1997). The Aleutian Canada goose would potentially be affected by zinc phosphide if allowed to consume treated grains. Zinc phosphide poses little secondary risk to non-target wildlife since it breaks down rapidly in the digestive tract of affected animals. Domestic dogs and cats are more susceptible than other animals (USDA 1997).

L.2.3 Direct Control of Predators—Species-Specific Protocols

The direct control of predators has historically been implemented by APHIS-WS through an interagency agreement with the Service. It is likely that this arrangement would continue in the future, provided funds are available. Contracts would be issued annually and would include detailed descriptions of approved control methods, disposition procedures for captured predators, and species-specific protocols. Predator management would be implemented year-round, although the majority of the contracted activities would occur during the snowy plover breeding season. During the non-breeding season for endangered species, APHIS-WS may be contracted to control feral dogs and cats and mammalian predators such as skunks and opossums.

Corvids. The Corvidae family is composed of over 100 species of birds including crows and ravens. Corvids are widespread across North America and are found on all continents, except Antarctica. Prior to European colonization of North America, corvids likely occurred at lower densities than found in many areas today. The ability of crows and ravens to adapt and thrive in human-altered landscapes, both rural and urban/suburban, has led to dramatic increases in range and population sizes in western North America, including California (Johnston 2001; Liebezeit and George 2002; Marzluff et al. 2001; USFWS 2007). Because they are effective predators on the nests and young of some threatened and endangered species, including snowy plovers, there is concern among management agencies that increases in corvid populations are having negative impacts on populations of some listed species (Liebezeit and George 2002). Liebezeit and George (2002) provide detailed review of corvid life history, ecology, and importance as predators.

The American crow (*Corvus brachyrhynchos*), northwestern crow (*Corvus caurinus*), and common raven (*Corvus corax*) are land birds recognized as potential predators of eggs and juvenile plovers and larks (Liebezeit and George 2002; Powell et al. 2002; USFWS 2002; Wilson-Jacobs and Dorsey 1985). All three species are currently suspected to be potential predation risks at Leadbetter Point. Some corvids use the lodgepole pine (*Pinus contorta*) forests at Leadbetter Point for resting, foraging, and nesting.

Specific local population data for corvids are currently unavailable. An initial step in the predator management plan will be implementation of a monitoring program to ensure that any impacts to corvid populations and their behaviors and use patterns can be assessed more precisely. The Refuge monitoring program would also reveal more information on the extent of threats that corvids pose to plovers and larks at Leadbetter Point. Under the proposed predator management strategy, any individual corvid could be controlled when it poses a threat to endangered species, as determined by the Refuge Manager, Refuge Biologist, or a qualified predator control contractor (e.g., APHIS-WS) as needed to protect the breeding population and production (see Section L.1.2). Any actions affecting corvids would only occur after consulting with the Refuge Manager and the Refuge Biologist. Individuals of those species requiring management because of conflicts with endangered species could be lethally removal. The overall adverse effects of control actions on corvid species would be temporary and localized in nature. Specifically, the small number of individual problem corvids that would potentially be removed by this project each year would not significantly impact their local or range-wide populations. Other species such as the savanna sparrow (*Passerculus sandwichensis*) and several shorebird species such as the killdeer (*Charadrius vociferous*) would also benefit from reduce predation pressure.

Control of a problem raven or crow exhibiting hunting behavior in and around snowy plover or streaked horned lark nesting areas on the Refuge would be authorized. The most effective, selective, and humane tools available to deter, relocate, or in very limited circumstances if necessary, lethally remove that individual would be implemented. As plover and lark numbers increase and meet breeding population and recruitment criteria, resident corvids would be allowed a more natural interaction with the local species of concern and active predator management would be de-emphasized. Translocation of corvids to other areas may negatively impact wildlife or agriculture in those areas, and thus would not be considered as a management option for corvids. Additionally, territorial vacancies created by translocation would likely be of short duration, because some translocated birds and/or birds from surrounding areas would quickly move into the vacated territory.

Lethal removal of avian predators is most often employed when an individual problem predator has focused its foraging activities on a specific nesting area. In this case, an entire colony's or community's productivity or even survival can be jeopardized in a short time frame. One such example occurred in 1997. A pair of burrowing owls was observed preying on adult and chick California least terns at the Tijuana Estuary. Refuge staff determined that live trapping was the preferred method of control because of a concern for the sensitivity of the local burrowing owl population. Over about a 12-day period (the time it took to locate and live-capture the owls), this pair of owls had taken between 70 and 80 breeding adult least terns and an unknown number of chicks. This one event resulted in the loss of approximately 18 percent of all breeding individuals in the colony during that nesting season (Patton 1998). Under this plan, selective removal of individual problem predators would be permitted for all avian predators.

Gulls. Several gull species are recognized as potential predators of snowy plover eggs (Liebezeit and George 2002; Powell et al. 2002; USFWS 2002, 2007). All occur on the Refuge; however, none are currently suspected as posing a predation risk at Leadbetter Point. Specific local population data for gulls are currently unavailable but any adverse effects of predator management on the local and range-wide population of the affected gull species would be insignificant.

An initial step in the predator management plan could include a monitoring program to ensure that any impacts on gull populations can be assessed more precisely. The Refuge monitoring program could also reveal more information on the magnitude and extent of threats that gulls pose to plovers and larks at Leadbetter Point. Under the proposed predator management plan, any individual gull could be controlled when it poses a threat to endangered species, as determined by the Refuge Manager, Refuge Biologist, or a qualified predator control contractor (e.g., USDA APHIS Wildlife Services). Actions affecting any gulls would only be taken after consulting with the Refuge Manager and the Refuge Biologist as needed to protect the breeding population and production (see Section L.1.2).

Control of any wildlife, including gull species, that are known to prey on western snowy plovers or streaked horned larks and that exhibit hunting behavior in nesting areas could be authorized. The most effective, selective, and humane tools available to deter, relocate, or in very limited circumstances if necessary, lethally remove that individual would be implemented. As plover and lark numbers increase and their populations stabilize, resident gulls would be allowed a more natural interaction with the local species of concern and active predator management would be de-emphasized.

Coyote. The coyote is one of the most widely distributed carnivores in North America. Despite more than 100 years of intensive efforts to control coyotes and reduce coyote depredation on livestock, coyotes are abundant and have expanded their range (Litvaitis and Mautz 1980). Human activities have often unintentionally benefited coyotes. For example, coyotes thrived in the Cascades, but only after their habitat was altered by clearcutting, and wolves, which were their primary competitors, were extirpated (Toweill and Anthony 1988).

The coyote's social organization revolves around the mated pair. Each pair occupies a home range that it defends against other coyotes. However, pairs often accept the presence of one or more "associates." These are nonbreeding adults that share the home range and assist in pup-rearing duties (Andelt 1985; Ryden 1989). Home range size and coyote density varies according to prey abundance, topography, and vegetative characteristics (Gese et al. 1988). Home ranges often occupy 10 to more than 40 square miles or more (Andelt and Gipson 1979; Gese et al. 1988; Litvaitis and Shaw 1980; Springer 1982), but home ranges may be considerably smaller when conditions are favorable. Gese et al. (1988) and Windberg and Knowlton (1988) reported home ranges as small as 2.59 square kilometers (1.0 mi^2). Densities may be higher than home range size would indicate (Hein and Andelt 1995). Ranges of adjacent pairs may overlap, at least at the peripheries (Litvaitis and Shaw 1980), and transient (unmated) individuals whose home ranges overlap those of mated pairs are usually present (Andelt 1985; Gese et al. 1989).

Densities and home ranges on the Refuge are unknown, but coyotes are common throughout the year. Small mammals provide an abundant, year-round prey base. The frequency with which coyotes are observed and heard by Refuge staff suggests that two or three mated pairs may be occupying the area. Coyote mating on the Willapa NWR typically occurs during January or February, and five to 10 pups for each breeding pair typically are born during April or May (Burt and Grossenheider 1964). Pups are fed by the adults for several months, and then disperse from their parents' home range before reaching 1 year of age, but they may remain longer (Andelt 1985; Bowen 1982; Nellis and Keith 1976). Mortality of pups often exceeds 50 percent during their first year (Andelt 1985; Nellis and Keith 1976).

The typical adult coyote weighs 25 to 30 pounds, although there is some geographic variation and occasionally individuals may be larger (Berg and Chesness 1978). Coyotes are opportunistic, omnivorous foragers, where the diet is flexible based upon prey that is available. Diets can include large and small mammals such as mice, rats, rabbits, and hares; deer and other wild ungulates; livestock and domestic pets; and carrion, as well as reptiles, amphibians, fish, insects, fruits, and even farm crops such as corn (Bailey 1936; Gier 1957). Deer, especially fawns, are often a major food item for coyotes (Andelt 1985; MacCracken 1984; Toweill and Anthony 1988). During the breeding season, coyotes seek larger prey (e.g., deer fawns) to feed their young (Till and Knowlton 1983). Harrison and Harrison (1984) found that pups at a site in Maine were fed deer fawns almost exclusively during June and July. A medium-sized coyote requires about 4,800 mice or eight adult deer per year to meet its basic resting energy needs (Litvaitis and Mautz 1980).

Coyotes would only be targeted if field investigations indicate they pose a direct and immediate threat to specific plovers, streaked horned larks, and their chicks (see Section L.1.2). Under the proposed action, about 15 to 70 coyotes could be removed, if they are found to be a threat to plovers. APHIS-WS estimated that total take of coyotes in 1998, which included fur harvest from hunting and trapping and depredation take, amounted to 3 percent of the population in northwest Oregon and 9 percent in southwest Oregon (unpublished monitoring reports of environmental assessments on predator damage management, APHIS-WS).

It is not expected that taking coyotes to protect plovers would add notably to the cumulative take of coyotes. Take is expected to remain well below the established USDA (1995) 70 percent allowable harvest for coyote. Cumulative mortality of coyotes from coastal counties included 775 coyotes taken from hunting, trapping, and depredation (ODFW 1999-2000 hunting and trapping and USDA MIS for FY 1999). Negligible impacts on the coyote population are expected as a result of plover protection.

Live trapping may include the use of box type mammal traps, bal-chatri traps (a type of baited monofilament line leg-hold/cage trap), scent-baited padded leg-hold traps and perch pole traps, or cage traps. Manual capture methods may also be employed using handheld capture poles or other manual techniques. Traps are inspected in accordance with State Fish and Wildlife Code and Service policy. Specifically, traps set out overnight for mammalian predators are checked within two hours of sunrise and traps left out during daylight hours are monitored regularly and checked a minimum of four times per day. The use and monitoring of pole traps will be conducted in accordance with Service policy.

Targeted animals that are live trapped are euthanized by lethal injection (sodium phenobarbital) or are shot or gassed using carbon monoxide or carbon dioxide gas. Lethal methods will be implemented as humanely and selectively as possible. It is not likely that all methods will be used because site conditions would render some tools more appropriate than others. APHIS-WS and Refuge personnel can determine for each unique situation what method or combination of methods is most appropriate and effective using the APHIS-WS Decision Model. Shooting will be conducted only by government personnel trained and certified in firearm safety. In order to avoid human safety hazards, shooting will take place only when members of the public are not in the area.

Small Mammals. Small mammals such as raccoons, opossums, weasels, skunks, mice, and rats may pose a low level of nest predation risk to plovers and larks, although the likelihood of actual predation at Leadbetter Point is thought to be rare. In California, red fox predation on snowy plovers was a major reason for the plovers' decline on the central coast (USFWS 1993) and is one of the major threats to the survival of the California least tern and light-footed clapper rail (USFWS and U.S. Navy 1990). The USFWS concluded that red fox are a major factor in snowy plover chick losses in California, based on numerous studies and on comparisons between areas with and without red fox. By reducing the number of red fox in the vicinity of plover breeding areas, the reproductive success of plovers may be dramatically improved (USFWS 1993). Red fox are not currently known to occur at Willapa NWR.

Selective control of problem mammalian predators will involve trapping and euthanizing by approved humane methods as described for coyote. Target and non-target predators that are injured during trapping will be treated on a case-by-case basis. These animals may be euthanized or taken to an approved rehabilitation or veterinary care facility depending on species and extent of injuries. Any non-target wildlife (an animal determined not to be a threat to listed species) that is captured unharmed would be immediately released near the capture site or at a suitable location.

All free-roaming domestic dogs and cats, when feasible, would be taken to an approved shelter facility operated by a cooperating local unit of government, humane society, or a veterinary care facility.

Raptors. Birds of prey, or raptors, are meat eaters that use their feet, instead of their beak, to capture prey. They have exceptionally good vision, a sharp, hooked beak, and powerful feet with curved, sharp talons. Raptor feeding strategies vary, but most are somewhat opportunistic, taking advantage of easily captured prey by using whatever means possible (Sibley 2000). Raptors primarily pursue small to medium sized birds and small mammals, or feed on carrion.

The northern harrier (*Circus cyaneus*), merlin (*Falco columbarius*), peregrine falcon (*Falco peregrinus*), and American kestrel (*Falco sparverius*) are recognized potential predators of both juvenile and adult plovers and larks (Liebezeit and George 2002; Powell et al. 2002; USFWS 2002). All occur at the Leadbetter Point Unit of Willapa NWR, but only the northern harrier and merlin are currently suspected to be potential predation risks at Leadbetter Point. Although not known to be predators at Leadbetter Point, snowy owls (*Nyctea scandiaca*) and short-eared owls (*Asio flammeus*) may opportunistically feed on shorebirds or land birds on an infrequent basis.

Specific local population data for raptors are currently unavailable. An initial step in the predator management plan will be implementation of a monitoring program to ensure that any impacts on raptor populations can be assessed more precisely. The Refuge monitoring program would also reveal more information on the magnitude and extent of threats that raptors pose to plovers and larks at Leadbetter Point.

Under the proposed predator management plan, any individual problem raptor that poses a threat to endangered species, as determined by the Refuge Biologist or a qualified predator control agent for the Service (e.g., USDA APHIS Wildlife Services), could be considered for control actions. Actions affecting raptors would only be taken after consulting with the Refuge Manager and the Refuge Biologist as needed to protect the breeding population and production (see Section L.1.2). If direct avian predator management is determined to be necessary, it could occur year-round but would be concentrated immediately prior to and during the snowy plover and streaked horned lark breeding season (March to September). If an individual non-corvid predator is evaluated as posing a threat to snowy plovers at the Refuge, it may be trapped and/or relocated as needed to protect the breeding population and production (see Section L.1.2). The determination that relocation is necessary will be made by Refuge staff in consultation with WDFW biologists. The Refuge Biological Resources Program staff will be responsible for monitoring and managing avian predators in cooperation with WDFW, APHIS-WS, and WSPRC.

Direct control of any raptor species would only focus on problem predators, which are defined in this context as individuals that belong to species that are known to prey on western snowy plovers or streaked horned larks and that exhibit hunting behavior in nesting areas. For most predatory species, direct management will be accomplished primarily by intentional hazing (scaring off) or live-capture, and holding and/or translocation of individual predators from nesting areas. Hazing or trapping will be used only on extremely rare occasions when it is demonstrably necessary, for example, when there is an immediate threat to snowy plover chicks. The decision to haze an avian predator will be determined on a case-by-case basis and will be based on the degree of threat, the breeding phase of snowy plovers and streaked horned larks, and professional judgment of the situation, and hazing will be done as needed to protect the breeding population and production (see Section L.1.2). Any traps set for avian predators would be regularly monitored.

Only licensed and authorized agencies or individuals will implement predator management actions. Management actions will be carried out by APHIS-WS, or other such qualified agencies or individuals. Refuge personnel and their cooperators may assist with capture efforts. All activities will be conducted using the most humane methods available, under the direction of the Refuge Biologist. Only non-lethal techniques will be used for problem raptors. A combination of live-trapping techniques will be used, including bal-chatri traps, dho gaza nets, bow nets, noose mats, net launchers with bait, and lures. Knowledge of the avian predator's habits will determine which trapping technique to employ. Efforts will be made to avoid and minimize losses of non-target native wildlife, and all uninjured non-target species inadvertently captured will be immediately released near the site of capture or at a suitable location at the discretion of the Refuge Manager in consultation with the Refuge Biologist.

Live captured raptors would be removed from the site and held in a licensed and permitted rehabilitation or holding center until they can be released back into the wild. Release would occur after the endangered species nesting season is completed and an appropriate release site has been approved by the Refuge Biologist. All translocated birds will be released in an area with suitable habitat. Raptors would be banded prior to release. As plover and lark numbers increase and their populations stabilize, raptors would be allowed a more natural interaction with the local species of concern and active predator management would be de-emphasized.

The Refuge and its cooperators will continue to research avian predator management alternatives that will protect the snowy plover while minimizing disturbance to avian predators. There is particular interest in developing management techniques that would permit problem predators to remain on the Refuge but would prevent them from hunting in snowy plover nesting areas.

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Appendix M. Hunt Plan

Table of Contents

M.1 Introduction	M-3
M.2 Conformance with Statutory Authorities	M-4
M.3 Statement of Objectives	M-5
M.4 Assessment	M-5
M.5 Description of the Hunting Program	M-7
M.5.1 Areas of the Refuge that Support Populations of the Target Species	M-7
M.5.2 Target Species	M-7
M.5.3 Existing Areas Opened to the Public	M-10
M.5.4 Existing Waterfowl Hunting Opportunities	M-10
M.5.5 Proposed Waterfowl Hunting Opportunities	M-11
M.5.6 Existing Upland Game Bird Hunting Opportunities	M-11
M.5.7 Upland Game Bird Hunting Opportunities	M-12
M.5.8 Existing Big Game Hunting Opportunities	M-12
M.5.9 Big Game Hunting Opportunities	M-12
M.5.10 Species to be Taken and Hunting Periods	M-16
M.6 Measures Taken to Avoid Conflicts with Other Management Plans	M-20
M.6.1 Biological Conflicts/Impacts	M-20
M.6.2 Public Use Conflicts	M-21
M.6.3 Administrative Conflicts	M-22
M.7 Conduct of the Hunt	M-22
M.7.1 Refuge-specific Hunting Regulations	M-22
M.7.2 Anticipated Public Reaction to the Hunting Program	M-24
M.7.3 Hunter Application and Registration Procedures	M-25
M.7.4 Description of Hunter Selection Process	M-25
M.7.5 Media Selection for Announcing and Publicizing Hunting	M-25
M.7.6 Description of Hunter Orientation, Including Pre-hunt Scouting	M-25
M.7.7 Requirements for Hunting	M-25
References	M-26

M.1 Introduction

The Willapa National Wildlife Refuge (Refuge or NWR) is located on Willapa Bay in southwest Washington. The Refuge was established in early 1937 by President Franklin Roosevelt in order to preserve and manage the important habitats and wildlife of Willapa Bay. The Refuge currently manages approximately 16,000 acres including sand dunes, sand beaches, intertidal mudflats, saltwater and freshwater marshes, grassland, open water, and forested lands.

The Refuge's wetland habitats support wintering populations of waterfowl such as black brant, trumpeter swans, Canada geese, scaup, canvasback, bufflehead, scoters, and American wigeon. The Refuge also hosts some of the largest concentrations of shorebirds on the Pacific Coast during their spring and fall migrations. These large concentrations of migrating shorebirds and the habitats that support them are now recognized as globally significant. The western snowy plover, listed as threatened under the Endangered Species Act, nests along Refuge beaches. Marbled murrelet, black bear, black-tailed deer, Roosevelt elk, bats, bobcats, and grouse can be found in the forests and upland habitats. The cool, wet climate of the Willapa Hills makes the area a "hotspot" of amphibian diversity in Washington. Habitats on the Refuge support up to 13 of the 24 native amphibians that occur in the state. Coastal rivers and streams on the Refuge provide habitat for western brook lamprey; western pearlshell mussel; Chinook, coho, and chum salmon; steelhead; and sea-run cutthroat trout.

The purpose of the Hunt Plan is to outline how the hunting program will be managed on the Willapa Refuge. The Hunt Plan documents how the Refuge will provide safe, quality hunting opportunities, while minimizing conflicts with other priority wildlife-dependent recreational uses (Service Manual 605 FW 2). The Hunt Plan will discuss the following topics: compatibility, the effect of hunting on Refuge objectives, assessment of target species, description of the hunting areas, avoiding biological and public conflicts, and the procedures to conduct the daily hunt.

The Refuge will maintain current hunting opportunities and expand the wildlife-dependent recreational hunting opportunities as identified in this plan and the comprehensive conservation plan (CCP).

The goals of Willapa Refuge as developed for the long term management of the Refuge in the CCP are:

- Goal 1. Protect, maintain and restore ecologically functional late-successional forest habitats (mature and old-growth forest) characteristic of the low-elevation temperate forests in the southwest Washington coastal region for the benefit of endangered and threatened species, migratory and resident birds, and a diverse assemblage of other native species.
- Goal 2. Protect, maintain, and restore estuarine habitats historically characteristic of the southwest Washington coastal region for the benefit of salmonids, Pacific brant, other waterfowl, shorebirds, seabirds, and a diverse assemblage of other native species.
- Goal 3. Protect, maintain, and restore freshwater habitats historically characteristic of the southwest Washington coastal region for the benefit of migratory birds, salmonids, amphibians, mussels, lamprey, and a diverse assemblage of other native species.
- Goal 4. Protect, maintain and restore coastal beach and dune habitats historically characteristic of the southwest Washington coastal region for the benefit of the western

snowy plover, streaked horned lark, pink sandverbena, Oregon silverspot butterfly, and a diverse assemblage of other native species.

- Goal 5. Provide short-grass fields (improved pastures) and grasslands for the benefit of Canada geese, Pacific jumping mouse and other grassland-dependent species and restore grasslands for the Oregon silverspot butterfly.
- Goal 6. Promote the recovery of federally threatened and endangered as well as federal candidate and state-listed species.
- Goal 7. Gather scientific information (inventories, monitoring, research, studies) in support of adaptive management decisions on the Refuge under Goals 1-6.
- Goal 8. Foster a connection between Refuge visitors and nature. Visitors will have the opportunity to participate in safe quality wildlife-dependent recreation activities located throughout Willapa NWR. These activities and programs include wildlife observation, hunting, fishing, interpretation/education, and photography.
- Goal 9. Protect and preserve the cultural resources of the Refuge for the benefit of present and future generations.
- Goal 10. Contribute to the protection of the long-term environmental health of the Willapa Bay ecosystem.
- Goal 11. Provide support for off-Refuge conservation efforts in southwest Washington in partnership with private landowners, agencies, and nongovernmental organizations.

M.2 Conformance with Statutory Authorities

National wildlife refuges are guided by the mission and goals of the National Wildlife Refuge System (Refuge System) and the purposes for which individual refuges were established, as well as other policies, laws, and international treaties. Relevant guidance includes the National Wildlife Refuge System Administration Act of 1966 (Administration Act), as amended by the National Wildlife Refuge System Improvement Act of 1997 (Improvement Act), the Refuge Recreation Act of 1962, and selected portions of the Code of Federal Regulations (C.F.R.) and Service Manual.

Refuge Recreation Act of 1962 (16 U.S.C. 460K) authorizes the Secretary of the Interior to administer refuges, hatcheries, and other conservation areas for recreational use. The Refuge Recreation Act requires that 1) any recreational use permitted will not interfere with the primary purpose for which the area was established; and 2) funds are available for the development, operation, and maintenance of the permitted forms of recreation.

Fundamental to the management of lands within the Refuge System is the Improvement Act, an amendment to the Refuge Administration Act of 1966. The Improvement Act provided a mission for the Refuge System, and clear standards for its management, use, planning, and growth. Its passage followed the promulgation of Executive Order 12996 (April 1996), Management of Public Uses on National Wildlife Refuges, reflecting the importance of conserving natural resources for the benefit of present and future generations of people.

The Improvement Act recognized that wildlife-dependent recreational uses involving hunting, fishing, wildlife observation and photography, and environmental education and interpretation, when determined to be compatible with the mission of the Refuge System and purposes of a refuge, are legitimate and appropriate public uses of the Refuge System. Compatible wildlife-dependent recreational uses are the priority general public uses of the Refuge System and shall receive priority consideration in planning and management.

The U.S. Fish and Wildlife Service (Service) has determined hunting of waterfowl, coot, snipe, elk, deer, bear, and grouse (ruffed and blue) to be a compatible wildlife-dependent recreational use on the Refuge (See Appendix C, Waterfowl, Big Game, and Upland Game Bird Hunting Compatibility Determinations). Based upon biological impacts described in the Hunting Compatibility Determination (CD)s, which are incorporated by reference, hunting on the Refuge is a compatible use and will not materially interfere with or detract from the purposes for which the Willapa Refuge was established. Stipulations within the Hunting CD ensure compatibility and include Refuge-specific regulations; monitoring of hunting activities, habitat conditions, public use activities, and wildlife population levels; and routine law enforcement patrols.

M.3 Statement of Objectives

In the CCP, the Service proposes maintaining existing waterfowl, upland game bird, and big game hunting, and opening additional areas of the Refuge to waterfowl, elk and deer hunting. The objectives of the Hunt Plan directly support several of the Refuge's long-term management goals and Service mandates:

- National Wildlife Refuge System Improvement Act of 1997 states that refuges shall provide quality hunting opportunities wherever compatible.
- Foster a connection between Refuge visitors and nature. Visitors will have the opportunity to participate in safe quality wildlife-dependent recreation activities located throughout Willapa Refuge. These activities and programs include wildlife observation, hunting, fishing, interpretation/education, and photography.
- Protect, maintain, and restore coastal beach and dune habitats historically characteristic of the southwest Washington coastal region for the benefit of the western snowy plover, streaked horned lark, pink sandverbena, Oregon silverspot butterfly, and a diverse assemblage of other native species.
- Promote the recovery of federally threatened and endangered as well as federal candidate and state-listed species.

This hunting program supports the mandate of the Improvement Act that refuges provide for priority public uses, including hunting, where compatible. A Section 7 Endangered Species Consultation will be completed for the existing and proposed changes to the waterfowl, upland game bird, and big game hunts. The current and expanded hunting program would be conducted to meet Refuge objectives for providing quality hunting opportunities, and assisting the Washington Department of Fish and Wildlife (WDFW) with achieving and maintaining state game population objectives.

M.4 Assessment

The hunting program would be thoroughly evaluated on an annual basis to determine if the Refuge is meeting its objectives. If there have been no unacceptable impacts to other wildlife populations or to other public use programs, the hunting program would be continued. At that time, the Service will also consider adding additional hunting areas if appropriate, including any newly acquired Refuge lands. Any reductions in, or other changes to, the hunt program would be made after evaluation of the program.

All existing and proposed hunting areas are located within Pacific County, Washington. Hunting of waterfowl, coot, snipe, elk, deer, bear, and grouse (ruffed and blue) will be allowed on the Refuge consistent and in accordance with all Washington State regulations except as specifically noted herein.

A. Are populations of waterfowl, coot, snipe, elk, deer, bear, or grouse (ruffed or blue) present in numbers that are sufficient to sustain an optimum population level for priority Refuge objectives other than hunting?

Yes, target wildlife populations are present in sufficient numbers for priority Refuge objectives for wildlife management and for the other priority wildlife-dependent recreational uses (wildlife observation, photography, environmental education, and interpretation). The Refuge has adopted harvest regulations set by the state, which uses concepts of density dependent compensatory mortality and adaptive harvest management to ensure sustained game species populations (See Section M.5.10, Species to be taken).

The Refuge was evaluated to determine the best public use strategy for providing high-quality wildlife-dependent public use opportunities. The Refuge will offer various public use opportunities on nearly the entire Refuge throughout various times of the year. Approximately 160 acres of the Refuge are currently closed to all public use. These areas include areas directly adjacent to buildings and are closed for safety purposes. Approximately 5,670 acres will be open for waterfowl, coot, and snipe hunting. There will be approximately 10,716 acres available for elk, deer, and bear hunting and 5,451 acres open for grouse hunting. Hunting programs need to be based on healthy, sustainable populations of the species hunted. The number of elk that enter the Refuge may vary from year to year. For the Leadbetter Point Unit, reproduction continues to add to the estimated population of 40 to 70 animals. Outside recruitment to the herd may also add to this population annually.

Under this Hunting Plan, the elk and deer populations will be monitored and the continual expansion kept in check. According to WDFW Wildlife Biologists, the management of the elk and deer herds is necessary to maintain an overall healthy population that does not have negative impacts on the environment or create negative impacts for the community.

B. Is there competition for habitat between target species and other wildlife?

Possibly. While each species occupies a unique niche, there is a finite amount of space available to satisfy various habitat requirements of water, food, cover, breeding, and roosting areas.

Browse is in limited supply on this unit. Non-native beach grass is abundant on the Leadbetter Point Unit. However, it is unlikely that this grass serves as much of a food source for elk. Shore pine dominates much of the shrub/tree community, although willows and other shrubby plants do exist. Shrubs and trees occupy greater than 50 percent of the 1,742-acre unit and coupled with the large areas of predominantly beach grasses, it is not surprising that the native plants which are occurring in the dune habitat restoration area are being consumed or trampled.

Elk are large animals and require extensive amounts of food. A 700-pound elk will typically eat 14 pounds air dry weight (approximately 30 pounds fresh weight) of forage per day (Nelson and Leege 1982). A herd of 40 to 70, or more, elk on the 1,742-acre unit exerts tremendous pressure on the native plant species that do occur, and conflicts with the nesting wildlife that occupy those areas.

Elk compete with deer for food and cover. Elk are often classified as being primarily grazers (feeding on grasses and forbs), whereas deer are often classified as being browsers (feeding on the leaves and twigs of shrubs and trees). However, both elk and deer are generalist herbivores and seek out the highest quality forage available at any given time, whether it be grasses, forbs (herbs other than grasses), or browse (Nelson and Leege 1982; Verme and Ullrey 1984).

Black bears are omnivores and consume both plants and animal matter, including insects. Movement within a home range is associated with seasonal availability of food and breeding activities and dispersal. Habitat competition with other species of wildlife is negligible.

C. Are there unacceptable levels of predation by target species on other wildlife forms?

No, target species (waterfowl, coot, snipe, elk, deer, bear, and ruffed and blue grouse) generally do not prey on other species at unacceptable levels.

Although elk and deer do not directly predate on other species, in large numbers they do create unacceptable levels of competition and habitat destruction (see above).

Predation levels on other species of wildlife have not been observed to be a problem with black bear on the Refuge.

M.5 Description of the Hunting Program

M.5.1 Areas of the Refuge that Support Populations of the Target Species

Target game species commonly occurring on the Refuge include waterfowl, coot, snipe, elk, deer, bear, and grouse (ruffed and blue). Descriptions of upland forest, estuarine open water, intertidal flat, salt marsh, riverine, wetlands, coastal dune and beach, and grassland habitats and their associated plant and wildlife species are described in further detail in Chapter 4 of the CCP. An overview of hunted target wildlife species is also described below in Section M.5.2.

M.5.2 Target Species

M.5.2.1 Migratory Game Birds

Status of Waterfowl, Coots, and Snipe on the Refuge: Willapa Bay is an important wintering ground for geese and ducks, many of which breed in Alaska and northern Canada. The Refuge's wetland habitats support wintering populations of waterfowl such as black brant, trumpeter swans, Canada geese, scaup, canvasback, bufflehead, scoters, and American wigeon. Thirty-five species of waterfowl have been observed on the Refuge.

The Pacific population of western Canada geese (*Branta canadensis moffitti*) nest in central and southern British Columbia, northwestern Alberta, northern and southwestern Idaho, western Montana, northwestern Nevada, northern California, and throughout Washington and Oregon. A large segment of this population is nonmigratory and resident throughout the year. In response to human activities, such as transplants and artificial nesting structures, the population has expanded its historic distribution. Agricultural practices, residential expansion, and park development has further expanded this population. In some urbanized areas, the geese have become acclimated to human interaction and reside in parks.

Willapa NWR, and the fields and farm pastures adjoining Willapa Bay, provide stopover habitat in Washington State for Aleutian cackling geese during the fall migration from September to late November. A peak count at Willapa during the mid-1990s averaged from 300 to 400 birds (Hays 1997; Kraege 2005). Winter goose survey numbers in Willapa Bay were much lower, comprising less than 1 percent of the geese examined from 2000 until 2004, when surveys were curtailed. Low numbers are typically seen during the northern migration in February and March each year. The highest number of spring migrating Aleutian cackling geese in Washington through the mid-1990s was 52 birds recorded in Willapa Bay by Pitkin and Lowe (1995). The 2008 calculated population index for Aleutian cackling geese in the Pacific Flyway was 193,321. The most recent three-year average population equals about 179,000, slightly below the Flyway objective of 250,000 birds set by the Pacific Flyway Council.

A primary rationale for creating Willapa NWR in 1937 was conservation of migratory and wintering populations of brant. Brant are one of the most abundant waterbird species passing through Willapa Bay during annual migrations. Brant utilize eel grass (*Zostera marina*) beds as a primary food source while in Willapa Bay, often numbering in the hundreds of birds. Use of the Bay is greatest during the northern spring migration, with peak bird numbers observed from March through May, with use typically highest in April. Brant also winter in the area from late October to early May. Total numbers of wintering birds are lower than in the spring, averaging several thousand, but overall there is a lesser degree of interannual variation (Wilson and Atkinson 1995). Historically the brant population was much higher than at present. Brant harvest in the Pacific Flyway states for 2007 was estimated at 2,800 birds, with Washington State comprising slightly less than 20 percent of the total rate of harvest. The 2008 population estimate based on an index derived from midwinter surveys totals 24,972.

M.5.2.2 Upland Game Birds

Status of Ruffed and Blue Grouse on the Refuge: Forest grouse in Washington include dusky blue grouse (*Dendragapus obscurus*), sooty blue grouse (*Dendragapus fuliginosus*), and ruffed grouse (*Bonsa umbellus*), which occur throughout the forested lands in Washington. Statewide biological surveys designed to estimate forest grouse populations have not been conducted in Washington (WDFW 2008). Forest grouse can be observed throughout the Refuge and adjacent lands

M.5.2.3 Big Game

Status of Roosevelt Elk on the Refuge: The Roosevelt elk (*Cervus elaphus roosevelti*) is one of six recognized subspecies of elk in North America (Bryant and Maser 1982). They are native to western Oregon and Washington, northwestern California, and Vancouver Island, British Columbia. Statewide elk populations are difficult to estimate but the statewide total ranges from approximately 55,000 to 60,000 elk (WDFW 2009). There are an estimated 16,000-17,000 Roosevelt elk in the state, of which approximately 7,600 are in the Willapa Hills herd (WDFW 2003). Southwest Washington and the Willapa Hills, which surround the Refuge, support one of the highest concentrations of elk in Washington State. Populations of elk in western Washington are variable, ranging from less than 1 elk/mi^2 to 12 elk/mi^2 (USFWS 1978). WDFW has a population objective of 7,600 to 8,800 for the Willapa Hills herd (WDFW 2008). One hundred thousand elk hunters harvest approximately 7,000 elk annual in Washington (WDFW 2008). Herd size is estimated by a range of methods including aerial surveys, cow/calf ratio, analysis of harvest data, etc. Adjustments in season length and the number of antlerless permits issued are used to maintain herd numbers at roughly the population objective.

Elk can be observed throughout the Refuge and adjacent lands. Habitat on the Refuge includes open fields, fresh and saltwater marshes, forested areas, and clearings in forests. An estimate of the elk population in the late 1970s on Long Island was 40 to 45 animals.

Records indicate that elk were not present on Leadbetter Point when the area became part of Willapa Refuge in the 1960s. It is surmised that a small group of elk located to this area in late 1980s or early 1990s by travelling up the Long Beach Peninsula. There are also records of elk swimming from Long Island to the peninsula. Elk are found on the Mainland and Long Island Units of the Refuge on a year-round basis. The population of the mainland elk herds are maintained through elk hunting on surrounding private lands and portions of the Refuge.

Elk hunting is currently prohibited within the Leadbetter State Park and the Leadbetter Point Unit of the Refuge. Elk numbers have grown gradually and continuously since their establishment on the peninsula. In the spring and summer months of 2007, Refuge biologists observed a herd of approximately 30 elk inside the western snowy plover nesting area. Reports of sightings in the area by WDFW and area residents confirm that the overall number of elk has increased and now may range from 40 to 70 animals.

Status of Black-tail Deer on the Refuge: WDFW conducts composition surveys from the air and the ground to index buck, doe, and fawn ratios (WDFW 2009). In western Washington, black-tailed deer (*Odocoileus hemionus*) surveys are coupled with hunter check station information and harvest data to model populations (WDFW 2009). In 2008, population estimates for deer in Game Management Units (GMU) 658, 660, 663, 672, 673, 681 (which includes the Refuge), and 684 was 25,797 (WDFW 2009).

Systematic surveys of black-tailed deer are not conducted on the Refuge. However, the Willapa Hills and the Long Beach Peninsula support healthy populations of black-tailed deer, and this species has been observed throughout the Refuge.

Status of Black Bear on the Refuge: The black bear (*Ursus americanus*) is the most common and widely distributed species of bear found in North America. In Washington, black bears inhabit 31 of 37 counties, occupying all forested habitats within western Washington, the Cascade Mountain Range, the Okanogan Region, and the Selkirk and Blue Mountains ranges (WDFW 2009). Although no formal statewide bear surveys are conducted in Washington, the black bear population is around 25,000 to 30,000 animals (WDFW 2009). Systematic surveys of black bear are not conducted on the Refuge. However, the Willapa Hills and the Long Beach Peninsula support healthy populations of black bear. This species has been observed throughout the Refuge. Although a population estimate does not exist for the entire Refuge, a study in 1973-1975 estimated the bear population on Long Island to be approximately 30 animals (Lindzey 1976).

M.5.3 Existing Areas Opened to the Public

The Refuge is open for a variety of wildlife-dependent public uses and currently offers waterfowl (3,128 acres), upland game bird (5,451 acres), and big game (6,980 acres) hunting programs (Map M-2).

M.5.4 Existing Waterfowl Hunting Opportunities

M.5.4.1 Leadbetter Point Unit

Portions of the Leadbetter Point Unit are open to free-roam waterfowl and goose hunting according to state regulations. Access is by Stackpole Road. Hunting is prohibited in the snowy plover closure area.

M.5.4.2 South Bay Units

Selected areas of the South Bay Units (Riekkola, Tarlatt, Porter Point) are open for waterfowl hunting (2,884 acres) (Map M-2). The Riekkola Unit is open to goose hunting (244 acres) only from assigned blinds on Saturday and Wednesday. There are eight blinds including one that provides barrier free access to hunters with disabilities. In 2010, 44 hunters (119 visits) used these blinds and harvested an average of 1.34 geese/hunter. This represents only 18 percent occupancy of the Refuge's hunting blinds. Hunters may not possess more than 25 shells per day. Ducks, coots, and snipe may be taken only incidental to goose hunting. Access occurs off 67th Street in Long Beach. Blind selection is done by lottery early in the morning of each hunt. Gates are open from 6 am to 5 pm. There is a small fee ($5.00) for use of the blinds. The user fee is $2.50 with a Golden Age or Golden Eagle passport.

Porter Point is open for free-roam waterfowl hunting on Sunday, Monday, and Thursday. The Porter Point Unit is suitable for car-top boats and small craft that can be easily moved. Parking for the car-top boat ramp is available to the northwest of the Riekkola Unit pastures in a delineated graveled parking area with 10 sites for waterfowl hunters. The freshwater wetland can be accessed by the Porter Point Unit dike or boating the wetland. No gas-operated engines are allowed in the freshwater wetland. The saltwater marsh of Willapa Bay can be reached from the existing footbridge on the east end of Porter Point Unit or by walking into the Bay from the dike on the west end of the unit. Signs are placed on the east and west boundary of the Porter Point Unit, extending into the Bay, to delineate the hunt area. Access occurs through the Riekkola Unit, off 67th Street in Long Beach (Map M-2).

M.5.4.3 East Hills Units

Potshot, North Potshot, and Stanley Peninsula are open for waterfowl and goose hunting according to state regulations (Map M-2).

M.5.4.4 Waterfowl Closure Areas

On November 7, 1940, the President issued another Proclamation (No. 2439), "Regulation Designating As Closed Area under the Migratory Bird Treaty Act Certain Lands and Waters Adjacent to and in the Vicinity of the Willapa National Wildlife Refuge Washington." As lands were acquired into the Refuge, with purposes derived from the earlier Executive Order it is also made clear in several Migratory Bird Conservation Commission Memorandum that "A Proclamation closes to hunting the water surrounding the island." That island refers to Long Island in south Willapa Bay. The Refuge maintains the Presidential Proclamation Boundary specifically prohibiting waterfowl hunting around Long Island (Map M-2).

Hunting was allowed on the Lewis Unit; however, access via Jeldness Road, a private road off U.S. Highway 101, was closed by property owners in 2008. This unit is now closed to all public access including hunting.

M.5.5 Proposed Waterfowl Hunting Opportunities

The following are changes proposed to waterfowl hunting opportunities.

M.5.5.1 South Bay Units

The expanded waterfowl hunt area identified in the management direction of the CCP will include opening an additional 2,542 acres (5,670 acres total) to waterfowl hunting in all newly restored areas in the South Bay Units (Map M-1). Three blinds will be available for goose hunting on the south half of the Riekkola Unit (100 acres) which will meet or exceed the Refuge's current average use of 4.4 hunters per day. Two of these blinds will be pit blinds and one will be an above ground barrier-free blind for hunters with disabilities. Two additional blinds will be created for waterfowl hunting. These blinds will provide walk-in access for waterfowl hunting and will provide a new opportunity for Refuge hunters that do not have a boat. One of these waterfowl blinds will also provide barrier-free access. Exact placement of the goose and waterfowl blinds will be determined at a later date to allow for input from hunter working groups and local hunters. Boat access to the South Bay Units will be provided by car-top boat ramp at Dohman Creek. Access to these blinds will be provided on a first-come, first-serve basis from a parking area located near Dohman Creek. In addition, a trail from the parking area will provide walk-in hunter access to Porter Point. According to State regulations, waterfowl hunting will be allowed seven days a week and goose hunting will be allowed two days a week (Wednesdays and Saturdays).

The parking area, car-top boat launch and trail to Porter Point will be open year round to all Refuge visitors. The blinds will be open only to hunters during the hunting season; however, during the non-hunting season, these blinds may be used by any Refuge visitor. This will provide access to additional areas for wildlife observation, photography, environmental education, and interpretation on the Refuge.

M.5.6 Existing Upland Game Bird Hunting Opportunities

M.5.6.1 Long Island Unit

Archery hunters interested in a remote hunting experience find Long Island (GMU 699) a challenging place to pursue ruffed and blue grouse on 5,451 acres. A free Refuge hunting permit is required to hunt on Long Island. No hunting with firearms permitted on Long Island.

Visitors must provide their own boat transportation to and from Long Island. Access is best at a higher tide (6 foot or higher). Construction or use of permanent tree stands is prohibited. Camping is permitted only in designated campsites on the island.

M.5.7 Upland Game Bird Hunting Opportunities

No changes are proposed to the upland game bird hunting opportunities.

M.5.8 Existing Big Game Hunting Opportunities

Willapa Refuge currently provides several opportunities for big game hunters. Big game hunting occurs on both the mainland, in some, but not all, of the management units, and Long Island (6,980 acres) (Map M-2). Existing big game hunting rules and regulations on the Refuge are consistent with the state regulations except as specifically noted herein.

M.5.8.1. Long Island Unit

The Long Island Unit (GMU 699) is annually open to archery Roosevelt elk, black-tailed deer, and black bear hunting (5,451 acres). No hunting with firearms is permitted on Long Island. A free Refuge hunting permit is required to hunt on Long Island. Many people who hunt on Long Island prefer to camp overnight since tides can make travel to and from the island challenging.

Hunters must obtain a Refuge hunt permit by visiting the Refuge headquarters. Hunters that are camping must register their campsite during the early hunt season at the parking lot kiosk prior to travelling to the island. Camping is on a first-come, first-served basis. Groups are limited to five people per campsite. Individuals and groups are limited to 14 consecutive camping nights on the island. Elk/deer/bear/grouse hunters must report success/failure and any hit-but-not-retrieved animals when they return their Refuge permit tag after each trip. Use of bicycles is permitted on Long Island logging roads/trails, except for the Cedar Grove Trail.

M.5.8.2. East Hills Units

Existing elk and deer hunting areas include designated portions of the East Hills Units (Bear River, Headquarters, and Teal Slough Units) (GMU 681). Most of the Refuge lands on the mainland between Bear River and Teal Slough with the exception of the quarters (Q88) and headquarters area are open for those interested in hunting Roosevelt elk or black-tailed deer using modern firearms or archery. The East Hills Units are not open to bear hunting. Use of bicycles is permitted on East Hills Units logging roads/trails, except for the Teal Slough and Willapa Interpretive Art trails.

M.5.9 Big Game Hunting Opportunities

The management direction of the CCP will expand elk and deer hunting opportunities to 10,716 acres in new areas of the Refuge (Map 1 and Map 4 of the CCP) in accordance with the State hunting regulations. No new bear hunting opportunities are proposed in this plan.

M.5.9.1 South Bay Units

Proposed elk and deer hunting areas include portions of the South Bay Units (Lewis, Porter Point, and Riekkola) once tidal restoration activities are complete in the South Bay Units. All of the existing South Bay Units and any future acquisitions are located in GMU 684 and therefore will typically be open for approximately five days in early October. The South Bay Units will not be open to bear hunting.

M.5.9.2 Nemah/Naselle and East Hills Units

Elk and deer hunting opportunities in the East Hills Units will continue as described above. In addition, elk and deer hunting opportunities will be expanded upon acquisition of any new areas within the Nemah/Naselle Unit (GMU 673) and East Hills Units (GMU 681) as identified in the management direction of the CCP (Map 2 of CCP). Currently the land owners allow elk and deer hunting on these proposed Refuge acquisition areas. Elk and deer hunting opportunities would be considered upon acquisition of any new areas in the future and would resolve potential problems over the exact position of the Refuge boundary and complement local hunting activities on adjacent lands. The Nemah/Naselle Unit and East Hills additions will not be open to bear hunting.

M.5.9.3 Leadbetter Point Unit

An early season, muzzleloader elk only hunt and a special permit hunt are proposed on the Leadbetter Point Unit (GMU 684). The entire unit (2,397 acres) will be open to the early elk muzzleloader season, which typically lasts approximately five days in early October. The public will be notified that the entire unit will be closed to all other uses including hiking and waterfowl hunting. Public use of the trails during this time is minimal, due to the inclement weather and seasonal rains that regularly flood the trails. The proposed hunt falls outside the general tourist season. Since the waterfowl hunting season is much longer than the elk muzzleloader season, there would be little, if any, impact on this user group. In keeping with existing elk hunting regulations on adjacent private property and for safety purposes, the use of muzzleloader firearms will only be authorized. The Leadbetter Point Unit will not be open to deer or bear hunting.

A special permit elk hunt will be offered sometime between October and February on this unit only, if needed. If the elk are not found within the unit during the early muzzleloader hunt season, or the elk hunt proves unsuccessful due to weather or other uncontrollable influences, the special permit hunt could be implemented. Opening the special permit hunt would offer an opportunity to assist the state in management of the expanding elk herd. This additional hunt would draw from a pool of hunters who have applied for a muzzleloader permit through WDFW. The number of permits in this additional hunt would be determined after consultation with WDFW after the early season hunt. Currently, the registration process for big game hunting on the Refuge requires an orientation to Refuge boundaries and hunting regulation review; this same process will be used for the elk hunt at the Leadbetter Point Unit.

By issuing the special permit for the muzzleloader elk hunt, it provides the Refuge staff an opportunity to control the number and timing of hunters in a specific area thereby reducing potential hunter impacts to the resource and/or other Refuge users. Providing permits addresses the elk management issue by limiting the amount of animals taken or not taken in the area. Due to the size and shape of the unit and limited access points, the number of hunters will be regulated. There is the potential for elk hunters to disturb waterfowl and waterfowl hunters at certain times of the year. The permit system offers staff the opportunity to monitor take and potential impacts to resources while providing an opportunity for a quality and safe hunting experience.

Since big game hunting on the Leadbetter Point Unit is new and is not an expansion of hunting boundaries, more details on the elk and unit are provided below:

About the Leadbetter Point Unit

Historically, habitats along the Long Beach Peninsula consisted of low hummocky sand dune formations characterized by large areas of open sand with sparsely vegetated native dune plant species. Coastal marine and wind processes worked to maintain native plant communities in early successional stages on the outer prism of the beach. The dunes were more stable and blowouts less frequent; a mosaic of native prairie and dune grasslands, freshwater lakes, swamps, bogs, and spruce-dominated forests developed. High rainfall maintained high water tables favorable for plant growth.

The Leadbetter Point Unit encompasses 2,397 acres and is located at the northern tip of the Long Beach Peninsula, near the mouth of Willapa Bay. The coastal dune habitats consist of sand dunes in various stages of ecological succession including bare unstable sand; beachgrass-covered dunes; a transition zone composed of shrubs, small lodgepole pine (shore pine) and grass; lodgepole pine (shore pine); freshwater wetlands; and salt marsh.

At one time, the Columbia River provided the coastal shoreline with an extensive transport load of sediment; the ocean currents influenced by a long-shore drift deposited the sediment creating and maintaining the coastal sand beaches. Today, dams on Columbia River have altered sediment loads, and jetties at the river mouth and entrances to the bays have altered sediment transport along the coast. The beaches no longer have the natural processes depositing large amounts of sand and sediment necessary to maintain the sand beaches and dune habitats for a variety of native plants.

The habitat has changed in recent history with an accelerated plant succession that is also due to fire suppression efforts. These efforts have encouraged a plant successional progress away from the historic herbaceous beach grass, to a shrub (often invasive non-natives such as Scotch broom and common gorse) habitat leading to a pioneer lodgepole pine or climax Sitka spruce forest.

The west side of the unit is characterized by open wind-swept beaches backed by vegetated dunes. The extreme tip of the peninsula is largely barren sand, and the east side consists of a narrow beach with a few small, sheltered openings cut into the beachgrass by high water in winter. A small, isolated portion of beach exists to the east, on Willapa Bay, and is referred to as Grassy Island although it is attached to the peninsula.

The northern end of the Long Beach Peninsula was in a state of gradual northward accretion from 1965 to 1999. Invasion by non-native beach grasses has followed accretion, progressively filling in the dunes. In conjunction with slowed accretion in more recent years, the vegetation line has moved westward and the vegetation-to-water distance has decreased resulting in a narrower beach. Recent maps from the Washington State Department of Transportation show that the tip or northern portion of the unit has been gradually eroding since mapping efforts began in 1999. As the tip has eroded, the peninsula to the southwest has become wider.

American dunegrass (*Leymus mollis* or *Elymus mollis*), a native dunegrass, exists in small patches on the Refuge unit. Two invasive non-native beachgrass species, American beachgrass and European beachgrass (*Ammophila breviligulata* and *A. arenaria*), planted to stabilize dunes, have changed historical dune morphology and native plant communities. American beachgrass is the most abundant of the three grass species on the Long Beach Peninsula dunes, although all three species can be found growing together and there are patches of these species growing separately. The beachgrasses form a continuous band of vegetation parallel to the high tide mark along the outer ocean beach.

Non-native beachgrasses out-compete native vegetation, alter the dune ecosystem, and form dense stands that reduce the amount and quality of nesting habitat for native wildlife, including the federally threatened, state-endangered western snowy plover and a state-endangered, federal candidate species, streaked horned lark. Non-native beachgrasses have rapidly taken over a majority of formerly open sand dunes that provide nesting habitat for these two species. Western snowy plover numbers have declined along the U.S. Pacific coast due to habitat degradation as well as impacts from the expanding predator populations. One of the most significant causes of habitat loss for coastal breeding population of western snowy plovers has been the encroachment of introduced beachgrasses.

The invasion of non-native beachgrasses has also caused a dramatic reduction of coastal native plants and is a primary threat to the state endangered pink sandverbena (*Abronia umbellata*) which is also a federal species of concern. Pink sandverbena and other rare native dune plants like yellow sandverbena (*Abronia latifolia*), grey beach pea (*Lathyrus littoralis*) and beach morning glory (*Convolvulus soldanella*) are found along the sparsely vegetated sand beaches and coastal dunes.

In order to protect and encourage native plant growth the Refuge has implemented a Coastal Habitat Restoration Project. This ongoing project was initiated in 2002 and has continued each year with successful results. The mechanical and chemical removal and control of non-native beachgrass has resulted in over 120 acres of restored habitat that has successfully attracted nesting western snowy plovers and streaked horned larks. Oystershell was added to portions of the cleared area to provide camouflage for nests and reduce blowing sand to protect the bird nests. This habitat restoration area supports the only known population of pink sandverbena in Washington State; this plant species was thought to be extirpated in the state (federal species of concern, Washington State endangered species). In 2006, pink sandverbena was able to re-establish itself, from a long-term seed bank, because beachgrass had been removed from the site. Thousands of plants now exist at the site due to transplantation of propagated individuals and broadcast seeding efforts as well as a high success rate due to natural seeding.

Leadbetter Point Research Natural Area (RNA) is located entirely in the Refuge. The original designation included 1,705 acres of the peninsula tip, Grassy Island, and the marsh between the island and peninsula tip; however, the unit is now approximately 2,397 acres due to sand accretion at the peninsula tip. This area represents the largest, highest quality coastal sand dune ecosystem in Washington State.

The natural elements protected include salt marsh, native dunegrass, lodgepole pine (shore pine) forest, shrub/lodgepole pine (shore pine), and open beach habitats. The Bay side of the unit contains some of the most significant saltmarsh habitats remaining in Washington. It also contains high-quality examples of high salinity Virginia glasswort/inland saltgrass marsh, low salinity marsh, and transition zone wetlands. Flora associated with the marshes are of primary significance, as are the dune grassland and deflation plain habitat communities. Pockets of native plants within the secondary dune, deflation plains, and dune troughs are also significant ecological features and are of high quality compared to these remaining plant communities in Washington.

There have been over 200 species of plants have been documented at Leadbetter Point (Sayce 2001) and over 180 species of birds have been documented. Open water off the point supports large concentrations of waterfowl, including brant. Extensive mudflats at low tide support large populations of wintering and migrating shorebirds which also utilize the beach side in large numbers. It has been estimated that this unit hosts approximately seven percent of Willapa Bay shorebirds in the spring. Willapa Bay has some of the largest concentrations of shorebirds on the Pacific Coast during spring and fall migration. A key stopover site along the Pacific Flyway, it hosts hundreds of thousands of shorebirds, with dunlin and western sandpipers being the most numerous. Although it is not officially a designated site, Willapa Bay meets the criteria for status as a site of international significance in the Western Hemisphere Shorebird Reserve Network. Willapa Bay meets these criteria because it supports up to 15.5 percent of the Pacific Flyway population of wintering dunlin and an average of over 100,000 total shorebirds in the spring. Over 35 shorebird species have been documented.

This area is also considered an important staging site for passerine birds during spring migration. The unit also serves as a daytime roost site for brown pelicans and is an important loafing and resting area for this species (Cullinan 2001). A variety of raptors can be found in the Leadbetter Unit including bald eagles, peregrine falcons, and in some years, snowy owls.

This area of the Refuge is found within the northernmost breeding range for the western snowy plover along the Pacific Coast and is also the largest of the remaining nesting areas for this plover in Washington. The 374-acre nesting area for the federally threatened snowy plover is closed to all public entry from March through September, though the season can vary due to changes in use by snowy plovers.

The primary public access occurs at the end of a narrow road near the northern end of peninsula. The Refuge provides parking, interpretive signs, vault toilets, hiking trails, and viewing platforms. Hiking trails allow visitors to walk through coastal woodlands, salt marshes, and beaches. These trails include 1.3-mile Bearberry Trail, 0.5-mile Beach Trail, and a 1.2-mile Bay Loop Trail which link to the adjacent Washington State Park trails. These trails are often flooded during the rainy season (October through May).

M.5.10 Species to be Taken and Hunting Periods

M.5.10.1 Hunting Season and Bag Limits Overview

Waterfowl populations throughout the United States are managed through an administrative process known as flyways, of which there are four (Pacific, Central, Mississippi, and Atlantic). The review of the policies, processes, and procedures for waterfowl hunting are covered in a number of documents identified below.

The National Environmental Policy Act (NEPA) considerations by the Service for hunted migratory game bird species are addressed by the programmatic document, ‘‘Final Supplemental Environmental Impact Statement: Issuance of Annual Regulations Permitting the Sport Hunting of Migratory Birds (FSES 88– 14),’’ filed with the Environmental Protection Agency on June 9, 1988. The Service published a Notice of Availability in the Federal Register on June 16, 1988 (53 FR 22582), and the Record of Decision on August 18, 1988 (53 FR 31341). Annual NEPA considerations for waterfowl hunting frameworks are covered under a separate Environmental Assessment and Finding of No Significant Impact. Further, in a notice published in the September 8, 2005 Federal Register (70 FR 53776), the Service announced its intent to develop a new Supplemental Environmental Impact Statement for the migratory bird hunting program. Public scoping meetings were held in the spring of 2006, as announced in a March 9, 2006 Federal Register notice (71 FR 12216).

Because the Migratory Bird Treaty Act stipulates that all hunting seasons for migratory game birds are closed unless specifically opened by the Secretary of the Interior, the Service annually promulgates regulations (50 C.F.R. Part 20) establishing the Migratory Bird Hunting Frameworks. The frameworks are essentially permissive in that hunting of migratory birds would not be permitted without them. Thus, in effect, federal annual regulations both allow and limit the hunting of migratory birds.

The Migratory Bird Hunting Frameworks provide season dates, bag limits, and other options for the states to select that should result in the level of harvest determined to be appropriate based upon Service-prepared annual biological assessments detailing the status of migratory game bird populations. In North America, the process for establishing waterfowl hunting regulations is conducted annually. In the United States, the process involves a number of scheduled meetings (Flyway Study Committees, Flyway Councils, Service Regulations Committee, etc.) in which information regarding the status of waterfowl populations and their habitats is presented to individuals within the agencies responsible for setting hunting regulations. In addition, public hearings are held and the proposed regulations are published in the Federal Register to allow public comment.

For waterfowl, these annual assessments include the Breeding Population and Habitat Survey, which is conducted throughout portions of the United States and Canada, and is used to establish a Waterfowl Population Status Report annually. In addition, the number of waterfowl hunters and resulting harvest are closely monitored through both the Harvest Information Program and Parts Survey. Since 1995, such information has been used to support the adaptive harvest management (AHM) process for setting duck-hunting regulations. Under AHM, a number of decision-making protocols render the choice (package) of pre-determined regulations (appropriate levels of harvest) which comprise the framework offered to the states that year. The Washington Fish and Wildlife Commission then selects season dates, bag limits, shooting hours and other options from the Pacific Flyway package. Their selections can be more restrictive but cannot be more liberal than AHM allows. Thus, the level of hunting opportunity afforded each state increases or decreases each year in accordance with the annual status of waterfowl populations.

Each National Wildlife Refuge considers the cumulative impacts to hunted migratory species through the Migratory Bird Frameworks published annually in the Service's regulations on Migratory Bird Hunting. Season dates and bag limits for National Wildlife Refuges open to hunting are never longer or larger than the state regulations. In fact, based upon the findings of an environmental assessment developed when a refuge opens a new hunting activity, season dates and bag limits may be more restrictive than the state allows.

M.5.10.2. Refuge Hunt Seasons and Bag Limits

Hunting will be permitted in accordance with state and federal regulations (Tables M-1 and M-2 give examples of annual state hunt seasons for areas within the Refuge) to ensure that it will not interfere with the conservation of fish and wildlife and their habitats. Therefore, the sport hunting of migratory and upland game birds and big game on the Refuge is in compliance with state regulations and seasons, the National Wildlife Refuge System Administration Act of 1966 as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-ee), and the Refuge Recreation Act of 1962 (16 U.S.C. 460k).

Table M-1. Willapa Refuge, Waterfowl and Upland Game Bird Hunting Season Bag Limit Summary for 2010-2011.

Species	Dates	Daily Bag Limits	Possession Limit
Ducks (youth hunt)	September 25-26	7 [A]	14 [A]
Ducks	October 16-20 & October 23-January 30 except scaup closed October 16-November 5	7 [A]	14 [A]
Geese (except brant) Mgmt. area 2B	8 am to 4 pm, Saturdays & Wednesdays only October 16-December 22 and January 5-15; December 26, 29; January 2	4 [B]	8[B]
Brant Pacific County	Jan. 15, 16, 18, 20, 22, 23, 25, 27, 29, 30	2	4
American coot	October 16-20 & October 23-January 30	25	25
Snipe	October 16-20 & October 23-January 30	8	16
Archery grouse (ruffed and blue) GMU 699	September 1-December 31	4 of any species	12 of any species

[A] **Daily bag limit:** to include not more than 2 hen mallard, 2 pintail, 3 scaup (see restricted dates above), 1 canvasback, and 2 redhead statewide; and to include not more than 1 harlequin, 2 scoter, 2 long-tailed duck, & 2 goldeneye in western Washington.
Possession limit: to include not more than 4 hen mallard, 4 pintail, 6 scaup (see restricted dates above), 2 canvasback, and 4 redhead statewide; and to include not more than 1 harlequin, 4 scoter, 4 long-tailed duck, and 4 goldeneye in western Washington.
Season limit: 1 harlequin in western Washington.
[B] **Daily bag limit:** to include not more than 1 dusky Canada goose & 2 cackling geese in Areas 2A & 2B; and to include not more than 1 Aleutian goose in Area 2B.
Possession limit: to include not more than 1 dusky Canada goose & 4 cackling geese in Areas 2A & 2B; and to include not more than 2 Aleutian geese in Area 2 B.
Season limit: 1 dusky Canada goose. A dusky Canada goose is defined as a dark breasted (Munsell 10YR, 5 or less) Canada goose with a culmen (bill) length of 40-50 mm. A cackling goose is defined as a goose with a culmen (bill) length of 32 mm or less.

Table M-2. Willapa Refuge, Big Game Hunting Season Bag Limit Summary for 2010.

Species	Dates	GMU	Legal
General deer (black-tailed)	October 16-31	681, 684	2 pt. min.
		684	Any buck
Late deer (black-tailed)	November 18-21	681, 684	2 pt. min.
		684	Any buck
Early archery deer (black-tailed)	September 1-24	681	2 pt. min. or antlerless
		684	Any
Late archery deer (black-tailed)	November 24-December 8	681	2 pt. min. or antlerless
	November 24-December 15	699	Any deer
Early muzzleloader (black-tailed)	September 25-October 3	684	Any buck
Late muzzleloader (black-tailed)	November 25-December 15	684	Any deer
General elk	November 6-16	681, 684	3 pt. min.
Early archery elk	September 7-19	681, 684, 699	3 pt. min. or antlerless
Late archery elk	November 24-December 15	681, 699	3 pt. min. or antlerless
Early muzzleloader (elk)	October 2-8	684	Any elk
Late muzzleloader (elk)	November 24-December 15	684	Any elk
Black bear	September 1-November 15	699	2/season

M.5.10.4 Procedures for Consultation and Coordination with State

To ensure that hunted wildlife populations are sustainable, the WDFW annually reviews the population censuses to establish season lengths and harvest levels. In addition, Refuge staff conducts habitat management reviews of each unit to evaluate wildlife population levels, habitat conditions, and public use activities.

Information on the Refuge's hunt program will be published in the state's regulations. If a special permit hunt is required at Leadbetter Point Unit, the Refuge staff will consult and coordinate with the WDFW regional biologists to determine the number and type of elk to be removed.

M.5.10.5 Methods of Control and Enforcement

The hunting program is managed in strict accordance with all applicable federal laws (50 C.F.R. subchapter C) and to the extent practicable, consistent with applicable state laws.

Hunters will be required to obtain and hold a Refuge permit from the Refuge headquarters prior to hunting on specified units of the Refuge. Permitted hunters must report success/failure and any hit-but-not-retrieved animals when they turn in their Refuge permit tag each day. Refuge and Washington State Fish and Wildlife enforcement officers will patrol and check hunters to ensure they are complying with all regulations.

M.5.10.6 Funding and Staffing Required for the Big Game Sport Hunting Program

It is estimated the following level of involvement by Refuge staff will be required to adequately monitor and manage the hunt program. The costs to administer the new program are found in Table M-3.

Table M-3. Willapa Refuge, Funding and Staffing for the Hunting Program.

Position and GS/WG Level	Involvement	FTE	Cost
Project Leader/Deputy Project Leader (GS 12/13)	Oversight Coordination with Washington Department of Fish And Wildlife	.01	$ 1,000
Wildlife Biologist (GS-11)	Elk Monitoring, Reporting, Hunt Plan Updates	.05	$ 4,200
Refuge Manager (GS -11)	Oversight of Hunt Program, Field Monitoring of Hunters	.04	$ 3,200
Visitor Services Manager (GS-11) / Refuge Law Enforcement Officer (GS-9)	Hunt Plan Orientation, Law Enforcement	.02	$ 1,600
	Signs, posts, brochures, etc		$ 5,000
	Total Annual FTEs And Cost	.12	$14,800

The expansion and continuation of big game hunting would not require any new infrastructure or personnel. Administration of the hunt and annual coordination with the State of Washington would be required as would some law enforcement patrols; however, Refuge staff is in place and capable of conducting these duties. Revision and printing of the Refuge brochure, updating the Refuge website and other outreach information such as informational signage would be required at an estimated cost of $14,800. Base funding is available to cover these costs.

M.6 Measures Taken to Avoid Conflicts with Other Management Plans

M.6.1 Biological Conflicts/Impacts

M.6.1.1 Biological Environment

There are several minor impacts to the biological environment that would result from continuing the existing big game hunting program and expanding the hunt to areas as proposed.

Elk, deer, and bear are presently thriving in southwest Washington. There are open elk, deer, and bear hunting seasons for archery, modern firearms, and muzzleloaders. While the Refuge hunt would reduce some elk, deer, or bear, the increased hunting opportunities on the Refuge would not have an impact on the overall populations. According to WDFW, controlling elk and deer numbers would help diminish the spread of diseases and parasites. It would also help maintain shrub habitat, which benefits the elk themselves as well as other wildlife such as many birds and small mammals that depend on understory vegetation for food, nests, etc.

Bear will continue to be hunted only on Long Island. A small number of bear are harvested annually due to the archery-only hunt, and impact on the existing population should continue to remain small. Disease and parasites are not an obvious problem with the bear population on Long Island.

Based on discussions with WDFW, there are approximately 40 to 70 elk currently accessing and using the Leadbetter Point Unit. The population may fluctuate due to hunting pressure and disturbance on private property nearby. The number of elk using this unit has steadily increased, and elk numbers are expected to further increase through migration and reproduction. This additional hunt area on the Refuge would provide an opportunity for a high-quality elk hunt and would assist the state with controlling the expanding elk population, while having the added benefit of protecting essential habitat for western snowy plovers, streaked horned larks, and pink sandverbena.

This existing and proposed hunting use would result in temporary displacement of migratory birds and resident wildlife in the hunt areas. Other species which may be temporarily displaced by the existing and proposed hunting program include bald eagles, great blue herons, and other birds that reside in and near Refuge uplands.

Nearby resting and feeding areas would be available for use by waterfowl, migratory birds, and other resident wildlife species that are disturbed. These species would likely move to other areas of the Refuge which are less accessible to the hunters. The combination of limited duration of the proposed hunts and the ability of disturbed wildlife to move to secure habitat represents a minor disturbance to the above-mentioned species.

Due to the limited number of hunters and limited field time, no negative effects to vegetation or fish populations are anticipated.

M.6.1.2 Physical Environment

Hunting activities would not have an adverse impact to the physical environment of the Refuge. The limited numbers of people who would be hunting for the short time frames hunting is allowed would not be enough to cause damage to features such as soils, air quality, and water quality.

M.6.1.3 Social and Economic Environment

There are several minor impacts to the social and economic environment that would result from continuing and/or expanding hunting.

Effects to other public recreational uses are expected to be minimal due to the timing of the activities and limited duration of the hunt. The hunting seasons occur when other public uses are at a minimum because they are outside the main tourist season and generally occur during the seasonal inclement weather.

Maintaining and/or expanding hunting opportunities on the East Hills Units, South Bay Units, Nemah/Naselle Unit, and the Leadbetter Point Unit will complement some of the local state permitted hunting activities. While hunting activity is not expected to increase according to surveys described in Chapter 5 of the CCP, expanding hunting opportunities may result in a slight increase in hunting visitation to the area and enhancement to the local economy.

Overall, hunting on the Refuge would provide increased opportunities for quality wildlife-dependent recreation. The hunt activity would have minor positive benefits to local economy and reduce impacts to the agricultural community. The expanded elk hunt for the Leadbetter Point Unit would create a temporary closure to other public uses, but this impact would be temporary and short in duration and would occur outside the regular tourist season.

M.6.2 Public Use Conflicts

There are several minor public use conflicts that will result from continuing the existing and expanded hunting areas proposed in the management direction of the CCP.

Effects to other public recreational uses are expected to be minimal due to the timing of the activities and limited duration of the hunting seasons. The hunting seasons occur when other public uses are at a minimum because they are outside the main tourist season and generally occur during the seasonal inclement weather. On the East Hills and South Bay units, many of the areas used for elk and deer hunting are not easily accessible to general public. Access to the Long Island Unit requires a boat, and use of the island during fall’s wet weather declines drastically for non-hunting recreation.

The current headquarters area (and proposed new headquarters area), where trails and visitor information kiosks exist, will remain closed to all hunting activity. Wildlife viewers and photographers will have access to the South Bay units through the new office/visitor center, and associated trail and observation deck, and trail to Porter Point. Therefore, it is not anticipated that any existing or proposed hunting opportunities will impact nor create a safety problem with other public uses.

At the Leadbetter Point Unit, some noise from the muzzleloaders may be experienced from the public on the adjacent Washington State Parks lands, and the public may occasionally observe elk or other wildlife species flushed into the open due to hunter activity. Refuge staff will, in advance, post signs and notify the public via media regarding the closure to all other activities on the unit during the elk hunt(s). The hiking trails and waterfowl hunting will be closed to other users during the short muzzleloader season. The closure is for safety purposes and to reduce potential user conflicts, but this hunt is only for a limited time period and occurs when the trails are flooded due to seasonal rains. Again, due to the limited scope and timing of the existing and proposed elk hunt program, all effects are expected to be minor and of short duration.

Without elk hunting on the Refuge, the herd is expected to grow. As the herd increases and outgrows the available habitat on the Refuge, the elk and deer may move off the Refuge into the surrounding areas in search of food. The largest economic impacts of elk in particular are felt in the agriculture industries. Elk and deer may cause damage to local crops and residential landscaping. Other incidental negative economic impacts of elk/deer include elk/deer-vehicle collisions and damage to fences. Implementing this hunt is expected to reduce the negative impacts a larger population of elk/deer may have to the local community.

For the most part, although bears are known to cross the narrow channel between the island and the mainland, most Long Island bears generally remain confined to the island. Bear/human conflicts have occurred on the Long Beach Peninsula but have not been reported from Long Island.

M.6.3 Administrative Conflicts

At this time, no administrative conflicts are anticipated. The Refuge currently has a successful big game hunting program.

M.7 Conduct of the Hunt

M.7.1 Refuge-specific Hunting Regulations

Willapa National Wildlife Refuge (50 C.F.R. Part 32.67). (These regulations will be updated once the tidal restoration of the South Bay Units and expanded hunting opportunities occur.)

A. Migratory Game Bird Hunting. We allow hunting of geese, ducks, coots, and snipe on designated areas of Riekkola, Lewis, Tarlatt Slough, and Leadbetter units in accordance with state hunting regulations and subject to the following conditions:

1) Prior to entering the hunt area at the Riekkola and Tarlatt Slough Units, we require you to obtain a Refuge permit, pay a recreation user fee, and obtain a blind assignment.
2) At the Riekkola and Tarlatt Slough Units, you may take ducks and coots only coincidental to hunting geese.
3) We allow hunting on Wednesday and Saturday in the Riekkola and Tarlatt Slough Units only from established blinds.
4) At the Lewis Unit, we prohibit hunting from the outer dike that separates the Bay from the freshwater wetlands.
5) At the Riekkola and Tarlatt Slough Units, you may possess no more than 25 approved nontoxic shells per day while in the field.
6) At the Leadbetter Unit, you may possess only approved nontoxic shot.

7) You may not shoot or discharge any firearm from, across, or along a public highway, designated route of travel, road, road shoulder, road embankment, or designated parking area.

B. Upland Game Hunting. We allow hunting of blue and ruffed grouse on Long Island, subject to the following conditions:

1) We require you to obtain and carry a Refuge permit and report game taken, as specified with the permit.
2) We allow only archery hunting.
3) We do not allow firearms on Long Island at any time.
4) We do not allow dogs on Long Island.
5) Condition A7 applies.

C. *Big Game Hunting.* We allow hunting of deer, elk, and bear on Long Island, and deer and elk only on designated areas of the Refuge north of the Bear River and east of Willapa Bay, in accordance with state regulations subject to the following conditions:

1) At Long Island you must possess a valid Refuge permit and report game taken, as specified with the permit.
2) At Long Island we allow only archery hunting and prohibit firearms.
3) We prohibit bear hunting on any portion of the Refuge except Long Island.
4) We prohibit dogs on the Refuge
5) You may not shoot or discharge any firearm from, across, or along a public highway, designated route of travel, road, road shoulder, road embankment, or designated parking area.

We allow hunting of waterfowl, coot, snipe, deer, elk, bear, and grouse (ruffed and blue) on specific designated units of the Refuge in accordance with state regulations subject to the following conditions:

- Law enforcement patrols to ensure compliance with regulations will be conducted. State fish and wildlife officers also patrol the Refuge.
- Harvest and season lengths are established by the state of Washington.
- Hunters are expected to comply with all current applicable state and Refuge regulations. This will be achieved through a combination of printed information, signage, outreach efforts, and enforcement of regulations by state and Refuge law enforcement officers.
- Refuge and WDFW staff will consult on issues regarding law enforcement and any significant changes in the number or behavior of wildlife.
- An Endangered Species Act Section 7 Consultation must be completed.
- Camping, overnight use, and fires are prohibited except in the designated campsites on Long Island.
- Access to the hunting areas will be by boat and/or foot access only.
- All hunters are required to use only federally approved nontoxic shot while waterfowl hunting. Use or possession of lead shot is prohibited while hunting waterfowl.
- Hunters may use dogs to aid in retrieval of birds, but dogs will need to be kept under control at all times.

- Hunters may set up temporary blinds/tree stands along the shoreline which must be removed at the conclusion of each hunting period.
- Additional help will be allowed to retrieve a downed elk.

Leadbetter Point Unit:

- All hunters participating in the elk hunt will be required to obtain a Refuge permit from Refuge headquarters and receive a brief orientation of boundaries and Refuge regulations.
- Hunters will be required to park at the existing parking lot and will be required to walk into the unit; no motorized vehicles are allowed to assist.
- Hunters will be required to return their Refuge hunt permit at the end of the day/trip, reporting any success/failure and any hit-but-not-retrieved animals.
- During the hunt, the entire unit will be closed to other users including waterfowl hunters and hikers during the approximately five-day early elk muzzleloader season.
- To limit the distance a missed shot would travel, only muzzleloader hunting would be permitted. (Archery is not a preferred option because of the likelihood of injured animals moving into public viewing areas, which would increase the likelihood of conflicts between hunters and other users. In addition, archery hunters generally have a lower success rate, which is less likely to take sufficient animals to reach management goals.)

M.7.2 Anticipated Public Reaction to the Hunting Program

Public reaction to hunting is expected to be mixed. There is a consistent desire among certain segments of the public to open more federally managed property, including the Refuge, to hunting. There are very few places in the state of Washington where elk hunters are encouraged in specified areas to take cows and small bulls. Limited hunting opportunities on the peninsula and in other areas should make the expansion of the hunt areas highly desirable among hunters, as hunters would not be crowded and should have an excellent chance at a successful hunt.

Other members of the public are expected to object to the hunting program on the grounds that a Refuge should be "a safe haven" for wildlife with no hunting permitted. One argument often made is to relocate the deer and elk. The WDFW has stated that they no longer conduct relocations for elk or deer. Across the state of Washington, elk are increasingly causing damage to private and commercial property including orchards and landscaping. In addition, elk relocation in the past has proven to be a very expensive option to implement annually and is not considered a feasible long-term solution to the problem; the Refuge is limited on how to manage the growing elk population.

Some members of the public may object because they enjoy viewing and photographing the waterfowl, elk, deer, and bear. The hunters would be on the Refuge for a very limited time, and the waterfowl, elk, deer, and bear would be available to photograph in many other areas of the Refuge and throughout the year.

There may be some opposition to elk hunting on the Refuge by area cranberry growers as they may have concerns that the pursued elk may relocate to and impact their cranberry bogs.

M.7.3 Hunter Application and Registration Procedures

Hunters would apply through the WDFW application processes, and in addition obtain a Refuge hunting permit from the Refuge headquarters.

M.7.4 Description of Hunter Selection Process

The Refuge will be open to those with valid Washington State hunting license. If a special permit hunt is necessary, all permits will be issued according to WDFW regulations and application process.

M.7.5 Media Selection for Announcing and Publicizing Hunting

The hunting regulations specific to the Willapa Refuge will be published in the Washington State Big Game and Migratory Waterfowl & Upland Game pamphlets. Press releases will be issued by the Refuge to local newspapers including *The Daily News* in Longview, the *Wahkiakum Eagle*, the *Pacific County Press*, the *Daily Astorian*, and the *Chinook Observer* in Long Beach. The Refuge's website will be posted and updated with current hunting information.

M.7.6 Description of Hunter Orientation, Including Pre-hunt Scouting

Hunters will be required to obtain a Refuge permit from the refuge headquarters office. At this time a pre-hunt orientation of the Refuge will be given. The orientation will include:

- A review of Refuge-specific regulations.
- Description of check-in and check-out procedures.
- Handout containing maps and/or aerial photographs of Refuge.
- Description of the access areas and location on the maps.
- A review of maps/aerial photographs of the Refuge to familiarize hunters with potential safety issues.
- Description of the current numbers and general location of the elk herd.
- Review areas (using maps/aerial photos) that have may have sensitive wildlife. Request hunters avoid those areas has much as possible.
- Hunters will be able to scout the Refuge after receiving their maps/aerial photos prior to actual hunt days.

M.7.7 Requirements for Hunting

M.7.7.1 Age

Age restrictions will be in accord with WDFW regulations.

M.7.7.2 Allowable Equipment

- Hunters will only be allowed to use muzzleloaders for the Leadbetter Point Unit. Archery only hunting is allowed on Long Island. Hunting in the East Hills and South Bay Units is in accordance with the state regulations.
- Weapons must comply with all Washington State weapon restrictions.

- Dogs, other than certified assistance dogs, are prohibited on the Refuge except while hunting waterfowl.
- Vehicles must remain on county or state roads or in the parking lot at all times.
- No motorized vehicles are permitted on the Refuge.
- All hunters are required to use only federally approved nontoxic shot while waterfowl hunting. Use or possession of lead shot is prohibited while hunting waterfowl.
- Hunters may set up temporary blinds/tree stands along the shoreline, which must be removed at the conclusion of each hunting period.
- Access to the hunting areas will be by boat and/or foot access only. Use of bicycles is also permitted on logging roads/trails on Long Island and in the East Hills Units, except for the Cedar Grove, Teal Slough and Willapa Interpretive Art trails.

M.7.7.3 Use of Open Fires

All open fires are prohibited.

M.7.7.4 License and Permits

All hunters will need a valid Washington State hunting license. All deer/elk/bear/grouse hunters on Long Island and elk hunters on Leadbetter Point Unit will also need a Refuge hunting permit. Currently, all goose hunters at the Riekkola Unit must have a Refuge permit. Once the South Bay restoration is complete, no Refuge permit will be needed.

M.7.7.5 Reporting Harvest

Hunters must report hunting success, failure, or any injured-but-not-retrieved target species to Refuge headquarters at the end of each day/trip. Hunters must fulfill all WDFW reporting requirements.

M.7.7.6 Hunter Training and Safety

Hunters must fulfill all state requirements for training and hunter safety classes.

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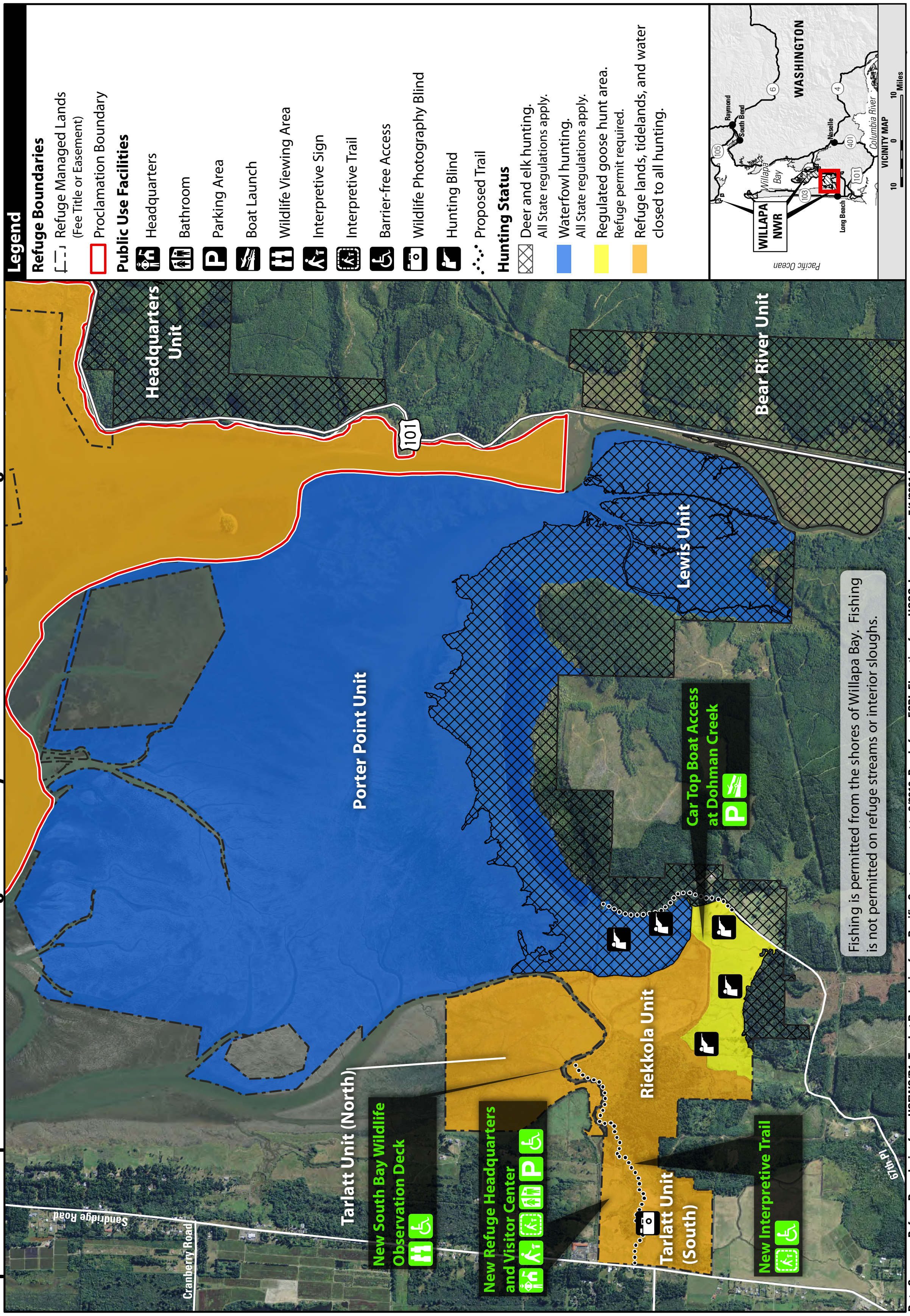
Map M-1. Willapa National Wildlife Refuge South Bay Units Public Use under Management Direction.



Data Sources: Refuge Boundaries from USFWS/R1; Tax Lot Boundaries from Pacific County, current to 3/2010; Roads from ESRI; Elevation from USGS; Imagery from 7/1/2001 Landsat

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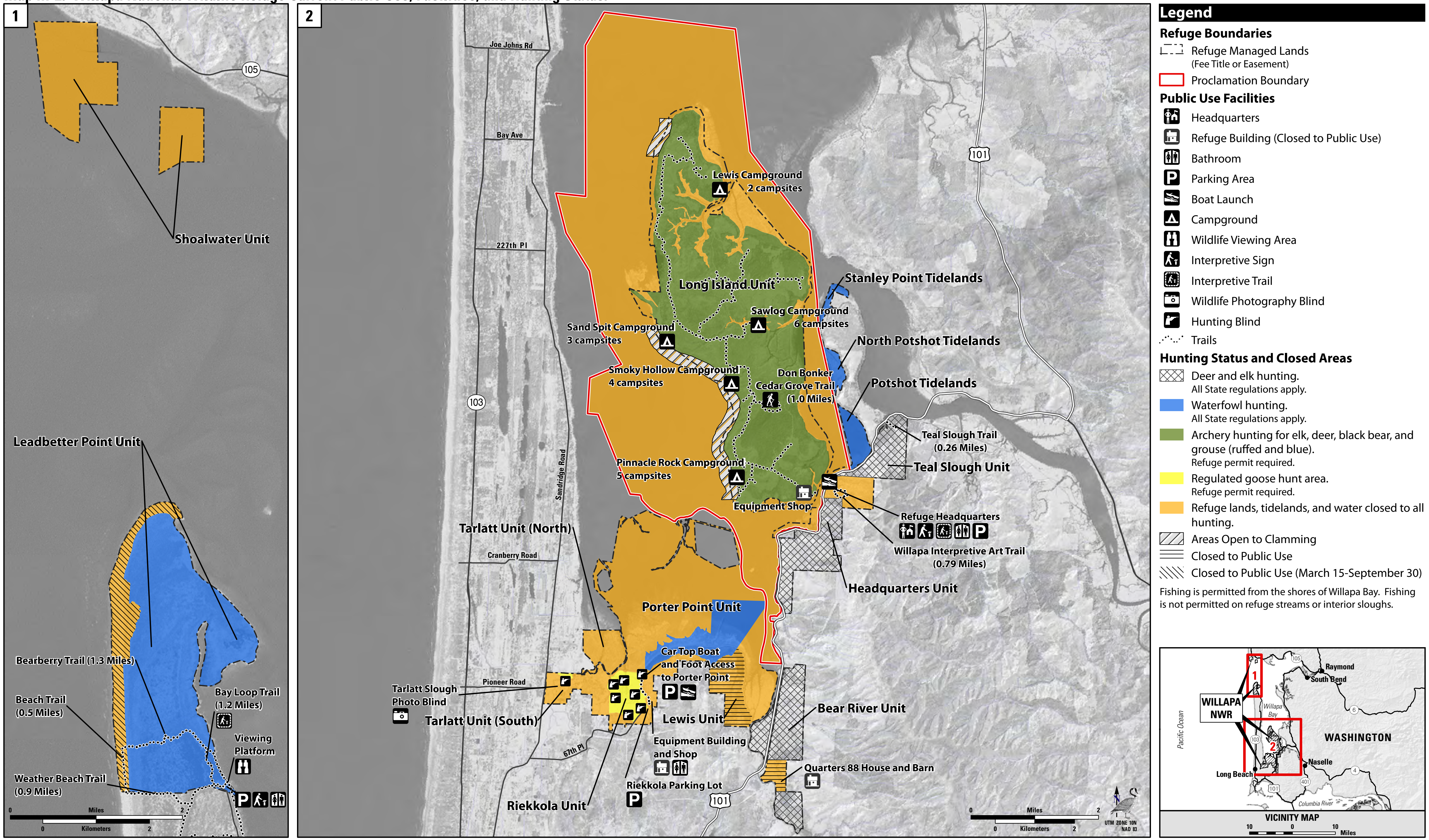
Map M-2. Willapa National Wildlife Refuge Current Public Use, Facilities, and Hunting Status.



Data Sources: Refuge Boundaries from USFWS/R1; Hydrology from NHD USGS; Roads from ESRI; Imagery fom 07/01/2001 Landsat

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Appendix O. Estuarine Restoration Plan

BEAR RIVER ESTUARY RESTORATION DRAFT BIOLOGICAL EVALUATION

Report

Prepared for:

Willapa Bay Regional Fisheries Enhancement Group

August 2, 2010

www.cherrycrk.com

Bear River Estuary Restoration
Draft Biological Evaluation

REPORT

Prepared for:

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TABLE OF CONTENTS

1.0 Introduction 1
2.0 Project Description 2
2.1 Project and Action Areas 3
2.2 Proposed Action Description 3
2.2.1 Proposed Construction 4
2.2.2 Project Timeline 4
2.2.3 Conservation Measures 5
3.0 Existing Environmental Conditions and Effects of the Action 5
3.1 General 5
3.1.1 Existing Conditions 5
3.1.2 Effects of the Action 6
3.2 Water Quality 7
3.2.1 Existing Conditions 7
3.2.2 Effects of the Action 7
3.3 Sediment, Substrate, and Bathymetry 8
3.3.1 Existing Conditions 8
3.3.1 Effects of the Action 8
3.4 Access and Refugia 8
3.4.1 Existing Conditions 8
3.4.2 Effects of the Action 8
3.5 Slope, Shoreline Condition, and Habitat Diversity 9
3.5.1 Existing Conditions 9
3.5.2 Effects of the Action 9
3.6 Flow, Current Patterns, Saltwater–Freshwater Mixing 9
3.6.1 Existing Conditions 9
3.6.2 Effects of the Action 9
3.7 Vegetation 10
3.7.1 Existing Conditions 10
3.7.2 Effects of the Action 10

3.8 Benthic Epifauna 10
3.8.1 Existing Conditions 10
3.8.2 Effects of the Action 10
3.9 Forage Fish 11
3.9.1 Existing Conditions 11
3.9.2 Effects of the Action 11
4.0 Evaluation of Effects on Listed Species 11
4.1 North American Green Sturgeon 11
4.1.1 Stock Status and Critical Habitat 11
4.1.2 Use of the Action Area 11
4.1.1 Effects of the Action 12
4.1.2 Effect Determination 12
4.2 Bull Trout 12
4.2.1 Stock Status and Critical Habitat 12
4.2.2 Use of the Action Area 12
4.2.3 Effects of the Action 12
4.2.4 Effect Determination 13
4.3 Marbled Murrelet 13
4.3.1 Population Status and Critical Habitat 13
4.3.2 Use of the Action Area 13
4.3.3 Effects of the Action 13
4.3.4 Effect Determination 13
4.4 Western Snowy Plover 14
4.4.1 Population Status and Critical Habitat 14
4.4.2 Use of the Action Area 14
4.4.3 Effects of the Action 14
4.4.4 Effect Determination 14
4.5 Streaked Horned Lark 14
4.5.1 Population Status 14
4.5.2 Use of the Action Area 14
4.5.3 Effects of the Action 15

4.5.4 Effect Determination 15
5.0 Interrelated and Interdependent Actions and Cumulative Effects 15
6.0 Summary 15
7.0 Cultural Resources Assessment 16
8.0 References 17

Appendices

Appendix A — ESA Species List

Appendix B — Design Sheets

Appendix C — Construction Narrative

Appendix D — Species Life Histories

Appendix E — EFH Assessment

Appendix F — Cultural Resources Assessment

BEAR RIVER ESTUARY RESTORATION
DRAFT BIOLOGICAL EVALUATION

EXECUTIVE SUMMARY

The Willapa Bay Regional Fisheries Enhancement Group is applying for a permit from the U.S. Army Corps of Engineers (Corps) to restore 760 acres of intertidal area and obtaining the Corps permit will require compliance with the Endangered Species Act. The restoration will occur by removing about 5.74 miles of existing dike, 38 culverts, 2 fish ladders, 2 tide gates, and 2 foot bridges, and reconnect 18 estuary channels at the southern end of Willapa Bay, just west of the mouth of the Bear River. Increases in noise levels and increases in turbidity during construction have the potential to impact species listed under ESA, but best management practices would be used to reduce these impacts. Therefore, this biological evaluation reaches the following conclusions:

- may affect, not likely to adversely affect North American green sturgeon (*Acipenser medirostris*) or its designated critical habitat;
- may affect, not likely to adversely affect bull trout (*Salvelinus confluentus*) or its designated critical habitat;
- may affect, not likely to adversely affect marbled murrelets (*Brachyramphus marmoratus marmoratus*) or its designated critical habitat; and
- will have no effect on Western snowy plover (*Charadrius alexandrinus nivosus*).

1.0 INTRODUCTION

The Willapa Bay Regional Fisheries Enhancement Group (WBRFEG) is applying for a permit from the U.S. Army Corps of Engineers (Corps) to restore 760 acres of intertidal area. The restoration will occur by removing about 5.74 miles of existing dike, 38 culverts, 2 fish ladders, 2 tide gates, and 2 foot bridges, and reconnect 18 estuary channels at the southern end of Willapa Bay, just west of the mouth of the Bear River. Because this work requires a Section 10 permit from the Corps, it qualifies as an action by a federal agency, and must comply with Section 7 of the Endangered Species Act (ESA). Section 7 of the ESA requires that "actions" of federal agencies should be "not likely to jeopardize the continued existence of any [listed] species or result in the destruction or adverse modification of habitat of such species." Issuance of permits by federal agencies is considered an "action" and therefore falls under this requirement. Under ESA Section 7(c), the Corps is required to produce a biological evaluation (BE) of the potential influence of its action (issuing the permit) on listed species or their critical habitat. To help the Corps evaluate the potential effects of the proposed project on listed species, Cherry Creek Environmental (CCE), has prepared this BE on behave of WBRFEG.

To determine if listed species or their critical habitat are present in the vicinity of the proposed project, on June 28, 2010 CCE consulted the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS 2010); and the U.S. Fish and Wildlife Service (USFWS 2010). Based on information from NMFS and USFWS (Appendix A), the following listed species may occur in the vicinity of the proposed project and are therefore addressed in this BE:

- North American green sturgeon (*Acipenser medirostris*);
- Bull trout (*Salvelinus confluentus*);
- Marbled murrelet (*Brachyramphus marmoratus marmoratus*); and
- Western snowy plover (*Charadrius alexandrinus nivosus*).

Streaked horned lark (*Eremophila alpestris strigata*), a candidate species, will also be addressed. Should the lark become listed during the life of the proposed project, this BE could be used to aid the Corps during any subsequent Section 7 consultation with USFWS.

Based on information from NMFS and USFWS (Appendix A), the following listed species may occur in Pacific County. Because the following species are found on the outer coast or their habitat requirements do not exist in the vicinity of the proposed project, they are not addressed in the BE:

- Columbia River smelt (*Thaleichthys pacificus*);
- southern resident killer whale (*Orcinus orca*)
- humpback whale (*Megaptera novaeangliae*)
- blue whale (*Balaenoptera musculus*)
- fin whale (*Balaenoptera physalus*)
- sei whale (*Balaenoptera borealis*)
- sperm whale (*Physeter macrocephalus*)
- Steller sea lion (*Eumetopias jubatus*);
- leatherback sea turtle *(Dermochelys coriacea)*
- green sea turtle (*Chelonia mydas)*
- olive ridley sea turtle (*Lepidochelys olivacea)*
- loggerhead sea turtle *(Caretta caretta)*
- brown pelican (*Pelecanus occidentalis*)
- northern spotted owl (*Strix occidentalis caurina*);
- Oregon silverspot butterfly (*Speyeria zerene hippolyta*); and
- short-tailed albatross (*Phoebastria albatrus*)

2.0 PROJECT DESCRIPTION

This section provides a brief description of the proposed project area and proposed action.

2.1 Project and Action Areas

The "project area" is within the Willapa National Wildlife Refuge (Refuge) in Pacific County, Washington at Township 10 North, Range 11 West, Sections 1, 6, 7, 11, and 12 and Township 10N, Range 10W, Section 6. The project area is within the Lewis, Porter Point, and Riekkola Units in the Refuge at the southern end of Willapa Bay, just west of the mouth of Bear River. Aerial photographs of the project area and design sheets are in Appendix B.

The "action area" for fish resources is defined as extending from mean higher high water out to the minus 30 feet mean lower low water (MLLW) depth contour, which is the elevation where open water channel depths begin (WNWR 2010). The action area for avian species is defined as a 1-mile radius around the project area.

2.2 Proposed Action Description

Historically, the project site was tidally connected to Willapa Bay. During the late 1940's and early 1950's a large portion of area's salt marsh habitat was eliminated by diking to create pasture lands and freshwater wetlands, believed to enhance overall waterfowl use of the refuge and increase land available for agricultural production. The dike was constructed by excavating a borrow ditch along the shoreward side of the dike. The dike has substantially reduced the amount of historical shoreline habitat and serves as a barrier, reducing nutrient input to the estuary and interrupting the physical, chemical and biological processes of the estuarine system. The conversion of estuarine wetlands to freshwater wetlands and pasture by diking has removed important natural habitat for waterfowl, waterbirds, shorebirds, and salmon as well as many other estuarine-dependent species. Construction of the dike also eliminated fish access to 3 small streams; Lewis Stream, Porter Point Stream and Dolman Creek to the estuary. In 2001, fish ladders were installed into the dikes to restore some fish passage to these creeks.

The proposed project would remove 5.74 miles of existing dike, 38 culverts, 2 fish ladders, 2 tide gates, and 2 foot bridges, and reconnect 18 estuary channels; resulting in up to 760 acres of restored estuarine habitat. Construction details are depicted in Appendix B. The resorted habitat includes reconnection of stream channels to the estuarine environment, open water, intertidal flats, and saltmarsh. The proposed project would provide unrestricted tidal exchange and channels currently isolated landward of the dike will be reconnected to the estuary. The proposed project will assist in improving and maximizing the current estuarine system and contribute to the health of the bay and associated habitats. In addition, the proposed project would reduce or eliminate the extent of a highly invasive exotic plant, reed canarygrass, which currently infests the refuge's freshwater impoundments. Similarly, tussock infestation will also be reduced. Other exotic species, including nutria and bullfrogs, which currently use the freshwater ponds landward of the dike will be eliminated by restoration of estuarine habitat. Juvenile salmon habitat will be restored and other expected benefits include increased waterfowl, waterbird, and shorebird use. Finally, protection and restoration of native estuarine and nearshore habitats is a major ecoregional and recovery goal in the Pacific Northwest Coast Ecoregional Assessment (TNC and WDFW 2006) and the Northern Pacific Coast Regional Shorebird Management Plan (Drut and Buchanan 2000).

2.2.1 Proposed Construction

The project would be accomplished by removal of dikes, culverts, fish ladders, and tide gates within the Lewis, Porter Point and Riekkola Units in the Refuge. Dikes will be removed completely to grade and material will be removed or used to fill in the associated borrow ditch. Approximately 114,812 cubic yards of fill from the dike will be placed back into the borrow ditch. Fish ladders and tide gates would be demolished and taken off-site for disposal and/or recycling. Heavy equipment utilized will include excavators, bulldozers, scrapers, and agricultural tractors. A detailed narrative of construction techniques and sequencing is in Appendix C. In summary, the first phase of construction would remove a portion of the dike fill, which will create a wider area for construction traffic than driving on the existing top of the dike. Construction would begin at the southern side of the project area, in the Lewis Unit and work northward/westward. In addition to removing the dike, the fish ladders and tide gates will be demolished. The demolished fish ladders and tide gates will be disposed of off-site at an approved location or recycled. Channels will be excavated as close as possible to their historic locations and have been sized so that tidal processes would accelerate the establishment of natural topography and vegetation.

Throughout the project, dewatering will need to occur. Dewatering techniques will be up to the contractor, but the recommended method (Appendix B) will be to create temporary culverts with tide gates. These would be placed in the constructed channels to allow construction traffic access during removal of the dikes and filling of the borrow ditch. This dewatering option would place the culvert and tide gate in the new channel location, Installation of riprap armoring may be necessary during construction, but would be removed when the temporary culvert and tide gate is removed.. As construction within weach unit is completed, these temporary culverts and tide gates would be removed and the channel enlarged to the required design. The advantage to this approach is that it is a passive and automatic approach that maintains the separation between the landward and waterward sides of the dike system.

2.2.2 Project Timeline

The proposed project would be constructed in phases, with each phase occurring during the in-water work window. Since there are three phase, the overall construction period is anticipated to last 3 years. Assuming all permits are received, the project would begin during the in-water work window of 2011. As stated above, work would begin at the southern end of the project area in the Lewis Unit. Removal of the dike and one of the fish ladders within the Lewis Unit would be finished by the end of the 2011 in-water work window. Construction would then stop until the beginning of the 2012 in-water work window. The cross-dike, located between the Lewis and Porter units would remain in place to serve as a sea dike until the 2012 in-water construction season. During 2012, work within the Porter Unit is expected to occur. That is, dike removal work would begin where it was left off during the 2011 construction season and second fish ladder would be removed with construction continuing to work northward/westward. Removal of the dike and one of the fish ladders within the Porter Unit would be finished by the end of the 201in-water work window. Construction would then stop until the beginning of the 2012 in-water work window. During 2013, work within the Riekkola Unit is expected to occur. That is, dike removal work would begin where it was left off during the 2012 construction season and the proposed project would be completed by 2013.

Prior to leaving the site at the end of each in-water work window, the active construction area would be stabilized to reduce erosion.

2.2.3 Conservation Measures

To avoid impacts to aquatic species, construction would occur during the in-water work window and occur in the dry as much as possible. Although work would occur below the ordinary high water mark, material would not likely be placed when tidal waters have inundated the project area. Additionally, WBRFEG proposes to monitor water quality and dike erosion during and following the first construction season. This information would be used in adaptive management for subsequent phases of construction (AMEC 2010).

Vehicles used in the project area will be routinely inspected for petroleum product or hydraulic fluid leaks, and defective equipment will be serviced before being allowed back into the project area.

3.0 EXISTING ENVIRONMENTAL CONDITIONS AND EFFECTS OF THE ACTION

Presented below are discussions of existing environmental conditions and temporary, permanent, direct, indirect, and net effects of project activities. This section addresses only environmental attributes and habitat qualities important to listed species that may be present in the action area and likely to be affected by the project in some way.

3.1 General

This section describes existing general environmental conditions and effects of the proposed action on the general environmental conditions of the action area.

3.1.1 Existing Conditions

The Bear River Estuary, located in Willapa Bay, is part of the Willapa National Wildlife Refuge. Willapa Bay is the second largest estuary on the Pacific Coast and is one of the most pristine estuaries in the United States. The refuge is over 15,000 acres of tidelands, temperate rainforest, ocean beaches and small streams. Within the project area the site can be divided into three areas; the Lewis Unit, the Porter's Point Unit, and the Riekkola Unit.

Freshwater impoundments were created behind the dike in the Lewis and Porter's Point units and their water levels are managed to provide freshwater foraging areas for migrating waterfowl, mostly ducks (USFWS 2010). Small seasonal freshwater wetlands are also maintained in the Riekkola Unit. Use of the freshwater impoundments by waterbirds other than waterfowl, include grebes, herons, bitterns, and rails. These shallow, vegetated wetlands provide breeding habitat for red-legged frogs, Pacific tree frogs, roughskin newts and northwestern salamanders. River otters and non-native nutria also use the freshwater impoundments.

Three small streams; Lewis Stream, Porter Point Stream and Dolman Creek flow from the foothills south of the project area to the estuary. However their historic connection was cut off and altered by the dike. To improve fish passage to these streams, fish ladders were installed in 2001. Although the fish ladders have improved fish passage, the conversion of estuarine wetlands to freshwater wetlands and pasture by diking has removed important natural transition habitat from freshwater streams and wetlands to estuaries.

The intertidal portion of the project area is dominated by mudflats and salt marsh. The mudflats consist of fine sediment combined with organic matter. Intertidal mudflats support an abundance of prey invertebrates including oysters, clams, mussels, amphipods, polychaete and oligochaete worms, insect larvae and nematodes. Foraging shorebirds follow the receding tide across the mudflats and fish and waterbirds frequent the mudflats when they are flooded to forage and find refuge (WNWR 2010).

The upper edges of the intertidal flats are ringed by salt tolerant plants which serve as sediment traps and add much organic matter to the estuarine system. Juvenile salmon and other fish find an abundance of food in the marshes, as well as shelter from strong currents and predators. Bald eagles, great blue herons, and other predators are attracted to the abundance of life. The productivity of the marshes is critical to the health of the estuary (WNWR 2010). It is estimated that Willapa Bay originally contained approximately 14,620 acres of saltwater wetlands, but only 5,277 acres remain, a 64% loss of estuarine wetlands (Coastal Resources Alliance 2007 as cited in (WNWR 2010).

No information on ambient noise levels in the Action Area was identified. A WSDOT noise assessment on the San Juan Islands identified a baseline of about 35 dBA, with regular noise intrusions from traffic and aircraft overflights ranging from 45 to 72 dBA (WSDOT 1994). Noise levels from breaking waves has been measured at levels ranging from 55 dBA to 80 dBA (Allan and Komar 2000; Bolin 2009; Tetra Tech 2005). For the purposes of evaluating ambient noise levels within the Project Area, it is assumed that background noise would likely be about 40 dBA.

3.1.2 Effects of the Action

Existing vegetation on the dikes will be permanently removed during the proposed action. Disturbed soils are expected to be colonized quickly by salt tolerant vegetation or converted to intertidal mudflats or stream channels. The streams will be directly reconnected to the estuary through reconstruction of stream channels where the dike was previously. The reconstructed stream channels are designed to provide efficient and unrestricted tidal exchange and effective low tide drainage. This will provide a vast improvement to fish passage in comparison to the existing conditions. Once the dike removal is complete, the proposed project would restore about 760 acres of land to estuarine open water, salt marsh, and intertidal flats.

A variety of construction equipment will likely be used in the project area, depending on the activity that is occurring. Based on average maximum noise levels of different construction equipment, noise levels associated with construction are likely to be around 80 dBA (WSDOT 2010). Based on existing site conditions, an estimated ambient noise level o f40 dBA, and a maximum construction noise level of 80 dBA, construction noise would attenuate to ambient levels at a distance of 15,811 feet. The increased noise level would be temporary and only occur during active construction). Terrestrial animals not used to the increased noise may avoid the immediate work area. Since the construction is occurring in the dry there will be no appreciable increases in underwater noise.

3.2 Water Quality

This section describes existing conditions and expected effects of the proposed action related to water quality in the action area.

3.2.1 Existing Conditions

No information on existing water quality in the action areas was identified. Dissolved oxygen and high temperatures have been determined to be limiting factors affecting the aquatic habitat and fish in the Willapa system (Ecology 2008a), although the action area is not on Ecology's 303d list for these or any other parameters (Ecology 2008b).

3.2.2 Effects of the Action

During active construction and shortly afterward, temporary increases in turbidity are likely to occur. Construction techniques (e.g. dewatering) would be implemented to reduce increases in turbidity. The increases in turbidity are not expected to persist long after construction. Construction activities are not expected to alter dissolved oxygen or temperature conditions in the Action Area. To ensure construction does not significantly impact water quality during construction, temperature, turbidity, and fecal coliform levels would likely be monitored as part of the Hydraulic Project Approval permit.

3.3 Sediment, Substrate, and Bathymetry

This section describes existing conditions and expected effects of the proposed action related to sediment, substrates, and bathymetry in the action area.

3.3.1 Existing Conditions

The dike was constructed mostly with site soils and some imported fill material. Landward of the dike, the substrate is likely fine grained with a high organic content because the area is cut off from tidal exchange and high flows, and is routinely planted with aquatic vegetation. Waterward of the dike, the area is tidal saltmarsh and mudflat. Since the project area was diked and drained, the surface has subsided by approximately 1-3 ft below the natural marsh elevation of mean higher high water (9 ft NAVD) (Vandever 2010).

3.3.1 Effects of the Action

The proposed project will remove the dike, changing surface elevations along the dike from upland to intertidal. Sediment transport will be restored to conditions similar to what existed prior to the construction of the dike. With the removal of the dike and reconnection of the stream channels, bathymetry will be restored to historic or near historic conditions. Removal of the dike will allow tidal exchange to be restored. It is anticipated that the removal of the dike and restoration of tidal exchange, over time, may return the salt marsh surface elevation to the natural elevations of the salt mash outside of the action area.

3.4 Access and Refugia

This section describes existing conditions and expected effects of the proposed action related to refugia and access in the action area.

3.4.1 Existing Conditions

The conversion of estuarine wetlands to freshwater wetlands and pasture following construction of the dikes has eliminated refuge habitat for waterfowl, waterbirds, shorebirds, and estuarine fish (e.g. juvenile salmon, juvenile flatfish, crabs). Three small streams, Lewis Stream, Porter Point Stream and Dolman Creek no longer had a direct connection to the estuary. In 2001, WBRFEG and the Refuge received grants funding to install the two fish ladders in the dikes. Installation of the fish ladders allowed salmonids to access and refuge habitat in the freshwater ponds landward of the dike, but their movements are still restricted from their historical spawning and rearing areas.

3.4.2 Effects of the Action

During construction the temporary culverts would allow access to the freshwater ponds and streams while the fish ladders are removed. Once the dike removal is complete, the proposed project would restore about 760 acres of land to estuarine open water, salt marsh, and intertidal flats available for access and refuge for fish and wildlife.

3.5 Slope, Shoreline Condition, and Habitat Diversity

This section describes existing conditions and expected effects of the proposed action related to habitat diversity, slopes, and shoreline conditions in the action area.

3.5.1 Existing Conditions

Construction of the dikes converted about 760 acres of land from estuarine open water, salt marsh, and intertidal flats to freshwater ponds, freshwater wetlands, and pasture. The conversion from estuarine habitats to freshwater/upland habitats reduced habitat diversity. Landward of the dikes, the site is currently infested with invasive plant species such as reed canarygrass and tussock and animal species such as nutria and bullfrogs. Waterward of the dike, beyond the dike footprint, the action area is relatively flat and consists of salt marsh, mudflats, and open water.

3.5.2 Effects of the Action

Removal of the dike will restore about 760 acres of land to estuarine open water, salt marsh, and intertidal flats, restore the unrestricted tidal exchange to the three small creeks, and reduce or eliminate non-salt tolerant invasive plants, such as reed canarygrass and tussock and animals, like bullfrogs and nutria within the action area. The proposed project does not include planting the area with native salt marsh vegetation. The Refuge has an existing spartina elimination program and will monitor the site for spartina infestation and eradicate any infestation.

3.6 Flow, Current Patterns, Saltwater–Freshwater Mixing

This section describes existing conditions and expected effects of the proposed action related to flow, current patterns, saltwater–freshwater mixing in the action area.

3.6.1 Existing Conditions

Construction of the dikes and installation of the tide gates altered and reduced the saltwater-freshwater mixing zone and altered current patterns. Currently, saltwater-freshwater mixing s limited within the project area to the areas waterward of the dikes.

3.6.2 Effects of the Action

The proposed project will result in the unrestricted tidal exchange within the project area currently isolated behind the dikes. The proposed project would assist in restoring the estuarine system, including historic current patterns and saltwater-freshwater mixing zones.

3.7 Vegetation

This section describes existing conditions relevant to vegetation and expected effects of the proposed action.

3.7.1 Existing Conditions

Two vegetation communities are dominant in the action area; freshwater wetlands and salt marsh. Freshwater wetland plants include bulrush, cattail, sedges, spikerush, bur-reed, beggarticks, juncus, smartweed, mannagrass, water pennywort, several species of pondweed and duckweed. Native emergent and submerged aquatic plants are present as are non-native invasive species including reed canarygrass, tussock and bog loosestrife.

Salt marsh vegetation include pickleweed, seashore salt grass, jaumea, alkali grass, sea arrow grass, sand-spurry, seaside plantain, and salt marsh wort. Tufted hairgrass, Pacific silverweed, salt marsh bulrush and Lyngbye's sedge are found in higher elevations within the salt marsh, in areas that are occasionally covered by tidal water.

3.7.2 Effects of the Action

The proposed project will eliminate all of the vegetation on the dikes and effectively drain the freshwater impoundments. Areas dominated by non-salt tolerant plant communities will shift to salt tolerant plant communities. The distinction between freshwater wetland and salt mash will no longer be a discrete line (i.e. the dike), but become a natural gradient likely similar to historic conditions. Disturbed soils are expected to revegetate quickly because of the abundant native vegetation in the immediate vicinity will provide a seed source.

3.8 Benthic Epifauna

This section describes existing conditions relevant to benthic epifauna and expected effects of the proposed action in the action area.

3.8.1 Existing Conditions

Currently benthic epifauna are limited to the areas waterward of the dike. Although no studies of species abundance or richness were identified, epibenthic species present within the project area are likely typical of those found in estuarine mudflats.

3.8.2 Effects of the Action

During construction, benthic epifauna living on the dikes will be eliminated during the dike removal process. Benthic epifauna are expected to colonize quickly because of the large area of undisturbed habitat within the action area providing recruitment. Removal of the dike will restore about 760 acres of land to estuarine area and restore the unrestricted tidal exchange to the three small creeks. Benthic epifauna will be able to colonize within areas where it was unable to prior to the dike removal.

3.9 Forage Fish

This section describes existing conditions relevant to forage fish and expected effects of the proposed action in the action area.

3.9.1 Existing Conditions

Forage fish are limited to estuarine areas of the action area (i.e. waterward of the dike) and are those typically found in estuaries.

3.9.2 Effects of the Action

During construction, forage fish would likely avoid the vicinity where active in-water construction is occurring. However, avoidance of the area is temporary and would not persist after construction. Removal of the dike will restore about 760 acres of land to estuarine area and restore the unrestricted tidal exchange to the three small creeks. Forage fish will be able to utilize newly restored estuarine areas within the action area where it was unable to prior to the dike removal.

4.0 EVALUATION OF EFFECTS ON LISTED SPECIES

This section discusses use by listed species of the action area, describes effects on listed species from project activities (Section 2.2), and provides an effect determination. This section discusses only attributes of listed species that are relevant to the project area and likely to be affected by the project. Life histories for the species discussed in this section are presented in Appendix D. Appendix E describes habitat for federally managed commercial fish species, potential project impacts, and proposed conservation measures.

4.1 North American Green Sturgeon

4.1.1 Stock Status and Critical Habitat

There are no good data on current stock sizes or population trends of the North American green sturgeon (NMFS 2009). NMFS has proposed designating critical habitat for the southern DPS green sturgeon in coastal U.S. marine waters within 110 meters (m) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including certain coastal bays and estuaries in California, Oregon, and Washington, including Willapa Bay (73 FR 52084).

4.1.2 Use of the Action Area

The North American green sturgeon is present in Willapa Bay (Lindley, et al. 2010), but are not believed to spawn in any mainstem rivers in Willapa Bay (NMFS 2009). Since spawning is not expected to occur in the mainstem rivers of Willapa Bay, use of the bay by green sturgeon is likely limited to foraging and juvenile refuge.

4.1.1 Effects of the Action

During construction, the green sturgeon may avoid the vicinity where elevated turbidity occurs. However, avoidance of the area is temporary and would not persist after active construction. Removal of the dike would restore about 760 acres of land to estuarine area. Green sturgeon will be able to utilize newly restored estuarine areas within the action area.

4.1.2 Effect Determination

Because the proposed project would cause temporary increases in turbidity and restore about 760 acres of estuarine habitat that could be used by green sturgeon for foraging and refuge, this BE concludes that the proposed project may affect, not likely to adversely affect North American green sturgeon or its designated critical habitat.

4.2 *Bull Trout*

4.2.1 Stock Status and Critical Habitat

Willapa Bay does not have a breeding population of bull trout (WDFW 2000). Therefore, any bull trout in Willapa Bay are likely foraging. While bull trout critical habitat has been designated, no critical habitat for bull trout has been designated in Willapa Bay.

4.2.2 Use of the Action Area

Bull trout using Willapa Bay are believed to use the bay for occasional foraging. The nearest confirmed bull trout was caught in the Willapa River, the mouth of which is approximately 22 miles to the north of the action area. The single fish was caught by a Washington State Department of Fish and Wildlife technician near river mile 29, approximately one mile downstream of the Willapa/Forks Creek State Salmon Hatchery.

4.2.3 Effects of the Action

Bull trout are not expected to use the action area because bull trout are not frequent users of Willapa Bay. However, during construction, any bull trout in the area may avoid the vicinity where elevated turbidity occurs. However, avoidance of the area is temporary and would not persist after active construction. Removal of the dike would restore about 760 acres of land to estuarine area. Any bull trout in Willapa Bay would be able to utilize newly restored estuarine areas within the action area.

4.2.4 Effect Determination

Because the proposed project would cause temporary increases in turbidity and restore about 760 acres of estuarine habitat important that could be used by bull trout, this BE concludes that the proposed project may affect, not likely to adversely affect bull trout or its designated critical habitat.

4.3 Marbled Murrelet

4.3.1 Population Status and Critical Habitat

The estimated population size of marbled murrelets in North America is about 950,000 birds (Huff et al. 2006). Most of these birds occur in Alaska (about 860,000) and Canada (about 55,000 to 78,000). Huff et al (2006) conducted at sea surveys to estimate the marbled murrelet population in the Pacific Northwest (Washington, Oregon, and northern California). The population was estimated at about 22,000 birds, indicating only a small fraction of the total population (2 to 3%) uses the coast of the Pacific Northwest. The four year survey was not sufficient to detect population trends (declines or increases) (Huff et al 2006).

Critical habitat has been designated by USFWS, but there is no critical habitat within the action area (Appendix A). The closest WDFW Marbled Murrelet Detection Sections is about 0.5 mile to the south of the action area (WDFW 2010).

4.3.2 Use of the Action Area

No nesting habitat exists within the action area. Since marbled murrelets forage in nearshore waters, they may fly over the action area to reach foraging habitat near the action area

4.3.3 Effects of the Action

During active construction, increases in noise would occur. Behavioral effects from noise during marbled murrelet foraging occur at 70 dBA (WSDOT 2010). Construction noise would attenuate to the behavioral effects threshold of 70 dBA within 500 feet of the active construction area. However, since marbled murrelet use is likely limited to an occasional fly over, as the birds head out to open water to forage or return to their nests effects from construction noise are expected to be negligible.

4.3.4 Effect Determination

Although the proposed project would cause temporary increases in noise during active construction, marbled murrelet use of the action area is likely limited to occasional fly over's as they fly to and from their nesting sites to foraging sites. Thus, this BE concludes that the proposed project may affect, not likely to adversely affect marbled murrelets or its designated critical habitat.

4.4 *Western Snowy Plover*

4.4.1 Population Status and Critical Habitat

In Washington, snowy plovers formerly nested at five coastal locations but only three sites currently are known to be active (Pearson et al. 2009). The average number of breeding pairs over the four years reported in this study was approximately 25 pairs but the population is declining (Pearson et al. 2009). Critical habitat has been designated by USFWS, but there is no critical habitat within the action area (Appendix A).

4.4.2 Use of the Action Area

The Western snowy plover is found within the refuge in the Leadbetter Point Unit located approximately 15 miles away from the action area. The western snowy plover uses sparsely vegetated coastal dunes and beach, since this type of habitat does not exist within the action area, the Western snowy plover is not expected to be found within the action area.

4.4.3 Effects of the Action

During active construction, increases in noise would occur. However, the Western snowy plover is not expected to be within the action area because their preferred habitat (sparsely vegetated coastal dunes) does not exist in the action area.

4.4.4 Effect Determination

Because the Western snowy plover is not expected to be present in the action area, this BE concludes that the proposed project will have no effect on the Western snowy plover or its designated critical habitat.

4.5 *Streaked Horned Lark*

4.5.1 Population Status

Although no systematic range wide attempt has been made to estimate the total population of the streaked horned lark, results from winter and breeding surveys suggest that the entire population of this species is likely less than 1,000 birds (Pearson and Altman 2005).

4.5.2 Use of the Action Area

Results from these U.S. and Canadian surveys indicate that the streaked horned lark currently breeds on beaches and accreted lands near Grays Harbor and Willapa Bays (Pearson and Altman 2005). However, the streaked horned lark is not expected to be within the action area because their preferred habitat, sparsely vegetated coastal dunes, is not present there.

4.5.3 Effects of the Action

During active construction, increases in noise would occur. However, like the Western snowy plover, the streaked horned lark is not expected to be within the action area because their preferred habitat (sparsely vegetated coastal dunes) does not exist there.

4.5.4 Effect Determination

Because the streaked horned lark is not expected to be present in the action area, this BE concludes that the proposed project will not jeopardize the streaked horned lark or its habitat.

Should the streaked horned lark become listed as threatened or endangered under ESA during the construction of the proposed project, this BE would conclude that the proposed project would have no effect on the streaked horned lark or its designated critical habitat.

5.0 INTERRELATED AND INTERDEPENDENT ACTIONS AND CUMULATIVE EFFECTS

Cumulative effects are effects from state agency or private activities that are reasonably certain to occur within the area of the federal action subject to consultation (50 CFR 402.02 Definitions). The future construction of a trail and viewing platform on the 2,000 lineal feet of remaining dike in the Riekkola Unit would be considered a cumulative action. Federal actions unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Interdependent actions are from actions with no independent utility apart from the proposed action. Interrelated actions include those that are part of a larger action and depend on the larger action for justification.

6.0 SUMMARY

The proposed project has the potential to adversely affect listed species or their habitat. Construction could temporarily increase noise and turbidity and possibly causes listed species to avoid the immediate work area, but best management practices would be used to reduce impacts. Therefore, this biological evaluation reaches the following conclusions:

- may affect, not likely to adversely affect North American green sturgeon or their designated critical habitat;
- may affect, not likely to adversely affect bull trout or their designated critical habitat;
- may affect, not likely to adversely affect marbled murrelets or their designated critical habitat; and

- will have no effect on Western snowy plover or their designated critical habitat.

Similarly, the proposed project will not jeopardize the streaked horned lark, a species proposed for listing. Should the streaked horned lark become listed during the proposed project, this BE reaches the conclusion that the proposed project may affect, not likely to adversely affect the streaked horned lark or their critical habitat.

7.0 CULTURAL RESOURCES ASSESSMENT

Section 106 of the National Historic Preservation Act requires any project receiving federal funds or a federal permit to undergo consultation with the "affected" Native American Tribe(s). To assist the WBRFEG with the Section 106 consultation, a cultural resources assessment was conducted. This assessment included a record search of the Washington State Department f Archaeology and Historic Preservation and a review of the ethnographic ad historical literature on Native American and early Euro-American use of the action area. The results of the review and record search are detailed in Appendix F. In summary, the cultural resources assessment identified two previously documented archaeological resources directly adjacent to the Project's Area of Potential Effects (APE). Sites 45PC125 and 45PC126 are pre-contact fish traps located within the mudflats adjacent to the Bear River channel. Radiocarbon (C-14) dates on the wooden stakes from 45PC126 dated the site to 1,000 Before Present (or approximately 1000 AD). It is anticipated other unknown fish weirs are located within the Bear River watershed due to the limited survey area covered during the original project which documented them.

There are no previously documented Traditional Cultural Properties (TCPs) identified within and/or directly adjacent to the APE. Ethnographic research does identify at least one place name associated with a former village (*nu?x*^{w}*as?nł* - "blackberry town") that was once located near the confluence of Bear River and Willapa Bay. The exact village location is unknown, but it may be closely associated with the previously documented fish traps in the area.

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Appendix A—
ESA listed Species

Endangered Species Act Status of West Coast Salmon & Steelhead

(Updated July 1, 2009)

Species[1]			Current Endangered Species Act Listing Status[2]	ESA Listing Actions Under Review
Sockeye Salmon (*Oncorhynchus nerka*)	1	Snake River	*Endangered*	
	2	Ozette Lake	*Threatened*	
	3	Baker River	*Not Warranted*	
	4	Okanogan River	*Not Warranted*	
	5	Lake Wenatchee	*Not Warranted*	
	6	Quinalt Lake	*Not Warranted*	
	7	Lake Pleasant	*Not Warranted*	
Chinook Salmon (*O. tshawytscha*)	8	Sacramento River Winter-run	*Endangered*	
	9	Upper Columbia River Spring-run	*Endangered*	
	10	Snake River Spring/Summer-run	*Threatened*	
	11	Snake River Fall-run	*Threatened*	
	12	Puget Sound	*Threatened*	
	13	Lower Columbia River	*Threatened*	
	14	Upper Willamette River	*Threatened*	
	15	Central Valley Spring-run	*Threatened*	
	16	California Coastal	*Threatened*	
	17	Central Valley Fall and Late Fall-run	*Species of Concern*	
	18	Upper Klamath-Trinity Rivers	*Not Warranted*	
	19	Oregon Coast	*Not Warranted*	
	20	Washington Coast	*Not Warranted*	
	21	Middle Columbia River spring-run	*Not Warranted*	
	22	Upper Columbia River summer/fall-run	*Not Warranted*	
	23	Southern Oregon and Northern California Coast	*Not Warranted*	
	24	Deschutes River summer/fall-run	*Not Warranted*	
Coho Salmon (*O. kisutch*)	25	Central California Coast	*Endangered*	
	26	Southern Oregon/Northern California	*Threatened*	
	27	Lower Columbia River	*Threatened*	• Critical habitat
	28	Oregon Coast	*Threatened*	
	29	Southwest Washington	*Undetermined*	
	30	Puget Sound/Strait of Georgia	*Species of Concern*	
	31	Olympic Peninsula	*Not Warranted*	
Chum Salmon (*O. keta*)	32	Hood Canal Summer-run	*Threatened*	
	33	Columbia River	*Threatened*	
	34	Puget Sound/Strait of Georgia	*Not Warranted*	
	35	Pacific Coast	*Not Warranted*	
Steelhead (*O. mykiss*)	36	Southern California	*Endangered*	
	37	Upper Columbia River	*Threatened*	
	38	Central California Coast	*Threatened*	
	39	South Central California Coast	*Threatened*	
	40	Snake River Basin	*Threatened*	
	41	Lower Columbia River	*Threatened*	
	42	California Central Valley	*Threatened*	
	43	Upper Willamette River	*Threatened*	
	44	Middle Columbia River	*Threatened*	
	45	Northern California	*Threatened*	
	46	Oregon Coast	*Species of Concern*	
	47	Southwest Washington	*Not Warranted*	
	48	Olympic Peninsula	*Not Warranted*	
	49	Puget Sound	*Threatened*	• Critical habitat
	50	Klamath Mountains Province	*Not Warranted*	
Pink Salmon (*O. gorbuscha*)	51	Even-year	*Not Warranted*	
	52	Odd-year	*Not Warranted*	

1 The ESA defines a "species" to include any distinct population segment of any species of vertebrate fish or wildlife. For Pacific salmon, NOAA Fisheries Service considers an evolutionarily significant unit, or "ESU," a "species" under the ESA. For Pacific steelhead, NOAA Fisheries Service has delineated distinct population segments (DPSs) for consideration as "species" under the ESA.

Page Title: ESA Other List
URL: http://www.nwr.noaa.gov/Other-Marine-Species/ESA-Other-List.cfm

Other ESA-Listed Species

Under the jurisdiction of NOAA Fisheries that may occur off Washington & Oregon:

- distinct population segment, or DPS, of bocaccio *(Sebastes paucispinis)* (E) in Puget Sound
- distinct population segment, or DPS, of canary rockfish *(Sebastes pinniger)* (T) in Puget Sound
- distinct population segment, or DPS, of yelloweye rockfish *(Sebastes ruberrimus)* (T) in Puget Sound
- southern distinct population segment, or DPS, of eulachon (Columbia River smelt) *(Thaleichthys pacificus)* (T)
- southern distinct population segment, or DPS, of north American green sturgeon (*Acipenser medirostris*) (T), listed in the NOAA Fisheries Southwest Region

(E) = Endangered
(T) = Threatened

Page last updated: 2010-06-15 10:22:36

Page Title: ESA MM List
URL: http://www.nwr.noaa.gov/Marine-Mammals/ESA-MM-List.cfm

ESA-Listed Marine Mammals

Under the jurisdiction of NOAA Fisheries that may occur:

off Washington & Oregon

- Southern Resident killer whale (*Orcinus orca*) (E); critical habitat
- humpback whale *(Megaptera novaeangliae)* (E)
- blue whale *(Balaenoptera musculus)* (E)
- fin whale (*Balaenoptera physalus)* (E)
- sei whale (*Balaenoptera borealis)* (E)
- sperm whale (*Physeter macrocephalus)* (E)
- Steller sea lion *(Eumetopias jubatus)* (T); critical habitat

in Puget Sound

- Southern Resident killer whale *(Orcinus orca*) (E); critical habitat
- humpback whale *(Megaptera novaeangliae)* (E)
- Steller sea lion *(Eumetopias jubatus)* (T); critical habitat

(E) = Endangered
(T) = Threatened

Page last updated: 2010-06-15 11:08:13

Page Title: ESA Turtle List
URL: http://www.nwr.noaa.gov/Other-Marine-Species/ESA-Turtle-List.cfm

ESA-Listed Marine Turtles

Under the jurisdiction of NOAA Fisheries that may occur off Washington & Oregon:

- leatherback sea turtle *(Dermochelys coriacea)* (E)
- green sea turtle (*Chelonia mydas)* (E)
- olive ridley sea turtle (*Lepidochelys olivacea)* (E)
- loggerhead sea turtle *(Caretta caretta)* (T)

Sightings and strandings of these animals are very rare, and there are no breeding beaches in the Northwest Region.

(E) = Endangered
(T) = Threatened

Feb. 19, 2010: NOAA Fisheries extended the comment period on the proposed revision to existing critical habitat for the leatherback turtle under the Endangered Species Act. See the *Federal Register* notice *(PDF 49KB)* for details.

Jan. 5, 2010: NOAA Fisheries proposed to revise and expand critical habitat for the leatherback turtle under the Endangered Species Act. Additional information about this proposal can be found in the links below and on NOAA Fisheries' Office of Protected Resources Website.

- News Release *(PDF 73KB -- links to NOAA Fisheries Website)*
- *Federal Register* notice *(PDF 711KB)*

Page last updated: 2010-06-17 23:03:52

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CRITICAL HABITAT; CANDIDATE SPECIES; AND SPECIES OF CONCERN

IN **PACIFIC COUNTY**

AS PREPARED BY

THE U.S. FISH AND WILDLIFE SERVICE

WESTERN WASHINGTON FISH AND WILDLIFE OFFICE

(Revised November 1, 2007)

LISTED

Brown pelican (*Pelecanus occidentalis*) [outer coast]

Bull trout (*Salvelinus confluentus*)

Marbled murrelet (*Brachyramphus marmoratus*)

Northern spotted owl (*Strix occidentalis caurina*)

Oregon silverspot butterfly (*Speyeria zerene hippolyta*)

Short-tailed albatross (*Phoebastria albatrus*) [outer coast]

Western snowy plover (*Charadrius alexandrinus nivosus*)

Major concerns that should be addressed in your Biological Assessment of project impacts to listed species include:

1. Level of use of the project area by listed species.

2. Effect of the project on listed species' primary food stocks, prey species, and foraging areas in all areas influenced by the project.

3. Impacts from project activities and implementation (e.g., increased noise levels, increased human activity and/or access, loss or degradation of habitat) that may result in disturbance to listed species and/or their avoidance of the project area.

DESIGNATED

Critical habitat for the marbled murrelet

Critical habitat for the western snowy plover

PROPOSED

None

CANDIDATE

Streaked horned lark (*Eremophila alpestris strigata*)

SPECIES OF CONCERN

Bald eagle (*Haliaeetus leucocephalus*)
Coastal cutthroat trout (*Oncorhynchus clarki clarki*) [southwest Washington DPS]
Columbia torrent salamander (*Rhyacotriton kezeri*)
Long-eared myotis (*Myotis evotis*)
Long-legged myotis (*Myotis volans*)
Makah=s copper (butterfly) (*Lycaena mariposa charlottensis*) [historic]
Newcomb's littorine snail (*Algamorda newcombiana*)
Northern goshawk (*Accipiter gentilis*)
Northern sea otter (*Enhydra lutris kenyoni*)

Olive-sided flycatcher (*Contopus cooperi*)

Pacific lamprey (*Lampetra tridentata*)

Pacific Townsend=s big-eared bat (*Corynorhinus townsendii townsendii*)

Peregrine falcon (*Falco peregrinus*)

River lamprey (*Lampetra ayresi*)

Tailed frog (*Ascaphus truei*)

Van Dyke=s salamander (*Plethodon vandykei*)

Western toad (*Bufo boreas*)

Abronia umbellata ssp. *acutalata* (pink sandverbena)

Dodecatheon austrofrigidum (frigid shootingstar)

Filipendula occidentalis (queen of the forest)

Sanicula arctopoides (footsteps of spring; bear=s-foot sanicle)

Endangered Species Act Section 7 Consultation Form
for
Estuarine Restoration

File #: R1-13552-2010-NS-004

Refuge Name: Willapa National Wildlife Refuge
Address: 3888 State Route 101, Ilwaco, WA 98624
Phone: 360-484-3482

Refuge Action: Restoration of historical estuarine habitat (currently managed pasture and managed freshwater impoundments) is being considered through the CCP (Comprehensive Conservation Plan) process. Estuarine restoration is planned to occur on portions of the Lewis, Porter Point and Riekkola Units within the Willapa National Wildlife Refuge in Pacific County, WA.

Part 1

I. Project Overview

1. Project Location

The proposed project is located at the Willapa National Wildlife Refuge in Pacific County, Washington. The specific project sites are the Lewis, Porter Point and Riekkola Units at the southern end of Willapa Bay. The legal location of the sites is Township 10 North, Range 11 West and Sections 11,12,7,1and 6.

2. Description of the Proposed Action

Historically, the project site was tidally connected to Willapa Bay and the Bear River. Prior actions by the refuge in the late 1940's and early 1950's contributed to loss of this estuarine habitat. At that time, a large portion of refuge salt marsh habitat was eliminated by diking to create pasture lands and freshwater wetlands, believed to enhance overall waterfowl use of the refuge and increase land available for agricultural production. The dikes have substantially reduced the amount of historical shoreline habitat and serve as a barrier, reducing nutrient input to the estuary and interrupting the physical, chemical and biological processes of the estuarine system. Small streams including Lewis stream, Porter Point stream and Dolman creek do not connect directly with the estuary. Although fish ladders were incorporated into two water control structures in the dike system in 2001, anadromous fish species, including salmon, are restricted in their movements to and from spawning and rearing areas. The conversion of estuarine wetlands to freshwater wetlands and pasture by diking has removed important natural habitat for waterfowl, waterbirds, shorebirds, and salmon as well as many other estuarine-dependent species.

The property which consists of managed non-tidal pasture and freshwater impoundments is currently of low quality. During this project up to 2760.2 acres will be restored to estuarine habitat (includes open water, intertidal flats and salt marsh). Unrestricted tidal exchange will be the goal and historic channels currently isolated within diked areas which are now removed from tidal influence will be reconnected to the Willapa Bay estuary. Such an action will assist in improving and maximizing the current estuarine system and contribute to the health of the bay and associated habitats. The project will be accomplished by removal of dikes and water control structures within the Lewis, Porter Point and Riekkola Units (In Alternative 3 of the CCP the Riekkola Unit will not be restored). Dikes will be removed completely to grade and material will be removed or used to fill in the associated borrow ditch. Partial removal or breaching of dikes will not be considered as problems may result, including restricted tidal penetration and circulation, ponding, and erosion (USFWS 2004). Heavy equipment utilized will include excavators, bulldozers, scrapers, and agricultural tractors. Concentration will be on restoration of functional processes including tidal influences, sediment delivery, native vegetative communities and channel networks. These processes will be instrumental to accomplish associated restoration of historical geomorphology and hydrodynamics. This action will also reduce or eliminate the extent of a highly invasive exotic plant, reed canarygrass, which currently infests the refuge's freshwater impoundments. Tussock infestation will also be reduced. Other exotic species, including nutria and bullfrogs, which currently use the freshwater impoundments will be eliminated by restoration of estuarine habitat. Juvenile salmon habitat will be restored and other expected benefits include increased waterfowl, waterbird, and shorebird use. Protection and restoration of native estuarine and nearshore habitats is a major ecoregional and recovery goal in the North Pacific Coast Ecoregion Plan (1995) and the Northern Pacific Coast Regional Shorebird Management Plan (Drut and Buchanan 2000).

3. Project Timeline

Work on the project will commence in 2011 after approval of the CCP for the Willapa National Wildlife Refuge. It is expected that work will occur in several stages and take several weeks per stage, depending on weather and tides.

4. Federally Listed Species and Critical Habitat

A. Listed species and/or their critical habitat:

Bull trout (*Salvelinus confluentus*) – Federally Threatened. Not found within the refuge or the action area.

Western Snowy Plover (*Charadrius alexandrinus nivosus*) – Federally Threatened. Found within the refuge but not within the action area. No officially designated critical habitat occurs on the refuge.

Marbled Murrelet (*Brachyramphus marmoratus*)– Federally Threatened. Found within the refuge but not within the action area. Occupied sites exist on the refuge but no officially designated critical habitat occurs on the refuge.

B. Proposed species and/or proposed critical habitat: None

C. Candidate species:

Streaked horned lark (*Eremophila alpestris strigata*) – Found within the refuge but not within the action area.

Part 2 – Informal Consultation

II. Effects Analysis

Species:

Bull trout (*Salvelinus confluentus*) – Federally Threatened. Not found within the refuge or the action area. NO EFFECT

Western Snowy Plover (*Charadrius alexandrinus nivosus*) – Federally Threatened. Found within the refuge but not within the action area. No officially designated critical habitat occurs on the refuge. NO EFFECT

Marbled Murrelet (*Brachyramphus marmoratus*)- Federally Threatened. Found within the refuge but not within the action area. Occupied sites exist but no officially designated critical habitat occurs on the refuge. NO EFFECT

Streaked Horned Lark (*Eremophila alpestris strigata*)- Found within the refuge but not within the action area. NO EFFECT

Bull Trout

The Bull Trout is a federally listed threatened species. Bull Trout have not been found in this portion of Willapa Bay. The nearest confirmed Bull Trout was caught in the Willapa River, the mouth of which is approximately 22 miles to the north of the project area. The single fish was caught by a Washington State Department of Fish and Wildlife technician near river mile 29, approximately one mile downstream of the Willapa/Forks Creek State Salmon Hatchery. There is not believed to be a breeding population in the Willapa River, or anywhere off Willapa Bay. Bull Trout are believed to use the Willapa River only for occasional foraging. Due to the distance from the sighting and the rarity of the sighting, we believe that this project will not have any impact on Bull Trout.

Western Snowy Plover

The Western Snowy Plover is a federally listed threatened species. Habitat consists of sparsely vegetated coastal dunes and beach. The Western Snowy Plover is found within the refuge in the Leadbetter Point Unit located approximately 15 miles away from the action area. It is not found within the action area. The project will have no effect on the Western Snowy Plover.

Marbled Murrelet

The Marbled Murrelet is a federally listed threatened species. Marbled Murrelets have been detected on the Long Beach Peninsula in low densities. The nearest terrestrial occupied habitat was documented by WDFW biologists about 2 miles southwest of the project site in T10N, R11W, Section 23. No potential Marbled Murrelet habitat exists at the project site. The project will have no effect on the Marbled Murrelet.

Streaked Horned Lark

The Streaked Horned Lark is a federal candidate species. Habitat consists of sparsely vegetated coastal dunes. The Streaked Horned Lark is found within the refuge in the Leadbetter Point Unit located approximately 15 miles away from the action area. It is not found within the action area. The project will have no effect on the Streaked Horned Lark.

III. Effects Determination and Response Requested:

Determination

A. no effect/no adverse modification

species:	**Marbled Murrelet**	**status:**	**Threatened**
species:	**Western Snowy Plover**	**status:**	**Threatened**
species:	**Streaked Horned Lark**	**status:**	**Threatened**
species:	**Bull Trout**	**status:**	**Threatened**
critical habitat:			

B. may affect, but is not likely to adversely affect species/adversely modify critical habitat

species:	**status:**
species	**status:**

critical habitat: ______________________

C. may affect, and is likely to adversely affect species/adversely modify critical habitat

species: ________________________________ status: __________ *

species: ________________________________ status: __________ *

critical habitat: ____ *

D. may affect, and is likely to adversely affect species/adversely modify critical habitat

species: ______________________________ status: Proposed **

species: ______________________________ status: Candidate **

proposed critical habitat: ________________________________ **

Marie Fernandez

Signature of Preparer

__6-28-2010_____

Date

Evaluation by Project Leader:

1. *For A & B above:* Concurrence __X___ Non-concurrence _______

2. *For C above:* Formal consultation required _______

3. *For D above:* Conference required _______

____

Signature of Project Leader

6/30/10

Date

References:

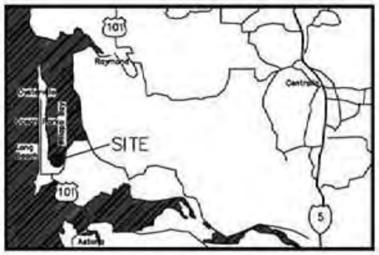
Drut, M.S. and J.B. Buchanan. 2000. U.S. Shorebird Conservation Plan. Northern Pacific Coast Regional Shorebird Management Plan. U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Portland, Oregon.

North Pacific Coast Ecoregion Plan (1995) Northern Pacific Coast Regional Shorebird Management Plan (Drut and Buchanan 2000).

U.S. Fish and Wildlife Service. 2004. Nisqually National Wildlife Refuge. Final Comprehensive Conservation Plan and Environmental Impact Statement.

Appendix B—
Design Sheets (AMEC)

BEAR RIVER ESTUARY RESTORATION PROJECT
70% DESIGN
SOUTH WILLAPA BAY
PACIFIC COUNTY, WA



VICINITY MAP
(NOT TO SCALE)

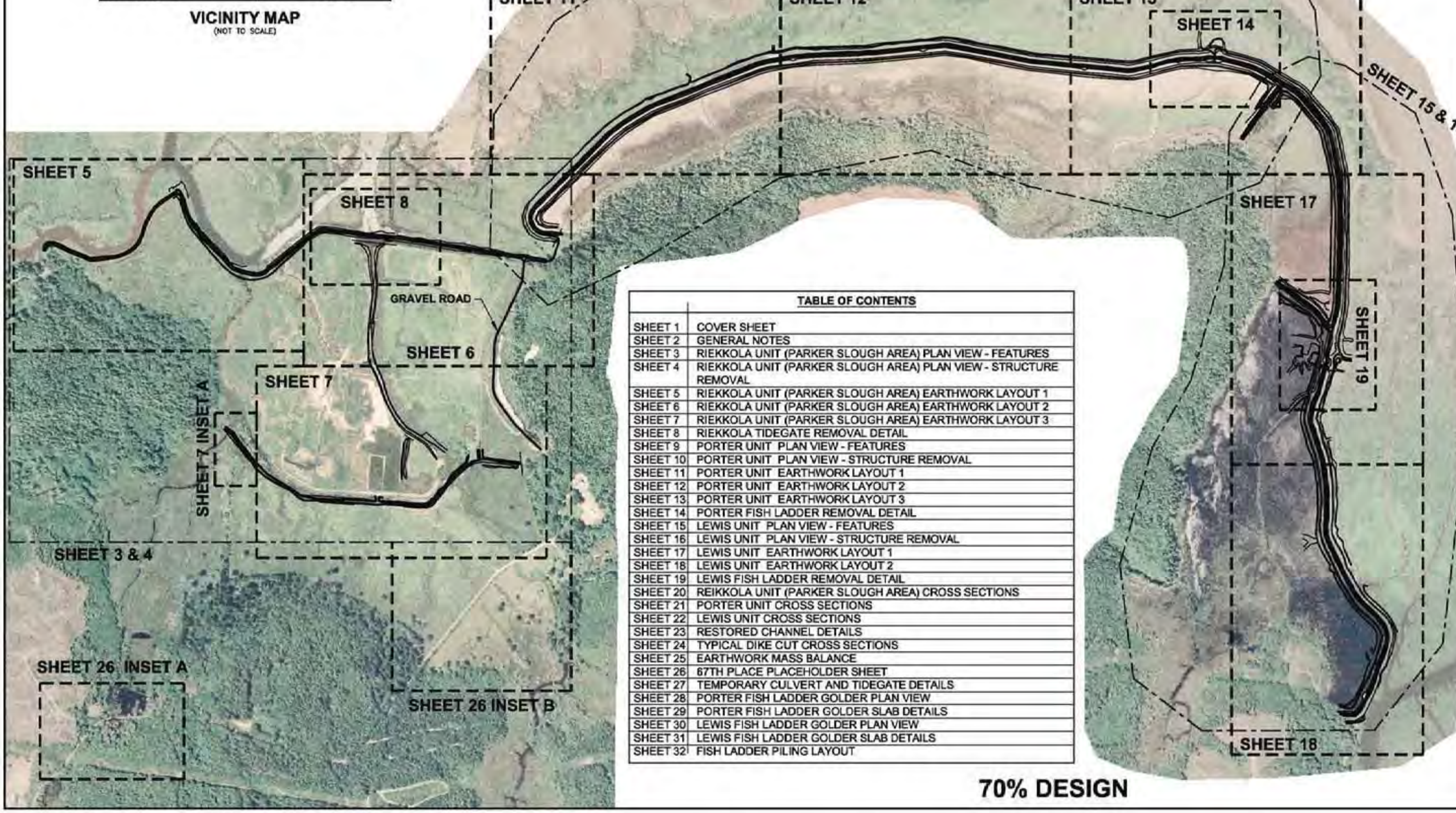


TABLE OF CONTENTS	
SHEET 1	COVER SHEET
SHEET 2	GENERAL NOTES
SHEET 3	RIEKKOLA UNIT (PARKER SLOUGH AREA) PLAN VIEW - FEATURES
SHEET 4	RIEKKOLA UNIT (PARKER SLOUGH AREA) PLAN VIEW - STRUCTURE REMOVAL
SHEET 5	RIEKKOLA UNIT (PARKER SLOUGH AREA) EARTHWORK LAYOUT 1
SHEET 6	RIEKKOLA UNIT (PARKER SLOUGH AREA) EARTHWORK LAYOUT 2
SHEET 7	RIEKKOLA UNIT (PARKER SLOUGH AREA) EARTHWORK LAYOUT 3
SHEET 8	RIEKKOLA TIDEGATE REMOVAL DETAIL
SHEET 9	PORTER UNIT PLAN VIEW - FEATURES
SHEET 10	PORTER UNIT PLAN VIEW - STRUCTURE REMOVAL
SHEET 11	PORTER UNIT EARTHWORK LAYOUT 1
SHEET 12	PORTER UNIT EARTHWORK LAYOUT 2
SHEET 13	PORTER UNIT EARTHWORK LAYOUT 3
SHEET 14	PORTER FISH LADDER REMOVAL DETAIL
SHEET 15	LEWIS UNIT PLAN VIEW - FEATURES
SHEET 16	LEWIS UNIT PLAN VIEW - STRUCTURE REMOVAL
SHEET 17	LEWIS UNIT EARTHWORK LAYOUT 1
SHEET 18	LEWIS UNIT EARTHWORK LAYOUT 2
SHEET 19	LEWIS FISH LADDER REMOVAL DETAIL
SHEET 20	REIKKOLA UNIT (PARKER SLOUGH AREA) CROSS SECTIONS
SHEET 21	PORTER UNIT CROSS SECTIONS
SHEET 22	LEWIS UNIT CROSS SECTIONS
SHEET 23	RESTORED CHANNEL DETAILS
SHEET 24	TYPICAL DIKE CUT CROSS SECTIONS
SHEET 25	EARTHWORK MASS BALANCE
SHEET 26	67TH PLACE PLACEHOLDER SHEET
SHEET 27	TEMPORARY CULVERT AND TIDEGATE DETAILS
SHEET 28	PORTER FISH LADDER GOLDER PLAN VIEW
SHEET 29	PORTER FISH LADDER GOLDER SLAB DETAILS
SHEET 30	LEWIS FISH LADDER GOLDER PLAN VIEW
SHEET 31	LEWIS FISH LADDER GOLDER SLAB DETAILS
SHEET 32	FISH LADDER PILING LAYOUT

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: COVER SHEET

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

amec

AMEC Earth & Environmental

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

1

SHEET NUMBER

GENERAL CONSTRUCTION NOTES

1. THE DRAWINGS INCLUDE LOCATION, PROFILES, SECTIONS, DETAILS AND NOTES NECESSARY TO DESCRIBE THE WORK AT THE LEVEL OF DETAIL DESIRED BY CLIENT.
2. ALL PERMITS, RIGHTS OF WAYS, AND/OR EASEMENTS THAT ARE APPLICABLE FOR THE CONSTRUCTION AND/OR OPERATION ARE THE RESPONSIBILITY OF THE LANDOWNER/OPERATOR AND SHALL BE AVAILABLE ON SITE DURING CONSTRUCTION.
3. THE CONTRACTOR IS RESPONSIBLE FOR COMPLIANCE WITH ALL LAWS, ORDINANCES, CODES, AND/OR REGULATIONS APPLICABLE FOR THE INSTALLATION.
4. DUE TO THE REMOTE NATURE OF THE PROJECT SITE, THE CONTRACTOR MUST HAVE ACTION PLANS IN PLACE FOR NORMAL OPERATIONS AND CONTINGENCY PLANS ACCOUNTING FOR SITUATIONS SUCH AS SPILLS, SOFT GROUND, STUCK EQUIPMENT, UNANTICIPATED FLOODING, AND OTHER SUCH EVENTS.
5. ALL PUBLIC ACCESS OR HAUL ROADS USED BY THE CONTRACTOR DURING CONSTRUCTION ACTIVITIES PROJECT SHALL BE SPRINKLED OR OTHERWISE TREATED TO FULLY SUPPRESS DUST.
6. ALL CONSTRUCTION EQUIPMENT SHALL BE STAGED IN A LOCATION AND MANNER TO MINIMIZE AIR, SOIL AND WATER POLLUTION.
7. ALL FUEL AND LUBRICANTS SHALL BE STORED IN CONTAINERS AND AREAS THAT ARE IN CONFORMANCE WITH APPLICABLE REGULATIONS.
8. ALL FUEL AND LUBRICANTS USED IN THE SERVICING OF CONSTRUCTION EQUIPMENT SHALL BE DONE IN A MANNER THAT AVOIDS SPILLS AND OVER FILLING.
9. ALL POLLUTION CONTROL MEASURES SHALL BE ADEQUATELY MAINTAINED IN A FUNCTIONAL CONDITION AS LONG AS NEEDED DURING THE CONSTRUCTION OPERATION. ALL TEMPORARY MEASURES SHALL BE REMOVED AND THE SITE RESTORED TO THE ORIGINAL CONDITIONS AS PRACTICABLE.

GENERAL DEMOLITION AND STRUCTURE REMOVAL NOTES

1. STRUCTURES SHALL BE REMOVED TO THE EXTENT AND DEPTH SHOWN ON THE DRAWINGS OR AS DESIGNATED BY THE TECHNICAL REPRESENTATIVE.
2. ALL HAZARDOUS MATERIALS SHALL BE IDENTIFIED PRIOR TO STRUCTURE REMOVAL BY A QUALIFIED INDIVIDUAL AND IDENTIFIED ACCORDINGLY IN A REPORT OR BY DRAWINGS.
3. ALL IDENTIFIED HAZARDOUS MATERIALS SHALL BE DISPOSED OF IN ACCORDANCE WITH APPLICABLE REGULATIONS.

GENERAL DEWATERING NOTES

1. PROTECTIVE MEASURES NEEDED TO DIVERT STREAMFLOW AND OTHER SURFACE WATER SHALL BE BUILT, MAINTAINED AND OPERATED DURING CONSTRUCTION.
2. THE CONSTRUCTION SITE SHALL BE DEWATERED AND KEPT FREE OF STANDING WATER OR EXCESSIVELY MUDDY CONDITIONS AS NEEDED FOR PROPER EXECUTION OF THE CONSTRUCTION WORK. DEWATERING SHALL INCLUDE FURNISHING, INSTALLING, OPERATING AND MAINTAINING ALL EQUIPMENT, SUCH AS PUMPS, AS NEEDED.
3. AFTER THE TEMPORARY WORKS HAVE SERVED THEIR PURPOSES, THEY SHALL BE REMOVED WITHOUT INTERFERING WITH PERMANENT DRAINAGE SYSTEMS OR STREAM FLOWS.
4. ALL TEMPORARY WORKS SHALL BE ACCOMPLISHED IN SUCH A MANNER THAT EROSION AND THE TRANSMISSION OF SEDIMENT AND OTHER POLLUTANTS ARE MINIMIZED.

GENERAL FILL NOTES

1. ALL EARTH CUT AND FILL QUANTITIES LISTED ARE BASED ON IN-PLACE VOLUMES.
2. ALL FILL MATERIAL SHALL BE OBTAINED FROM THE APPROVED EXCAVATION OR BORROW AREAS.
3. MINIMUM WEIGHT OF CONSTRUCTION EQUIPMENT USED FOR COMPACTION SHALL BE 40,000 POUNDS AND THE TRACKS OR WHEELS SHALL TRAVERSE THE ENTIRE SURFACE OF EACH FILL LAYER, OR IF THAT ISN'T POSSIBLE, USE OTHER MEANS TO TAMP OR OTHERWISE REASONABLY CONSOLIDATE AND COMPACT THE MATERIAL.
4. DITCH PLUGS SHALL BE A MINIMUM OF 100 FEET IN LENGTH EXCLUDING SLOPING ENDS OF 3H:1V GRADIENT. PLUG MATERIAL SHALL CONSIST OF THE HIGHEST-QUALITY FINE GRAINED FILL LOCALLY AVAILABLE AND SHALL BE APPROPRIATELY COMPACTED BY TRAVERSING CONSTRUCTION EQUIPMENT OVER THE ENTIRE SURFACE OF THE FILL. ARMOR EXPOSED DITCH PLUG ENDS WITH 1-2 FEET OF SUITABLE COARSE GRAINED MATERIAL, WHERE SUCH MATERIAL IS AVAILABLE.
5. DITCH PLUG DEPICTIONS ON CONSTRUCTION DRAWINGS ARE CONCEPTUAL IN NATURE AND DO NOT REFLECT ACTUAL LINEAL DIMENSIONS. DITCH PLUG FILL VOLUMES SHOWN ON CONSTRUCTION DRAWINGS HAVE BEEN CALCULATED TO MEET OR EXCEED MINIMUM PLUG DIMENSIONS. ACTUAL DIMENSIONS AND VOLUMES WILL VARY BASED UPON LOCAL CONDITIONS.

SITE SURVEY NOTES (CTS ENGINEERS)

BASIS OF BEARING

NAD 83 (1996), WASHINGTON SOUTH ZONE COORDINATES.

HORIZONTAL DATUM

HELD WSDOT HORIZONTAL STATIONS DESCRIBED BELOW:

1. MONUMENT ID 5509 (J 306), US ARMY CORPS OF ENGINEERS BRASS DISK SET INTO A 20CM DIAMETER ROUND CONCRETE MONUMENT THAT PROJECTS 16CM ABOVE THE GROUND. LOCATED ON THE EASTERLY SIDE OF SR 101 BEHIND A LONG RUN OF BEAM GUARDRAIL, 7.79 MILES NORTHEASTERLY FROM JUNCTION OF SR 100 AND SR 101.
   GRID NORTHING: 119736.624 METERS
   GRID EASTING: 234322.002 METERS
2. MONUMENT ID 6547 (TANGENT 1937), US ARMY CORPS OF ENGINEERS BRASS DISK SET IN THE TOP OF A ROUND CONCRETE MONUMENT, WHICH IS SET LEVEL WITH THE GROUND SURFACE. LOCATED ON FORMER SR 101 ALIGNMENT HEADING SOUTHERLY, 80 METERS PASS THROUGH A LOCKED GATE.
   GRID NORTHING: 118712.213 METERS
   GRID EASTING: 234096.237 METERS

VERTICAL DATUM

HELD WSDOT STATIONS DESCRIBED ABOVE:

1. MONUMENT ID 5509 (J 306)
   ELEVATION: 4.284 METERS (NAVD88)
2. MONUMENT ID 6547 (TANGENT 1937)
   ELEVATION: 4.463 METERS (NAVD88)
3. GRID COORDINATES AND ELEVATIONS WERE TRANSFORMED TO STATE PLANE COORDINATES (WA SOUTH) THROUGH CORPSCON VER. 6.0.1 (www.tec.army.mil)

SURVEY EQUIPMENT

1. CONVENTIONAL AND GPS SURVEY EQUIPMENTS WERE USED IN THE PERFORMANCE OF THIS SURVEY. ALL EQUIPMENT IS MAINTAINED IN CONFORMANCE WITH CURRENT STATE STATUTE.

SURVEY PROCEDURES

1. OREGON REAL-TIME GPS NETWORK (ORGN), PROVIDED BY OREGON DOT WAS UTILIZED TO PROVIDE RTK MEASUREMENTS IN THIS PROJECT.
2. FIELD TRAVERSE METHOD MEETS OR EXCEEDS MINIMUM REQUIREMENTS IN ACCORDANCE WITH WAC 332-130-090.

ADDITIONAL NOTES

1. ELEVATIONS SHOWN IN THIS SURVEY ARE IN US SURVEY FEET.

70% DESIGN

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: GENERAL NOTES

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

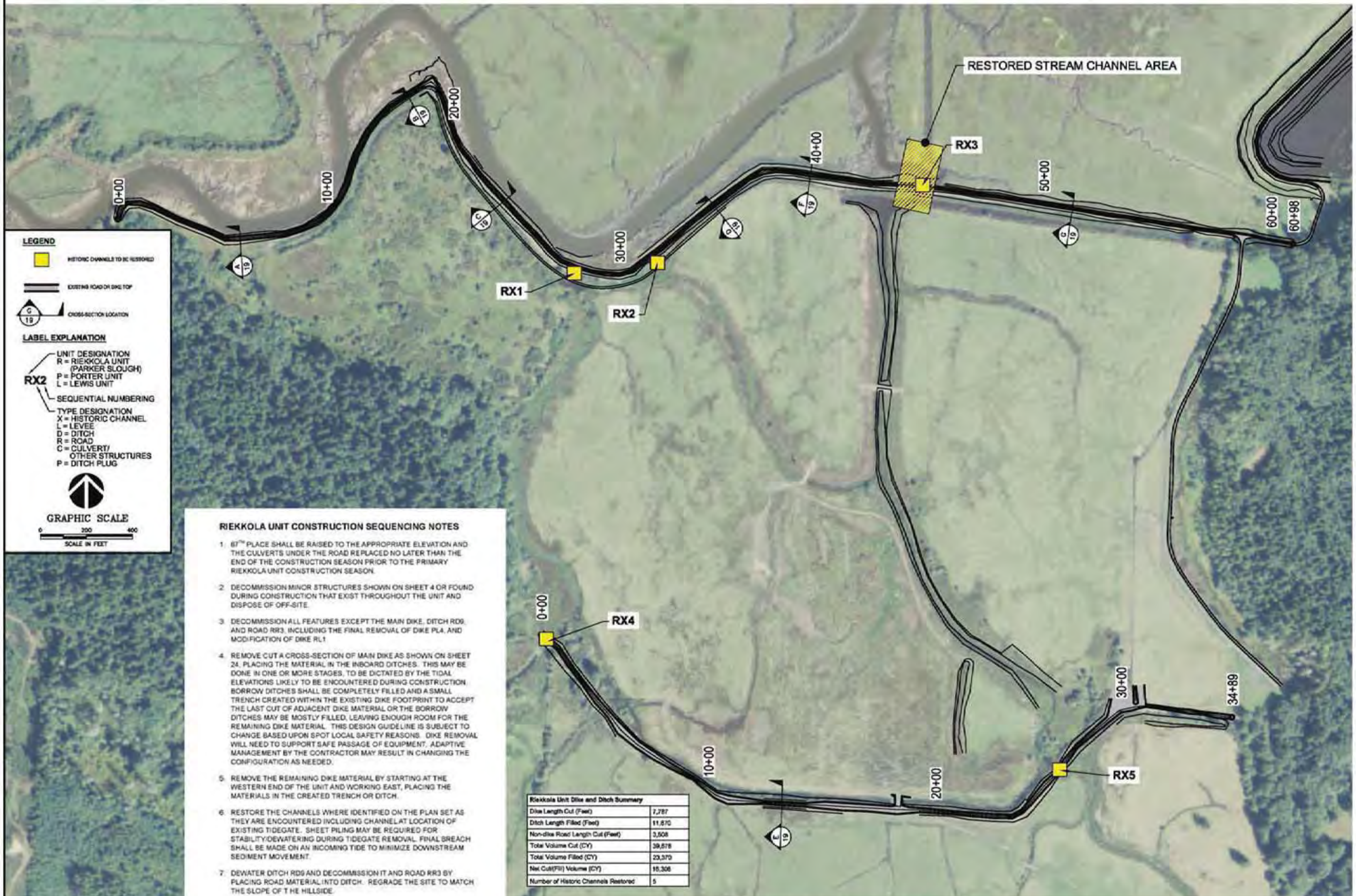
BEAR RIVER ESTUARY RESTORATION

Project No. 0-915-16933-0 REV No. 3

DR: JRS CHK: RB/PS

DATE: JULY 2010

2
SHEET NUMBER



RIEKKOLA UNIT CONSTRUCTION SEQUENCING NOTES

1. 67TH PLACE SHALL BE RAISED TO THE APPROPRIATE ELEVATION AND THE CULVERTS UNDER THE ROAD REPLACED NO LATER THAN THE END OF THE CONSTRUCTION SEASON PRIOR TO THE PRIMARY RIEKKOLA UNIT CONSTRUCTION SEASON.
2. DECOMMISSION MINOR STRUCTURES SHOWN ON SHEET 4 OR FOUND DURING CONSTRUCTION THAT EXIST THROUGHOUT THE UNIT AND DISPOSE OF OFF-SITE.
3. DECOMMISSION ALL FEATURES EXCEPT THE MAIN DIKE, DITCH RD9, AND ROAD RR3, INCLUDING THE FINAL REMOVAL OF DIKE PL4, AND MODIFICATION OF DIKE RL1.
4. REMOVE CUT A CROSS-SECTION OF MAIN DIKE AS SHOWN ON SHEET 24, PLACING THE MATERIAL IN THE INBOARD DITCHES. THIS MAY BE DONE IN ONE OR MORE STAGES, TO BE DICTATED BY THE TIDAL ELEVATIONS LIKELY TO BE ENCOUNTERED DURING CONSTRUCTION. BORROW DITCHES SHALL BE COMPLETELY FILLED AND A SMALL TRENCH CREATED WITHIN THE EXISTING DIKE FOOTPRINT TO ACCEPT THE LAST CUT OF ADJACENT DIKE MATERIAL OR THE BORROW DITCHES MAY BE MOSTLY FILLED, LEAVING ENOUGH ROOM FOR THE REMAINING DIKE MATERIAL. THIS DESIGN GUIDELINE IS SUBJECT TO CHANGE BASED UPON SPOT LOCAL SAFETY REASONS. DIKE REMOVAL WILL NEED TO SUPPORT SAFE PASSAGE OF EQUIPMENT. ADAPTIVE MANAGEMENT BY THE CONTRACTOR MAY RESULT IN CHANGING THE CONFIGURATION AS NEEDED.
5. REMOVE THE REMAINING DIKE MATERIAL BY STARTING AT THE WESTERN END OF THE UNIT AND WORKING EAST, PLACING THE MATERIALS IN THE CREATED TRENCH OR DITCH.
6. RESTORE THE CHANNELS WHERE IDENTIFIED ON THE PLAN SET AS THEY ARE ENCOUNTERED INCLUDING CHANNEL AT LOCATION OF EXISTING TIDEGATE. SHEET PILING MAY BE REQUIRED FOR STABILITY/DEWATERING DURING TIDEGATE REMOVAL. FINAL BREACH SHALL BE MADE ON AN INCOMING TIDE TO MINIMIZE DOWNSTREAM SEDIMENT MOVEMENT.
7. DEWATER DITCH RD9 AND DECOMMISSION IT AND ROAD RR3 BY PLACING ROAD MATERIAL INTO DITCH. REGRADE THE SITE TO MATCH THE SLOPE OF THE HILLSIDE.

Riekkola Unit Dike and Ditch Summary	
Dike Length Cut (Feet)	7,787
Ditch Length Filled (Feet)	11,870
Non-dike Road Length Cut (Feet)	3,508
Total Volume Cut (CY)	39,678
Total Volume Filled (CY)	23,370
Net Cut/(Fill) Volume (CY)	16,308
Number of Historic Channels Restored	5

NOTE: USFWS REFERS TO THIS AREA AS THE RIEKKOLA UNIT (PARKER SLOUGH AREA), AND THIS CONVENTION IS FOLLOWED THROUGHOUT THIS PLAN SET. TARLATT SLOUGH IS LOCATED ALONG THE OUTBOARD DIKE, AND PARKER SLOUGH IS WITHIN THIS AREA.

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: RIEKKOLA UNIT (PARKER SLOUGH AREA) PLAN VIEW - FEATURES

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

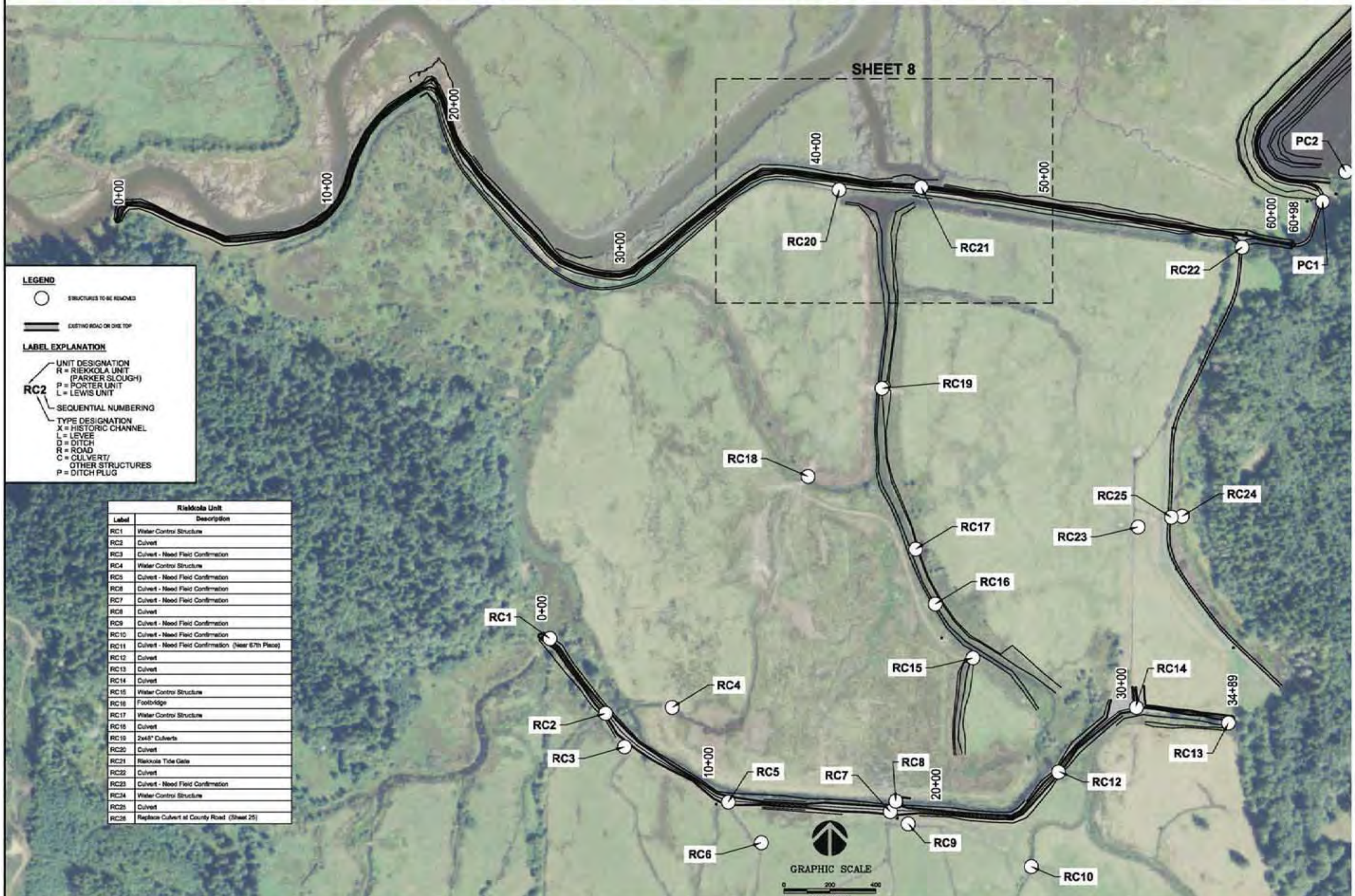
AMEC Earth & Environmental

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

3

SHEET NUMBER



LEGEND

○ STRUCTURES TO BE REMOVED

═ EXISTING ROAD OR DIKE TOP

LABEL EXPLANATION

RC2
- UNIT DESIGNATION
  - R = RIEKKOLA UNIT (PARKER SLOUGH)
  - P = PORTER UNIT
  - L = LEWIS UNIT
- SEQUENTIAL NUMBERING
- TYPE DESIGNATION
  - X = HISTORIC CHANNEL
  - L = LEVEE
  - D = DITCH
  - R = ROAD
  - C = CULVERT/ OTHER STRUCTURES
  - P = DITCH PLUG

Riekkola Unit	
Label	Description
RC1	Water Control Structure
RC2	Culvert
RC3	Culvert - Need Field Confirmation
RC4	Water Control Structure
RC5	Culvert - Need Field Confirmation
RC6	Culvert - Need Field Confirmation
RC7	Culvert - Need Field Confirmation
RC8	Culvert
RC9	Culvert - Need Field Confirmation
RC10	Culvert - Need Field Confirmation
RC11	Culvert - Need Field Confirmation (Near 67th Place)
RC12	Culvert
RC13	Culvert
RC14	Culvert
RC15	Water Control Structure
RC16	Footbridge
RC17	Water Control Structure
RC18	Culvert
RC19	2x48" Culverts
RC20	Culvert
RC21	Riekkola Tide Gate
RC22	Culvert
RC23	Culvert - Need Field Confirmation
RC24	Water Control Structure
RC25	Culvert
RC26	Replace Culvert at County Road (Sheet 25)

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: RIEKKOLA UNIT (PARKER SLOUGH AREA) PLAN VIEW - STRUCTURE REMOVAL

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

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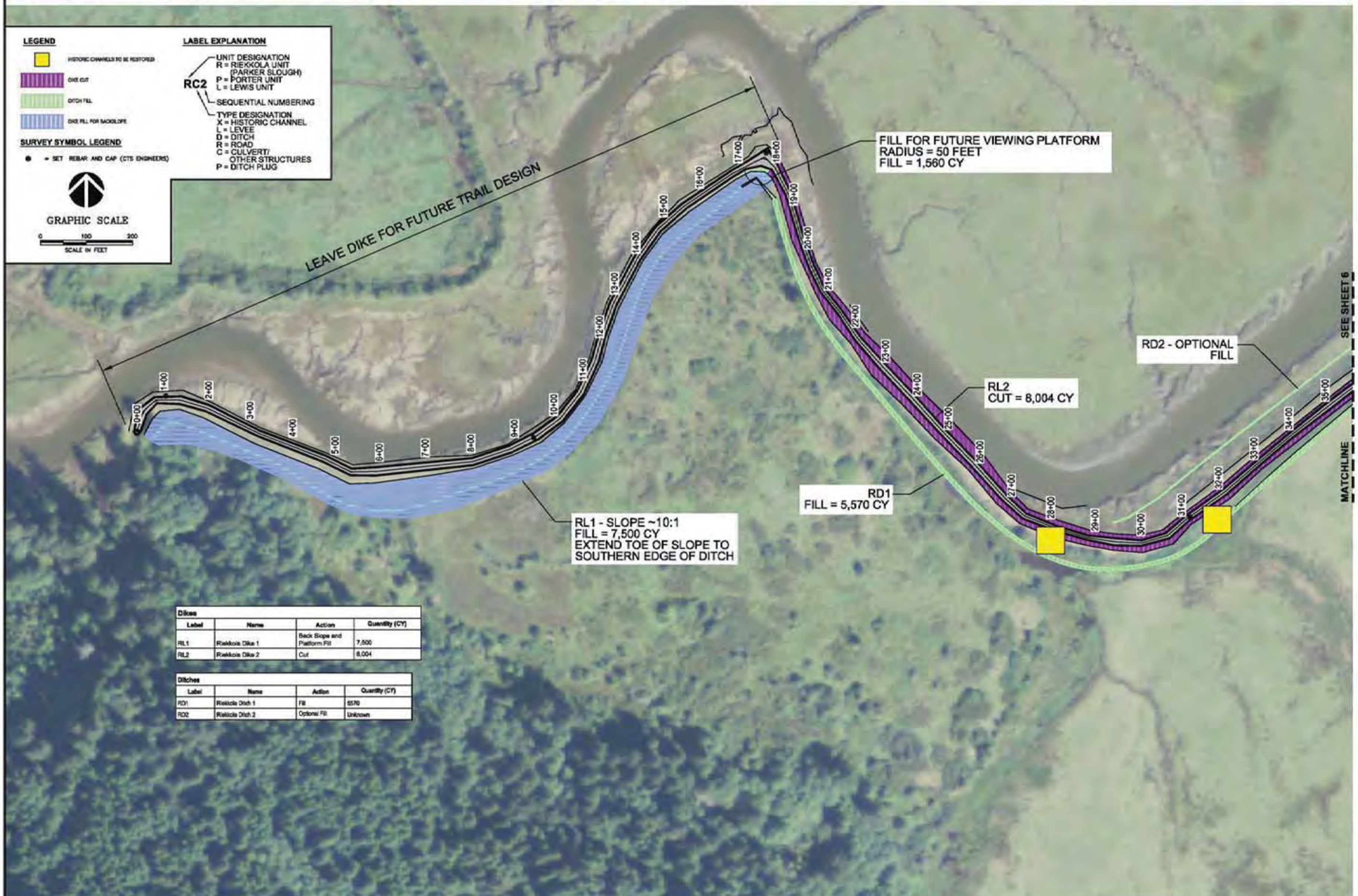
BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

4

SHEET NUMBER



Dikes

Label	Name	Action	Quantity (CY)
RL1	Riekkola Dike 1	Back Slope and Platform Fill	7,500
RL2	Riekkola Dike 2	Cut	8,004

Ditches

Label	Name	Action	Quantity (CY)
RD1	Riekkola Ditch 1	Fill	5570
RD2	Riekkola Ditch 2	Optional Fill	Unknown

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: RIEKKOLA UNIT (PARKER SLOUGH AREA) EARTHWORK LAYOUT 1

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

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BEAR RIVER ESTUARY RESTORATION

Project No. 0-913-15630-0 | REV No.

DR: JRS | CHK: RB/PB

DATE: JULY 2010

5

SHEET NUMBER

Dikes

Label	Name	Action	Quantity (CY)
RL3	Riekkola Dike 3	Cut	11758
PL1	Porter Dike 1	Cut	3881

Ditches

Label	Name	Action	Quantity (CY)
RD3	Riekkola Ditch 3	Fill	1481
RD4	Riekkola Ditch 4	Optional Fill	Unknown
RD5	Riekkola Ditch 5	Fill	5333
RD6	Riekkola Ditch 6	Fill	From adjacent road
RD7	Riekkola Ditch 7	Fill	107
PD1	Porter Ditch 1	Fill	5095

Plugs

Label	Name	Quantity (CY)
PP1	Porter Plug 1	65

Roads

Label	Name	Action	Quantity (CY)
RR1	Riekkola Road 1	Cut	Unknown

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: RIEKKOLA UNIT (PARKER SLOUGH AREA) EARTHWORK LAYOUT 2

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

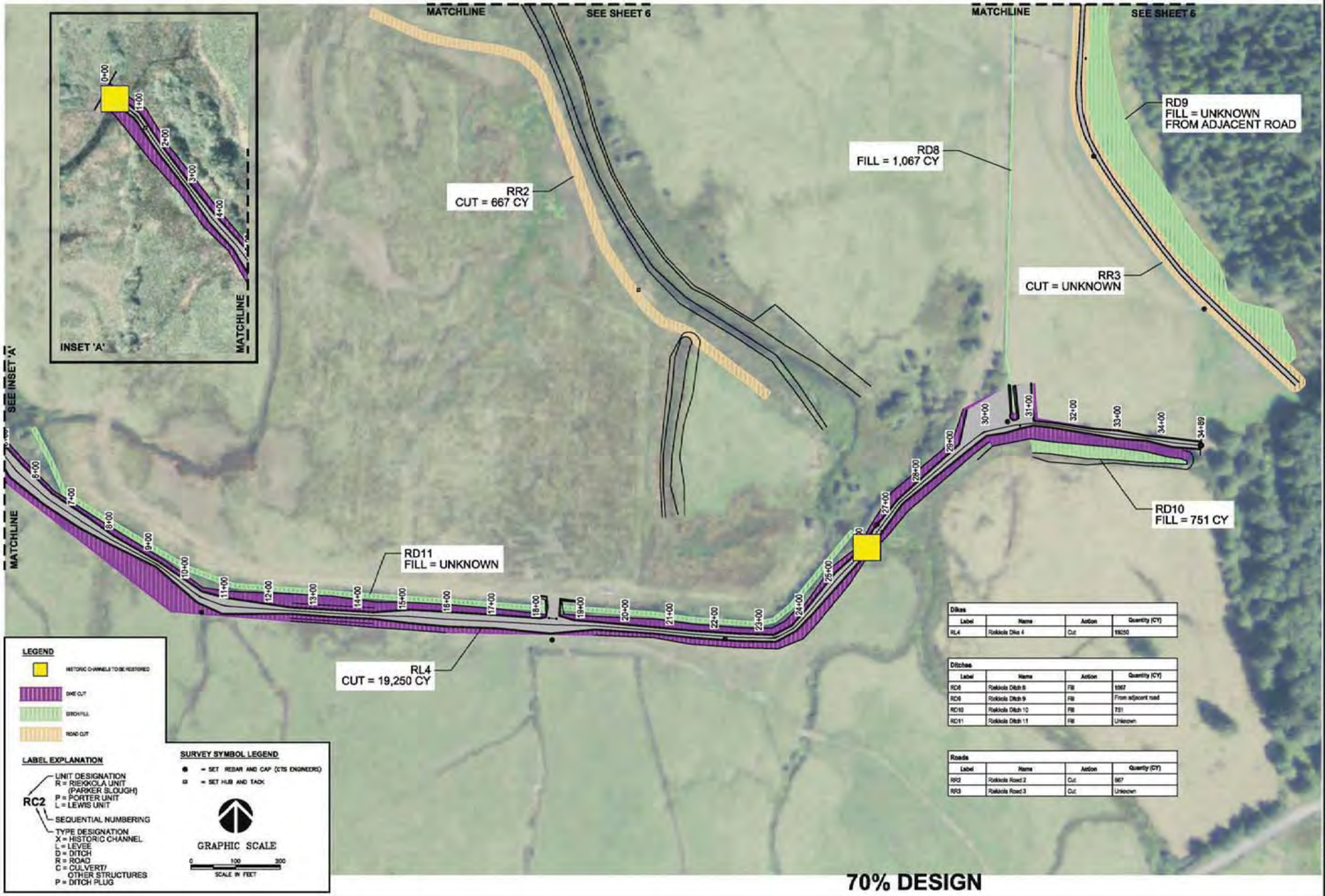
amec

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

6

SHEET NUMBER



Dikes

Label	Name	Action	Quantity (CY)
RL4	Riekkola Dike 4	Cut	19250

Ditches

Label	Name	Action	Quantity (CY)
RD8	Riekkola Ditch 8	Fill	1067
RD9	Riekkola Ditch 9	Fill	From adjacent road
RD10	Riekkola Ditch 10	Fill	751
RD11	Riekkola Ditch 11	Fill	Unknown

Roads

Label	Name	Action	Quantity (CY)
RR2	Riekkola Road 2	Cut	667
RR3	Riekkola Road 3	Cut	Unknown

70% DESIGN

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: RIEKKOLA UNIT (PARKER SLOUGH AREA) EARTHWORK LAYOUT 3

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

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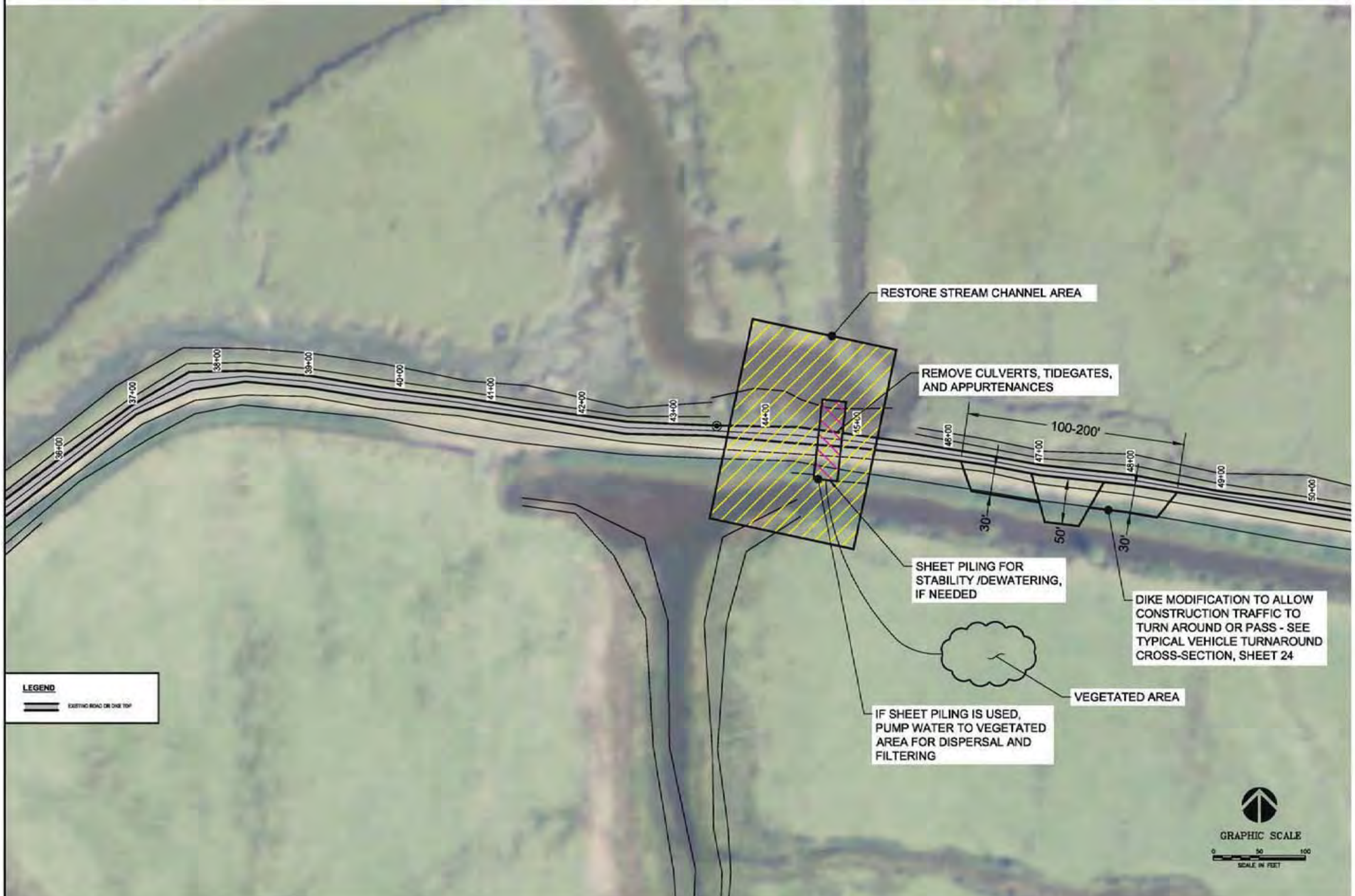
BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

7

SHEET NUMBER



70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: RIEKKOLA (PARKER SLOUGH AREA) TIDEGATE REMOVAL DETAIL

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

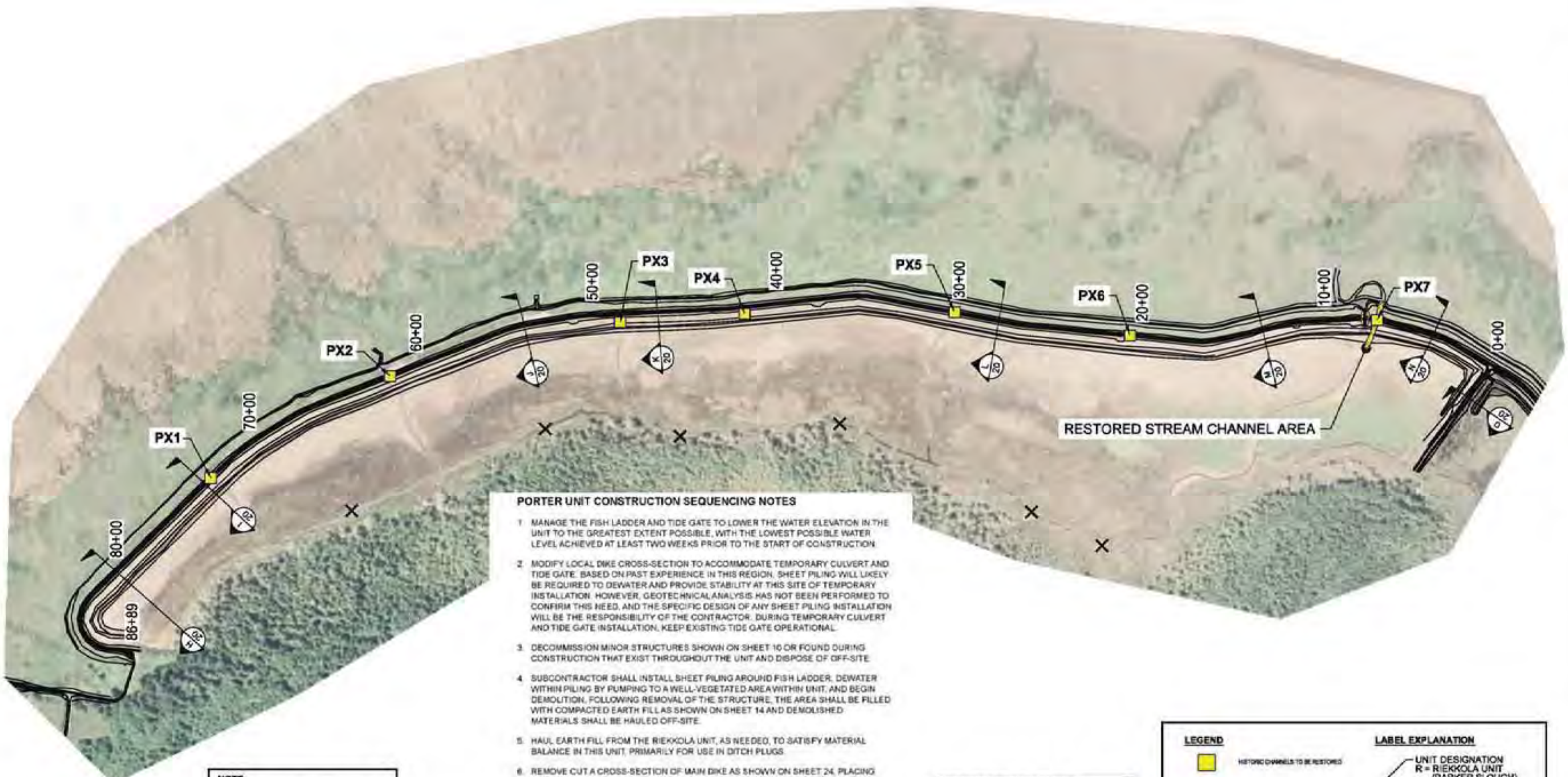
amec

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

8

SHEET NUMBER



PORTER UNIT CONSTRUCTION SEQUENCING NOTES

1. MANAGE THE FISH LADDER AND TIDE GATE TO LOWER THE WATER ELEVATION IN THE UNIT TO THE GREATEST EXTENT POSSIBLE, WITH THE LOWEST POSSIBLE WATER LEVEL ACHIEVED AT LEAST TWO WEEKS PRIOR TO THE START OF CONSTRUCTION.
2. MODIFY LOCAL DIKE CROSS-SECTION TO ACCOMMODATE TEMPORARY CULVERT AND TIDE GATE. BASED ON PAST EXPERIENCE IN THIS REGION, SHEET PILING WILL LIKELY BE REQUIRED TO DEWATER AND PROVIDE STABILITY AT THIS SITE OF TEMPORARY INSTALLATION. HOWEVER, GEOTECHNICAL ANALYSIS HAS NOT BEEN PERFORMED TO CONFIRM THIS NEED, AND THE SPECIFIC DESIGN OF ANY SHEET PILING INSTALLATION WILL BE THE RESPONSIBILITY OF THE CONTRACTOR. DURING TEMPORARY CULVERT AND TIDE GATE INSTALLATION, KEEP EXISTING TIDE GATE OPERATIONAL.
3. DECOMMISSION MINOR STRUCTURES SHOWN ON SHEET 10 OR FOUND DURING CONSTRUCTION THAT EXIST THROUGHOUT THE UNIT AND DISPOSE OF OFF-SITE.
4. SUBCONTRACTOR SHALL INSTALL SHEET PILING AROUND FISH LADDER, DEWATER WITHIN PILING BY PUMPING TO A WELL-VEGETATED AREA WITHIN UNIT, AND BEGIN DEMOLITION. FOLLOWING REMOVAL OF THE STRUCTURE, THE AREA SHALL BE FILLED WITH COMPACTED EARTH FILL AS SHOWN ON SHEET 14 AND DEMOLISHED MATERIALS SHALL BE HAULED OFF-SITE.
5. HAUL EARTH FILL FROM THE RIEKKOLA UNIT, AS NEEDED, TO SATISFY MATERIAL BALANCE IN THIS UNIT, PRIMARILY FOR USE IN DITCH PLUGS.
6. REMOVE CUT A CROSS-SECTION OF MAIN DIKE AS SHOWN ON SHEET 24, PLACING THE MATERIAL IN THE INBOARD DITCHES. THIS MAY BE DONE IN ONE OR MORE STAGES, TO BE DICTATED BY THE TIDAL ELEVATIONS LIKELY TO BE ENCOUNTERED DURING CONSTRUCTION. BORROW DITCHES SHALL BE COMPLETELY FILLED AND A SMALL TRENCH CREATED WITHIN THE EXISTING DIKE FOOTPRINT TO ACCEPT THE LAST CUT OF ADJACENT DIKE MATERIAL OR THE BORROW DITCHES MAY BE MOSTLY FILLED, LEAVING ENOUGH ROOM FOR THE REMAINING DIKE MATERIAL. THIS DESIGN GUIDELINE IS SUBJECT TO CHANGE BASED UPON SPOT LOCAL SAFETY REASONS. DIKE REMOVAL WILL NEED TO SUPPORT SAFE PASSAGE OF EQUIPMENT. ADAPTIVE MANAGEMENT BY THE CONTRACTOR MAY RESULT IN CHANGING THE CONFIGURATION AS NEEDED.
7. REMOVE THE REMAINING DIKE MATERIAL BY STARTING AT THE EASTERN END OF THE UNIT AND WORKING WEST, PLACING THE MATERIALS IN THE CREATED TRENCH OR DITCH.
8. RESTORE THE CHANNELS WHERE IDENTIFIED ON THE PLAN SET AS THEY ARE ENCOUNTERED. FINAL BREACH SHALL BE MADE ON AN INCOMING TIDE TO MINIMIZE DOWNSTREAM SEDIMENT MOVEMENT.
9. REMOVE TEMPORARY CULVERT AND TIDE GATE WHEN LOCAL CHANNEL IS RESTORED.
10. CREATE MINOR PLUGS IN INTERCEPTOR DITCH AND RESTORE CHANNEL CONNECTIONS BETWEEN THE UPSLOPE PART OF THE UNIT AND THE RESTORED CHANNELS.

NOTE:
PLUGS SHOWN IN INTERCEPTOR DITCH ARE REPRESENTATIONS OF THE INTENT TO REDIRECT FLOWS THROUGH RESTORED STREAM CROSSINGS AFTER THEY HAVE BEEN OPENED UP. NO SURVEYS OR QUANTITY CALCULATIONS HAVE BEEN COMPLETED FOR THESE PLUGS. MATERIAL CUTS AND FILLS WILL BE LOCALIZED.

Porter Unit Dike and Ditch Summary	
Dike Length Cut (Feet)	9,378
Ditch Length Filled (Feet)	8,860
Total Volume Cut (CY)	44,832
Total Volume Filled (CY)	47,843
Net Cut/(Fill) Volume (CY)	(3,011)
Number of Historic Channels Restored	7

LEGEND

- HISTORIC CHANNELS TO BE RESTORED
- EXISTING ROAD OR DIKE TOP
- CROSS-SECTION LOCATION
- INTERCEPTOR DITCH PLUGS

LABEL EXPLANATION

PC2
- UNIT DESIGNATION: R = RIEKKOLA UNIT (PARKER SLOUGH); P = PORTER UNIT; L = LEWIS UNIT
- SEQUENTIAL NUMBERING
- TYPE DESIGNATION: X = HISTORIC CHANNEL; L = LEVEE; D = DITCH; R = ROAD; C = CULVERT/ OTHER STRUCTURES; P = DITCH PLUG

GRAPHIC SCALE
0 300 600
SCALE IN FEET

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER UNIT
PLAN VIEW - FEATURES

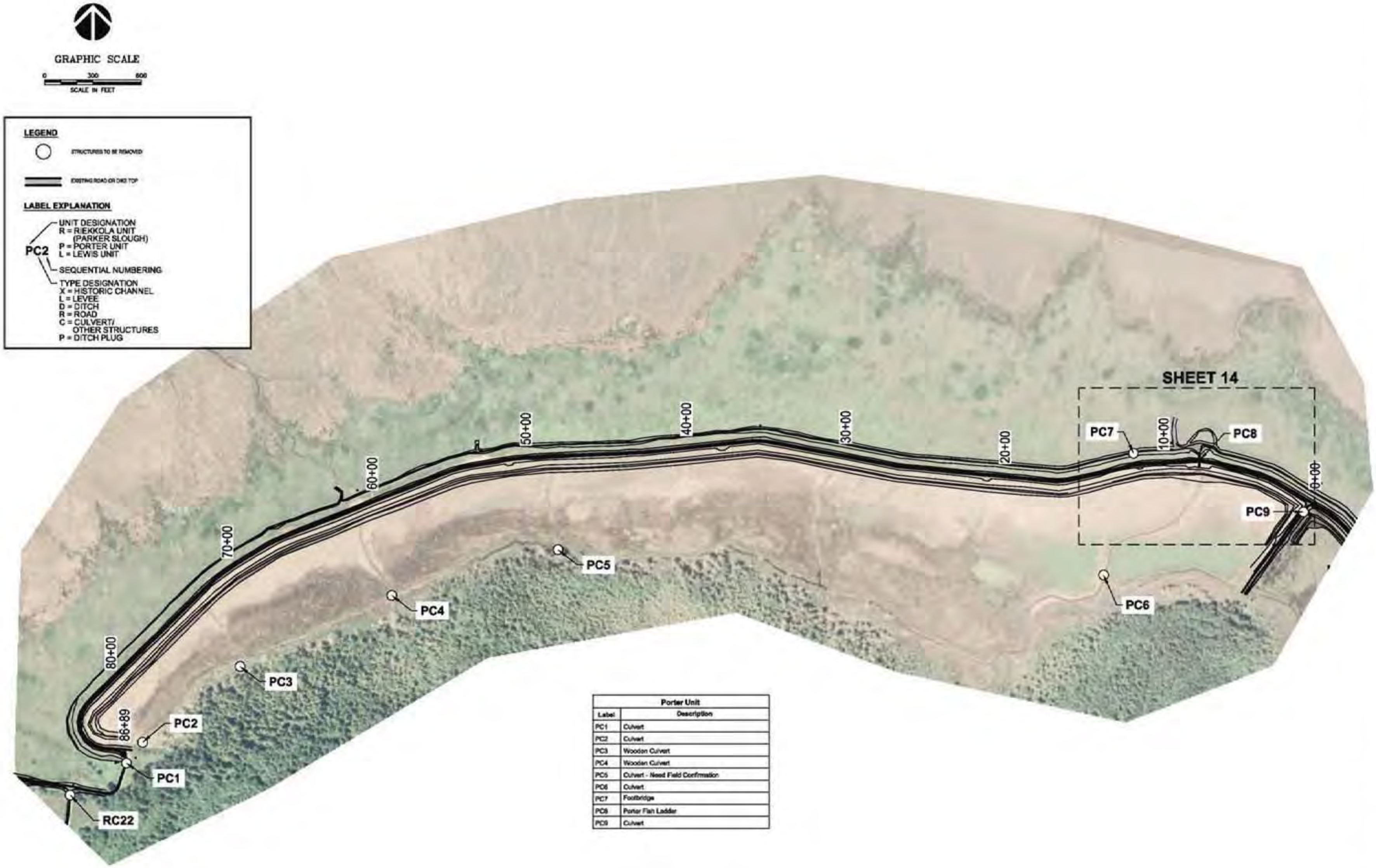
Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

amec

BEAR RIVER ESTUARY RESTORATION
Project No. 0-915-15933-0 | REV No.
DR: JRB | CHK: RB/PS
DATE: JULY 2010

9
SHEET NUMBER



Porter Unit	
Label	Description
PC1	Culvert
PC2	Culvert
PC3	Wooden Culvert
PC4	Wooden Culvert
PC5	Culvert - Need Field Confirmation
PC6	Culvert
PC7	Footbridge
PC8	Porter Fish Ladder
PC9	Culvert

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER UNIT
PLAN VIEW - STRUCTURE REMOVAL

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

10

SHEET NUMBER

LEGEND

- (yellow square) HISTORIC CHANNELS TO BE RESTORED
- (purple hatch) DIKE CUT
- (green hatch) DITCH FILL

LABEL EXPLANATION

PC2
- UNIT DESIGNATION
  - R = RIEKKOLA UNIT (PARKER SLOUGH)
  - P = PORTER UNIT
  - L = LEWIS UNIT
- SEQUENTIAL NUMBERING
- TYPE DESIGNATION
  - X = HISTORIC CHANNEL
  - L = LEVEE
  - D = DITCH
  - R = ROAD
  - C = CULVERT/ OTHER STRUCTURES
  - P = DITCH PLUG

SURVEY SYMBOL LEGEND

● = SET REBAR AND CAP (DTS ENGINEERS)

GRAPHIC SCALE

0 100 200

SCALE IN FEET

Dikes

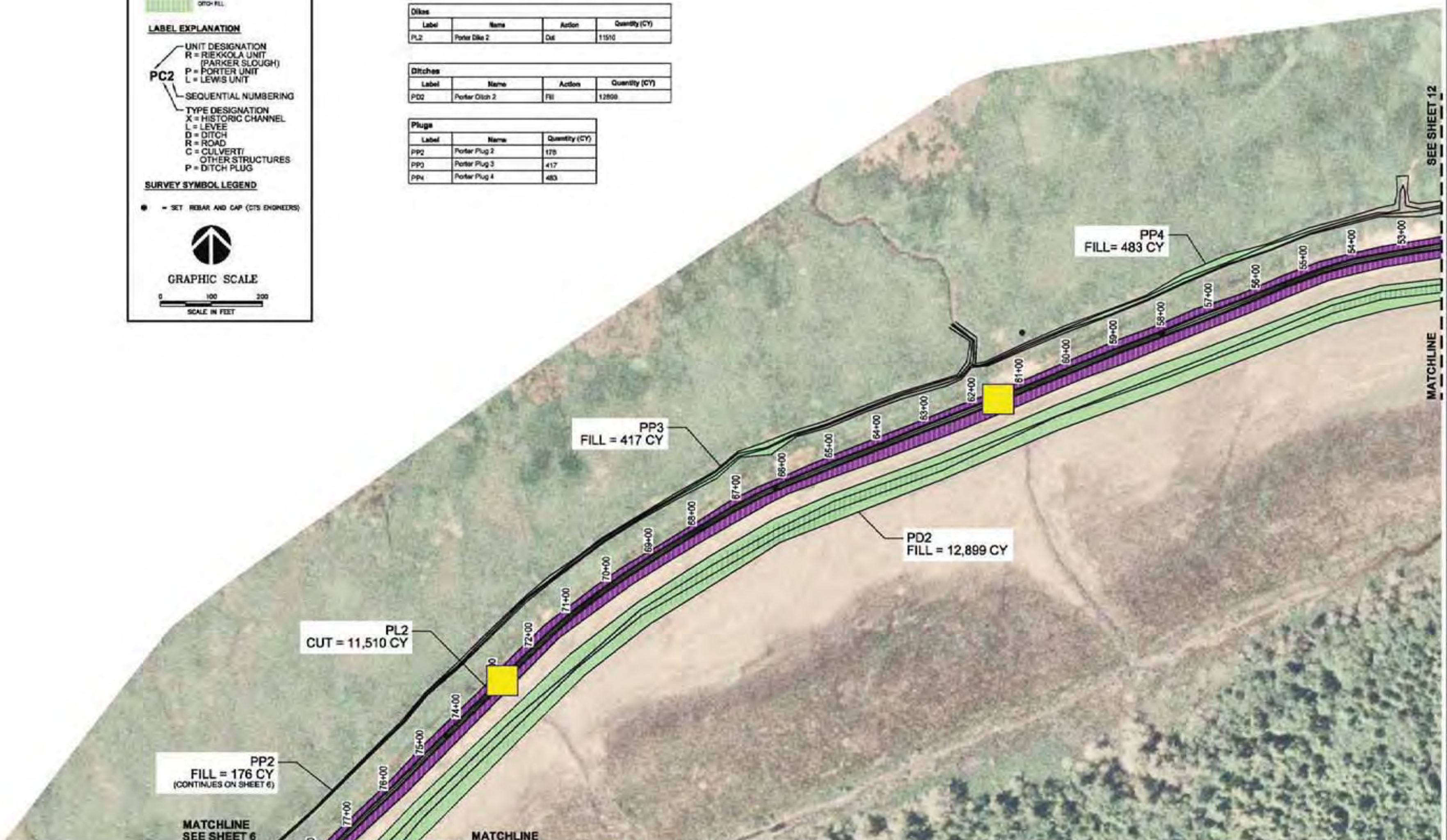
Label	Name	Action	Quantity (CY)
PL2	Porter Dike 2	Cut	11510

Ditches

Label	Name	Action	Quantity (CY)
PD2	Porter Ditch 2	Fill	12899

Plugs

Label	Name	Quantity (CY)
PP2	Porter Plug 2	176
PP3	Porter Plug 3	417
PP4	Porter Plug 4	483



70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER UNIT EARTHWORK LAYOUT 1

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

BEAR RIVER ESTUARY RESTORATION

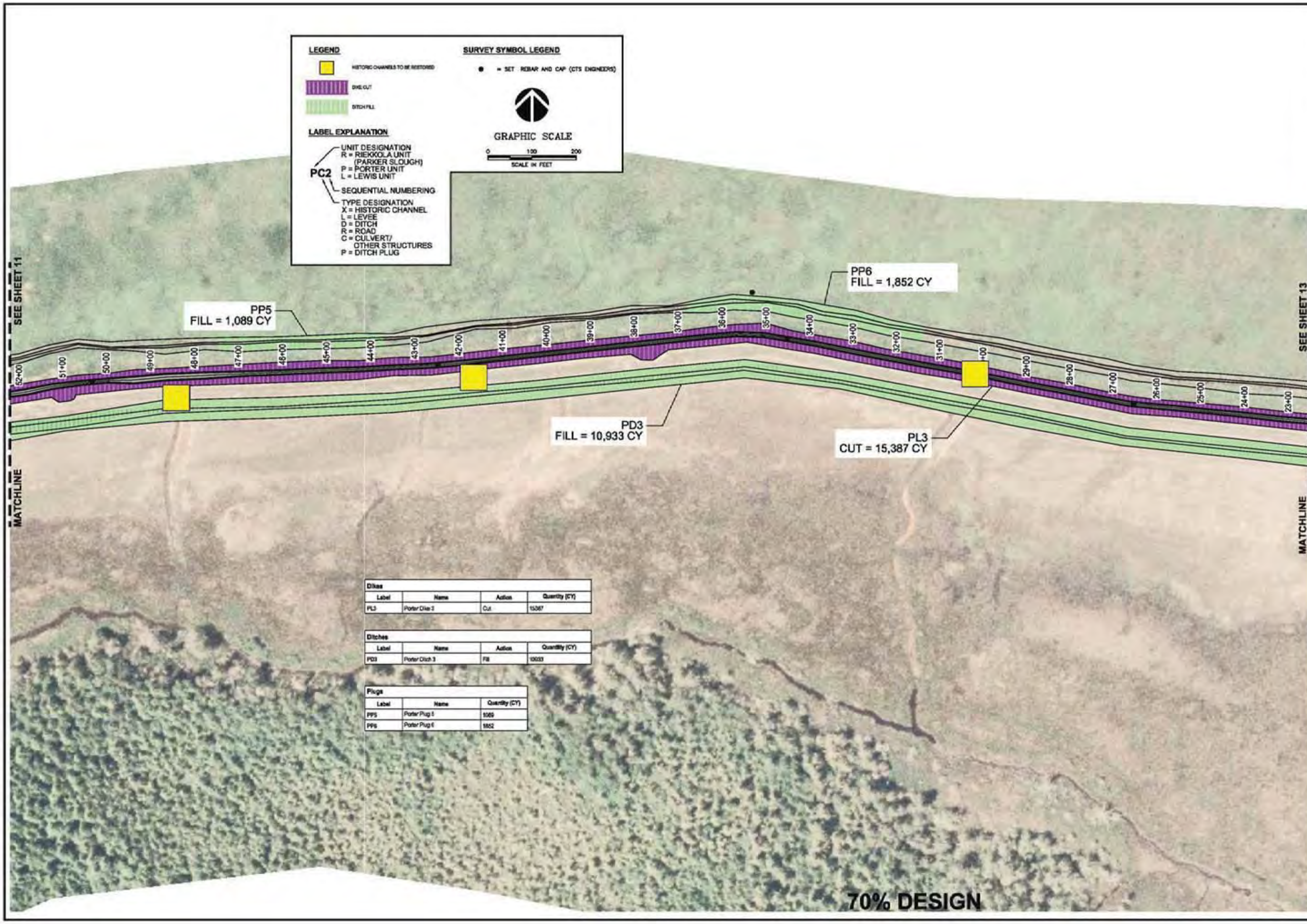
Project No. 0-915-16930-0 | REV No.

DR: JRB | CHK: RB/PB

DATE: JULY 2010

11

SHEET NUMBER



Dikes

Label	Name	Action	Quantity (CY)
PL3	Porter Dike 3	Cut	15387

Ditches

Label	Name	Action	Quantity (CY)
PD3	Porter Ditch 3	Fill	10933

Plugs

Label	Name	Quantity (CY)
PP5	Porter Plug 5	1089
PP6	Porter Plug 6	1852

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER UNIT EARTHWORK LAYOUT 2

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

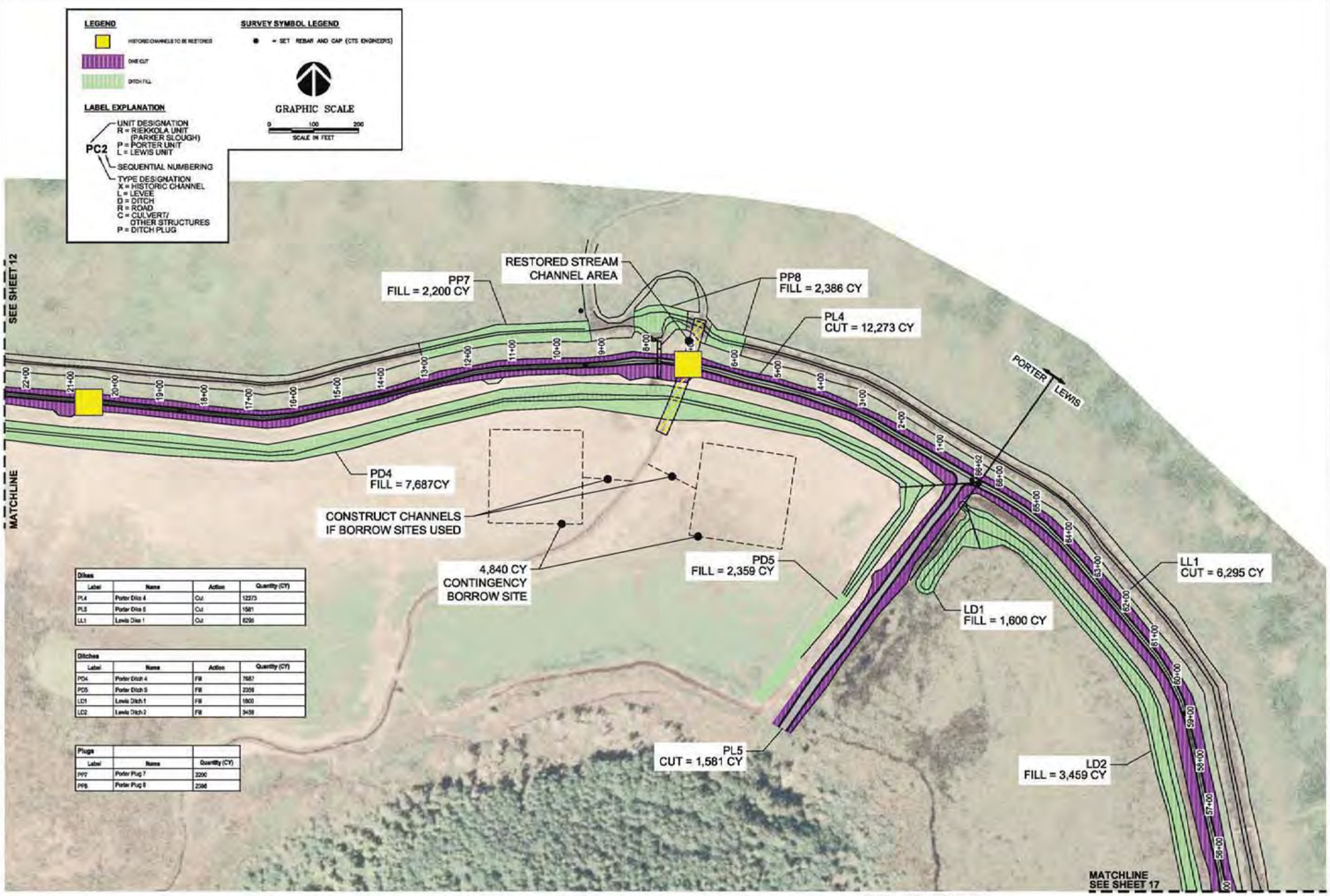
AMEC Earth & Environmental

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

12

SHEET NUMBER



Dikes			
Label	Name	Action	Quantity (CY)
PL4	Porter Dike 4	Cut	12273
PL5	Porter Dike 5	Cut	1581
LL1	Lewis Dike 1	Cut	6295

Ditches			
Label	Name	Action	Quantity (CY)
PD4	Porter Ditch 4	Fill	7687
PD5	Porter Ditch 5	Fill	2359
LD1	Lewis Ditch 1	Fill	1600
LD2	Lewis Ditch 2	Fill	3459

Plugs		
Label	Name	Quantity (CY)
PP7	Porter Plug 7	2200
PP8	Porter Plug 8	2386

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER UNIT EARTHWORK LAYOUT 3

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

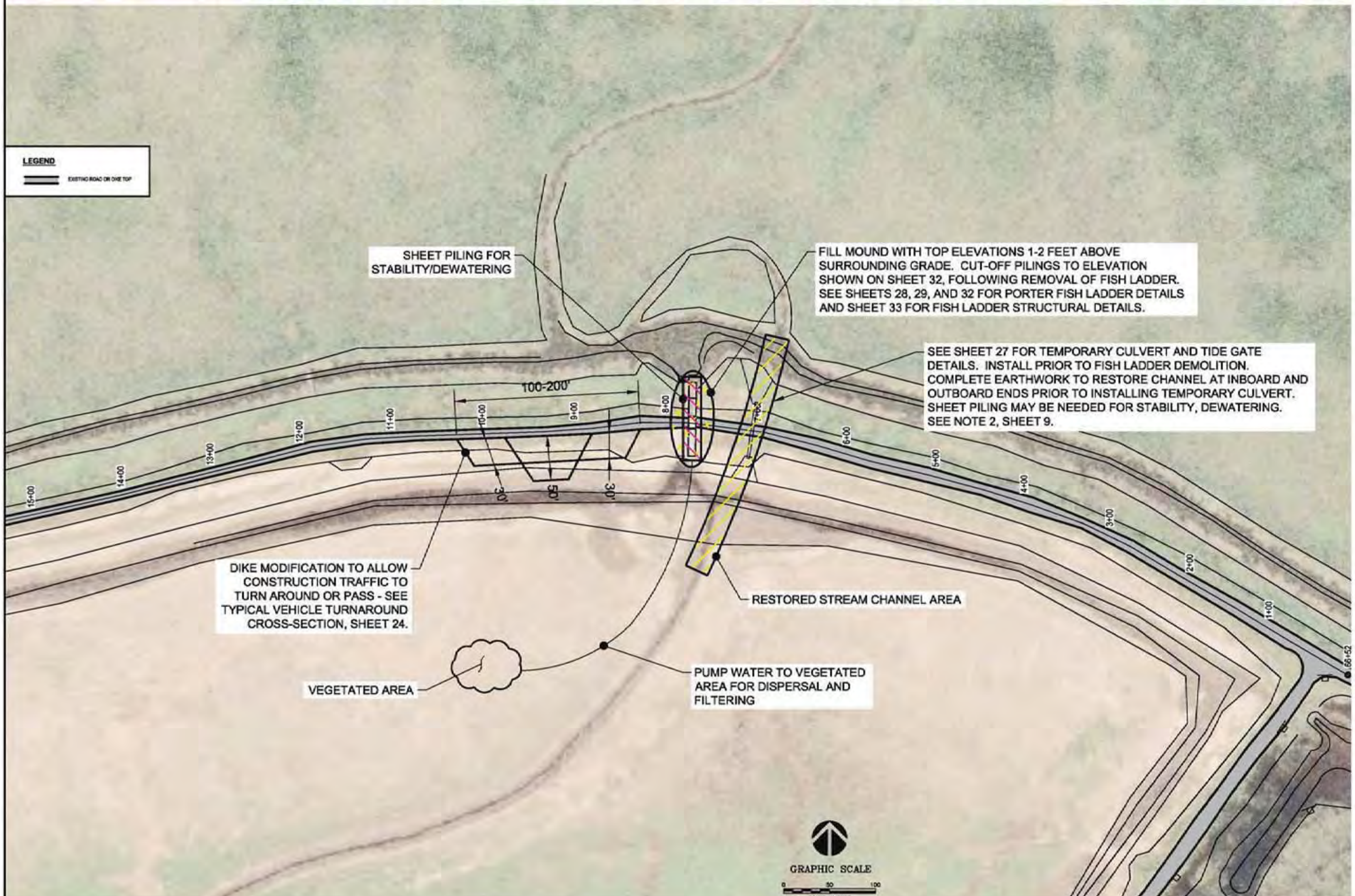
AMEC Earth & Environmental

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

13

SHEET NUMBER



70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER FISH LADDER REMOVAL DETAIL

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

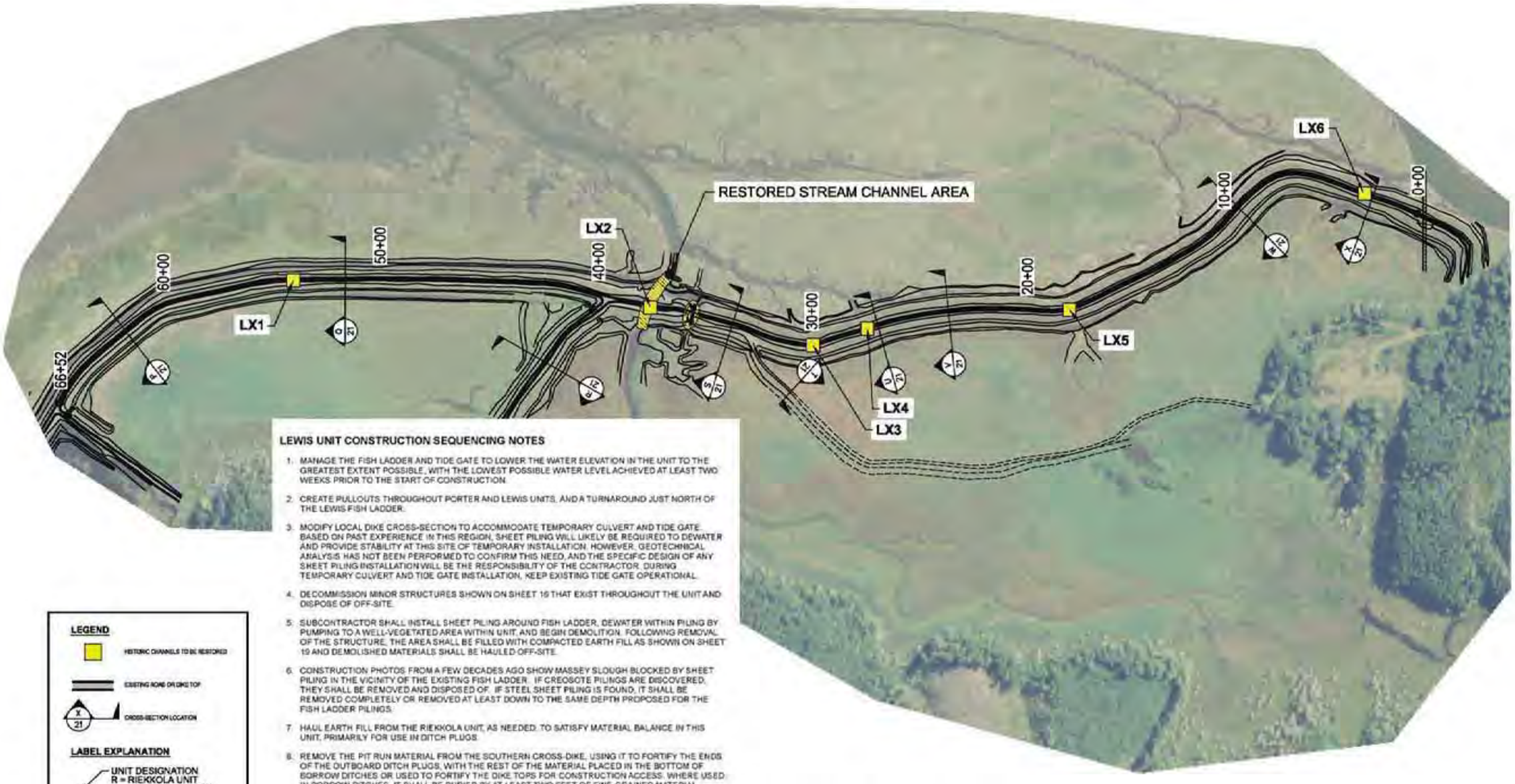
AMEC Earth & Environmental

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

14

SHEET NUMBER



LEWIS UNIT CONSTRUCTION SEQUENCING NOTES

1. MANAGE THE FISH LADDER AND TIDE GATE TO LOWER THE WATER ELEVATION IN THE UNIT TO THE GREATEST EXTENT POSSIBLE, WITH THE LOWEST POSSIBLE WATER LEVEL ACHIEVED AT LEAST TWO WEEKS PRIOR TO THE START OF CONSTRUCTION.
2. CREATE PULLOUTS THROUGHOUT PORTER AND LEWIS UNITS, AND A TURNAROUND JUST NORTH OF THE LEWIS FISH LADDER.
3. MODIFY LOCAL DIKE CROSS-SECTION TO ACCOMMODATE TEMPORARY CULVERT AND TIDE GATE. BASED ON PAST EXPERIENCE IN THIS REGION, SHEET PILING WILL LIKELY BE REQUIRED TO DEWATER AND PROVIDE STABILITY AT THIS SITE OF TEMPORARY INSTALLATION. HOWEVER, GEOTECHNICAL ANALYSIS HAS NOT BEEN PERFORMED TO CONFIRM THIS NEED, AND THE SPECIFIC DESIGN OF ANY SHEET PILING INSTALLATION WILL BE THE RESPONSIBILITY OF THE CONTRACTOR. DURING TEMPORARY CULVERT AND TIDE GATE INSTALLATION, KEEP EXISTING TIDE GATE OPERATIONAL.
4. DECOMMISSION MINOR STRUCTURES SHOWN ON SHEET 19 THAT EXIST THROUGHOUT THE UNIT AND DISPOSE OF OFF-SITE.
5. SUBCONTRACTOR SHALL INSTALL SHEET PILING AROUND FISH LADDER, DEWATER WITHIN PILING BY PUMPING TO A WELL-VEGETATED AREA WITHIN UNIT, AND BEGIN DEMOLITION. FOLLOWING REMOVAL OF THE STRUCTURE, THE AREA SHALL BE FILLED WITH COMPACTED EARTH FILL AS SHOWN ON SHEET 19 AND DEMOLISHED MATERIALS SHALL BE HAULED OFF-SITE.
6. CONSTRUCTION PHOTOS FROM A FEW DECADES AGO SHOW MASSEY SLOUGH BLOCKED BY SHEET PILING IN THE VICINITY OF THE EXISTING FISH LADDER. IF CREOSOTE PILINGS ARE DISCOVERED, THEY SHALL BE REMOVED AND DISPOSED OF. IF STEEL SHEET PILING IS FOUND, IT SHALL BE REMOVED COMPLETELY OR REMOVED AT LEAST DOWN TO THE SAME DEPTH PROPOSED FOR THE FISH LADDER PILINGS.
7. HAUL EARTH FILL FROM THE RIEKKOLA UNIT, AS NEEDED, TO SATISFY MATERIAL BALANCE IN THIS UNIT, PRIMARILY FOR USE IN DITCH PLUGS.
8. REMOVE THE PIT RUN MATERIAL FROM THE SOUTHERN CROSS-DIKE, USING IT TO FORTIFY THE ENDS OF THE OUTBOARD DITCH PLUGS, WITH THE REST OF THE MATERIAL PLACED IN THE BOTTOM OF BORROW DITCHES OR USED TO FORTIFY THE DIKE TOPS FOR CONSTRUCTION ACCESS. WHERE USED IN BORROW DITCHES, IT SHALL BE BURIED BY AT LEAST TWO FEET OF FINE-GRAINED MATERIAL. ALTERNATELY, IF THIS MATERIAL COULD BE SUITABLE AS CHANNEL BOTTOM MATERIAL, STOCKPILE IT FOR LATER PLACEMENT.
9. REMOVE CUT A CROSS-SECTION OF MAIN DIKE AS SHOWN ON SHEET 24, PLACING THE MATERIAL IN THE INBOARD DITCHES. THIS MAY BE DONE IN ONE OR MORE STAGES, TO BE DICTATED BY THE TIDAL ELEVATIONS LIKELY TO BE ENCOUNTERED DURING CONSTRUCTION. BORROW DITCHES SHALL BE COMPLETELY FILLED AND A SMALL TRENCH CREATED WITHIN THE EXISTING DIKE FOOTPRINT TO ACCEPT THE LAST CUT OF ADJACENT DIKE MATERIAL OR THE BORROW DITCHES MAY BE MOSTLY FILLED, LEAVING ENOUGH ROOM FOR THE REMAINING DIKE MATERIAL. THIS DESIGN GUIDELINE IS SUBJECT TO CHANGE BASED UPON SPOT LOCAL SAFETY REASONS. DIKE REMOVAL WILL NEED TO SUPPORT SAFE PASSAGE OF EQUIPMENT. ADAPTIVE MANAGEMENT BY THE CONTRACTOR MAY RESULT IN CHANGING THE CONFIGURATION AS NEEDED.
10. REMOVE THE CROSS-DIKE JUST NORTH OF THE LEWIS FISH LADDER.
11. REMOVE THE REMAINING DIKE MATERIAL BY STARTING AT THE SOUTHERN END OF THE UNIT AND WORKING NORTH, PLACING THE MATERIALS IN THE CREATED TRENCH WITHIN THE CURRENT DIKE FOOTPRINT OR THE DITCH.
12. RESTORE THE CHANNELS WHERE IDENTIFIED ON THE PLAN SET AS THEY ARE ENCOUNTERED. FINAL BREACH SHALL BE MADE ON AN INCOMING TIDE TO MINIMIZE DOWNSTREAM SEDIMENT MOVEMENT.
13. REMOVE TEMPORARY CULVERT AND TIDE GATE WHEN LOCAL CHANNEL IS RESTORED.

Lewis Unit Dike and Ditch Summary	
Dike Length Cut (Feet)	9,896
Ditch Length Filled (Feet)	7,424
Total Volume Cut (CY)	43,226
Total Volume Filled (CY)	46,185
Net Cut/(Fill) Volume (CY)	(2,959)
Number of Historic Channels Restored	6

LEGEND

HISTORIC CHANNELS TO BE RESTORED

EXISTING ROAD OR DIKE TOP

CROSS-SECTION LOCATION

LABEL EXPLANATION

LC2
- UNIT DESIGNATION
  - R = RIEKKOLA UNIT (PARKER SLOUGH)
  - P = PORTER UNIT
  - L = LEWIS UNIT
- SEQUENTIAL NUMBERING
- TYPE DESIGNATION
  - X = HISTORIC CHANNEL
  - L = LEVEE
  - D = DITCH
  - R = ROAD
  - C = CULVERT/ OTHER STRUCTURES
  - P = DITCH PLUG

GRAPHIC SCALE

0 250 500

SCALE IN FEET

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

amec

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS UNIT PLAN VIEW - FEATURES

BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

15

SHEET NUMBER

LEGEND

○ STRUCTURES TO BE REMOVED

═ EXISTING ROAD OR DIKE TOP

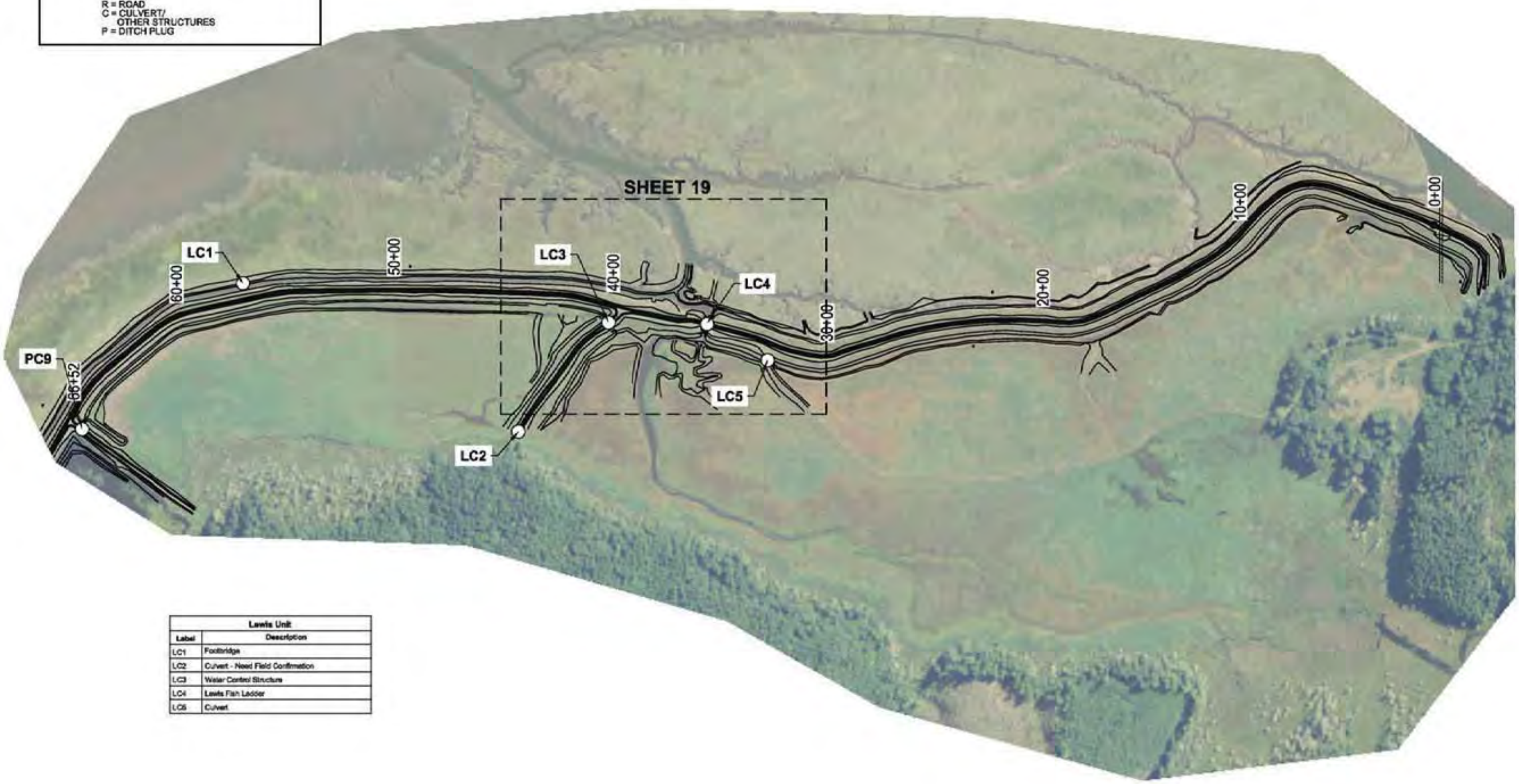
LABEL EXPLANATION

LC2
- UNIT DESIGNATION
  - R = RIEKKOLA UNIT (PARKER SLOUGH)
  - P = PORTER UNIT
  - L = LEWIS UNIT
- SEQUENTIAL NUMBERING
- TYPE DESIGNATION
  - X = HISTORIC CHANNEL
  - L = LEVEE
  - D = DITCH
  - R = ROAD
  - C = CULVERT/ OTHER STRUCTURES
  - P = DITCH PLUG

GRAPHIC SCALE

0 250 500

SCALE IN FEET



Lewis Unit	
Label	Description
LC1	Footbridge
LC2	Culvert - Need Field Confirmation
LC3	Water Control Structure
LC4	Lewis Fish Ladder
LC5	Culvert

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS UNIT
PLAN VIEW - STRUCTURE REMOVAL

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

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BEAR RIVER ESTUARY RESTORATION

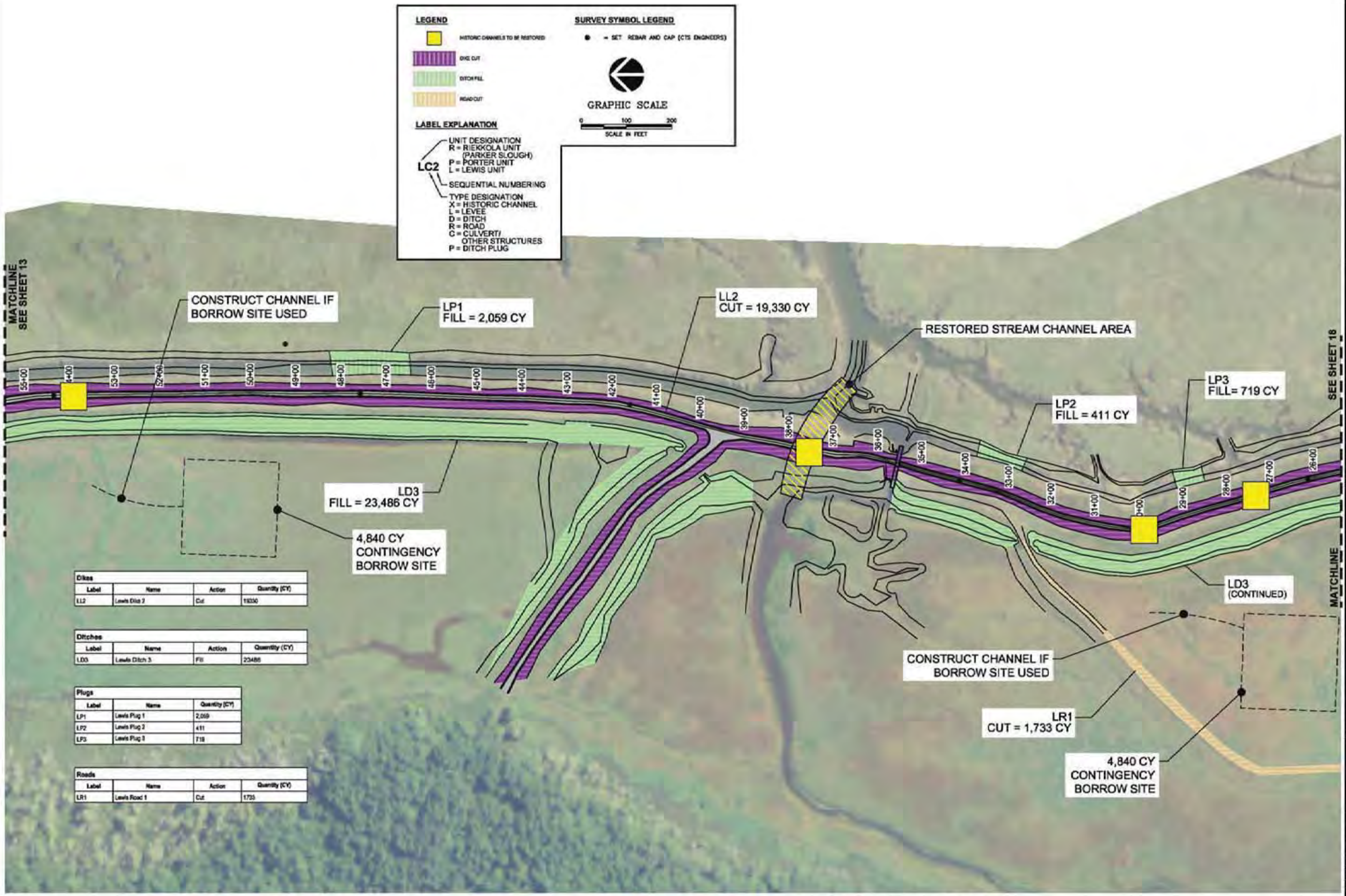
Project No. 5-915-15030-0 | REV No.

DR: JRS | CHK: REPS

DATE: JULY 2010

16

SHEET NUMBER



Dikes

Label	Name	Action	Quantity (CY)
LL2	Lewis Dike 2	Cut	19330

Ditches

Label	Name	Action	Quantity (CY)
LD3	Lewis Ditch 3	Fill	23486

Plugs

Label	Name	Quantity (CY)
LP1	Lewis Plug 1	2,059
LP2	Lewis Plug 2	411
LP3	Lewis Plug 3	719

Roads

Label	Name	Action	Quantity (CY)
LR1	Lewis Road 1	Cut	1733

70% DESIGN

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS UNIT EARTHWORK LAYOUT 1

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

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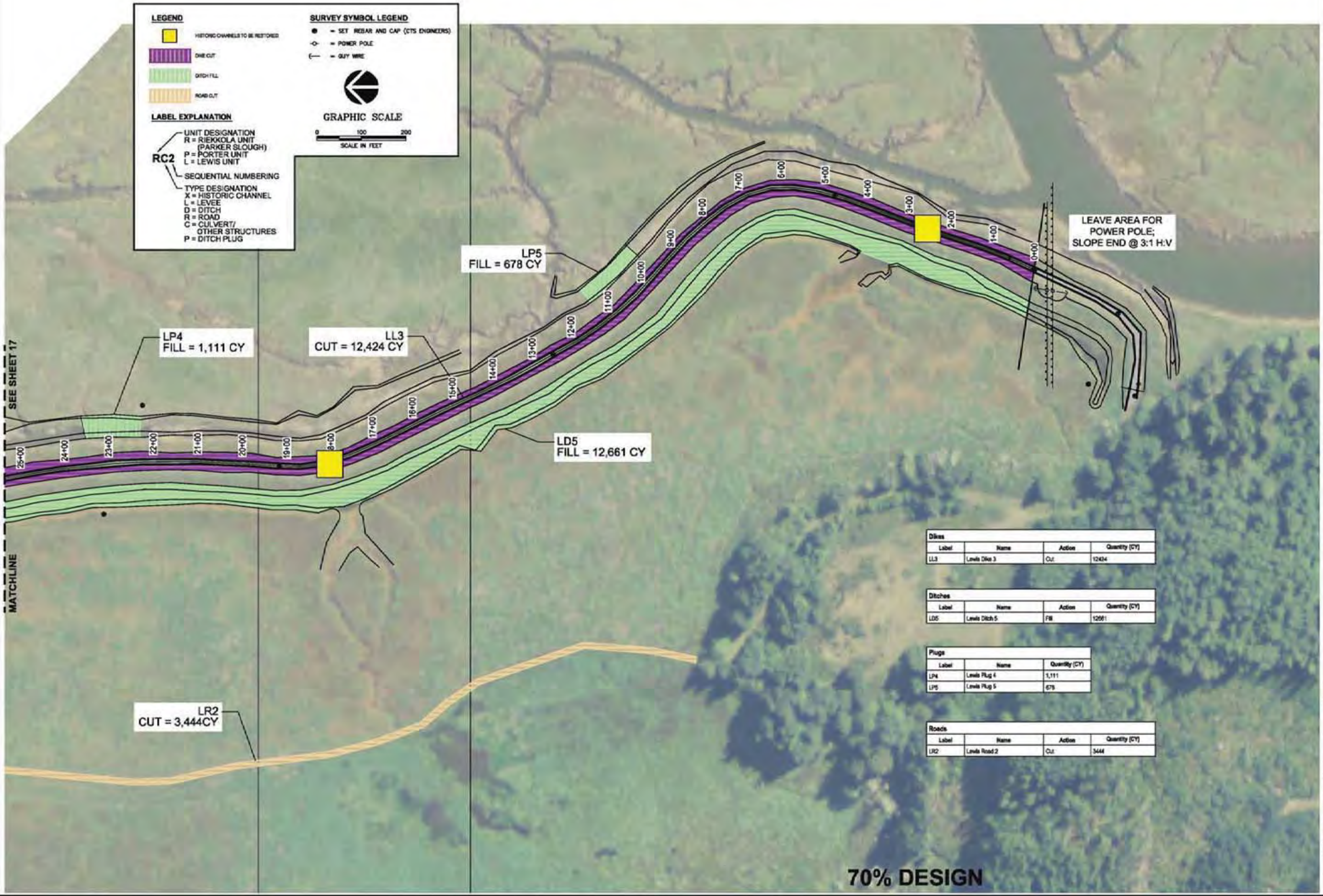
BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

17

SHEET NUMBER



Dikes

Label	Name	Action	Quantity (CY)
LL3	Lewis Dike 3	Cut	12424

Ditches

Label	Name	Action	Quantity (CY)
LD5	Lewis Ditch 5	Fill	12661

Plugs

Label	Name	Quantity (CY)
LP4	Lewis Plug 4	1,111
LP5	Lewis Plug 5	678

Roads

Label	Name	Action	Quantity (CY)
LR2	Lewis Road 2	Cut	3444

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS UNIT
EARTHWORK LAYOUT 2

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental

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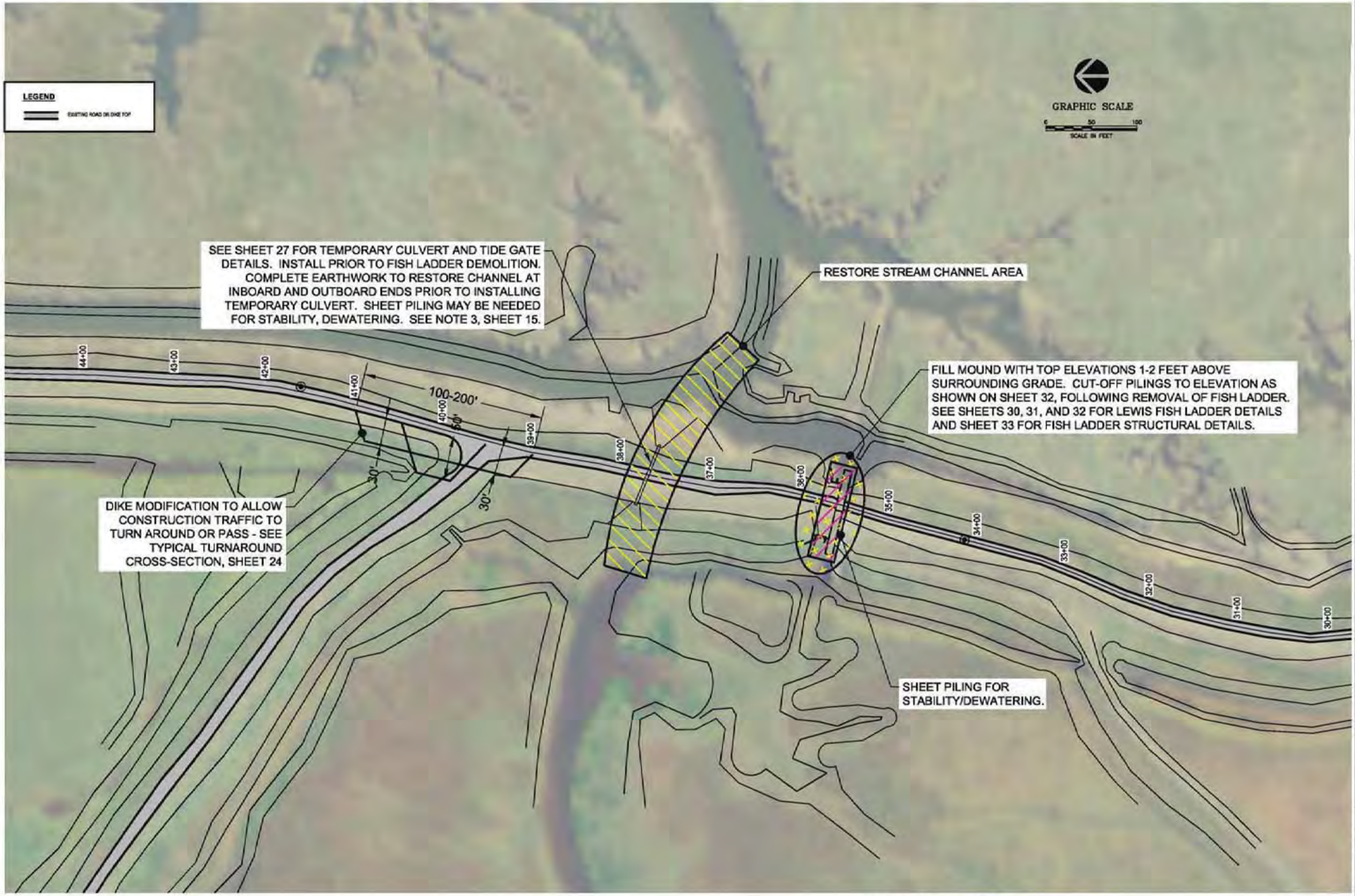
BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

18

SHEET NUMBER



70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS FISH LADDER REMOVAL DETAIL

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

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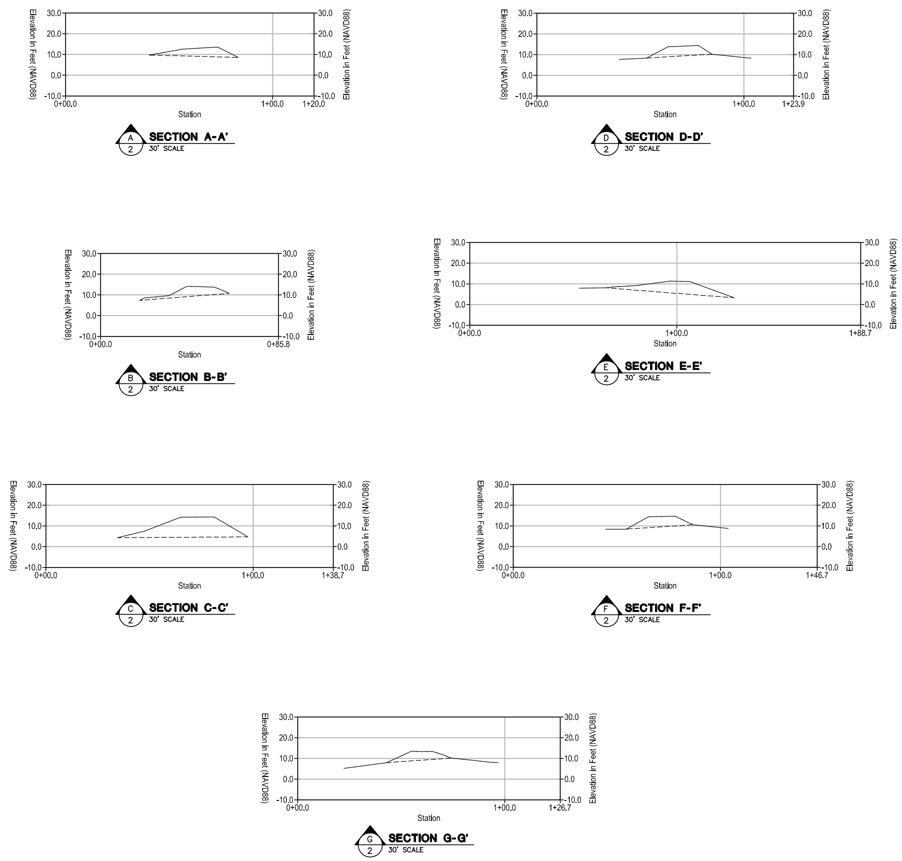
AMEC Earth & Environmental

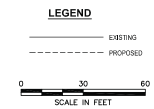
BEAR RIVER ESTUARY RESTORATION

DATE: JULY 2010

19

SHEET NUMBER





RIEKKOLA UNIT (PARKER SLOUGH AREA) EXISTING CROSS SECTIONS

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: REIKKOLA UNIT (PARKER SLOUGH AREA) CROSS SECTIONS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

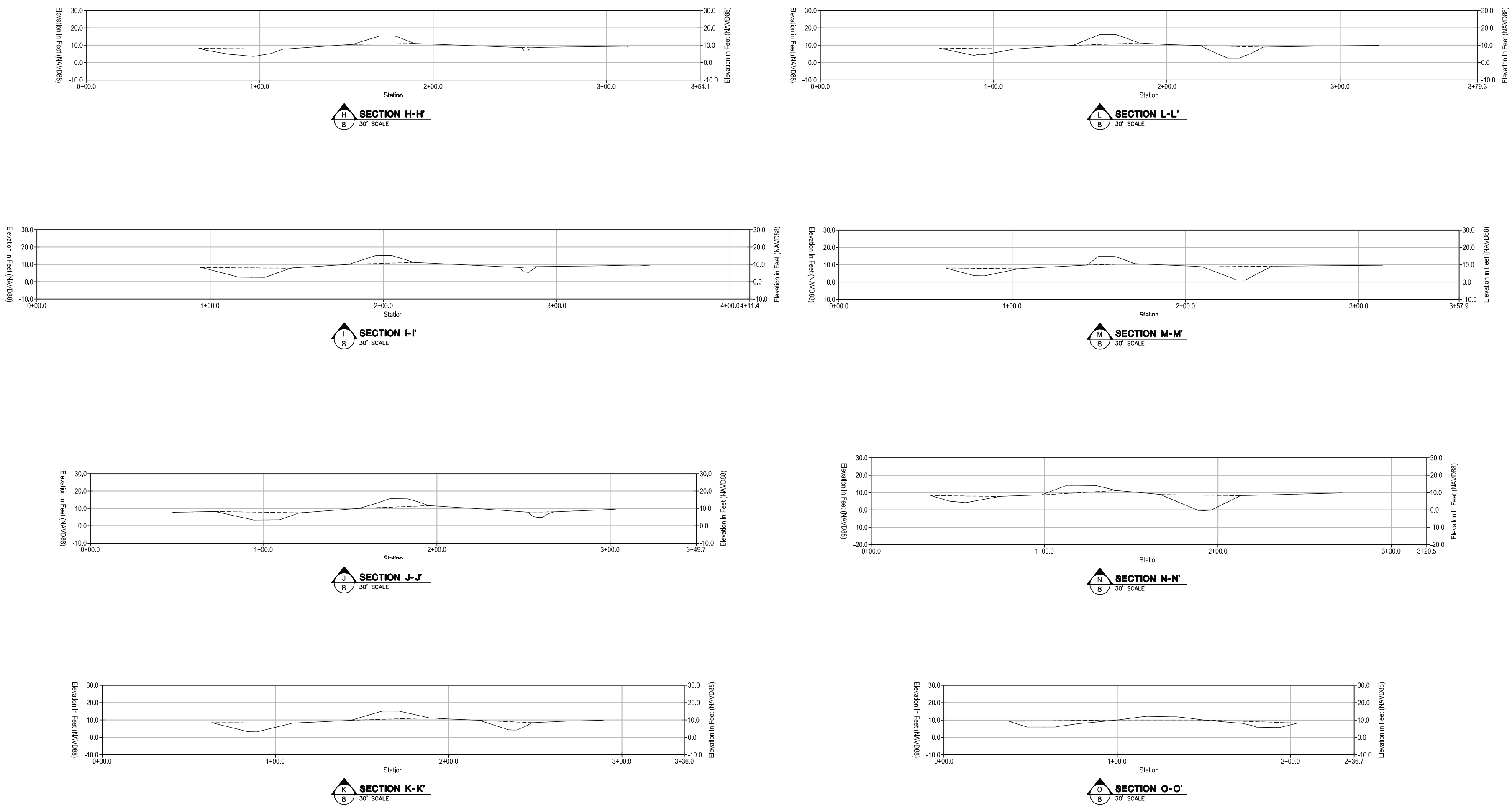
BEAR RIVER ESTUARY RESTORATION

Project No. 0-915-16933-0 | REV No.

DR: JRS | CHK: RB/PS

DATE: JULY 2010

20
SHEET NUMBER



PORTER UNIT EXISTING CROSS SECTIONS

LEGEND

EXISTING

PROPOSED

0 30 60
SCALE IN FEET

70% DESIGN

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER UNIT CROSS SECTIONS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

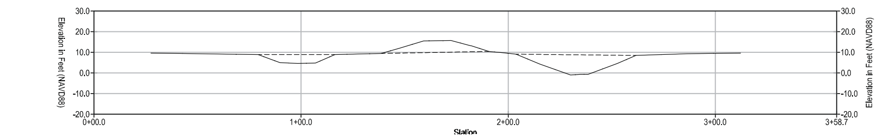
BEAR RIVER ESTUARY RESTORATION

Project No. 0-915-16933-0 | REV No.

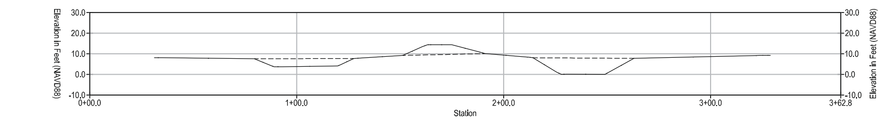
DR: JRS | CHK: RB/PS

DATE: JULY 2010

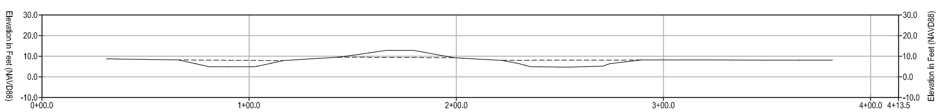
21
SHEET NUMBER



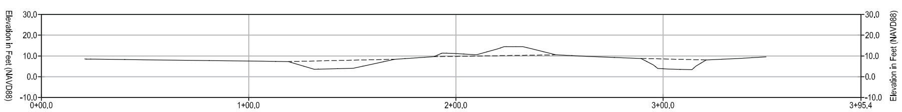
SECTION P-P'
P 14 30' SCALE



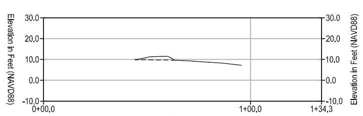
SECTION Q-Q'
Q 14 30' SCALE



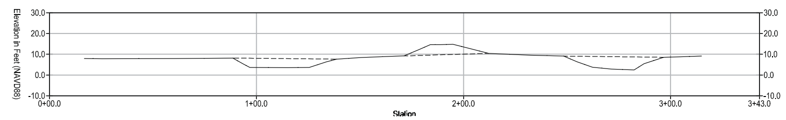
SECTION R-R'
R 14 30' SCALE



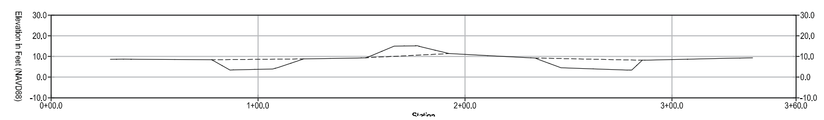
SECTION S-S'
S 14 30' SCALE



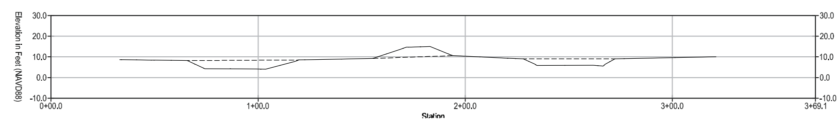
SECTION T-T'
T 14 30' SCALE



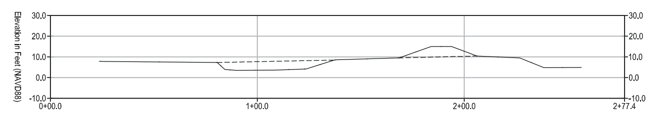
SECTION U-U'
U 14 30' SCALE



SECTION V-V'
V 14 30' SCALE



SECTION W-W'
W 14 30' SCALE



SECTION X-X'
X 14 30' SCALE

LEGEND

——— EXISTING
- - - - PROPOSED

0 30 60
SCALE IN FEET

LEWIS UNIT EXISTING CROSS SECTIONS

70% DESIGN

NO.	DESCRIPTION	BY	DATE

REVISIONS

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS UNIT CROSS SECTIONS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

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BEAR RIVER ESTUARY RESTORATION
Project No. 0-915-16933-0 | REV No.
DR: JRS | CHK: RB/PS
DATE: JULY 2010

22
SHEET NUMBER

G:\91\16000\16933 - Bear River Estuary\Element 1-2 Combined\16933-02.dwg - P022 - Jul. 16, 2010 1:19pm - jeffrey.sanders

THE MOST IMPORTANT PARAMETERS FOR THE CHANNELS ARE THE ELEVATION, WIDTH, AND SIDE SLOPES. THE RECOMMENDED DEPTHS AND WIDTHS FOR THE CHANNELS HAVE BEEN COMPUTED CONSERVATIVELY. THESE RECOMMENDED CONFIGURATIONS REPRESENT PREDICTED CHANNEL SIZES AND DEPTHS, USING EMPIRICAL RELATIONSHIPS FROM OTHER LOCATIONS, EXTRAPOLATED TO THE TIDE RANGE AT THIS PROJECT SITE. THERE ARE A NUMBER OF UNCERTAINTIES IN THE RELATIONSHIPS, LOCAL FACTORS, AND DATA. THEREFORE, THE HISTORIC CHANNEL DEPTHS SHOULD BE CONSTRUCTED AT AN ELEVATION NO HIGHER THAN EXISTING, AND AS CLOSE AS POSSIBLE TO THE RECOMMENDED ELEVATION. SIMILARLY, THE BOTTOM WIDTH SHOULD BE CONSTRUCTED AT LEAST AS WIDE AS THE EXISTING CHANNELS ON BOTH SIDES OF THE RESTORED CROSSING, AND AS CLOSE AS POSSIBLE TO THE RECOMMENDED WIDTH. AMEC RECOMMENDS THAT SIDE SLOPES SHOULD BE MADE AT LEAST AS FLAT AS THE EXISTING OUTBOARD CHANNEL, WITH AS CLOSE TO 3:1 AS POSSIBLE. IF THE EXISTING CHANNEL ON THE BAY SIDE OF A HISTORIC CHANNEL CROSSING IS AT A LOWER ELEVATION OR IS WIDER THAN WHAT IS LISTED IN THE TABLE, THE CHANNEL SHALL BE CONSTRUCTED TO THE LOWER ELEVATION AND/OR WIDER WIDTH OF THE EXISTING CHANNEL. SEE DESIGN NARRATIVE FOR ADDITIONAL INFORMATION.

Historic Channel To Be Restored	Bottom Elevation (NAVD ft)	Bottom Width (feet)
RX1	-4.8	31.0
RX2	-0.2	10.0
RX3	-5.8	42.0
RX4	-3.3	16.0
RX5	-3.2	16.0
PX1	1.8	3.0
PX2	1.3	6.0
PX3	2.0	3.0
PX4	1.9	3.0
PX5	1.6	6.0
PX6	1.1	4.0
PX7	0.0	12.0
LX1	0.2	3.0
LX2	-1.5	8.0
LX3	3.6	8.0
LX4	3.1	12.0
LX5	0.4	4.0
LX6	1.9	6.0

Side slopes shall be constructed at 3 horizontal : 1 vertical

NOTE: IF THE EXISTING CHANNEL ON THE BAY SIDE OF A HISTORIC CHANNEL IS AT A LOWER ELEVATION OR IS WIDER THAN WHAT IS LISTED IN THE TABLE, THE CHANNEL SHALL BE CONSTRUCTED TO THE LOWER ELEVATION AND/OR WIDER WIDTH OF THE EXISTING CHANNEL.

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: RESTORED CHANNEL DETAILS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

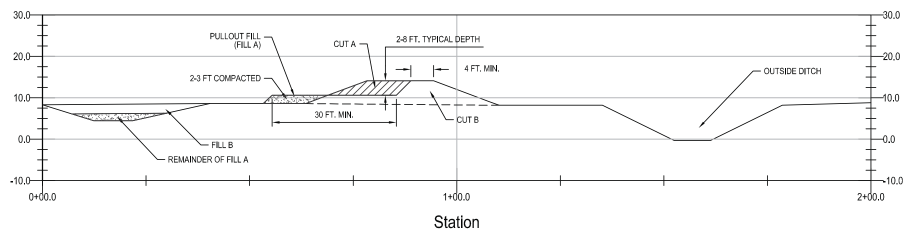
BEAR RIVER ESTUARY RESTORATION

Project No. 0-915-16933-0 REV No.

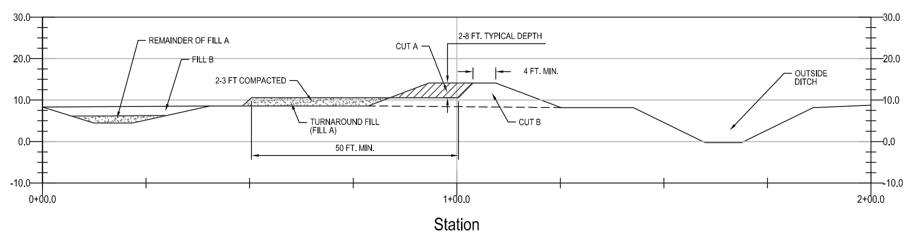
DR: JRS CHK: RB/PS

DATE: JULY 2010

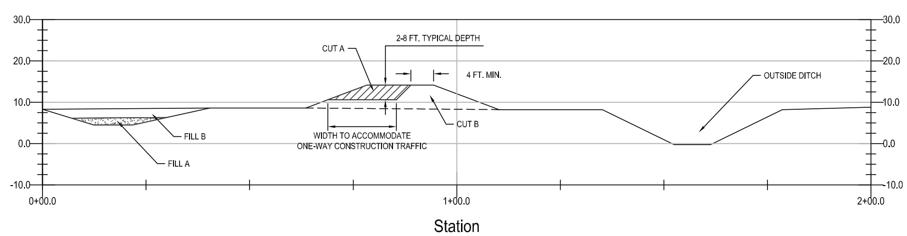
23
SHEET NUMBER



TYPICAL VEHICLE PULLOUT AREA CROSS-SECTION
CONCEPTUAL SCALE



TYPICAL VEHICLE TURNAROUND CROSS-SECTION
CONCEPTUAL SCALE



TYPICAL DIKE CUT CROSS-SECTION
CONCEPTUAL SCALE

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: TYPICAL DIKE CUT CROSS SECTIONS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
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24
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Earthwork quantities calculated for this project were based on survey data by CTS Engineers, where available. For those features not surveyed, their volumes are a best professional estimate based on interpretation of aerial photography and comparison with similar surveyed features on-site. All volumes are based on in-place yardage. The overall balance of materials depends significantly on the conditions experienced in the field. To anticipate potential material shortages resulting from varying conditions, contingency borrow areas have been identified in both the Porter and Lewis Units.

Cut and fill actions are organized in an approximately sequential order in this table. Cut features are listed on the left-hand column of the table, with the proposed destinations for that material shown as fill features across each row of the table. Although organized in the table by unit, certain earthwork actions in different units can be completed concurrently without breaching external dikes. Variations in soil material, quality, and moisture content, along with compaction conditions will result in volumes different from those calculated. The construction sequence reflected in this table is hypothetical in nature and suggests minor differences in earthwork actions not reflected in the raw cut/fill balance summaries on Sheets 3, 9, and 15. It is recommended that those sheets be consulted for overall project cut/fill balance information.

Earthwork Mass Balance

Earth Fill In Lewis Unit (In-place cubic yards)

Earth Cut	LP5	LP4	LP3	LP2	LP1	LD5	LC4 Fill	LD3	LD2	LD1	PD5					Earth Cut Total
RL4	678	1,111	719	411	2,059	237		115								5,330
LR2	18	30	29	17	42		1,000	2,308								3,444
LR1								1,733								1,733
LL3						12,424										12,424
LL2								19,330								19,330
LL1									3,459	1,600	1,236					6,295
Earth Fill Total	696	1,141	748	428	2,101	12,661	1,000	23,486	3,459	1,600	1,236					

Earth Fill In Porter Unit (In-place cubic yards)

Earth Cut	PD5	PC8	PD4	PP8	PP7	PD3	PP6	PP5	PD2	PP4	PP3	PP2	PD1	PP1		Earth Cut Total
RL4		542								483	417	176	1,090	65		2,773
PL5	1,123	458														1,581
PL4			7,687	2,386	2,200											12,273
PL3						10,933	1,852	1,089	1,513							15,387
PL2									11,386				124			11,510
PL1													3,881			3,881
Earth Fill Total	1,123	1,000	7,687	2,386	2,200	10,933	1,852	1,089	12,899	483	417	176	5,095	65		

Earth Fill in Riekkola Unit (Parker Slough area) (In-place cubic yards)

Earth Cut	RD11	RD10	RD8	RD7	Backslope	Platform Fill	County Road	RD5	RD3	RD4	RD2	RD1	RD6	RD9	Spread	Earth Cut Total
RL4	Unknown	751	1,067	107	1,682		7,540									11,147
RL3								5,333	1,481	Optional	Optional	4,944				11,758
RL2					5,818	1,560						626				8,004
RR1													Unknown	Unknown		
RR3													Unknown	Unknown		
RR2															667	667
Earth Fill Total	0	751	1,067	107	7,500	1,560	7,540	5,333	1,481	0	0	5,570	0	0	667	

70% DESIGN

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION ELEMENT

TITLE: EARTHWORK MASS BALANCE

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

amec

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BEAR RIVER ESTUARY RESTORATION
Project No. 0-915-16933-0 REV No.
DR: JRS CHK: RB/PS
DATE: JULY 2010

25
SHEET NUMBER

INSET A
SCALE: AS NOTED

INSET B
SCALE: AS NOTED

NOTE: GRAPHICS HERE WERE PROVIDED BY CTS ENGINEERS AND ARE SHOWN "AS-IS".

70% DESIGN

REVISIONS		
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION ELEMENT

TITLE: 67TH PLACE PLACEHOLDER SHEET

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

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Phone: (425) 368-1000 Fax: (425) 368-1001

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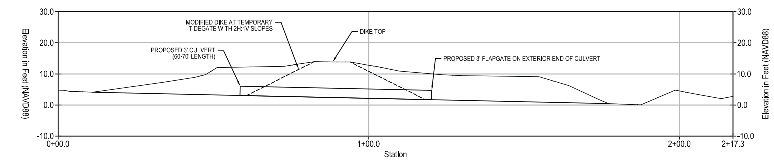
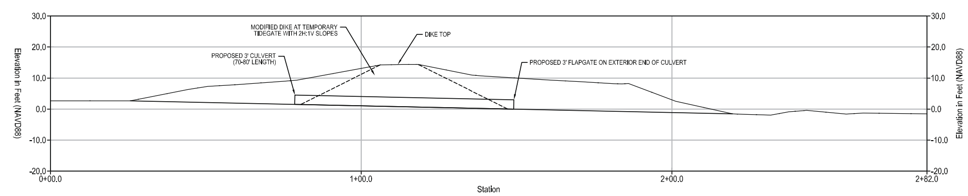
Project No. 0-915-16933-0 REV No.
DR: JRS CHK: RB/PS
DATE: JULY 2010

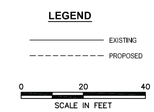
26
SHEET NUMBER



PORTER UNIT TEMPORARY TIDEGATE DETAIL PROFILE
20' SCALE



LEWIS UNIT TEMPORARY TIDEGATE DETAIL PROFILE
20' SCALE



NOTE: TEMPORARY CULVERTS AND TIDEGATES SHALL BE INSTALLED AT AS LOW OF AN ELEVATION AS PRACTICAL AND POSSIBLE, AND IN NO CASE SHALL THEIR INVERT ELEVATIONS BE HIGHER THAN THOSE OF THE EXISTING DRAINAGE STRUCTURES. TARGET INVERT ELEVATION IN LEWIS UNIT IS -1.5 (LX2), AND 0.0 IN PORTER UNIT (PX7), TO MATCH ELEVATION PROPOSED FOR RESTORED CHANNEL ELEVATION.

70% DESIGN

REVISIONS			
NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: TEMPORARY CULVERT AND TIDEGATE DETAILS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
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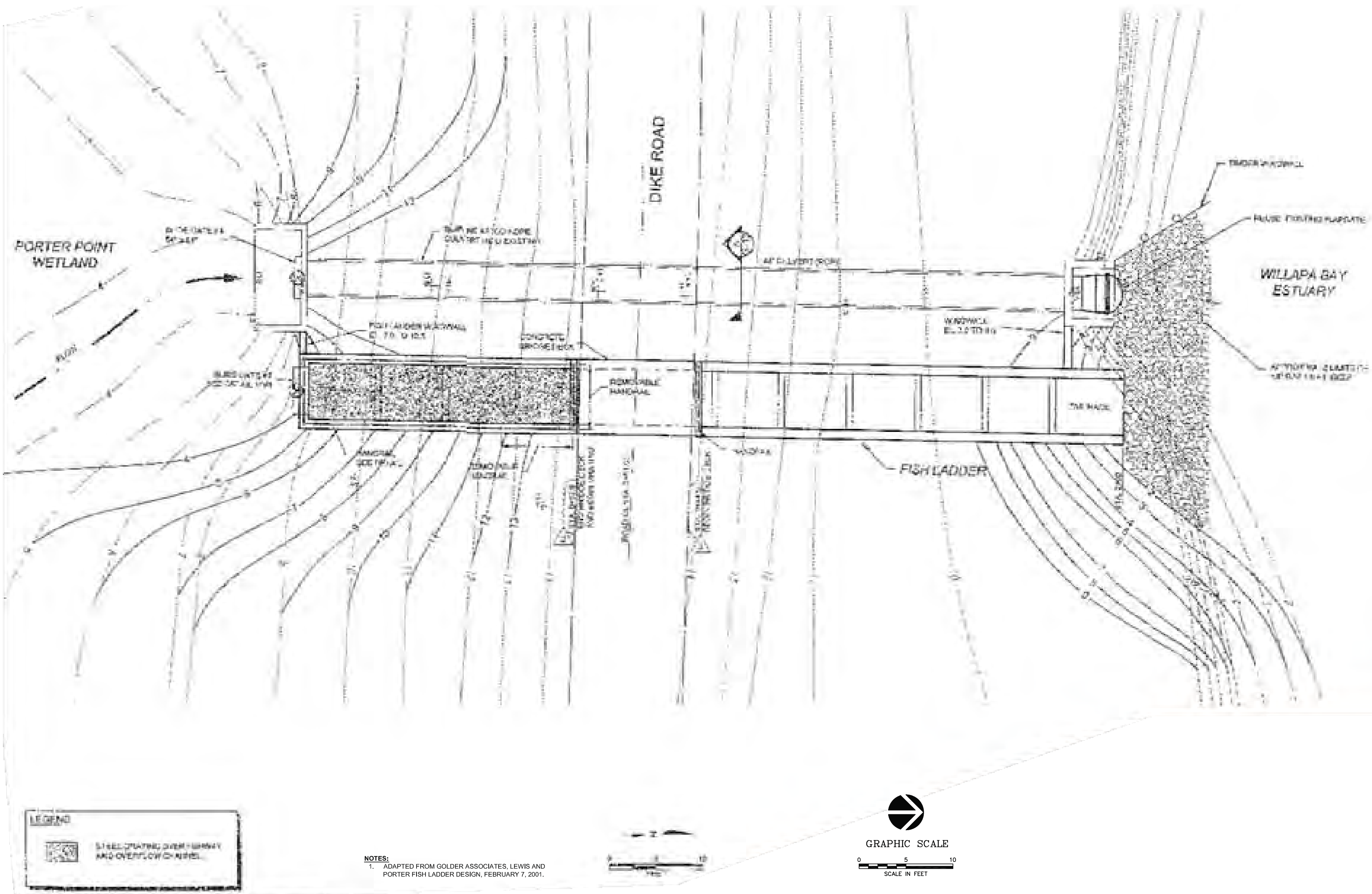
Project No. 0-915-16933-0 REV No.
DR: JRS CHK:
DATE: JULY 2010

27
SHEET NUMBER



NOTES:
1. ADAPTED FROM GOLDER ASSOCIATES, LEWIS AND PORTER FISH LADDER DESIGN, FEBRUARY 7, 2001.

70% DESIGN

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER FISH LADDER GOLDER PLAN VIEW

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

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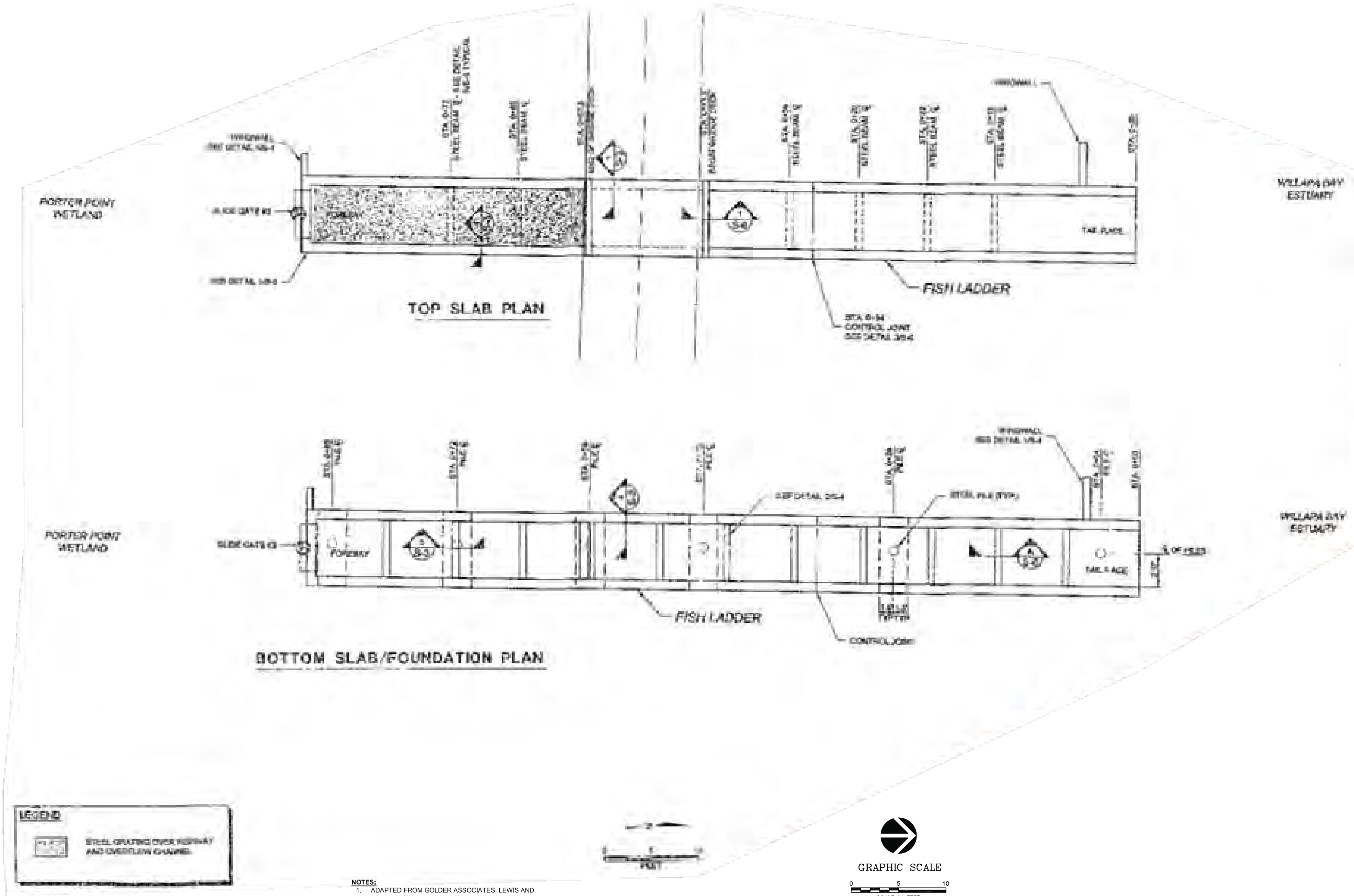
Project No. 0-915-16933-0	REV No.
DR: JRS	CHK: RB/PS

DATE: JULY 2010

28
SHEET NUMBER



NOTES:

1. ADAPTED FROM GOLDER ASSOCIATES, LEWIS AND PORTER FISH LADDER DESIGN, FEBRUARY 7, 2001.

GRAPHIC SCALE

0 5 10

SCALE IN FEET

70% DESIGN

REVISIONS

NO.	DESCRIPTION	BY	DATE

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: PORTER FISH LADDER GOLDER SLAB DETAILS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

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BEAR RIVER ESTUARY RESTORATION

Project No. 0-915-16933-0 | REV No.

DR: JRS | CHK: RB/PS

DATE: JULY 2010

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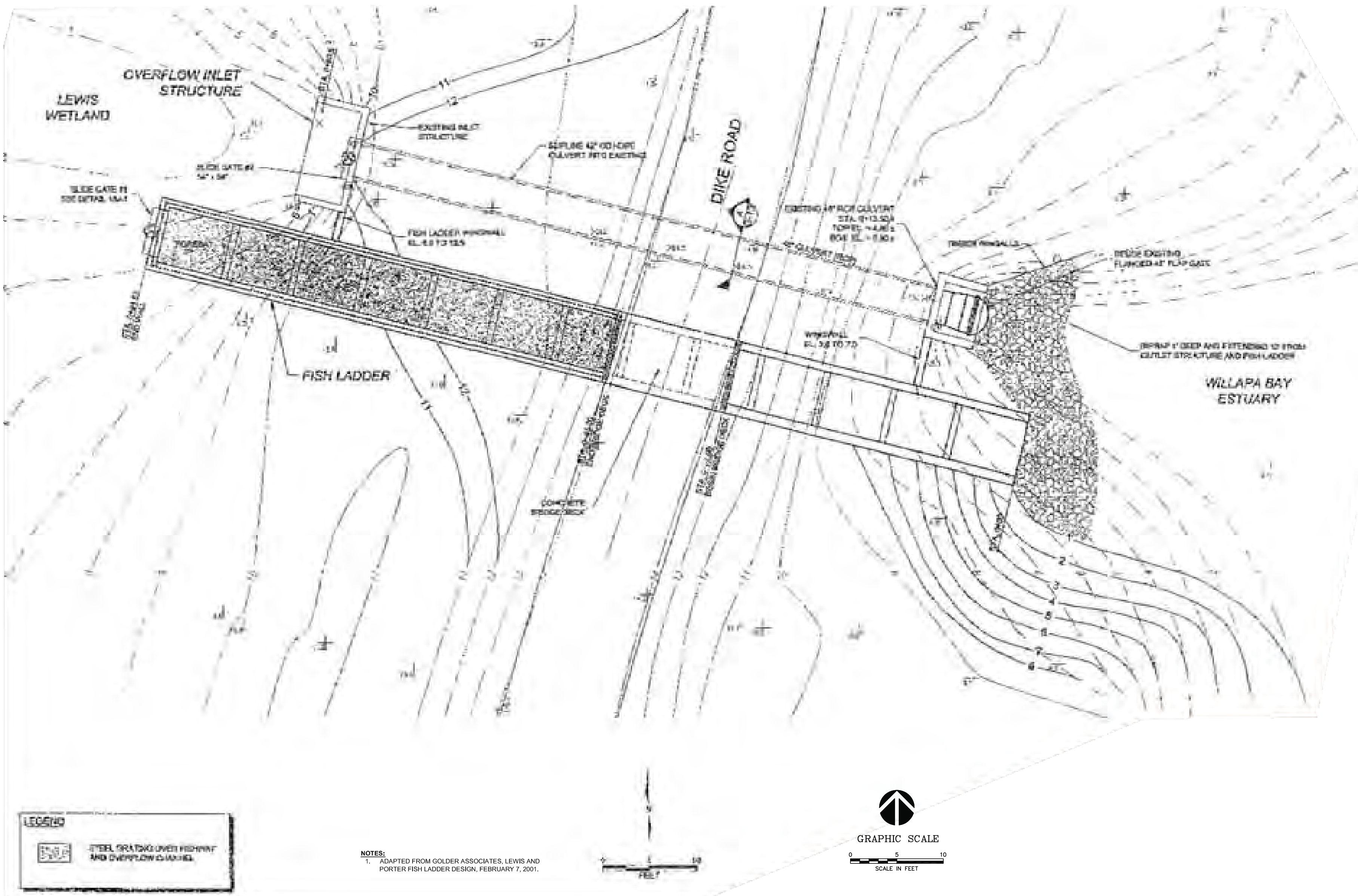
SHEET NUMBER



NOTES:
1. ADAPTED FROM GOLDER ASSOCIATES, LEWIS AND PORTER FISH LADDER DESIGN, FEBRUARY 7, 2001.

70% DESIGN

NO.	DESCRIPTION	BY	DATE

REVISIONS

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS FISH LADDER GOLDER PLAN VIEW

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

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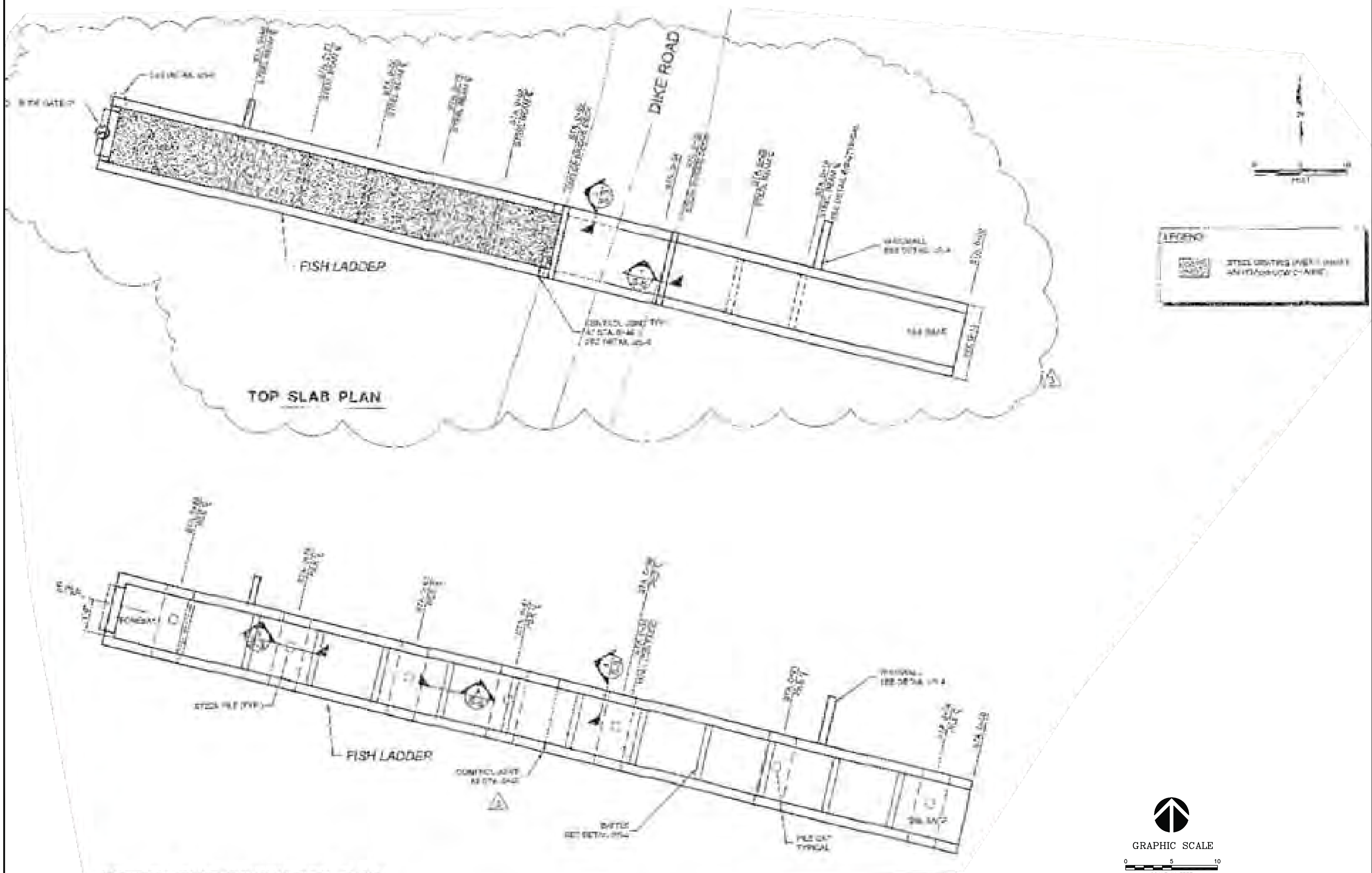
Project No. 0-915-16933-0 | REV No. 0
DR: JRS | CHK: RB/PS
DATE: JULY 2010

30
SHEET NUMBER



NOTES:

1. ADAPTED FROM GOLDER ASSOCIATES, LEWIS AND PORTER FISH LADDER DESIGN, FEBRUARY 7, 2001.

70% DESIGN

NO.	DESCRIPTION	BY	DATE
	REVISIONS		

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: LEWIS FISH LADDER GOLDER SLAB DETAILS

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

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Project No. 0-915-16933-0 | REV No.

DR: JRS | CHK: RB/PS

DATE: JULY 2010

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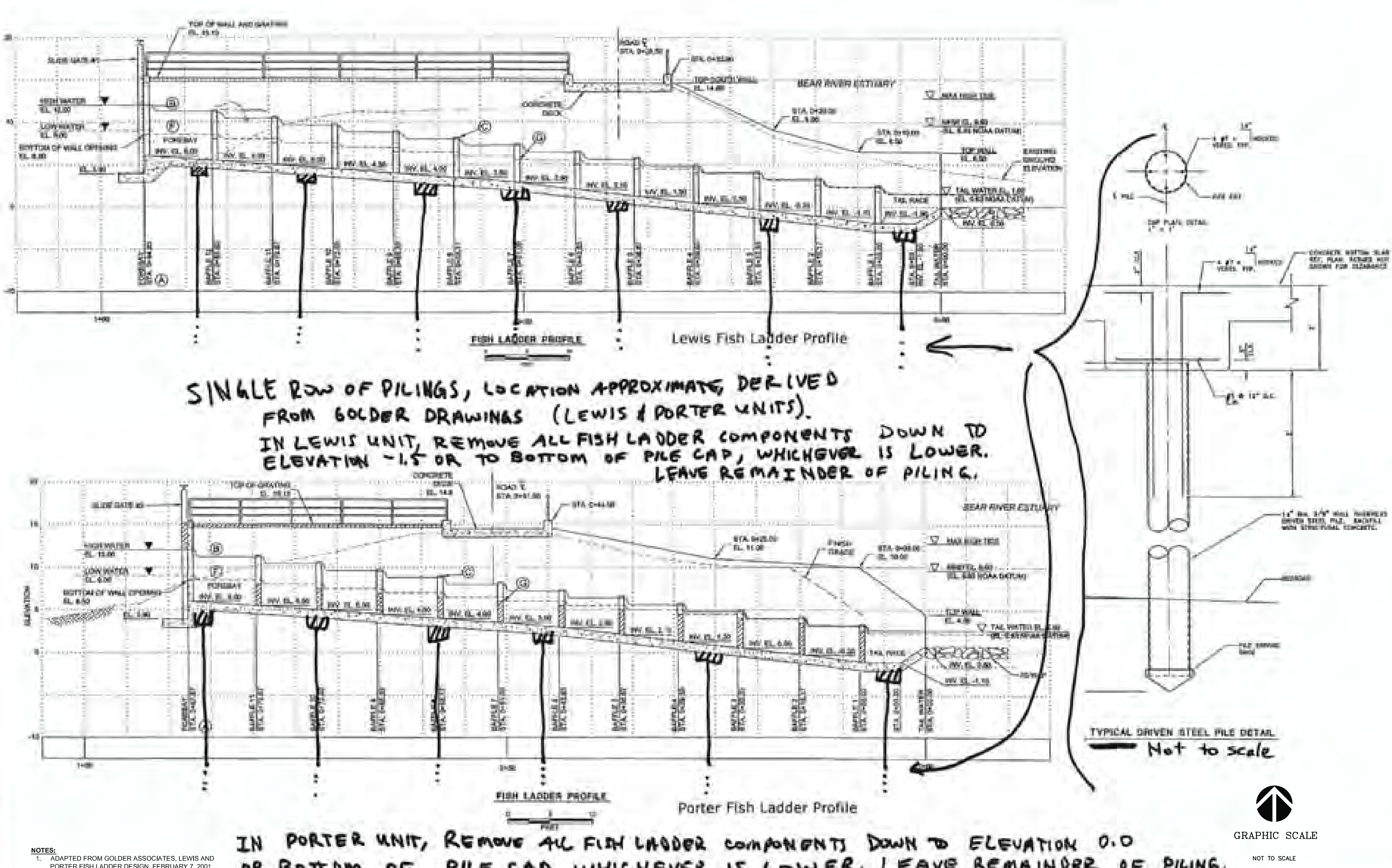
SHEET NUMBER



NOTES:

1. ADAPTED FROM GOLDER ASSOCIATES, LEWIS AND PORTER FISH LADDER DESIGN, FEBRUARY 7, 2001.

70% DESIGN

NO.	DESCRIPTION	BY	DATE
	REVISIONS		

PROJECT: BEAR RIVER ESTUARY RESTORATION

TITLE: FISH LADDER PILING LAYOUT

Client: WILLAPA BAY REGIONAL FISHERIES ENHANCEMENT GROUP

AMEC Earth & Environmental
11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201
Phone: (425) 368-1000 Fax: (425) 368-1001

BEAR RIVER ESTUARY RESTORATION

Project No. 0-915-16933-0 | REV No.
DR: JRS | CHK: RB/PS
DATE: JULY 2010

32
SHEET NUMBER

Appendix C—
Construction Narrative (AMEC)

BEAR RIVER ESTUARY RESTORATION PROJECT:
70 PERCENT DESIGN NARRATIVE

Submitted to:
Ron Craig
Willapa Bay Regional Fisheries Enhancement Group
PO Box 46
South Bend, WA 98586

Submitted by:
AMEC Earth & Environmental, Inc.
11810 North Creek Parkway North
Bothell, Washington 98011

July 16, 2010

AMEC Project No. 0-915-16933-0

TABLE OF CONTENTS

1.0 INTRODUCTION....................2
2.0 DEWATERING....................2
2.1 Lewis and Porter Units....................2
2.2 Riekkola Unit....................3
2.3 Pump System Discharge....................3
2.4 Ditch Fill....................3
3.0 CONSTRUCTION ACCESS....................4
4.0 CROSS-DIKES....................4
5.0 DIKE MODIFICATIONS AND BREACHING....................5
6.0 RIPRAP AND GRAVEL....................5
7.0 CHANNEL DIMENSIONS AT DIKE CROSSINGS....................6
8.0 EARTHWORK QUANTITY CONSIDERATIONS....................7

LIST OF TABLES

TABLE 1 HISTORIC CHANNEL CROSSING DETAILS....................7

APPENDICES

APPENDIX A. Breach sizing recommendations for Bear River Restoration Project. Memorandum from PWA to Ryan Bartelheimer dated June 23, 2010.

1.0 INTRODUCTION

The Willapa Bay Regional Fish Enhancement Group (WBRFEG) hired AMEC Earth & Environmental, Inc. (AMEC) and its subconsultant, Philip Williams & Associates (PWA), to complete a 70 percent design for the removal of approximately 5 miles of dikes and associated roads and drainage features in south Willapa Bay in the vicinity of the Bear River estuary, Washington. WBRFEG also directed AMEC to develop and implement a monitoring plan to document the environmental changes that will occur on the project site.

The "Bear River Estuary Restoration Project Basis of Design" (Basis of Design; AMEC, May 3, 2010) gives details about the specific objectives, design considerations, and activities associated with the design and the monitoring plan. AMEC developed the Basis of Design in consultation with a design team comprising representatives of WBRFEG, the Willapa National Wildlife Refuge (WNWR), the Washington Department of Fish and Wildlife, Friends of WNWR, University of Washington, Pacific County, and a trusted construction contractor.

The 70 percent design consists of the design drawings and this report, which together depict and describe the approach used to fulfill the objectives identified in the Basis of Design. The purpose of this report is to supplement information presented in the design drawings, focusing on important elements of the design and its implementation.

The Bear River Estuary Restoration Project Monitoring Plan is on a different schedule and will be addressed in a separate report.

2.0 DEWATERING

Water levels should be kept low in the construction area behind the dikes in each management unit to facilitate construction and minimize water quality impacts.

2.1 Lewis and Porter Units

AMEC recommends installing temporary culverts and tide gates in the Lewis and Porter Units before starting work on the existing fish ladders or tide gates. This approach will keep tidal waters out of the area behind the dikes, while still allowing freshwater to drain to the bay during low tide.

Before construction starts, operate the existing fish ladders and tide gates in the Lewis and Porter Units to give the area behind the dikes as much time as possible to dry out. The temporary culverts and tide gates will facilitate drainage of these units during construction, up until the time the dikes are breached.

In each unit, after the area behind the dike has been dewatered, the contractor should modify the cross-section where the temporary culvert and tide gate are to be installed so that a shorter culvert can be used. Sheet piling and pumping may be required to stabilize and dewater the area where the temporary culvert and tide gate will be installed. Install the culvert and tide gate, place and compact backfill to rebuild the dike, and remove the sheet piling. Once the temporary tide gate is functioning, the contractor should surround the existing tide gate and fish ladder with sheet piling and dewater the area as described in section 2.3, “Pump System Discharge.”

Temporary culverts can be smaller in diameter (minimum 24 inches) if they are to be removed in the same year they are installed. If they are to remain in place for a second year, the culverts should be larger in diameter (minimum 36 inches).

2.2 Riekkola Unit

In the Riekkola Unit (also referred to as the Parker Slough area), the existing tide gates will provide for unit-wide water level control. These tide gates will be removed late in the construction sequence when the historic stream crossing is restored at this location.

2.3 Pump System Discharge

The contractor should use pumps for any localized dewatering needed in the Riekkola Unit or in the vicinity of the fish ladders and tide gates in the Porter and Lewis units. The pump system should discharge to a well-vegetated location so that the water is filtered before leaving the project area. If the receiving area is not well-vegetated or is not adequately treating the water, the contractor should implement other best management practices (BMPs) to meet water quality criteria.

2.4 Ditch Fill

Additional dewatering measures may be necessary to avoid problems associated with placing fill in ditches with water present. Slurry that forms while working in the ditches can be dealt with in one of three ways:

1. a peristaltic pump system can be used to pump the material to a nearby containment area,
2. the slurry can be bailed out with an excavator and allowed to dry on the ground surface, or
3. the slurry can be contained in an isolated portion of the ditch by placing fill on either side.

3.0 CONSTRUCTION ACCESS

All construction access will be from Sandridge Road to 67th Place[1]. The construction staging will occur at the eastern end of 67th Place in the Riekkola Unit. Construction access to all units will originate from this location, following the existing roads and dikes on the project site.

To facilitate two-way vehicle traffic on top of the dikes, AMEC recommends constructing pullouts at regular intervals in the Porter and Lewis Units and turnarounds near each fish ladder and tide gate. The plan set shows the typical details of the pullouts and turnarounds. The contractor should construct pullouts and turnarounds from material available locally in the dike, not brought in from other parts of the site. If needed, the pit-run gravelly materials in the southernmost cross-dike in the Lewis Unit, or other durable surfacing materials, should be used to top the construction travel corridors to maintain the viability of construction traffic on the dikes, pullouts, and turnarounds.

The contractor should haul fill from the inner Riekkola Unit dike or create local borrow sites to meet the import requirements in the Lewis and Porter Units, using the top of the main dikes as the corridor for moving equipment and materials. The contractor should remove the pullouts and turnarounds during the initial stage of dike modifications. The contractor shall place the material from the pullouts and turnarounds into the ditches when the initial modification to the dike cross section is made in each unit. Typical cross-sections for these areas of the dike are shown within the construction drawings.

4.0 CROSS-DIKES

Construction will begin first in the Lewis Unit, which contains three cross-dikes. The cross-dike just north of the fish ladder can be removed at any time prior to breaching the main dike. The cross-dike south of the fish ladder can also be removed at any time prior to breaching the main dike, but unlike the other dikes in this unit, it is composed of imported pit-run material. AMEC recommends using some of this material at the ends of the ditch plugs to resist erosion. The ditch plug material should be at a moisture content that allows it to be placed and compacted to be resistant to erosion. The ditch plugs are designed to be constructed in locations that break up artificial outboard drainage features but that maintain channel connections downstream to minimize the risk of fish stranding. The cross-dike between the Lewis and Porter units will not be removed until later, as part of the work in the Porter Unit.

The cross-dike between the Lewis and Porter Units will serve as a temporary sea dike after the Lewis Unit is deconstructed. The cross-dike could be augmented to have a similar top elevation and cross section as the outer dike (increasing its strength and reducing the risk of being overtopped), or the water level in the Porter Unit could be kept high in the winter, minimizing the amount of dike exposed to flowing water and the time it would take for the water levels on either side of the dike to equalize. The risk of a premature breach would be very low in either case.

[1] The eastern end of 67th Place is identified on some maps as Honeyman Road.

The design team has discussed the possibility of demolishing the Porter Unit fish ladder and tide gate and installing a temporary tide gate at the same time that similar work would be done in the Lewis Unit, which would be a year before construction in the Porter Unit. In this scenario, AMEC recommends raising the cross-dike between the Porter and Lewis Units, because there would not be water impounded within the Porter Unit to reduce the risk of a premature breach in an overtopping event.

The inner dike in the Riekkola Unit may be removed at any time before breaching the main dike. This unit has a large surplus of fill; some of this surplus should be hauled to the Lewis and Porter Units, or used as fill to raise 67th Place, to help meet the material needs in those locations. About 2,000 lineal feet of dike is proposed to remain in the northwestern part of the Riekkola Unit. The top of this dike is proposed to serve as the location of a future trail and observation platform. AMEC recommends filling the borrow ditch along this dike and creating a flatter dike backslope that stays within the ditch footprint. The flattened slope will improve the dike's stability, resistance to erosion during storms, aesthetics from the trail, and will provide a habitat face that allows wider bands or zones of different vegetation types.

5.0 DIKE MODIFICATIONS AND BREACHING

The Basis of Design identified the goal of completing as much work as possible before creating the initial dike breach in each unit. This approach relies on maintaining dry work conditions, excavating drainage channels, removing as much dike material as possible, and filling borrow ditches before breaching. Material can be removed from the top and inboard side of each dike, and then hauled away or placed into nearby borrow ditches. This material will be drier than earth fill located on the outside and lower parts of the dike. It will be easier to place and compact and should therefore be more resistant to erosion than wetter materials. AMEC recommends hauling the minimum materials needed to address fill deficits in each area, primarily for the outboard ditch plugs. As mentioned previously, fill should be moved between and within units to meet the import needs before the initial modification to the dike cross section, in order to make use of the existing road surface atop the dike.

After the dike in each unit is modified as described above, the contractor should remove the remaining material during a neap tide cycle (minimal tidal range) in order to avoid or minimize the amount of water flowing into and over the construction areas. The contractor should make the initial breach as large as possible during an incoming tide, which will keep the outbound water velocities low as the first high tide recedes, minimizing sediment movement and water quality issues outside the project area. The contractor should finish the remaining dike deconstruction and ditch filling work during the same neap tide cycle, when the high tide levels are low enough to minimize water contacting the construction area.

6.0 RIPRAP AND GRAVEL

Some sections of dike or cross-dike contain riprap armoring, pit-run, or other rocky materials. These materials should either be buried under a minimum of 2 feet of fine-grained material to leave exposed soils that are most suitable to recreate mudflat habitat or incorporated in the exposed ends of the ditch plugs to minimize the potential for erosion there.

7.0 CHANNEL DIMENSIONS AT DIKE CROSSINGS

AMEC designed channels to be located as close as possible to where they historically existed and sized them so that tidal processes would accelerate the re-establishment of natural topography and vegetation conditions. AMEC used regression equations that correlate measured tidal channel characteristics to the size of tidal marsh areas that drain through these channels, and compared the results to measurements obtained from recent and historic aerial photographs. The stormwater flow rates were calculated using USGS regression equations. The drainage basin and the tidal basin areas used in the calculations were derived by delineating these basins from available elevation data. The channel sizes on this project are dictated by tidal processes rather than precipitation processes, which will be clarified later in this section.

The plans depict the channels as trapezoidal in cross section. The most important parameters are the elevation and width of channel bottoms and the slope of the channel sides. In all cases, AMEC calculated that much larger channels are needed to convey tidal waters than runoff from precipitation. Table 1 lists the recommended depths and bottom widths for channels to be reconnected at dike crossings in the restored units. The recommended depths and widths for the channels have been computed conservatively. These recommended configurations represent predicted channel sizes and depths, using empirical relationships from other locations, extrapolated to the tide range at this project site. There are a number of uncertainties in the relationships, local factors, and data. Therefore, the historic channel depths should be constructed at an elevation no higher than existing, and as close as possible to the recommended elevation. Similarly, the bottom width should be constructed at least as wide as the existing channels on both sides of the restored crossing, and as close as possible to the recommended width. AMEC recommends that side slopes should be made at least as flat as the existing outboard channel, with as close to 3:1 as possible. Because of the shallow side slopes needed for stability, the resulting channel top widths are greater than those calculated by the regression equations. The cross-sectional areas of the reconnected channels should therefore be adequate to convey tidal flows under conditions that will exist following construction. If the existing channel on the bay side of a historic channel crossing is at a lower elevation or is wider than what is listed in the table, the channel should be constructed to the lower elevation and/or wider width of the existing channel. AMEC also recommends removing vegetation and root mass along the top and edges of the existing inboard and outboard channels, and excavating a transition area between the restored channels and the existing channels.

Table 2. Historic channel crossing details

Historic Crossing To Be Restored	Bottom Elevation (NAVD ft)	Bottom Width (feet)
RX1	-4.8	31.0
RX2	-0.2	10.0
RX3	-5.8	42.0
RX4	-3.3	16.0
RX5	-3.2	16.0
PX1	1.8	3.0
PX2	1.3	6.0
PX3	2.0	3.0
PX4	1.9	3.0
PX5	1.6	6.0
PX6	1.1	4.0
PX7	0.0	12.0
LX1	0.2	3.0
LX2	-1.5	8.0
LX3	3.6	8.0
LX4	3.1	12.0
LX5	0.4	4.0
LX6	1.9	6.0

The ground on the landward side of the dikes has subsided by approximately 1-3 feet since the dikes were built, so the quantity and rate of water flowing through the reconnected channels will be greater than in a salt marsh without subsidence. However, the beds of historical channels outside the dikes have since aggraded due to a reduction in tidal flows through them since the dikes were built. Following construction, outboard channels are expected to eventually revert to their historical sizes and depths. Channels on the inside of the dikes can be expected initially to deepen and widen but then gradually to aggrade and become more narrow as sediment is deposited over the larger subsided area. Channels will reach equilibrium when ground elevations on the inside of the dike approximately equal those on the outboard side. As this happens, AMEC predicts that the channels will evolve to sizes and depths closer to those predicted by the tidal drainage area relationships than what currently exists.

8.0 EARTHWORK QUANTITY CONSIDERATIONS

AMEC calculated earthwork quantities for this project using survey data from CTS Engineers, where available. For those features not surveyed, volumes are best professional estimates based on interpretation of aerial photography and comparison with similar surveyed features on site. All volumes were calculated as in-place yardage. The overall balance of material to be imported or exported depends significantly on the conditions experienced in the field. To address potential material shortages resulting from varying conditions, AMEC has identified contingency borrow areas in both the Porter and Lewis Units.

Cut and fill actions are organized in an approximately sequential order in the table on Sheet 25 of the design set. Cut features are listed on the left-hand column of the table, with the proposed destinations for that material shown as fill features across each row of the table. Although organized in the table by unit, certain earthwork actions, most notably the removal of the inboard Riekkola Unit dike, in different units can be completed concurrently without breaching external dikes. Variations in soil material, quality, and moisture content, along with compaction conditions, will result in volumes different from those calculated.

Appendix D—
Species Life Histories

APPENDIX D
LIFE HISTORIES

INTRODUCTION

This appendix provides brief descriptions of the life histories of species listed under the Endangered Species Act (ESA) that may occur in the action area of the proposed project. The species discussed herein include:

- North American green sturgeon (*Acipenser medirostris*);
- Marbled murrelet (*Brachyramphus marmoratus marmoratus*);
- Western snowy plover (*Charadrius alexandrinus nivosus*); and
- Streaked horned lark (*Eremophila alpestris strigata*).

NORTH AMERICAN GREEN STURGEON

This section presents descriptions of the biology, distribution, and population trends of the North American green sturgeon.

Life History

The North American green sturgeon (green sturgeon) is a long-lived, slow-growing fish and the most marine-oriented of the sturgeon species. Mature males range from 4.5 to 6.5 feet in fork length and do not mature until they are at least 15 years old, while mature females range from 5 to 7 feet in fork length and do not mature until they are at least 17 years old. Maximum ages of adult green sturgeon are likely to range from 60 to 70 years.

Green sturgeon lack scales; however, they have five rows of characteristic bony plates on their body called scuutes. The backbone of the green sturgeon curves upward into the caudal fin, forming their shark-like tail. On the underside of their flattened snouts are sensory barbels and a siphon-shaped, protrusible, toothless mouth. Recent genetic information suggests that green sturgeon in North America is taxonomically distinct from morphologically similar forms in Asia (NMFS 2009b).

Green sturgeon are believed to spend the majority of their lives in nearshore oceanic waters, bays, and estuaries. Early life-history stages reside in fresh water, with adults returning to freshwater to spawn when they are more than 15 years of age and over 4 feet in size. Spawning is believed to occur every 2 to 5 years. Adults typically migrate into fresh water beginning in late February; spawning occurs from March to July, with peak activity from April to June. Females produce 60,000 to 140,000 eggs. Juvenile green sturgeon spend 1 to 4 years in fresh and estuarine waters before dispersal to saltwater. They disperse widely in the ocean after their out-migration from freshwater (NMFS 2009b).

The only feeding data available for adult green sturgeon shows that they eat benthic invertebrates, including shrimp, mollusks, amphipods, and even small fish (NMFS 2009b).

Distribution and Habitat

The green sturgeon is the most broadly distributed, wide-ranging, and marine-oriented species of the sturgeon family, ranging from Mexico to at least Alaska in marine waters, and is observed in bays and estuaries up and down the west coast of North America (NMFS 2009b).

The historical and current spawning distribution of this species is unclear, as green sturgeon make non-spawning movements into coastal lagoons and bays in the late summer to fall, and because their original spawning distribution may have been reduced due to harvest and other anthropogenic effects. Today, green sturgeon are believed to spawn in the Rogue River, Klamath River Basin, and the Sacramento River. Spawning appears to occur rarely in the Umpqua River. Green sturgeon in the South Fork of the Trinity River were thought extirpated, but juveniles have been captured at Willow Creek on the Trinity River, and it is suspected that the fish could be coming from either the South Fork or the Trinity River. Green sturgeon appear to occasionally occupy the Eel River (NMFS 2009b).

Green sturgeon utilize both freshwater and saltwater habitat, spawning in deep pools or “holes” in large, turbulent, freshwater river mainstems. Eggs are likely broadcast over large cobble substrates, and may be deposited in clean sand to bedrock substrates as well. Regardless, it is likely that cold, clean water is important for proper embryonic development (NMFS 2009b).

Adults live in oceanic waters, bays, and estuaries when not spawning. Green sturgeon are known to forage in estuaries and bays ranging from San Francisco Bay to British Columbia (NMFS 2009b).

Population Trend

Good data on current population sizes does not exist and data on population trends are lacking (NMFS 2009b).

BULL TROUT

This section presents descriptions of the biology, distribution, and population trends of bull trout.

Life History

Bull trout typically use pristine headwater areas to spawn (WDFW 1998). Spawning begins in late August, peaks in September and October, and ends in November. Fish in a given stream spawn over a period of two weeks or fewer. Almost immediately after spawning, adults begin to work their way back to the mainstem rivers, lakes, or reservoirs to overwinter. Some of these fish stay in these areas while others move into salt water in the spring. Bull trout will spawn a second or even third time. Kelts (adults that have spawned) feed aggressively to recover from the stress of spawning (WDFW 1998).

Newly hatched bull trout emerge from the gravel in the spring (WDFW 1998). Adfluvial, fluvial, and anadromous bull trout typically spend two years in fresh water before they migrate to lakes, reservoirs, the mainstems of rivers, or salt water. Nonmigratory populations spend their entire lives in the same stretch of headwater stream. Fish that exhibit this behavior may not mature until they are 7 to 8 years old, and rarely reach sizes greater than 14 inches in length (WDFW 1998).

Bull trout are opportunistic feeders, eating aquatic insects, shrimp, snails, leeches, fish eggs, and fish. Contrary to earlier beliefs, these fish are generally no longer considered serious predators of salmon and steelhead (WDFW 1998).

Distribution and Habitat

The historical range of bull trout includes major river basins in the Pacific Northwest at about 41 to 60 degrees North latitude, from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada to the headwaters of the Yukon River in the Northwest Territories, Canada. To the west, bull trout range includes Puget Sound, various coastal rivers of British Columbia, Canada, and southeast Alaska. Bull trout occur in portions of the Columbia River and tributaries within the basin, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River basin of south-central Oregon. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta and Montana and in the MacKenzie River system in Alberta and British Columbia, Canada (USFWS 2002).

Population Trend

Although bull trout are presently widespread within their historical range in the coterminous United States, they have declined in overall distribution and abundance during the last century. Retaining migratory forms of bull trout in a population is important because these forms allow fish access to more resources (i.e., food and habitat), opportunities for genetic exchange, and the ability to recolonize habitats after local extirpations (e.g., by a watershed-wide disturbance affecting all bull trout in a resident population) (USFWS 2002). In Washington, WDFW has identified 80 bull trout populations, of which 14 were considered in healthy condition, two were in poor condition, six were in critical condition, and 58 were in unknown condition (WDFW 1998).

MARBLED MURRELET

This section presents descriptions of the biology, distribution, and population trends of the marbled murrelet.

Life History

The marbled murrelet is a small seabird that nests in the coastal, old-growth forests of the Pacific Northwest. In contrast to other seabirds, murrelets do not form dense colonies and may fly about 43 miles or more inland to nest, generally in older coniferous forests. They are more commonly found inland during the summer breeding season, but make daily trips to the ocean to gather food and have been detected in forests throughout the year. When not nesting, the birds live at sea, spending their days feeding and then moving several kilometers offshore at night (SEI 2006).

The breeding season of the marbled murrelet generally begins in April, with most egg-laying occurring in late May and early June. Peak hatching occurs in July after a 27- to 30-day incubation. Chicks remain in the nest and are fed by both parents. By the end of August, chicks have fledged and dispersed from nesting areas (Marks and Bishop 1997). The marbled murrelet differs from other seabirds in that its primary nesting habitat is old-growth coniferous forest within 50 to 75 miles of the coast. The nest typically consists of a depression on a moss-covered branch where a single egg is laid. Marbled murrelets appear to exhibit high fidelity to their nesting areas and have been observed in forest stands for up to 20 years (Marks and Bishop 1997).

Marbled murrelets are presumably a long-lived species but are characterized by low fecundity (one egg per nest) and low nesting and fledging success. Fledging success has been estimated at 45 percent. Nest predation on both eggs and chicks appears to be higher for marbled murrelets than for other alcids and may be cause for concern. Principal predators are birds, primarily corvids (jays, ravens, and crows) (Marks and Bishop 1997).

At sea, foraging murrelets are usually found as widely spaced pairs. In some instances murrelets form or join flocks that are often associated with river plumes and currents. These flocks may contain sizable portions of local populations (Ralph and Miller 1994).

Distribution and Habitat

The marbled murrelet inhabits the Pacific Coast of North America from the Bering Sea to central California (SEI 2006).

Marbled murrelets are more commonly found inland during the summer breeding season, but make daily trips to the ocean to gather food, primarily fish and invertebrates, and have been detected in forests throughout the year. When not nesting, the birds live at sea, spending their days feeding and then moving several kilometers offshore at night (SEI 2006). Marbled murrelets feed in nearshore marine waters, mainly within 1 to 2 km from shore, consuming small fish such as Pacific herring, Pacific sand lance, sardines, and juvenile salmonids, as well as invertebrates such as euphasids and shrimp (USFWS 1997).

Throughout the forested portion of the species' range, marbled murrelets used forest stands with old-growth forest characteristics, generally within 80 km of the coast for nesting. The farthest known nesting site from the marine environment in Washington is 63 km. In Washington, marbled murrelet detections increased when old-growth/mature forests comprised more than 30 percent of the landscape, but decreased when the percentage of clear-cut/meadow in the landscape increased above 25 percent (USFWS 1997).

Population Trend

With declines documented separately for Conservation Zones 1 through 5 (coastal area from California to Washington) and Conservation Zone 6 (Strait of Juan de Fuca/Puget Sound), the U.S. Fish and Wildlife Service (USFWS) concluded that the listed population has declined significantly since 2002, the year of the estimate in the USFWS' previous 5-year review. For Conservation Zones 1 through 5 combined, population estimates from monitoring for 2000 to 2008 indicate an annual rate of decline in the range of 2.4 to 4.3 percent. For Conservation Zone 6, new data indicate an annual decline of about 15 percent between 2003 and 2008. Based on the tri-state estimate of about 24,400 birds used in the analysis for the 2004 5-year review, the 2008 population estimate of about 18,000 birds represents a decline of about 26 percent across the listed range from that estimate (USFWS 2009a).

WESTERN SNOWY PLOVER

This section presents descriptions of the biology, habitat, distribution, population trend, threats, and conservation efforts for the western snowy plover.

Life History

The western snowy plover is a small shorebird distinguished from other plovers (family Charadriidae) by its small size, pale brown upper parts, dark patches on either side of the upper breast, and dark gray to blackish legs. Snowy plovers weigh between 1.2 and 2 ounces. They are about 5.9 to 6.6 inches long (USFWS 2010a).

The nesting season extends from early March through late September. The breeding season generally begins earlier in more southerly latitudes, and may be 2 to 4 weeks earlier in southern California than in Oregon and Washington. Fledging of late-season broods may extend into the third week of September throughout the breeding range. Nests typically occur in flat, open areas with sandy or saline substrates. Vegetation and driftwood are usually sparse or absent. The typical clutch size is three eggs but can range from two, and in rare cases, up to six eggs (USFWS 2010a).

Snowy plover chicks leave the nest within hours after hatching to search for food. They are not able to fly for approximately 4 weeks after hatching, during which time they are especially vulnerable to predation. Adult plovers do not feed their chicks, but lead them to suitable feeding areas. Adults use distraction displays to lure predators and people away from chicks. Adult plovers signal the chicks to crouch, with calls, as another way to protect them. They may also lead chicks, especially larger ones, away from predators. Most chick mortality occurs within 6 days after hatching (USFWS 2010a).

Snowy plovers are primarily visual foragers. They forage on invertebrates in the wet sand and among surf-cast kelp within the intertidal zone; in dry, sandy areas above the high tide; on salt pans; and along the edges of salt marshes, salt ponds, and lagoons. They nest in open, flat, sparsely vegetated beaches and sand spits above the high tide. Plovers often return to the same breeding sites year after year (USFWS 2010a).

Distribution and Habitat

The Pacific Coast population of the western snowy plover is defined as those individuals that nest beside or near tidal waters, and includes all nesting colonies on the mainland coast, peninsulas, offshore islands, adjacent bays, and estuaries from southern Washington to southern Baja California, Mexico. Historic records indicate that western snowy plovers nested in at least 29 locations on the Oregon coast. Currently, only eight locations in Oregon support nesting western snowy plovers, a 72-percent reduction in active breeding locations.

The Pacific Coast population of western snowy plovers breeds on coastal beaches from southern Washington to southern Baja California, Mexico. Plovers lay their eggs in shallow depressions in sandy or salty areas that generally do not have much vegetation. Because the sites they choose are in loose sand or soil, nesting habitat is constantly changing under the influence of wind, waves, storms, and encroaching plants (USFWS 2010a).

Population Trend

The current Pacific Coast breeding population of snowy plover extends from Damon Point, Washington, to Bahia Magdalena, Baja California, Mexico (ICF 2009). There are approximately 2,230 breeding birds along the Pacific coast of California, 162 resident adults in Oregon, and 70 adult birds in Washington (ICF 2009). In 2008, the Oregon Natural Heritage Information Center observed 187 to 199 adult snowy plovers; a minimum of 129 individuals were known to have nested. The adult plover population was the highest estimate recorded since monitoring began in 1990 (USFWS 2009b). A survey of breeding snowy plovers along the Pacific coast of Baja California, Mexico, in 1991 and 1992 found 1,344 adults. A current population estimate for Baja Mexico is 2,470 (ICF 2009).

The Pacific Coast population of snowy plover in Oregon was once found along the entire coast but is currently located among eight breeding areas from Florence south (ICF, 2009). Oregon breeding sites in 2006 included Sutton Beach, the Siltcoos River Estuary, beachgrass removal sites at Dunes Overlook, the Tahkenitch Creek Estuary, the Tenmile Creek Estuary, Coos Bay North Spit, Bandon State Nature Area, and the New River spit area. Other Oregon sites where snowy plovers have nested in the recent past (since 1980) include the beach between Clatsop Spit and Gearhart, mouth of the Necanicum River, Bayocean Spit, Sand Lake Spits, South Beach (Newport), mouth of the Siuslaw River, Threemile Creek/Umpqua River, Menasha Spoils (Coos Bay North Spit), and the Floras Lake area (ICF 2009).

As early as the 1970s, observers suspected a decline in plover numbers. The primary cause of decline is loss and degradation of habitat. The introduced European beachgrass (*Ammophila arenaria*) contributes to habitat loss by reducing the amount of open, sandy habitat and contributing to steepened beaches and increased habitat for predators. Urban development has reduced the available habitat for western snowy plovers while increasing the intensity of human use, resulting in increased disturbance to nesting plovers.

STREAKED HORNED LARK

This section presents descriptions of the biology, distribution, and population trends of the streaked horn lark.

Life History

The streaked horned lark is small, ground-dwelling songbird with conspicuous feather tufts, or "horns," on its head. Its back is heavily streaked with black, contrasting sharply with its deeply ruddy nape and yellow underparts.

Nesting begins in late March and continues into June. The nest consists of a shallow depression built in the open or near a grass clump and lined with fine dead grasses. The female lays a clutch of three to five heavily streaked white eggs. Incubation is only 11 days and the young are able to fly within 9 to 12 days after hatching. Horned larks are mainly insect eaters but may eat seeds in winter (USFWS 2010b).

Distribution and Habitat

The streaked horned lark once occurred from British Columbia, Canada, south to northern California. In Oregon, the streaked horned lark was a common summer resident in the Rogue River, Umpqua, and Willamette Valleys, as well as many other smaller valleys on the west side of the Cascade Mountain range. Streaked horned larks winter in eastern Washington, Oregon, and Northern California (USFWS 2010b).

The streaked horned lark nests and breeds in short herbaceous vegetation (<30 centimeters [cm] tall [about 12 inches]) where woody plants are absent and a relatively high percentage of bare ground and patches of sparsely vegetated areas are interspersed with more densely vegetated patches (Altman 1999). Canadian and U.S. surveys indicate that the streaked horned lark currently breeds on prairie remnants and airports in the southern Puget lowlands, on beaches and accreted lands near Grays Harbor and Willapa Bays, on dredge spoil islands in the Columbia River, on an industrial site along the lower Columbia River in Oregon, and on a number of agricultural, pasture, grass, and mudflat habitats in the Willamette Valley from Portland to Eugene, Oregon. Streaked horned larks winter along the Washington Coast on dunes and beaches adjacent to open water with few or no trees and shrubs (Pearson and Altman 2005).

Population Trend

Although population estimates are not exact, the Washington Department of Fish and Wildlife (WDFW) estimates that there are approximately 774 streaked horned larks with 29 percent breeding in the Puget lowlands, 11 percent breeding on the Washington Coast, 9 percent breeding on the lower Columbia River, and 51 percent breeding in the Willamette Valley (Pearson and Altman 2005).

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Appendix E—
EFH Assessment

APPENDIX E
ESSENTIAL FISH HABITAT

ACTION AGENCY

U.S. Army Corps of Engineers, Seattle District

LOCATION

The project is located within the Willapa National Wildlife Refuge (Refuge) in Pacific County, Washington at Township 10 North, Range 11 West, Sections 1, 6, 7, 11, and 12 and Township 10 North, Range 10 West, Section 6. The project area is within the Lewis, Porter Point, and Riekkola Units in the Refuge at the southern end of Willapa Bay, just west of the mouth of Bear River.

PROJECT NAME

Bear River Estuary Restoration, Pacific County, Washington

ESSENTIAL FISH HABITAT BACKGROUND

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), requires federal agencies to consult with the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) on activities that may adversely affect Essential Fish Habitat (EFH). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (NMFS, 1999).

This assessment evaluates the impacts of the proposed project to determine whether it "may adversely affect" designated EFH for federally managed fisheries species in the proposed action area. The assessment also describes conservation measures to avoid, minimize, or otherwise offset potential adverse effects of the proposed action on designated EFH.

IDENTIFICATION OF EFH

Groundfish, coastal pelagic, and salmonid fish species that could have designated EFH in the action area are listed in the table below. Several of these species are not typically found in the high-energy regime of the action area. Assessment of the impacts on species that may occur in the action area is based on life-history stages described in Casillas et al. (1998) and PFMC (1998a, 1998b, and 1999).

Species of Fish with Designated Essential Fish Habitat in the Project Area

Common Name	Scientific Name	Common Name	Scientific Name
Groundfish		**Groundfish (cont.)**	
arrowtooth flounder	*Atheresthes stomias*	Pacific sanddab	*Citharichthys sordidus*
big skate	*Raja binoculata*	petrale sole	*Eopsetta jordani*
black rockfish	*Sebastes melanops*	quillback rockfish	*Sebastes maliger*
bocaccio	*Sebastes paucispinis*	ratfish	*Hydrolagus colliei*
brown rockfish	*Sebastes auriculatus*	redbanded rockfish	*Sebastes babcocki*
butter sole	*Isopsetta isolepis*	redstripe rockfish	*Sebastes proriger*
cabezon	*Scorpaenichthys marmoratus*	rex sole	*Glyptocephalus zachirus*
California skate	*Raja inornata*	rock sole	*Lepidopsetta bilineata*
canary rockfish	*Sebastes pinniger*	rosethorn rockfish	*Sebastes helvomaculatus*
China rockfish	*Sebastes nebulosus*	rosy rockfish	*Sebastes rosaceus*
copper rockfish	*Sebastes caurinus*	rougheye rockfish	*Sebastes aleutianus*
curlfin sole	*Pleuronichthys decurrens*	sablefish	*Anoplopoma fimbria*
darkblotch rockfish	*Sebastes crameri*	sand sole	*Psettichthys melanostictus*
Dover sole	*Microstomus pacificus*	sharpchin rockfish	*Sebastes zacentrus*
English sole	*Parophrys vetulus*	shortspine thornyhead	*Sebastolobus alascanus*
flathead sole	*Hippoglossoides elassodon*	spiny dogfish	*Squalus acanthias*
greenstriped rockfish	*Sebastes elongatus*	splitnose rockfish	*Sebastes diploproa*
hake	*Merluccius productus*	starry flounder	*Platichthys stellatus*
jack mackeral	*Trachurus symmetricus*	striptail rockfish	*Sebastes saxicola*
kelp greenling	*Hexagrammos decagrammus*	tiger rockfish	*Sebastes nigrocinctus*
lingcod	*Ophiodon elongatus*	vermilion rockfish	*Sebastes miniatus*
longnose skate	*Raja rhina*	yelloweye rockfish	*Sebastes ruberrimus*
Pacific cod	*Gadus macrocephalus*	yellowtail rockfish	*Sebastes flavidus*
Pacific ocean perch	*Sebastes alutus*		
Coastal Pelagic		**Salmonid Species**	
anchovy	*Engraulis mordax*	Chinook salmon	*Oncorhynchus tshawytscha*
market squid	*Loligo opalescens*	coho salmon	*Oncorhynchus kisutch*
Pacific mackerel	*Scomber japonicus*	pink salmon	*Oncorhynchus gorbuscha*
Pacific sardine	*Sardinops sagax*		

DETAILED DESCRIPTION OF THE PROPOSED PROJECT

The proposed project would remove about 5.74 miles of existing dike, 38 culverts, 2 fish ladders, 2 tide gates, and 2 foot bridges, and reconnect 18 estuary channels; resulting in up to 760 acres of restored estuarine habitat. The resorted habitat includes reconnection of stream channels to the estuarine environment, open water, intertidal flats, and salt marsh. Unrestricted tidal exchange is the goal and historic channels currently isolated within diked areas which are now removed from tidal influence will be reconnected to the Willapa Bay estuary. The proposed project will assist in improving and maximizing the current estuarine system and contribute to the health of the bay and associated habitats. In addition, the proposed project would reduce or eliminate the extent of a highly invasive exotic plant, reed canarygrass, which currently infests the refuge's freshwater impoundments. Tussock infestation will also be reduced. Other exotic species, including nutria and bullfrogs, which currently use the freshwater ponds behind the dike will be eliminated by restoration of estuarine habitat. Juvenile salmon habitat will be restored and other expected benefits include increased waterfowl, waterbird, and shorebird use. Protection and restoration of native estuarine and nearshore habitats is a major ecoregional and recovery goal in the Pacific Northwest Coast Ecoregional Assessment (TNC and WDFW 2006) and the Northern Pacific Coast Regional Shorebird Management Plan (Drut and Buchanan 2000).

For a more detailed project description, see Section 2.2 of the Draft Biological Evaluation.

POTENTIAL ADVERSE EFFECTS OF PROPOSED PROJECT

Groundfish Species

The proposed project could affect EFH beneficially for a limited number of groundfish species by creating 750 acres of intertidal saltmarsh and mudflats. Construction could affect EFH adversely by creating temporary and localized increases in turbidity and could eliminate nonmobile benthic and epibenthic food sources within the footprint of the base of the dike area.

Coastal Pelagic Species

The proposed project is not expected to adversely affect EFH for coastal pelagic species because the project area is limited to intertidal and subtidal zones, where coastal pelagic species are unlikely.

Salmonid Species

Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch)*, particularly juveniles of these species, may occur in the project area or immediately offshore at any time of the year. Because of project timing, few, if any, juvenile or adult Chinook are expected to be in the action area during construction. The proposed project would increase turbidity briefly in the project area, possibly causing salmonids to avoid certain areas in the vicinity. This possible impact would be temporary and not persist beyond the construction period. The proposed project would affect salmonids beneficially by creating 750 acres of intertidal saltmarsh and mudflats.

CONSERVATION MEASURES

Implementing the conservation measures specified in Section 2.2.3 of the Draft Biological Evaluation would avoid and minimize potential adverse effects of the proposed project.

CONCLUSION

As described above, the proposed activities may cause temporary, localized adverse impacts on certain EFH parameters but should not reduce the overall value of the EFH of managed species. After completion of the proposed project, the disturbed areas would be recolonized and the benthic and epibenthic communities should return to conditions similar to those before project construction. The project would create 760 acres of intertidal saltmarsh and mudflats. Although the proposed project may have localized and temporary adverse effects on designated EFH for groundfish and salmonids, the conservation measures described above would avoid, minimize, or otherwise offset such adverse effects.

REFERENCES

Casillas, E., Crockett, L., deReynier, Y., Glock, J., Helvey, M., Meyer, B., Schmitt, C., Yoklavich, M., Bailey, A., Chao, B., Johnson, B., and Pepperell, T. 1998. Essential Fish Habitat West Coast Groundfish Appendix. National Marine Fisheries Service, Seattle, Washington.

Drut, M.S. and J.B. Buchanan. 2000. U.S. shorebird conservation plan. Northern Pacific Coast Regional Shorebird Management Plan. U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1999. Essential Fish Habitat consultation guidance. NMFS, Office of Habitat Conservation, Silver Spring, Maryland.

PFMC (Pacific Fishery Management Council). 1998a. The coastal pelagic species fishery management plan – amendment 8. PFMC, Portland, Oregon.

PFMC. 1998b. Final environmental assessment/ regulatory review for amendment 11 to the Pacific Coast groundfish fishery management plan. PFMC, Portland, Oregon.

PFMC. 1999. Amendment 14 to the Pacific Coast Salmon plan – appendix a, description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon. PFMC, Portland, Oregon.

TNC (The Nature Conservancy) and WDFW (Washington Department of Fish and Wildlife. 2006. Pacific Northwest Coast ecoregional assessment. The Nature Conservancy, Portland Oregon. <http://conserveonline.org/coldocs/2007/02/PNW%20Coast%20EA%20Final_Main_Report_Aug21.pdf> (accessed July 12, 2010).

Appendix F—
Cultural Resources Assessment (AMEC)

CULTURAL RESOURCES REPORT COVER SHEET

Author: Cooper, Jason B., M.A., R.P.A

Title of Report: Cultural Resources Existing Conditions Report for the Bear River Estuary Restoration Project, Pacific County, Washington

Date of Report: July 30, 2010

County: Pacific Section: 1, 11, and 12 Township: 10 North Range: 11 W and Section: 6, 7, and 18 Township: 10 North Range: 10 W

Quads: Chinook, Long Beach, Ocean Park, and Cape Disappointment Acres: 760

PDF of report submitted (REQUIRED) ☒ Yes

Historic Property Export Files submitted? ☐ Yes ☒ No

Archaeological Site(s)/Isolate(s) Found or Amended? ☐ Yes ☒ No

TCP(s) found? ☐ Yes ☒ No

Replace a draft? ☐ Yes ☒ No

Satisfy a DAHP Archaeological Excavation Permit requirement? ☐ Yes # ______ ☒ No

DAHP Archaeological Site #:

______
______
______
______
______
______
______
______
______

- Submission of paper copy is required.
- Please submit paper copies of reports ***unbound.***
- Submission of PDFs is required.
- Please be sure that any PDF submitted to DAHP has its cover sheet, figures, graphics, appendices, attachments, correspondence, etc., compiled into one single PDF file.
- Please check that the PDF displays correctly when opened.

PROJECT REVIEW SHEET – EZ1
HISTORIC & CULTURAL RESOURCES REVIEW

PROPERTY / CLIENT NAME: Bear River Estuary Restoration Project **FUNDING AGENCY:** Recreation and Conservation Office

Project Applicant:	Willapa Bay RFEG				
Contact Person:	Ron Craig				
Address:	P.O. Box 46				
City, State:	South Bend	**Zip:**	98586	**County:**	Pacific
Phone/ FAX:	360 875 6402/360 875 5802				
E-Mail:	rcraig@willapabay.org				

Funding Agency:

Organization:	Recreation and Conservation Office		
Address:	PO Box 40917		
City, State:	Olympia, WA	**Zip:**	98504-0917
Phone:	(360) 902-		
	RCO #		
Date prepared:	July 30, 2010		

PLEASE DESCRIBE THE TYPE OF WORK TO BE COMPLETED
(Be as detailed as possible to avoid having to provide additional information)

☒ **Provide a detailed description of the proposed project:**

See attached existing conditions report.

☒ **Describe the existing project site conditions:**

See attached existing conditions report.

☒ **Describe the proposed ground disturbing activities:**

See attached existing conditions report.

☐ **Check if building(s) will be altered or demolished. If so please complete a DAHP Determination of Eligibility "EZ2" form for each building effected by the proposed project.**

PLEASE ATTACH A COPY OF THE RELEVANT PORTION OF A 7.5 SERIES USGS QUAD MAP AND OUTLINE THE PROJECT INPACT AREA.
(USGS Quad maps are available on-line at http: www.topozone.com)

Project Location

Township: 10 and 11 North **Range:** 10 and 11 West **Section:** multiple
Address: _____ **City:** _____ **County:** Pacific

Place Map Here

See Figures within the attached existing condition report

Please be aware that this form may only initiate consultation. For some projects, DAHP may require additional information to complete our review such as plans, specifications, and photographs. An historic property inventory form may need to be completed by a qualified preservation professional.

July 30, 2010
9-915-17055-0

Cherry Creek Environmental
146 North Canal Street, Suite 111
Seattle, Washington 98103-8652

Attention: Kerrie McArthur

Subject: Cultural Resources Existing Conditions Report for the Bear River Estuary Restoration Project, Pacific County, Washington

Dear Kerrie:

A record search and literature review was conducted on July 26, 2010 on the Washington State Department of Archaeology and Historic Preservation (DAHP) electronic database by a qualified AMEC cultural resources specialist for the Bear River Estuary Restoration Project (Project). A one-mile study area was investigated surrounding the project's Area of Potential Effect (APE), which is situated in Pacific County, Washington. The proposed Project is located partially within Sections 1, 11, and 12 of Township 10 North, Range 11 West and Sections 6, 7, and 18 of Township 10 North, Range 10 West, Willamette Meridian (USGS Chinook, Long Beach, Ocean Park, and Camp Disappointment, WA-OR 7.5 minute topographic quadrangles [1949; photorevised 1984]) (Figure 1).

In 2009, the Willapa Bay Regional Fish Enhancement Group obtained funding from the Washington State Salmon Recovery Funding Board 1 to develop design plans for removing approximately 5 miles of levees, thereby restoring tidal exchange and high quality estuarine habitat to 760 acres on its landward side (Figure 1-1). The levees and associated water management features were constructed over the last 50 years. Since the Project will be receiving either federal funds and/or federal permit to complete this work, it must comply with Section 106 of the National Historic Preservation Act (NHPA) of 1966 (as amended), its implementing regulations in 36 C.F.R. 800.

To assist Cherry Creek Environmental in submitting a Biological Evaluation for the Project, AMEC conducted a background literature review and record search of the DAHP electronic database and provided an existing conditions report that documents our results of the record search. The level of effort and information provided in this document is geared toward initiating the Section 106 of the NHPA process. Formal consultation, known as government-to-government consultation, is required between the lead federal agency and affected Native

American tribes under Section 106. AMEC was scoped to assemble cultural resources information that is known about the APE and identify areas that may contain unknown and significant cultural resources. There was no fieldwork associated with this phase of cultural resources work. If fieldwork is determined necessary at a later date, this effort will be conducted under a separate task order.

RECORD SEARCH RESULTS

The record search and literature review indicated that there are two previously documented archaeological sites within and/or adjacent to the Project's Area of Potential Effects (APE). Sites 45PC125 and 45PC126 are fish traps and located approximately 500 feet east of the APE near the point where Bear River reaches Willapa Bay. They were recorded during a surveying effort to map archaeological resources of the Willapa Bay area (Losey 2006a).

Site 45PC125, termed Big Bear River Fish Trap, consists of three closely spaced lines of densely packed vertical wood stakes that parallel the river channel for much of their length. Stakes in the features were a mix of branch wood and split stakes. Many protruded far above the mudflat surface. All wood stakes were vertical, and no horizontal elements were noted (Losey 2006b).

Site 45PC126, termed Otter Fish Trap, consists of four lines of densely arranged stakes and two lines of widely spaced single larger posts/stakes. The features are being eroded at their north end by the outer edge of the river channel as it turns northward. Stakes in the features were a mix of branch wood and split stakes. Radiocarbon tests on the portions of two wood stakes resulted in dating the age of the fish trap to approximately 1000 B.P. (Losey 2006c).

The first systematic attempt to identify archaeological resources near the Project area was conducted by Dr. Richard Daugherty in the 1940s. Dr. Daugherty (1947) surveyed large coastal sections of Washington, including the Willapa Bay area.

Abramowitz (1980) reported on a cultural resource survey of portions of the Willapa National Wildlife Refuge in Pacific County for the Office of Public Archaeology. No evidence of cultural resources were recorded during their survey, but the author did indicate that archaeological deposits may be present further upstream on Bear River associated with potential Chinook winter village locations or for travel camps (Abramowitz 1980).

Cooper (2009) conducted a cultural resources survey and evaluation of the Oman Berm-Tarlatt Slough Set-Back Project for WSDOT. A pedestrian survey coupled with an extensive sub-surface exploration program (i.e., shovel test probes and mechanical trenching) failed to identify any archaeological resources. AMEC documented a primary ditch, east/west lateral ditches, a dike and several footbridges as a historic-era structure. AMEC recommended the water management feature as not being eligible for listing in the NRHP because it lacked association with an historic event and/or persons.

GEOLOGICAL CONTEXT

The APE is predominately covered by Ocosta silty clay loam, a clayey alluvial soil deposited in coastal bays (Pringle 1986). Upland areas within the project area are generally covered by Willapa silt loam soils, which typically develop in marine sediment on coastal terraces. The APE is categorized as Agriculture (AG) by the Pacific County Comprehensive Plan. Agricultural land in the County is classified as: (1) “agricultural land of long-term significance,” including all land devoted to the production of aquaculture, cranberries, or other bog related crops; and (2) “agricultural land of local importance,” including diked tideland involved in existing and ongoing activities.

RECOMMENDATIONS

There are two previously documented archaeological resources directly adjacent to the Project’s Area of Potential Effects (APE). Sites 45PC125 and 45PC126 are pre-contact fish traps located within the mudflats adjacent to the Bear River channel. Radiocarbon (C-14) dates on the wooden stakes from 45PC126 dated the site to 1,000 Before Present (or approximately 1000 AD). It is anticipated other unknown fish traps are located within the Bear River watershed due to the limited survey area covered during the original project which documented them.

Based on the evaluation of historic aerial photographs of the APE, the dike and ditch drainage system that extends from Tarlatt Slough around Porter Point to the Bear River channel was built / improved upon between 1942 and 1959. This would make the water management feature at least 50 years old.

There are no previously documented Traditional Cultural Properties (TCPs) identified within the APE. Ethnographic research does identify one place name associated with a former Chinook village (*nu?x*^{w}*as?nł* - “blackberry town”) that was once located near the confluence of Bear River and Willapa Bay, immediately outside the Project’s APE. The exact village location is unknown, but it may be closely associated with the previously documented fish traps in the area.

Government-to-government consultation with all affected Native American tribes, as directed by Section 106 of the National Historic Preservation Act of 1966, as amended, is required for this project. Consultation with the affected Native American tribes may identify culturally sensitive areas within the watershed that would require further evaluation.

Please feel free to call (425.368.0953) or email (jason.cooper@amec.com) if you have any questions about this existing conditions report.

Sincerely,

AMEC Earth & Environmental, Inc.

Jason B. Cooper, M.A., RPA
Senior Archaeologist

Attachments-Figures 1, 1-1, and 1-2

REFERENCES

Abramowitz, A.W.

1980 *A Cultural Resource Survey of Lewis, Porter Point and Riekkola Units, Willapa National Wildlife Refuge, Pacific County, Washington*. Submitted to U.S. Department of the Interior, Lower Columbia River Refuge Complex, Longview, Washington. Office of Public Archaeology, Institute for Environmental Studies, University of Washington, Seattle.

Daugherty, R.D.

1947 *Archaeological Research Conducted along the Coastal Area of the State of Washington*. Manuscript on file at the Washington State Department of Archaeology and Historic Preservation, Olympia.

Cooper, J.B. *Cultural Resources Assessment for the Oman Berm Tarlatt Slough Set-Back Project, Pacific County, Washington*. Prepared for WSDOT under Contract Y-10800-AA. Submitted by AMEC Earth & Environmental, Bothell, Washington.

Losey, R.J.

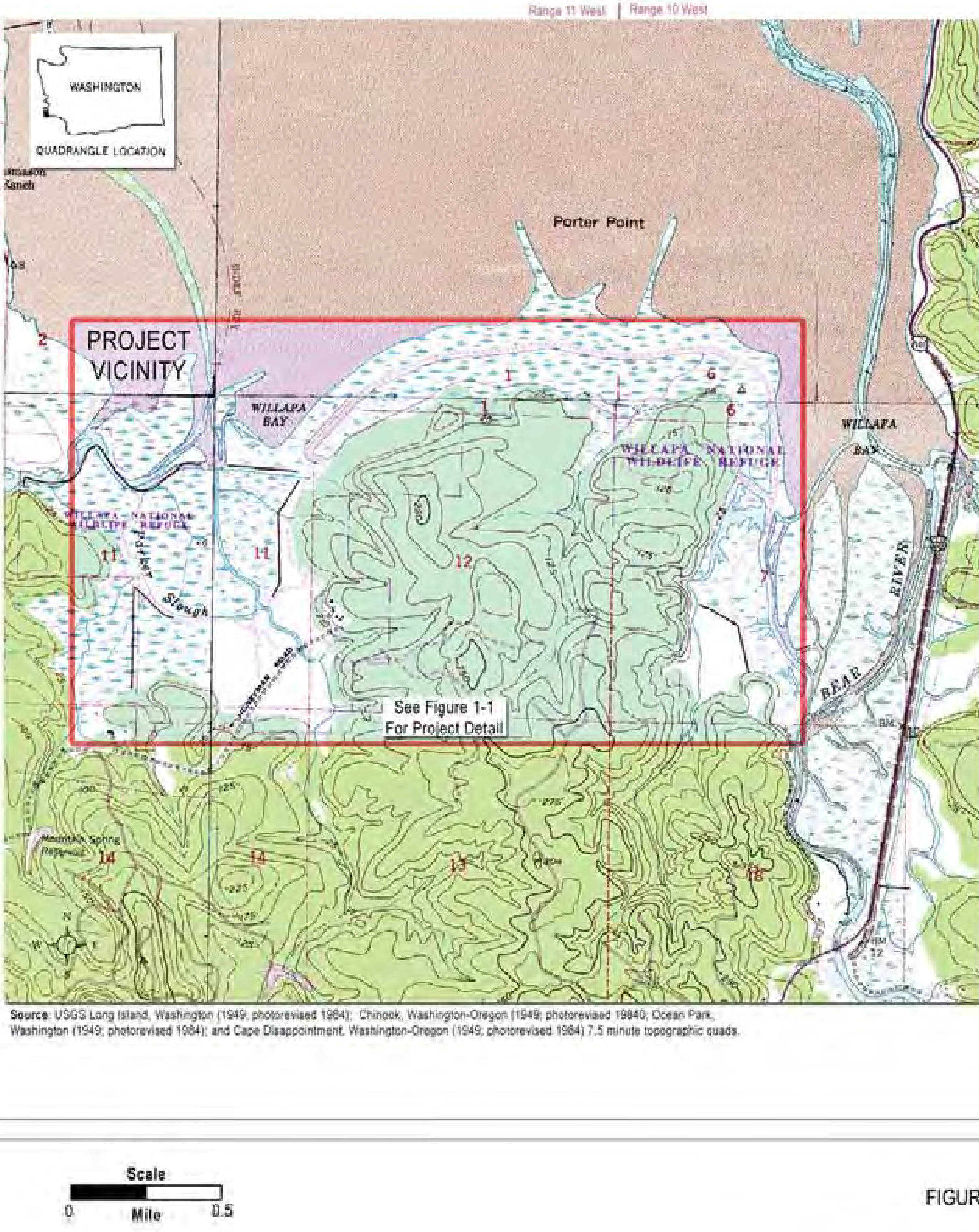
2006a *Report on the Survey of Willapa Bay, Washington for Ancient Fish Traps*. Department of Anthropology, University of Alberta, Edmonton.

2006b *Site 45PC125*. State of Washington Archaeological Site Inventory Form. On file at the Washington State Department of Archaeology and Historic Preservation, Olympia.

2006c *Site 45PC126*. State of Washington Archaeological Site Inventory Form. On file at the Washington State Department of Archaeology and Historic Preservation, Olympia.

Pringle, R.F.

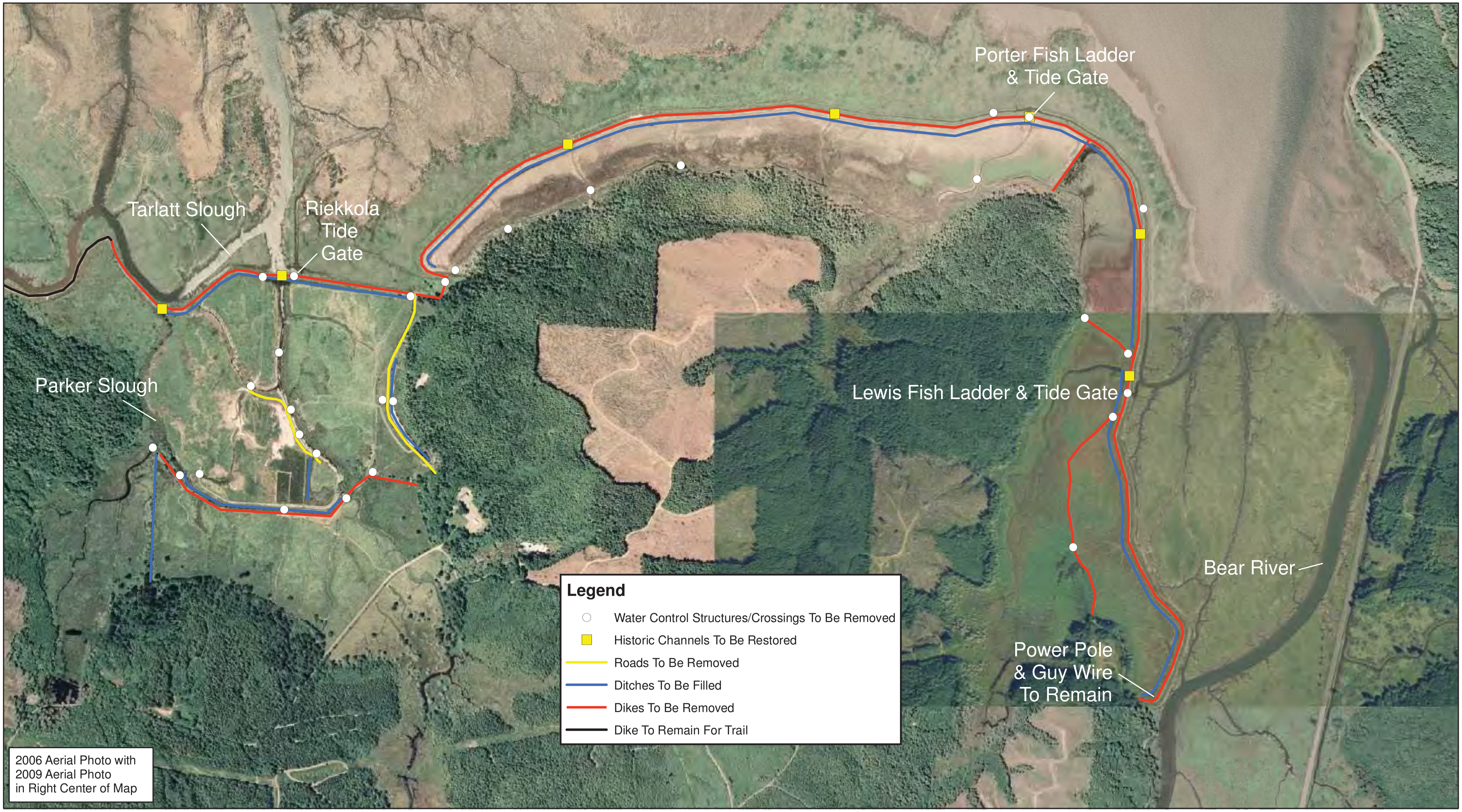
1986 *Soil Survey of Grays Harbor County Area, Pacific County, and Wahkiakum County, Washington*. United States Department of Agriculture, Soil Conservation Service in cooperation with Washington State Department of Natural Resources, and Washington State University, Agriculture Research Center.



Source: USGS Long Island, Washington (1949; photorevised 1984); Chinook, Washington-Oregon (1949; photorevised 1984); Ocean Park, Washington (1949; photorevised 1984); and Cape Disappointment, Washington-Oregon (1949; photorevised 1984) 7.5 minute topographic quads.

FIGURE 1

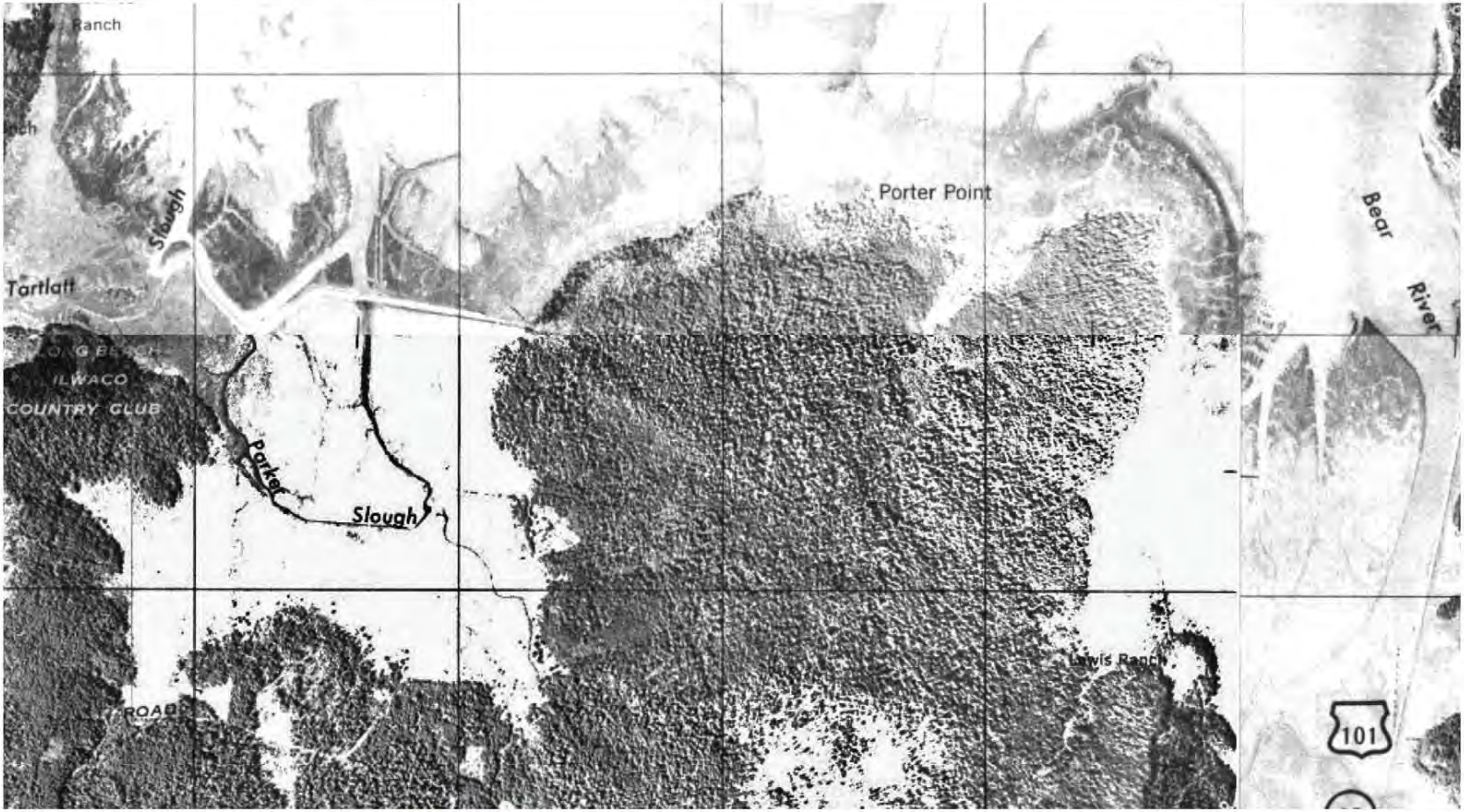
Project Vicinity Map



AMEC Earth & Environmental
11810 North Creek Parkway N
Bothell, WA 98011

Project Map
Bear River Estuary Restoration
Willapa Bay Regional Fisheries Enhancement Group
Willapa National Wildlife Refuge

Figure 1-1



amec

AMEC Earth & Environmental
11810 North Creek Parkway N
Bothell, WA 98011

1943 Aerial Photo
Bear River Estuary Restoration
Willapa Bay Regional Fisheries Enhancement Group
Willapa National Wildlife Refuge

Figure 1-2

Appendix P. Willapa National Wildlife Refuge Headquarters Draft Site Plan

In addition, the Willapa National Wildlife Refuge Headquarters Site Plan includes the following technical memoranda and reports:

1. Wetland Delineation Report for Willapa NWR Tarlatt Slough/95th Street Property, Long Beach, WA. Prepared by Key Environmental Solutions. April 2, 2010. 220 pages.

2. Willapa NWR Headquarters Civil Concept Narrative. Prepared by KPFF Consulting Engineers. December 18, 2009. 6 pages.

3. Willapa NWR Headquarters Preliminary Transportation Assessment. Prepared by Kittelson &Associates, Inc. December 17, 2009. 8 pages.

4. Willapa NWR Site Master Plan. Memorandum on Sizing of Sanitary Septic System Drainfields. Prepared by KPFF Consulting Engineers. July 15, 2010. 6 pages.

5. Willapa NWR New Headquarters Site Plan. Updated Site Program Requirements. Prepared by WalkerMacy. July 16, 2010. 2 pages.

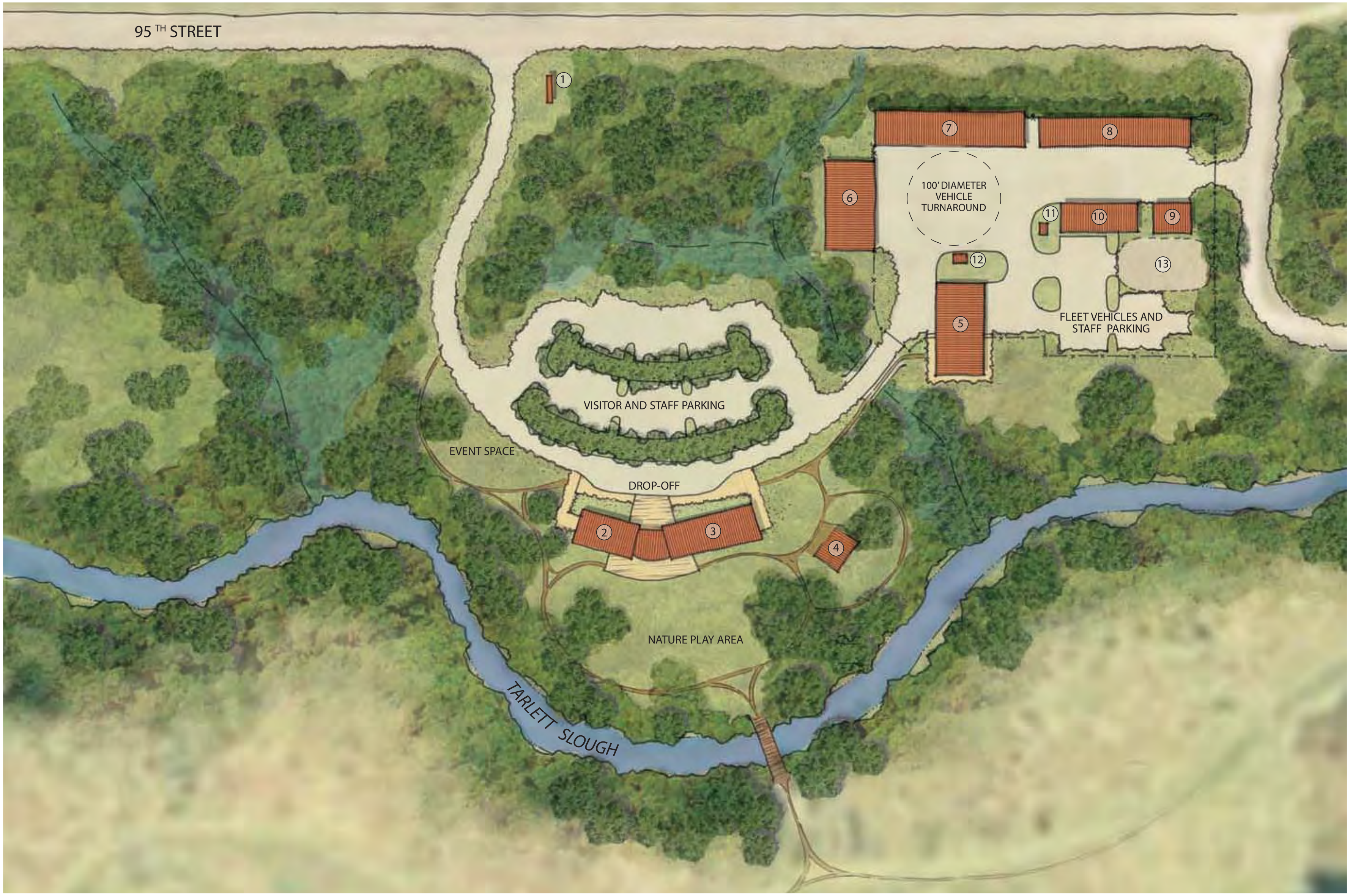
6. Willapa NWR Master Plan Program Elements for Site Planning and Structures. Prepared by SERA Architecture, July 15, 2010.

7. Willapa NWR Headquarters Preliminary Site and Building Cost Estimates. Prepared by H&A Construction. October 1, 2010. 9 pages.

8. Willapa HQ Site Assessment Map. Prepared by WalkerMacy. February 2010. 1 sheet.

9. Willapa HQ Site Context Map. Prepared by WalkerMacy. February 2010. 1 sheet.

10. Concept Drawings and Floor Elevations for Proposed HQ and Outdoor Classroom. Prepared by SERA Architecture. August 30, 2010. 4 sheets.



1. ENTRY SIGN
2. VISITOR CENTER
3. ADMINISTRATIVE OFFICE
4. COVERED SHELTER (TO ACCOMODATE 60 PEOPLE)
5. SHOP BUILDING
6. LARGE EQUIPMENT STORAGE
7. BOAT STORAGE
8. STANDARD EQUIPMENT STORAGE
9. SMALL EQUIPMENT STORAGE
10. CARPORT
11. HAZMAT
12. FILLING STATION
13. BONEYARD

DRAFT SITE PLAN

WALKER·MACY

WILLAPA NATIONAL WILDLIFE REFUGE HEADQUARTERS
U.S. Fish & Wildlife Service
August 2010

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Appendix Q. Wildlife and Plant List for Willapa National Wildlife Refuge

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Ferns & Fern Allies			
Polypodiaceae			
	Athyrium filix-femina	Lady fern	Freshwater marsh, swamp
	Blechnum spicant	Deer fern	Forest
	Dryopteris expansa	Spreading wood fern	Forest
	Polystichum munitum	Sword fern	Forest
	Polypodium glyccyrhiza	Western licorice fern	Epiphyte on hardwoods
	Pteridium aquifolium	Bracken fern	Forest, pastures
Salvinaceae			
	Azolla mexicana	Mexican waterfern	Water; ponds
Conifers			
Cupressaceae			
	Thuja plicata	Western red cedar	Marsh edges, upland, and planted in Tarlatt lowlands
Pinaceae			
	Abies grandis	Grand fir	Planted in Tarlatt lowlands
	Picea sitchensis	Sitka spruce	
	Pinus contorta var. contorta	Shore pine	Planted at Tarlatt homesite
	Pseudotsuga menziesii	Douglas-fir	
	Tsuga heterophylla	Western hemlock	
Monocots			
Alismataceae			
	Alisma plantago-aquatica	Water plantain	Wet areas, likes shallow ponded water
Araceae			
	Lysichiton americanum	Skunk cabbage	Wet areas, marshes, forested wetlands
Cyperaceae			
	Carex lenticularis var. limnophila	Lenticular sedge	*C. Hindsii*, salt marsh
	Carex lyngbyei	Lyngby's sedge	Salt marsh
	Carex obnupta	Slough sedge	Freshwater marsh
	Carex spp.	Sedge	Wet meadow, Tarlatt Unit
	Eleocharis palustris	Common spike-rush	Freshwater marsh
	Scirpus microcarpus	Small-fruited bulrush	Freshwater marsh

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Juncaceae			
	Juncus acuminatus	Tapered rush	Ditches
	Juncus articus var. balticus	Baltic rush	*J. Balticus*, freshwater marsh & brackish edges
	Juncus bufonius	Toad rush	Roadways, dikes, open wet areas
	Juncus effusus var. Compactus	Small soft rush	Freshwater marsh
	Juncus effusus var. Effusus	soft rush	Freshwater marsh; introduced variety
	Juncus effusus var. Gracilis	Graceful soft rush	Freshwater marsh
	Juncus tenuis	Slender rush	Roadways in marshes
Juncaginaceae			
	Triglochin concinnum	Graceful arrowgrass	Salt marsh
	Triglochin maritima	Seaside arrowgrass	Salt marsh
Lemnaceae			
	Lemna minor	Water lentil	Freshwater marsh
Lilaceae			
	Maianthemum dilatatum	False lily-of-the-valley	Dikes, shady forest areas
	Narcissus pseudonarcissus	Daffodils	Planted at Riekkola & Tarlatt homesites
	Prosartes smithii	Smith's fairybells	*Disporum smithii*, shady forest sites, east end Lewis Unit
Poaceae			
	Agropyron caninum var. Andinum	Bearded wheatgrass	Dikes, recently seeded
	Agrostis alba var. Alba	Redtop	Freshwater marsh
	Agrostis spicata	Spike bentgrass	Salt marsh
	Aira caryophyllea	Silver hairgrass	Dikes
	Alopecurus pratensis	Meadow foxtail	Freshwater marsh
	Anthoxanthum odoratum	Sweet vernal grass	Dikes
	Bromus hordeaceus	Soft cheat	*B. mollis*, dikes
	Bromus japonicus	Hairy chess	*B. commutatus*, dikes
	Bromus pacificus	Pacific brome	Outer (salty) side of dikes
	Calamagrostis nutkaensis	Pacific reedgrass	Marsh edge, forest edge
	Cynosurus cristata	Crested dog's-tail grass	Road at Shier's farm yard

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Dactylis glomerata	Orchard grass	Dikes
	Deschampsia caespitosa var. Arctica	Tufted hairgrass	Salt marsh
	Distichlis spicata	Salt grass	Salt marsh
	Festuca arundinaceae	Tall fescue	Dikes, pastures
	Festuca rubra	Red fescue	Salt marsh
	Glyceria boreali	Northern mannagrass	Freshwater marsh
	Glyceria elata	Tall mannagrass	Freshwater marsh
	Holcus lanatus	Common velvet grass	Dikes, roads, pastures
	Holcus mollis	Creeping velvet grass	Dikes, roads, pastures
	Hordeum brachyantherum	Meadow barley	Salt marsh
	Lolium perenne	Perennial rye	Dikes, recently seeded
	Phalaris arundinacea	Reed canary grass	Pastures, marshes
	Poa annua	Annual bluegrass	Dikes, roads, pastures
	Poa palustris	Fowl bluegrass	Pastures
	Poa pratensis	Kentucky bluegrass	Pastures
	Puccinellia spp.	*Alkali grass*	Salt marsh
	Spartina alterniflora	Smooth cordgrass	Salt marsh
	Trisetum cernum	Nodding trisetum	Shady dike areas, Lewis Unit
	Zizania palustris	Wild rice	Freshwater marsh, seeded
Potamogetonaceae			
	Potamogeton natans	Floating-leaved pondweed	Standing water, ditches, sloughs
Sparganiaceae			
	Sparganium emersum ssp. Emersum	Simple-stem bur-reed	Ditches, sloughs
Typhaceae			
	Typha latifolia	Broad-leaved cattail	Ditches, sloughs
Zosteraceae			
	Zostera japonica	Dwarf eelgrass	Upper to lower tidelands
	Zostera marina	Eelgrass	Mid tidelands to subtidal
Dicots			
Apiaceae			
	Angelica lucida	Sea-watch	Dikes along edge of salt marsh
	Heracleum lanatum	Cow-parsnip	Dikes, marshes

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Hydrocotyle ranunculoides	Floating marsh pennywort	Ditches, sloughs; WA sensitive
	Oenanthe sarmentosa	Pacific water-parsley	Marshes
Aquifoliaceae			
	Ilex aquifolium	English holly	Tarlatt Unit
Araliaceae			
	Hedera hibernica	Atlantic ivy	Riekkola Unit, in trees, expect elsewhere
Asteraceae			
	Achillea millifolium	Yarrow	Dikes
	Anaphalis margaritacea	Pearly-everlasting	Dikes
	Aster subspicatus	Douglas' aster	Freshwater marsh
	Bidens cernua	Nodding bur-marigold	Freshwater marsh
	Cirsium edule	Indian or edible thistle	Upper edge of salt marsh
	Cirsium vulare	Bull thistle	Pastures, dikes
	Cotula coronopifolia	Brass buttons	Marshes, fresh to brackish
	Crepis capillaris	Smooth hawksbeard	Dikes
	Erechtites minima	Toothed coast burnweed	Dikes, pastures
	Erechtites serratula	Serrate-leaf coast burnweed	Dikes, pastures
	Gnaphalium ulignosum	Marsh cudweed	Pastures
	Hypochaeris radicata	Hairy cat's ear	Dikes, pastures
	Jaumea carnosa	Fleshy jaumea	Salt marsh
	Lactuca serriola	Prickly lettuce	Dikes
	Lapsana communis	Nipplewort	Shade, lewis end of dike
	Leucanthemum vulgare	Ox-eye daisy	Dikes
	Matricaria matricarioides	Pineapple weed	Dikes
	Senecio jacobaea	Tansy ragwort	Dikes
	Senecio vulgaris	Common groundsel	Dikes
	Sonchus arvensis	Perennial sow-thistle	Dikes
	Sonchus asper	Prickly sow-thistle	Dikes
	Sonchus oleraceus	Common sow-thistle	Dikes
	Taraxacum officinale	Common dandelion	Pastures, dikes
Balsaminaceae			
	Impatiens capensis	Touch-me-not	Tarlatt Slough, south of dike and road
Brassicaceae			
	Barbarea orthoceras	American wintercress	Upper edge of salt marsh

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Rorippa islandica var. Islandica	Marsh yellow cress	Edge of freshwater marsh
Callitrichaceae			
	Callitriche heterophylla var. Bolanderi	Different-leaved water starwort	Standing water and open mud
Caprifoliaceae			
	Lonicera involucrata	Black twinberry	Dikes
	Sambucus racemosa	Red elderberry	Dikes
Chenopodiaceae			
	Cerastium arvensis	Field chickweed	Dikes
	Cerastium fontanum ssp. Vulgare	Common chickweed	Dikes, pastures
	Cerastium glomeratum	Sticky chickweed	Dikes
	Minuartia rubra	Boreal sandwort	Roadways
	Spergularia marina var. Marina	Saltmarsh sandspurry	Salt marsh
	Stellaria crispa	Crisped starwort	Dikes, forests
	Stellaria longipes var. Longipes	Long-stalk starwort	Dikes, marsh edge
Ericaceae			
	Gaultheria shallon	Salal	Dikes, forest
	Vaccinium ovatum	Evergreen huckleberry	
	Vaccinum parvifolium	Red huckleberry	Forest
Fabaceae			
	Lotus corniculatus	Bird's-foot trefoil	Upland pastures, red tinged flowers
	Lotus pedunculatus	Greater bird's-foot trefoil	Wet pastures, yellow flowers
	Robinia pseudo-acacia	Black locust	Planted, old farmhouse sites
	Trifolium pratense	Red clover	Wet pastures, freshwater marsh
	Trifolium procumbens	Hop clover	Dikes, roads
	Trifolium repens	White clover	Wet pastures, freshwater marsh
	Vicia disperma	Two-seeded vetch	Dikes, roads
	Vicia gigantea	Giant vetch	Edge of salt marsh
	Vicia sativa var. Angustifolius	Common vetch	Dikes, roads

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Geraniaceae			
	Geranium robertianum	Herb-robert	Aggressive weed of roadsides, edges; first seen on road to southeast dike, Lewis Unit, June 2007
Grossulariaceae			
	Ribes divaricatum	Wild gooseberry	Dikes
	Ribes laxiflorum	Trailing black currant	Dikes
Lamiaceae			
	Prunella vulgaris var. Lanceolata	Self-heal, heal-all	Shady areas along dikes
	Stachys ajugoides var. Rigida	Mexican hedge-nettle	Shady areas along dikes
Nymphaeaceae			
	Nuphar polysepalum ssp. Luteum	Yellow pond lily	Water (sloughs, ditches, ponds)
Oleaceae			
	Fraxinus latifolia	Oregon ash	Planted; Tarlatt Unit
Onagraceae			
	Epilobium angustifolium	Fireweed	Dikes
	Epilobium paniculatum ssp. Jucundum	Tall annual willowherb	Dikes
	Ludwigia palustris	Water-pursland	Shallow water to mud
Plantaginaceae			
	Plantago lanceolata	Ribwort	Dikes, roads
	Plantago major var. Major	Common plantain	Dikes, roads
	Plantago maritima ssp. Juncoides	Seaside plantain, goose-tongue greens	Salt marsh
Polygonaceae			
	Polygonum lapathifolium	Willowweed	Freshwater marsh, large plain leaves
	Polygonum persicaria	Lady's thumb	Freshwater marsh, large blotched leaves
	Polygonum polystachya	Himalayan knotweed	Tarlatt Unit, large woody shrub
	Rumex acetosella	Sheep sorrel	Roads, open ground
	Rumex crispus	Curly dock	Freshwater marsh

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Rumex obtusifolius	Broad-leaved dock	Marshes
	Rumex occidentalis var. Procerus	Western dock	Salt marsh
Portulacaceae			
	Claytonia sibirica	Siberian candyflower	Forest areas
Ranunculaceae			
	Ranunculus repens	Creeping buttercup	Pastures, freshwater marsh, dikes
Rhamnaceae			
	Rhamnus purshiana	Cascara	Forests, occ among shrubs along dikes
Rosaceae			
	Aruncus sylvester	Goatsbeard	Forests, shade
	Fragaria chilonensis	Coast strawberry	Dikes, roads
	Geum macrophyllum	Large-leaved avens	Forests, shade
	Malus fusca	Western crabapple	*Pyrus fusca*, marshes
	Malus sylvestris	Domestic apple	Old farmhouse sites
	Potentilla pacifica	Pacific silverweed	Saltmarsh to freshwater marsh
	Prunus avium	Sweet cherry	Old farmhouse sites
	Rosa spp.	White rambler rose	Domestic rambler, small white flowers, little scent, double petals, near Riekkola homesite
	Rosa nutkana	Nootka rose	Dikes
	Rubus armeniacus	Himalayan blackberry	*R. discolor*, *R. procerus*, pastures, dikes
	Rubus laciniatus	Evergreen blackberry	Pastures, dikes
	Rubus parviflorus	Thimbleberry	Forest
	Rubus spectabilis	Salmonberry	Dikes, forest, swamps
	Rubus ursinus	Trailing blackberry	Dikes, forest, swamps
	Spiraea douglasii	Douglas' spiraea	Freshwater marsh
Rubiaceae			
	Galium aparine	Cleavers	Freshwater marsh
	Galium trifidum	Small bedstraw	Freshwater marsh
Salicaeae			
	Salix hookeriana	Hooker's willow	Freshwater marsh

Table Q-1. Plant Species Occurring on or near Willapa National Wildlife Refuge – Porter Point (Lewis, Riekkola, and Tarlatt Units).

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Salix lucida ssp. Lasiandra	Pacific willow	Planted, shier unit
	Salix scouleriana	Scouler's willow	Freshwater marsh
	Salix sitchensis	Sitka willow	Upland, near road
Saxifragaceae			
	Tellima grandiflora	Fringecups	Forest near dikes
Scrophulariaceae			
	Digitalis purpurea	Foxglove	Color forms include purple, lavender, white and blush pink
	Parentucellia viscosa	Sticky parentucellia	Along dikes, roads, seeded areas
	Scrophularia californica	California figwort	Dikes, west end
	Triphysaria pusilla	Dwarf owl-clover	*Orthocarpus pusillus*, dikes, roads
	Veronica americana	American brookline	Freshwater marsh
	Veronica scutellata	Marsh speedwell	Freshwater marsh
Solanaceae			
	Solanum dulcamara	Bittersweet	Freshwater marsh
Violaceae			
	Viola glabella	Early yellow violet	Forest areas
	Viola palustris	Marsh violet	Tarlatt pastures

K Sayce, N Eid, B Arnoldy, Last update: 6/8/2007

Codes
Introduced species (gray bar)

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge − Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Ferns & fern allies			
Lycopodiaceae			
	Lycopodium clavatum	Ground pine	Coastal forest
Ophioglossaceae			
	Botrychium multifidum	Leathery grape fern	Open dunes
Polypodiaceae			
	Athyrium filix-femina	Lady fern	Freshwater, along sloughs, wet sites
	Polypodium glycrrhiza	Licorice fern	Dunes
	Polypodium scouleri	Leather-leaved polypody	Between young dunes and coastal forest
	Polystichum munitum	Swordfern	Coastal forest, and old to young dunes
	Pteridium aquilinum	Bracken	All habitats except youngest dunes

Conifers

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Cupressaceae			
	Thuja plicata	Western red cedar	Older coastal forests, wet
Pinaceae			
	Picea sitchensis	Sitka spruce	Coastal forest, sea cliffs
	Pinus contorta ssp. Contorta	Shore pine	All habitats except outer dunes
	Tsuga heterophylla	Western hemlock	Older forests, needs wood-based fungi in soil

Monocots

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Cyperaceae			
	Carex brevicaulis	Short-stemmed sedge	Dunes
	Carex cusickii	Cusick's sedge	Dunes
	Carex lenticularis	Lenticular sedge	Brackish wetlands
	Carex lyngbyei	Lyngby's sedge	Edges of salt marshes in tidelands
	Carex macrocephala	Big-headed sedge	Beaches

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge − Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Carex obnupta	Slough sedge	Freshwater wetlands, common
	Carex pansa	Sanddune sedge	Old dunes
	Carex phyllomanica	Coast stellate sedge	Wetlands among dunes
	Carex sitchensis	Sitka sedge	Wetlands
	Eleocharis palustris	Common spike-rush	Marshes
	Eleocharis parvula	Small spike-rush	Salt marshes, open ground
	Scirpus americanus	Three-square bulrush	Salt water intertidal
Iridaceae			
	Sisyrinchium californica	Golden-eyed grass	Open fresh wetlands
	Sisyrinchium littorale	Coastal blue-eyed grass	Old dunes, back of salt marsh
Juncaceae			
	Juncus acuminatus	Tapered rush	Marshes
	Juncus articulatus	Jointed rush	Interdunal wetlands
	Juncus balticus	Baltic rush	Brackish upper edges of salt marshes
	Juncus bolanderi	Bolander's rush	Fresh to salt marshes
	Juncus bufonius	Toad rush	Open, freshwater marshes
	Juncus covillei	Coville's rush	Fresh marshes, formerly considered part of *J. falcatus* complex
	Juncus effusus var. Pacificus	Soft rush	Damp to wet; common
	Juncus ensifolius	Dagger-leaved rush	Fresh marshes
	Juncus gerardii	Mud rush	Salt marshes
	Juncus lesueurii	Salt rush	Salt to fresh marshes, also low-ground among old dunes; wet sandy places
	Juncus pelocarpus	Brown-fruited rush	Introduced; fresh marshes, very similar to toad rush
	Luzula parviflora	Small-flowered woodrush	Forests
Juncaginaceae			
	Triglochin concinnum var. Concinnum	Graceful arrowgrass	Salt marsh
	Triglochin maritimum	Seaside arrowgrass	Salt marsh

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge − Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Liliaceae			
	Lilaea scilloides	Flowering quillwort	Brackish edge of salt marsh
	Maianthemum dilatatum	False lily-of-the-valley	Coastal forest
Orchidaceae			
	Goodyear oblongifolia	Western rattlesnake plantain	Coastal forest
	Spiranthes romanzoffiana	Lady's tresses	Old dunes
Poaceae			
	Agrostis pallens	Dune bentgrass	Old dunes
	Agrostis capillaris	Colonial bentgrass	Introduced; grasslands, old name - A. tenuis
	Agrostis stolonifera	Fiorin	Introduced; grasslands
	Aira caryophyllea	Silver hairgrass	Introduced; grasslands
	Aira praecox	Little hairgrass	Introduced; grasslands
	Alopecurus geniculatus	Water foxtail	Marshes, open wet sites
	Ammophila arenaria	European beachgrass	Introduced; young dunes
	Ammophila breviligulata	American beachgrass	Introduced; young dunes
	Anthoxanthum odoratum	Sweet vernal grass	Introduced; old and young dunes
	Bromus mollis	Soft brome	Introduced; young dunes
	Bromus pacificus	Pacific brome	Old dunes
	Bromus sitchensis	Sitka brome	Old dunes
	Calamagrostis nutkaensis	Nootka reed grass	Pine forest near bay, north of old dune
	Deschampsia caespitosa	Tufted hairgrass	Salt marsh, near upper edge
	Distichlis spicata	Salt grass	Salt marsh
	Leymus mollis	American dunegrass	All dune prairies, back of salt marshes; former name *Elymus mollis*
	Festuca arundinacea	Tall fescue	Introduced; dunes
	Festuca rubra var. Littoralis	Red fescue	Old dunes, back of salt marshes
	Festuca rubra var. Rubra	Red fescue	Old dunes, sea cliffs
	Holcus lanatus	Common velvet grass	Introduced; dunes
	Holcus mollis	Creeping velvet grass	Introduced; dunes
	Hordeum jubatum	Foxtail barley	Introduced; salt marsh
	Poa annua	Annual bluegrass	Introduced; dunes

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge – Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Poa confinis	Coastline bluegrass	Old dunes
	Poa douglasii ssp. Macrantha	Seashore bluegrass	Old dunes
	Poa praetensis	Kentucky bluegrass	Introduced; dunes
	Puccinellia pumila	Dwarf alkaligrass	Salt marsh
	Sieglingia decumbens	Heathgrass	Introduced; forest
	Spartina alterniflora	Smooth cordgrass	Introduced; salt water intertidal and salt marsh
	Vulpia bromoides	Barren fescue	Introduced; dunes
	Vulpia microstachys	Small fescue	Forests, dunes
Zosteraceae			
	Zostera japonica	Dwarf eelgrass	Introduced; saltwater intertidal
	Zostera marina	Big eelgrass	Saltwater intertidal

Dicots

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Apiaceae			
	Angelica lucida	Seacoast angelica	Back of salt marshes
	Glehnia leiocarpa	Beach-carrot	Open sand, beaches
	Heracleum lanatum	Cow parsnip	Wet areas, often back edge of salt marsh
	Sanicula arctopoides	Bear's foot sanicle	Old dunes
Asteraceae			
	Achillea millefolium	Yarrow	Dunes
	Agoseris exarata	Seaside agoseris	Dunes
	Ambrosia chamissonis	Silver bursage	Beaches
	Anaphalis margaritacea	Pearly-everlasting	Dunes
	Aster subspicatus var. Douglasii	Douglas' aster	Wetlands
	Chrysanthemum leucanthemum	Ox-eye daisy	Introduced; dunes
	Cirsium edule	Edible thistle	Old dunes, back of salt marsh, sea cliffs
	Cirsium vulgare	Bull thistle	Introduced; dunes
	Cotula coronopifolia	Brass buttons	Introduced; brackish back of salt marshes

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge − Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Gnaphalium chilense	Cotton-batting cudweed	Dunes
	Gnaphalium purpureum	Purple cudweed	Dunes
	Gnaphalium ulignosum	Marsh cudweed	Introduced; marsh
	Grindelia integrifolia	Gumweed	Salt marsh
	Hypocharis radicata	Hairy cat’s ear	Introduced; dunes
	Jaumea carnosa	Jaumea	Salt marsh
	Leontodon nudicaulis	Hairy hawkbit	Introduced; dunes
	Microseris biglovii	Coast microseris	Dunes
	Senecio jacobea	Tansy ragwort	Introduced; dunes
	Senecio sylvaticus	Wood groundsel	Dunes
	Senecio vulgare	Common groundsel	Introduced; dunes
	Solidago spathulata	Coast goldenrod	Dunes
	Tanacetum douglasii	Seaside tansy	Dunes
	Taraxacum officinale	Common dandelion	Introduced; dunes
	Taraxacum laevigatum	Red-seeded dandelion	Introduced; dunes
Betulaceae			
	Alnus rubra	Red alder	Coastal forest, wet and dry
Boraginaceae			
	Myosotis laxa	Small-flowered forget-me-not	Dunes
Brassicaceae			
	Barbarea orthoceras	American wintercress	Back of salt marsh
	Brassica sativa	Wild mustard	Introduced; wet areas
	Cakile edentula	European searocket	Introduced; beaches
	Cakile maritima	American searocket	Introduced; beaches
	Capsella bursa-pastoris	Shepherd’s purse	Introduced; dunes
	Honkenya peploides	Honkenya	Beaches
	Lepidium perfoliatum	Clasping peppergrass	Introduced; marshes
	Lilaeopsis ranunculoides	Lilaeopsis	Brackish marshes
	Teesdalia nudicaulis	Teesdalia	Open sand in dunes
Caprifoliaceae			
	Lonicera involucrata	Black twinberry	Wetlands
Caryophyllaceae			
	Arenaria stricta	Slender sandwort	Dunes, new name *Minuartia stricta*
	Cardionema ramosissima	Sandbur	Open sand in dunes
	Cerastium arvense	Field chickweed	Dunes

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge – Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Cerastium vulgatum	Common chickweed	Dunes
	Cerastium viscosum	Sticky chickweed	Introduced; dunes
	Sagina maxima ssp. Crassicaulis	Stick-seeded pearlwort	Dunes, sea cliffs
	Spergularia canadensis var. Occidentalis	Canada sandspurry	Upper salt marsh
	Spergularia macrotheca	Beach sandspurry	Beaches, open sand
	Spergularia marina	Salt marsh sandspurry	Salt marshes
	Stellaria humifusa	Low starwort	Salt marshes
	Stellaria longipes	Long-stalk starwort	Dunes
Chenopodiaceae			
	Atriplex patula	Shore orache	Salt marsh
	Chenopodium album	Lambs'quarter	Introduced; salt marsh
	Salicornia virginica	Pickleweed	Salt marsh
	Suaeda maritima	Seablite	Salt marsh; southern end of range
Clusiaceae			
	Hypericum anagalloides	Bog St. John's wort	Marshes
Convolvulaceae			
	Calystegia sepium	Rutland beauty	Introduced; beaches, edge of salt marshes; formerly *Convolvulus*
	Calystegia soldanella	Beach morning-glory	Beaches; formerly *Convolvulus*
Cuscutaceae			
	Cuscuta salina	Dodder	Salt marsh; primarily parasitic on pickleweed
Ericaceae			
	Arctostaphyllos uva-ursi	Kinnikinnick, bear berry	Coastal forest, grassland-forest transition zone
	Gautheria shallon	Salal	Coastal forest
	Pyrola asarifolia	Common pink wintergreen	Marshes
	Vaccinium ovatum	Evergreen huckleberry	Coastal forest
	Vaccinium parviflorum	Red huckleberry	Coastal forest

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge − Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
Fabaceae			
	Cytisus scoparius	Scotch broom	Introduced; grasslands, disturbed sites
	Lathyrus japonicus	Beach pea	Open sand, edge of dunes
	Lathyrus littoralis	Beach peavine	Dunes
	Lotus corniculatus	Birds' foot trefoil	Introduced; dunes
	Lotus formosissimus	Seaside lotus	Edge of salt marsh, dunes
	Lupinus littoralis	Seashore lupine	Open sand, edge of dunes
	Trifolium wormskjoldii	Springbank clover	Wetter areas in dunes
	Ulex europaeus	Common gorse	Introduced; grasslands, disturbed sites
	Vicia gigantea	Giant vetch	Edge of salt marsh
	Vicia sativa	Common vetch	Introduced; dunes
	Vicia villosa	Woolly vetch	Dunes
Gentianaceae			
	Centaurium umbellatum	Rosy centaury	Introduced; dunes
Malvaceae			
	Sidalcea hendersonii	Henderson's sidalcea	Back of salt marsh
Myricaceae			
	Myrica californica	Pacific wax myrtle	Dunes, esp. pine forests
Nyctaginaceae			
	Abronia latifolia	Yellow sandverbena	Beaches
	Abronia umbrellata	Pink sandverbena	Open sand in dunes; rediscovered in 2006
Onagraceae			
	Epilobium angustifolium	Fireweed	Dunes
	Epilobium brachycarpum	Tall willow-herb	Dunes
	Epilobium ciliatum spp. Gladulosum	Common willow-herb	Dunes
	Epilobium minutum	Small-flowered willow-herb	Dunes
	Ludwigia palustris var. Pacifica	Water-purslane	Seasonal wetlands, sloughs
	Oenothera glazioviana	Red-sepaled evening primrose	Open sand in dunes
Plantaginaceae			
	Plantago coronopus	Tooth-leaved plantain	Edge of salt marsh near slough, introduced

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge – Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Plantago lanceolata	Ribwort	Introduced; dunes
	Plantago major var. Major	Common plantain	Introduced: dunes
	Plantago maritima	Seaside plantain	Salt marsh
	Plantago subnuda	Mexican plantain	Dunes
Plumbaginaceae			
	Armeria maritima	Sea thrift, sea blush	Open sand, dunes
Polygonaceae			
	Polygonum polystachya	Himalayan knotweed	Wetter sites
	Polygonum paronchyia	Black knotweed	Dunes
	Rumex acetosella	Sorrel	Introduced; dunes
	Rumex crispus	Curly dock	Introduced; salt marsh
	Rumex maritimus	Seaside dock	Salt marsh
	Rumex occidentalis	Western dock	Salt marsh
	Rumex salicifolius	Willow-leaved dock	Dunes, salt marshes
Portulaceae			
	Montia parviflora	Littleleaf montia	Dunes
	Montia perfoliata	Miners' lettuce	Dunes
Primulaceae			
	Glaux maritima	Saltwort	Salt marshes
Ranunculaceae			
	Ranunculus flammula	Creeping spearwort	Marshes
	Ranunculus repens	Creeping buttercup	Introduced; dunes
	Ranunculus scleratus	Celery-leaved buttercup	Marshes
Rhamnaceae			
	Rhamnus purshiana	Cascara	Forests
Rosaceae			
	Fragaria chiloensis	Beach strawberry	Dunes
	Malus fusca (pyrus fusca)	Western crabapple	Swamps, willow thickets
	Potentilla edgii var. Groenlandica	Marsh silverweed	Back of salt marsh, fresh marshes
	Potentilla palustris	Purple cinquefoil	Marshes
	Pyracantha coccinea	Firethorn	Introduced; dune-forest transition zone
	Rosa gymnocarpa	Baldhip rose	Coastal forests
	Rosa nutkana	Nootka rose	Coastal forests

Table Q-2. Plant Species Occurring on or near Willapa National Wildlife Refuge − Leadbetter Point: Dunes, Beaches, Salt Marshes, Freshwater Habitats.

FAMILY	SCIENTIFIC NAME	COMMON NAME	NOTE
	Rubus armeniacus	Himalayan blackberry	Introduced; dunes, forests (old names- *R. procera*, *R. discolor*)
	Rubus laciniatus	Cut-leaved blackberry	Introduced; dunes, forests
	Rubus spectabilis	Salmonberry	Forests, swamps
	Rubus ursinus	Pacific blackberry	Old dunes, forests
	Spirea douglasii	Hardhack, Douglas' spirea	Marshes
Rubiaceae			
	Galium aparine	Goose-grass, cleavers	Introduced; dunes
	Galium cymosum	Pacific bedstraw	Dunes
	Galium trifidum var. Pacificum	Small bedstraw	Dunes
Salicaceae			
	Populus balsamifera ssp. Trichocarpa	Black cottonwood	Swamps, only known plant along coast
	Salix hookeriana	Hooker's willow	Swamps, hybridizes with Scouler's willow
	Salix lucida ssp. Lasiandra	Pacific willow	Swamps
	Salix rigida var. Mackenzieana	Mackenzie willow	Swamps; very long leaves
	Salix scouleriana	Scouler's willow	Swamps; hybridizes with Hooker's willow
Scrophulariaceae			
	Castilleja ambigua	Paint-brush owl-clover	Back of salt marsh on low plain; former name *Orthocarpus castilljoides*
	Digitalis purpureum	Foxglove	Dunes
	Orthocarpus pusillus	Dwarf owl-clover	Dunes
	Veronica americana	Wall speedwell	Fill in new parking lot
	Veronica scutellata	Marsh speedwell	Marshes
Valerianaceae			
	Plectritis congesta	Sea blush	Back of salt marsh

K Sayce, N Eid, 2003 assessment (rev. 2011)

Codes *Introduced species (gray bar)*

Species of note: rare, at/near limit of range, or ESA-listed

Table Q-3. Mammal Species Occurring on or near Willapa National Wildlife Refuge.

ORDER/COMMON NAME	SCIENTIFIC NAME
Marsupalia (opossums)	
Virginia opossum	*Didelphis virginiana*
Insectivora (shrews and moles)	
Vagrant shrew	*Sorex vagrans*
Dusky shrew	*Sorex monticolus*
Pacific water shrew	*Sorex bendirii*
Trowbridge's shrew	*Sorex trowbridgii*
Shrew-mole	*Neurotrichus gibbsii*
Townsend's mole	*Scapanus townsendii*
Coast mole	*Scapanus orarius*
Chiroptera (bats)	
Little brown myotis	*Myotis lucifugus*
Yuma myotis	*Myotis yumanensis*
Long-eared myotis	*Myotis evotis*
Long-legged myotis	*Myotis volans*
California myotis	*Myotis californicus*
Silver-haired bat	*Lasionycteris noctivagans*
Big brown bat	*Eptesicus fuscus*
Hoary bat	*Lasiurus cinereus*
Carnivora (carnivores)	
Coyote	*Canis latrans*
Black bear	*Ursus americanus*
Raccoon	*Procyon lotor*
Pine marten	*Martes americana*
Long-tailed weasel	*Mustela frenata*
Mink	*Mustela vison*
Striped skunk	*Mephitis mephitis*
River otter	*Lontra canadensis*
Bobcat	*Lynx rufus*
Cougar	*Puma concolor*
Northern fur seal	*Callorhinus ursinus*
Stellar sea lion	*Eumetopias jubatus*
California sea lion	*Zalophus californianus*
Harbor seal	*Phoca vitulina*
Rodentia (rodents)	
Mountain beaver	*Aplodontia rufa*
Townsend's chipmunk	*Tamias townsendii*
Douglas squirrel	*Tamiasciurus douglasii*
Northern flying squirrel	*Glaucomys sabrinus*

Table Q-3. Mammal Species Occurring on or near Willapa National Wildlife Refuge.

ORDER/COMMON NAME	SCIENTIFIC NAME
Beaver	*Castor canadensis*
Deer mouse	*Peromyscus maniculatus*
Forest deer mouse	*Peromyscus keeni*
Bushy-tailed woodrat	*Neotoma cinerea*
Southern red-backed vole	*Myodes gapperi*
Townsend’s vole	*Microtus townsendii*
Long-tailed vole	*Microtus longicaudus*
Creeping vole	*Microtus oregoni*
Muskrat	*Ondatra zibethicus*
Norway rat	*Rattus norvegicus*
Pacific jumping mouse	*Zapus trinotatus*
Porcupine	*Erethizon dorsatum*
Nutria	*Myocastor coypus*
Lagomorpha (rabbits and hares)	
Snowshoe hare	*Lepus americanus*
Artiodactyla (even-toed ungulates)	
Roosevelt elk	*Cervus elaphus roosevelti*
Black-tailed deer	*Odocoileus hemionus columbianus*
Cetacea (dolphins, porpoises, and whales)	
Gray whale	*Eschrichtius robustus*
Harbor porpoise	*Phocoena phocoena*

Table Q-4. Amphibian and Reptile Species Occurring on or near Willapa National Wildlife Refuge.

	FAMILY/COMMON NAME	SCIENTIFIC NAME
AMPHIBIANS		
	Ambystomatidae (mole salamanders)	
	Northwestern salamander	*Ambystoma gracile*
	Dicamptodontidae (Pacific giant salamanders)	
	Cope's giant salamander	*Dicamptodon copei*
	Coastal Giant salamander	*Dicamptodon tenebrosus*
	Rhyacotritonidae (torrent salamanders)	
	Columbia torrent salamander	*Rhyacotriton kezeri*
	Salamandridae (newts)	
	Rough-skinned newt	*Taricha granulosa*
	Plethodontidae (lungless salamanders)	
	Ensatina	*Ensatina eschscholtzii*
	Dunn's salamander	*Plethodon dunni*
	Van Dyke's salamander	*Plethodon vandykei*
	Western red-backed salamander	*Plethodon vehiculum*
	Ascaphidae (tailed frogs)	
	Tailed frog	*Ascaphus truei*
	Bufonidae (true toads)	
	Western toad	*Bufo boreas*
	Hylidae (New World tree frogs)	
	Pacific treefrog	*Pseudacris regilla*
	Ranidae (riparian frogs and true frogs)	
	Red-legged frog	*Rana aurora*
	Bullfrog	*Rana catesbeiana*
REPTILES		
	Cheloniidae (sea turtles)	
T	Loggerhead sea turtle	*Caretta caretta*
T	Green sea turtle	*Chelonia mydas*
	Dermochelyidae (leatherback turtle)	
E	Leatherback sea turtle	*Dermochelys coriacea*
	Colubridae (colubrids)	
	Common gartersnake	*Thamnophis sirtalis*
	Northwestern gartersnake	*Thamnophis ordinoides*

Key
T = Threatened Species
E = Endangered Species

Table Q-5. Fish Species Occurring on or near Willapa National Wildlife Refuge.

	FAMILY/COMMON NAME	SCIENTIFIC NAME
	Petromyzontidae (lamprey)	
	Pacific lamprey	*Lampetra tridentata*
	River lamprey	*Lampetra ayresi*
	Western brook lamprey	*Lampetra richardsoni*
	Hexanchidae (cow sharks)	
	Sevengill shark	*Notorynchus cepedianus*
	Squalidae (dogfish sharks)	
	Spiny dogfish	*Squalus acanthias*
	Acipenseridae (sturgeon)	
T	Green sturgeon	*Acipenser medirostris*
	White sturgeon	*Acipenser transmontanus*
	Engraulidae (anchovies)	
	Northern anchovy	*Engraulis mordax*
	Clupeidae (herrings)	
	American shad	*Alosa sapidissima*
	Pacific herring	*Clupea pallasii*
	Pacific sardine	*Sardinops sagax*
	Osmeridae (smelts)	
	Longfin smelt	*Spirinchus thaleichthys*
T	Eulachon	*Thaleichthys pacificus*
	Salmonidae (salmon and trout)	
	Cutthroat trout	*Oncorhynchus clarki clarki*
	Chum salmon	*Oncorhynchus keta*
	Coho salmon	*Oncorhynchus kisutch*
	Steelhead	*Oncorhynchus mykiss*
	Chinook salmon	*Oncorhynchus tshawytscha*
	Gadidae (cods)	
	Pacific cod	*Gadus macrocephalus*
	Gasterosteidae (sticklebacks)	
	Threespine stickleback	*Gasterosteus aculeatus*
	Scorpaenidae (scorpionfishes/rockfishes)	
	Brown rockfish	*Sebastes auriculatus*
	Hexagrammidae (greenlings)	
	Kelp greenling	*Hexagrammos decagrammus*
	Lingcod	*Ophiodon elongatus*
	Cottidae (sculpins)	
	Cabezon	*Scorpaenichthys marmoratus*
	Ictaluridae (catfish)	
	Brown bullhead	*Ameiurus nebulosus*

Table Q-5. Fish Species Occurring on or near Willapa National Wildlife Refuge.

FAMILY/COMMON NAME	SCIENTIFIC NAME
Embiotocidae (surfperches)	
Unknown species	
Pholidae (gunnels)	
Saddleback gunnel	*Pholis ornata*
Scombridae (mackerels and tunas)	
Pacific mackerel	*Scomber japonicus*
Bothidae (lefteye flounders)	
Pacific sanddab	*Citharichthys sordidus*
Pleuronectidae (righteye flounders)	
English sole	*Parophrys vetulus*
Starry flounder	*Platichthys stellatus*

Key:
T = Threatened Species
E = Endangered Species

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

	COMMON NAME	SCIENTIFIC NAME
Loons		
	Red throated loon	*Gavia stellata*
	Pacific loon	*Gavia pacifica*
	Common loon	*Gavia immer*
Grebes		
	Red-necked grebe	*Podiceps grisegena*
	Horned grebe	*Podiceps auritus*
*	Pied-billed grebe	*Podilymbus podiceps*
	Western grebe	*Aechmophorus occidentalis*
Shearwaters		
	Black-footed albatross	*Phoebastria nigripes*
	Northern fulmar	*Fulmarus glacialis*
	Buller’s shearwater	*Puffinus bulleri*
	Pink-footed shearwater	*Puffinus creatopus*
	Manx shearwater	*Puffinus puffinus*
	Short-tailed shearwater	*Puffinus tenuirostris*
	Sooty shearwater	*Puffinus griseus*
Storm-petrels		
	Leach’s storm-petrel	*Oceanodroma leucorhoa*
	Fork-tailed storm petrel	*Oceanodroma furcata*
Pelicans and cormorants		
	Brown pelican	*Pelecanus occidentalis*
*	Double-crested cormorant	*Phalacrocorax auritus*
*	Pelagic cormorant	*Phalacrocorax pelagicus*
*	Brandt’s cormorant	*Phalacrocorax penicillatus*
Bitterns, herons and egrets		
*	American bittern	*Botaurus lentiginosus*
*	Great blue heron	*Ardea herodias*
	Great egret	*Ardea alba*
*	Green heron	*Butorides virescens*
Ducks, geese and swans		
	Trumpeter swan	*Cygnus buccinator*
	Tundra swan	*Cygnus columbianus*
*	Canada goose	*Branta canadensis*
	Cackling goose	*Branta hutchinsii*
	Brant	*Branta bernicla*
	Greater white-fronted goose	*Anser albifrons*
	Emperor goose	*Chen canagica*
	Ross’s goose	*Chen rossii*

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

	COMMON NAME	SCIENTIFIC NAME
	Snow goose	*Chen caerulescens*
*	Wood duck	*Aix sponsa*
*	Mallard	*Anas platyrhynchos*
	Gadwall	*Anas strepera*
	Northern pintail	*Anas acuta*
	American wigeon	*Anas americana*
	Eurasian wigeon	*Anas penelope*
	Northern shoveler	*Anas clypeata*
*	Cinnamon teal	*Anas cyanoptera*
	Blue-winged teal	*Anas discors*
	Green-winged teal	*Anas crecca*
	Canvasback	*Aythya valisineria*
	Ring-necked duck	*Aythya collaris*
	Greater scaup	*Aythya marila*
	Lesser scaup	*Aythya affinis*
	Harlequin duck	*Histrionicus histrionicus*
	Long-tailed duck	*Clangula hyemalis*
	Surf scoter	*Melanitta perspicillata*
	Black scoter	*Melanitta americana*
	White-winged scoter	*Melanitta fusca*
	Common goldeneye	*Bucephala clangula*
	Bufflehead	*Bucephala albeola*
*	Hooded merganser	*Lophodytes cucullatus*
*	Common merganser	*Mergus merganser*
	Red-breasted merganser	*Mergus serrator*
	Ruddy duck	*Oxyura jamaicensis*
Vultures		
*	Turkey vulture	*Cathartes aura*
Kites, hawks, eagles, and osprey		
*	Northern harrier	*Circus cyaneus*
*	White-tailed kite	*Elanus leucurus*
	Sharp-shinned hawk	*Accipiter striatus*
*	Cooper’s hawk	*Accipiter cooperii*
	Northern goshawk	*Accipiter gentilis*
	Red-shouldered hawk	*Buteo lineatus*
*	Red-tailed hawk	*Buteo jamaicensis*
	Rough-legged hawk	*Buteo lagopus*
*	Bald eagle	*Haliaeetus leucocephalus*
*	Osprey	*Pandion haliaetus*

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

		COMMON NAME	SCIENTIFIC NAME
	Falcons		
	*	Merlin	*Falco columbarius*
		American kestrel	*Falco sparverius*
		Gyrfalcon	*Falco rusticolus*
	*	Peregrine falcon	*Falco peregrinus*
	Gallinaceous birds		
	*	Northern bobwhite	*Colinus virginianus*
	*	Ring-necked pheasant	*Phasianus colchicus*
	*	Sooty grouse	*Dendragapus fuliginosus*
	*	Ruffed grouse	*Bonasa umbellus*
		Wild turkey	*Meleagris gallopavo*
	Rails		
		American coot	*Fulica americana*
	*	Virginia rail	*Rallus limicola*
		Sora	*Porzana carolina*
	Plovers		
		Black-bellied plover	*Pluvialis squatarola*
		Pacific golden-plover	*Pluvialis fulva*
		American golden-plover	*Pluvialis dominica*
		Semipalmated plover	*Charadrius semipalmatus*
T	*	Western snowy plover	*Charadrius nivosus*
	*	Killdeer	*Charadrius vociferus*
	Oystercatchers		
		Black oystercatcher	*Haematopus bachmani*
	Shorebirds		
		Greater yellowlegs	*Tringa melanoleuca*
		Lesser yellowlegs	*Tringa flavipes*
		Willet	*Tringa semipalmata*
		Spotted sandpiper	*Actitis macularius*
		Whimbrel	*Numenius phaeopus*
		Long-billed curlew	*Numenius americanus*
		Bar-tailed godwit	*Limosa lapponica*
		Marbled godwit	*Limosa fedoa*
		Ruddy turnstone	*Arenaria interpres*
		Black turnstone	*Arenaria melanocephala*
		Wandering tattler	*Tringa incana*
		Surfbird	*Aphriza virgata*
		Rock sandpiper	*Calidris ptilocnemis*
		Red knot	*Calidris canutus*

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

	COMMON NAME	SCIENTIFIC NAME
	Sanderling	*Calidris alba*
	Dunlin	*Calidris alpina*
	Pectoral sandpiper	*Calidris melanotos*
	Sharp-tailed sandpiper	*Calidris acuminata*
	Baird's sandpiper	*Calidris bairdii*
	Western sandpiper	*Calidris mauri*
	Semipalmated sandpiper	*Calidris pusilla*
	Least sandpiper	*Calidris minutilla*
	Ruff	*Philomachus pugnax*
	Stilt sandpiper	*Calidris himantopus*
	Long-billed dowitcher	*Limnodromus scolopaceus*
	Short-billed dowitcher	*Limnodromus griseus*
	Buff-breasted sandpiper	*Tryngites subruficollis*
	Wilson's snipe	*Gallinago delicata*
Phalaropes		
	Wilson's phalarope	*Phalaropus tricolor*
	Red-necked phalarope	*Phalaropus lobatus*
	Red phalarope	*Phalaropus fulicarius*
Jaegers		
	Long-tailed jaeger	*Stercorarius longicaudus*
	Parasitic jaeger	*Stercorarius parasiticus*
	Pomarine jaeger	*Stercorarius pomarinus*
Gulls and terns		
	Bonaparte's gull	*Chroicocephalus philadelphia*
	Mew gull	*Larus canus*
*	Ring-billed gull	*Larus delawarensis*
	California gull	*Larus californicus*
	Herring gull	*Larus argentatus*
	Thayer's gull	*Larus thayeri*
	Glaucous gull	*Larus hyperboreus*
*	Glaucous-winged gull	*Larus glaucescens*
*	Western gull	*Larus occidentalis*
	Heermann's gull	*Larus heermanni*
	Sabine's gull	*Xema sabini*
	Black-legged kittiwake	*Rissa tridactyla*
*	Caspian tern	*Hydroprogne caspia*
	Common tern	*Sterna hirundo*
	Arctic tern	*Sterna paradisaea*

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

		COMMON NAME	SCIENTIFIC NAME
	Alcids		
		Common murre	*Uria aalge*
	*	Pigeon guillemot	*Cepphus columba*
T	*	Marbled murrelet	*Brachyramphus marmoratus*
		Cassin’s auklet	*Ptychoramphus aleuticus*
		Rhinoceros auklet	*Cerorhinca monocerata*
		Tufted puffin	*Fratercula cirrhata*
	Doves		
	*	Rock dove	*Columba livia*
	*	Band-tailed pigeon	*Patagioenas fasciata*
		Eurasian collared-dove	*Streptopelia decaocto*
		Mourning dove	*Zenaida macroura*
	Owls		
	*	Barn owl	*Tyto alba*
	*	Western screech owl	*Megascops kennicottii*
	*	Great horned owl	*Bubo virginianus*
		Snowy owl	*Bubo scandiacus*
	*	Northern pygmy-owl	*Glaucidium gnoma*
T		Northern spotted owl	*Strix occidentalis caurina*
	*	Barred owl	*Strix varia*
		Short-eared owl	*Asio flammeus*
	*	Northern saw-whet owl	*Aegolius acadicus*
	Nighthawks		
	*	Common nighthawk	*Chordeiles minor*
	Swifts		
	*	Vaux’s swift	*Chaetura vauxi*
	Hummingbirds		
		Anna’s hummingbird	*Calypte anna*
	*	Rufous hummingbird	*Selasphorus rufus*
	Kingfishers		
	*	Belted kingfisher	*Megaceryle alcyon*
	Piciformes (woodpeckers)		
	*	Red-breasted sapsucker	*Sphyrapicus ruber*
	*	Downy woodpecker	*Picoides pubescens*
	*	Hairy woodpecker	*Picoides villosus*
	*	Northern flicker	*Colaptes auratus*
	*	Pileated woodpecker	*Dryocopus pileatus*
	Flycatchers		
	*	Olive-sided flycatcher	*Contopus cooperi*

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

	COMMON NAME	SCIENTIFIC NAME
*	Western wood-pewee	*Contopus sordidulus*
*	Willow flycatcher	*Empidonax traillii*
	Hammond's flycatcher	*Empidonax hammondii*
*	Pacific-slope flycatcher	*Empidonax difficilis*
	Ash-throated flycatcher	*Myiarchus cinerascens*
Shrikes		
	Northern shrike	*Lanius excubitor*
Vireos		
	Cassin's Vireo	*Vireo cassinii*
*	Hutton's vireo	*Vireo huttoni*
*	Warbling vireo	*Vireo gilvus*
Jays and crows		
*	Gray jay	*Perisoreus canadensis*
*	Steller's jay	*Cyanocitta stelleri*
*	Western scrub-jay	*Aphelocoma californica*
*	American crow	*Corvus brachyrhynchos*
*	Common raven	*Corvus corax*
Larks		
*	Streaked horned lark	*Eremophila alpestris strigata*
Swallows		
*	Purple martin	*Progne subis*
*	Tree swallow	*Tachycineta bicolor*
*	Violet-green swallow	*Tachycineta thalassina*
*	Northern rough-winged swallow	*Stelgidopteryx serripennis*
*	Cliff swallow	*Petrochelidon pyrrhonota*
*	Barn swallow	*Hirundo rustica*
Chickadees and allies		
*	Black-capped chickadee	*Poecile atricapillus*
*	Chestnut-backed chickadee	*Poecile rufescens*
*	Bushtit	*Psaltriparus minimus*
Nuthatches and creepers		
*	Red-breasted nuthatch	*Sitta canadensis*
*	Brown creeper	*Certhia americana*
Wrens		
*	Bewick's wren	*Thryomanes bewickii*
*	Pacific wren	*Troglodytes pacificus*
*	Marsh wren	*Cistothorus palustris*
Kinglets		
*	Golden-crowned kinglet	*Regulus satrapa*

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

	COMMON NAME	SCIENTIFIC NAME
	Ruby-crowned kinglet	*Regulus calendula*
Bluebirds and thrushes		
	Western bluebird	*Sialia mexicana*
	Townsend's solitaire	*Myadestes townsendi*
*	Swainson's thrush	*Catharus ustulatus*
	Hermit thrush	*Catharus guttatus*
*	American robin	*Turdus migratorius*
*	Varied thrush	*Ixoreus naevius*
Starlings and mynas		
*	European starling	*Sturnus vulgaris*
Wagtails and pipits		
	American pipit	*Anthus rubescens*
Waxwings		
*	Cedar waxwing	*Bombycilla cedrorum*
Warblers		
*	Orange-crowned warbler	*Oreothlypis celata*
*	Yellow warbler	*Dendroica petechia*
*	Yellow-rumped warbler	*Dendroica coronata*
*	Black-throated gray warbler	*Dendroica nigrescens*
	Townsend warbler	*Dendroica townsendi*
	Hermit warbler	*Dendroica occidentalis*
	Palm warbler	*Dendroica palmarum*
	Macgillivray's warbler	*Oporornis tolmiei*
*	Common yellowthroat	*Geothlypis trichas*
*	Wilson's warbler	*Wilsonia pusilla*
Tanagers		
*	Western tanager	*Piranga ludoviciana*
Towhees and sparrows		
*	Spotted towhee	*Pipilo maculatus*
	Chipping sparrow	*Spizella passerina*
*	Savannah sparrow	*Passerculus sandwichensis*
	Fox sparrow	*Passerella iliaca*
*	Song sparrow	*Melospiza melodia*
	Lincoln's sparrow	*Melospiza lincolnii*
	White-throated sparrow	*Zonotrichia albicollis*
	Golden-crowned sparrow	*Zonotrichia atricapilla*
*	White-crowned sparrow	*Zonotrichia leucophrys*
*	Dark-eyed junco	*Junco hyemalis*
	Lapland longspur	*Calcarius lapponicus*

Table Q-6. Bird Species Occurring on or near Willapa National Wildlife Refuge.

	COMMON NAME	SCIENTIFIC NAME
	Snow bunting	*Plectrophenax nivalis*
Grosbeaks and buntings		
*	Black-headed grosbeak	*Pheucticus melanocephalus*
Blackbirds, meadowlarks and orioles		
*	Red-winged blackbird	*Agelaius phoeniceus*
*	Western meadowlark	*Sturnella neglecta*
*	Brewer's blackbird	*Euphagus cyanocephalus*
*	Brown-headed cowbird	*Molothrus ater*
Finches		
	Evening grosbeak	*Coccothraustes vespertinus*
*	Purple finch	*Carpodacus purpureus*
*	House finch	*Carpodacus mexicanus*
*	Red crossbill	*Loxia curvirostra*
*	Pine siskin	*Carduelis pinus*
*	American goldfinch	*Spinus tristis*
Old world sparrows		
*	House sparrow	*Passer domesticus*

Key:

T = Threatened Species

E = Endangered Species

* = Species known to nest in the checklist area.

Table Q-7. Birds Recorded in the Willapa National Wildlife Refuge Area Five Times or Less and Considered Accidentals.

COMMON NAME	SCIENTIFIC NAME
Laysan albatross	*Phoebastria immutabilis*
Flesh-footed shearwater	*Puffinus carneipes*
Magnificent frigatebird	*Fregata magnificens*
Snowy egret	*Egretta thula*
Cattle egret	*Bubulcus ibis*
Falcated duck	*Anas falcata*
Redhead	*Aythya americana*
Tufted duck	*Aythya fuligula*
Barrow’s goldeneye	*Bucephala islandica*
Hudsonian godwit	*Limosa haemastica*
Ancient murrelet	*Synthliboramphus antiquus*
Horned puffin	*Fratercula corniculata*
Long-eared owl	*Asio otus*
Eastern phoebe	*Sayornis phoebe*
Mountain bluebird	*Sialia currucoides*
Rose-breasted grosbeak	*Pheucticus ludovicianus*

Appendix R. Economic Effects of Willapa National Wildlife Refuge's Comprehensive Conservation Plan

The Economic Effects of Willapa National Wildlife Refuge's Comprehensive Conservation Plan: Baseline and Alternatives

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TABLE OF CONTENTS

EXECUTIVE SUMMARY R-5
INTRODUCTION R-9
Background........ R-9
Approach to Estimating Economic Effects R-9
Structure of this Report........ R-10
OVERVIEW R-12
Area Demographics R-12
Area Outdoor Recreational Opportunities and Trends........ R-17
Forest Management R-17
Timber Harvests R-17
Forest Excise Taxes........ R-19
Cranberry Production R-20
Revenue Sharing Payments R-21
ALTERNATIVE 1 (STATUS QUO) – Continue Current Management........ R-23
Recreational Activities R-23
Description of Recreational Activities R-23
Regional Economic Impacts of Recreational Activities R-24
Refuge Expenditures........ R-26
Forest Management R-27
Timber Harvests and Economic Impact R-27
Forest Excise Taxes........ R-30
Cranberry Production R-31
Revenue Sharing Payments R-31
15-Year Present Value Impacts R-32
ALTERNATIVE 2 – Healthy Wildlife Habitats, Endangered Species and Biodiversity Gains, Focused Refuge Expansion, Simplified Expanded Public Use R-33
Recreational Activities R-33
Description of Activities R-33
Regional Economic Impacts of Recreational Activities R-34
Refuge Expenditures........ R-38
Forest Management R-39
Timber Harvests and Economic Impacts R-39
Forest Excise Taxes........ R-42
Cranberry Production R-43
Revenue Sharing Payments R-44
15-Year Present Value Impacts R-46
ALTERNATIVE 3 – Partial Restoration of Habitats, Endangered Species Gains, Limited Refuge Expansion, Moderate Public Use........ R-48
Recreational Activities R-48
Description of Activities R-48
Regional Economic Impacts of Recreational Activities R-49
Refuge Expenditures........ R-52
Forest Management R-54
Timber Harvests and Economic Impacts R-54

Forest Excise Taxes R-57
Cranberry Production R-58
Revenue Sharing Payments R-59
15-Year Present Value Impacts R-61
REFERENCES R-62
APPENDIX 1 – Measuring Economic Impacts R-65

EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service (USFWS or the Service) has published a comprehensive conservation plan (CCP) for the Willapa National Wildlife Refuge. This CCP set forth management guidance for the Refuge for the next 15 years as required by the National Wildlife Refuge System (NWRS or the Refuge System) Administration Act of 1966, as amended (16 U.S. Code [U.S.C.] 688dd-688ee). This report supports the CCP document by providing an economic analysis for Willapa National Wildlife Refuge (Refuge). This report analyzes the economic impacts of three alternatives from the draft CCP/Environmental Impact Statement (EIS): Alternative 1 (Baseline) – Continue current Refuge management; Alternative 2 (Preferred Alternative) – healthy wildlife habitats, endangered species and biodiversity gains, focused refuge expansion, simplified expanded public use; and Alternative 3 - Partial restoration of habitats, endangered species gains, limited refuge expansion, moderate public use. For each alternative, five subject areas are discussed: Refuge recreation, Refuge budget, the timber industry (timber harvests and forest excise taxes), cranberry production, and Refuge revenue sharing payments. Economic impacts are estimated for each subject area except cranberry production due to the difficulty in quantifying the linkages between Refuge land management, elk populations, and cranberry production. Impacts to local area cranberry production are discussed qualitatively.

Executive Order 12866 Regulatory Planning and Review (U.S. Office of Management and Budget 1993) identify guidelines for the economic analysis of Federal regulations. To calculate the present value[1] for a 15-year period, the social discount rates of 3 percent and 7 percent are applied per U.S. Office of Management and Budget (OMB) guidance (U.S. Office of Management and Budget 1992).

Alternative 1

Alternative 1 is the status quo (baseline). Under Alternative 1, the Refuge would continue its current management program, and no additional impacts would occur. The existing boundary of approximately 16,000 acres including sand dunes, sand beaches, intertidal mudflats, saltwater and freshwater marshes, grassland, open water, and forested lands would not change. The existing boundary would continue to be managed for healthy habitat and wildlife, and the Refuge would continue to offer the same recreational opportunities.

Alternative 2

Under Alternative 2 (preferred Alternative), the Refuge would acquire a proposed land acquisition, thereby expanding its boundary by 6,809 acres. The volume of timber harvested on the existing Refuge boundary would not change, and the volume of timber harvested on the proposed land acquisition would decrease. Furthermore, the Refuge would increase recreational opportunities, construct a variety of projects, and restore habitat.

[1] Per OMB guidance, "a discount factor should be used to adjust the estimated benefits and costs for differences in timing. The further in the future the benefits and costs are expected to occur, the more they should be discounted. The discount factor can be calculated given a discount rate. The formula is $1/(1+\text{the discount rate})^t$ where "t" measures the number of years in the future that the benefits or costs are expected to occur. Benefits or costs that have been adjusted in this way are called "discounted present values" or simply "present values" (U.S. Office of Management and Budget 2003).

Recreational visitors would increase because additional public use opportunities such as wildlife observation and hunting would be offered. As a result, recreation expenditures would average $2.2 million annually. The 15-year present value for recreation expenditures would be $25.8 million discounted at 3 percent or $19.0 million discounted at 7 percent. Impacts associated with Refuge expenditures would increase because a number of projects (such as a new visitor center, a new trail and overlook, the Bear River tidal project, and others) would be completed. Refuge budget expenditures would average $3.1 million annually over 15 years. Refuge budget expenditures would total $36.4 million discounted at 3 percent or $26.7 million discounted at 7 percent over 15 years. Under Alternative 2, timber revenue and forest excise taxes would be impacted because the Refuge would manage the proposed land acquisition differently than current landowners. Over 15 years, timber revenue (including the current Refuge land and the proposed land acquisition) would average $2.1 million annually, and forest excise taxes would average $86,000 annually. The 15-year present value for timber revenue (including the current Refuge land and the proposed land acquisition) would be $24.5 million discounted at 3 percent or $17.8 million discounted at 7 percent. Forest excise taxes would total $980,900 discounted at 3 percent or $710,900 discounted at 7 percent. Revenue sharing payments would increase due to the proposed land acquisition. Payments would average $60,000 to $639,800 annually. Revenue sharing payments would total $709,300 to $7.2 million discounted at 3 percent or $533,400 to $5.1 million discounted at 7 percent.

Alternative 3

Under Alternative 3, the Refuge would acquire a proposed land acquisition, thereby expanding its boundary by 4,901 acres. The volume of timber harvested on the existing Refuge boundary would not change, and the volume of timber harvested on the proposed land acquisition would decrease. The Refuge would also increase some recreational opportunities, construct a variety of projects, and restore habitat to a lesser extent compared to Alternative 2.

Recreational visitors would increase because additional public use opportunities such as wildlife observation and hunting would be offered. As a result, recreation expenditures would average $2.0 million annually. The 15-year present value for recreation expenditures would be $23.6 million discounted at 3 percent or $17.3 million discounted at 7 percent. Impacts associated with Refuge expenditures would increase because a number of projects (such as a new visitor center, a new trail, the Bear River tidal project, and others) would be completed. Refuge budget expenditures would average $3.1 million annually over 15 years. Refuge budget expenditures would total $36.3 million discounted at 3 percent or $26.7 million discounted at 7 percent over 15 years. Under Alternative 3, timber revenue and forest excise taxes would be impacted because the Refuge would acquire land that is currently harvested commercially. Over 15 years, timber revenue would average $2.0 million annually, and forest excise taxes would average $78,200 annually. The 15-year present value for timber revenue (including the current Refuge land and the proposed land acquisition) would be $22.3 million discounted at 3 percent or $16.2 million discounted at 7 percent. Forest excise taxes would total $891,700 discounted at 3 percent or $647,800 discounted at 7 percent. Revenue sharing payments would total $637,900 to $6.7 million discounted at 3 percent or $479,800 to $4.7 million discounted at 7 percent.

Summary

Tables ES-1 through ES-3 provide a summary of the potential economic impacts for each alternative. Table ES-1 summarizes the annual average for each activity by Alternative. Table ES-2 summarizes the annual change for recreation, budget, and revenue sharing payments over 15 years for

Alternatives 2 and 3, compared to Alternative 1. Table ES-3 summarizes the annual change in timber activities over 15 years for Alternatives 2 and 3, compared to Alternative 1. For Alternatives 2 and 3, the projected annual decline in timber harvest represents 1 percent of all logs harvested in Pacific County. The decline in timber revenue and forest excise tax receipts represents 2 to 3 percent (Alternatives 3 and 2, respectively) of Pacific County's average timber revenue and forest excise tax receipts.

Under Alternatives 2 and 3, there is a general decline in timber revenue due to a reduction in timber harvest and a lower overall value of logs from federal lands as they cannot be exported. However, these effects are mitigated by jobs associated with processing log products domestically, increased recreational visits and associated spending in the local area, Refuge budget expenditures, and non-quantifiable benefits to watershed health and protection of Willapa Bay. County revenue reductions associated with decreasing forest excise taxes would be alleviated by Refuge revenue sharing payments.

Table ES-1. Annual Average Impact by Activity over 15 Years (2010 dollars in thousands)

	Alternative 1	Alternative 2	Alternative 3
Recreation Expenditures	$1,466.0	$2,232.2	$2,037.1
Budget Expenditures	$2,540.9	$3,140.2	$3,133.1
Timber Volume (mbf)			
Existing Boundary	2,373	2,373	2,373
Proposed Acquisition	5,656	2,463	2,022
Timber Revenue			
Existing Boundary	$1,055.8	$1,055.8	$1,055.8
Proposed Acquisition	$3,195.4	$1,096.1	$900.0
Timber Net Revenue			
Existing Boundary	$391.5	$391.5	$391.5
Proposed Acquisition	$2,047.8	$320.2	$262.9
Forest Excise Taxes			
Existing Boundary	$42.2	$42.2	$42.2
Proposed Acquisition	$127.8	$43.8	$36.0
Revenue Sharing Payments			
Existing Boundary	$38.5 to $400.4	$38.5 to $400.4	$38.5 to $400.4
Proposed Acquisition	0	$21.6 to $239.3	$15.5 to $194.3

Table ES-2. Refuge Recreation/Budget/Revenue Activities: Average Annual Change Compared to Baseline Condition (Alternative 1) (2010 dollars in thousands)

	Alternative 2	Alternative 3
Recreation Expenditures	$766.2	$571.1
Budget Expenditures	$599.3	$592.2
Revenue Sharing Payments		
Existing Boundary	–	–
Proposed Acquisition	$21.6 to $239.3	$15.5 to $194.3

Table ES-3. Timber Activities: Average Annual Change Compared to Baseline Condition (Alternative 1) (2010 dollars in thousands)

	Alternative 2		Alternative 3	
	Change from Alternative 1	**Percentage of Pacific County***	**Change from Alternative 1**	**Percentage of Pacific County**
Timber Volume (mbf)				
Existing Boundary	–	–	–	–
Proposed Acquisition	-3,193	-1%	-3,634	-1%
Timber Net Revenue				
Existing Boundary	–	–	–	–
Proposed Acquisition	-$1,727.6	-3%	-$1,784.9	-2%
Forest Excise Taxes				
Existing Boundary	–	–	–	–
Proposed Acquisition	-$84.0	-3%	-$91.8	-2%

*Note: The Pacific County estimate is based on the 10-year average, 2001-2010.

INTRODUCTION

Background

The U.S. Fish and Wildlife Service (USFWS or the Service) is adopting and implementing a comprehensive conservation plan (CCP) for the Willapa National Wildlife Refuge. This CCP will set forth management guidance for the Refuge for the next 15 years as required by the National Wildlife Refuge System (NWRS or the Refuge System) Administration Act of 1966, as amended (16 U.S. Code [U.S.C.] 688dd-688ee).

The purpose of this report is to support the CCP document by providing an economic analysis for Willapa National Wildlife Refuge (Refuge). This report addresses the economic effects of ongoing activities at the Refuge and the economic effects of the alternatives that were considered in the draft CCP/environmental impact statement (EIS).

Approach to Estimating Economic Effects

From an economic perspective, Willapa National Wildlife Refuge provides a variety of environmental and natural resource goods and services used by people either directly or indirectly. The use of these goods and services may result in economic impacts to both local and state economies. The various services the Refuge provides can be grouped into five broad categories: (1) Maintenance and conservation of environmental resources, services and ecological processes; (2) Production and protection of natural resources such as fish and wildlife; (3) Production and protection of cultural and historical sites and objects; (4) Provision of educational and research opportunities; and (5) Outdoor and wildlife-related recreation. People who use these services benefit in the sense that their individual welfare or satisfaction level increases with the use of a particular good or service. One measure of the magnitude of the change in welfare or satisfaction associated with using a particular good or service is ***economic value***. Aside from the effect on the individual, use of the good or service usually entails spending money in some fashion. These expenditures, in turn, create a variety of economic effects collectively known as ***economic impacts***. For this report, the term ***economic effects*** encompasses both economic value and economic impacts.

Economic value is the economic trade-off people would be willing to make in order to obtain some good or service. It is the maximum amount people would be willing to pay in order to obtain a particular good or service minus the actual cost of acquisition. In economic theory this is known as *net economic value* or *consumer surplus*. In the context of this report, estimates of the economic value of particular recreational activities are used to determine the aggregate value of recreational use of Willapa National Wildlife Refuge.

Economic impacts refer to employment, employment or labor earnings, economic output and federal, local, county and state tax revenue that occur as the result of Refuge activities. *Economic output* includes three types of effects: direct, indirect and induced effects. "Indirect effects result from changes in sales for suppliers to the directly-affected businesses (including trade and services at the retail, wholesale and producer levels. Induced effects are associated with further shifts in spending on food, clothing, shelter and other consumer goods and services, as a consequence of the change in workers and payroll of directly and indirectly affected businesses" (Weisbrod and Weisbrod p.11, 1997). The indirect and induced effects represent any multiplier effects due to the loss of revenue. These cost estimates include the various potential scenarios that were considered. Both job income and tax revenue are derived from total economic output (aggregate sales). For example, labor costs are paid out of total sales revenue for a company as are taxes. To add taxes and job income to output would double-count economic impacts.

Economic output is explained above**.** *Jobs* and *job income* include direct, indirect and induced effects in a manner similar to economic output. Employment includes both full and part-time jobs, with a job defined as one person working for at least part of the calendar year, whether one day or the entire year. *Tax revenues*[2] are shown for business taxes, income taxes, and a variety of taxes at the local, state and national level. Like output, employment, and income, tax impacts include direct, indirect and induced tax effects.

For this report, three types of economic impacts are addressed: (1) impacts associated with annual consumer expenditures on Refuge related recreation; (2) impacts associated with Refuge expenditures; and (3) impacts associated with timber harvests. (For more information about estimating economic impacts, refer to Appendix 1.)

A comprehensive economic profile (baseline) of the Refuge and estimates of the economic effects of alternative management strategies would address all applicable economic effects associated with the use of refuge-produced goods and services. However, for those goods and services having nebulous or non-existent links to the market place, economic effects are more difficult or perhaps even impossible to estimate. Some of the major contributions of the Refuge to the natural environment, such as watershed protection, maintenance and stabilization of ecological processes, and the enhancement of biodiversity would require extensive on-site knowledge of biological, ecological and physical processes and interrelationships even to begin to formulate economic benefit estimates. This is beyond the scope of this report.

This report focuses on a limited subset of refuge goods and services, primarily those directly linked in some fashion to the marketplace, such as recreation use, Refuge budget expenditures, and timber sales. It should be kept in mind that the emphasis on these particular market-oriented goods and services should not be interpreted to imply that these types of goods and services are somehow more important or of greater value (economic or otherwise) than the non-market goods and services previously discussed.

Structure of this Report

The remainder of this report is structured as follows:

- **Overview:** This section presents an overview of the study area demographics, outdoor recreation trends, and the regional timber industry.

- **Alternative 1 – Continue Current Management (Baseline):** This section analyzes the impacts of the current Refuge management plan. It analyzes the baseline for recreational activities, Refuge budget, forest management, cranberry production, and revenue sharing payments.

[2] The overall tax rate is about 13.7 percent of economic output and includes direct, indirect and induced tax effects nationwide. The tax rate is calculated within the economic modeling software used to estimate economic impacts.

- **Alternative 2 – Healthy Wildlife Habitats, Endangered Species and Biodiversity Gains, Focused Refuge Expansion, Simplified Expanded Public Use:** This section analyzes the impacts to recreational activities, Refuge budget, forest management, cranberry production, and revenue sharing payments if the highest level of habitat improvement of all three alternatives is chosen.

- **Alternative 3 - Partial Restoration of Habitats, Endangered Species Gains, Limited Refuge Expansion, Moderate Public Use:** This section analyzes the impacts to recreational activities, Refuge budget, forest management, cranberry production, and revenue sharing payments, if the alternative for partial restoration of habitats is chosen.

OVERVIEW

This section presents an overview of the area demographics, outdoor recreation trends, the regional timber industry, area cranberry production, and revenue sharing payments.

Area Demographics

The Refuge is situated entirely within Pacific County, Washington. Pacific County is situated along the Pacific coast of western Washington, including Willapa Bay and south to the mouth of the Columbia River. It is bordered to the north by Grays Harbor County, the south by the Columbia River and State of Oregon, to the east Lewis and Wahkiakum counties, and to the west the Pacific Ocean. With 975 square miles, Pacific County ranks thirtieth in size among Washington counties. The nearest towns are located on the Long Beach Peninsula (Oysterville, Nahcotta, Ocean Park, Oceanside, Long Beach, Seaview, Ilwaco, and Chinook) and inland (South Bend, Raymond, Nemah, and Naselle).

The population of Pacific County is just over 21,000 with a density of 23.37 persons per square mile (Office of Financial Management 2009). Population growth is predicted to be less than the State average, with a low estimate of 19,906 and a high estimate of 28,043 for the year 2030. According to Washington State's Office of Financial Management, Pacific County experienced a population increase by 12.6 percent over the decade, growing from 1990 to 1997, and then decreased at an average annual rate of 0.4 percent from 1997 to 2000. Between the years 2000 and 2008, Pacific County experienced a slight increase of 0.4 percent. Pacific County has key competitive assets for future growth: competitive land cost, reasonable property taxes, proximity to urban amenities, education and training resources, dedication to industrial growth, and gateway status for parks and recreation. Because of these assets Pacific County continues to see growth in new housing developments in the North and South County, and anticipates a slight population growth in the future. Additionally, because of the proximity of the Refuge to population centers in the Portland/Vancouver area of northwest Oregon and southwest Washington, the Refuge can expect much greater pressure for recreational and tourism use in the future. Visitation to Pacific County is over 1 million visitor-days per year. In 2008, Cape Disappointment by itself saw 89,286 day-visits and over 92,230 overnight visits. It is likely that an increase in parks and conserved areas for recreation would increase visitations, prolong by days the duration of each visit, and proportionately increase local spending by visitors (Pacific County Economic Development Council 2009).

Table 1 summarizes the population and associated social statistics of Pacific County and Washington State.

Table 1. Selected Population and Associated Social Statistics

Population Statistics	Pacific County	Washington State
Population, 2008 estimate	21,271	6,549,224
Population, percent change, April 1, 2000 to July 1, 2008	1.4%	11.1%
Population estimates base, 2000	20,984	5,894,143
Persons under 5 years old, percent, 2008	5.1%	6.6%
Persons under 18 years old, percent, 2008	18.8%	23.5%
Persons 65 years old and over, percent, 2008	23.9%	12.0%
White persons, percent, 2008	92.0%	84.3%
African American persons, percent 2008	0.5%	3.7%
American Indian and Alaska Native persons, percent, 2008	2.6%	1.7%
Asian persons, percent, 2008	2.1%	6.7%
Native Hawaiian and Other Pacific Islander persons, percent, 2008	0.1%	0.5%
Persons reporting two or more races, percent 2008	2.7%	3.1%
Persons of Hispanic or Latino origin, percent, 2008	6.9%	9.8%
White persons not Hispanic, percent, 2008	85.7%	75.5%
Living in same house in 1995 and 2000, percent of persons age 5+	57.0%	48.6%
Foreign-born persons, percent, 2000	6.0%	10.4%
Language other than English, percent of persons age 5+, 2000	8.2%	14.0%
High school graduates, percent of persons age 25+, 2000	78.9%	87.1%
Bachelor’s degree or higher, percent of persons age 25+, 2000	15.2%	27.7%
Persons with a disability, age 5+, 2000	5,410	981,007
Housing units, 2007	14,598	2,744,069
Homeownership rate, 2000	74.8%	64.6%
Housing units in multi-unit structures, percent, 2000	7.5%	25.6%
Median value of owner-occupied housing units, 2000	$102,700	$168,300
Households, 2000	9,096	2,271,398
Persons per household, 2000	2.27	2.53
Median household income, 2007	$37,501	$55,628
Per capita money income, 1999	$17,322	$22,973
Persons below poverty, percent, 2007	16.0%	11.4%

Source: U.S. Census Bureau 2009

Pacific County's economy is identified as natural resource–based. Beyond those that are natural resource–based, key industries in Pacific County include food products manufacturing, high-tech/light manufacturing, tourism, and health care/retirement, as summarized in Table 2.

Table 2. 2009 Pacific County Economic Summary by Industry

Industries	Summary
Natural resources	There are 12 industrial timber companies that own and harvest timber in Pacific County. These companies together have employed and/or subcontracted jobs to over 500 residents annually since 1993, providing an average annual wage of $46,881. Fishing (which includes shellfish) is an important subsector of the income base in Pacific County, as well as the seafood supply in Washington. Half of the state's oysters, 25% of the state's crabs, 99% of the sturgeon catch, and over 10% of the salmon catch are landed in this region. The industry generates over $12 million in personal income and provides nearly 600 jobs to the local economy. At one time, farming made up a large proportion of Pacific County's economic activity, but the last 25 years have shown steady declines in income. While the area has diverse cultivated crops and ranches, the majority of activity is in the cranberry industry.
Food products manufacturing	The food processing industry accounted for an average of 45% of the manufacturing activity in Pacific County throughout the 1990s and into the twenty-first century. Pacific County has businesses throughout the county that process shellfish and oysters. Changes continue to occur in the food processing industry in Pacific County, which is highly dependent upon favorable harvesting seasons and market prices each year for cranberries, fish, and shellfish.
High-tech/light manufacturing	With the necessary infrastructure in place, Pacific County has begun to see interest from small light industries relocating to port properties. In 2005, the first light manufacturing of aerospace components moved to the Port of Willapa Harbor providing high tech machining and fabrication employment opportunities.
Tourism	With its strategic location, bordered on the southwest by the Columbia River and the west by the Pacific Ocean, Pacific County offers breathtaking views of the Columbia River and the Pacific Ocean, recreational opportunities, fishing, hunting, birding, clamming and a variety of outdoor experiences. The significance of tourism to Pacific County cannot be understated. As a gross revenue engine, tourism delivers over $90 million annually to local businesses, by any measure a huge contribution of the county's total output of goods and services. Business earnings from tourism approach $25 million annually. There are over 2,000 jobs related to or dependent on this industry.
Health care/retirement	Pacific County's two hospitals made significant improvements or expansion of their health care facilities in recent years. With the population in Pacific County has a median age of 45.8 years, and the health care industry is an extremely important part of the social and economic picture. An estimated 650 direct jobs depend on health care while another 271 jobs exist in support of this cluster.

Source: This summary is compiled from the Comprehensive Economic Development Strategy for Pacific County (Pacific County Economic Development Council 2009).

The largest industry sectors for Pacific County are ranked below by employment (Table 3). The largest employer is the State and local government. Natural resource–based industries (fishing, seafood preparation, sawmills, and logging) totaled 1,713 jobs. Food services and retail stores, which are both impacted by Refuge visitation, are also important contributors to the economy (846 jobs).

Table 3. Industry Summary for Pacific County (dollars in thousands)

Industry	Employment	Output	Employment Income
State and Local Government	1,898	188,912	99,482
Commercial Fishing	771	$37,386	$17,988
Food Services	603	$30,379	$9,638
Seafood product preparation and packaging	548	$177,360	$15,296
Private household operations	319	$2,506	$2,187
Animal production, except cattle and poultry and eggs	239	$22,213	$2,120
Retail Stores	223	$15,145	$6,472
Nursing	199	$9,026	$6,600
Sawmills and wood preservation	198	$50,159	$11,177
Commercial logging	196	$44,056	$8,968
Federal Government	190	$17,795	$12,147

Source: Implan 2008

While the Refuge is entirely located within Pacific County, economic impacts reach beyond the immediate vicinity. That is, activities occurring on the Refuge can affect employment, employment income, economic output, and tax revenue impacts in neighboring counties. Therefore, study areas were determined for particular Refuge activities. For recreation impacts, a two-county study area was defined to account for residential visitors, and a six-county study area was defined for the non-residential visitors. Since 62 percent of recreational visitors to the Refuge are non-residents, the inclusion of additional counties is justified. Many shop in Longview, WA (70 miles away), Vancouver, WA (110 miles away), and Portland, OR (115 miles away). Therefore, Pacific, Cowlitz, Wahkiakum, and Clark counties in Washington and Clatsop and Multnomah counties in Oregon comprise the local study area for estimating the economic effects of the recreational use of the Refuge. For budget impacts, the study area includes Pacific County, Washington and Clatsop County, Oregon. For timber impacts, a nine county study area was defined. These counties include where loggers most likely live and where the saw mills and pulp mills that process the Refuge's forest products are most likely located. To a lesser extent, there are also economic effects to the States of Washington and Oregon and the United States. Table 4 summarizes the study areas for each activity.

Table 4. Study Area by Refuge Activity

County	Timber	Recreation	Budget
Washington:			
Clark (Vancouver)		✓	
Cowlitz (Longview)	✓	✓	
Grays Harbor	✓		
Jefferson	✓		
Lewis	✓		
Mason	✓		
Pacific	✓	✓	✓
Skagit	✓		
Thurston	✓		
Wahkiakum	✓	✓	
Oregon:			
Clatsop (Astoria)	✓	✓	✓
Multnomah (Portland)		✓	

Table 5 shows the population and area economy for Willapa Bay National Wildlife Refuge. As discussed above, the local study area includes a 13-county area within Washington and Oregon.

Table 5. Summary of Population and Area Economy, 2009
(Population & Employment in 000's; Per Capita Income in 2010 dollars)

County	Population		Employment		Per Capita Income	
	2009	Percent change 1999-2009	2009	Percent change 1999-2009	2009	Percent change 1999-2009
Clark, WA	432.0	27.2%	182.9	17.8%	$35,602	-0.7%
Cowlitz, WA	102.0	9.9%	45.8	-4.1%	$31,365	5.3%
Grays Harbor, WA	71.8	6.7%	31.5	0.0%	$29,963	9.4%
Jefferson, WA	29.7	15.7%	14.2	11.3%	$43,807	19.9%
Lewis, WA	74.7	9.4%	34.1	-1.2%	$30,664	8.0%
Mason, WA	58.0	19.0%	20.3	16.3%	$31,926	11.2%
Pacific, WA	21.3	1.1%	9.3	0.6%	$30,902	17.3%
Skagit, WA	119.5	17.5%	64.0	14.0%	$38,852	12.6%
Stevens, WA	42.3	7.1%	15.7	-0.5%	$28,570	16.6%
Thurston, WA	251.0	22.5%	130.6	20.4%	$41,470	17.1%
Wahkiakum, WA	4.1	7.2%	1.5	-7.4%	$30,492	7.5%
Clatsop, OR	37.2	4.3%	23.7	8.8%	$34,095	8.0%
Multnomah, OR	726.9	10.5%	560.5	4.4%	$41,154	2.6%
Washington	6,664.2	14.1%	3,826.3	11.2%	$43,573	9.1%
Oregon	3,825.7	12.7%	2,202.7	7.5%	$36,785	4.0%
United States	307,006.6	10.0%	173,809.2	7.6%	$40,285	8.6%

Source: U.S. Department of Commerce 2011.

Area Outdoor Recreational Opportunities and Trends

The most recently released 2007 Washington Outdoor Recreation Survey (RCO 2007) did not offer forecasts of future regional recreation demands. The previous survey, which was released by the Washington Interagency Committee for Outdoor Recreation (IAC 2002b), states that outdoor recreation in most activities continues to increase at high growth rates. Many non-consumptive activities generally permitted on refuges are expected to show participation increases of 20 to 40 percent over the next 20 years. Participation in fishing and hunting activities are projected to decline. Table 6 shows the percentage change expected for Washington State by activity as reported by IAC in 2002. Therefore, new non-consumptive activities are likely to bring new money to the local area.

Table 6. Projected Future Increase in Participation for Selected Outdoor Recreation Activities

Activity	Estimated Change, 10 years (2002-2012)	Estimated Change, 20 years (2002-2022)
Walking	23%	34%
Hiking	10%	20%
Nature activities	23%	37%
Fishing	-5%	-10%
Hunting	-15%	-21%
Sightseeing	10%	20%
Camping	10%	20%
Canoeing/kayaking	21%	30%

The National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57), recognizes that wildlife-dependent recreational uses involving hunting, fishing, wildlife observation and photography, and environmental education and interpretation, when determined to be compatible, are legitimate and appropriate public uses of the Refuge System. These compatible wildlife-dependent recreational uses are the priority general public uses of the Refuge System. Willapa National Wildlife Refuge recognizes and offers these compatible uses.

Forest Management

Timber Harvests

Washington State ranks 2nd (after Oregon) as a producer of softwood products. As an economic driver, wood products contribute $5 billion to GDP and support about 30,000 jobs (Washington Department of Natural Resources 2008). Timber and wood products create economic opportunity through logging, hauling, and processing. Table 7 shows the timber harvest in Pacific County and Washington State from 2004 to 2009. The majority of harvested timberland is private land (85 percent). Harvests in Pacific County have remained relatively steady over the last 6 years, averaging 335,089 mbf annually. Comparatively, Washington’s timber harvest has declined 41 percent since 2004.

Table 7. Timber Harvest by Land Ownership (thousand board feet – mbf)

	Pacific County					
Year	**Private Land**	**State Land**	**Federal Land**	**Other Land**	**Pacific County Total**	**Washington State: Total**
2004	302,799	31,239	0	0	334,038	3,786,329
2005	313,406	16,919	0	0	330,325	3,570,581
2006	280,712	24,423	0	0	305,135	3,323,853
2007	274,609	35,067	0	0	309,676	3,264,253
2008	368,354	59,156	0	6,655	434,165	2,758,088
2009	170,681	124,247	0	2,266	297,194	2,217,311
Annual Average	**285,094**	**48,509**	**0**	**1,487**	**335,089**	**3,153,403**

Source: Washington Department of Natural Resources 2004, 2005, 2006, 2007, 2008, 2009.

After harvest, logs are processed at a number of mills, including sawmills, veneer and plywood mills, shake and shingle mills, post, pole, and piling mills, chipping mills, and export operations. While two sawmills are located near the Refuge, no other mills are located in Pacific County (Washington Department of Natural Resources 2010). Therefore, logs harvested in Pacific County are processed by operations throughout the State or exported to be processed elsewhere. Table 8 shows how logs harvested in Pacific County are processed throughout Washington. Since only two sawmills are located in Pacific County, data for logs processed in the County are summarized along with Jefferson and Thurston Counties. Up to 34,572 mbf (38 percent) of all logs harvested in Pacific County are processed in the 3-County area. The remaining harvest is transported to other areas, with the majority (20 percent) being processed in Grays Harbor County. The economic study area for timber was defined by the counties where Pacific County logs are processed (Skagit, Grays Harbor, Lewis, Mason, Jefferson, Pacific, Thurston, Clark, and Cowlitz). Although Pacific County logs are also processed in Stevens County, it was not included in the study area because only 0.2 percent are transported to the area.

Table 8. Logs Harvested in Pacific County, 2008: Consumption by County of Operation in Washington [Logs harvested (thousand board feet)]

Economic Area and County of Operation	Area of Log Harvest		Percentage of Total
	Pacific County	Washington State	
Puget Sound			
Pierce	0	272,353	0.0%
Skagit	2,883	124,108	2.3%
Snohomish	0	230,391	0.0%
Others* (Whatcom, King)	0	14,378	0.0%
Olympic Peninsula			
Clallum	0	152,908	0.0%
Grays Harbor	108,433	542,777	20.0%
Lewis	16,011	212,785	7.5%
Mason	5,141	198,758	2.6%
Others* (including Jefferson, Pacific, Thurston)	34,572	91,440	37.8%
Lower Columbia			
Clark	6,343	45,057	14.1%
Cowlitz	8,034	317,564	2.5%
Others* (Wahkiakum, Skamania, Klickitat)	0	38,621	0.0%
Central Washington	0	182,050	0.0%
Inland Empire			
Stevens	950	416,859	0.2%
Others* (Ferry, Pend Oreille, Spokane, Whitman, Walla Walla, Columbia, Garfield, Asotin)	0	25,306	0.0%
State Total	**182,367**	**2,865,355**	**6.4%**

*"others" indicates counties were combined to avoid disclosing individual corporate data
Source: Washington Department of Natural Resources, February 2010.

Forest Excise Taxes

In addition to the economic impacts generated by timber harvests and processing, Pacific County also benefits through the receipt of forest excise taxes. Timber harvested from private, State, or Federal land is subject to a 5 percent excise tax on the stumpage value of the timber when harvested (Washington Department of Natural Resources 2010). This revenue is distributed between the County where the timber was harvested (4 percent) and the State general fund (1 percent) (Washington Department of Natural Resources 2010).

The following table summarizes the Pacific County forest excise tax revenue over 10 years (2001 – 2010). Typically, the top revenue receiving Counties are located in the southwest corner of the State. Over the past 10 years, Pacific County has consistently ranked among the top 5 counties receiving forest excise taxes (along with Grays Harbor, Lewis, Cowlitz, Mason, and Pierce Counties). Pacific County's forest excise tax revenue peaked in 2006 at $4.1 million. More recently, the County's forest excise tax revenue has declined to $1.9 million in 2009 and $1.2 million in 2010. This decline is consistent with the decrease in timber harvests the past 2 years and is comparable to the overall State decline in forest excise tax revenue.

Table 9. Distribution of Forest Excise Tax (2010$, thousands)

Year	Pacific County	All Counties Total	Percentage of Total
2001	$4,151.4	$52,207.4	8%
2002	$2,956.2	$42,453.0	7%
2003	$3,104.4	$37,666.7	8%
2004	$3,091.4	$38,561.8	8%
2005	$3,504.4	$42,125.6	8%
2006	$4,072.2	$45,298.8	9%
2007	$3,641.0	$41,803.8	9%
2008	$3,738.0	$29,647.6	13%
2009	$1,874.3	$17,038.8	11%
2010	$1,152.7	$17,781.0	6%
Annual Average	**$3,128.6**	**$36,458.4**	**9%**

Source: State of Washington Department of Revenue 2001-2010.

Cranberry Production

Washington consistently ranks 5th in cranberry production nationwide behind Wisconsin, Massachusetts, New Jersey, and Oregon (National Agricultural Statistics Service 2010). Table 10 shows Washington's cranberry production for 2000-2009. Over the last 10 years, Washington cranberry production has ranged from 190,000 barrels in 2003 to 109,000 barrels in 2008. Washington's cranberry production typically comprises about 3 percent of production nationwide. In 2009, Washington cranberries grossed nearly $9.6 million.

Table 10. Cranberry Production

Year	Washington			United States: Total Production (Barrels)
	Total Production (Barrels)	Harvested Acres	Real Value (2010$, thousands)	
2000	180,000	1,500	$4,659	5,712,000
2001	142,000	1,600	$4,726	5,329,000
2002	167,000	1,700	$6,979	5,689,000
2003	190,000	1,700	$7,929	6,183,000
2004	170,000	1,700	$6,990	6,175,000
2005	187,000	1,700	$7,867	6,635,000
2006	114,000	1,700	$5,615	6,900,000
2007	176,000	1,700	$9,188	6,554,000
2008	109,000	1,700	$6,278	7,865,000
2009	161,000	1,700	$9,578	6,913,000

Source: U.S. Department of Agriculture, 2010.

Pacific County's wet conditions are conducive to growing cranberries. The majority of Washington's cranberry growers are located in Pacific County (88 farms or 68 percent of the State total) (Table 11).

Table 11. Cranberry Farms and Acres (2007)

County	Farms	Acres
Clallam	1	(D)
Clark	5	1
Grays Harbor	25	313
Kitsap	3	(D)
Pacific	88	(D)
Pierce	2	(D)
Thurston	1	(D)
Whatcom	5	(D)
Washington State	130	1,899

Source: 2007 Census of Agriculture.

Revenue Sharing Payments

Under provisions of the Refuge Revenue Sharing Act (Public Law 95-469), the Service would annually reimburse Pacific County for tax revenue which is lost as a result of the Services acquisition of private property. This law states that the Secretary of the Interior (Secretary) shall pay to each county in which any area acquired in fee title is situated, the greater of the following amounts:

- An amount equal to the product of 75 cents multiplied by the total acreage of that portion of the fee area that is located within such county.
- An amount equal to three-fourths of one percent of the fair market value, as determined by the Secretary, for that portion of the fee area that is located within such county.
- An amount equal to 25 percent of the net receipts collected by the Secretary in connection with the operation and management of such fee area during such fiscal year. If a fee area is located in two or more counties, however, the amount for each county shall be apportioned in relationship to the acreage in that county.

Some payments to the counties have been less than the legislated amounts because of governmental funding deficits. Congress may appropriate, through the budget process, supplemental funds to compensate local governments for any shortfall in revenue sharing payments. The Refuge Revenue Sharing Act requires Service lands be reappraised every five years to ensure that payments to local governments remain equitable. Payments under this Act would be made only on lands that the Service acquires in fee title. On lands where the Service acquires only partial interest through easement, all taxes would remain the responsibility of the individual landowner.

The most recent appraisal (2010 Appraisal Review and Approval of the Willapa Bay NWR Appraisal, Pacific County, Washington) identified 4,121 acres as second growth forest lands, timberland with reproduction, at an appraised/estimated value of $2,800 per acre. These Refuge lands are appraised and evaluated as if they are privately owned parcels; the Refuge timberlands are in some cases generally larger continuous tracts of forested land specifically set aside for conservation purposes. The appraisal estimate value is based on the current local land and timber values at the time of the appraisal.

The most recent Refuge Revenue Sharing Act payment to Pacific County of $48,146 was based on the 2005 Refuge Revenue Share Appraisal and may also be representative of federal budgetary constraints determined annually by Congress. Appraisals of Refuge lands are conducted every five years and the 2005 appraisal evaluated approximately 11,000 fee title acres.

Table 12 shows payments made to Pacific County from FY 2002 through FY 2009. The Revenue Sharing payment from 2006 to 2009 has declined due to government funding deficits.

Table 12. Revenue Sharing Payments made to Pacific County, 2002-2009. (2010$)

Year	Fee Acres*	Payment
2002	10,466	$86,715
2003	10,466	$81,496
2004	10,872	$72,982
2005	11,112	$80,689
2006	11,387	$72,696
2007	11,387	$68,331
2008	11,387	$51,055
2009	11,387	$48,146

*No payments are made for easement lands, use deed agreement lands, or lands that were withdrawn from public domain and were never in private ownership, e.g. Leadbetter and Shoalwater Units.
Source: Willapa National Wildlife Refuge, 2011.

ALTERNATIVE 1 (STATUS QUO) – Continue Current Management

This section will discuss the various impacts of continuing the current management direction at Willapa Bay National Wildlife Refuge. In addition to qualitatively discussing the potential impacts, this section also addresses the regional economic impacts of Alternative 1 and, thus, establishes the baseline to compare each Alternative.

Recreational Activities

Willapa National Wildlife Refuge offers waterfowl hunting, upland game hunting, big game hunting, estuarine fishing, and a variety of non-consumptive activities. The majority of the public recreation in the local area centers on the Pacific Ocean, Willapa Bay and the many trails. Visitors to the Refuge can enjoy viewing a wide variety of wildlife, from spawning thousands of migrating shorebirds that crowd the beaches at Leadbetter Point and shores of Willapa Bay. As would be expected, outdoor activities significantly increase during the summer season, although many recreational activities are not restricted to a specific season. Visitors are a blend of both local residents and out-of-towners. Visitors from outside of the area usually visit the refuge when visiting the Long Beach area during the summer.

A growing visitor presence on the Refuge can be expected in the future. Many of the public use opportunities currently provided at the Refuge are very popular and are forecasted to attract increasing amounts of participants in the coming years. Regardless of which alternative is selected, population growth and increasing recreational demand, particularly in nature activities, are expected to increase the demand for outdoor recreation on the Refuge.

Description of Recreational Activities

Under Alternative 1, there would be no changes to the recreational activities offered at the Refuge. All programs would continue to follow current management goals. Improved signage, updated maps and hunting brochures, and increased law enforcement would result in a positive effect on the overall recreational experience.

The hunt programs for waterfowl and big game would continue to follow current management. The regulated goose hunt on the Riekkola Unit would occur two days a week, the waterfowl hunt on the Porter Point Unit would occur three days a week, and the waterfowl hunts on the Leadbetter and Stanley Point units would continue seven days a week. There would be no expansion of waterfowl hunting.

Big game hunting would continue on Long Island (archery only) and the mainland portion of the Refuge between Bear River and Teal Slough (excluding Headquarters and Quarters areas). The areas currently closed to hunting would remain closed. There would be no expansion of big game hunting.

The refuge portion of Willapa Bay and the channel portion of Bear River would continue to be open for fishing according to Washington State fishing regulations. The small streams on the Refuge will remain closed to fishing.

The maintenance of the two Willapa Bay Shellfish Areas (Diamond Point and Pinnacle Rock) on Long Island according to Washington State shellfish harvesting regulations would continue.

Only the current interpretive trails would be maintained under Alternative 1. Wildlife observation or photography activities would continue.

Since a large portion of the Refuge consists of navigable waters and island habitat, visitors to the Refuge often use some type of watercraft to access these areas. Also, due to the difficulty of accessing Long Island during tidal fluctuations, camping is allowed in designated sites. The five campgrounds with 20 campsites on Long Island would continue to be maintained.

Regional Economic Impacts of Recreational Activities

Two types of information are needed to estimate the economic impacts of recreational visits to the Refuge: (1) the amount of recreational use on the Refuge by activity; and (2) expenditures associated with recreational visits to the refuge. Recreational use is estimated by Refuge staff. With this information, total expenditures for each activity can be estimated. These expenditures, in turn, can be used in conjunction with regional economic models to estimate industrial output, employment, employment income and tax impacts associated with these expenditures. The annual recreational visitation and economic impacts detailed here are expected to continue under Alternative 1.

Table 13 shows approximately 128,000 visitors enjoyed Willapa National Wildlife Refuge in 2010. Visitors came to the Refuge to partake in recreational opportunities, educational and interpretation programs, and restroom stops at the visitor center. The environmental education and interpretation programs and the availability of a restroom do benefit the community. However, these types of opportunities do not contribute to the local economic impacts because the events do not bring visitors who are spending money toward travel-related goods and services. Therefore, only visits associated with recreational activities are used to estimate economic effects.

Table 13. Alternative 1: Annual Visitors

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	36,971	68,660	105,640
Auto Tour	0	0	0
Boat Trail/Launch Visits	293	240	550
Bicycle visits	48	3	50
Photography	3,366	2,244	5,610
Other Recreation	510	1,190	1,700
Environmental Education	1,360	240	1,600
Interpretation	180	120	300
Facilities	3,510	8,190	11,700
Hunting:			
Waterfowl	263	88	350
Other Migratory Birds	0	0	0
Upland Game	6	5	10
Big Game	144	176	320
Fishing:			
Freshwater	0	0	0
Estuarine	128	23	150
Total Visitation	**46,790**	**81,191**	**127,980**

About 114,380 of Refuge visitors were visiting primarily for recreational opportunities. Sixty-four percent of recreational visitors (72,641 people) were non-residents. Nearly all recreation visitors participated in non-consumptive activities such as hiking, boating, and photography. Less than 1 percent of visitors participated in hunting and fishing combined. Under Alternative 1, these visits would be expected to continue into the future.

The economic impact area for recreational activities is the 6-county area including Pacific, Wahkiakum, Cowlitz, and Clark Counties in Washington and Clatsop and Multnomah Counties in Oregon. It is assumed that resident visitor expenditures occur primarily within Pacific and Clatsop Counties while non-resident visitor expenditures occur within all six counties. Expenditure patterns used in this report were obtained from the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior et al. 2007). These expenditures include only travel-related expenses, including food, lodging, transportation, and other travel-related miscellaneous expenses. Visitor recreation expenditures for 2010 are shown in Table 14. Total annual expenditures were about $1.5 million with non-residents accounting for about $1.3 million or 85 percent of total expenditures. Expenditures associated with non-consumptive activities accounted for 97 percent of all expenditures, followed by hunting and fishing at 2.5 percent and less than 1 percent respectively. These annual expenditures are expected to continue throughout the 15-year time period of the analysis.

Table 14. Alternative 1: Annual Visitor Recreation Expenditures (2010 dollars in thousands)

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	$149.41	$1,011.54	$1,160.95
Auto Tour	$0.00	$0.00	$0.00
Boat Trail/Launch Visits	$1.18	$3.53	$4.72
Bicycle visits	$0.19	$0.04	$0.23
Photography	$27.21	$66.12	$93.33
Other recreation	$17.94	$143.79	$161.73
Total Non Consumptive	$195.94	$1,225.02	$1,420.96
Hunting:			
Waterfowl	$7.1	$8.2	$15.2
Other Migratory Birds	$0.0	$0.0	$0.0
Upland Game	$0.1	$0.4	$0.5
Big Game	$5.7	$16.2	$21.9
Total Hunting	$12.9	$24.8	$37.7
Fishing:			
Freshwater	$0.0	$0.0	$0.0
Estuarine	$4.7	$2.7	$7.4
Total Fishing	$4.7	$2.7	$7.4
Total Annual Expenditures	**$213.5**	**$1,252.5**	**$1,466.0**

Input-output models were used to determine the economic impact of expenditures on the local and surrounding areas of the Refuge. Local effects are defined as impacts occurring within Pacific County, Washington and Clatsop County, Oregon. Surrounding effects are defined as impacts occurring within Cowlitz, Wahkiakum, and Clark Counties in Washington and Multnomah County in Oregon. Table 15 summarizes the economic effects associated with recreation visits under Alternative 1. Economic output would total almost $1.7 million with associated employment of 13 jobs, $456,000 in employment income and $122,700 in total tax revenue. These annual economic impacts are projected to continue throughout the 15-year period of the analysis.

Table 15. Alternative 1: Local Annual Economic Effects Associated with Recreation Visits (2010 dollars in thousands)

	Residents	Non-Residents		Total
	Local Effects	Local Effects	Surrounding Effects	
Economic Output	$237.0	$783.7	$642.7	$1,663.4
Jobs	2	7	4	13
Job Income	$66.5	$209.6	$179.9	$456.0
Total Tax Revenue	$31.0	$46.7	$45.0	$122.7

The economic impacts from recreation expenditures estimated in this report are gross area-wide impacts. Information on where expenditures may occur locally and the magnitude and location of resident and non-resident expenditures (resident and non-resident relative to the geographical area of interest) is not currently available. Generally speaking, non-resident expenditures bring outside money into the area and thus generate increases in real income or wealth. Spending by residents is simply a transfer of expenditures on one set of goods and services to a different set within the same area. In order to calculate net economic impacts within a given area derived from resident expenditures, much more detailed information would be necessary on expenditure patterns and visitor characteristics. Since this information is not currently available, the gross area-wide estimates are used as an upper-bound for the net economic impacts of total resident and non-resident spending in the two and six county areas. The economic impacts of non-resident spending in Table 15 represent a real increase in wealth and income for the area (for additional information, see Loomis p. 191).

Refuge Expenditures

In addition to impacts from recreational visitors, there are also economic effects related to the Refuge expenditures that contribute to local and regional economies. In 2010, the Refuge budget totaled $1.9 million. Approximately $1.6 million (84 percent) is allocated to salaries while the remaining $303,000 is allocated to goods and services supporting the Refuge. In addition to the Refuge's budget, it also receives funds from other sources to complete various projects such as the protection of endangered species and management of invasive species. Table 16 summarizes the Refuge's expenditures in 2010. Under Alternative 1, these budget expenditures would continue annually from 2012 to 2026.

Table 16. Alternative 1: Willapa National Wildlife Refuge Annual Expenditures (2010 dollars in thousands)

Expenditure:	Annual Expenditures
Salary – Permanent Employees	$1,385.4
Salary – Temporary Employees	$215.4
Non-Salary	$303.1
Funds from Other Sources	$637.0
Total	**$2,540.9**

Table 17 shows the jobs, job income, and tax revenues generated by Refuge expenditures. The Refuge's annual budget generates approximately 15 jobs and $584,000 in job income. Funds from other sources generate about 7 jobs and $431,000 in job income. Overall, Refuge expenditures result in about $2.2 million in economic output. The economic output is less than budget expenditures due to leakage outside the area economy. That is, the area does not manufacture or support all the services and products that are purchased. Therefore, some of the expenditures "leak" to other areas. Under Alternative 1, these economic impacts would continue annually throughout the 15-year time period of the analysis.

Table 17. Alternative 1: Local Annual Economic Effects Associated with 2010 Refuge Budget (2010 dollars in thousands)

	Salary		Non-Salary		Funds from Other Sources	Total
	Local Effects	Surrounding Effects	Local Effects	Surrounding Effects	Local Effects	
Economic Output	$1,023.3	$204.3	$290.4	$29.8	$642.5	$2,190.3
Jobs	11	1	3	0.2	7	22
Job Income	$311.4	$62.3	$194.8	$15.8	$430.9	$1,015.1
Total Tax Revenue	$78.5	$10.6	$12.4	$1.0	$27.4	$129.9

Forest Management

Timber Harvests and Economic Impact

Under Alternative 1, the management of Willapa National Wildlife Refuge would include the thinning of tree stands to promote healthy habitat and support wildlife. To establish a timber baseline, the timber volume to be harvested over the next 15 years was estimated (The Nature Conservancy 2011). Table 18 shows the projected timber volume and value expected to accrue within the existing Refuge boundary from 2012 to 2026. Annual harvests over about 4,844 acres of timberland vary depending on management needs. Timber net revenue is based on stumpage value of $445 per mbf and harvesting cost by thinning of $315 per mbf. Annual timber net revenue ranges from a low of $54,000 in 2013 to high of $998,900 in 2026. Compared to Pacific County's annual average timber harvest (335,089 mbf), the Refuge's timber harvest represents less than 1 percent of all logs harvested in Pacific County.

Table 18. Alternative 1: Projected Baseline for Timber Harvest in Existing Refuge Boundary – (2010 dollars in thousands)

Year	Timber Harvest (MBF)	Timber Revenue	Net Timber Revenue
2012	4,72	$2,104.4	$780.3
2013	327	$145.5	$54.0
2014	1,375	$611.9	$226.9
2015	10,834	$4,821.1	$1,787.6
2016	5,284	$2,351.3	$871.8
2017	999	$444.7	$164.9
2018	4,046	$1,800.5	$667.6
2019	-	-	-
2020	516	$229.8	$85.2
2021	657	$292.5	$108.5
2022	-	-	-
2023	772	$343.4	$127.3
2024	-	-	-
2025	-	-	-
2026	6,048	$2,691.4	$998.9
15-Year Total	**35,588**	**$15,836.6**	**$5,872.0**
Annual Average	**2,373**	**$1,055.8**	**$391.5**

Source: The Nature Conservancy (2011)

Under Alternative 1, the Refuge would not expand its existing boundary. However, Alternatives 2 and 3 both propose to increase the size of the Refuge. The following discussion estimates the future timber harvests from the proposed Refuge land acquisition to establish a baseline to compare Alternatives. The proposed expansion area is 6,809 acres. The largest percentage (approximately 50 percent) is held by six corporations for investment and timber production purposes. Two non-governmental organizations hold approximately 36 percent of the land. The City of Long Beach and the State of Washington hold approximately 10 percent, and four private individuals own approximately 4 percent of these lands (Refer to Appendix A in the CCP for more information regarding the Land Protection Plan.)

Table 19 shows the projected timber harvests for the proposed land acquisition under private ownership. The estimate assumes that South Bay would be clearcut while East Hills and Nemah would be both thinned and clearcut over the next 15 years. Under Alternative 1, these tracts of land would continue their current management and would not be acquired by the Refuge. Timber net revenue is based on stumpage value of $565 per mbf and harvesting cost of $180 to $315 per mbf (depending on whether the stand is clearcut or thinned)[3]. Compared to Pacific County's annual

[3] The stumpage value for commercially-owned land differs from federally-owned land because federal timber cannot be exported. Currently, the export market is very strong fueled by a weak domestic market. Thus, timber harvested on commercially-owned land averages $120 per mbf more than timber harvested on federally-owned land (Bill Lecture, personal communication May 2011). The Washington Department of Natural Revenue also projects strong export demand over the next 3 years (Washington DNR 2011). Due to the difficulty in estimating long term changes in lumber and log prices, this analysis assumes constant lumber and log prices.

average timber harvest (335,089 mbf), the projected timber harvest from the proposed land acquisition represents 2 percent of all logs harvested in Pacific County.

Table 19. Alternative 1: Projected Baseline for Timber Harvest in Proposed Land Acquisition (6,809 acres) – (2010 dollars in thousands)

	Timber Harvest (mbf)				Total Timber	Total Net
Year	**East Hills**	**South Bay**	**Nemah**	**Total**	**Revenue**	**Revenue**
2012	360	-	-	360	$203.4	$90.0
2013	-	-	-	0	$0.0	$0.0
2014	1,698	-	-	1,698	$959.4	$424.5
2015	2,127	-	-	2,127	$1,201.8	$531.8
2016	13,878	695	-	14,573	$8,233.8	$5,489.1
2017	660	-	-	660	$372.9	$165.0
2018	4,137	1,540	-	5,677	$3,207.5	$2,185.6
2019	-	-	912	912	$515.3	$351.1
2020	89	-	90	179	$101.1	$44.8
2021	29,215	1,435	5,447	36,097	$20,394.8	$13,326.3
2022	118	-	-	118	$66.6	$29.5
2023	4,402	-	-	4,402	$2,487.1	$1,659.0
2024	-	-	-	0	$0.0	$0.0
2025	1,056	-	-	1,056	$596.8	$264.1
2026	6,190	1,015	9,770	16,975	$9,591.0	$6,156.3
15-Year Total	**63,931**	**4,685**	**16,219**	**84,835**	**$47,931.5**	**$30,717.1**
Annual Average	**4,262**	**312**	**1081**	**5,656**	**$3,195.43**	**$2,047.8**

Source: The Nature Conservancy (2011)

Timber harvests have distinct impacts on Washington's economy. This report focuses on the economic impacts generated by logging, hauling, processing the logs, and processing the residuals. The impacts at the logging and primary processing sectors differ between Refuge-harvested timber and commercially-harvested timber. First, the Refuge would thin timber stands, which would thereby be more labor intensive than commercial clearcutting. As a result, a greater number of jobs would be generated for every thousand board feet harvested compared to commercial clearcutting. About 25 percent more jobs are generated for thinning compared to clearcutting (Lippke and Mason 2005). Second, the impacts at the primary processing level (i.e., sawmills) for logs harvested on commercially-owned land differ from the impacts for logs harvested on federally-owned land because federal timber cannot be exported. Due to the strong export market, about 50 percent of commercial timber volume is currently exported (Lecture, May 2011). As a result, 50 percent of commercial timber is not processed in the area and does not generate additional jobs or tax revenue beyond the amount generated by the actual felling.

The economic impacts associated with timber are derived using timber response coefficients[4] for Washington (DOI 2009, Winters 2011). Thus, the economic impacts depicted below would not be localized in Pacific County. Instead, the impacts would occur throughout the State. (Refer to the *Overview* section for more details regarding the timber industry.) As noted above, the economic impacts presented in Table 20 include statewide impacts associated with logging, hauling, processing the logs, and processing any residuals. Table 20 shows the average annual projected jobs and job

[4] *Response coefficients* estimate the effect on the economy for a change in the amount of timber harvested.

income generated by timber harvests on the Refuge and the proposed Refuge land acquisition from 2012 to 2026.

Table 20. Alternative 1: Timber Harvest – Projected Average Annual Economic Effects in Washington (2012-2026) (dollars in thousands)

	Existing Refuge Boundary	Proposed Land Acquisition
Timber Harvested (mbf)	2,373	5,656
Economic Output	$5,426.3	$7,995.6
Jobs	22	36
Job Income	$1,096.3	$1,855.5

Forest Excise Taxes

In addition to the economic impacts generated by timber harvests and processing, Pacific County also benefits through the receipt of forest excise taxes. Timber harvested from private, State, or Federal land is subject to a 5 percent excise tax on the stumpage value of the timber when harvested (Washington Department of Natural Resources 2010). This revenue is distributed between the County where the timber was harvested (4 percent) and the State general fund (1 percent) (Washington Department of Natural Resources 2010).

Table 21 shows the local forest excise taxes paid to Pacific County under Alternative 1. Forest excise taxes generated by timber harvests within the existing Refuge boundary would total $633,500 over 15 years. The proposed land acquisition is projected to generate $1.9 million in forest excise taxes over 15 years. Compared to Pacific County's 10-year annual average ($2.8 million), the annual taxes generated by the existing Refuge boundary and proposed land acquisition represent 1.5 percent and 4.5 percent, respectively.

Table 21. Alternative 1: Projected Baseline for Forest Excise Taxes in Existing and Proposed Refuge Boundaries – (2010 dollars in thousands)

Year	Forest Excise Taxes Paid to Pacific County	
	Existing Refuge Boundary	Proposed Land Acquisition
2012	$84.2	$8.1
2013	$5.8	$0.0
2014	$24.5	$38.4
2015	$192.8	$48.1
2016	$94.1	$329.4
2017	$17.8	$14.9
2018	$72.0	$128.3
2019	-	$20.6
2020	$9.2	$4.0
2021	$11.7	$815.8
2022	-	$2.7
2023	$13.7	$99.5
2024	-	$0.0
2025	-	$23.9
2026	$107.7	$383.6
15-Year Total	**$633.5**	**$1,917.3**
Annual Average	**$42.2**	**$127.8**

Cranberry Production

Under Alternative 1, current Refuge management practices would continue. Therefore, cranberry harvests would continue with no additional impacts. With no control of elk on the Leadbetter Unit of the Refuge, the herd is expected to grow. As the herd increases and outgrows the available habitat on the Refuge, they may move off the Refuge into the surrounding area in search of food. As a result, impacts would continue in cranberry bogs. Currently, there are 94.6 acres of cranberry bogs within a half mile radius of the Tarlatt and Riekkola Units of the Refuge and 768.5 acres within a twelve mile radius (This acreage represents only areas south of the Refuge up to the Columbia River and on the Long Beach Peninsula).

Revenue Sharing Payments

Under Alternative 1, the Refuge would acquire 761 acres within the Refuge's current boundary. Thus, the Refuge's fee acreage would increase to 12,148 acres. The Service would continue to annually reimburse Pacific County for tax revenue which was lost due to the Service's acquisition of private property.

Forecasting revenue sharing payments is complex. Actual payments are a function of the appraised value and appropriations. The Refuge Revenue Sharing Act requires Service lands be reappraised every five years to ensure that payments to local governments remain equitable. However, some payments are less than the legislated amounts due to governmental funding deficits. Congress may appropriate, through the budget process, supplemental funds to compensate local governments for any shortfall in revenue sharing payments. The final calculation for the payment to local governments depends on the total amount of funds available from revenue receipts collected on Refuges nationwide and any appropriations. As a result, payments fluctuate based on the revenue receipts and appropriations. As shown in the *Overview* section, payments steadily decreased from 2002 to 2009.

Table 22 shows the estimated revenue sharing payment from 2012 to 2026 under Alternative 1. Lower bound and upper bound estimates were derived for the projected payments. For the lower bound, estimates were developed based on the Refuge's payment patterns from 2002 to 2009. For the upper bound, estimates were developed based on "an amount equal to three-fourths of one percent of the fair market value, as determined by the Secretary, for that portion of the fee area that is located within such county." The 2012 payment is based on the 2010 appraisal value of $39.4 million. The increase at the 5-year appraisal was based on the percentage increase in appraisal value from 2005 to 2010. Both the lower bound and upper bound estimates assume the land would be reappraised in years 2015, 2020, and 2025.

Table 22. Alternative 1: Projected Revenue Sharing Payments to Pacific County (2010 dollars in thousands)

Year	Fee Acres*	Lower Bound Estimate	Upper Bound Estimate
2012	12,148	$49.2	$295.7
2013	12,148	$45.8	$295.7
2014	12,148	$42.7	$295.7
2015	12,148	$47.2	$390.3
2016	12,148	$43.9	$390.3
2017	12,148	$40.9	$390.3
2018	12,148	$38.1	$390.3
2019	12,148	$35.5	$390.3
2020	12,148	$39.2	$515.3
2021	12,148	$36.5	$515.3
2022	12,148	$34.0	$515.3
2023	12,148	$31.6	$515.3
2024	12,148	$29.5	$515.3
2025	12,148	$32.6	$680.1
2026	12,148	$30.3	$680.1

*No payments are made for easement lands, use deed agreement lands, or lands that were withdrawn from public domain and were never in private ownership, e.g. Leadbetter and Shoalwater Units. Fee acreage for Alternative 1 includes the potential acquisition of 761 acres within the Refuge boundary. This estimate assumes the newly acquired 761 acreage would be comparable to the current 11,387 acreage.

15-Year Present Value Impacts

The present value of impacts under Alternative 1 are shown in Table 23. To calculate the present value for a 15-year period, the social discount rates of 3 percent and 7 percent are applied per OMB guidance (U.S. Office of Management and Budget 1992). The 15-year present value impacts under Alternative 1 (excluding the proposed land acquisition) are estimated to be $60.2 million to $64.3 million (discounted at 3 percent) or $44.9 million to $47.7 million (discounted at 7 percent).

Table 23. Alternative 1: 15-Year Present Value (2012-2026) (dollars in thousands)

Impact	Annualized Average	15-Year Present Value	
		3 % Discount Rate	*7% Discount Rate*
Recreation Expenditures	$1,466.0	$16,991.5	$12,478.8
Budget Expenditures	$2,540.9	$29,449.6	$21,628.3
Timber Revenue*			
Existing Boundary	$1,055.8	$12,864.6	$10,062.7
Proposed Land Acquisition	$3,195.4	$35,115.7	$23,899.8
Forest Excise Taxes*			
Existing Boundary	$42.2	$514.6	$402.5
Proposed Land Acquisition	$127.8	$1,404.6	$956.0
Revenue Sharing Payments*			
Existing Boundary	$38.5 - $400.4	$454.5 - $4,516.7	$341.8 - $3,203.3
Proposed Land Acquisition	0	0	0

*Timber revenue, forest excise taxes, and revenue sharing payments depict impacts generated by both the Refuge's existing boundary and the Refuge's proposed boundary to establish a baseline to compare Alternatives.

ALTERNATIVE 2 – Healthy Wildlife Habitats, Endangered Species and Biodiversity Gains, Focused Refuge Expansion, Simplified Expanded Public Use

This section will discuss the various impacts of the preferred Alternative (Alternative 2). In addition to discussing the potential impacts, this section also addresses the regional economic impacts of Alternative 2. The assumptions that apply to the analysis for Alternative 2 are the same as those described for Alternative 1 (Status Quo). For a more detailed description of the baseline, to which each activity is compared, refer to "Alternative 1 (Status Quo) – Continue Current Management."

Under Alternative 2, the Refuge would expand its boundary by 6,809 acres, which is 1.1 percent of the total 975 square miles of Pacific County (Pacific County 2010). The long-term benefits of expanding the preferred alternative boundary, would add protection and enhancements of the forests within the watershed, would help to provide for healthy water quality and benefit the mariculture industry and salmon streams. The future Refuges lands which may be acquired from willing sellers, would be opened to wildlife-dependent public use opportunities such as wildlife observation, hunting and environmental education.

Recreational Activities

Each of the alternatives presented strive to provide quality recreation programs in concert with other wildlife-dependent public uses and habitat programs on the Refuge. The proposed actions common to all alternatives, which include improved signage, updated maps and hunting brochures, and increased law enforcement, would result in a positive effect on the overall recreation experience.

Description of Activities

This alternative would change the hunt program by opening up more of the Refuge to hunting. It is important to note that this alternative is only possible when adopted in conjunction with the proposed habitat management plans of tidal restoration in the South Bay Units. The result of this alternative's implementation would be an intermediate, positive, long-term effect to the hunting opportunities on Willapa NWR.

The waterfowl hunt area will include opening an additional 2,542 acres (5,670 acres total) to waterfowl hunting in all newly restored areas in the South Bay Units. Three blinds will be available for goose hunting on the south half of the Riekkola Unit. Two additional blinds would be created for waterfowl hunting. One goose and one waterfowl blind will provide barrier-free access for hunters with disabilities. Boat access to the South Bay Units will be provided by car-top boat ramp at Dohman Creek. In addition, a trail from the parking area will provide walk-in hunter access to Porter Point. According to state regulations, waterfowl hunting would be allowed seven days a week and goose hunting would be allowed two days a week (Wednesdays and Saturdays). It is expected by providing goose hunting blinds and opening of more of the Refuge to hunting would increase the opportunities for waterfowl hunters.

This alternative would change the big game hunt program by opening up more of the Refuge to hunting. The result of this would be an intermediate, positive, long-term effect to the hunting opportunities on Willapa NWR. Big game hunting would remain the same as current management except for the expanded elk and deer hunting in the East Hills and South Bay Units and a regulated elk hunt on Leadbetter Point Unit. The regulated elk hunt (permit only) is proposed for managing the herd size on the Leadbetter Point Unit.

Under Alternative 2, there are no significant changes identified in the fishing program. The refuge portion of Willapa Bay and the channel portion of Bear River would continue to be open for fishing according to Washington State fishing regulations. The small streams on the Refuge would remain closed to fishing.

There are no significant changes identified for shellfish harvesting under Alternative 2. The two Willapa Bay Shellfish Areas (Diamond Point and Pinnacle Rock) on Long Island would continue to be maintained according to Washington State shellfish harvesting regulations.

Under Alternative 2, new headquarter facilities would be constructed closer to the population center on the Long Beach Peninsula, which would allow greater public access to Refuge visitor services. The site plan combines visitor facilities with habitat restoration efforts in an attempt to provide the visitor with a natural and educational experience. Other features of the project include picnic tables and a new interpretive trail. The interpretive trail would be along an existing road from the new visitor center to a new observation deck on the South Bay, which would offer unparalleled views of the bay and migratory birds. Alternative 2 would also maintain all current trails.

Facilities to improve opportunities for wildlife observation and wildlife photography would be upgraded and enhanced under Alternative 2. All facilities and programs described in Alternative 1 would remain the same with the expansion of wildlife viewing opportunities and photography at the Tarlatt Unit. A new office, visitor center, trail, and South Bay observation deck would provide unparalleled views of the bay. With concurrent habitat improvements including tidal restoration and improved forest management proposed under Alternative 2, it is reasonable to assume that these improvements would create an increase in wildlife viewing and photography opportunities for some species.

All current programs described in Alternative 1 would be maintained. In addition to the current programs, the addition of the new visitor facilities on the Tarlatt Unit would allow the Refuge to offer expanded on-site environmental education. This can be viewed as having an intermediate, positive effect on educational and interpretive opportunities because the Refuge would be prepared with facilities and environmental education programming to accommodate the current and expected increase in demand for such opportunities.

Since a large portion of the Refuge consists of navigable waters and island habitat, visitors to the Refuge often use some type of watercraft to access these areas. Also, due to the difficulty of accessing Long Island during tidal fluctuations, camping is allowed in designated sites. The five campgrounds with 20 campsites on Long Island would continue to be maintained under Alternative 2. All camping regulations would remain in place. Alternative 2 would move the car-top boat access to Doman Creek on the Riekkola Unit. Although the location of the boat ramp access would change, the overall effect on boating at Willapa NWR would be neutral.

Regional Economic Impacts of Recreational Activities

Two types of information are needed to estimate the economic impacts of recreational visits to the Refuge: (1) the amount of recreational use on the Refuge by activity; and (2) expenditures associated with recreational visits to the Refuge. Recreational use is estimated by Refuge staff. Expenditures from the National Survey of Wildlife Related Recreation are used to estimate the types of purchases due to recreating at the Refuge (2007). With this information, total expenditures for each activity can be estimated. These expenditures, in turn, can be used in conjunction with regional economic models to estimate industrial output, employment, employment income and tax impacts associated with these expenditures. The recreational visitation and economic impacts detailed here are expected to occur under Alternative 2.

Table 24 shows approximately 202,000 visitors are projected to visit Willapa National Wildlife Refuge under Alternative 2. Visitors would be likely to partake in recreational opportunities, educational and interpretation programs, and restroom stops at the visitor center. The environmental education and interpretation programs and the availability of a restroom do benefit the community. However, these types of opportunities do not contribute to the local economic impacts because the events do not bring visitors who are spending money toward travel-related goods and services. Therefore, only visits associated with recreational activities are used to estimate economic effects.

Under Alternative 2, recreation visits are projected to rise due to increased opportunities. The addition of an outreach employee will allow for more interpretation to take place (such as self guided tours/audio casts, social media, etc), as well as more marketing and education for the hunt and fish programs. The new visitor center location (closer to Long Beach hotels and rentals) and the addition of a new trail, gathering facilities and wildlife observation site will be a draw to residents and non-residents looking for additional outdoor activities. Expansion of elk hunting to Leadbetter and duck hunting to 7 days will increase use.

Table 24 shows approximately 202,000 visitors are expected to visit Willapa National Wildlife Refuge under Alternative 2. Visitors would partake in recreational opportunities, educational and interpretation programs, and restroom stops at the visitor center. The environmental education and interpretation programs and the availability of a restroom do benefit the community. However, these types of opportunities do not contribute to the local economic impacts because the events do not bring visitors who are spending money toward travel-related goods and services. Therefore, only visits associated with recreational activities are used to estimate economic effects.

Under Alternative 2, recreation visits are projected to increase by 61 percent compared to Alternative 1 (Table 24). About 184,100 of Refuge visitors would visit primarily for recreational opportunities. Fifty-nine percent of recreational visitors (109,165) would travel from outside the local area. Similar to Alternative 1, nearly all recreational visitors would participate in non-consumptive activities such as hiking, boating, and photography. Less than 1 percent of visitors would participate in hunting and fishing combined. Under Alternative 2, these recreation visits would be expected to continue into the future.

Table 24. Alternative 2: Projected Annual Visits

Activity		Residents	Non-Residents	Total
Non-Consumptive:				
	Pedestrian	67,603	101,405	169,008
	Auto Tour	200	300	500
	Boat Trail/Launch Visits	358	293	650
	Bicycle Visits	40	10	50
	Photography	5,610	5,610	11,220
	Other Recreation	510	1,190	1,700
	Environmental Education	4,080	720	4,800
	Interpretation	735	315	735
	Facilities	3,577	8,345	11,922
Hunting:				
	Waterfowl	300	100	400
	Other Migratory Birds	0	0	0
	Upland Game	6	5	10
	Big Game	189	231	420
Fishing:				
	Freshwater	0	0	0
	Estuarine	128	23	150
Total Visitation		**83,334**	**118,546**	**201,880**

The economic impact area for recreational activities is the 6-county area including Pacific, Wahkiakum, Cowlitz, and Clark Counties in Washington and Clatsop and Multnomah Counties in Oregon. It is assumed that resident visitor expenditures occur primarily within Pacific and Clatsop Counties while non-resident visitor expenditures also include the surrounding counties. Expenditure patterns used in this report were obtained from the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior et al. 2007). These expenditures include only travel-related expenses. The estimated visitor recreation expenditures under Alternative 2 are shown in Table 25. Total annual expenditures are estimated to be $2.2 million with non-residents accounting for about $1.9 million or 84 percent of total expenditures. Expenditures associated with non-consumptive activities would account for 98 percent of all expenditures, followed by hunting and fishing at 2 percent and less than 1 percent respectively. Under Alternative 2, these annual expenditures would continue into the future.

Table 25. Alternative 2: Projected Annual Visitor Recreation Expenditures (2010 dollars in thousands)

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	$273.2	$1,494.0	$1,767.2
Auto Tour	$1.6	$8.8	$10.5
Boat Trail/Launch Visits	$4.3	$12.9	$17.3
Bicycle visits	$0.3	$0.3	$0.6
Photography	$45.3	$165.3	$210.6
Other recreation	$22.4	$149.5	$172.0
Total Non Consumptive	$347.2	$1,830.9	$2,178.1
Hunting:			
Waterfowl	$8.1	$9.3	$17.4
Other Migratory Birds	–	–	–
Upland Game	$0.1	$0.4	$0.5
Big Game	$7.5	$21.3	$28.8
Total Hunting	$15.7	$31.0	$46.7
Fishing:			
Freshwater	–	–	–
Estuarine	$4.7	$2.7	$7.4
Total Fishing	$4.7	$2.7	$7.4
Total Annual Expenditures	**$367.6**	**$1,864.6**	**$2,232.2**

Input-output models were used to determine the impact of expenditures on the local and surrounding areas of the Refuge under Alternative 2. Local effects are defined as those impacts occurring within Pacific County, Washington and Clatsop County, Oregon. Surrounding effects are defined as impacts occurring within Cowlitz, Wahkiakum, and Clark counties in Washington and Multnomah County in Oregon. Table 26 summarizes the economic effects associated with recreation visits under Alternative 2. Economic output would total $2.5 million with associated employment of 21 jobs, $694,100 in employment income and $163,900 in total tax revenue. These annual economic impacts are projected to continue throughout the 15-year period of the analysis under Alternative 2.

Table 26. Alternative 2: Projected Local Annual Economic Effects Associated with Recreation Visits (2010 dollars in thousands)

	Residents	Non-Residents		Total
	Local Effects	Local Effects	Surrounding Effects	
Economic Output	$408.3	$1,167.5	$955.0	$2,530.8
Jobs	4	11	6	21
Job Income	$114.6	$312.2	$267.3	$694.1
Total Tax Revenue	$27.6	$69.5	$66.8	$163.9

Table 27 shows the projected increase in annual recreation impacts under Alternative 2. Refuge visits would increase by 69,728 generating 7 jobs and $238,200 in job income annually.

Table 27. Alternative 2: Annual Change in Recreation Compared to the Baseline (Alternative 1) (2010 dollars in thousands)

Visits	+69,728
Recreation Expenditures	+$766.2
Economic Output	+$867.4
Jobs	+7.0
Job Income	+$238.2
Total Tax Revenue	+$41.2

The economic impacts from recreation expenditures estimated in this report are gross area-wide impacts. Information on where expenditures may occur locally and the magnitude and location of resident and non-resident expenditures (resident and non-resident relative to the geographical area of interest) is not currently available. Generally speaking, non-resident expenditures bring outside money into the area and thus generate increases in real income or wealth. Spending by residents is simply a transfer of expenditures on one set of goods and services to a different set within the same area. In order to calculate net economic impacts within a given area derived from resident expenditures, much more detailed information would be necessary on expenditure patterns and visitor characteristics. Since this information is not currently available, the gross area-wide estimates are used as an upper-bound for the net economic impacts of total resident and non-resident spending in the two and six county areas. The economic impacts of non-resident spending in Table 27 represent a real increase in wealth and income for the area (for additional information, see Loomis p. 191).

Refuge Expenditures

In addition to impacts from recreational visitors, there are also economic effects related to the Refuge expenditures that contribute to local and regional economies. Under Alternative 2, the Refuge annual expenditures are not expected to change ($2.5 million annually). However, in addition to annual expenditures, the Refuge would also have one-time expenses to complete management goals over various timelines. These projects would include (1) dike removal and rebuilding, (2) new visitor center, (3) new trail and overlook, (4) demolition and restoration of current headquarters, and (5) Bear River tidal project. These projects would total nearly $9.0 million over 10 years (Table 28).

Table 28. Alternative 2: Projected Willapa National Wildlife Refuge Expenditures (thousands)

Expenditure:		
Annual Expenses:		
	Salary – Permanent Employees	$1,385.4
	Salary – Temporary Employees	$215.4
	Non-Salary	$303.1
	Funds from Other Sources	$637.0
	Total Annual:	*$2,541.0*
One-Time Expenses:		
	Dike Removal and Rebuilding (2012-2019)	$1,000.0
	Visitor Center (2017-2019)	$6,500.0
	New Trail and Overlook (2017-2018)	$370.0
	Demolition and Restoration of Current Headquarters site (2020-2021)	$120.0
	Bear River Tidal Project (2013-2014)	$1,000.0
	Total One-Time Expenditures:	*$8,990.0*
Total		**$11,530.0**

Under Alternative 2, the Refuge's annual expenses (budget and funds from other sources) would not change compared to Alternative 1. Therefore, the Refuge's annual budget would continue to generate approximately 15 jobs and $584,000 in job income. Funds from other sources would still generate about 7 jobs and $431,000 in job income. Overall, Refuge annual expenditures result in about $2.2 million in economic output. The economic output is less than budget expenditures due to leakage outside the area economy. That is, the area does not manufacture/support all the services and products that are purchased. Therefore, some of the expenditures "leak" to other areas.

Table 29 shows the expected impact due to one-time expenses under Alternative 2. These impacts represent additional economic impacts compared to Alternative 1. Under Alternative 2, a variety of projects would be undertaken. Effects would be distributed over the next 15 years, depending on the timing of each project. These expenses would generate approximately 4 jobs and $183,800 in job income annually over 15 years. Overall, these project expenses would result in about $513,500 annually in economic output. After 15 years, these benefits would no longer continue. The economic output is less than budget expenditures due to leakage outside the area economy. That is, the area does not manufacture or support all the services and products that are purchased. Therefore, some of the expenditures "leak" to other areas.

Table 29. Alternative 2: Average Annual Change in Local Economic Effects Associated with One-Time Expenses Compared to Baseline (Alternative 1) (2012-2026) (2010 dollars in thousands)

	Jobs	Job Income	Total Tax Revenue	Economic Output
Annual Average	+4	+$183.8	+$23.2	+$513.5

Forest Management

Timber Harvests and Economic Impacts

Under Alternative 2, the Refuge would continue to manage its existing boundary to promote healthy habitat and aid in the support of target species. Annual timber harvests over about 4,844 acres of timberland would continue, logging about 35,588 mbf over 15 years. Timber harvest impacts on the Refuge's existing boundary would not change compared to Alternative 1.

In addition to managing the existing Refuge boundary, Alternative 2 proposes to purchase 6,809 acres. Expansion of the Refuge would result in the reduction of future commercial timber harvest opportunities and the conversion of some timberlands into long term conservation status for habitats. Forest restoration and management practices of the younger-aged stands on the lands identified for potential acquisition would include some standard timber management practices, such as thinning (see Appendix K in the CCP). The proposed total acquisition is less than 2 percent of the 70 percent of Pacific County that is currently managed for long-term commercial forest production.

Table 30 shows the projected timber harvests for three tracts of land if purchased by the Refuge under Alternative 2. These tracts of land would be managed to achieve Refuge goals for wildlife and habitat. Timber harvests from the proposed land acquisition would total 36,946 mbf over 15 years.

Table 30. Alternative 2: Projected Refuge's Timber Harvest and Revenue in Proposed Land Acquisition – (2010 dollars in thousands)

Year	Timber Harvest (mbf)				Timber Revenue
	East Hills	South Bay	Nemah	Total	
2012	360	-	-	360	$160.2
2013	629	440	-	1,069	$475.6
2014	1,698	200	240	2,138	$951.4
2015	2,127	-	-	2,127	$946.5
2016	900	-	1,490	2,390	$1,063.6
2017	660	-	-	660	$293.7
2018	-	-	-	0	$0.0
2019	-	-	1,620	1,620	$720.9
2020	89	-	90	179	$79.7
2021	4,230	410	2,510	7,150	$3,181.8
2022	118	-	-	118	$52.5
2023	265	180	220	665	$295.9
2024	-	-	120	120	$53.4
2025	1,056	-	-	1,056	$470.0
2026	16,286	688	320	17,294	$7,695.9
15-Year Total	**28,418**	**1,918**	**6,610**	**36,946**	**$16,441.1**
Annual Average	**1,895**	**128**	**441**	**2,463**	**$1,096.1**

Source: The Nature Conservancy 2011.

Table 31 shows the projected change in timber harvests under Alternative 2 compared to Alternative 1. On average, timber harvests within these tracts of land would decrease by 3,193 mbf annually compared to previous ownership over 15 years. Average annual timber revenue would decrease by $2.1 million compared to previous ownership. Timber revenue would decrease due to decreased harvest and lower stumpage value ($445 per mbf) than commercial stumpage value ($565 per mbf)[5]. Compared to Pacific County's annual average timber harvest (335,089 mbf), the projected annual decline in timber harvest from the proposed Refuge boundary represents 1 percent of all logs harvested in Pacific County.

[5] The stumpage value for commercially-owned land differs from federally-owned land because federal timber cannot be exported. Currently, the export market is very strong fueled by a weak domestic market. Thus, timber harvested on commercially-owned land averages $120 per mbf more than timber harvested on federally-owned land (Bill Lecture, personal communication May 2011). The Washington Department of Natural Revenue also projects strong export demand over the next 3 years (Washington Department of Natural Resources 2011). Due to the difficulty in estimating long term changes in lumber and log prices, this analysis assumes constant lumber and log prices.

Table 31. Alternative 2: Change in Timber Harvests and Revenue for Proposed Land Acquisition Compared to Baseline (Alternative 1) (2010 dollars in thousands)

				Expected Percentage Change	
Year	**Timber Harvest (mbf)**	**Timber Revenue**	**Timber Net Revenue**	**Timber Harvest (mbf)**	**Timber Revenue**
2012	0	-$43.2	-$43.2	-	-21%
2013	1,069	$475.6	$138.9	-	-
2014	440	-$8.0	-$146.6	+26%	-1%
2015	0	-$255.2	-$255.2	-	-21%
2016	-12,183	-$7,170.2	-$5,178.4	-84%	-87%
2017	0	-$79.2	-$79.2	-	-21%
2018	-5,677	-$3,207.5	-$2,185.6	-100%	-100%
2019	708	$205.6	-$140.5	+78%	+40%
2020	0	-$21.5	-$21.5	-	-21%
2021	-28,947	-$17,213.1	-$12,396.8	-80%	-84%
2022	0	-$14.1	-$14.1	-	-21%
2023	-3,737	-$2,191.2	-$1,572.5	-85%	-88%
2024	120	$53.4	$15.6	-	0%
2025	0	-$126.7	-$126.7	-	-21%
2026	319	-$1,895.1	-$3,908.1	+2%	-20%
15-Year Total	-47,888	-$31,490.4	-$25,914.1	**-56%**	**-66%**
Average Annual Change	-3,193	-$2,099.4	-$1,727.6	**-4%**	**-4%**

Under Alternative 2, the volume of timber harvested on the existing Refuge boundary would not change, and the volume of timber harvested on the proposed Refuge land acquisition would decrease. Revenue would also decrease due to a lower price received because the Refuge would be restricted from selling timber to the strong export market. However, the economic impacts would not decrease at the same rate.

Timber harvests have distinct impacts on Washington's economy. This report focuses on the economic impacts generated by logging, hauling, processing the logs, and processing the residuals. The impacts at the logging and primary processing sectors differ between Refuge-harvested timber and commercially-harvested timber. First, the Refuge would thin timber stands, which would thereby be more labor intensive than commercial clearcutting. As a result, a greater number of jobs would be generated for every thousand board feet harvested compared to commercial clearcutting. About 25 percent more jobs are generated for thinning compared to clearcutting (Lippke and Mason 2005). Second, the impacts at the primary processing level (i.e., sawmills) for logs harvested on commercially-owned land differ from the impacts for logs harvested on federally-owned land because federal timber cannot be exported. Due to the strong export market, about 50 percent of commercial timber volume is currently exported (Lecture, May 2011). As a result, 50 percent of commercial timber is not processed in local mills and does not generate additional jobs or tax revenue beyond the amount generated by the actual felling.

The economic impacts associated with timber were derived using timber response coefficients[6] for Washington (DOI 2009, Winters 2011). Thus, the economic impacts depicted below would not be localized in Pacific County. Instead, the impacts would occur throughout the State. (Refer to the *Overview* section for more details regarding the timber industry.) As noted above, the economic impacts presented in Tables 32 and 33 include statewide impacts associated with logging, hauling, processing the logs, and processing any residuals.

The average annual economic impacts of timber associated with Alternative 2 are depicted in Table 32. Economic output would average $11.1 million annually with associated employment of 45 jobs, and $2.2 million in job income. These are the average annual economic impacts projected to continue over the 15-year period of the analysis under Alternative 2.

Table 32. Alternative 2: Timber Harvest – Projected Average Annual Economic Effects in Washington (2012-2026)

	Existing Refuge Boundary	Proposed Refuge Land Acquisition	Total
Timber Harvested (MBF)	2,373	2,463	4,836
Economic Output	$5,426.3	$5,633.4	$11,059.7
Jobs	22	23	45
Job Income	$1,096.3	$1,138.1	$2,234.4

Table 33 shows the projected change in statewide timber impacts under Alternative 2. Refuge management of the proposed land acquisition would decrease average annual timber harvests by 3,193 mbf. Thus, employment and job income would decrease annually by 13 jobs and $717,400 respectively in Washington over 15 years.

Table 33. Alternative 2: Timber Harvest – Change in Average Annual Economic Impacts in Washington Compared to the Baseline (Alternative 1) (2012-2026) (2010 dollars in thousands)

Timber Harvest (mbf)	-3,193
Economic Output	-$2,362.2
Jobs	-13
Job Income	-$717.4

Tables 32 and 33 showed the economic impacts of reducing the timber harvest in the proposed land acquisition. However, the Refuge would manage the proposed land acquisition for not only timber but for ecological benefits as well. Forests offer not only timber value but also many non-timber benefits such as wildlife habitat, recreational opportunities, nutrient cycling, and flood control. These nonmarket ecosystem services are difficult to quantify. Therefore, the economic impacts depicted in this analysis do not completely represent the value of the Refuge managing the proposed land acquisition.

Forest Excise Taxes

Under Alternative 2, forest excise taxes paid to Pacific County would not change for the existing Refuge boundary and would decline for the proposed Refuge boundary. Forest excise tax revenue for the proposed land acquisition would total $657,600 over 15 years, averaging $43,800 annually (Table 34). Overall, the average annual forest excise taxes generated by the existing Refuge

[6] *Response coefficients* estimate the effect on the economy for a change in the amount of timber harvested.

boundary and the proposed land acquisition would represent 3 percent of Pacific County's annual forest excise tax receipts ($2.8 million).

Table 34. Alternative 2: Projected Forest Excise Tax Paid to Pacific County (2010 dollars in thousands)

Year	Existing Refuge Boundary	Proposed Land Acquisition	Total
2012	$84.2	$6.4	$90.6
2013	$5.8	$19.0	$24.8
2014	$24.5	$38.1	$62.5
2015	$192.8	$37.9	$230.7
2016	$94.1	$42.5	$136.6
2017	$17.8	$11.7	$29.5
2018	$72.0	$0.0	$72.0
2019	$0.0	$28.8	$28.8
2020	$9.2	$3.2	$12.4
2021	$11.7	$127.3	$139.0
2022	$0.0	$2.1	$2.1
2023	$13.7	$11.8	$25.6
2024	$0.0	$2.1	$2.1
2025	$0.0	$18.8	$18.8
2026	$107.7	$307.8	$415.5
15-Year Total	**$633.5**	**$657.6**	**$1,291.1**
Annual Average	**$42.2**	**$43.8**	**$86.1**
Percentage of Annual Pacific County Forest Excise Taxes	**2%**	**1%**	**3%**

Under Alternative 2, the forest excise tax revenue is projected to decrease due to the lower timber revenue generated when the land is managed by the Refuge compared to private ownership. Reduced timber revenue would result due to less volume harvested and a lower stumpage value received. Table 35 shows forest excise tax revenue would decrease by $1.3 million (averaging $84,000 annually) over 15 years. This decline represents 3 percent of Pacific County's average annual forest excise tax receipts.

Table 35. Alternative 2: Change in Forest Excise Taxes Compared to Baseline (Alternative 1) (2010 dollars in thousands)

15-Year Total	-$1,259.6
Annual Average	-$84.0
Percentage Change Compared to Pacific County Total	-3%

Cranberry Production

Under Alternative 2, forest restoration efforts would occur, elk hunting would increase, and pasture habitat would decrease. These proposed actions could potentially impact elk herds, thereby impacting cranberry growers. Currently, there are 94.6 acres of cranberry bogs within a half mile radius of the Tarlatt and Riekkola Units of the Refuge and 768.5 acres within a twelve mile radius. (This acreage represents only areas south of the Refuge up to the Columbia River and on the Long Beach Peninsula.)

Forest restoration efforts on the Refuge should assist in creating additional elk habitat due to variable density thinning and thinning with skips and gaps, which set back plant succession to a degree, and along with more natural processes such as windthrow and occasional fires create openings in the forest and favorable foraging conditions for elk. The additional elk habitat may decrease the elk impact on cranberries.

Proposed elk hunting in the South Bay area of the Refuge (Riekkola, Porter Point and Lewis Units) and a proposed elk hunt on the Leadbetter Point Unit (under Alternatives 2 and 3) could help alleviate some of the elk damage that occurs on adjacent lands and help to address some concerns expressed by nearby cranberry bog owners about elk impacts on their properties.

Pasture is an important elk habitat on the west side of the Cascades (personal communication WDFW). There are 2,544 acres of pastures within a twelve mile radius of the Tarlatt and Riekkola Units of the Refuge. The Refuge currently contains approximately 11% of this pasture habitat. A reduction in pasture habitat is proposed in Alternative 2 due to estuarine restoration. Pasture at the Riekkola Unit would be reduced by approximately 120 acres. The short grass and old field habitat that would remain at Riekkola is in a location that has consistently demonstrated the most use by elk. The loss of pasture habitat may increase the elk impact on cranberries.

While cranberry growers have historically stated that elk herds negatively impact harvests, Schirato and Wiltse (1990) determined that there was no correlation for berry damage between elk use areas and non-elk use areas. This analysis does not estimate the impact of elk on cranberries because the magnitude of each proposed action on the elk population is unknown. The Washington Department of Fish and Wildlife does have a compensation program in place for elk damage that occurs to private property. The number of complaints reported for elk damage to cranberry bogs in Pacific County from 2000 to 2010 has totaled two incidents with a total payment of $4,759.37. There is no indication that this impact to local cranberry bogs would change significantly in the near future.

Revenue Sharing Payments

Under Alternative 2, the Refuge would expand its boundary by 6,809 acres. The expansion represents 1.1 percent of the total 975 square miles of Pacific County, of which more than 95 percent is private land (Pacific County 2010). The future Refuge land, which may be acquired from willing sellers, would be subject to revenue sharing payments.

Forecasting revenue sharing payments is complex. Actual payments are a function of the appraised value and appropriations. The Refuge Revenue Sharing Act requires Service lands be reappraised every five years to ensure that payments to local governments remain equitable. However, some payments are less than the legislated amounts due to governmental funding deficits. Congress may appropriate, through the budget process, supplemental funds to compensate local governments for any shortfall in revenue sharing payments. The final calculation for the payment to local governments depends on the total amount of funds available from revenue receipts collected on Refuges nationwide and any appropriations. As a result, payments fluctuate based on the revenue receipts and appropriations. As shown in the *Overview* section, payments steadily decreased from 2002 to 2009.

Tables 36 and 37 shows the estimated revenue sharing payment from 2012 to 2026, assuming the land is acquired in 2012. Lower bound and upper bound estimates for the existing Refuge boundary were derived for the projected payments. For the lower bound, estimates were developed based on the Refuge's payment patterns from 2002 to 2009. For the upper bound, estimates were developed based on "an amount equal to three-fourths of one percent of the fair market value, as determined by the Secretary, for that portion of the fee area that is located within such county." The 2012 payment is based on the 2010 appraisal value of $39.4 million. The increase at the 5-year appraisal was based on the percentage increase in the actual appraisal value from 2005 to 2010. Both the lower bound and upper bound estimates assume the land would be reappraised in years 2015, 2020, and 2025.

This analysis assumes the proposed land acquisition would be comparable in value to the existing Refuge fee acreage. Therefore, the lower bound and upper bound payments for the proposed land acquisition were estimated by the payment per acre for the existing Refuge boundary. Under Alternative 2, approximately 19,000 acres would be used to develop the land appraisal (12,148 acres under the existing boundary plus 6,809 acres under the proposed land acquisition). Under Alternative 2, the revenue sharing payment would range from $900,500 to $10.4 million.

Under Alternative 2, the revenue sharing payment is projected to increase due to proposed land acquisition. Table 38 shows the revenue sharing payments would increase by $323,400 to $3.6 million (averaging $21,600 to $239,300 annually) over 15 years.

Table 36. Alternative 2: Projected Revenue Sharing Payments to Pacific County – Lower Bound (2010 dollars in thousands)

Year	Fee Acres*	Revenue Sharing Payment		
		Existing Boundary	Proposed Land Acquisition	Total
2012	18,957	$49.2	$27.6	$76.8
2013	18,957	$45.8	$25.7	$71.5
2014	18,957	$42.7	$23.9	$66.6
2015	18,957	$47.2	$26.4	$73.6
2016	18,957	$43.9	$24.6	$68.6
2017	18,957	$40.9	$22.9	$63.8
2018	18,957	$38.1	$21.3	$59.4
2019	18,957	$35.5	$19.9	$55.3
2020	18,957	$39.2	$22.0	$61.2
2021	18,957	$36.5	$20.5	$57.0
2022	18,957	$34.0	$19.1	$53.0
2023	18,957	$31.6	$17.7	$49.4
2024	18,957	$29.5	$16.5	$46.0
2025	18,957	$32.6	$18.3	$50.8
2026	18,957	$30.3	$17.0	$47.3
Total		**$577.1**	**$323.4**	**$900.5**

*No payments are made for easement lands, use deed agreement lands, or lands that were withdrawn from public domain and were never in private ownership, e.g. Leadbetter and Shoalwater Units.

Table 37. Alternative 2: Projected Revenue Sharing Payments to Pacific County – Upper Bound (2010 dollars in thousands)

Year	Fee Acres*	Revenue Sharing Payment		
		Existing Boundary	Proposed Land Acquisition	Total
2012	18,957	$295.7	$176.7	$472.5
2013	18,957	$295.7	$176.7	$472.5
2014	18,957	$295.7	$176.7	$472.5
2015	18,957	$390.3	$176.7	$567.1
2016	18,957	$390.3	$176.7	$567.1
2017	18,957	$390.3	$233.3	$623.6
2018	18,957	$390.3	$233.3	$623.6
2019	18,957	$390.3	$233.3	$623.6
2020	18,957	$515.3	$233.3	$748.5
2021	18,957	$515.3	$233.3	$748.5
2022	18,957	$515.3	$307.9	$823.2
2023	18,957	$515.3	$307.9	$823.2
2024	18,957	$515.3	$307.9	$823.2
2025	18,957	$680.1	$307.9	$988.1
2026	18,957	$680.1	$307.9	$988.1
Total		**$6,775.4**	**$3,589.9**	**$10,365.3**

*No payments are made for easement lands, use deed agreement lands, or lands that were withdrawn from public domain and were never in private ownership, e.g. Leadbetter and Shoalwater Units.

Table 38. Alternative 2: Change in Revenue Sharing Payments Compared to Baseline (Alternative 1) (2010 dollars in thousands)

15-year Total	+$323.4 to $3,589.9
Annual Average	+$21.6 to $239.3

15-Year Present Value Impacts

The present value of impacts under Alternative 2 are shown in Table 39. To calculate the present value for a 15-year period, the social discount rates of 3 percent and 7 percent are applied per OMB guidance (U.S. Office of Management and Budget 1992). The 15-year present value impacts under Alternative 2 are estimated to be $88.0 million to $95.0 million (discounted at 3 percent) or $64.4 million to $69.3 million (discounted at 7 percent).

Table 39. Alternative 2: 15-Year Present Value (2012-2026)

Impact	Annualized Average	15-Year Present Value	
		3 % Discount Rate	*7% Discount Rate*
Recreation Expenditures	$2,232.2	$25,871.9	$19,000.8
Budget Expenditures	$3,140.2	$36,396.0	$26,729.9
Timber Revenue*			
Existing Boundary	$1,055.8	$12,864.6	$10,062.7
Proposed Land Acquisition	$1,096.1	$11,659.1	$7,708.7
Forest Excise Taxes*			
Existing Boundary	$42.2	$514.6	$402.5
Proposed Land Acquisition	$43.8	$466.4	$308.3
Revenue Sharing Payments*			
Existing Boundary	$38.5 to $400.4	$454.5 to $4,516.7	$341.8 to $3,203.3
Proposed Land Acquisition	$21.6 to $239.3	$254.8 to $2,699.4	$191.6 to $1,914.5

*Timber revenue, forest excise taxes, and revenue sharing payments include impacts generated by both the Refuge's existing boundary and the Refuge's proposed boundary.

ALTERNATIVE 3 – Partial Restoration of Habitats, Endangered Species Gains, Limited Refuge Expansion, Moderate Public Use

This section will discuss the various impacts of Alternative 3. In addition discussing the potential impacts, this section also addresses the regional economic impacts of Alternative 3. The assumptions that apply to the analysis for Alternative 3 are the same as those described for Alternative 1 (Status Quo). For a more detailed description of the baseline, to which each activity is compared, refer to "Alternative 1 (Status Quo) – Continue Current Management."

Recreational Activities

Each of the alternatives presented strive to provide quality recreation programs in concert with other wildlife-dependent public uses and habitat programs on the Refuge. The proposed actions common to all alternatives, which include improved signage, updated maps and hunting brochures, and increased law enforcement, would result in a positive effect on the overall recreation experience.

Description of Activities

Alternative 3 would result in a limited expansion of the hunt program. The limited expansion of the hunt program in this alternative is due to the fact that only part of the South Bay Units would be tidally restored under this alternative. The waterfowl hunt would have limited expansion in the Porter Point and Lewis units on the South Bay, and the regulated goose hunt would remain on the Riekkola Unit. Big game hunting would remain the same as Alternative 1 but have limited expansion of elk and deer hunting in the South Bay Units and the regulated elk hunt on Leadbetter Point Unit.

Under Alternative 3, there are no significant changes identified in the fishing program. The refuge portion of Willapa Bay and the channel portion of Bear River would continue to be open for fishing according to Washington State fishing regulations. The small streams on the Refuge would remain closed to fishing.

There are no significant changes identified for shellfish harvesting under Alternative 3. The two Willapa Bay Shellfish Areas (Diamond Point and Pinnacle Rock) on Long Island would continue to be maintained according to Washington State shellfish harvesting regulations.

Under Alternative 3, new headquarter facilities would be constructed closer to the population center on the Long Beach Peninsula, which would allow greater public access to Refuge visitor services. The site plan combines visitor facilities with habitat restoration efforts in an attempt to provide the visitor with a natural and educational experience. Other features of the project include picnic tables and a new interpretive trail. The interpretive trail would be along an existing road from the new visitor center to a new observation deck on the South Bay, which would offer unparalleled views of the bay and migratory birds. Alternative 3 proposes the same relocation and consolidation of visitor, office, and administrative facilities as Alternative 2.

Only the current interpretive trails would be maintained under Alternative 3. This can be considered to have a negligible effect on opportunities for visitors to access interpretive trails.

Current visitor facilities and programs would continue under Alternative 3. Effects on opportunities for wildlife observation and photography would be minor, positive, long-term improvements associated with habitat restoration and maintenance. The opportunities for self-guided wildlife observation and photography on the Leadbetter Point, Long Island, and Mainland units would be maintained.

Since a large portion of the Refuge consists of navigable waters and island habitat, visitors to the Refuge often use some type of watercraft to access these areas. Also, due to the difficulty of accessing Long Island during tidal fluctuations, camping is allowed in designated sites. The five campgrounds with 20 campsites on Long Island would be maintained under Alternative 3. All camping regulations would remain in place. There will be a neutral effect to camping on the Refuge regardless of the alternative selected. Under Alternative 3, car-top boat access at Porter Point would continue.

Regional Economic Impacts of Recreational Activities

Two types of information are needed to estimate the economic impacts of recreational visits to the refuge: (1) the amount of recreational use on the Refuge by activity; and (2) expenditures associated with recreational visits to the refuge. Recreational use is estimated by Refuge staff. Expenditures from the National Survey of Wildlife Related Recreation are used to estimate the types of purchases due to recreating at the Refuge (2007). With this information, total expenditures for each activity can be estimated. These expenditures, in turn, can be used in conjunction with regional economic models to estimate industrial output, employment, employment income and tax impacts associated with these expenditures. The recreational visitation and economic impacts detailed here are expected to occur under Alternative 3.

Table 40 shows approximately 178,000 visitors are projected to visit Willapa National Wildlife Refuge under Alternative 3. Visitors would be likely to partake in recreational opportunities, educational and interpretation programs, and restroom stops at the visitor center. The environmental education and interpretation programs and the availability of a restroom do benefit the community. However, these types of opportunities do not contribute to the local economic impacts because the events do not bring visitors who are spending money toward travel-related goods and services. Therefore, only visits associated with recreational activities are used to estimate economic effects.

Under Alternative 3, recreation visits are expected to rise due to increased opportunities. Recreation visits are projected to increase by 41 percent compared to the baseline (Alternative 1). Table 40 shows the estimated annual recreation visits under Alternative 3. About 160,200 of Refuge visitors would visit primarily for recreational opportunities. Sixty-four percent of recreational visitors (102,511) would travel from outside the local area. Similar to Alternative 1, nearly all recreational visitors would participate in non-consumptive activities such as hiking, boating, and photography. Less than 1 percent of visitors would participate in hunting and fishing combined. Under Alternative 3, these recreation visits would be expected to continue into the future.

Table 40. Alternative 3: Projected Annual Visits

Activity	Residents	Non-Residents	Total
Non-Consumptive:			
Pedestrian	51,759	96,123	147,882
Auto Tour	200	300	500
Boat Trail/Launch Visits	358	293	650
Bicycle Visits	40	10	50
Photography	4,250	4,250	8,500
Other Recreation	510	1,190	1,700
Environmental Education	4,080	720	4,800
Interpretation	735	315	1,050
Facilities	3,577	8,345	11,922
Hunting:			
Waterfowl	263	88	350
Other Migratory Birds	0	0	0
Upland Game	6	5	10
Big Game	189	231	420
Fishing:			
Freshwater	0	0	0
Estuarine	128	23	150
Total Visitation	**66,092**	**111,892**	**177,984**

The economic impact area for recreational activities is the 6-county area including Pacific, Wahkiakum, Cowlitz, and Clark Counties in Washington and Clatsop and Multnomah Counties in Oregon. It is assumed that resident visitor expenditures occur primarily within Pacific and Clatsop Counties while non-resident visitor expenditures also include the other surrounding counties. Expenditure patterns used in this report were obtained from the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior et al. 2007). These expenditures include only travel-related expenses. The estimated visitor recreation expenditures under Alternative 3 are shown in Table 41. Total annual expenditures are estimated to be $2.0 million with non-residents accounting for about $1.7 million or 86 percent of total expenditures. Expenditures associated with non-consumptive activities would account for 97 percent of all expenditures, followed by hunting and fishing at 2 percent and less than 1 percent respectively. Under Alternative 3, these annual recreation expenditures would continue into the future.

Table 41. Alternative 3: Projected Annual Visitor Recreation Expenditures (2010 dollars in thousands)

Activity		Residents	Non-Residents	Total
Non-Consumptive:				
	Pedestrian	$209.2	$1,416.15	$1,625.33
	Auto Tour	$1.6	$8.84	$10.46
	Boat Trail/Launch Visits	$4.3	$12.93	$17.26
	Bicycle visits	$0.32	$0.29	$0.62
	Photography	$34.35	$125.23	$159.58
	Other recreation	$22.43	$149.54	$171.97
	Total Non Consumptive	$272.23	$1,712.98	$1,985.21
Hunting:				
	Waterfowl	$7.1	$8.2	$15.2
	Other Migratory Birds	$0.0	$0.0	$0.0
	Upland Game	$0.1	$0.4	$0.5
	Big Game	$7.5	$21.3	$28.8
	Total Hunting	$14.7	$29.8	$44.5
Fishing:				
	Freshwater	$0.0	$0.0	$0.0
	Estuarine	$4.7	$2.7	$7.4
	Total Fishing	$4.7	$2.7	$7.4
Total Annual Expenditures		**$291.6**	**$1,745.5**	**$2,037.1**

Input-output models were used to determine the impact of expenditures on the local and surrounding areas of the Refuge under Alternative 3. Local effects are defined as those impacts occurring within Pacific County, Washington and Clatsop County, Oregon. Surrounding effects are defined as impacts occurring within Cowlitz, Wahkiakum, and Clark Counties in Washington and Multnomah County in Oregon. Table 42 summarizes the economic effects associated with recreation visits under Alternative 3. Economic output would total $2.3 million with associated employment of 18 jobs, $633,300 in employment income and $149,500 in total tax revenue. These annual economic impacts are projected to continue throughout the 15-year period of the analysis under Alternative 3.

Table 42. Alternative 3: Local Economic Effects Associated with Recreation Visits (2010 dollars in thousands)

	Residents	Non-Residents		Total
	Local Effects	Local Effects	Surrounding Effects	
Economic Output	$323.7	$1,092.9	$894.1	$2,310.7
Jobs	3	10	5	18
Job Income	$90.8	$292.3	$250.3	$633.3
Total Tax Revenue	$21.9	$65.0	$62.6	$149.5

Table 43 shows the projected increase in annual recreation impacts under Alternative 2. Annual Refuge visitors would increase by 45,832 generating 5 jobs and $177,400 in job income annually.

Table 43. Alternative 3: Annual Change in Recreation Compared to the Baseline (Alternative 1) (2010 dollars in thousands)

Visitors	+45,832
Recreation Expenditures	+$571.1
Economic Output	+$647.3
Jobs	+5
Job Income	+$177.4
Total Tax Revenue	+$26.8

The economic impacts from recreation expenditures estimated in this report are gross area-wide impacts. Information on where expenditures may occur locally and the magnitude and location of resident and non-resident expenditures (resident and non-resident relative to the geographical area of interest) is not currently available. Generally speaking, non-resident expenditures bring outside money into the area and thus generate increases in real income or wealth. Spending by residents is simply a transfer of expenditures on one set of goods and services to a different set within the same area. In order to calculate net economic impacts within a given area derived from resident expenditures, much more detailed information would be necessary on expenditure patterns and visitor characteristics. Since this information is not currently available, the gross area-wide estimates are used as an upper-bound for the net economic impacts of total resident and non-resident spending in the two and six county areas. The economic impacts of non-resident spending in Table 43 represent a real increase in wealth and income for the area (for additional information, see Loomis p. 191).

Refuge Expenditures

In addition to impacts from recreational visitors, there are also economic effects related to the Refuge expenditures that contribute to local and regional economies. Under Alternative 3, the Refuge annual expenditures are not expected to change ($2.5 million annually). However, in addition to annual expenditures, the Refuge would also have one-time expenses to complete the projects over various timelines. These projects would include (1) dike removal and rebuilding, (2) new visitor center, (3) new trail, (4) demolition and restoration of current headquarters, and (5) Bear River tidal project. These projects would total $8.7 million over 15 years (Table 44).

Table 44. Alternative 3: Willapa National Wildlife Refuge Expenditures (2010 dollars in thousands)

Expenditure:	
Annual Expenses:	
Salary – Permanent Employees	$1,385.4
Salary – Temporary Employees	$215.3
Non-Salary	$303.1
Funds from Other Sources	$637.0
Total Annual:	*$2,540.9*
One-Time Expenses:	
Dike Removal and Rebuilding (2012-2019)	$893.0
Visitor Center (2017-2019)	$6,500.0
Demolition and Restoration of Current Headquarters site (2020-	$120.0
New Trail at Visitor Center	$320.0
Bear River Tidal Project (2013-2014)	$893.0
Total One-Time Expenditures:	*$8,726.0*
Total	**$11,266.9**

Under Alternative 3, the Refuge's annual expenses (budget and funds from other sources) would not change compared to Alternative 1. Therefore, the Refuge's annual budget would continue to generate approximately 15 jobs and $584,000 in job income. Funds from other sources would still generate about 7 jobs and $431,000 in job income. Overall, Refuge annual expenditures result in about $2.2 million in economic output. The economic output is less than budget expenditures due to leakage outside the area economy. That is, the area does not manufacture/support all the services and products that are purchased. Therefore, some of the expenditures "leak" to other areas.

Table 45 shows the expected impact due to one-time expenses under Alternative 3. These impacts represent additional economic impacts compared to Alternative 1. Under Alternative 3, a variety of projects would be undertaken. Effects would be distributed over the next 15 years, depending on the timing of each project. These expenses would generate approximately 4 jobs and $180,000 in job income annually over 15 years. Overall, these project expenses would average $504,600 annually in economic output. After 15 years, these benefits would no longer continue. The economic output is less than budget expenditures due to leakage outside the area economy. That is, the area does not manufacture/support all the services and products that are purchased. Therefore, some of the expenditures "leak" to other areas.

Table 45. Alternative 3: Average Annual Change in Local Economic Effects Associated with One-Time Expenses Compared to Baseline over 15 Years (Alternative 1) (2010 dollars in thousands)

	Jobs	Job Income	Total Tax Revenue	Economic Output
Annual Average (2012-2026)	4	$180.0	$22.4	$504.6

Forest Management

Timber Harvests and Economic Impacts

Under Alternative 3, the Refuge would continue to manage its existing boundary to promote healthy habitat and aid in the support of target species. Annual timber harvests over about 4,844 acres of timberland would continue, logging about 35,588 mbf over 15 years. Timber harvest impacts on the Refuge's existing boundary would not change compared to Alternative 1.

In addition to managing the existing Refuge boundary, Alternative 3 proposes to purchase 4,901 acres. This Alternative would not include the purchase of the Nemah tract, unlike Alternative 2. The Nemah tract would continue to be managed under private ownership. Expansion of the Refuge by 4,901 acres would result in the reduction of future commercial timber harvest opportunities and the conversion of some timberlands into long term conservation status for habitats. Forest restoration and management practices of the younger-aged stands on the lands identified for potential acquisition would include some standard timber management practices, such as thinning (see Appendix K in the CCP).

Table 46 shows the projected timber harvests for three tracts of land if purchased by the Refuge under Alternative 3. These tracts of land would be managed to achieve Refuge goals for wildlife and habitat. Timber harvests from the proposed land acquisition would total 30,336 mbf over 15 years.

Table 46. Alternative 3: Projected Refuge's Timber Harvest and Revenue in Proposed Land Acquisition (4,901 acres) – (2010 dollars in thousands)

Year	Timber Harvested (mbf)			Timber Revenue	Timber Net Revenue
	East Hills	South Bay	Total		
2012	360	-	360	$160.2	$46.8
2013	629	440	1,069	$475.6	$138.9
2014	1,698	200	1,898	$844.6	$246.7
2015	2,127	-	2,127	$946.5	$276.5
2016	900	-	900	$400.6	$117.0
2017	660	-	660	$293.7	$85.8
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	89	-	89	$39.6	$11.6
2021	4,230	410	4,640	$2,064.8	$603.2
2022	118	-	118	$52.5	$15.3
2023	265	180	445	$198.0	$57.9
2024	-	-	-	-	$0.0
2025	1,056	-	1,056	$470.0	$137.3
2026	16,286	688	16,974	$7,553.5	$2,206.6
15-Year Total	**28,418**	**1,918**	**30,336**	**$13,499.6**	**$3,943.7**
Annual Average	**1,895**	**128**	**2,022**	**$900.0**	**$262.9**

Source: The Nature Conservancy 2011.

Table 47 shows the projected change in timber harvests under Alternative 3 compared to Alternative 1. Over 15 years, timber harvests within these tracts of land would decrease by 38,279 mbf compared to previous ownership. Timber revenue would decrease by about $25.3 million compared to previous ownership. Timber revenue would decrease due to decreased harvest and lower stumpage value ($445 per mbf) than commercial harvests ($565 per mbf)[7]. Compared to Pacific County's annual average timber harvest (335,089 mbf), the projected annual decline in timber harvest from the proposed Refuge boundary represents less than 1 percent of all logs harvested in Pacific County.

Table 47. Alternative 3: Change in Timber Harvests and Revenue for Proposed Land Acquisition Compared to Baseline (Alternative 1) (2010 dollars in thousands)

				Expected Percentage Change from Alternative 3	
Year	Timber Harvest (mbf)	Timber Revenue	Timber Net Revenue	Timber Harvest (mbf)	Timber Revenue
2012	-	-$43.2	-$43.2	0%	-21%
2013	+1,069	+475.6	+138.9	-	-
2014	+200	-$114.8	-$177.8	12%	-12%
2015	-	-$255.2	-$255.2	0%	-21%
2016	-13,673	-$7,833.3	-$5,372.1	-94%	-95%
2017	-	-$79.2	-$79.2	0%	-21%
2018	-5,677	-$3,207.5	-$2,185.6	-100%	-100%
2019	-	-	-	-	-
2020	-	-$10.7	-$10.7	0%	-21%
2021	-26,010	-$15,252.5	-$10,626.0	-85%	-88%
2022	-	-$14.1	-$14.1	-	-21%
2023	-3,957	-$2,289.1	-$1,601.1	-90%	-92%
2024	-	-	-	-	-
2025	-	-$126.7	-$126.7	-	-21%
2026	+9,769	+$3,482.6	-$188.2	136%	86%
15-year Total	**-38,279**	**-$25,268.1**	**$20,541.2**	**-47%**	**-55%**
Average Annual Change	**-2,552**	**-$1,684.5**	**-$1,369.4**	**-3%**	**-4%**

Under Alternative 3, the volume of timber harvested on the existing Refuge boundary would not change, and the volume of timber harvested on the proposed Refuge land acquisition would decrease. Revenue would also decrease due to a lower price received because the Refuge would be restricted

[7] The stumpage value for commercially-owned land differs from federally-owned land because federal timber cannot be exported. Currently, the export market is very strong fueled by a weak domestic market. Thus, timber harvested on commercially-owned land averages $120 per mbf more than timber harvested on federally-owned land (Bill Lecture, personal communication May 2011). The Washington Department of Natural Revenue also projects strong export demand over the next 3 years (Washington Department of Natural Resources 2011). Due to the difficulty in estimating long term changes in lumber and log prices, this analysis assumes constant lumber and log prices.

from selling timber to the strong export market. However, the economic impacts would not decrease at the same rate.

The impacts at the logging and primary processing sectors differ between Refuge-harvested timber and commercially-harvested timber. First, the Refuge would thin timber stands, which would thereby be more labor intensive than commercial clearcutting. As a result, a greater number of jobs would be generated for every thousand board feet harvested compared to commercial clearcutting. About 25 percent more jobs are generated for thinning compared to clearcutting (Lippke and Mason 2005). Second, the impacts at the primary processing level (i.e., sawmills) for logs harvested on commercially-owned land differ from the impacts for logs harvested on federally-owned land because federal timber cannot be exported. Due to the strong export market, about 50 percent of commercial timber volume is currently exported (Lecture, May 2011). As a result, 50 percent of commercial timber is not processed in local mills and does not generate additional jobs or tax revenue beyond the amount generated by the actual felling.

The economic impacts associated with timber were derived using timber response coefficients[8] for Washington (DOI 2009, Winters 2011). Thus, the economic impacts depicted below would not be localized in Pacific County. Instead, the impacts would occur throughout the State. (Refer to the *Overview* section for more details regarding the timber industry.) The economic impacts presented in Tables 48 and 49 include statewide impacts associated with logging, hauling, processing the logs, and processing any residuals.

The timber economic impacts in Washington associated with Alternative 3 are depicted in Table 48. Economic output would average $10.1 million annually with associated employment of 41 jobs, and $2.0 million in job income. These are the average annual statewide economic impacts projected to continue over the 15-year period of the analysis under Alternative 3.

Table 48. Alternative 3: Timber Harvests – Projected Average Annual Economic Effects in Washington over 15 Years (2012-2026) (2010 dollars in thousands)

	Existing Refuge Boundary	Proposed Refuge Land Acquisition	Total
Timber Harvested (MBF)	2,373	2,022	4,395
Economic Output	$5,426.3	$4,625.5	$10,051.8
Jobs	22	19	41
Job Income	$1,096.3	$934.5	$2,030.8

Table 49 shows the projected change in average annual timber impacts for Washington under Alternative 3. Refuge management of the proposed land acquisition would decrease timber harvests by 2,552 mbf annually. Thus, average annual statewide employment and job income would decrease by 11 jobs and $566,300 respectively compared to Alternative 1.

Table 49. Alternative 3: Average Annual Change in Timber Economic Impacts in Washington Compared to the Baseline (Alternative 1) (2012-2026) (2010 dollars in thousands)

Timber Harvest (mbf)	-2,552
Economic Output	-$1,841.5
Jobs	-11
Job Income	-$566.3

[8] *Response coefficients* estimate the effect on the economy for a change in the amount of timber harvested.

Tables 48 and 49 showed the economic impacts of reducing the timber harvest in the proposed land acquisition. However, the Refuge would manage the proposed land acquisition for not only timber but for ecological benefits as well. Forests offer not only timber value but also many non-timber benefits such as wildlife habitat, recreational opportunities, nutrient cycling, and flood control. These nonmarket ecosystem services are difficult to quantify. Therefore, the economic impacts depicted in this analysis do not completely represent the value of the Refuge managing the proposed land acquisition.

Forest Excise Taxes

Under Alternative 3, forest excise taxes paid to Pacific County would not change for the existing Refuge boundary and would decline for the proposed Refuge boundary. Forest excise tax revenue for the proposed land acquisition would total $550,100 over 15 years, averaging $36,700 annually (Table 50). Overall, the average annual forest excise taxes generated by the existing Refuge boundary and the proposed land acquisition would represent 2.5 percent of Pacific County's annual forest excise tax receipts ($2.8 million).

Table 50. Alternative 3: Projected Forest Excise Tax Paid to Pacific County (2010 dollars in thousands)

Year	Existing Refuge Boundary	Proposed Land Acquisition	Total
2012	$84.2	$6.4	$90.6
2013	$5.8	$19.0	$35.0
2014	$24.5	$33.8	$58.3
2015	$192.8	$37.9	$230.7
2016	$94.1	$16.0	$110.1
2017	$17.8	$11.7	$29.5
2018	$72.0	$0.0	$72.0
2019	$0.0	$0.0	$0.0
2020	$9.2	$1.6	$10.8
2021	$11.7	$82.6	$94.3
2022	$0.0	$2.1	$2.1
2023	$13.7	$7.9	$21.6
2024	$0.0	$0.0	$0.0
2025	$0.0	$18.8	$18.8
2026	$107.7	$302.1	$409.8
15-Year Total	**$633.5**	**$539.9**	**$1,173.4**
Annual Average	**$42.2**	**$36.0**	**$78.2**
Percentage of Annual Pacific County Forest Excise Taxes	**1.5%**	**1.3%**	**2.5%**

Under Alternative 3, forest excise tax revenue is projected to decrease due to the lower timber revenue generated when the land is managed by the Refuge compared to private ownership. Decreased timber revenue would result due to less volume harvested and a lower stumpage value received. Table 51 shows forest excise tax revenue would decrease by $1.2 million (averaging $78,200 annually) over 15 years. This decline represents 2 percent of Pacific County's average annual forest excise tax receipts.

Table 51. Alternative 3: Change in Forest Excise Taxes Compared to Baseline (Alternative 1) (2010 dollars in thousands)

15-year Total	-$1,010.7
Annual Average	-$67.4
Percentage Change Compared to Pacific County Total	-2%

Cranberry Production

Under Alternative 3, forest restoration efforts would occur, elk hunting would increase, and pasture habitat would decrease. These proposed actions could potentially impact elk herds, thereby impacting cranberry growers. Currently, there are 94.6 acres of cranberry bogs within a half mile radius of the Tarlatt and Riekkola Units of the Refuge and 768.5 acres within a twelve mile radius. (This acreage represents only areas south of the Refuge up to the Columbia River and on the Long Beach Peninsula.)

Forest restoration efforts on the Refuge should assist in creating additional elk habitat due to variable density thinning and thinning with skips and gaps, which set back plant succession to a degree, and along with more natural processes such as windthrow and occasional fires create openings in the forest and favorable foraging conditions for elk. The additional elk habitat may decrease the elk impact on cranberries.

Proposed elk hunting in the South Bay area of the Refuge (Porter Point and Lewis Units) and a proposed elk hunt on the Leadbetter Point Unit under Alternative 3 could help alleviate some of the elk damage that occurs on adjacent lands and help to address some concerns expressed by nearby cranberry bog owners about elk impacts on their properties.

Pasture is an important elk habitat on the west side of the Cascades (personal communication WDFW). There are 2,544 acres of pastures within a twelve mile radius of the Tarlatt and Riekkola Units of the Refuge. The Refuge currently contains approximately 11% of this pasture habitat. A reduction in pasture habitat is proposed in Alternative 3 due to estuarine restoration. The loss of pasture habitat may increase the elk impact on cranberries.

The proposed elk hunting and forest restoration efforts may help to address some concerns expressed by nearby cranberry bog owners about elk impacts on their properties. While cranberry growers have historically stated that elk herds negatively impact harvests, Schirato and Wiltse (1990) determined that there was no correlation for berry damage between elk use areas and non-elk use areas. This analysis does not estimate the impact of elk on cranberries because the magnitude of each proposed action on the elk population is unknown.

Revenue Sharing Payments

Under Alternative 3, the Refuge would expand its boundary by 4,901 acres. The expansion represents 1 percent of the total 975 square miles of Pacific County, of which more than 95 percent is private land (Pacific County 2010). The future Refuge land, which may be acquired from willing sellers, would be subject to revenue sharing payments.

Forecasting revenue sharing payments is complex. Actual payments are a function of the appraised value and appropriations. The Refuge Revenue Sharing Act requires Service lands be reappraised every five years to ensure that payments to local governments remain equitable. However, some payments are less than the legislated amounts due to governmental funding deficits. Congress may appropriate, through the budget process, supplemental funds to compensate local governments for any shortfall in revenue sharing payments. The final calculation for the payment to local governments depends on the total amount of funds available from revenue receipts collected on Refuges nationwide and any appropriations. As a result, payments fluctuate based on the revenue receipts and appropriations. As shown in the *Overview* section, payments steadily decreased from 2002 to 2009.

Tables 52 and 53 shows the estimated revenue sharing payment from 2012 to 2026, assuming the land is acquired in 2012. Lower bound and upper bound estimates for the existing Refuge boundary were derived for the projected payments. For the lower bound, estimates were developed based on the Refuge's payment patterns from 2002 to 2009. Thus, this forecast is based on the payment increase after each 5-year reappraisal (11 percent) and the average annual payment decline due to funding deficits (7 percent) over each 5-year period. For the upper bound, estimates were developed based on "an amount equal to three-fourths of one percent of the fair market value, as determined by the Secretary, for that portion of the fee area that is located within such county." The 2012 payment is based on the 2010 appraisal value of $39.4 million. The increase at the 5-year appraisal was based on the percentage increase in the actual appraisal value from 2005 to 2010. Both the lower bound and upper bound estimates assume the land would be reappraised in years 2015, 2020, and 2025.

This analysis assumes the proposed land acquisition would be comparable in value to the existing Refuge boundary. Therefore, the lower bound and upper bound payments for the proposed land acquisition were estimated by the payment per acre for the existing Refuge boundary. Under Alternative 3, 17,049 acres would be used to develop the land appraisal (12,148 acres under the existing boundary plus 4,901 acres under the proposed land acquisition). Under Alternative 3, the revenue sharing payment would range from $809,900 to $9.7 million.

Table 52. Alternative 3: Projected Revenue Sharing Payments to Pacific County – Lower Bound (2010 dollars in thousands)

Year	Fee Acres*	Revenue Sharing Payment		
		Existing Boundary	Proposed Land Acquisition	Total
2012	17,049	$49.2	$19.9	$69.1
2013	17,049	$45.8	$18.5	$64.3
2014	17,049	$42.7	$17.2	$59.9
2015	17,049	$47.2	$19.0	$66.2
2016	17,049	$43.9	$17.7	$61.7
2017	17,049	$40.9	$16.5	$57.4
2018	17,049	$38.1	$15.4	$53.5
2019	17,049	$35.5	$14.3	$49.8
2020	17,049	$39.2	$15.8	$55.0
2021	17,049	$36.5	$14.7	$51.2
2022	17,049	$34.0	$13.7	$47.7
2023	17,049	$31.6	$12.8	$44.4
2024	17,049	$29.5	$11.9	$41.4
2025	17,049	$32.6	$13.1	$45.7
2026	17,049	$30.3	$12.2	$42.6
Total		**$577.1**	**$232.8**	**$809.9**

*No payments are made for easement lands, use deed agreement lands, or lands that were withdrawn from public domain and were never in private ownership, e.g. Leadbetter and Shoalwater Units.

Table 53. Alternative 3: Projected Revenue Sharing Payments to Pacific County – Upper Bound (2010 dollars in thousands)

Year	Fee Acres*	Revenue Sharing Payment		
		Existing Boundary	Proposed Land Acquisition	Total
2012	17,049	$295.7	$127.2	$422.9
2013	17,049	$295.7	$127.2	$422.9
2014	17,049	$295.7	$127.2	$422.9
2015	17,049	$390.3	$167.9	$558.3
2016	17,049	$390.3	$167.9	$558.3
2017	17,049	$390.3	$167.9	$558.3
2018	17,049	$390.3	$167.9	$558.3
2019	17,049	$390.3	$167.9	$558.3
2020	17,049	$515.3	$221.7	$736.9
2021	17,049	$515.3	$221.7	$736.9
2022	17,049	$515.3	$221.7	$736.9
2023	17,049	$515.3	$221.7	$736.9
2024	17,049	$515.3	$221.7	$736.9
2025	17,049	$680.1	$292.6	$972.7
2026	17,049	$680.1	$292.6	$972.7
Total		**$6,775.4**	**$2,914.7**	**$9,690.1**

*No payments are made for easement lands, use deed agreement lands, or lands that were withdrawn from public domain and were never in private ownership, e.g. Leadbetter and Shoalwater Units.

Under Alternative 3, the revenue sharing payment is projected to increase due to proposed land acquisition. Table 54 shows the revenue sharing payments would increase by $232,800 to $2.9 million (averaging $15,500 to $194,300 annually) over 15 years.

Table 54. Alternative 3: Change in Revenue Sharing Payments Compared to Baseline (Alternative 1) (2010 dollars in thousands)

15-year Total	+$232.8 to $2,914.7
Annual Average	+$15.5 to $194.3

15-Year Present Value Impacts

The present value of impacts under Alternative 2 are shown in Table 55. To calculate the present value for a 15-year period, the social discount rates of 3 percent and 7 percent are applied per OMB guidance (U.S. Office of Management and Budget 1992). The 15-year impacts under Alternative 2 are estimated to be $83.7 million to $89.8 million (discounted at 3 percent) or $61.3 million to $65.6 million (discounted at 7 percent).

Table 55. Alternative 3: 15-Year Present Value (2012-2026)

Impact	**Annualized Average**	**15-Year Present Value**	
		3 % Discount Rate	***7% Discount Rate***
Recreation Expenditures	$2,037.1	$23,610.8	$17,340.2
Budget Expenditures	$3,133.1	$36,313.3	$26,669.2
Timber Revenue*			
Existing Boundary	$1,055.8	$12,864.6	$10,062.7
Proposed Land Acquisition	$900.0	$9,429.0	$6,132.7
Forest Excise Taxes*			
Existing Boundary	$42.2	$514.6	$402.5
Proposed Land Acquisition	$36.0	$377.2	$245.3
Revenue Sharing Payments*			
Existing Boundary	$38.5 - $400.4	$454.5 - $4,516.7	$341.8 - $3,203.3
Proposed Land Acquisition	$15.5 - $194.3	$183.4 - $2,180.8	$137.9 - $1,536.8

*Timber revenue, forest excise taxes, and revenue sharing payments include impacts generated by both the Refuge's existing boundary and the Refuge's proposed boundary.

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APPENDIX 1 – Measuring Economic Impacts

Spending associated with Refuge activities can generate a substantial amount of economic activity in local and regional economies. For example, refuge visitors spend money on a wide variety of goods and services. Trip-related expenditures may include expenses for food, lodging and transportation. Because this spending directly affects towns and communities where these purchases are made, recreational visitation can have a significant impact on local economies, especially in small towns and rural areas. These direct expenditures are only part of the total picture, however. Businesses and industries that supply the local retailers where the purchases are made also benefit from recreation spending. For example, a family may decide to purchase binoculars for an upcoming vacation. Part of the total purchase price will go to the local retailer, say a sporting goods store. The sporting goods store in turn pays a wholesaler who in turn pays the manufacturer of the binoculars. The manufacturer then spends a portion of this income to cover manufacturing expenses. In this fashion, each dollar of local retail expenditures can affect a variety of businesses at the local, regional and national level. Consequently, consumer spending associated with Refuge recreation can have a significant impact on economic activity, employment, household earnings and local, state and Federal tax revenue.

Similarly, timber sales also generate a substantial amount of economic activity. For example, timber may be harvested, hauled to the mill, processed as lumber, and then processed as furniture. Furthermore, processing residuals may be processed into paper. Each step in production can impact economic activity, employment, income, and tax revenue.

To estimate the total economic activity, employment, employment income and federal and state taxes generated by Refuge activities, this report uses IMPLAN[9], a regional input-output model and software system. The following is a list of terms and definitions that are commonly used in economic impact analysis (Minnesota IMPLAN Group, Inc. 2004 and Miller and Blair 1985).

Expenditures shows the estimated expenditures/revenue due to Refuge visitors, Refuge budget expenditures, or timber revenue.

Economic output (aggregated sales) shows the total industrial output associated with the estimated retail sales. Total output is the production value (alternatively, the value of all sales plus or minus inventory) of all output generated by an activity. Total output includes the direct, indirect and induced effects of visitor expenditures, budget, or timber sales. Direct effects are simply the initial effects or impacts of spending money; for example, spending money in a sporting goods store for binoculars. The purchase of the binoculars by the sporting goods store from a wholesaler would be examples of an indirect effect. Finally, induced effects refer to the changes in production associated with changes in household income (and spending) caused by changes in employment related to both direct and indirect effects. More simply, people who are employed by the retailer, by the wholesaler, and by the manufacturer of binoculars spend their income on various

[9] "IMPLAN…was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the USDOI Bureau of Land Management to assist the Forest Service in land and resource management planning." (Minnesota IMPLAN Group, Inc. 2004). First developed in 1979, IMPLAN data and software was privatized in 1993 by the Minnesota IMPLAN Group, Inc. For additional information, see www.implan.com. For additional information on input-output modeling, see Miller and Blair ***Input-Output Analysis***.

goods and services which in turn generate a given level of output. The dollar value of this output is the induced effect of the initial binocular purchase.

Jobs and **job income** include direct, indirect and induced effects in a manner similar to total industrial output. Employment includes both full and part-time jobs, with a job defined as one person working for at least part of the calendar year, whether one day or the entire year.

Tax revenues are shown for business taxes, income taxes, and a variety of taxes at the local, state and national level. Like output, employment and income, tax impacts include direct, indirect and induced tax effects of snake expenditures.

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