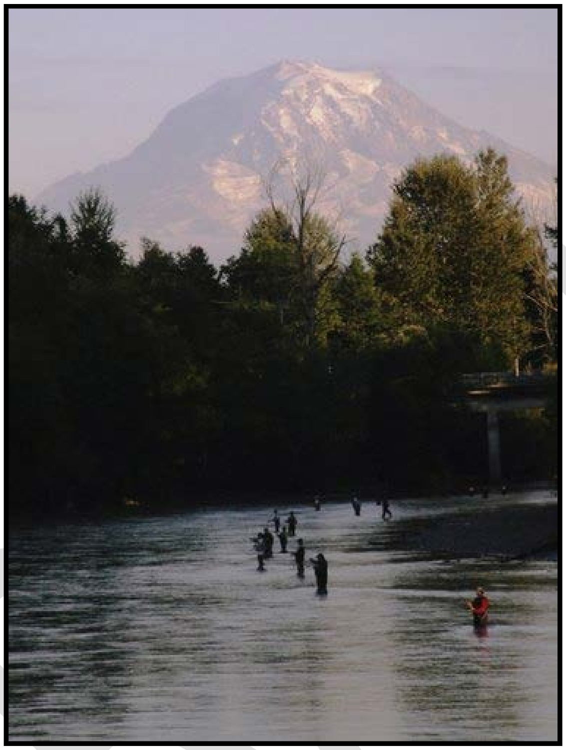
PUYALLUP RIVER BASIN
PIERCE COUNTY, WASHINGTON
FLOOD RISK MANAGEMENT GENERAL INVESTIGATION



Draft Integrated Feasibility Report and Environmental Impact Statement

March 2016

US Army Corps of Engineers®
Seattle District

Pierce County
Public Works and Utilities
Surface Water Management

Contents

Throughout this document, sections that are required for NEPA compliance are denoted with an asterisk (*) following the section heading.

Figures

Tables

Appendices

Acronyms and Abbreviations

ACE annual chance exceedance
ACHP Advisory Council on Historic Preservation
ADM Agency Decision Milestone
ADTC average daily traffic count
AEP annual exceedance probability
AIRFA American Indian Religious Freedom Act
APE Area of Potential Effect
ARPA Archaeological Resources Protection Act
AQI air quality index
ATR Agency Technical Review
BA Biological Assessment
BCR benefit-cost ratio
BMP Best Management Practice
BNSF Burlington Northern Santa Fe Railroad
CAA Clean Air Act
CAR Coordination Act Report
CBD central business district
CEMP Comprehensive Emergency Management Plan
CEQ Council for Environmental Quality
CERCLA Comprehensive Environmental Response, Compensation and Liability Act
cfs cubic feet per second
County Pierce County
CO_2 carbon dioxide
Corps U.S. Army Corps of Engineers
CWA Clean Water Act
cy cubic yards
CZMA Coastal Zone Management Act
DA Design Agreement
DAHP Department of Archaeology and Historic Preservation
dBA A-weighted decibel
DO Dissolved Oxygen
DPS Distinct Population Segment
DQC District Quality Control
DRS discharge regulation schedule
EAD Expected Annual Damages
EC Engineering Circular
EFH Essential Fish Habitat
EFSEC Energy facility Site Evaluation Council
EIS Environmental Impact Statement
EM Engineering Manual
EO Executive Order
EPA U.S. Environmental Protection Agency
EQ Environmental Quality
ER Engineer Regulation
ESA Endangered Species Act
ETL Engineering Technical Letter
FARR Federal Air Rules for Reservations
FAL Federal Authorized Levee
FAZ forecast analysis zones
FDA Flood Damage Analysis
FCSA Feasibility Cost Sharing Agreement
FEMA Federal Emergency Management Agency
FHWA Federal Highway Administration
DFR/EIS Draft Feasibility Report/Environmental Impact Statement
FRM flood risk management
FRM-PCX Flood Risk Management, Planning Center of Expertise
FWCA Fish and Wildlife Coordination Act
GHG Greenhouse Gas
GI General Investigation
GIS geographic information systems
GMA Growth Management Act
HCMZ historical channel migration zone
HEC Hydrologic Engineering Center
HPI Historic Property Inventory
HQUSACE Headquarters, U.S. Army Corps of Engineers
HTRW Hazardous, Toxic and Radioactive Waste
ICS Incident Command System
IEPR Independent External Peer Review
LB left bank
LERRD lands, easements, right-of-ways, relocations, and disposals
LWD large woody debris
MMD Mud Mountain Dam
MOA memorandum of agreement
NAAQS National Ambient Air Quality Standards
NAGPRA Native American Graves Protection and Repatriation Act
NEPA National Environmental Policy Act

NED National Economic Development
NHPA National Historic Preservation Act
NLD National Levee Database
NMFS National Marine Fisheries Service
NOI Notice of Intent
NPDES National Pollutant Discharge Elimination System
NRCS National Resources Conservation Service
NRHP National Register of Historic Places
NS non-structural
NWD Northwestern Division
NWI National Wetlands Inventory
NWS National Weather Service
NWS Seattle District, Corps of Engineers
OMRR&R Operations, Maintenance, Repair, Replacement and Rehabilitation
ORMA Ocean Resource Management Act
OSE Other Social Effects
O&M Operation and Maintenance
P&G Principles and Guidelines
PA Programmatic Agreement
PCRHP Pierce County Registry of Historic Places
PDO Pacific Decadal Oscillation
PED pre-construction engineering and design
P.L. Public Law
PM particulate matter
PPA Project Partnership Agreement
PSCAA Puget Sound Clean Air Agency
PSRC Puget Sound Regional Council
RB right bank
RCRA Resource Conservation and Recovery Act
RED Regional Economic Development
RM River Mile
SARA Superfund Amendments and Reauthorization Act
SBA Small Business Administration
SEPA State Environmental; Protection Act
SHPO State Historic Preservation Office
SLC sea level change
SR State Route
SWPPP Storm Water Pollution Protection Plan
TSCA Toxic Substances Control Act
TSP tentatively selected plan
U&A usual and accustomed
USACE U.S. Army Corps of Engineers
USFWS U.S. Fish & Wildlife Service
USGS U.S. Geological Survey
UST underground storage tank
WA Washington state
WAC Washington Administrative Code
WDFW Washington Department of Fish and Wildlife
WDOE Washington Department of Ecology
WHBR Washington Historic Barn Registry
WHR Washington Historic Register
WISAARD Washington Information System for Architectural and Archaeological Records Data
WRDA Water Resources Development Act
WRIA Washington Resource inventory Area
WSDOT Washington Department of Transportation

This page intentionally left blank

Executive Summary

This integrated draft feasibility report and environmental impact statement (DFR/EIS) presents the results to date of a U.S. Army Corps of Engineers (Corps) Flood Risk Management (FRM) feasibility study (study) undertaken to identify and evaluate alternatives to manage flood risk in the Puyallup River Basin (Basin) in the state of Washington. The Corps is undertaking this action in partnership with Pierce County, Washington. This DFR/EIS documents the plan formulation process to identify a Tentatively Selected Plan (TSP), along with environmental, engineering and cost of the TSP. This report also documents the environmental consequences analysis of the array of alternatives per requirements of the National Environmental Policy Act (NEPA).

The Puyallup River Basin drains approximately 1,000 square miles of western-central Washington and originates on the glaciers of Mount Rainier in the Cascade mountain range and flows in a northwesterly direction to Commencement Bay on Puget Sound. Elevations vary from sea level at the city of Tacoma to 14,411 feet at the summit of Mount Rainier. The upper Basin is characterized by steep, mountainous terrain while the lower Basin is characterized by broad floodplains and low gradient stream channels. The Basin is diverse and comprised of three glacially-fed rivers, the Puyallup River and its tributaries, the White River and the Carbon River. Each of these major river systems originates on the northern slopes of Mount Rainier and join together upstream of Tacoma before draining into Puget Sound. The study area is located in Pierce County, except for a portion north of the main stem of the White River located in King County.

The upper watershed is primarily rural and composed largely of public and private forest lands. The lower reaches are densely populated and include major residential areas and industrial hubs. The Basin includes the cities of Tacoma, Fife, Puyallup, Sumner, Auburn, and Orting, and large areas of unincorporated Pierce County. Existing development in the floodplain within the study area includes residential, industrial and commercial development, critical infrastructure such as schools and water treatment plants, and major transportation infrastructure, including Interstate 5, railroad lines and the Port of Tacoma. Two federally recognized tribes, along with tribal lands, are located in the Study area: the Puyallup Tribe of Indians (Puyallup Tribe) and the Muckleshoot Indian Tribe (Muckleshoot Tribe).

Reducing flood risks to life, safety, property, and critical infrastructure in the Puyallup River Basin through the planning period of analysis was identified as one of several objectives for the study. Corps staff from planning, economics, real estate, environmental and cultural resources, and multiple engineering disciplines, in coordination with the non-Federal sponsor of the Study, stakeholders, and the public, identified structural and non-structural measures that were combined into alternatives. Alternatives were formulated based on preliminary data collection, analysis of existing information and best professional judgment. The Corps identified and screened an initial array of eight flood risk management alternatives to identify a final array of three alternatives:

- Alternative 1 - No Action Alternative
- Alternative 2 - Levee Modification Alternative
- Alternative 3 - Sediment Management with Levee Modification Alternative

These three alternative were evaluated and compared using a concept-level design at a 1% annual chance exceedance (ACE) probability, to determine which alternative would be carried forward as the TSP. The evaluation and comparison was primarily qualitative and used the Principles and Guidelines (P&G) criteria of completeness, effectiveness, efficiency, and acceptability along with sub-sets of the P&G criteria to assist in better evaluating and comparing the alternative plans. The evaluation and comparison of the final array of alternatives was based on concept-level designs.

The Corps has identified the Levee Modification Alternative (Alternative 2) as the TSP. The Corps conducted a separable elements analysis for each Study reach, to confirm that elements of the TSP is economically justified. During feasibility-level design analysis of the TSP, the Corps will identify the optimal effects and benefits of TSP features by incrementally evaluating features with additional hydraulic and economic analysis. This process will identify the National Economic Development (NED) Plan - the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment

Alternative 3 is not recommended due to increased impacts to significant resources, higher O&M costs, and it does not reduce flood risks as well as the TSP (Alternative 2) over the planning period of analysis. The No Action Alternative was not selected because it does not meet the study objectives.

The TSP would modify the existing levee system to manage flood risk by setting back an existing levee, increasing existing levee heights, improving existing levee reliability, or constructing new levees or floodwalls. The proposed levee modifications would be the primary flood risk management measure within this alternative and would work with other flood risk management measures in the alternative, including flow control structures and property acquisition, to reduce flood risk in the Basin. This is a passive approach to managing sediment, where levees are modified in order to accommodate the sediment deposition expected over the planning period of analysis. The TSP includes approximately 11.2 total miles of new levee and/or floodwall construction and approximately 8.7 total miles of modification to existing features, including a levee setback. Actual levee alignments and alternative measures will be refined during feasibility-level design analysis.

The total estimated project first cost of the TSP is $341,144,000 (October 2015 price level). The fully funded cost estimate to the midpoint of construction is $380,030,000[1]. O&M costs have been estimated for the TSP. At this time it is assumed that the TSP would require maintenance estimated to be approximately $600,000 per year or less with O&M activities focusing on semi-annual inspections and reports, proper operation and maintenance of culverts and floodwall closures, and periodic levee maintenance activities to include repair and replacement of damaged or deficient components. The current estimated Federal portion of the cost is $221,744,000 and the estimated non-Federal sponsor's portion is $119,400,000, or 65 percent and 35 percent of the total estimated cost respectively.

[1] The midpoint of construction is used for this estimate rather than an estimate at the start of construction to account for an assumption that materials and other construction costs may increase between the start and end of the construction period.

Implementation of the TSP would result in some temporary impacts and direct loss of wetland and riparian habitat and critical habitat for threatened and endangered species. There would also be permanent impacts/adverse effects to cultural resources with the TSP. The NEPA, Council of Environmental Quality (CEQ) implementing regulations require the action agency to consider mitigation for the loss and degradation of environmental resources, including wetlands, fish spawning and refuge areas, and other habitat features that are impacted by Federal actions. As a result, the DFR/EIS includes a mitigation plan to address impacts and a thorough analysis to meet NEPA requirements. The Clean Water Act (CWA) and the Endangered Species Act (ESA) also require the action agency to develop mitigation for actions impacting wetlands and other waters of the U.S., and threatened and endangered species respectively. Impacts would be minimized to the extent possible. In addition, implementation of best management practices and in-water work window timing would reduce temporary impacts. For impacts to wetlands and riparian areas, the most widely accepted mitigation would include, but not necessarily limited to, onsite and off-site plantings, development of off channel habitat, reconnecting floodplain/wetland areas, and installation of large woody debris (LWD) structures in the river system. The potential to use onsite riverbank plantings and LWD is limited because of the potential impact on hydraulic conductivity and compliance with current Corps levee vegetation requirements.

A 45 day public comment period will be provided for the DFR/EIS, expected to begin March 25, 2016 and end May 9, 2016, concurrent with Corps-required technical, peer, legal, and policy reviews. The purpose of these reviews is to seek feedback on the TSP that will inform feasibility-level design and analysis that will be conducted to finalize the engineering, cost estimating, environmental, economic, and real estate elements of the plan. Results of the reviews and additional feasibility-level design and analysis will be incorporated into the final FR/EIS. The final FR/EIS will then be reviewed by the USACE Chief of Engineers who would make the final approval of the project recommendation.

This page intentionally left blank

1 Introduction

This integrated DFR/EIS documents the planning process for flood risk management in the Puyallup River Basin (Basin), Washington, to demonstrate consistency with U.S. Army Corps of Engineers (Corps) planning policy and to meet the regulations that implement the National Environmental Policy Act (NEPA). The following sections provide background information regarding the basis for this study. Throughout this document, sections that are required for NEPA compliance are denoted with an asterisk (*) following the section heading.

1.1 Study Purpose and Scope

The purpose of the Puyallup River Flood Risk Management General Investigation (Study) is to identify, evaluate and recommend an appropriate, coordinated, implementable solution to the identified flood risk problems and opportunities in the basin. This report documents the alternatives formulation process and the evaluation of alternatives per Corps Planning policy in Engineer Regulation (ER) 1105-2-100 and the National Environmental Policy Act (NEPA).

1.2 Study Authority

The Puyallup River Basin Flood Risk Management Feasibility Study is being carried out under the Corps' General Investigation (GI) Program. This study is authorized under Section 209 of the Flood Control Act of 1962 (PL 87-874) and Study Resolution, Docket 2645, Committee on Transportation and Infrastructure, U.S. House of Representatives, dated June 21, 2000. The study resolution states:

> *"That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Upper Puyallup River, Washington, dated 1936, as referenced in the Flood Control Act of 1936 (P.L. 74-738), the Puget Sound and Adjacent Waters Study, authorized by Section 209 of the Rivers and Harbors Act of 1962 (P.L. 87-874) and other pertinent reports to determine whether modifications to the recommendations contained therein are advisable, with references toward providing improvements in the interest of water resource and watershed issues affecting Lake Tapps and the White River Watershed downstream of Mud Mountain Dam, Washington."*

The referenced 1936 report included the entire Puyallup watershed, including the Puyallup River and tributaries such as the White River and Carbon River (further described in Section 1.5.1).

1.3 Lead Federal Agency, Non-Federal Sponsor and Stakeholders

The Corps is the lead Federal agency for this study. The non-Federal, cost-sharing sponsor (sponsor) is Pierce County, Washington (County). As the non-Federal sponsor, the County contributes 50 percent of the total feasibility study costs in the form of cash or in-kind contributions. The Corps and County executed a Feasibility Cost Sharing Agreement (FCSA) in September 2010 for a single-purpose, flood risk management feasibility study.

Project stakeholders include those who have executed an Inter-Local Agreement with Pierce County to financially support the County's non-Federal sponsor cost share including: City of Tacoma, City of Sumner, City of Puyallup, City of Orting, City of Pacific, City of Fife, and the Puyallup Tribe of Indians. Additionally, other stakeholders include Federal, state and local agencies such as Washington Department of Transportation (WDOT), Port of Tacoma, City of Auburn, other Federally-recognized tribes and the general public.

In 2011 the Pierce County Council created the Pierce County Flood Control Zone District. The Flood Control Zone District is a special purpose district governed by a board of supervisors and an executive committee. The board receives recommendation on various budget, policy and flood project priorities from an Advisory Committee. The Advisory Committee is made up of 15 member and represent various cities, unincorporated Pierce County, Water Resource Inventory Areas, businesses, the Port of Tacoma, Puyallup Tribe of Indians, agriculture or forestry interest organizations. There are 15 members on the committee; including representatives from the Pierce County Executive; two citizens from unincorporated Pierce County, representatives from City of Tacoma, Sumner, Puyallup, Orting, and Fife, and representatives from the Puyallup Tribe of Indians, WRIA 10, WRIA 11, WRIA 12, WRIA 15 and Port of Tacoma.

1.4 Cooperating Agencies*

The Corps has requested that each of the following agencies become a cooperating agency as defined in NEPA regulations at 40 CFR 1501.6.

- U.S. Environmental Protection Agency (EPA)
- Federal Emergency Management Agency (FEMA)
- National Marine Fisheries Service (NMFS)
- U.S. Fish and Wildlife Service (USFWS)

Only FEMA requested to be a cooperating agency for this Study. In accordance with the CEQ guidance, the degree of a cooperating agency's involvement in the process is based on the extent of that agency's authorities and responsibilities, expertise, resources, and availability. The other agencies declined to be cooperating agencies on this Study.

1.5 Study Area*

The study area is comprised of the floodplains of the major populated tributaries within the Puyallup River Basin (Basin) (Figure 1-1).

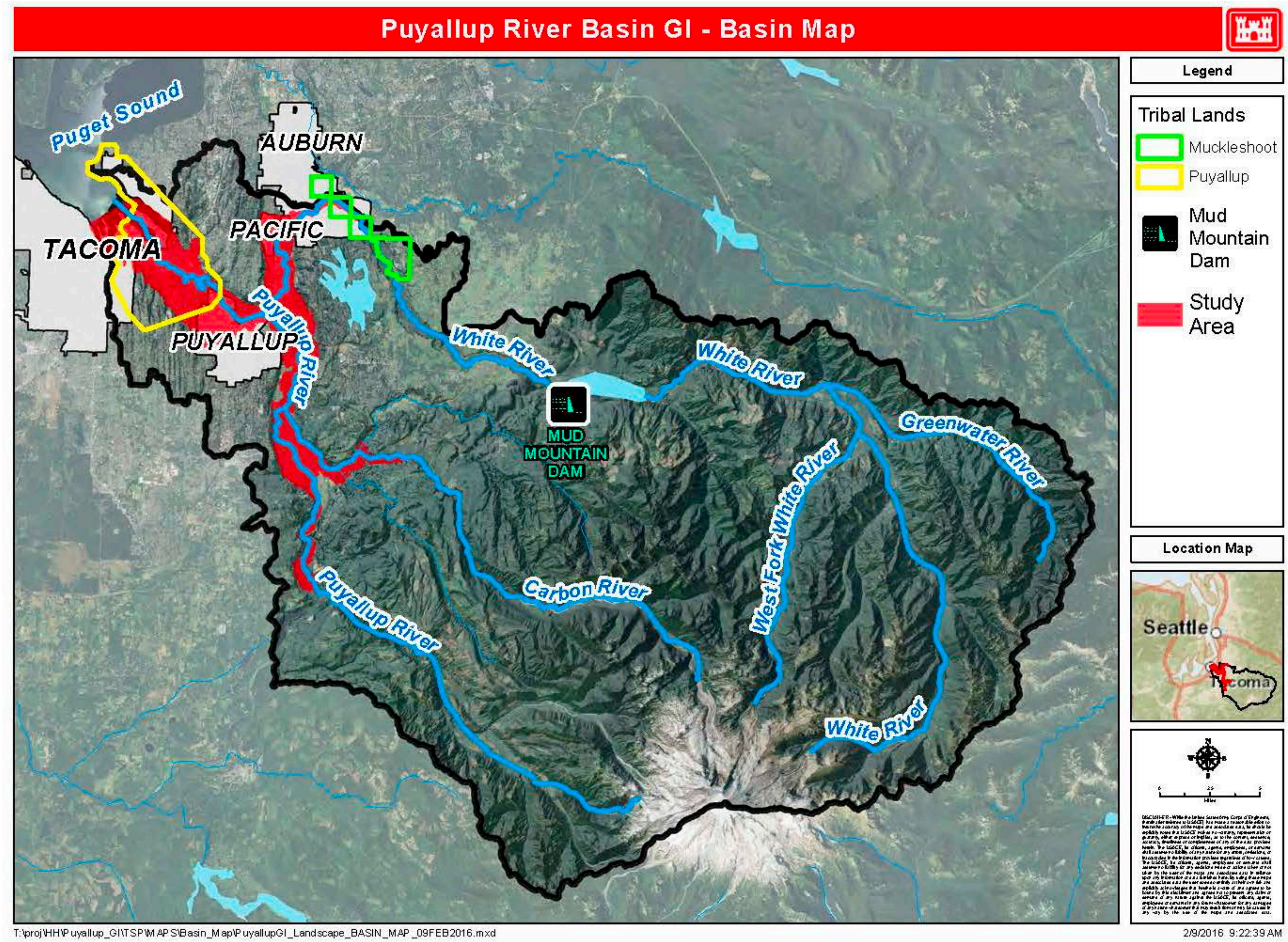


Figure 1-1. Puyallup River Basin

The Basin drains approximately 1,000 square miles of western-central Washington and originates on the glaciers of Mount Rainier in the Cascade mountain range and flows in a northwesterly direction to Commencement Bay on Puget Sound. Elevations vary from sea level at Tacoma to an elevation of 14,411 feet at the summit of Mount Rainier. The upper portion of the Basin is characterized by steep, mountainous terrain while the lower portion is characterized by broad floodplains and low gradient stream channels.

The Basin is diverse and is comprised of three glacially-fed rivers, the Puyallup River and its tributaries, the White River and the Carbon River. Each of these major river systems originates on the northern slopes of Mount Rainier and join together upstream of the city of Tacoma (the third largest city in the state of Washington) before draining into Puget Sound. The study area is located in Pierce County, Washington with the exception of a portion of the study area north of the main stem of the White River located in King County.

- The Puyallup River drains the northwest slope of Mount Rainier and flows northwest for approximately 50 miles before discharging into Commencement Bay in the city of Tacoma, Washington. Clear Creek (RM 2.7) and Clarks Creek (RM 5.8) are tributaries to the lower Puyallup River).
- The White River drains the northeastern slope of Mount Rainier and flows in a general northwest direction for about 50 miles before turning southward and entering the Puyallup River from the north at RM 10.3. The White River is the largest tributary to the Puyallup River. Mud Mountain Dam (MMD), a federally authorized flood control project, is located at RM 29.6 on the White River.
- The Carbon River originates on the north face of Mount Rainier at the Carbon Glacier and enters the Puyallup River at RM 17.3. South Prairie Creek at RM 5.8 is a major tributary to the Carbon River.

The upper watershed is primarily rural and is composed largely of public and private forest lands. The lower reaches are densely populated and include major residential areas and industrial hubs. The Basin includes the cities of Tacoma, Fife, Puyallup, Sumner, Auburn, and Orting, and large areas of unincorporated Pierce County. Existing development in the floodplain within the study area includes residential, industrial and commercial development, critical infrastructure such as schools and water treatment plants, and major transportation infrastructure, including Interstate 5, railroad lines and the Port of Tacoma.

Two federally recognized tribes are located in study area: the Puyallup Tribe of Indians (Puyallup Tribe) and the Muckleshoot Indian Tribe (Muckleshoot Tribe). Muckleshoot Tribe land is primarily located around the City of Auburn on parcels that span both sides of the White River. Puyallup Tribe lands are located on the lower Puyallup River, downstream of the confluence with the White River. Puyallup Tribal lands are unusual in that per an 1857 Executive Order, the Tribe has ownership rights over the bed of the river in this area (see Section 6.3). In addition to the Puyallup Tribe and the Muckleshoot Tribe, the Nisqually Indian Tribe, Squaxin Island Tribe, Snoqualmie Tribe, and Yakama Nation have Usual and Accustomed Hunting and Fishing Rights in the project area as designated by the following: The

Muckleshoot, Puyallup, Nisqually and Squaxin Island Tribes signed the Treaty of Medicine Creek in 1854. The Snoqualmie Tribe signed the Treaty of Point Elliot in 1855 and the Yakama Nation singed the Treaty with the Yakima in 1855.

The study area includes 28 levee segments currently in the USACE National Levee Database (NLD). This includes 26 non-federal levees and two federally owned and operated levees. Completed in 1950, the federal levees were built from RM 0.7 to RM 2.8 on the lower Puyallup River and were authorized as a companion project to Mud Mountain Dam (MMD). The levees are 2.2 miles in length on the left and right banks and allow for an in-channel conveyance capacity of 50,000 cfs (cubic feet per second).

Due to the configuration of the Puyallup River, the study area is described for planning and modeling purposes as the lower Puyallup River (RM 0.0 – RM 10.3), middle Puyallup River (RM 10.3 – RM 17.4) and upper Puyallup River (RM 17.4 – RM 29.6), the Carbon River, and the White River. Figure 1-2 shows the Study area by reach, and Figure 1-3 through Figure 1-7 show the cities and major infrastructure in the study area, by study reach.

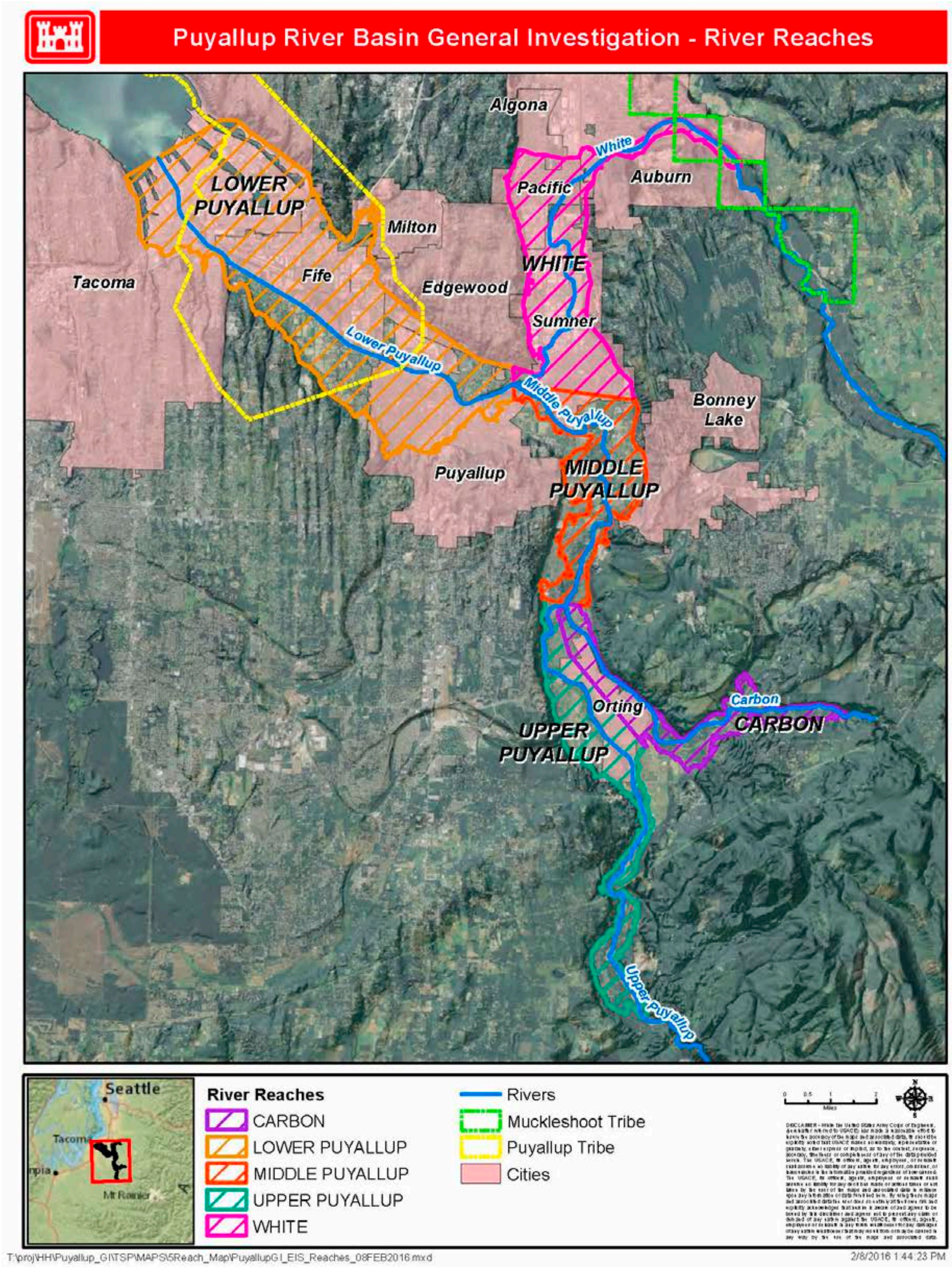


Figure 1-2. Study Area

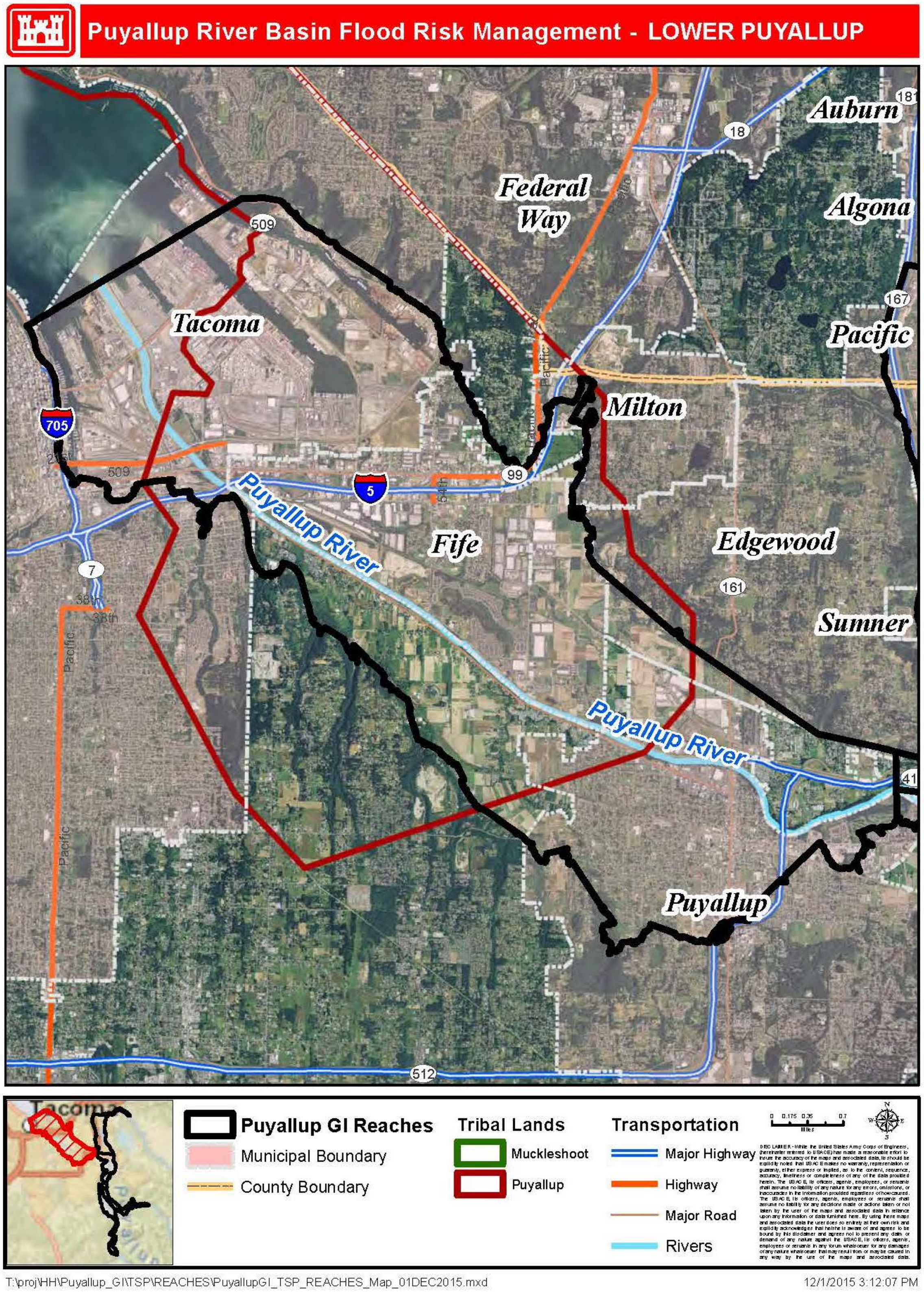


Figure 1-3. Lower Puyallup Reach

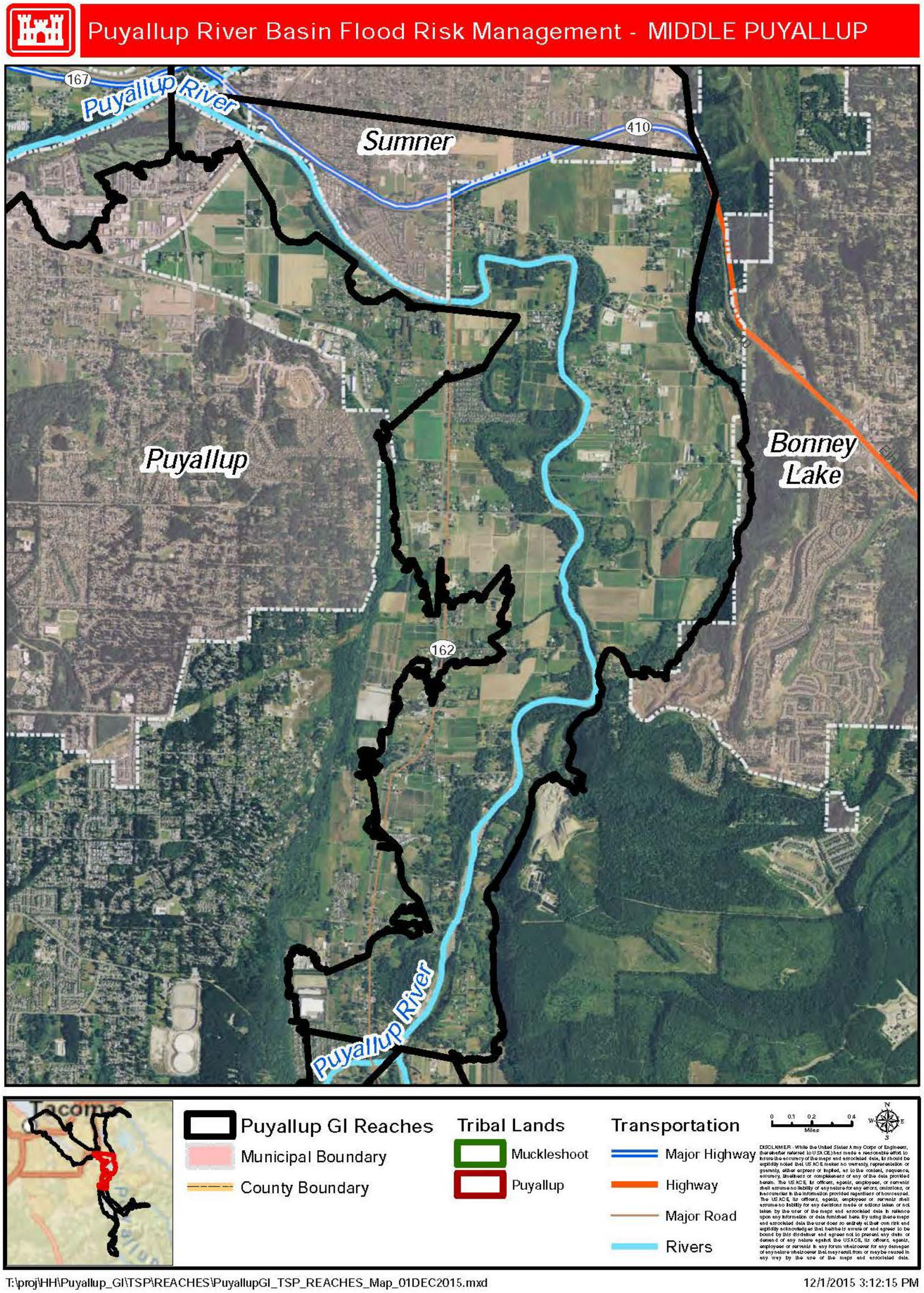


Figure 1-4. Middle Puyallup Reach

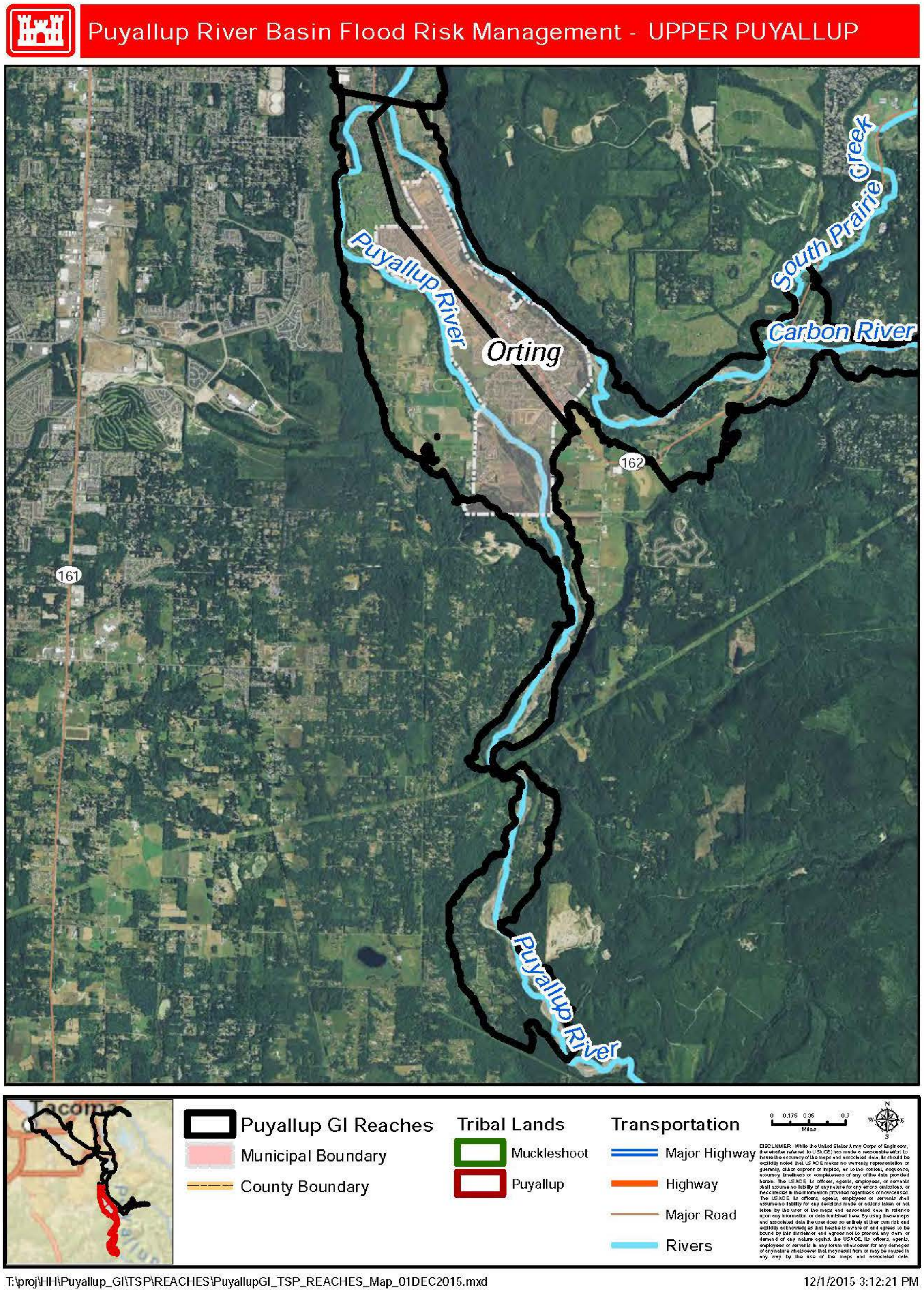
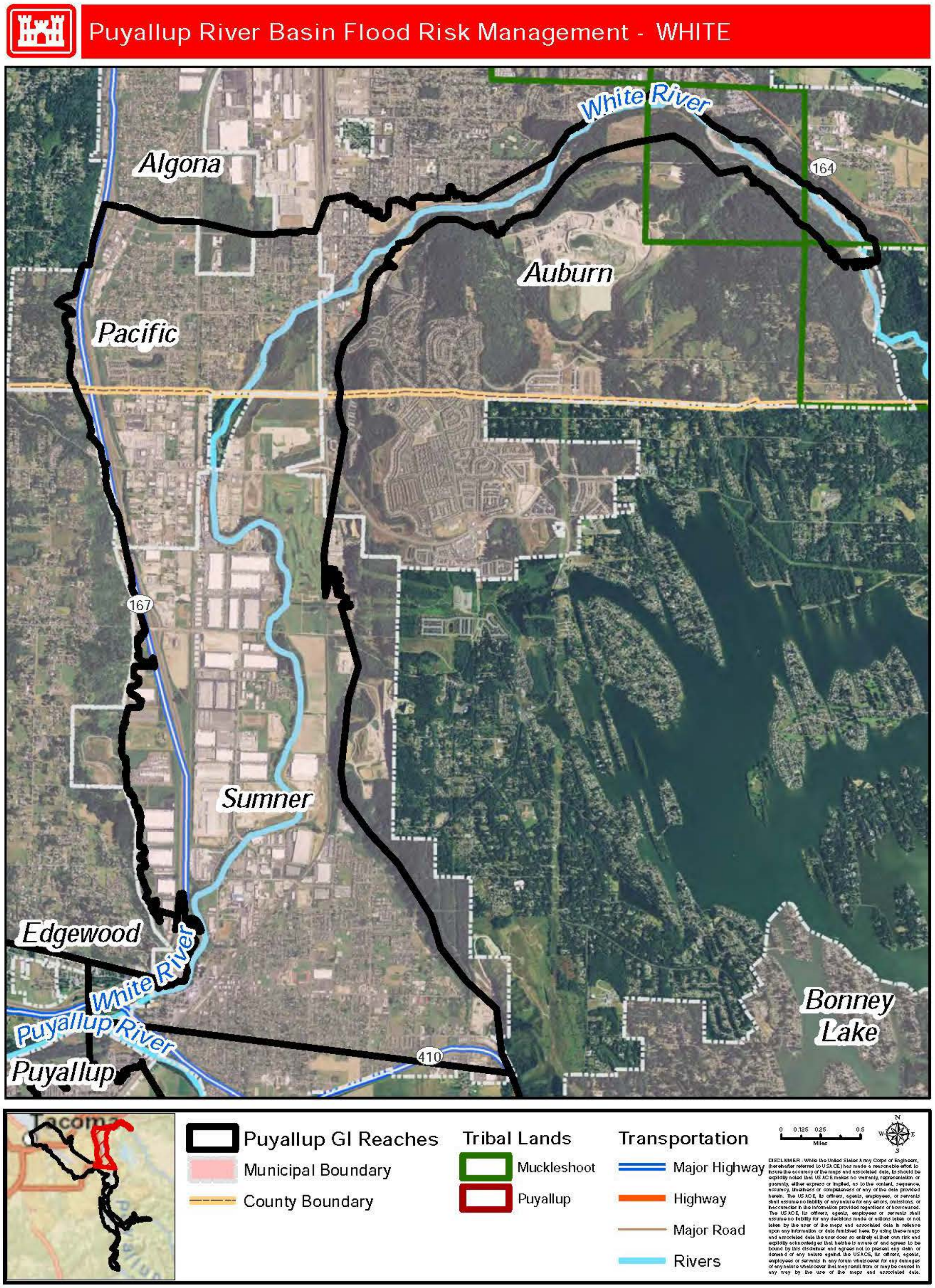


Figure 1-5. Upper Puyallup Reach



T:\proj\HH\Puyallup_GI\TSP\REACHES\PuyallupGI_TSP_REACHES_Map_01DEC2015.mxd 12/1/2015 3:12:28 PM

Figure 1-6. White River Reach

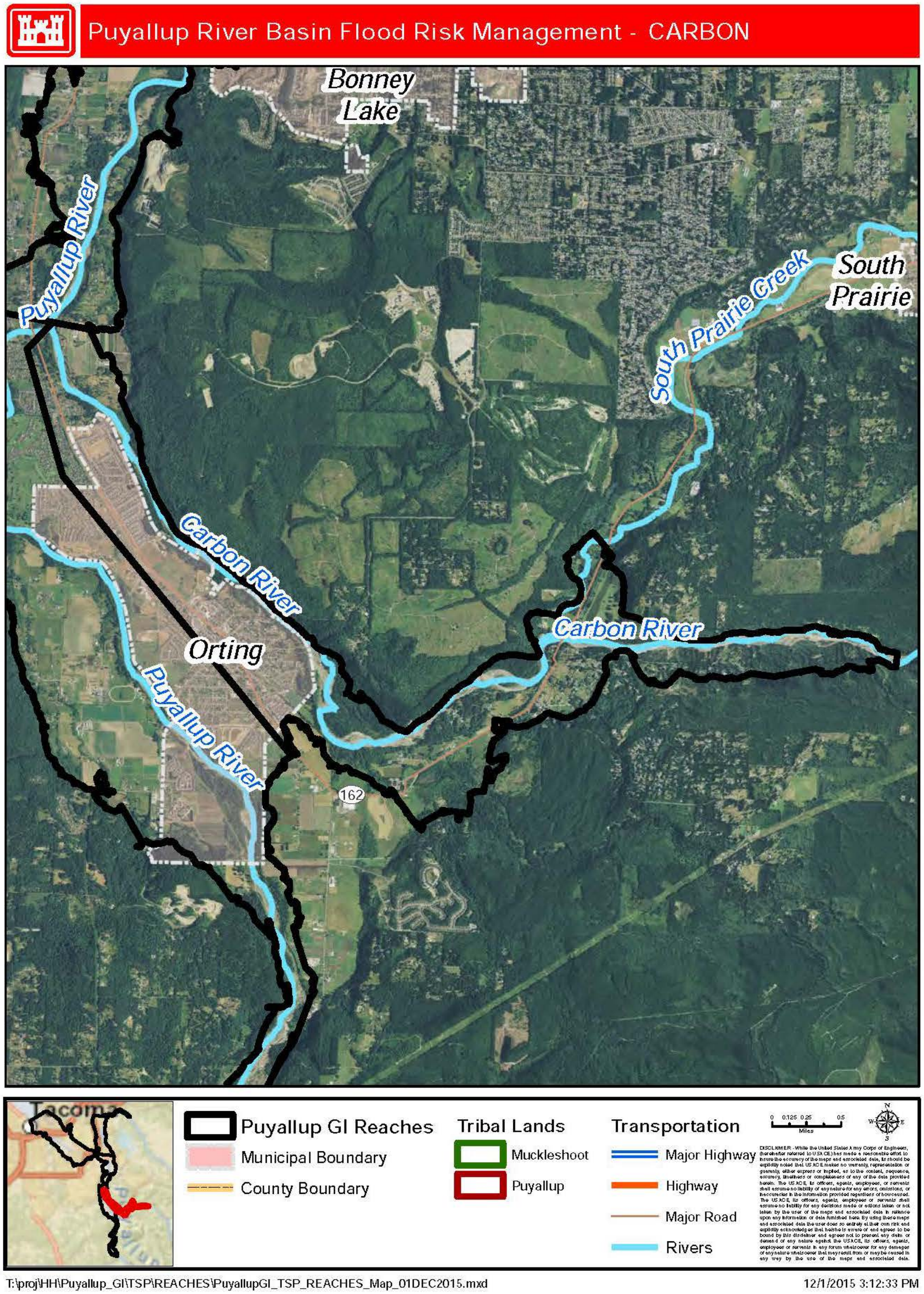


Figure 1-7. Carbon River Reach

1.6 Proposal for Federal Action*

The proposal to implement flood risk management in the Puyallup River Basin triggered the NEPA process recorded in this document (40 CFR 1501.2). Based on study results, the proposed Federal action is flood risk management in the Puyallup River Basin in the state of Washington. The proposed Federal (Corps) action area is focused on the lower, middle and upper reaches of the Puyallup River and on the White River due to high flood risks in this area. The proposed Federal (Corps) action area is densely populated and includes major residential areas, industrial hubs and critical infrastructure. The Corps has an opportunity to address problems associated with flood risk and life safety risk in the lower Basin.

1.7 History of the Investigation

In 2002, Pierce County, in coordination with the Corps' Seattle District, initiated a Reconnaissance Study, a preliminary analysis in accordance with the guidelines of Section 905(b) of the Water Resources Act (WRDA) of 1986. The preliminary analysis found there was a Federal interest in conducting a feasibility study to address local basin needs for ecosystem restoration and flood risk management projects. During the Reconnaissance Study, the Corps identified 120 potential projects throughout the basin that are consistent with the Corps' high-priority mission areas in ecosystem restoration and flood risk management that warrant further investigation. These projects were identified through a collaborative effort between the Corps, Pierce County, King County, the Puyallup Tribe, and various municipal, non-profit and Federal entities. A feasibility study did not go forward due to lack of non-Federal sponsor participation.

The Corps initiated a Reconnaissance study in 2008 for the lower eight miles of the Puyallup River. The study found there was a Federal interest in pursuing a flood risk reduction feasibility study. By addressing the state of the current levee system and combining new flood risk management methods, it is likely that the Corps and the local jurisdictions could reduce flood risks and protect existing infrastructure. Implementation of flood risk management measures to the lower eight mile reach of the Puyallup River would likely decrease the flood risk at that time and address the recertification issues surrounding the existing levee system.

After initiation of the 2008 Reconnaissance study, the Basin experienced wide scale flooding in January 2009. Due to this severe flood event, the non-Federal sponsor requested an increase in scope for the study in September 2009 to address basin wide flooding issues. The Reconnaissance Report for the Puyallup River was completed in early 2010 and was approved by the Corps' Northwestern Division (NWD) in April 2010. The Corps and County executed an FCSA in September 2010 for a single-purpose, flood risk management feasibility study.

1.8 Overview of Integrated DFR/EIS

This document is an integrated feasibility report and Environmental Impact Statement (DFR/EIS). The purpose of the feasibility report is to identify the plan that maximizes flood risk management benefits, is technically feasible and considers environmental and cultural resource impacts. The purpose of the EIS portion of the report is to identify and present information about any potentially significant environmental effects of the alternatives and to incorporate environmental considerations into the decision-making process. The six steps of the Corps planning process and NEPA requirements are shown in Table 1-1, which lists the DFR/EIS sections for the Corps planning steps and corresponding NEPA elements. Throughout this document, sections that are required for NEPA compliance are denoted with an asterisk (*) following the section heading.

Table 1-1. Overview of DFR/EIS

Corps Planning Step	Analogous NEPA Requirement	DFR/EIS Section
Step One – Specify Problems and Opportunities	Purpose and Need for Action	Chapter 2.
Step Two – Inventory and Forecast Conditions	Affected Environment	Section 2.7 and Chapter 4
Step Three – Formulate Alternative Plans	Alternatives including Proposed Action	Chapter 3
Step Four – Evaluate Effects of Alternative Plans	Environmental Consequences	Chapter 4
Step Five – Compare Alternative Plans	Alternatives including Proposed Action	Chapters 3 and 4
Step Six – Select Recommended Plan	Agency Preferred Alternative	Chapters 3 and 5

In this report, as in all new Corps reports that discuss flood risk management, the risk of an individual storm or flood event occurring is expressed as the *annual chance of exceedance* (ACE) probability, which is the probability that the specified discharge, or flood event, could be equaled or exceeded during any given year. A 1% ACE probability has in the past commonly been referred to as a "100 year flood." The occurrence of a specific ACE probability in one year does not alter its ACE in the next year. Many documents referenced in this report, however, along with maps and other supporting materials, use “x-year flood” expressions, in which the number of years is sometimes known as “the return interval.” To aid in understanding these differing expressions, Table 1-2 provides a cross-reference between ACE and return-interval expressions.

Table 1-2. Annual Chance of Exceedance (ACE) Probability Conversion from Return-Interval to Years

Annual Chance of Exceedance (ACE) in %	Average Return Interval in Years
50	2
10	10
5	20
4	25
2	50
1	100
0.4	250
0.2	500

The Corps created the inundation data and maps contained in the DFR/EIS in November-December 2015, based on the best available information at that time. This information may or may not accurately reflect existing conditions and may be updated in the final FR/EIS.

2 Need for and Objectives of Action*

This chapter presents results of the first step of the Corps planning process, the identification of water and related land resources problems and opportunities in the study area. The chapter also establishes the planning objectives and planning constraints, which are the basis for formulation of alternative plans.

2.1 Problems and Opportunities

The primary concern this study addresses is flood risk management in the Basin, which includes public, private and tribal land. The Corps, non-Federal sponsor and concerned stakeholders identified the following problem and opportunity statements for this study (Table 2-1):

Table 2-1. Problems and Opportunities

Problem	Opportunities
Development and ongoing related activities have promoted an increase in risk to life safety, property and infrastructure within the Puyallup River Basin.	• Minimize risks to public safety and potential loss of life during flood events • Reduce the need for emergency flood fighting efforts • Improve access to transportation corridors for evacuation and emergency services
Sedimentation has heavily contributed to the decrease in channel capacity resulting in an increase in channel migration and flood risks throughout the Puyallup River Basin.	• Minimize risks to public safety and potential loss of life during flood events • Manage sedimentation and its effects as it relates to the increase in flood risks
The existing levee systems have experienced significant and repetitive damages increasing overall flood risks.	• Improve the function and reliability of the flood risk management system • Reduce the need for levee rehabilitation efforts
Portions of the basin are subject to channel constrictions caused by levees, revetments and bridges, which limits channel capacity, thereby increasing flood risks.	• Minimize risks to public safety and potential loss of life during flood events • Re-establish floodplain connectivity for the purpose of expanding channel conveyance
Changing conditions within the basin inhibit the ability of MMD to operate as designed and authorized without flooding some localized developed areas.	• Minimize risks to public safety and potential loss of life during flood events • Optimize MMD operations in coordination with other flood risk management efforts

2.2 Purpose and Need for Action*

The purpose of the Federal action is to reduce flood risks, life safety threats and damages in the Puyallup River Basin as a result of flooding. The action is needed because the Basin experiences frequent flooding, resulting in damages to both rural and urban areas throughout the Basin.

2.3 National Objective

The National or Federal objective of water and related land resources planning is to contribute to national economic development (NED) consistent with consideration of impacts to the Nation's environment pursuant to national environmental statutes, applicable Executive Orders, and other Federal planning requirements. Contributions to NED include increases in the net value of the national output of goods and services over a certain period of time, expressed in monetary units. These contributions are the direct net benefits that accrue in the Study area and the rest of the Nation. Forecasts of conditions in this Study extend from the base year (the year when an alternative is expected to be operational) to the end of the period of analysis, which for this Study is 50 years. For this study, the analysis assumes a base year of 2026 and a 50-year planning period of analysis out to 2076.

2.4 Planning Goal and Objectives

The **goal** of the study is to identify a flood risk management plan that reasonably maximizes NED benefits, reduces life safety risks and is in accordance with the Corps' Environmental Operating Principles. Based on the problems identified in the study area, the following planning objectives were established. All objectives and consist of an effect, subject, location, and timing per ER 1105-2-100:

- **Objective 1:** Reduce flood risks to life, safety, property, and critical infrastructure in the Puyallup River Basin through the planning period of analysis.
- **Objective 2:** Manage the effects of sedimentation and geomorphic changes within the Puyallup River Basin riverine system to sustain the effectiveness of the flood management system through the planning period of analysis.
- **Objective 3:** Optimize contribution of Mud Mountain Dam to flood risk management within the Puyallup River Basin.
- **Objective 4:** Improve the reliability and integrity of the existing levees and their associated structures to ensure optimal flood risk reduction within the Puyallup River Basin.
- **Objective 5:** Optimize natural floodplain functions and sustainability, including conveyance and storage, within the Puyallup River Basin.

Table 2-2 lists the study objectives and the problems they address.

Table 2-2. Study Objectives and Problems Addressed

		Problems in the Study Area			
Objective	Increased risk to life safety, property and infrastructure	Decrease in channel capacity due to sedimentation	Significant and repetitive damages to existing levee system	Channel constrictions in portions of basin caused by levees, revetments and bridges	Changing conditions in Basin that inhibit MMD ability to operate as designed and authorized
Reduce flood risks	x		x		
Manage the effects of sedimentation and geomorphic changes	x	x	x		x
Optimize contribution of MMD to flood risk management	x		x	x	x
Improve reliability and integrity of	x		x	x	x

existing levees and associated structures					
Optimize natural floodplain functions and sustainability	x	x	x	x	x

2.5 Planning Constraints

Planning constraints are significant barriers or restrictions that limit the extent of the planning process. Study-specific planning constraints are statements of things unique to a specific planning study that alternative plans should avoid. The following constraints (i.e. limitations on the range of measures and alternatives that can be proposed) have been identified for the study:

- **Constraint 1:** Any structural and/or operational modification to MMD included in any proposed alternative should not impair the hydraulic function and structural integrity of the dam. All proposed modifications must ensure that MMD continues to serve as a Corps flood control dam and be consistent with Corps Dam Safety requirements.
- **Constraint 2:** FEMA's Hazard Mitigation Grant Program Funds were used to purchase some of the County acquired and owned lands. These lands are restricted from having any flood risk management structures being constructed on them without FEMA's review, consideration, and approval prior to proposed actions.

2.6 Public Scoping Comments and Resources of Concern*

Public involvement is a key component of NEPA and the Corps' Planning process. Through the NEPA scoping period conducted early in the Study, a number of public comments were received that discuss issues directly associated with flood risk management, including comments related to flooding, river channel capacity, sediment management, and water quality. Residents are specifically concerned about the impact of frequent flooding on residents and their properties, natural habitat, and sediment buildup in the region. Causes of flooding mentioned in comments were increased rainfall, deteriorating or weak structures, lack of drainage, and heavy run-off. Comments suggest that reduced flood impact would improve the quality of life in the region and ultimately improve the economic condition of the Basin. Comments suggested the Study should focus on implementing solutions to reduce flood risks with minimal environmental impacts. These concerns were taken into account during the analysis of which resources should be included in the detailed analysis that appears in Chapter 4. A more detailed discussion of public involvement is included in Chapter 7 and in Appendix I.

2.7 Existing Conditions

The existing (without-project) condition for the Study area was established as part of the second step of the Corps planning process. Establishment of the existing condition requires documentation of present day conditions and serves as the foundation for development of alternatives that address identified problems.

2.7.1 Existing Flood Conditions

The Study area includes the main river channels of the Puyallup River, Carbon River, and White River. In the conventional river mile system starting at Commencement Bay, the White River meets the Puyallup River at RM 10.3 and the Carbon meets the Puyallup River at RM 17.3. The majority of flood risks are located on the Puyallup River near Tacoma, the Puyallup River near Orting, and the White River near the Town of Pacific. The rivers are diked along many of these areas. Levees have greatly reduced the active footprint of the river to its present confined state.

The climate of the Puyallup River Basin is predominantly wet and temperate (WRCC, 2011). The prevailing wind direction is from the south or southwest during the rainy season (October to June) and from the northwest during the relatively dry summer from July to September (WRCC, 2011). In January, the average maximum temperature is about 42°F, and the minimum is about 29°F. In July, the average maximum temperature is about 78°F and the minimum is about 50°F. The average annual precipitation in the lower elevations of the study area (0 to 2,000 feet) is approximately 41 to 65 inches, and the winter snowfall ranges from approximately 0.2 to 15 inches, depending on location. In the upper portion of the study area (at elevations exceeding 2,000 feet above sea level) the annual rainfall ranges from 65 to 93 inches, with total annual snowfall typically exceeding 75 inches (WRCC, 2011; Pierce County, 2008a). Approximately 75% of the annual precipitation occurs between October and March each year. Consequently, floods in the Puyallup Basin tend to occur between November and February. Large floods are typically the result of atmospheric rivers (also known as a Pineapple Express), which also describes the transfer of moist tropical air to the higher west coast latitudes to seasonally produce consecutive heavy rain events in western Washington and Oregon seasonally during the winter months.

Long term periods of greater than and lower than average precipitation in this basin cycle with the Pacific Decadal Oscillation (PDO) (Czuba et al., 2012). The PDO is a sea-surface temperature pattern that lasts several years to decades. Researchers have identified a distinct cool period in the PDO from 1947-1978 with greater than average precipitation, and a warm period from 1978 to mid-1994 with lower than average precipitation. Precipitation directly contributes to runoff and flow in rivers, which in turn affects the ability of these rivers to transport sediment from Mount Rainier to lower areas of the basin. From the middle 1990s to 2005 runoff was close to the long term average. Since 2005, runoff appears to have increased (USGS, 2012).

Topography varies considerably across the basin from Mount Rainier, the highest point in Washington, to Puget Sound at sea level. The Basin can generally be divided into two areas: high gradient uplands above the city of Auburn on the White River and the city of Orting on the Puyallup River and Carbon River and the low gradient Puget Sound lowlands. As an example, in the White River the stream gradient upstream of RM 14 averages over 30 feet/mile, whereas the downstream river profile for RM 0-3 averages 3 feet/mile. The Study area tends to correspond to lowland or transitional topography. Throughout the Basin, flood event runoff evolves quickly with initial response occurring on an hourly time scale. Average flood duration is typically one to two days. The Puyallup River Basin, like other western Washington basins, typically does not experience large floods from seasonal snowmelt runoff.

From a hydrologic perspective, the upper watersheds of the Basin are virtually undeveloped, consisting of Mount Rainier National Park and surrounding Federal forest lands. In contrast, the lower river reaches of the Puget Sound lowlands have been highly engineered. Two dams exist in the upper high gradient reaches of the basin, MMD on the White River for flood risk management and the Electron Hydroelectric Project, owned by Electron Hydro LLC, operated as a hydropower dam on the Puyallup River. Both dams are run-of-the-river dams which do not hold a steady storage reservoir. MMD is located near Buckley, Washington and is operated by the Corps to provide flood regulation for the lower 10 miles of the Puyallup River and the White River. The primary objective of MMD is to limit Puyallup River peak flows to less than 45,000 cfs. A secondary objective is to limit flows on the lower White River to less than 12,000 cfs. Currently, a deviation authorizing lower releases is in place due to changing river conditions on the lower White River at Pacific. The present channel capacity is thought to be between 6,000 to 8,500 cfs through this area. Peak flows on the White River are reduced by MMD during flood events until the peak on the lower Puyallup River has passed. The MMD pool is then immediately evacuated to regain capacity for additional storms. The remainder of the basin is unregulated with only small hydropower diversions. MMD is designed to reduce flows in the Puyallup River during flood events by reducing flood flows in the White River and Electron Dam uses a diversion flume as a water source for turbine generation. In addition, the Cascade Water Alliance owns a diversion dam downstream of MMD at RM 23 which historically diverted flows up to 2000 cfs to Lake Tapps, an off-channel reservoir. The lake previously served as a hydropower reservoir for the White River Power Plant but is now primarily a residential lake and diversions of up to 1000 cfs are made. Diverted water is stored in Lake Tapps and overflow is discharged through the tailrace of the decommissioned power plant back to the White River. Cascade Water Alliance diverts flows to Lake Tapps for the purposes of maintaining the lake level and future water supply for the region.

The largest flood events in western Washington are predominately caused by atmospheric rivers which focus intense precipitation on distinct geographic regions. The four largest documented floods to occur on the Puyallup River were in 1933 (before MMD and the current levee system were built), 2009, 2006 and 1996. Each of these events was caused by an atmospheric river and produced widespread flooding which exceeded the capability of existing flood control works in several locations. Table 2-3 summarizes major flood events since 1990.

The flood of record (based on peak flow) in the lower Puyallup occurred in December of 1933, prior to the construction of MMD. This event produced a peak flow (as recorded by USGS gage 12101500) of 57,000 cfs at Puyallup, Washington. This value could have been even higher as this event exceeded the channel capacity resulting in water in the floodplain that could not be measured by the stream gage. The 1933 flood event was a driver for the planning, authorization and construction of MMD in the 1940's.

Although other floods have produced higher peak flows at different points throughout the basin, the flood of February 1996 was the worst basin-wide (as well as regional) flood event seen in recent times. The peak flow at Puyallup, WA was approximately 47,000 cfs. Total costs in damages to Pierce County and surrounding local jurisdictions for this event were estimated to be over $40 million. Over 1,300 people in Pierce County requested Federal assistance in response to this flood event (Pierce County, 2013). The largest recent event in terms of peak flow, on January 8, 2009, produced a peak flow of 48,200 cfs at USGS gage 12101500 at Puyallup. According to a study by Mastin et al. (2010), heavy rainfall, warmer winter temperatures, and melting snowpack resulting in high runoff caused flooding of the many rivers in Western Washington in January 2009. The 2009 storm event, combined with aggraded streambeds, caused overtopping of levees at several locations along the White, Carbon, and Puyallup Rivers in King and Pierce counties, causing extensive flooding and damage (Mastin et al. 2010). Although flood events in the last decade have been somewhat frequent, the USGS has summarized in a 2012 report that there are no statistically significant trends of increasing peak flows during the 20th century in the rivers draining Mount Rainier. The USGS has surmised that there may be a possible correlation between the PDO and the occurrence of atmospheric rivers that the data from stream gages in the basin may be too limited to detect (Czuba et al., 2012).

Table 2-3. Major Flood Events since 1990, Puyallup River Basin

Year	Disaster	Stafford Act Obligated Funds in Pierce County	Total Individual Assistance from FEMA in Pierce County	Corps of Engineers (Emergency Response and PL 84-99 rehab)	Public Funding Disaster Relief Total
Nov 1990	WA DR 852	N/A	N/A	$350,000	$350,000
Nov-Dec 1995	WA DR 1079	$386,830	$30,241	$2,500,000	$2,917,071
Feb 1996	WA DR 1100	$18,760,197	$3,543,262	$3,500,000	$25,803,459
Dec 1996 – Feb 1997	WA DR 1159	$6,527,150	$830,501	$2,000,000	$9,357,651
Nov 2006	WA DR 1671	$8,472,418	$1,284,246	$1,064,900	$10,821,561
Jan 2009	WA DR 1817	$4,730,594	$1,529,007	$3,928,409	$10,188,010

Source: Pierce County Rivers Flood Hazard Management Plan, 2012

Shown below, Table 2-4 lists Federal flood disaster declarations in the Basin since 1964.

Table 2-4. Federal Flood Disaster Declarations

Federal Flood Disaster Declarations	Notes
DR-1817-WA—01/06-6/2009	Flooding from a severe storm throughout much of Washington. 23 counties declared.
DR-1734-WA—12/1-17/2007	Flooding throughout most of western Washington. Pierce County, while having flooding, was not declared.
DR-1671-WA--11/5-6/2006	Major flooding on the Puyallup, Carbon, White, Stuck and Nisqually rivers.
DR-1499-WA--10/2003	Surface flooding
DR-1159-WA--12/96-2/1997	Ice storm, snow and flood. Stafford Act assistance - $83 million, SBA $31.7 million.
DR-1100-WA--1-2/1996	Three deaths in Washington. Stafford Act disaster assistance provided – $113 million. SBA disaster loans approved - $61.2 million
DR-1079-WA--11-12/1995	1% ACE flood at Alderton on the Puyallup and 50-year flood at La Grande
DR-896-WA--12/1990	Stafford Act assistance provided $5.1 million
DR-883-WA--11/1990	Stafford Act assistance provided $57 million
DR-852-WA--1/1990	Stafford Act assistance provided $17.8 million

DR-784-WA--11/1986	Two deaths. $11 million in private property damage and $6 million in public damage
DR-545-WA--12/1977	16 counties were declared. Very heavy rain in the upper Nisqually caused significant damage.
DR-492-WA--12/1975	13 counties flooded
DR-328-WA--2/1972	King, Pierce and Thurston counties flooding
DR-185-WA--12/1964	Wide ranging flooding affected 19 counties in both eastern and western Washington

Source: Pierce County Rivers Flood Hazard Management Plan: Programmatic recommendations FPW #16

The following photos show historic flood damage in the Study area.

Figure 2-1. Looking northeast across the Puyallup River near RM 11.2 (January 8, 2009)

Figure 2-2. Looking east toward Puyallup River along 128th Street, SE near RM 16.7 (November 7, 2008)

Figure 2-3. Looking north across Puyallup River near RM 12.4 (November 7, 2006)

Figure 2-4. Looking northeast across Puyallup River Deer Creek Tributary near RM 9.6, in the city of Puyallup, left bank of Puyallup River (November 7, 2006)

Figure 2-5. Looking southeast along SR 410 and the Puyallup River in Sumner, near RM 10.7 (November 7, 2006)

2.7.2 Existing Geomorphology and Sediment Transport

Historically, river channel patterns within the Puget Sound lowlands were highly variable. At the beginning of the 20th century, a valley existed between the White River (then called the Stuck River) to the south and the Green River (then called the White River) to the north which served to distribute flood flows between the two systems. Part of the flow was sent towards Tacoma down the White-Puyallup system and other times sent towards Seattle to the north through the Green-Duwamish river system. It has been estimated that 25-30% of the total flow typically went to the South. In 1898, a manmade landslide diverted the river south into the Stuck. This diversion was reinforced by a debris jam in 1906. The original Corps Puyallup River Basin investigation in 1931 (House Document, HD 72-153) noted the following:

> *"For many years prior to 1906, the Puyallup received only a fractional part of the water flowing in the White River, some observers estimated one-third, others less than one-third, the remainder passing into the [Green-]Duwamish. During the flood of November 1906, the Duwamish branch of the White River became jammed with drift, closing that branch completely, and turning all the water of the White southward through the Stuck Valley into the Puyallup. At the peak of this flood, the estimated discharge of the Puyallup River at Puyallup was 36,000 second-feet, which was beyond any previous record and proved to be especially destructive."*

In 1914, the debris blockage was further armored to make the containment of flows within the White-Puyallup system permanent. Increases in flows and developing communities led to the construction of levees throughout the lowland areas of the basin. Today, Federal and non-Federal levees exist in a patchwork throughout the study area, confining the floodplains of the major tributaries.

The Study area can be divided into four geomorphic reaches based upon river slope and channel configuration. Low gradient developed areas are primarily the focus of this flood risk management study. The upper reaches of the White River, Carbon River, and upper Puyallup River within the Study area are located in steep canyons upstream of heavily developed areas, with bed slopes ranging from 1% to 0.6%. The rivers through these reaches are braided in planform with high energy flow. Bed material consists of gravel, cobbles, and boulders. Channel banks along some upper reaches are characterized by significant erosion and mass wasting of soil into the river. The few levees that exist in these reaches are often heavily damaged by flood events, and several were obliterated by the 1996 and 2006 floods. The river bed slope decreases significantly in the Orting area of the upper Puyallup River and Carbon River, and the Pacific area of the White River, becoming 0.5-0.3%. The valley floor widens through this reach and the channel, although confined between levees, becomes more complex. The active channel has tended to braid where it was able to adjust within older levee setbacks such as the Old Soldiers Home levee and the Ford levee. Large woody debris (LWD) is common and tends to concentrate at the upstream ends of gravel bars and at the entrances to side channels. These areas are characterized by significant deposition of gravel and large cobble material and shifting gravel bars. Historically, the Orting, Pacific, Sumner, and Puyallup areas of the river were heavily braided alluvial fans that spread between valley walls long before levees were constructed. The river bed slope below Orting on the upper Puyallup River and below Pacific on the White River becomes 0.2-0.1%. Although the rivers are contained between levees, large historical meander belts are visible in the terrain. The channel bed is composed of primarily gravel and sand with significant LWD present. The lower Puyallup River below its confluence with the White River is low gradient with a bed slope of 0.06-0.01%. This reach is essentially a straightened canal, with large historical meanders and braids visible in the terrain. This reach was historically a very large alluvial fan that spread between valley walls long before development. The present river is typically about 200 ft wide between levees and ends at Commencement Bay. The channel bed is composed of sand, silt, and fine gravel.

Supply of sediment from Mount Rainier and surrounding areas to the Puyallup basin study area is highly variable, with much of the bedload coming from sporadic rock falls at the glacial origins of its rivers. Transport of glacial material into the fluvial system is highly dependent upon the occurrence of extreme rainfall events- described earlier as atmospheric rivers (USGS, 2010). Residence time of sediment from glacial origins to the basin study area can be on the order of decades to centuries (USGS, 2010). A significant amount of sediment can also be produced from within the national park boundaries. Estimation of historic annual total sediment loads range from 1,000,000 tons/yr on the lower Puyallup and around 500,000 tons/yr on the White River (Czuba et al., 2012). Areas that have historically seen aggradation of sediment will likely continue to aggrade as the system transports large quantities of sediment to levied reaches. In a typical river system with high sediment loads, deposition of material on the channel bed occurs when the available supply of sediment exceeds the transport capacity of a given section of the river. This process typically continues, in the absence of destabilizing events, until some dynamic equilibrium state is reached where the system has adjusted its bed slope to generally transport sediment through a given reach without net erosion or deposition (Leopold, 1964). Due to the highly developed and leveed state of the Puyallup system within the Study area, it is doubtful that such an equilibrium state could exist within the confines of the existing levied system. Following the last ice age, developed areas such as Orting, Pacific, and Puyallup existed as massive alluvial fans consisting of braided channels and massive gravel bars that were periodically buried by catastrophic mud flow events. Returning the system to even a quasi-equilibrium state, if it ever really existed, is likely not possible given the present level of development. The result of confining rivers in this system has been a need to dredge or to raise levees higher in the most active depositional areas.

Sediment is transported from Mount Rainier to the Puget Sound through a sequence of glacial and river processes working simultaneously to deliver material downstream. Sediment sources include that from both melting glaciers triggered by rainfall events as well as episodic slope failures along upland areas of the system. Sediment loads range from fine suspended sediments to coarse gravels and boulders transported as bedload. The major tributaries in the basin originate from glaciers on the slopes of Mount Rainier and carry large rock (cobbles and gravel) and finer sediments downstream, with high suspended sediment and bed-loads. As the basin topography transitions from the Cascade Mountains to the Puget Sound lowlands, a change in stream gradient occurs, creating sediment deposition areas where sediment can accumulate. In the lower Puyallup River below the confluence with the White River, the low gradient of the river is conducive to the deposition of suspended sediment. In the study area upstream of the Puyallup-White confluence, bedload is deposited. Upstream of the confluence of the White and Puyallup rivers, steep slope headwaters of each of the major tributaries transitions to flat lowlands. The steeper river reaches are characterized by canyons which serve as sediment transport zones. Once the slope of each river decreases, river's sediment transport capacity is reduced resulting in deposition in the lowland reaches. At the time, the 1931 Corps report was completed, the extremely high sediment loads were recognized which had previously led the Corps to abandon a Federal navigation channel on the lower Puyallup River due to the high frequency of maintenance required to adequately provide for sufficient navigation depths.

Sediment deposition and the associated reduction in channel capacity is a primary driver for recent changes to flood risk in the Study area. Most of the Study area is generally experiencing long term channel aggradation resulting in a reduction of channel capacity. USGS completed an analysis of topographic and bathymetric survey data in 2010 for the major tributaries along with sediment analysis and geomorphic interpretation (USGS 2010). The analysis of this report compared surveyed river cross-sections from 1984 with information from equivalent locations in 2009. Analysis shows decreasing channel capacity at a number of locations within the Basin (Figure 2-6), with a loss of channel depth of several feet in some areas. The USGS report concludes that the reduction in channel capacity is correlated to sediment transport patterns demonstrated through modeling conducted. The reduction of channel capacity has an adverse impact on stage-discharge relationships, resulting in a higher frequency for flood stages. This became very apparent on the White River during the 2009 flood. After the flood peak, MMD releases were ramped up to 12,000 cfs to begin evacuating flood storage. During the previous flood, November 2006, a similar amount of water was released from MMD without issue. In 2009 however, there was significant flooding at the town of Pacific, WA. Subsequent investigation showed that bedload deposition since 2006 had reduced the channel capacity in this area to approximately 6,000 to 8,500 cfs. In 2015 releases of 6,000 from the dam (which does not include local inflows) caused flooding in the same area further illustrating the reduction in channel capacity.

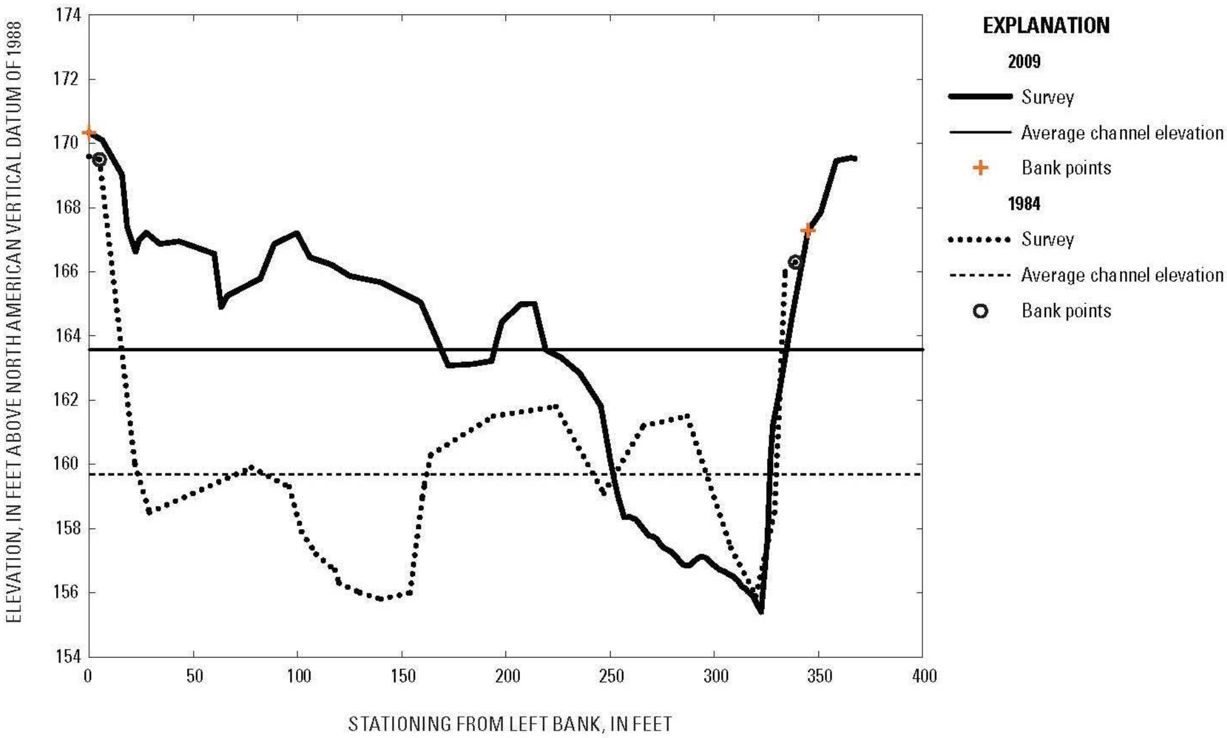


Figure 2-6. Comparison of Average Channel Elevations at Cross-Section P120 (RM 20), Upper Puyallup River (USGS, 2010)

Once sediment arrives and deposits in the Puyallup riverine system, there are limited methods for managing sediment to reduce flood risk. Sediment management is further complicated by the risk of more intense precipitation in western Washington from climate change. As a result, larger floods may lead to increased sediment production and delivery from Mount Rainier in the future. Sediment within the system had previously been actively managed by local entities. Monitoring of bed aggradation would trigger excavation of river beds on all three of the major tributaries. From the 1970s to the 1990s, concerns regarding salmon habitat led to agreements between tribal interests and Pierce County to reduce the overall amount of disturbance along the river including vegetation and sediment removal. In 1998, the State of Washington approved an administrative law which prohibited dredging to lower the average channel cross-section. This effectively eliminated the practice altogether.

2.7.3 Existing Flood Risk Management

The Basin consists of 28 levee segments currently in the Corps' National Levee Database (NLD). This includes 26 non-federal levees and two federally owned and operated levees on the lower Puyallup River. In addition, the Flood Control Act of June 28, 1938 provided for the construction and maintenance of a channel conveyance project on the lower Puyallup River. Completed in 1950, the federally constructed and maintained levees were built from RM 0.7 to RM 2.8 on the lower Puyallup River and were authorized as a companion project to MMD. The levees are 2.2 miles in length on the left and right banks.

The Basin contains a patchwork of locally constructed and maintained levee systems on each of the tributaries. Most of the non-Federal levees were constructed during a period between the 1910s and the 1930s and many have been repaired, realigned or otherwise modified in the ensuing decades. Due to the age and condition of the infrastructure, reliability of flood risk management works is of critical concern to the County. Major flood events in 1996, 2006, and 2009 resulted in overtopping, scour, and breaching of levees throughout the basin prompting significant repair costs and maintenance activities at a local level. Figure 2-7 through Figure 2-11 show the existing flood risk management features in the study area.

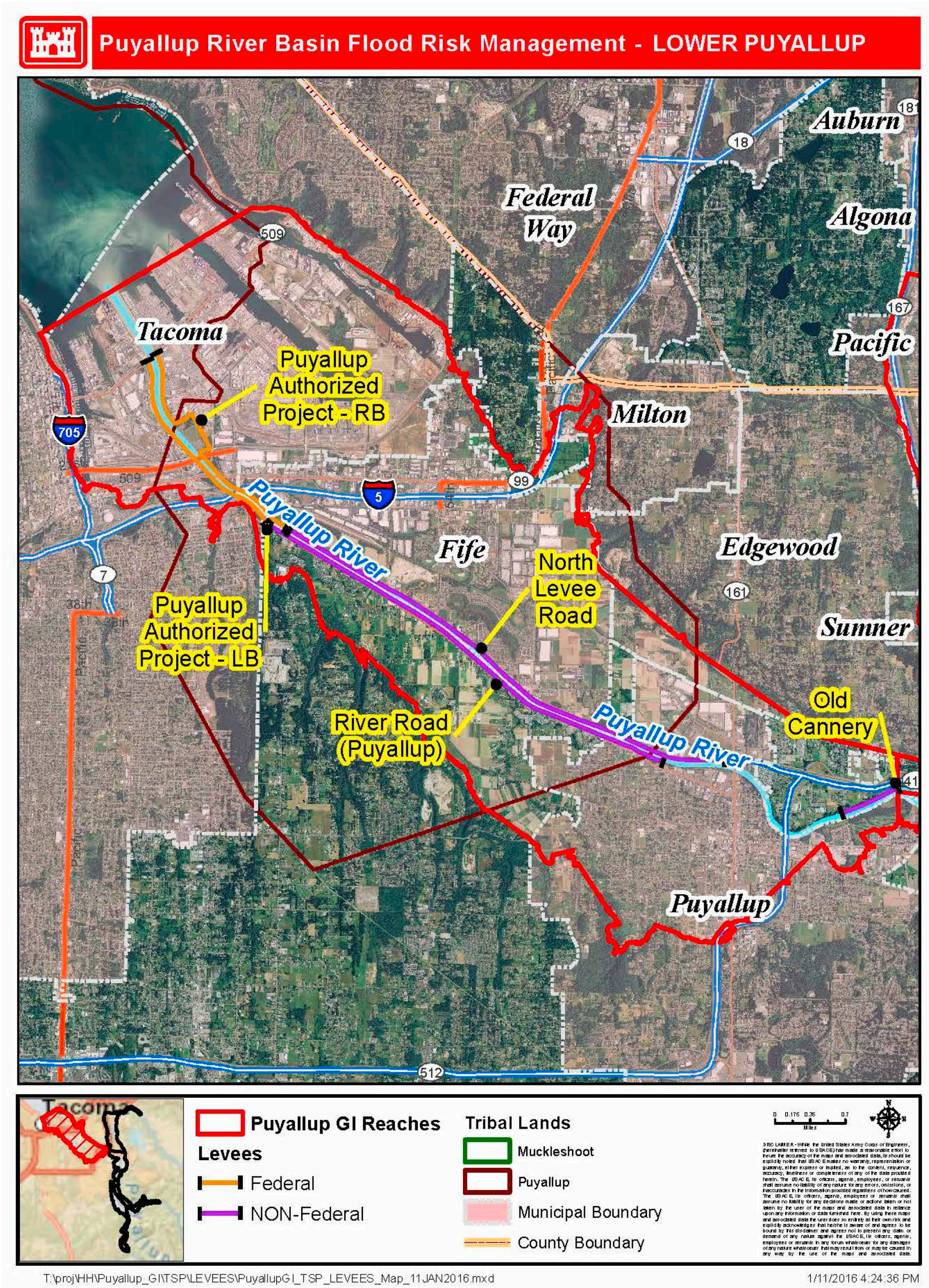


Figure 2-7. Existing Flood Risk Management, Lower Puyallup River

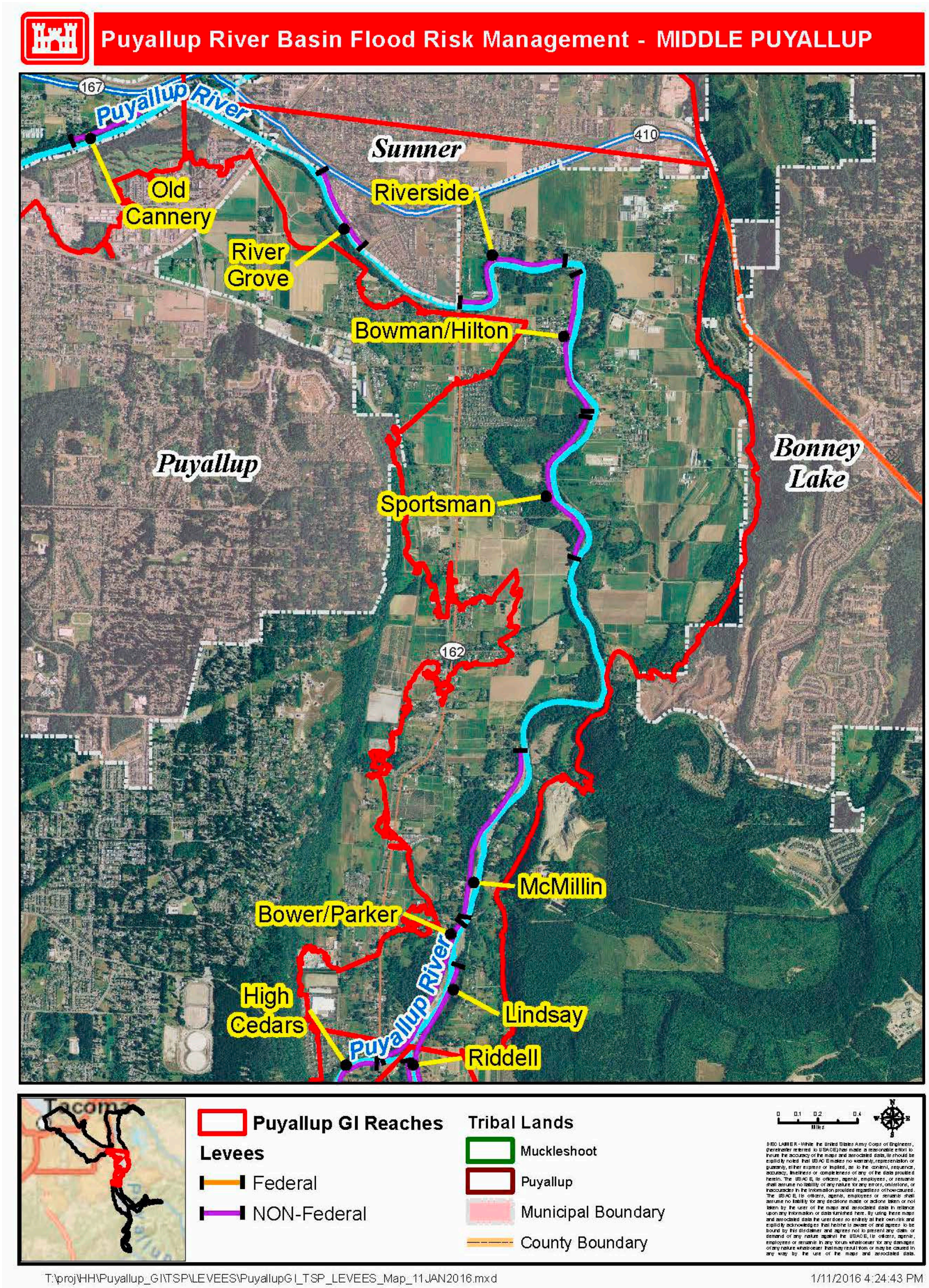


Figure 2-8. Existing Flood Risk Management, Middle Puyallup River

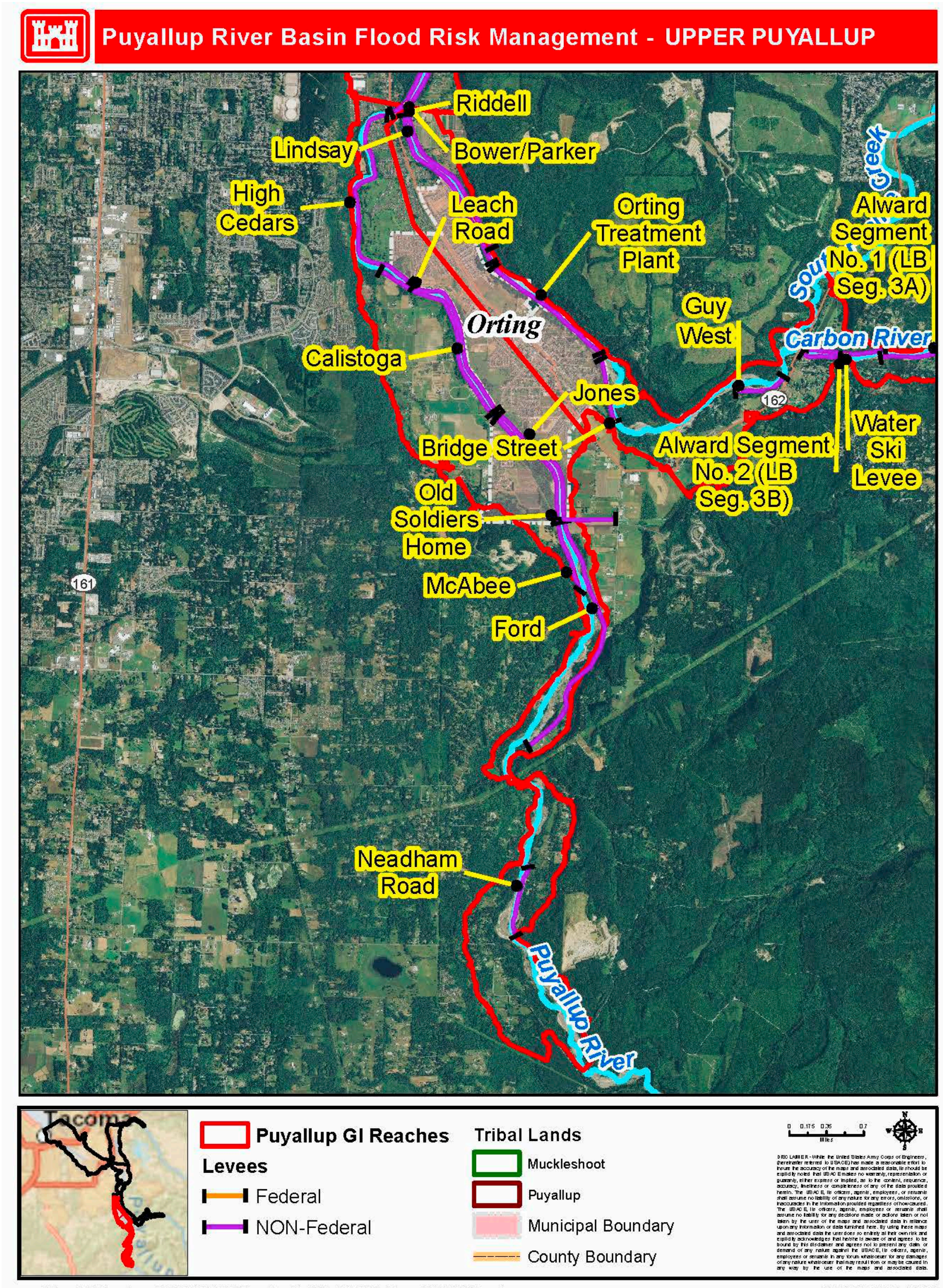


Figure 2-9. Existing Flood Risk Management, Upper Puyallup River

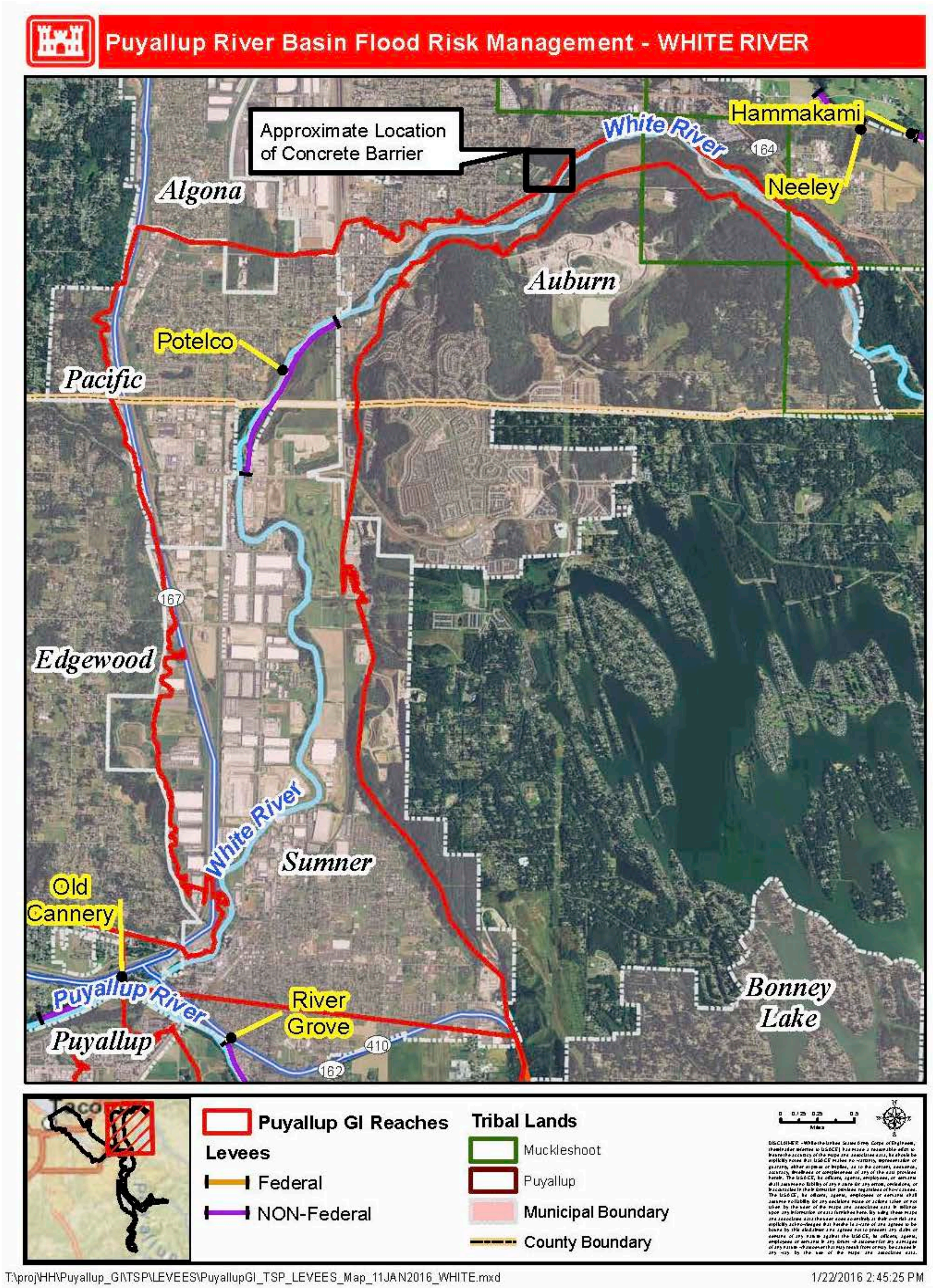


Figure 2-10. Existing Flood Risk Management, White River

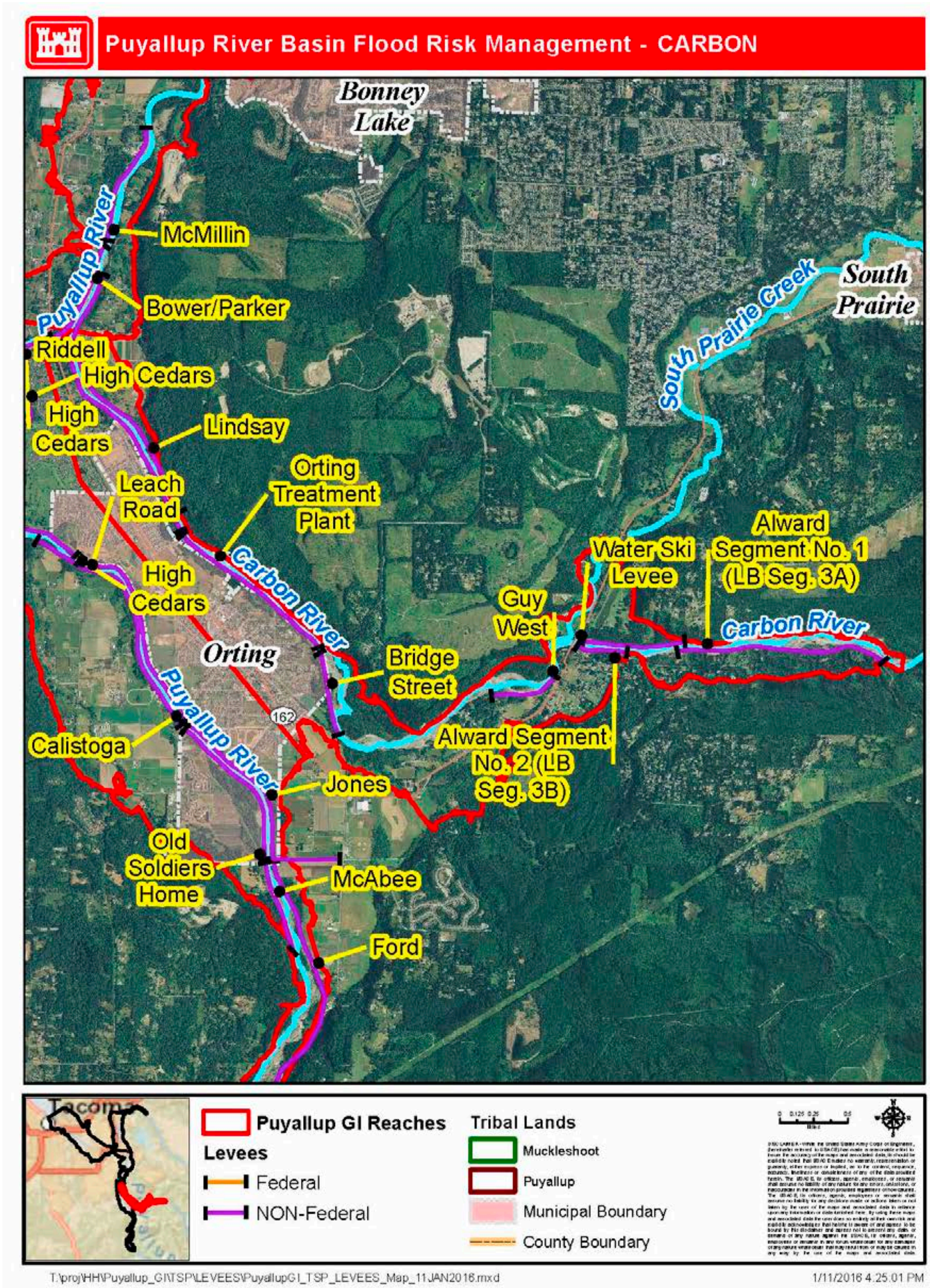


Figure 2-11. Existing Flood Risk Management, Carbon River

2.7.3.1 Existing Levee Performance and Reliability

To characterize the existing levee conditions the local geology, historic performance during flood loading, and probabilistic reliability assessment was performed for three primary failure modes: underseepage and piping, slope stability, and erosion. The reliability assessment was completed utilizing fragility curves, which provide a probability of failure based on hydraulic loading. The methodology for this effort can be found in part 2 of Appendix F (Geotechnical Appendix) and the results found in part 3 of Appendix F. The reliability assessment used geologic maps, existing subsurface explorations, and a 2011 geotechnical exploration specifically targeted to provide soil information for the development of the fragility curves. The geotechnical exploration information is available in part 4 of Appendix F. The levee systems were divided into major reaches to characterize the levees: the lower Puyallup River, the middle Puyallup River, the upper Puyallup River, the Carbon River, and the White River. A summary of the existing conditions is presented below. Additional detail in the site characterization can be found in part 1 of Appendix F.

Lower Puyallup

The levees in the lower eight miles of the Puyallup River include two non-Federal levees constructed around 1917 that use concrete panels for erosion protection and two Federal projects constructed in 1950 in conjunction with MMD. These existing levee structures range in height from approximately 3 to 12 feet in height with typical slopes of 2H:1V. The Federal projects utilize a light loose riprap blanket for erosion protection. Silt deposits have accumulated on the levee slopes in areas. Most significantly are the vegetated silt banks along North Levee Road. These features were not designed, but are considered advantageous to the prevention of lateral channel movement. Portions of this established silt bench experienced erosion during the 2009 flood event and were repaired by the County in 2009. Based on historic performance, the threat of lateral channel migration has been characterized as low. However, the non-Federal levees were constructed with a concrete panel slope protection that is nearly 100 years old and the scour protection was a brush mat design that is no longer evident in numerous locations. At the time of the levee construction, the Puyallup River was artificially straightened cutting off portions of active channel at a few locations. These locations are visible in aerial photographs circa 1940 and in LiDAR data sets. Historic performance has included underseepage and piping during the January 2009 flood event on the North Levee Road Levee which loaded the levee to approximately 90 percent of the levee height. The seepage boils and shallow landside slope instability occurred in a localized location of the ShaDadx environmental restoration site at a cutoff portion of the historic Puyallup River alignment. This location was identified and used as the potential failure point for the North Levee Road in the development of the fragility curve (Appendix F, parts 2 and 3). In summary, the Lower Puyallup levees have performed relatively well given significant loadings experienced in 2006 and 2009. The ageing concrete panels and underseepage concerns in localized areas of historic channel cutoffs are the primary potential failure modes and drivers for characterized levee reliability in the fragility curves.

Middle Puyallup

The Middle Puyallup region includes seven levee segments within the Corps' National Levee Database (NLD). The levees are relatively short; overtopping is considered more likely than a prior to overtopping breach. Most of the levees in this region have received unacceptable maintenance ratings based on levee inspection criteria in of the P.L. 84-99 program. These levees are currently eligible, as of December 2015, based on Pierce County's participation in the system wide improvement framework (SWIF) program. The levee structures have experienced numerous ovetopping and erosion damages during moderate and major flood events including 1995, 1996, 2006, 2008, and 2009. Erosion is the most significant failure mode in the Middle Puyallup. The current unacceptable condition of the levee is anticipated to impact performance of the levee structures (Appendix F, parts 2 and 3).

Upper Puyallup

The Upper Puyallup region includes eight levee segments within the NLD. At the time of construction in the 1960s, the levees straightened and reduced the channel width. The levees were constructed of side cast spoils form the channel and armored the embankments with riprap. Foundation soils are primarily alluvial deposits of unconsolidated sands and gravels. The levees have experienced significant and recurring erosion damages including levee breaches (See part 1 of Appendix F for a table of historic damages from 1990 to 2009). The City of Orting, Pierce County, and the Corps have helped sponsor and construct setback levees in the reach to return the active channel to historic widths. The Calistoga Levee setback (2014), Old Soldiers Home Levee Setback (2006), and the Ford Levee setback (1996) were constructed based on this floodplain management strategy with success. Erosion remains the primary failure mode for these levees. Based on current understanding of the channel hydraulics, historic levee repairs have identified the need to increase the size of the riprap gradation and thickness of the armoring blanket. Seepage and stability were not major risk contributors based on the probabilistic analysis based on the levee geometry and height to width ratio of the existing sections.

Carbon River

The Carbon River region includes eight levee segments within the Corps' NLD. The construction, condition, and performance of the Carbon River levees are very similar to the levees along the Upper Puyallup region. Again, the levees were constructed in the active river floodway straightening and narrowing the channel. The river reach is steep and erosion damages have been prevalent, especially on the upper levee segments (Alward Segment 1, Alward Segment 2, and Water Ski). The probabilistic analysis identified these levees as having the highest probability of poor performance in the study area due to erosion (See part 3 of Appendix F). The findings of the analysis is supported by historic performance which has included numerous and recurring damages and levee breaches resulting in flooding of the associated leveed area.

White River

The White River reach only has one levee segment within the Corps' NLD. The levee segment is in poor maintenance condition and a planning study by King County is developing a setback levee design. The reach is governed by overbank flooding conditions rather than levee performance.

Performance summary

Several levees within the study area do not meet current USACE levee maintenance criteria and have performance vulnerabilities prior to overtopping. Table 2-5 summarizes the estimated performance of levees with and without geotechnical fragility (the risk of poor geotechnical performance of the levee at a given water surface elevation or flood frequency) along the Lower Puyallup reach left and right banks to show the significance of the geotechnical condition of the levees in overall levee performance. Although failure is most likely to occur near the top of levee, the likelihood that the levee on the Lower Puyallup right bank (DR_67) would contain the 1% ACE peak flow is nearly twice as great at 13% if there were levee integrity concerns. With levee fragility, that assurance for the same peak flow condition is 6%.

Table 2-5. Performance of Existing Levees

Median Flood Frequency	Assurance with Fragility	Assurance without Fragility
Lower Puyallup Right Bank (DR_67)		
10% (1/10)	57%	93%
1% (1/100)	6%	13%
0.4% (1/250)	0.2%	3%
Lower Puyallup Left Bank (DR_60)		
10% (1/10)	88%	99%
1% (1/100)	49%	65%
0.4% (1/250)	26%	46%

Three without-project levee breach scenarios were developed and evaluated to determine the inundation area for flood events of different magnitude within the study area. Figure 2-12 is a summary, or composite, of the 1% (1/100) ACE inundation areas for the entire study area from all evaluated breach and levee overtopping locations that have less than a 90% reliability for a given mean annual exceedence event (in this case 1%). While this floodplain is larger than would likely be seen in a single flood/breach event, it is meant to represent the relative residual risk for the area from all remaining breach locations. This figure shows that several communities along the Puyallup and White Rivers would be flooded, including portions of the Port of Tacoma near the mouth of the Puyallup River. Additionally, several evacuation routes and major transportation corridors are at risk in the Lower Puyallup reach.

Geotechnical issues, such as underseepage breach failures, result in large volume flood flows at high velocities that are sudden and unpredictable. These failures allow for minimal warning time and minimal time for effective implementation of evacuation and emergency plans. Study area flood events generally occur during the winter months when cold air and water temperatures significantly increase the risk of death by exposure. The probability of unexpected levee failure coupled with the consequence of basin-wide flooding presents a continued threat to public safety, property, and critical infrastructure in the Puyallup Basin.

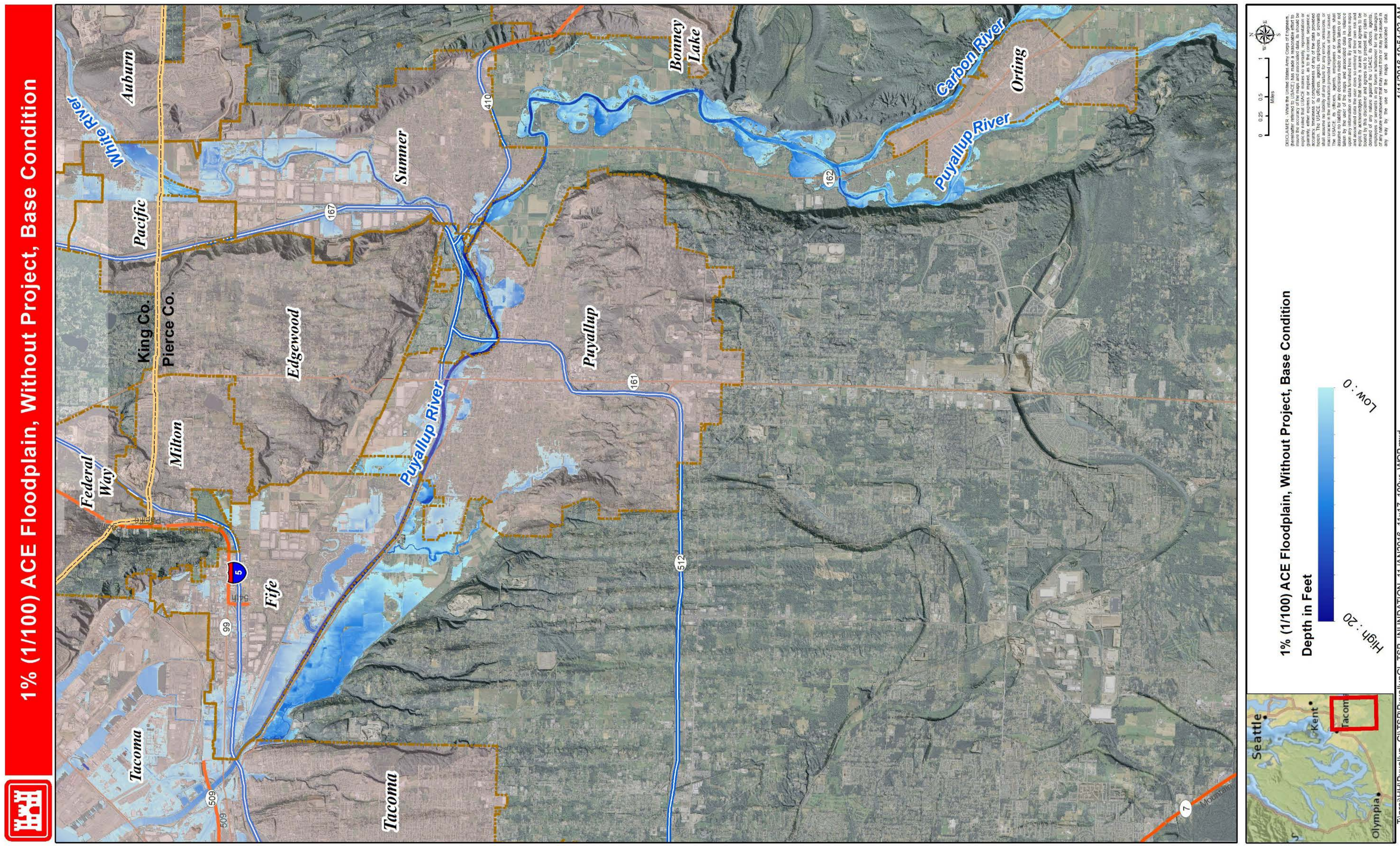


Figure 2-12. 1% (1/100) ACE Composite Without-Project Floodplain, Existing Conditions

This page intentionally left blank.

2.7.3.2 Emergency Planning

The existing County flood education and outreach program includes a website, flood preparedness trainings, a flood warning system, technical assistance to respond to citizen flood-related inquires, outreach at local fairs and events, brochures, and an annual mailing for floodplain residents in unincorporated Pierce County .

In addition, the County has a four phase flood warning system (Pierce County, 2013) (Table 2-6):

- Phase 1 – No Flooding -no flooding is occurring; however, river flows may be at an elevated flow stage;
- Phase 2 – Minor Flooding – minor flooding is likely to occur. Low lying areas and pasture may flood due to rivers or streams overtopping their banks;
- Phase 3 – Moderate Flooding – moderate flooding is likely to occur. Adjacent property may be flooding and have more dangerous high-velocity flow and debris; and
- Phase 4 – Severe Flooding – severe flooding is likely to occur. Adjacent and nearby property may be flooding with a very dangerous high-velocity flow, debris and deep water.

Table 2-6. Four-Phase Flood Warning System in Pierce County

River System (location)	Phase 1	Phase 2	Phase 3	Phase 4
Middle/Lower Puyallup River (Puyallup gage)	Less than 25,000 cfs	25,000-30,000 cfs	30,000-45,000cfs	> 45,000 cfs
Upper Puyallup (Orting gage)	Less than 4,500 cfs	4,500-8,000 cfs	8,000-10,000cfs	> 10,000 cfs
Carbon River (Fairfax gage)	4,000 - 6,500 cfs	6,500 - 8,000 cfs	8,000 - 10,000 cfs	> 10,000 cfs
White River (Auburn gage)	6,000 - 8,000 cfs USGS	8,000 - 12,000 cfs	12,000 - 15,000 cfs	> 15,000 cfs
White River (above Buckley)	2,500 - 6,000 cfs	6,000 - 8,000 cfs	8,000 - 12,000 cfs	> 12,000 cfs
(Pierce County, 2013)				

Multiple County departments have been involved in flood-related activities, including coordination with cities, towns, tribes, and other agencies located in the County (Pierce County, 2013).

The County trains its responders in the Federal Incident Command System (ICS) and the National Incident Management System guidelines for response in the field and in emergency operation center operations. The County's Comprehensive Emergency Management Plan (CEMP) follows the federal recommendations and is consistent with national guidelines and the Washington state-level CEMP (Pierce County, 2013).

The County has sandbag and other flood fighting materials procedures for before, during and after events that include: pre-flood coordination of volunteers, public education, and flood fighting materials; dissemination of information and coordination of resources during a flood event; and informing users about disposal of sandbags after an event (Pierce County, 2013).

2.7.3.3 Mud Mountain Dam (MMD)

MMD is an existing Federal flood control dam authorized to regulate conveyance flows during flood events at the lower Puyallup River to 50,000 cfs and lower White River to 12,000 cfs. MMD is designed to work in tandem with Federal levees downstream near Tacoma in order to reduce the peak flood stages and protect the most densely populated areas of the Basin. As a result of sediment aggradation and decreased channel capacity in the White River near Pacific, MMD is presently operated under an approved deviation from the Water Control Manual. The deviation allows lower managed outflows during flood events (limited to no more than the approximate channel capacity flow of 6,000 to 8,500 cfs, rather than 12,000 cfs). The deviation has been approved through Water Year 2016, while the feasibility study identifies long-term solutions to the flood risk problems in the Basin. Early in the Study, the Corps vertical team, including the Corps' Northwestern Division (NWD) and Headquarters (HQUSACE), resolved an important question about future MMD release assumptions for purposes of the Study. At the time of the vertical team discussion, when the existing conditions model was being developed, a MMD outflow of 8,000 cfs remained within the channel capacity. Given the relatively short time frame (i.e. several years) associated with deviation requests and the uncertainty regarding the approval of any future similar requests, the vertical team decided that, for study purposes, MMD operations during flood events would be depicted as follows:

- For Existing Conditions, limit releases to 8,000 cfs for the White River and 50,000 cfs for the lower Puyallup River
- For Base Year and Future Without-Project Conditions, releases would be as stated in the approved Water Control Manual (limiting releases to 12,000 cfs for the White River and 50,000 cfs for the lower Puyallup River).

MMD was authorized and constructed for flood control as Mud Mountain Reservoir by the Flood Control Act of 22 June 1936, 74th Congress, 2nd Session. The Flood Control Act of 1938 provided for operation and maintenance (O&M) of the project by the Corps and the Flood Control Act of 1944 authorized construction and O&M of recreational facilities at the project.

MMD operation and the construction of levees in the system changed the character of floods in the Basin. MMD storage reduces peak flows on the White River and lower Puyallup River compared to the natural condition, but creates higher flows after the peak has passed. The presence of levees reduced the amount of natural floodplain storage available to reduce flood flows.

MMD is an earthen structure which, at the time of its construction, was the highest rock and earth filled dam in the world. MMD and its appurtenant works consist of a rolled earthfill dam, a concrete-lined spillway, and two concrete-lined outlet tunnels. The core of MMD is a compacted blend of approximately 3,000,000 cubic yards (cy) of sand, gravel and glacial till. Upstream and downstream sides of the dam are crushed rock covered by large quarry rocks. The massive weight of the rock holds the core firmly in place. The two tunnels channel the river through the dam and regulate downstream discharges. A 9-foot-wide tunnel passes normal flows and most bedload sediment. A 23-foot-wide tunnel is used during periods of high flows and high pools. The dam is approximately 425 feet high and 2200 feet thick at the base along the river bed.

MMD generally provides flood flow management during winter peak flow events between October and March and can provide approximately 106,000 acre feet of storage for use in regulating floods. Under the original authorization, MMD was primarily intended to protect the Puyallup Valley and the Tacoma industrial area against floods having an unregulated discharge of about 80,000 cfs at Puyallup. This is achieved through reduction of flows delivered by the White River to the Puyallup River at their confluence 10.4 miles above the mouth of the Puyallup River. At the time of the MMD authorization, it was assumed that the discharges of the White River and Puyallup River were approximately equal. Therefore, by holding the White River discharge to 10,000 cfs, a natural flood of 80,000 cfs at Puyallup could be reduced to 50,000 cfs through the reduction provided by the dam.

During peak discharge, flow on the White River is retained by MMD until the flood peak on the lower Puyallup River has abated, at which time releases from MMD are increased to evacuate water and regain reservoir capacity in preparation for subsequent storms (USACE, 2009). The intake structure of the dam and the 9-foot tunnel is near the elevation of the channel invert of the White River; the reservoir is empty for much of the year, which allows the river to flow through the dam reach at a grade similar to the pre-dam river profile. Unlike other dams where trap efficiency of bedload can approach 100 percent, MMD passes significant volumes of bedload containing particles as large as boulders (Rick Emry, U.S. Army Corps of Engineers, written commun., 2010).

The Lake Tapps diversion currently (as of 2010) is operated by Cascade Water Alliance. Water is diverted from the White River near Buckley (RM 24.3) through the Lake Tapps diversion and then is returned to the White River near Dieringer (RM 3.6). The diverted water can contain a large amount of sand, which deposits in settling basins in the flume. These are periodically cleaned to maintain flow to the lake (Joe Mickelson, Cascade Water Alliance, oral commun., 2010).

Since construction of MMD, communities downstream of the dam have developed. Flood damages today may be incurred along the lower White River when releases from MMD are approximately 6,000 cfs cfs. During the December 2015 flood, the “White River at R Street Near Auburn” USGS streamgage (#12100490) reached approximately 8,000 cfs. MMD outflow at that time was approximately 6,000 cfs. These flood-damage thresholds are subject to change given the dynamic nature of the White River channel and potential for continued loss of channel capacity due to sediment aggradation. Releases are carefully monitored and spotters are used to prevent damages from occurring to the greatest extent possible. The Corps’ MMD Water Control Manual regulates the White River flows to avoid discharges above 12,000 cfs to the greatest extent possible within the hydraulic limits of the dam. The control flow on the Puyallup River is 45,000 cfs gage flow at Puyallup. Although the channel capacity in the lower Puyallup is 50,000 cfs, the control flow is established at 45,000 cfs to provide a factor of safety against forecasting errors.

When flow at the Puyallup gage is projected to exceed the control flow within 8 hours, then MMD discharges are regulated to hold downstream flows at the control flow (45,000 cfs) until the flood is over. Since MMD controls only 42-percent of the Puyallup River Basin, the required flow reduction at MMD may be substantial. For example, during the 1996 flood of record, MMD discharges were reduced to less than 500 cfs for several hours. Evacuation (drafting) of storage begins after flood forecasts indicate a falling trend in the flow at Puyallup and a discharge below 45,000 cfs for at least two consecutive hours. The dam then releases all of the stored water downstream into the river.

During non-flood periods, the dam is operated as a run-of-river project with outflows equal to inflows. The two tunnels allow for passage of water, fish, small wood debris, and sediment downstream through the dam. The smaller 9-foot tunnel is used primarily for run-of-the-river flows while the 23-foot tunnel may operate independently when necessary (e.g. during maintenance on the smaller tunnel). In addition to flood events, water storage behind the dam occurs as needed to facilitate maintenance activities including repair of the barrier structure at the Buckley fish trap-and-haul facility.

2.7.4 Existing Economic Conditions

Land use within the basin ranges from rural, public and resource lands in the upper watershed to high density residential, commercial and industrial development near the outlet to Puget Sound at Tacoma. As such, the study area focuses on the populated portion of the basin, particularly the floodplain areas of the Puyallup River and major tributaries, the White River and Carbon River. Moving downstream throughout the study area, the floodplain becomes progressively urbanized, densely populated and characterized by significant development.

The dominant land use within the developed portions of the study area is residential; however, significant areas of vacant, public or resource lands, and open space exist within the study area (Figure 2-13). The area near the mouth of the Puyallup River in the Lower Puyallup is dominated by industrial and commercial land use. The three largest cities within the study area include portions of Tacoma, Puyallup and Auburn.

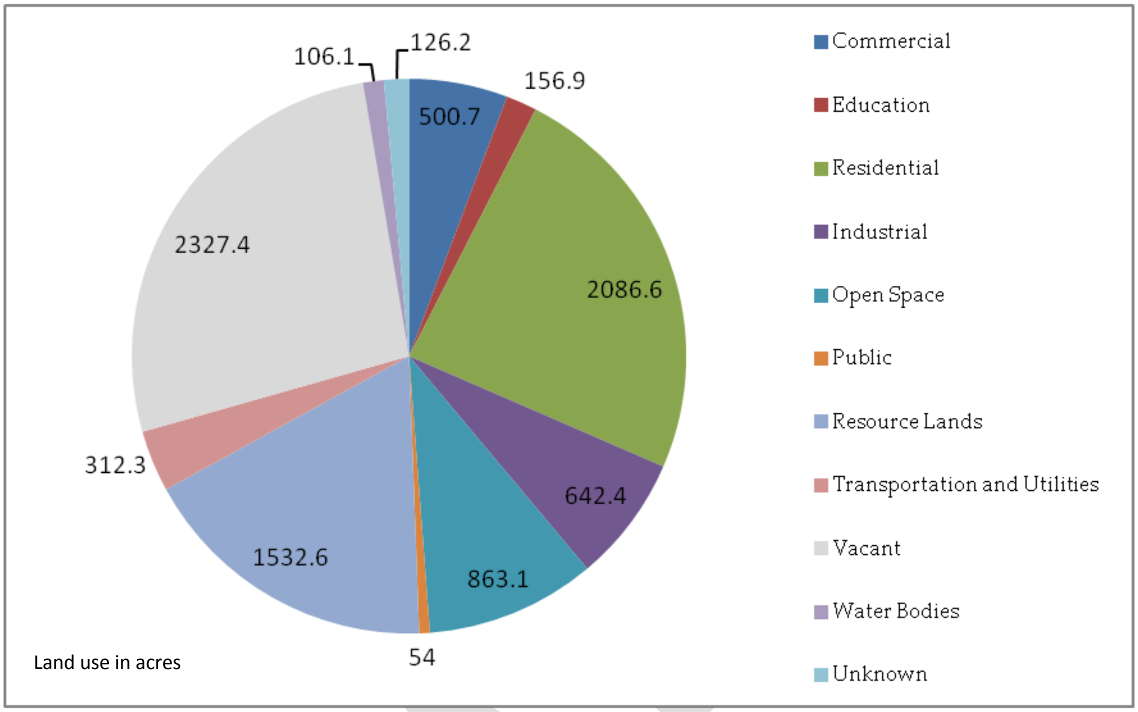


Figure 2-13. Puyallup Basin Land-Use within the Designated FEMA 1% ACE Floodplain

The Port of Tacoma comprises a six square mile area of land located at the mouth of the lower Puyallup River at the entrance to Puget Sound at Commencement Bay, existing on lands both within and outside of the study area. The Port owns and operates a 2500-acre industrial park on the shores of Puget Sound which includes terminal facilities, rental lands and an oil refinery. In 2010, the Port facilitated the movement of $28 billion in trade of materials, consisting primarily of container transport, making it one of the busiest ports in North America. Upstream of the Port of Tacoma lies the city of Fife which is entirely located within Puyallup Indian Tribe reservation lands and holds industrial and commercial areas within the floodplain of the lower Puyallup River comprised primarily of warehouses, transport distribution centers, as well as a casino owned and operated by the Puyallup Tribe of Indians. Near the confluence of the White River and Puyallup River is the city of Puyallup. The city contains the highest density of residential and commercial development within the basin, stretching downstream from the confluence to the city of Fife. There are extensive Federal and non-Federal levees on both sides of the lower Puyallup River reach which protect the Port of Tacoma, Fife, and the city of Puyallup.

Moving upstream on the Puyallup River, the land use begins to transition to lower density suburban and agricultural land uses. The city of Orting lies two miles upstream of the Carbon River-Puyallup River confluence and is situated between the two rivers. Upstream of Orting, land use consists primarily of agricultural lands and rural residential properties as both the upper Puyallup and Carbon Rivers move towards their headwaters through working forests and ultimately Mount Rainier National Park.

Upstream of the confluence with the Puyallup, areas adjacent to the White River within the cities of Sumner and Pacific are zoned as industrial and the city of Auburn holds a large area of commercial and industrial zoning within the study area. These areas support warehouses and storage yards which include support for lumber, manufacturing and agriculture. This includes the largest airplane parts manufacturing center in the world, with 2.1 million feet of production space. Both the cities of Pacific and Auburn hold large residential populations adjacent to the river, however, this density transitions to rural and agricultural land use following the river upstream. Urban growth plans for these communities highlight future annexation and rezoning of agricultural lands for future residential use. The city of Buckley is the last small urban community within the upstream portion of the study area. Reaches upstream of Buckley increase in slope, flowing through private, State and Federal forest lands.

Summary statistics for land uses within the FEMA 1% ACE probability floodplain are included below in Table 1. A summary map of land uses within the Study area is included below in Figure 4[2].

Table 2-7. Puyallup Basin Land Use Within FEMA 1% ACE Floodplain

	FEMA 100-Year Floodplain Land Use (acres)												Floodplain Residents	
Reach	Commercial	Education	Residential	Industrial	Open Space	Public	Resource Lands	Transportation and Utilities	Vacant	Water Bodies	Unknown	Total Acres	Structures	Population (2010)
Lower Puyallup (RM 0.0-10.4)	446.7	89.2	811.3	379.1	306	30.3	464.6	197.6	733.9	36.4	58.8	3553.9	3902	7469
Middle Puyallup (RM 10.4-17.4)	1.3	20.7	305.2	4	100.4	0.5	195.9	1.9	263.1	7	40.4	940.4	583	4169
Upper Puyallup (RM 17.4-29.0)	3.5	22.4	597.3	0.2	188.5	23.2	600.6	57.2	699.7	7.1	23	2222.7	1976	5063
White River (RM 0.0-5.5)	49.2	0	24.9	259.1	136.4	0	0	38.4	335.9	5.6	0	849.5	159	756
Carbon River (0.0-8.0)	0	24.6	347.9	0	131.8	0	271.5	17.2	294.8	50	4	1141.8	593	2702
Total	500.7	156.9	2086.6	642.4	863.1	54	1532.6	312.3	2327.4	106.1	126.2	8708.3	7213	20,159
*Source: Pierce County Risk Assessment (2011)														

[2] This figure was prepared in 2011 as part of a socioeconomic report (Northern Economics, 2011). The study area boundary has since been refined for other figures in this DFR/EIS, including the TSP features figure in Section 5.

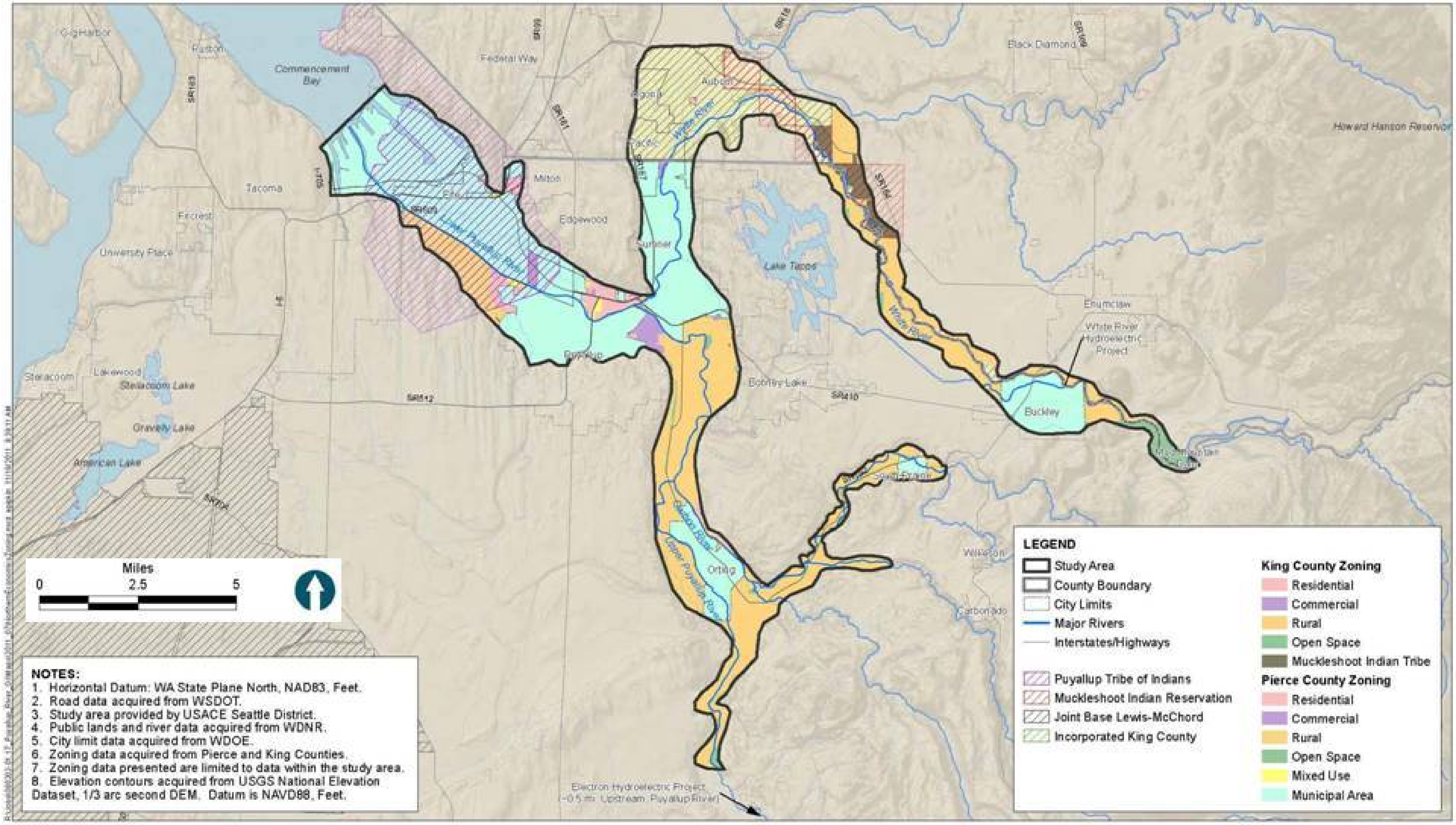


Figure 2-14. Land Use, Puyallup Basin

Major roadways within the study area include Interstate 5 (I-5) and State Route 167 (SR-167), also known as the "Valley Freeway." These two arterial highways provide north-south regional connections between Tacoma, surrounding communities, and Seattle to the north. State Route 410 (SR-410) provides an east-west connection to Yakima, Washington over White Pass to the west. Major transportation corridors are identified with summary traffic counts in Figure 2-15 (Northern Economics, 2011).

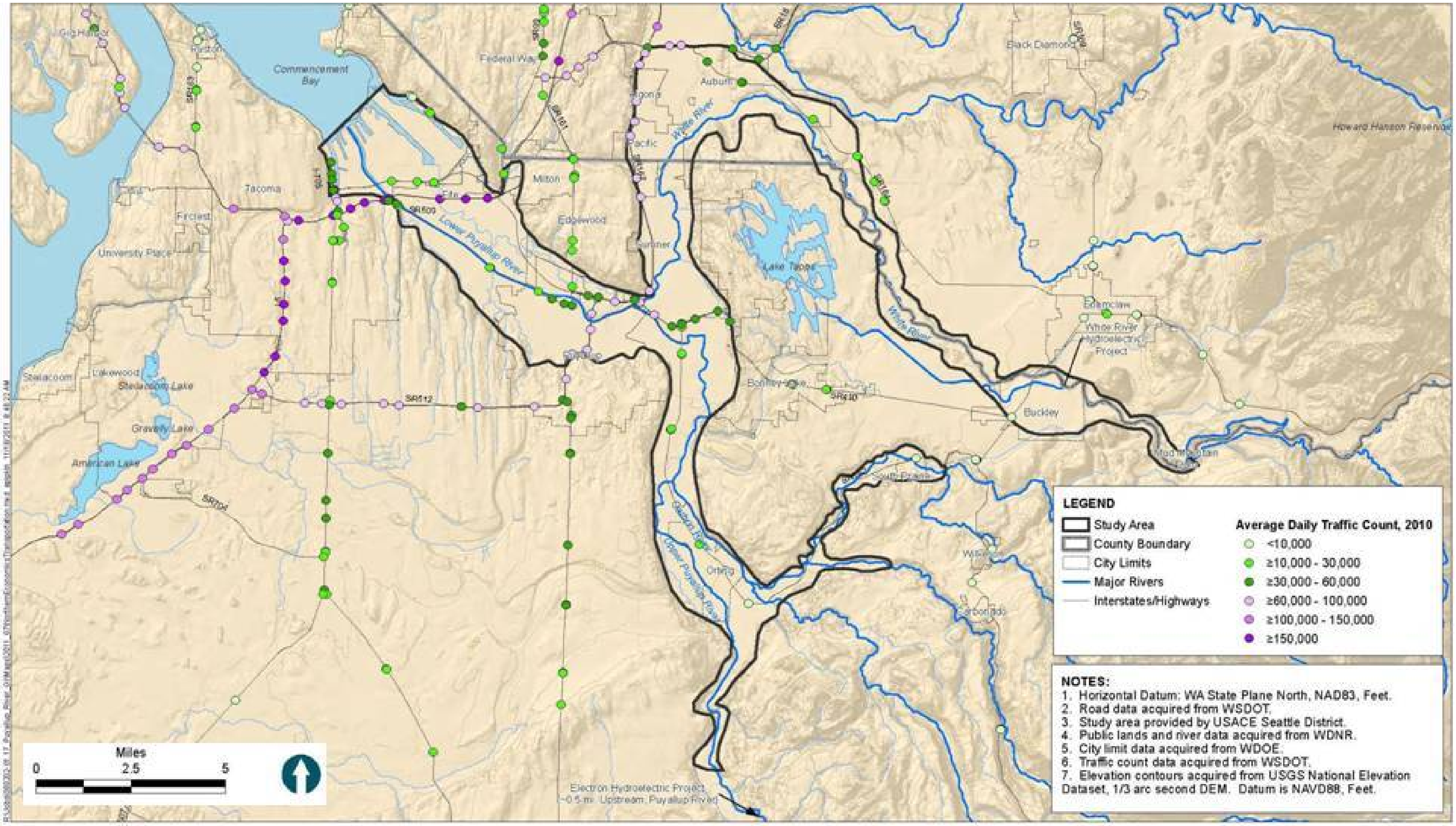


Figure 2-15. Major Transportation Corridors and Traffic Counts, Puyallup Basin

Several railways facilitate transport of people and goods through the study area and to-from the Port of Tacoma. The Union Pacific Railroad passes through Pacific and crosses the Puyallup River north of Puyallup on approach to the port. Burlington Northern Santa Fe Railway (BNSF) runs parallel to the Union Pacific Railway, crossing the White River at Auburn and then the Puyallup River at Sumner on approach to the port. Amtrak provides rail service connecting Eugene, Oregon and Vancouver, British Columbia on BNSF rail lines. In addition, commuter rail service is also administered by regional entities on the BNSF lines. An inventory was created following standard USACE methods. For the study area, a base GIS inventory with parcel attribute data was used for Pierce and King Counties. Field visits were conducted to collect and validate base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial, public, and farm building categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of the existing damageable property (structures, contents, and vehicles for residential structures) within the Puyallup Basin study area is estimated at $5.4 billion (October 2015 prices) as shown in Table 2-8. The lower Puyallup River reach makes up 63% and the White River makes up of 16% of total value in the 0.2% ACE floodplain, or $3.4 billion and $873 million, respectively. In addition, industrial and residential structure occupancies make up 31% and 47% of overall value, respectively. Table 2-9 displays the structural inventory by land use category. Total study area existing without-project condition expected annual damages (EAD) are approximately $42 million as shown in Table 2-10.

Table 2-8. Value of Damageable Property, Existing Conditions (Value in $1,000s, Oct 2015 price level)

	Structures, Contents and Vehicles within 0.2% (1/500) ACE Floodplain					
River Reach	**Commercial**	**Farm Building**	**Industrial**	**Public**	**Residential**	**TOTAL**
Carbon River	$7,328	$1,917	$325	$13,563	$47,523	$70,656
Lower Puyallup	691,216	6,959	1,255,905	169,733	1,311,600	3,435,414
Middle Puyallup	94,646	4,293	37,498	38,139	511,448	686,024
Upper Puyallup	14,335	2,913	696	17,127	336,643	371,715
White River	130,372	591	383,562	21,437	336,902	872,865
TOTAL	***$937,897***	***$16,674***	***$1,677,987***	***$260,000***	***$2,544,117***	***$5,436,675***

Table 2-9. Structural Inventory – Existing Conditions

	Number of Structures within 0.2% (1/500) ACE Floodplain					
River Reach	**Commercial**	**Farm Building**	**Industrial**	**Public**	**Residential**	**TOTAL**
Carbon River	13	8	3	14	276	314
Lower Puyallup	474	25	391	66	5,566	6,522
Middle Puyallup	99	22	27	27	2,209	2,384
Upper Puyallup	24	14	4	13	1,476	1,531
White River	86	4	115	13	1,347	1,565
TOTAL	**696**	**73**	**540**	**133**	**10,874**	**12,316**

Table 2-10. Puyallup River Basin Without Project Base Condition Expected Annual Damages (EAD) (Oct 2015 price level, 3.125% discount rate, $1,000s)

River Reach	Commercial	Farm Building	Industrial	Public	Residential	Transit Delays	Total EAD
Carbon River	$0	$57	$5	$1	$84	0	$147
Lower Puyallup	2,920	85	3,585	562	1,804	617	$9,572
Middle Puyallup	85	20	312	53	1,705	0	$2,182
Upper Puyallup	23	119	0	19	751	0	$892
White River	1,031	1	5,796	0	21,918	0	$28,747
Total EAD	**$4,059**	**$281**	**$9,706**	**$635**	**$26,242**	**$617**	**$41,540**

Critical facilities consist of public service facilities which are important for maintaining public health and welfare, particularly during emergency response operations. Most of the existing critical facilities within the 1% (1/100) annual chance of exceedance (ACE) floodplain are located within the lower Puyallup River reach, however several schools exist within both the upper Puyallup River and Carbon River floodplains as summarized in Table 2-11. Approximately 35,000 people are at risk from flooding in the 1% ACE event who either live or work in the floodplain.

Table 2-11. Critical Facilities within FEMA 1% ACE Floodplain

Reach	Critical Facilities				
	Police Stations	Fire Stations	Wastewater Treatment	Schools	**Total (by reach)**
Lower Puyallup (RM 0.0-10.4)	1	2	2	4	**9**
Middle Puyallup (RM 10.4-17.4)	0	0	1	0	**1**
Upper Puyallup (RM 17.4-29.0)	0	0	0	2	**2**
White River (RM 0.0-5.5)	0	0	0	0	**0**
Carbon River (RM 0.0-8.0)	0	0	0	1	**1**
Total (by facility type)	**1**	**2**	**3**	**7**	**13**
Source: Pierce County Rivers Flood Hazard Management Plan, Risk Assessment (2012)					

2.7.5 Existing Environmental Conditions

This section summarizes existing environmental conditions in the Study area. Detailed analyses of the existing conditions/affected environment in the Study area are described in detail in Section 4 (Affected Environment and Environmental Consequences).

The Puyallup River, White River and Carbon River flow through heavily urbanized areas where the rivers have been channelized, straightened, and disconnected from their floodplain by levees and revetments before discharging into Commencement Bay. Due to extensive urban and industrial development starting as early as the 1870s, the entire Puyallup River estuary has been altered dramatically, with very little of the natural environment remaining (Simenstad 2000). Essentially, all of the habitat areas within the delta, including the historical estuarine transition zones, estuarine marsh and mudflats, and creek and river channels, have been significantly decimated and degraded.

Complex systems of side- and off-channel aquatic habitats that likely existed during the pre-settlement era no longer exist, because the river processes that formed these aquatic habitats were disrupted by channelization and construction of levees (Kerwin 1999). Riparian vegetation is generally lacking in the lower reaches of the study area, especially coniferous vegetation, which was historically present. Remaining riparian vegetation is fragmented and less than 5% of riparian areas can be considered functional (Simenstad 2000). There has been dramatic loss of estuarine, riverine, and wetland habitat processes and their associated functions throughout the Puyallup River Basin (Kerwin 1999). The Pierce County Environmental Health Trends (Pierce County 2008b) suggests that the historic loss and degradation of wetlands can be primarily attributed to the expansion of agriculture and the siting of ports and industrial facilities.

The Puyallup River basin supports several species of salmonids including: Chinook (fall and spring stocks; Oncorhynchus tshawytscha), pink (O. gorbuscha), coho (O. kisutch), chum (O. keta), sockeye (O. nerka), winter steelhead (O. mykiss), cutthroat (O. clarkii), native char (bull trout) (Salvelinus confluentus), and non-native brook trout (Salvelinus fontinalis). Chinook, steelhead and bull trout are all listed as threatened under the Endangered Species Act. Critical habitat for Chinook and bull trout has been designated throughout the study area (Federal Register 2005b, 2010a) and has been proposed as critical habitat for steelhead (Federal Register 2013). Proposed critical habitat designations have been excluded from Tribal Reservation lands.

The historic loss of estuarine, wetland, and channel habitat has been cited as a significant limiting factor in salmonid recovery within the watershed (Kerwin 1999). Commencement Bay has lost more than 98% of its intertidal and subtidal habitat to development (Kerwin 1999). The presence of levee/revetment systems throughout the study area remove the natural sinuosity of the rivers, limit spawning and rearing habitat for fish species, and prevent floodplain connectivity, adversely affecting salmon recovery. Maintenance of existing flood control infrastructure continues to limit riparian vegetation growth and perpetuates degraded habitat quality throughout much of the study area. MMD on the White River, and Electron Dam on the Puyallup River are modifications that affect stream flow and fish passage (Kerwin 1999). Adult salmon returning to spawn above the dams are collected in a trap-and-haul system at MMD and trucked around both dams on the White River. Smolt passage downstream occurs through the dams and not through the trap-and-haul system. On the Puyallup River, the Electron Hydroelectric Project (approximately RM 42) has blocked upstream passage for more than 90 years. The construction of a fish ladder in 2000 provided access to more than 10 miles of mainstem habitat.

2.8 Future Without-Project Conditions

The following conditions were forecasted for the most likely scenario if no Federal (Corps) flood risk management project were implemented in the study area. This establishment of the future without-project condition is required in the second step of the Corps planning process. The future without-project condition is used as the baseline against which the results and impacts of proposed study alternatives are compared for the same period of analysis. The future without-project condition is synonymous with the No Action Alternative under NEPA. These forecasts of future conditions are from the base year (year when a project is expected to be operational) to the end of the period of analysis (50 years). Future without-project conditions for this study are projected assuming base year 2026 and a 50-year period of analysis out to 2076. More information is included in Appendix B (Hydraulics and Hydrology), Appendix C (Economics) and in Section 4 of this report (Affected Environment and Environmental Consequences).

The river system is characterized by levees and revetments, seasonal flooding, sedimentation, channel migration, developed floodplain, bridge constrictions, and tributary backwatering effects. Forecasts of the future without-project condition consider reasonably knowledgeable actions, plans, and programs that would be implemented in the future to address the problems and opportunities in the study area, in the absence of a Corps project. Changes in land use, economic activity, and physical setting can affect flood damages. Future without-project projections have two major purposes: to determine how changes in drainage patterns that occur as a result of physical development will affect water surface elevation-frequency relationships and to determine how changes in development and how economic activity will affect water surface elevation – damage relationships. These two relationships are combined to estimate damages under the future without-project condition. With expected changes in land use, economic activity, and river morphology the future without project condition for the Puyallup River Basin is forecasted to include significantly greater flood risks than the conditions that currently exist.

2.8.1 Future Flood Conditions

The upper watershed is generally national park, wilderness, or forest service lands. No significant changes to land use that would alter flood hydrology are expected in these areas. Logging on Forest Service lands could increase or decrease depending upon federal policy, but neither course is expected to have significant impacts on flood hydrology.

The 1% and 0.2% ACE floodplains are forecasted to experience greater impacts from flooding under future conditions, increasing the risk to life safety, existing structures and critical infrastructure, as well as additional development that is expected to occupy the floodplain in the future. Traffic delays, school closures, railroad losses, decreased public service, and commercial and industrial business closures are also forecasted to occur for events more frequent than the 1% ACE probability flood event.

Actions by the Study sponsor may result in changes in flooding and sedimentation within the basin (see Section 2.8.4). Areas not modified by the sponsor will continue to see similar or more frequent damages as depositional areas of the river system aggrade (the river bed rises) and the levees remain static.

2.8.2 Climate Change and Sea Level Change

Hydrologic conditions are expected to change with climate change over the next 50 years. Hydrologic trends with climate change show a likely increase in river flows and transported sediment during the 50-year planning period of analysis. Sediment material conveyance and consequential deposition in the Puyallup River, White River and Carbon River creates an impediment to flood flow conveyance, raises water surface elevations during flood flows and redirects flows in a way that increases channel migration risks. Channel capacity in the Puyallup riverine system will continue to decrease and flood risks will continue to occur at lower discharges in the future than it does today. Sediment loading will continue to affect rivers downstream of Mount Rainier as long as this stratovolcano is actively producing sediment at the headwaters and large flood events transport the sediment into the fluvial system. Sea level change will likely increase stages on levees at the downstream end of the Puyallup River.

The three main parameters of interest are increased flood discharges, and increased sediment yields, and sea level change. Each of these factors can have an impact on future flood risks. The Corps' Engineering and Construction Bulletin 2014-10 requires a qualitative analysis of climate change variability in hydrologic analysis for inland watersheds. An increase in frequency and/or magnitude of extreme precipitation events (such as atmospheric rivers) will drive higher flows in rivers of the basin. Models from the University of Washington Climate Impacts Group indicate that over the next century, the Pacific Northwest will likely see a trend toward wetter, warmer winters and hotter, drier summers in response to climate change (Vano et al. 2009). Climate change during the next 50 years is projected to result in earlier snowmelt and reduced summer river flows (Vano et al. 2009). Based on recent studies, if climate change leads to increased rainfall, temperatures, and snowmelt, such changes will impact the runoff and discharge of rivers in the Puyallup River Basin. Prediction of future climate change in Washington state has included an 11.6% increase in runoff for 2010-2034 and an 18.1% increase in runoff for 2035-2059 (Czuba et al., 2012). Over the project life, an 18% change would translate a present day 0.01 ACE flow into a 0.05 ACE. An increase in runoff in the upper basin will transport more sediment from Mt. Rainier to leveed areas of the lower basin. This increase in sediment load will likely accelerate deposition in many leveed areas. The USGS has estimated that bedload in these rivers may increase on the order of 30-50% with increased flows.

The Corps' Engineering Regulation 1110-2-8162 requires feasibility studies examine three scenarios to consider the sensitivity and adaptability of projects to Sea Level Change (SLC). SLC is an artifact of climate change. The scenarios include a "low, "intermediate" and "high" forecast of future SLC for the period-of-analysis, which is a period extending 50 years beyond the year when the first project benefits can be expected. For this study, the period-of-analysis is 2026-2076. For Commencement Bay the forecasted sea level change increases are: low 0.34 ft, intermediate 0.86 ft and high 2.53 ft. Each of these three sea level change scenarios would alter tidal influence in the lower Puyallup River, which presently can extend approximately 2 miles upstream from the river's mouth. An increase in sea level would increase loading on the two federal levees at the lower end of the Puyallup River. Sea level change predictions could exacerbate flooding if a riverine flood event occurs coincidentally with an extremely high tide event. However, beyond the typical occurrence of highest winter tides with the winter flood season, this is unlikely as the two are not strongly correlated on an event basis. Sea level change is discussed further in Appendix B, Hydraulics and Hydrology.

2.8.3 Future Geomorphology and Sediment Transport

Few planform changes (i.e. change in the form of the river channel from an aerial perspective) are expected along each of the river reaches in the Study area because the river is heavily confined between levees. Future conditions within the project study area will likely continue to be characterized by abundant sediment supply. The most likely outcome of the two levee setbacks planned by local municipalities (the Countyline and Calistoga Levees) is increased deposition in those sections of the river. The increased width of the channel may trap larger sediment sizes, which in turn may affect a change in bed slope as discharge and sediment supply remain the same. The river is expected to become braided in these areas. Areas not changed by the Study sponsor will remain confined as a single thread channel between levees. Deposition is expected to continue into the future with historic trends from the past 25 years ranging from 0-6 ft (USGS 2010). The most active depositional areas have been identified by the USGS as RM 9-10 on the Puyallup River, just below the confluence with the White, RM 22-25 on the upper Puyallup, and RM 5-6 on the White River. The Carbon River is in a state of quasi-equilibrium and is not expected to experience significant change.

Due to global warming trends, it is anticipated that runoff from the upper watershed will increase. An increase in runoff in the upper basin will transport more sediment from Mt. Rainier to leveed areas of the lower basin. This increase in sediment load will likely accelerate deposition in many leveed areas. The USGS has estimated that bedload in these rivers may increase on the order of 30-50% with increased flows.

2.8.4 Future Flood Risk Management

With the current system of levees, risk of flooding from unexpected problems, larger floods or uncertainty associated with the reliability of the existing levees will remain. Many of the existing levees do not provide adequate protection to over 12,000 structures and pose a life safety risk to an even greater population which occupies the floodplain. It is forecasted that as channel capacity decreases from sedimentation the ability of the levees to provide the necessary flood risk management will be further compromised. However, no quantifiable changes to the levee reliability can be inferred. Barring unforeseen events, Pierce County is expected to continue its maintenance and any minor damages done to the levees throughout this time period are expected to be repaired. Therefore, the levee structures are expected to perform similarly in the future without-project condition as they do currently. Under the authority of P.L. 84-99, the Corps' Seattle District can provide temporary flood assistance to meet the immediate threat, and will be undertaken only to supplement state and local efforts. Corps emergency efforts are not intended to provide permanent solutions to flood problems. The County is expected to continue other flood risk management efforts described in 2.7.3 (Existing Flood Risk Management) and seek to implement other recommendations in the County's 2013 Flood Hazard Management Plan.

There are flood control zone districts and other local entities actively engaged in addressing flood risk management within the Study area. Defining the future without-project conditions for the Study included consideration of these activities to the extent possible. The alternatives proposed for the DFR/EIS may contain features also under consideration for implementation by other entities. The Corps will continue to coordinate with the flood control zone districts and local entities as the Study progresses. Information and/or comments on the DFR/EIS provided during the public comment period about other work being implemented in the Study area will be considered. Based on the level of assuredness (budget, schedule, etc) any work identified for completion by others that is currently in the TSP, would then be eliminated from the final recommendation and assumed as part of the future without-project condition for the purposes of this Study.

Levee setbacks are planned by local municipalities at two locations in the basin, the Calistoga levee on the upper Puyallup (RM 20.5) at Orting and the Countyline setback levee on the White River (RM 5.5) at Pacific. Clear Creek on the lower Puyallup River is a planned area for removal of the outlet gate and a construction of a new levee by Pierce County. Additional projects are proposed in the County's Flood Hazard Management Plan. These projects would significantly reduce flood risks in their immediate vicinities. MMD will continue to operate to reduce flood risks in the lower basin as determined by project authorization. The present deviation allowing lower releases to prevent flooding the City of Pacific will likely be renewed until significant changes to the levee system occur (such as the County Line levee setback) or a re-study is completed.

To adequately capture flood damages that would be imposed within Basin, the future without-project conditions assess flood conditions under MMD releases at 12,000 cfs as authorized in the approved MMD Water Control Manual, despite the temporary, approved operational deviation from the Water Control Manual under which MMD currently operates.

2.8.5 Future Economic Conditions

The economic evaluation of future without-project conditions included several assumptions in the analysis of flood damages. Existing levee performance trends, as given by the existing condition levee fragility curves for the Lower Puyallup reach, are assumed to continue into the future. Future hydraulic conditions assume 50 years of aggradation which is based on recent historic 25-year observations, which reduces channel capacity in some areas in the future (Note: a more robust sediment analysis is underway which will help inform feasibility-level design, but is not reflected in the economic analysis at this time). Economic analysis assumes development will continue in urban growth areas as defined by city land use plans by either developing vacant lands or replacing existing development with more dense development and multifamily residences, as well as growth in Port-related business and infrastructure as the economy grows locally in Puget Sound and nationally. Currently there is not consistency between city land use and development codes, but a recommendation of the Pierce County Flood Hazard Management Plan is to adopt best practices for floodplain development which includes no development in floodways and at a minimum elevating structures above the FEMA 1% ACE floodplain. For the purposes of the economic analysis, the base structure inventory was used to project flood damages but it should be acknowledged that future development could pose additional risks to property damage and life safety in the Study area. The analysis also assumes non-Federal implementation of a levee along Clear Creek, a tributary to the Lower Puyallup along the left bank and buyouts of at-risk structures, as noted in the description of Future Flood Risk Management in Section 2.8.4.

Because sediment aggradation is a key problem in the Puyallup basin, a future without project condition with 50 years of aggradation was simulated which indicates increased overbank flooding and damage associated with reduced channel capacity. Figure 2-16 shows the composite 1% ACE floodplain for the without-project future condition (assumed to be 2076). Flooding increases in this future condition, resulting in greater flood depths and inundation extents.

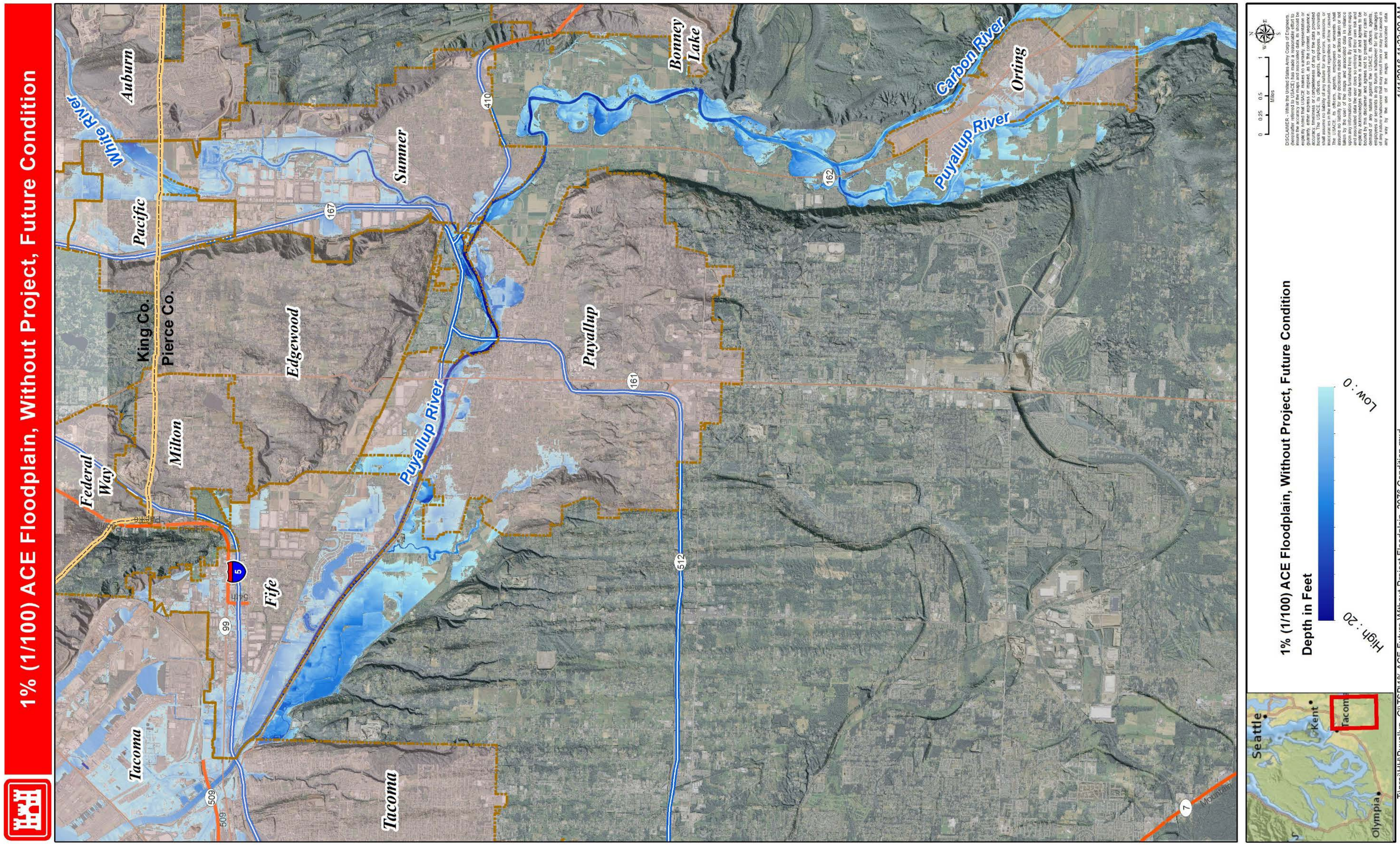


Figure 2-16. 1% ACE Future Without-Project Floodplain, 2076 Condition

This page intentionally left blank.

Table 2-12 summarizes the expected annual damages and Table 2-13 summarizes equivalent annual damages in the Study area, or damages over the 50-year period of analysis which includes the results of the existing condition presented in Section 2.7.4 using the current Federal discount rate of 3.125 percent (fiscal year 2016). Damages are presented at the October 2015 price level and are estimate to be $75 million in the future condition, and $53 million over the period of analysis. The lower Puyallup River and White River reaches account for 23% and 64% of equivalent EAD for this study area, respectively.

Table 2-12. Without-Project Future Condition, Expected Annual Damages (Oct 2015 price level, 3.125% discount rate, $1,000s)

River Reach	Commercial	Farm Buildings	Industrial	Public	Residential	Transit Delays	Total EAD
Carbon River	$0	$56	$5	$0	$71	$0	$132
Lower Puyallup	4,755	119	7,305	931	3,208	985	$17,303
Middle Puyallup	51	38	894	96	2,376	0	$3,455
Upper Puyallup	797	147	2	1,129	6,418	0	$8,494
White River	5,483	3	11,598	38	28,154	0	$45,276
Total EAD	**$11,086**	**$363**	**$19,804**	**$2,194**	**$40,227**	**$985**	**$74,660**

Table 2-13. Future Without-Project Condition, Equivalent Expected Annual Damages (2026-2076) (Oct 2015 price level, 3.125% discount rate, $1,000s)

River Reach	Commercial	Farm Buildings	Industrial	Public	Residential	Transit Delays	Total EAD
Carbon River	$0	$57	$5	$0	$79	$0	$141
Lower Puyallup	3,606	98	4,977	700	2,329	755	$12,465
Middle Puyallup	73	27	534	69	1,956	0	$2,659
Upper Puyallup	313	129	1	434	2,859	0	$3,736
White River	2,697	2	7,267	14	24,251	0	$34,231
Total	**$6,689**	**$313**	**$12,784**	**$1,217**	**$31,474**	**$755**	**$53,232**

2.8.6 Future Environmental Conditions

This section provides a brief summary of future environmental conditions in the Study area. The future environmental conditions in the Study area are described in detail in Section 4 (Affected Environment and Environmental Consequences).

The Commencement Bay portion of the Lower Puyallup River sub-basin is nearly fully developed and continued development, dredging, and filling are anticipated. Several areas in Commencement Bay contain contamination. However, some cleanup and associated mitigation/restoration actions are anticipated to occur during the next 50 years. It is expected that these actions will result in a slight increase of the extent and quality of estuarine and marine habitat. Sea level change will have major impacts throughout Puget Sound; however, effects within the study area will likely be limited due to extensive flood risk management around the Puyallup River.

In addition to climate change, there are a number of other factors that could negatively affect plant and wildlife species, including agriculture, bank stabilization, forestry, grazing, wastewater/pollutant discharge, woody debris removal, flood risk management practices (PFMC 1999). Continued development such as building construction, utility installation, road and bridge construction, and stormwater discharge could substantially alter the land surface, soil, vegetation, and hydrology of the study area, which could adversely impact wildlife through habitat loss or modification. Development near shore may result in removal of shoreline and riparian vegetation, which could destroy aquatic habitat directly or indirectly by interrupting sediment supply, increasing turbidity levels and diminishing light availability to eelgrass and other aquatic vegetation, altering hydrology and flow characteristics, raising water temperature, and re-suspending pollutants (Phillips 1984 in PFMC 1999).

Bank stabilization repairs needed to maintain the existing flood risk management system in the study area would be expected to continue in the future. These repairs can remove riparian vegetation, reduce recruitment of spawning gravel by eliminating lateral erosion, and impede the development of side channels (PFMC 1999). Pierce County and other non-Federal entities are proposing projects to set back some of these levees in the area. Currently planned non-Federal restoration projects including levee setbacks along the White River in the city of Pacific and the Calistoga levee setback project at RM 21.5 along the Puyallup River, which will connect 53 acres of floodplain habitat may provide some improvement to floodplain ecology over the next 50 years. Each implemented levee setback project will improve local habitat conditions. The majority of the riparian areas particularly in the lower portion of the study area would continue to be constricted by levees and would continue to prevent the establishment of a vegetated riparian corridor.

Pierce County is participating in the USACE System Wide Improvement Framework (SWIF) program. The County proposed vegetation maintenance plan targets clearing invasive and underbrush to provide avenues for inspection while maintaining larger trees for ecological benefit. Vegetation maintenance is no longer directly tied to eligibility requirements for the PL84-99 program; therefore, it is anticipated that vegetation will be managed to preserve riparian vegetation at least to the current level existing presently

Wetland areas in the Basin above Commencement Bay are expected to remain relatively unchanged. Current federal, state, and local regulations protect wetlands and require the maintenance of wetland habitat function. Currently planned floodplain restoration projects could also benefit wetland habitat by expanding riparian wetland areas.

3 Plan Formulation

The guidance for conducting Corps Civil Works planning studies, ER 1105-2-100, Planning Guidance Notebook, requires the systematic formulation of alternative plans that contribute to the Federal objective. To ensure that sound decisions are made with respect to development of alternatives and, ultimately, with respect to plan selection, the plan formulation process requires a systematic and repeatable approach. This chapter presents the results of the plan formulation process for this Study. Alternatives were developed in consideration of Study area problems and opportunities, and Study objectives and constraints, with respect to the four evaluation criteria described in the Principles and Guidelines (completeness, effectiveness, efficiency, and acceptability). Figure 3-1 presents a summary of the plan formulation process that will be presented throughout this chapter.

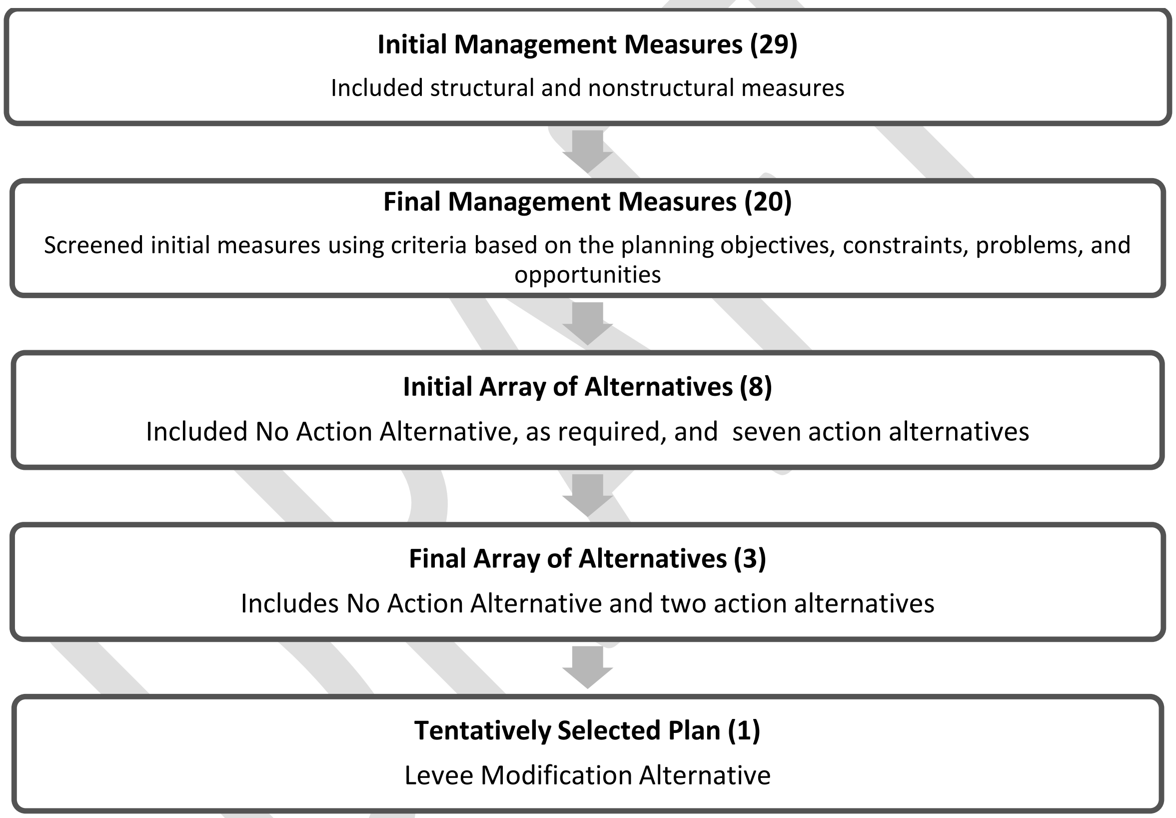


Figure 3-1. Plan Formulation Process

3.1 Management Measures

3.1.1 Initial and Final Array of Management Measures

A *management measure* is a feature or activity that could be implemented at a specific geographic site to address one or more planning objectives. A *feature* is a structural element that requires construction or assembly on-site and an *activity* is defined as a non-structural action. The Corps conducted this step at the December 2012 Study scoping charette, using existing information to complete the initial steps in the planning process leading to the identification and screening of the initial array of management measures.

The Corps identified 29 initial measures for consideration, based on input from the non-Federal sponsor, public meetings comments, stakeholders meetings, coordination with the Puyallup Tribe and Muckleshoot Tribe, and review of prior studies. Management measures for this study appear in Table 3-2, along with the related objective(s) that each measure addresses. (Study objectives are summarized below for reference. See Section 2.4 for more details of the objectives.)

- Objective 1 - Reduce flood risks
- Objective 2 - Manage the effects of sedimentation and geomorphic changes
- Objective 3 - Optimize contribution of MMD to flood risk management
- Objective 4 - Improve reliability and integrity of existing levees and associated structures
- Objective 5 - Optimize natural floodplain functions and sustainability

Table 3-2 also summarizes the screening process for the initial array of measures, indicating which screening criteria were not met for measures that were not carried forward for further consideration. Measures evaluation and screening is an ongoing process of elimination and is based on applying planning criteria to determine what is no longer efficient and/or effective to meet the Study objectives. Criteria were based on the planning objectives, constraints, problems, and opportunities described earlier. The measures were qualitatively screened using the evaluation criteria and best professional judgment. Table 3-1 lists the screening criteria that were used to screen the initial array of measures.

All river mile locations, and levee or floodwall lengths and heights for measures during the plan formulation process are approximate and based on professional judgment and/or concept-level design. River miles, heights and other characteristics of measures included in the TSP will be refined for the recommended plan during feasibility-level design analysis, based on additional information from sedimentation modeling, geotechnical and utility survey data, economic analysis/optimization, comments received on the DFR/EIS during public, technical, and legal and policy reviews, and will be documented in the final FR/EIS.

Table 3-1. Screening Criteria for the Initial Array of Management Measures

Criteria	Metric
GENERAL CRITERIA	
Meets Study Objectives	Yes / No - Identify whether the measure meets Objective 1.
Technical Feasibility	Yes / No - Can the measure be accomplished?
Risk Acceptability	The acceptability of the risk associated with the measure to all stakeholders?
FLOOD RISK MANAGEMENT FOCUS CRITERIA	
Flood Risk Reduction	Change in damages
Reduction in Life Safety Risks	Average reduction in people at risk or affected by flooding
NATURAL RESOURCES CRITERIA	
Impact to Riparian Habitat and ESA Listed Species	What is the adverse impact to riparian habitat and adverse impact to ESA listed species?

Table 3-2. Management Measures Screening

Management Measure	Structural/ Non-Structural	Description	Objectives Met	Screened out or Retained for Inclusion in Alternatives?
Channel bank widening	S	Widen the channel to increase the flow carrying capacity of the river. This measure is not the same as levee modifications, bridge modification, and other flood risk management structures	1, 2, 5	Yes. Did not meet Technical Feasibility or Flood Risk Reduction criteria. Channel widening refers to setting back the bank of the channel not channel excavation. The river system is primarily constrained on both banks by levees therefore; such a modification would be a setback levee which is considered a measure for this project.
Channel realignment	S	Realignment of the river to change the distance and straightness of the river channel and lower water surface elevations	1, 2, 5	Yes. Did not meet Technical Feasibility or Flood Risk Reduction criteria. The channel is primarily straight with levees. Channel alignment would not be as effective in reducing flood risks within the Basin.
Construct diversion channel / bypass channel	S	Construct new channel to divert excess water from the river during high flows.	1, 2, 5	Yes. Did not meet the Technical Feasibility criterion. There is no feasible location within the Basin for a diversion channel. This is due to development and/or topography constraints. In 1909, the White River was permanently diverted from flowing north into the current Green River valley, into the Stuck River channel and into its current channel flowing into the lower Puyallup River. This measure has low sponsor and tribal support, impacts to railroads, and potential impacts to tribal lands.
Modify bridges and approaches	S	Modify bridges and approaches to eliminate or reduce constrictions and sediment accumulation points. Modifications can include protection by reinforcement, underpinnings, or construction to ensure the structural integrity of the bridge foundations, piers or abutments.	1, 2, 5	Not screened out. This channel modification measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Reconnect side channels	S	Reconnect side channels in order to direct backwater and provide a return pathway for flood water.	1, 2, 5	Not screened out. This channel modification measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Overbank storage	S	Reconnect natural floodplain areas next to the river where floodwaters can spread out to reduce flood peaks or decrease water surface elevations.	1, 2, 5	Not screened out. This channel modification measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Construct new flood risk reduction dam	S	Construct a barrier to contain and manage the flow of water and upstream sediments.	1, 2	Yes. Did not meet the Risk Acceptability or Impact to Riparian Habitat and Endangered Species Act (ESA) Listed Species criteria. This measure is not acceptable to the non-Federal sponsor or its stakeholders. Constructing a dam may reduce flood risks; however, it would be too costly to the non-Federal sponsor and the Sponsor does not think it would be as beneficial as other measures. A new dam would cost approximately $300M which exceeds the entire cost of the projects identified in the Pierce County Flood Hazard Management Plan. The benefit-cost ratio would not justify this measure. A new dam would pose a new barrier to fish passage, and even with fish passage facilities, would likely result in significant impacts to ESA listed fish species.
Raise high pool elevation of existing dam	S	Raise elevation of top of existing dam in order to increase storage capacity behind dam to reduce downstream flows.	2, 3	Yes. Did not meet the Technical Feasibility, Flood Risk Reduction, or Reduction in Life Safety Risks criteria. MMD currently has enough storage to reduce its releases to zero cfs for events as large as an 0.2% ACE flood event, so there would be no benefit from increasing the capacity of MMD. In light of this and the high cost of physically raising the structure, increasing storage volume of the project would not result in a positive benefit-cost ratio.
Raise low pool elevation of dam	NS[3]	By increasing the low pool elevation, the velocity of the water in the pool would decrease allowing the sediment to settle. This would cause sediment to accumulate in the reservoir and loss of storage capacity. This prevents settlement accumulation downstream.	2, 3	Yes. Did not meet the Technical Feasibility criterion. This measure was screened out as a separate measure and instead was added to the sediment trap measure. Raising the low pool elevation of the dam would cause the reservoir to act as a sediment trap.
MMD Optimization	NS	Modify the operations of MMD to change regulation of flood flows in the White River and lower Puyallup River during flood events	1, 2, 3	Not screened out. This non-structural measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Culverts: add, remove, replace, upgrade	NS	Alterations to culverts to manage water levels and/or influence routing of flows to improve interior drainage.	1, 4, 5	Not screened out. This interior drainage measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.

[3] *Nonstructural* approaches to flood risk management are intended to reduce damage from encroaching flood water by altering the property. These can include acquiring and/or relocating a building, preparing emergency measures, such as sandbagging, and flood proofing structures.

Creek management with use of gates and pumps	NS	Physical barrier that prevents exchange of flood water between creeks/tributaries and the main stem to reduce interior flooding. Pumps can be used to prevent flooding from high creek flows.	1, 4, 5	Not screened out. This interior drainage measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Construct new levees	S	An embankment built along a river.	1, 2, 4	Not screened out. This levee modification measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Construct setback levees	S	New embankment constructed at a location some distance away from the river channel and away from an existing levee. Removal of material from existing levees would vary (breach, grading, dredging, etc.).	1, 2, 4	Not screened out. This levee modification measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Repair/Improve existing levee system	S	Repair damaged levees and/or improve existing levees by raising the existing structure, armoring the bank, or upgrading the levee material.	1, 2, 4	Not screened out. This levee modification measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Construct floodwalls	S	A vertical concrete wall designed to reduce flood risks in locations where space is limited.	1, 2, 4	Not screened out. This levee modification measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Hardened vegetated buffer	S	A complex revetment emulating natural riparian shoreline. It is constructed by stacking logs or other organic material to restrict bank erosion (Biorevetment or Engineered Log Jam)	1, 2, 4, 5	Yes. Did not meet the Technical Feasibility or Flood Risk Reduction criteria. This measure was screened out as a separate measure and is considered as a design feature to the bank stabilization measure.
Install stream gages	NS	Install stream gages to measure the volumetric discharge of a body of water to better evaluate flows. - packaged with flood warning systems.	1, 3	Yes. Did not meet the Technical Feasibility or Flood Risk Reduction criteria. This measure was screened out but instead is considered as a part of the Flood Warning System Measure.
Flood proof existing structures: a) buildings; b) septic systems/utilities; c) well heads; d) dry flood proofing.	NS	a) Elevate the structure or create property specific barrier. b) Change soil to allow infiltration. Protect vital water/power/storm infrastructure. c) Protect potable water from nonpotable water by raising well heads. d) Seal a building so water will not enter by installing backflow valves, shields at openings and external coating impervious to flood water.	1	Not screened out. This non-structural measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Flood warning system	NS	Enhance existing system whereby local, regional, or national authorities can contact members of the public en masse to warn them of an impending flood, using stream gages and inundation mapping techniques	1	Not screened out. This non-structural measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Response plan for local residents / Evacuation Plan	NS	Enhance existing action plan to advise local residents how to respond to a flood warning.	1	Not screened out. This non-structural measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Relocation of residents/property acquisition	NS	Transfer of land ownership or development rights to a conservation interest through purchase in order to remove citizens from flood prone areas. Relocate residents subjected to multi-year flood incidents either by moving the house to a different location on the same property or developing "safe" neighborhoods either on or off the floodplain.	1	Not screened out. This non-structural measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Bank stabilization	S	Install large woody debris, netting, or other physical barriers on at-risk river banks to prevent erosion.	1, 2, 4	Not screened out. This non-structural measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Enhance existing roadways	NS	Raise road elevations in potential flood areas (low elevation areas) or enhance existing roadways and bridges to redirect the flow of traffic out of frequently inundated areas to ensure emergency access.	1	Not screened out. This non-structural measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.

Mainstem dredging	S	Remove significant accumulated sediments from mainstem river channel on a reach-level, thereby lowering water surface profiles through the reach.	1, 2	Not screened out. This sediment management measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Spot-dredge	S	Remove accumulated sediments at specific limited areas in the mainstem river channel, thereby lowering water surface elevations.	1, 2	Not screened out. This sediment management measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Gravel bar scalping	S	Remove sediment at specific locations along banks and accumulated gravel bars outside of mainstem river channel and typically above ordinary high water.	1, 2	Not screened out. This sediment management measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Sediment traps	S	Large excavated in-channel sediment trap structures that allows for repetitive accumulation and removal of large volumes of sediments.	1, 2, 5	Not screened out. This sediment management measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.
Flow Control Structures	S	Structure to control the depth, velocity, or direction of flowing water. Also called River Training Works.	1, 2, 4	Not screened out. This sediment management measure was considered for inclusion in alternative plans, based on meeting the measures screening criteria.

This page intentionally left blank

3.1.2 Measures Siting

Locations where the management measures would be located in the Study area were identified (known as "siting") to determine the appropriate location for viable measures to resolve the flood problems within the Basin (Table 3-3). The measures were sited based on existing structures and their conditions, knowledge of existing repetitive flood damage areas, previous studies within the Basin, and conditions based on levee inspections and County O&M responsibilities. Siting the measures allowed the team to formulate an array of alternatives comprised of combinations of measures.

Table 3-3. Measures Siting Summary

CODE[4]	LOCATION	MEASURE TYPE	NAME	FLOOD CONCERNS ADDRESSED
WHT-001	RM 0.2-0.3, LB	Levee Modification	State Street Floodwall (LW1)	• Protects wastewater treatment plant (WWTP) and provides access to the WWTP and 2 residential structures during a flood event.
WHT-002	RM 1.8-4.9, RB	Levee Modification	Lower White River New Levee (LW2)	• Flooding of industrial, commercial, and residential properties • Flooding of transportation corridors, closing of transportation corridors • Decreased channel capacity
WHT-003	LB	Channel Modification	Stewart Street Avenue Bypass Channel	Excess water in the river during high flows in the area of Stewart Street
WHT-004	Somewhere between RM 1.8-4.9, RB	Levee Modification	White River Floodwall	Flood risk in location where space is limited for other measures
WHT-005	RM 4.6-5.5, LB	Non-Structural Property Acquisition	Property Acquisition	Repeated flooding of property
WHT-006	RM 4.9	Channel Modification	Stewart Street Bridge Widening	Emergency flow of traffic out of frequently inundated areas
WHT-007		Sediment Management	Sediment Trap in the White River	Conveyance capacity
WHT-008	RB	Levee Modification	Pacific Park Levee Setback	Conveyance capacity
WHT-009	RM 4.3-5.5	Sediment Management	Spot Dredging / Mainstem Dredging	Remove accumulated sediment near Stewart Street Bridge and RM 6 (near East Valley Highway), A Street to R Street, and other locations as determined
LPY-001	RM 2.4 – Frank Albert Road (North	Levee Modification	North Levee Road Setback @ Union	Increase conveyance capacity of lower Puyallup reach at Union Pacific

[4] In this table, abbreviations for river reaches are: WHT = White River, LPY = lower Puyallup River, MPY = middle Puyallup River, UPY = upper Puyallup River, and CAR = Carbon River.

	Levee Road), RB		Pacific (LP4-Section 1)	
LPY-003	RM Frank Albert Road – 8.1, RB	Levee Modification	North Levee Road Levee Setback	Flood risks in Fife and Tacoma
LPY-004	RM0.0-2.0, LB/RB	Levee Modification	Federal Authorized Levees Setback	Conveyance capacity
LPY-005	RM 2.8-7.4, LB	Levee Modification	River Road Levee Setback	Conveyance capacity
LPY-006	RM 5.0, RB	Levee Modification	Freeman Oxbow Setback Levee Alignment	Conveyance capacity
LPY-007		Sediment Management	Spot Dredging / Mainstem Dredging	Conveyance capacity
LPY-008		Non-Structural	Property Acquisition	Repeated flooding of property
MPY-001	RM 10.7-11.8, RB	Levee Modification	Hwy 410 Floodwall and Levee (MP1)	• Flooding of Hwy 410 and Sumner • Flooding of Rainier Manor Mobile Home Park • Flooding of Rivergrove Apartments • Flooding of River Walk developments
MPY-002	RM 11.0-11.5, LB	Non-structural	Flood Storage Basin	Reduce flood peaks or decrease water surface elevations.
MPY-003	RM 11.0-11.46, RB	Property Acquisition / Non-structural	Flood Storage Basin and Property Acquisition	Reduce flood peaks or decrease water surface elevations. Repeated flooding of property.
MPY-004	RM 15.8-16.0, LB	Sediment Management	116th St E. Point Bar Gravel Removal	• Increases conveyance capacity • Floods 116th St east, mobile homes, and public infrastructure
MPY-005	RM 15.8-16.5	Levee Modification	116th Street Levee Setback	• Prevents levee overtopping and channel migration
MPY-006	RM 15.8-16.3, RB	Property Acquisition / Non-Structural	Middle Puyallup Property Acquisition	Repeated flooding of property
MPY-007	RM 16.7-16.8	Flood Proofing	McCutcheon Rd Raising	Emergency flow of traffic out of frequently inundated areas
MPY-008	RM 16.7-17.4, LB/RB	Levee Modification	McCutcheon Road and 128 Street East Levee Setbacks	• Backwatering • Flooding of McCutheon Rd • Traps residents
MPY-009	RM 16.7-17.4	Non-Structural	Middle Puyallup Confluence Property Acquisition	Repeated flooding of property

UPY-001	RM 17.5-18.5, LB	Levee Modification	South Fork Levee Setback	• Gravel bar accumulation • Toe scouring • Overtopping levee • Debris blocking excess road • Loss of side channel habitat
UPY-002	RM 19.1-21.25, LB	Levee Modification	Leach Road Levee Setback	• Levee has low reliability • Orting long-term development plan includes this area • Provides additional channel capacity
UPY-003	RM 20.0-21.3, RB	Levee Modification	Calistoga Levee Setback (UP1)	• Overtopping of levee • Flooding of residential structures • Flooding of 2 schools and infrastructure
UPY-004	RM 23.4-24.9, RB	Sediment Management	Ford Levee Gravel Removal	Accumulated gravel bars outside mainstem river channel
UPY-005	RM 25.3-26.9, RB	Property Acquisition / Non-Structural	Neadham Road Flooding / Channel Migration Protection	• Repetitive flooding of residential homes • Expensive O&M of the areas • Channel migration
UPY-006	RM 26.2-28.6 LB	Sediment Management	Orville Road Large Woody Debris Deflector	Bank erosion.
UPY-007	RM 25.6-28.1, LB	Levee Modification	Orville Road Setback Levee	• Decreased conveyance capacity • Erosion • Reliability • Floods Orville Road a main roadway
UPY-008		Sediment Management	Sediment Trap in the Upper Puyallup River	Accumulation of sediments
UPY-009		Non-Structural	Orville Road Evacuation Re-Route	Emergency flow of traffic out of frequently inundated areas
UPY-010		Sediment Management	Spot Dredging / Mainstem Dredging	Conveyance capacity
CAR-001	RM 0.0-.04, LB	Levee Modification	Carbon River Confluence Levee Setback	• Overtopping at RM 0.0-0.4 • Reduces toe scour • SR 162 impacts • Widens channel and provides more channel conveyance, reduces velocity of water • Returns 16.5 acres back to the active floodplain

CAR-002	RM 0.0-3.0, LB	Levee Modification	Lower Carbon River Levee Improvement	• Levee overtopping at RM 0.0 and 0.4 • Levee washout at RM 0.8 and between RMs 3.0-3.2 • Tributary backwater flooding at RM 0.45 and saturates levee from RM 0.45-.08 • No outfall for stormwater outlet at RM 0.8 • Backwater channel flows downstream behind levee from RM 1.7 to RM 3.65 • Protects SR 162 and Orting Treatment Plant
CAR-003	RM 1.7, LB	Non-structural	Stream Gage at Orting Wastewater Treatment Plant (actual location TBD)	Supports/informs flood warning systems.
CAR-004	RM 3.2-4.9, LB	Non-structural	Carbon River Levee Bank Stabilization / Flow Deflection and Coplar Creek Backwater Improvements	Bank stabilization. Encourages the river to migrate away from the levee/revetment back to its former channel on the right bank of the river
CAR-006	RM 3.9-5.6, LB	Levee Modification	Carbon River Big Bend Levee Setback	• Provides additional channel conveyance Reduces reliability concerns; previous washouts, erosion, undercutting, and toe scour concerns
CAR-007		Non-structural	SR 162 Bridge Residential Property Acquisition	Flooding upstream
CAR-008		Channel Modification	SR 162 Bridge Widening	Flooding upstream
CAR-009	RM 5.95-6.4, LB	Levee Modification	Alward Road Levee Segment 2 Setback	Conveyance capacity
CAR-010	RM 6.4-8.8, LB	Levee Modification	Alward Road Levee Segment 1 Setback	• Decreasing channel capacity due to sedimentation • Reduces flood damages/risks • Enhances fish habitat due to loss of side channel habitat
CAR-011	RM 7-8, RB	Non-structural	Carbon River Levee Bank Stabilization	• Eroded levee exposing valley wall to erosion contributing to sediment aggradation or sediment loading into the channel • Channel migration

CAR-012		Sediment Management	Spot Dredging / Mainstem Dredging	Conveyance capacity
B-001		Non-structural	Flood Warning System	Public communication about flood risk
B-002		Non-structural	Countywide Floodplain Land Use Plan	Public communication about flood risk.
B-003		Non-structural	Countywide Emergency Evacuation Procedures	Public communication about flood risk.
B-004		Non-structural	Flood Proof Homes	Repeated flooding of existing structures.

3.2 Alternative Plans

3.2.1 Key Uncertainties During Plan Formulation

During the alternatives formulation process, the Corps identified the following key uncertainties that could impact planning decisions and selection of a TSP:

1. **Sedimentation:** Future sediment accumulation over the planning period of analysis is an uncertainty. A risk-informed decision identified a strategy to address sediment future predictions during this Study phase. For the purposes of evaluating and comparing alternatives to identify a TSP, the Corps estimated sediment deposition amounts using historic trends due to lack of observed sediment transport data. The Study will continue to evaluate the need for any additional sediment management features (beyond levee raises and setbacks) during the feasibility-level design analysis. The USACE Committee on Channel Stabilization consulted with Seattle District in September 2014, and recommended limited sediment transport modeling after the TSP milestone in order to identify any potential sediment transport feedback loops due to alternative measures and to better quantify the sustainability of the TSP. This limited modeling will inform the feasibility-level design analysis and will be documented in the final FR/EIS.
2. **Environmental/Cultural Resources Impacts:** There is uncertainty in the degree of environmental or cultural resources impacts the TSP poses and the subsequent mitigation required due to the conceptual level of design details at this stage of the Study. A concept level project footprint was identified to inform the future with-project conditions, considering only limited modeling efforts, and for evaluation and comparison of alternatives. The analysis of impacts based on the available information could be conservatively estimated, which could lead to over-compensation via mitigation. Revised impacts analysis and a final mitigation recommendation will be developed during the feasibility-level design analysis, and will be documented in the final FR/EIS.
3. **Potential Areas of induced flooding/transferred risks:** Individual measures, and the effects of combining measures, may impact other levees or areas of the system than those directly being modified. Induced and/or transferred risks have been addressed in the Final Array of Alternatives.

After the feasibility-level design analysis and modeling have been conducted, however, additional induced or transferred risks may be found and will need to be addressed for the final recommended plan and will be documented in the final FR/EIS.

4. **MMD Operations:** MMD currently operates under an approved deviation to the Water Control Manual. Given the reduced channel capacity due to sediment deposition, MMD cannot release more than about 6,000 to 8,500 cfs without flooding areas along the White River. This Study assumes MMD can release 12,000 cfs. A change in the MMD operation to a lower flow value could impact the ultimate alternative design along the White River portion of the Study. The ability to permanently change the MMD operation to facilitate scaled back alternative measures will be addressed during the feasibility-level design analysis and documented in the final FR/EIS. Doing this may have flood risk consequences elsewhere that have not been fully evaluated at this point.
5. **Property Acquisition:** Any property acquisition measures included in an initial or final array of alternatives, or the TSP would be based on concept level of design at this stage in the Study. As a result, there is uncertainty about specific numbers of acres or cost of property that may be acquired as part of a final recommended plan. The Corps will update property acquisition information and identify associated costs based on additional design details during feasibility-level design. This information will be included in the final FR/EIS.
6. **Future Without-Project Construction:** Other County projects that are not part of the feasibility study, where funding was certain, have been identified and included in the future without-project analysis of the Study. The Corps will continue to work closely with the County as the TSP is refined and detailed design analysis is conducted after the Agency Decision Milestone (ADM) to ensure assumptions on projects to be constructed by the County are still accurate. This information will be updated, as needed, in the final FR/EIS.

3.2.2 Initial Array of Alternative Plans

Table 3-4 summarizes the structural and non-structural alternative plans formulated through combinations of management measures, based on initial data collection and professional judgment.

Table 3-4. Initial Array of Alternatives

Alternative	Measures
Alternative A: No Action Alternative	This alternative means that no additional Federal action beyond the existing authorized projects will be undertaken in the Puyallup River Basin to reduce flood risks.
Alternative B: Non-Structural Alternative: This alternative takes a non-structural approach to reducing flood risks in the project area.	MMD Optimization Flood Warning System County-wide Evacuation Plan Property Acquisition Flood Proofing Creek Management Culverts Enhance Existing Roadways
Alternative C: In –Channel Flow Containment: This alternative would improve and increase channel conveyance so that the channels can contain flows during flood events without having to be setback or modified	New levees and/or floodwalls Repair/improve existing levee system MMD Optimization Modify Bridge

from its existing alignment. Does not include non-structural features.	Bank Stabilization Mainstem Dredging Spot Dredging Gravel Bar Removal
Alternative D: Increase Channel Capacity: This alternative would increase channel capacity in order to contain flood flows and reduce flood risks. Unlike Alternative C: In-Channel Flow Containment, this alternative includes setting back levees as an approach to increasing channel capacity. It does not include non-structural features.	Levee setbacks New levees and/or floodwalls Modify bridges Mainstem dredging Gravel bar removal Spot dredging
Alternative E: Increase in Flood Storage Capacity: This alternative would use areas for overbank flood storage to reduce flood risks.	Overbank storage areas Non-structural (may include measure types from the Non-Structural Alternative)
Alternative F: Sediment Management Alternative: This alternative would use mainstem dredging and sediment management to reduce flood risks within the project area.	Levee Setbacks New Levees and /or Floodwalls Mainstem Dredging Gravel Bar Removal Spot Dredging Sediment Traps Flow control structures Bank Stabilization Non-Structural (may include measure types from the Non-Structural Alternative)
Alternative G: Mainstem Dredging Alternative: This alternative would use mainstem dredging, sediment management, and MMD optimization changes to reduce flood risks within the project area.	Mainstem Dredging Spot Dredging Repair / Improve Existing Levee Systems MMD Optimization Sediment Trap Non-Structural (may include measure types from the Non-Structural Alternative)
Alternative H: MMD Optimization and Levee Modifications: This alternative would modify MMD operations and levee structures to manage sediment and reduce flood risks within the project area. Key features include:	MMD Optimization Sediment Traps Levee Setbacks New Levees and/or Floodwalls Repair/Improve Existing Levee System Modify Bridges Non-Structural (may include measure types from the Non-Structural Alternative)

3.2.3 Evaluation and Screening of Initial Array of Alternative Plans

The initial array of alternatives was evaluated and screened (Table 3-6 and Table 3-7). The first screening criterion was whether a given plan meets the planning objectives. Those alternatives that did not meet planning objective 1 - reduce flood risks to life, safety, property, and critical infrastructure in the Puyallup River Basin through the planning period of analysis - were screened out from further consideration. The Corps then used the remaining decision criteria to evaluate and screen the initial array of alternatives.

Table 3-5. Criteria, Metrics and Rating Scale for Evaluation of Initial Array of Alternative Plans

Evaluation Criteria	Metric	Rating Scale
General Criteria		
Meets Study Objectives	Identify whether the alternative meets Objective 1.	Meets primary objective Yes = IN No = OUT

Technical Feasibility	Yes / No Can the Alternative be Accomplished or Not?	Yes = IN No = OUT
Implementation Cost	High / Medium /Low This is a rough order magnitude cost.	Low = +1 points Medium = 0 points High = -1 points
Operations & Maintenance (O&M) Cost	High / Medium / Low This is a rough order of magnitude cost.	Low = +1 points Medium = 0 points High = -1 points
Cost Effectiveness	Yes / No and if Yes, High / Medium / Low How effective is the Alternative in reducing flood risk in comparison to cost of the Alternative?	Low = -1 points Medium = 0 points High = +1 points
Risk Acceptability	High / Medium / Low What is the risk of the Alternative being acceptable to all stakeholders?	Low = +1 points Medium = 0 points High = -1 points
Flood Risk Management Criteria		
Flood Risk Reduction	High / Medium / Low Change in Damages	Low = -1 points Medium = 0 points High = +1 points
Reduction in Life Safety Risks	High / Medium / Low Average reduction in people at risk or affected by flooding	Low = -1 points Medium = 0 points High = +1 points
Natural Resources Criteria		
Impact to Riparian Habitat and ESA Listed Species	Yes / No and if Yes, High / Medium / Low What is the adverse impact to riparian habitat and adverse impact to ESA listed species?	Low = +1 points Medium = 0 points High = -1 points

Table 3-6. Evaluation of Initial Array of Alternative Plans

Initial Array of Alternatives Evaluation Matrix								
	Meets Primary Objective 1	Technical Feasibility	Risk of Acceptability	Flood Risk Reduction	Reduction in Life Safety Risks	Impacts to Riparian Habitat & ESA Species	Total	Objectives Met
ALTERNATIVE								
Alternative A: No Action	No							none
Alternative B: Non-Structural	Yes	Yes	High (-1)	Low (-1)	Medium (0)	Low (+1)	-1/OUT	1, 5
Alternative C: In-Channel Flow Containment	Yes	Yes	High (-1)	High (+1)	High (+1)	High (-1)	0	1, 2, 3, 4
Alternative D: Increase Channel Capacity	Yes	Yes	High (-1)	High (+1)	High (+1)	High (-1)	0	1, 2, 4, 5
Alternative E: Increase In Flood Storage Capacity	No	n/a	n/a	n/a	n/a	n/a	OUT	1, 5
Alternative F: Sediment Management	Yes	Yes	High (-1)	High (+1)	High (+1)	High (-1)	0	1, 2, 4, 5
Alternative G: Mainstem Dredging	Yes	Yes	High (-1)	Medium (0)	Medium (0)	High (-1)	-2/OUT	1, 2, 3,4
Alternative H: MMD Optimization and Levee Modifications	Yes	Yes	Medium (0)	High (+1)	High (+1)	Medium (0)	2	1, 2, 3, 4, 5

Alternative plans A, C, D, F, and H were carried forward based on the initial evaluation of alternative plans above. Alternatives C and D were subsequently screened out because the measures included in alternatives C and D were the same or similar to measures included in alternatives F and H, leaving alternatives A, F, and H. Following the evaluation and screening exercise summarized above, additional consideration of management measures within the remaining alternative plans was undertaken. As a result, the following management measures identified in Table 3-7 (Sediment Traps, Pump Station, Bridge Modifications, and MMD Optimization) were eliminated from consideration in the remaining three alternative plans:

Table 3-7. Additional Screening of Measures from Initial Array of Alternative Plans

Measures Screened Out from initial Array of Alternative Plans		
Measure	**Evaluation Criteria Not Met**	**Rationale**
Sediment Traps	Flood Risk Reduction Reduction in Life Safety Risks	A risk-informed decision identified a strategy to address sediment management during the planning horizon. Alternatives F and H were formulated to contain the increase in sediment deposition. Alternative H includes levee setbacks and raises that over the planning horizon will contain sedimentation as it occurs. In addition, Alternative F includes mainstem dredging as the primary sediment management measure, with some levee modifications where dredging alone would not be effective Sediment traps were screened from further consideration based on engineering judgment that they would be less effective in meeting planning and guidance criteria than other measures. If it is determined that additional sediment management measures are needed; the Corps will work with District leadership and the vertical team to determine the best course of action to account for those changes during feasibility-level design analysis.
Pump Station	Flood Risk Reduction Reduction of Life Safety Risks	This measure was screened out due to existing data from a Pierce County 2012 study which determined the measure to be infeasible due to the magnitude of costs and operations.
Bridge Modifications	Flood Risk Reduction Reduction of Life Safety Risks	Bridge modifications were screened out from the alternatives because the levee setbacks and modifications alone reduced existing constriction points based on the current level of design and analysis. If it is determined that bridge modifications are needed, the Corps will work with District leadership and the vertical team to determine the best course of action to account for those changes during feasibility-level design analysis.
MMD Optimization	Flood Risk Reduction Technical Feasibility	The measure to optimize MMD operations was removed from subsequent alternative analysis to identify a TSP, and was not part of the evaluation and comparison step described in Section 3.3. The idea behind this measure was to potentially specify some lower MMD outflow, which might have allowed for scaled back alternative features along the White River. Currently, MMD limits releases to no more than 12,000 cfs, if possible, per the current Water Control Manual. There were two main reasons for deleting this measure. One has to do with MMD's Discharge Regulation Schedule (DRS) which specifies minimum releases at high inflow-pool conditions. Subsequent investigation indicates that at 1% ACE and larger events, the DRS would likely be triggered, thus overriding any new lower target outflow replacing the current 12,000 cfs value. For large floods of the magnitude the GI project would most likely be designed for on the White River, it appears the MMD DRS would negate a new lower target flow value.

		The second reason for deleting this measure has to do with sediment transport. Lower outflows would decrease the sediment transport capacity through the White River below MMD. This is a concern as it could lead to increased deposition rates in the vicinity of the city of Pacific and/or elsewhere in the White River over those which have historically occurred. This would require higher levees/floodwalls to contain the increased sediment deposition and/or the inclusion of maintenance dredging. This concern regarding altered sediment transport capacity was voiced by the USACE Committee on Channel Stabilization in the committee's report on the Puyallup system.

3.2.4 Final Array of Alternative Plans

To differentiate between the initial and final array of alternative plans, Alternative A was relabeled as Alternative 1, Alternative H was relabeled as Alternative 2, and Alternative F was relabeled as Alternative 3. During design and analysis of the alternatives, some additional measures were screened out due to inability to reduce flood risks and life safety risks as described in Section 3.2.3. Measures in Alternative 2 and Alternative 3 were sited in approximate locations of the study area. The reformulated Final Array of Alternative Plans is described in detail below.

The Corps used a 1% ACE probability as a starting point for the concept-level design used in evaluation and comparison of the Final Array of Alternatives, This was for all reaches in the Study area except the lower Puyallup River reach, where a conceptual 0.5% ACE was assumed in the base condition and 0.1% ACE at the end of the planning period of analysis. This is based on Pierce County service objectives outlined in the County's Rivers Flood Hazard Management Plan and Comprehensive Plan goals. Note that the percent ACE probability used for evaluation and comparison of alternatives may not be the same as a design performance with assurance, which will be defined during the feasibility-level design analysis of the TSP, as additional design information is available and the TSP is optimized to identify the NED plan which reasonably maximized net benefits for NED and reduces residual risk to life safety. This information will be documented in the final FR/EIS.

As noted earlier, all river mile locations, and levee or floodwall lengths and heights for measures during the plan formulation process are approximate and based on professional judgment and/or concept-level design for the purposes of evaluation and comparison of alternatives to identify a TSP. River miles, heights and other characteristics of measures included in the TSP will be refined for the recommended plan during feasibility-level design analysis, based on additional information from sedimentation modeling, geotechnical and utility survey data, economic analysis/optimization, comments received on the DFR/EIS during public, technical, legal, and policy reviews, and will be documented in the final FR/EIS. In addition, nonstructural measures - such as relocations or elevating structures - may be included, as needed, during feasibility-level design analysis of the TSP.

Alternative 1: No Action Alternative
The No Action Alternative assumes the future without-project conditions in the absence of any additional Federal action beyond O&M of existing authorized projects to estimate whether planning objectives would be achieved without a Federal project. Any reasonable activities to be pursued by state and local interests in the absence of a Federal project are assumed to be undertaken. The No Action Alternative forms the basis against which all other alternatives plans are measured.

Pierce County and King County would continue to acquire repetitively damaged properties within the floodplain as funding becomes available from FEMA and/or other sources, construct small scale levee modification projects such as the Calistoga Levee Setback and the Countyline Setback Levee. Those levee structures eligible for P.L. 84-99 rehabilitation assistance under P.L. 84-99 would continue to be repaired as they are damaged by flood events. In addition, the Corps would continue to maintain the Federal Authorized Levees to contain flows of 50,000 cfs. Levee reliability of those Pierce County projects that are not a part of the P.L. 84-99 program would continue to be an increasing concern due to challenging local budget and schedule limitations.

Sediment deposition would continue to occur within the system, decreasing channel conveyance and increasing flood risks. MMD would operate per its authorized Water Control Plan and could increase flood risks downstream as channel conveyance further decreases due to aggradation. Further, significant environmental resources are anticipated to continue to experience levels of degradations throughout the planning horizon.

Significant long-term risk of flooding would remain over the period of analysis under the No Action Alternative.

Alternative 2: Levee Modification Alternative
Alternative 2 (Table 3-8 and Figure 3-2) would modify the existing levee system to manage flood risk by setting back an existing levee, increasing existing levee heights, improving existing levee reliability, or constructing new levees or floodwalls. The proposed levee modifications would be the primary flood risk management measure within this alternative and would work with other flood risk management measures in the alternative, including flow control structures and property acquisition, to reduce flood risk in the Basin. This is a passive approach to managing sediment, where levees are modified in order to accommodate the sediment deposition expected over the planning period of analysis.

Alternative 3: Sediment Management with Levee Modification Alternative
Alternative 3 (Table 3-8 and Figure 3-3) would manage sediment and its effects by including mainstem dredging as the primary measure to manage flood risks in the Basin. This alternative would include some new levees and levee improvements to manage flood risks that the dredging measure could not provide alone. The dredging and levee modification measures would work with other measures in the alternative, such as flow control structures and property acquisition, to increase channel capacity and reduce flood risks in the Basin.

Table 3-8. Alternative 2 and Alternative 3 Descriptions

Measure	Alternative 2 – Levee Modification Alternative	Alternative 3 – Sediment Management with Levee Modification Alternative
General Description	Alternative 2 would modify the existing levee system to manage flood risk by setting back an existing levee, increasing existing levee heights, improving existing levee reliability, or constructing new levees or floodwalls. The proposed levee modifications would be the primary flood risk management measure within this alternative and would work with other flood risk management measures in the alternative such as flow control structures and property acquisition to reduce flood risk in the Basin. This is a passive approach to managing sediment, where levees are modified in order to accommodate the sediment deposition expected over the planning period of analysis. O&M activities would focus on semi-annual inspections and reports, proper operation and maintenance of culverts and floodwall closures, and periodic levee maintenance activities to include repair and replacement of damaged or deficient components.	Alternative 3 would manage sediment and its effects by including mainstem dredging as the primary measure to manage flood risks in the Basin. This alternative would include some new levees and levee improvements to manage flood risks that the dredging measure could not provide alone. The dredging and levee modifications measures would work with other measures in the alternative, such as flow control structures and property acquisition, to increase channel capacity and reduce flood risks in the Basin. This alternative would require initial construction dredging and subsequent maintenance dredging. ZOver the planning period of analysis, maintenance dredging is anticipated to occur one time within the lower Puyallup River, one time in the lower White reach, three times in the White River at City of Pacific, and two times in the upper Puyallup reach. The frequency of the maintenance dredging could be a challenging responsibility for the sponsor. O&M activities for the levee modifications would focus on semi-annual inspections and reports, proper operation and maintenance of culverts and floodwall closures, and periodic levee maintenance activities to include repair and replacement of damaged or deficient components.
	Lower Puyallup River	
Federal Authorized Levees	The existing Federal Authorized Levees (FAL) extend from RM 0.7 to RM 2.7 on the right bank and RM 0.7 to RM 2.9 on the left bank. This measure would raise a section of the existing left and right banks of the FAL along the lower Puyallup River. The authorized capacity of the Federal Levees is 50,000 cfs, which was intended to provide protection from floods up to 1% ACE magnitude. This measure was evaluated and compared at a 0.5% ACE probability. The FAL right bank levee would be raised from RM 2.0 to 2.7, and the FAL left bank levee would be raised from RM 1.5 to 2.9.	The existing Federal Authorized Levees (FAL) extend from RM 0.7 to RM 2.7 on the right bank and from RM 0.7 to RM 2.9 on the left bank of the lower Puyallup River. This measure would raise a section of the existing left and right bank levees over an area where it is less effective to dredge due to tidal influences. The authorized capacity of the Federal Levees is 50,000 cfs, which was intended to provide protection from floods with magnitude up to the 1% ACE flood event. This measure was evaluated and compared at a 0.5% ACE probability. The FAL right bank levee would be raised from RM 2.0-2.7, and the FAL left bank levee would be raised from RM 1.5 to RM 2.9.
Mainstem Dredging	Dredging is not included in Alternative 2 because the levee setback measure in Alternative 2 is intended to reduce flood risk by increasing conveyance capacity.	Mainstem dredging would occur once during construction and would include dredging between RM 3.1 and RM 7.4 (a total of 98 acres of riverbed and approximately one million cy) to increase channel conveyance capacity. The dredging is intended to deepen the lower Puyallup River by approximately 3 feet for 5.5 miles. Material removed during dredging would be characterized for physical characteristics and contaminants. If material is suitable it would either be used for construction activities or placed in a permitted placement site. Contaminated material would be placed in a site designated for placed of contaminated material. Maintenance dredging would be necessary. The lower Puyallup River and lower White River would be dredged once during the period of analysis while the White River near Pacific would be dredged three times and the upper Puyallup River would be dredged twice. Maintenance dredging is further detailed in Appendix B (Hydraulics and Hydrology). Alternative 3 would require initial construction dredging and subsequent maintenance dredging. Maintenance dredging is anticipated to occur within the lower Puyallup River one time over the planning timeframe.
North Levee Road Levee Raise	This levee raise measure is not included in Alternative 2 because the levee setback measure in Alternative 2 is intended to reduce flood risk in this area.	This measure would raise the existing North Levee Road levee from RM 2.7 to RM 4.9. The levee modification would manage flood risks to residential, commercial, and industrial properties.
North Levee Road A Setback	This measure would setback the existing North Levee Road levee on the right bank of the lower Puyallup River extending from RM 2.7 to the end of the North Levee Road at RM 8.1. The levee would be setback from RM 2.7 to RM 4.2 (Frank Albert Road) approximately 1,000 ft, from RM 4.2 to RM 6.0 approximately 80-100 ft, from RM 6.0 to RM 7.1 approximately 600 ft, and from RM 7.1 to RM 8.1 approximately 80-100 ft. The setback levee alignment would be approximately 32,000 linear feet with approximate levee heights ranging from 6 to15 feet. The proposed levee modification would manage flood risks to residential, commercial and industrial properties by increasing conveyance capacity in the river.	This levee setback measure is not included in Alternative 3 because the mainstem dredging measure that is part of Alternative 3 is intended to increase channel capacity.
River Road Levee Floodwall	A new floodwall would be added along the River Road Levee on the left bank of the lower Puyallup River extending from RM 2.9 to RM 7.2. This floodwall would reduce risks to the transportation corridor and residential, commercial and industrial structures. The floodwall height would range from 3-6 feet, with the average of approximately 5 feet.	A new floodwall would be added along the River Road Levee on the left bank of the lower Puyallup River extending from RM 2.9 to RM 4.9. This floodwall would reduce risks to the transportation corridor and residential, commercial, and industrial structures. The floodwall height would range from 3-4 feet with the average closer to 3 feet.
Lower Puyallup River Extension Levee	This new extension levee on the left bank of the lower Puyallup River would be from RM 7.2 to RM 8.6. The new extension levee would be 7,200 feet and would incorporate about 1,100 feet of the existing River Road Levee. The levee height would vary between 8-13 feet. In areas where the levee is 8 feet tall, there would be about 3.5 of additional fill placed on the existing berm.	This new extension levee on the left bank of the lower Puyallup River would be from RM 7.2 – RM 8.6. The new extension levee would be 7,200 feet and incorporates about 1,100 feet of the existing River Road Levee. The levee height would vary between 8-13 feet. In areas where the levee is 8 feet tall, there will be about 3.5 of additional fill placed on the existing berm.
	White River	
Mainstem Dredging	Dredging is not part of Alternative 2.	Dredging in this location would remove accumulated sediment near Stewart Street Bridge and RM 6 (near East Valley Highway), A Street to R Street, and other locations as determined. Mainstem dredging would occur once during construction and is proposed to increase conveyance capacity from RM 2.1 to RM 4.5 and RM 4.9 to RM 6.2 along the White River (a total of 59 acres of river bed and approximately one million cy). The dredging is intended to deepen the lower White River by approximately 7.5 feet for 3 miles and the White near the town of Pacific by approximately 3.2 feet for 1.1 miles. Material removed during dredging would be characterized for physical characteristics and contaminants. If material is suitable it would either be used for construction activities or placed in a permitted placement site. Contaminated material would be placed in a site designated for placed of contaminated material. Maintenance dredging would be necessary and is further detailed in Appendix B (Hydraulics and Hydrology). Alternative 3 would require initial construction dredging and subsequent maintenance dredging. Maintenance

		dredging is anticipated to occur within the lower White reach one time and White River at City of Pacific three times over the planning timeframe.
White River New Levees	This measure proposes new levees along the right bank of the White River to manage flood risks to residential, commercial, and industrial properties. The new levees would extend from RM 1.7 to RM 4.5 and RM 4.9 to 6.2 at Pacific Park.	This measure proposes new levees along the right bank of the White River to manage flood risks to residential, commercial, and industrial properties. The new levees would extend from RM 1.7 to RM 2.8. These levees are considered in areas where dredging alone would not provide sufficient flood risk reduction due to backwater from the Lower Puyallup River.
Property Acquisition	With this non-structural measure, 35 acres of property would be acquired, consisting of 14 parcels that would be impacted between RM 4.6 to RM 5.0 along the left bank of the White River. These properties have experienced repetitive flood impacts and are at risk of additional adverse flood impacts.	Not included in Alternative 3.
Middle Puyallup River		
Highway 410 Floodwall and Levee	This measure would add a combination of a new levee and new floodwall that would provide protection to the adjacent SR 410 and residential properties. Floodwalls are generally used where there are space limitations. The levee section is proposed between RM 10.7 – 11.0 and the floodwall would be located between RM 11.0 to 11.8. The height of the levee and floodwall would vary between 6-12 feet.	This measure would add a combination of a new levee and new floodwall that would provide protection to the adjacent to SR 410 and residential properties. Floodwalls are generally used where there are space limitations. The levee section is proposed between RM 10.7 to 11.0 and the floodwall will be located between RM 11.00 to 11.8. The height of the levee and floodwall would vary between 6-12 feet.
Upper Puyallup River		
Mainstem Dredging	Dredging is not part of Alternative 2.	Mainstem dredging would occur once during construction from RM 21.3 to RM 22.7 along the upper Puyallup River Jones levee (a total of 36 acres of river bed and approximately a half-million cy). The dredging is intended to deepen the upper Puyallup River by a depth of approximately 2.5 feet for 1.4 miles. Material removed during dredging would be characterized for physical characteristics and contaminants. If material is suitable it would either be used for construction activities or placed in a permitted placement site. Contaminated material would be placed in a site designated for placed of contaminated material. Maintenance dredging would be necessary and is further detailed in Appendix B (Hydraulics and Hydrology). Alternative 3 would require initial construction dredging and subsequent maintenance dredging. Maintenance dredging is anticipated to occur within the upper Puyallup reach two times over the planning timeframe.
Jones Levee Improvement	An existing segment of the Jones Levee from RM 21.3 to RM 22.5 along the right bank of the upper Puyallup River would be modified. This measure would modify the levee in place by increasing the levee heights by approximately 1.5 feet to 6.5 feet as well as improving the river-side erosion protection. This levee modification would also include a control structure on the riverward side of the Ford Levee.	Levee improvements would include improvements to sustain the reliability of the levee system after dredging. In addition, a control structure would be constructed on the riverward side of the Ford Levee from RM 23.4 to RM 23.6 to deflect flows from the levee and stop repetitive damages.
Carbon River		
Lower Carbon River Levee Improvement	This levee improvement would consist of raising from the Riddell Levee (RM 0.0 to 1.7) Orting Treatment Plant Levee (RM 1.7 to 3.1), and the Bridge Street Levee (RM 3.1 to 3.7). This measure would improve the reliability of the existing levee structures and raise the height of the levee to contain flood flows while reducing flood risks to the City of Orting, SR 162, and the Orting Treatment Plant. The levee height would be raised from 0-4 feet. A more efficient downstream tie-in section up to 7 feet in height would be constructed for the Riddell Levee section. This measure would also include a flow control structure design at the upstream end of the Bridge Street Levee between RM 3.2 and RM 4.0 to train flows away from the toe of the Bridge Street Levee and stop repetitive damages.	This levee improvement would consist of raising from the Riddell Levee (RM 0.0 to 1.7) Orting Treatment Plant Levee (RM 1.7 to 3.1), and the Bridge Street Levee (RM 3.1 to 3.7). This measure would improve the reliability of the existing levee structures and raise the height of the levee to contain flood flows while reducing flood risks to the City of Orting, SR 162, and the Orting Treatment Plant. The levee height would be raised from 0-4 feet. A more efficient downstream tie-in section up to 7 feet in height would be constructed for the Riddell Levee section. This measure would also include a flow control structure design at the upstream end of the Bridge Street Levee between RM 3.2 and RM 4.0 to train flows away from the toe of the Bridge Street Levee and stop repetitive damages.
Property Acquisition	This non-structural measure would include acquiring approximately 140 acres of property along the Carbon River that has experienced repetitive flood impacts and continues to be at risk to adverse flood impacts. Structures within the acquisition area would be demolished or relocated. Property acquisitions are considered along the Carbon River near SR 162 Bridge which is a known constriction point and behind Alward Road Segment 1 Levee.	This non-structural measure would include acquiring approximately 140 acres of property along the Carbon River that have experienced repetitive flood impacts and those structures that are at risk to adverse flood impacts. Structures within the acquisition area would be demolished or relocated. Property acquisitions are considered along the Carbon River near SR 162 Bridge which is a known constriction point and behind Alward Road Segment 1 Levee.
Additional Measures		
Dredge materials placement sites	Dredging is not part of Alternative 2, so this measure is not included.	For the three mainstem dredging measures in Alternative 3, a suitable placement site would be needed to accommodate the estimated dredge volumes: 98 acres of riverbed and approximately one million cy from the lower Puyallup, 36 acres of river bed and approximately a half-million cy from the upper Puyallup reach, and a total of 59 acres of river bed and approximately one million cy from the White River reach.

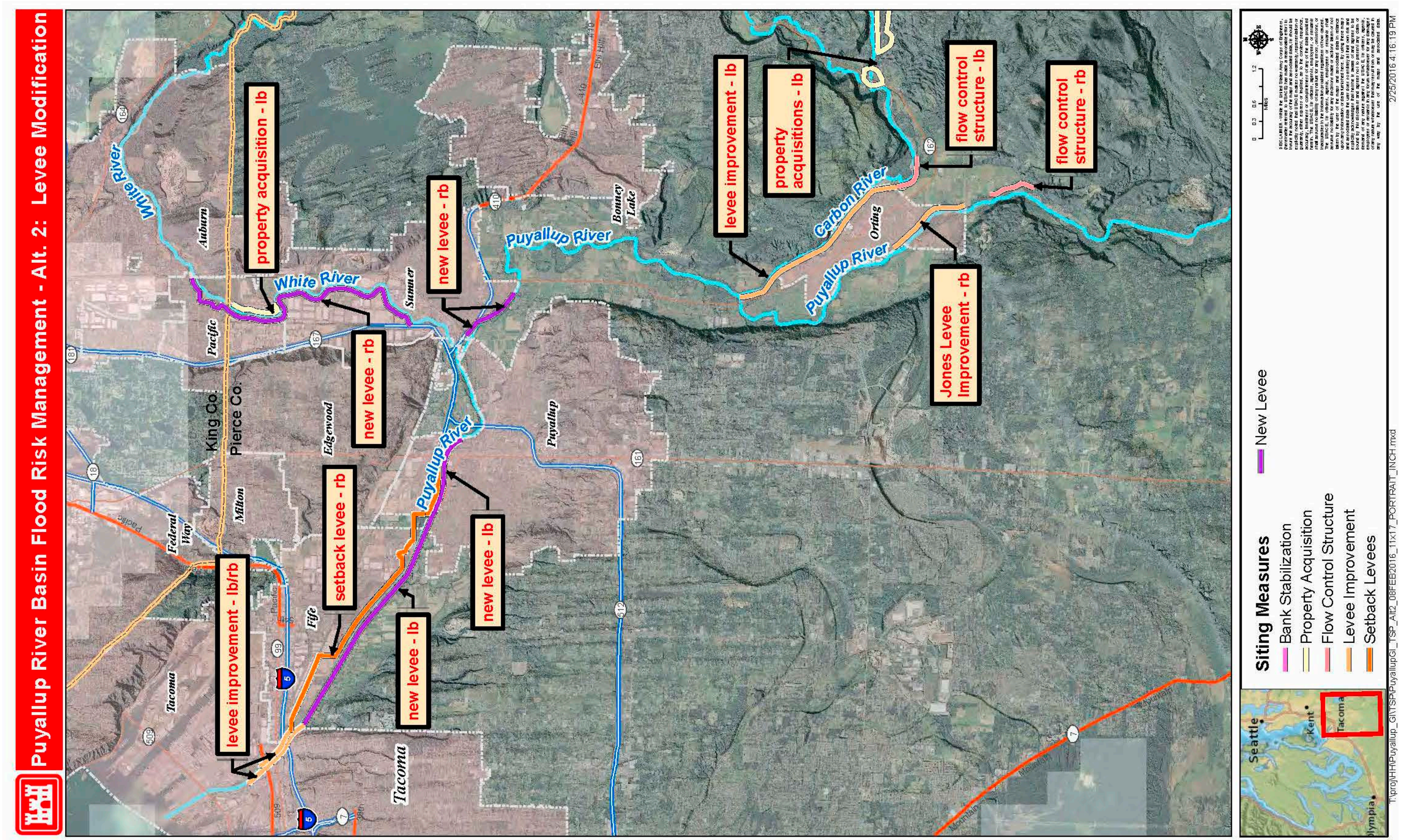


Figure 3-2. Alternative 2 - Levee Modification Alternative

This page intentionally left blank.

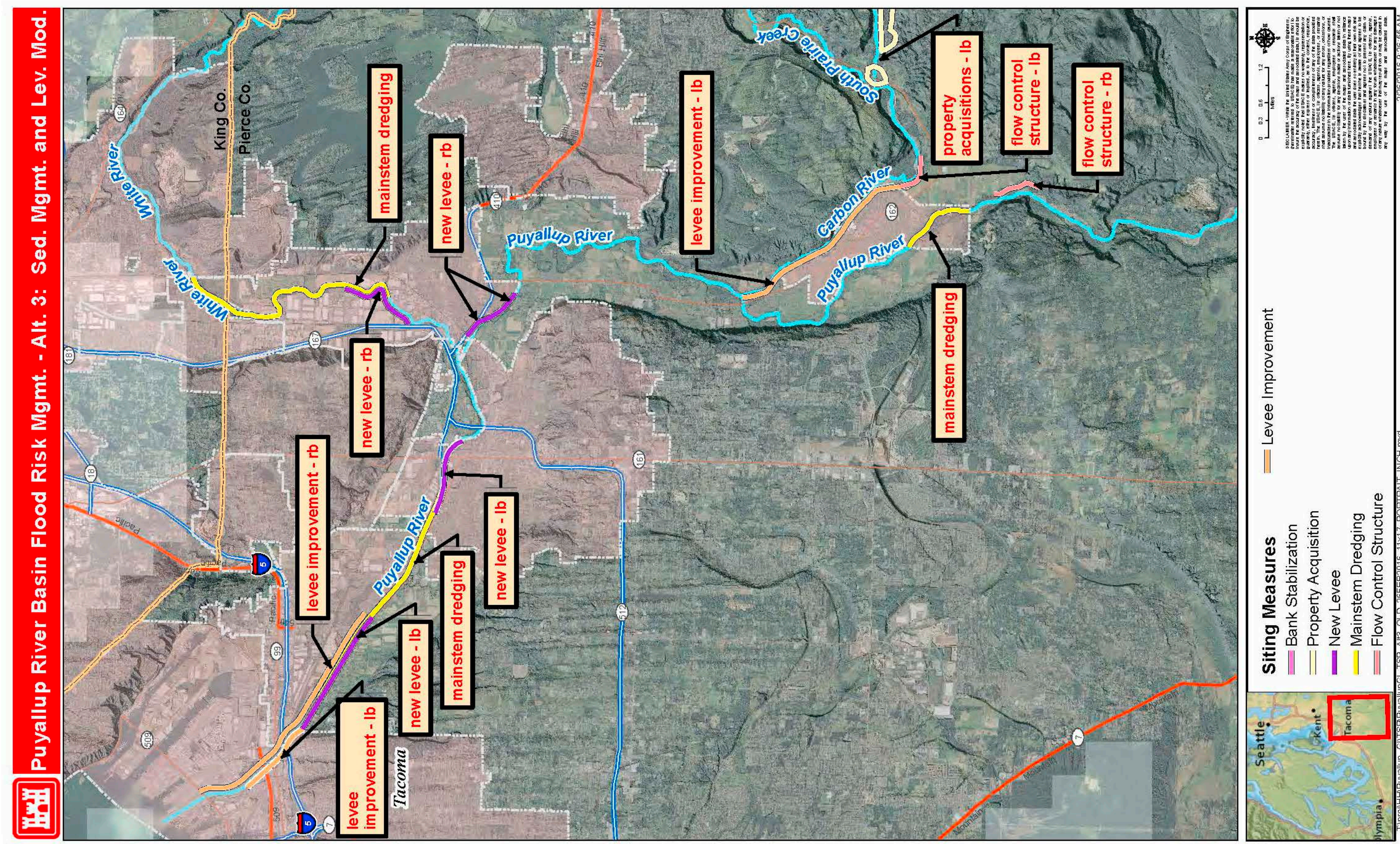


Figure 3-3. Alternative 3 - Sediment Management with Levee Modification Alternative

This page intentionally left blank.

3.3 Identifying the Tentatively Selected Plan

The Final Array of Alternative Plans was evaluated and then compared using the criteria in Table 3-9 to determine which alternative would be carried forward as the TSP. The evaluation and comparison analysis was primarily qualitative and used the Principles and Guidelines (P&G) criteria of *completeness, effectiveness, efficiency, and acceptability* along with sub-sets of the P&G criteria. The evaluation and comparison of the Final Array of Alternatives was based on a conceptual level of design. The evaluation and comparison process was an interdisciplinary effort, using a workshop format, and included the Study sponsor.

There is no single "best" plan, and there are a variety of approaches (quantitative and qualitative) to multi-criteria decision making. The methodology used for this Study was qualitative and subjective, but appropriate to this stage of a feasibility study, and is consistent with the Corps' risk-informed approach to planning for civil works projects, which requires balancing the level of uncertainty and risk at a given point in a study with the level of detail of the study. The level of detail required to make planning decisions grows over the course of the study, as the study team moves from an array of alternatives to a single recommended alternative. In this case, the Corps identified several key uncertainties (see Section 3.2.1) early in the plan formulation process, including sedimentation, anticipated impacts to environmental and cultural resources, and future projects that may be implemented outside of this Study and could change assumptions made for the Study. Assumptions and/or decisions related to how to consider these risks and uncertainties have been documented throughout this DFR/EIS.

For this evaluation and comparison, the Corps applied quantitative hydraulic analysis to characterize the future without-project and future with-project conditions for the Final Array of Alternatives, and used qualitative metrics and hydraulic engineering for evaluation, comparison and selection of a TSP.

One of the risks associated with this approach is that alternative alignments, earthwork, real estate cost estimates, or other aspects of an alternative could be different with more detailed information. Planning is an iterative process. Measures in a plan *not* selected as the TSP based on the evaluation and comparison of the Final Array of Alternatives are not off the table forever, and could be incorporated in the TSP during feasibility-level design analysis, when additional technical information is available, such as sediment modeling, geotechnical borings, utilities survey information. The TSP measures may also be adjusted during feasibility-level design based on technical, policy, legal, and public reviews of this DFR/EIS.

Evaluation Criteria

The evaluation of alternative plan effects is the fourth step of the Corps planning process and involves comparing the effects (or outputs) of each action alternative future with-project condition to the future without-project condition (i.e. the No Action Alternative). The evaluation is based on those project outputs that are important to evaluate to determine which plan should go forward as the TSP. The significant project outputs are reflected in the alternatives evaluation criteria. The 12 evaluation criteria used for this Study are sub-sets of the four P&G criteria, and are described below along with the scoring methodology. For example, the P&G criterion of e*ffectiveness* was evaluated using two criteria: *Flood*

Damage Reduction and *Improvement to Life Safety.* Table 3-9 describes the evaluation criteria and Table 3-10 describes how the evaluation criteria correspond with the four P&G criteria.

Table 3-9. Measures Evaluation Criteria

Alternatives Evaluation Criteria	Definition	Scoring Methodology
Flood Damage Reduction	The degree to which the alternative reduces risk of flood damages to public and private properties and infrastructure.	The higher the reduction of flood risks the higher the score: Short-term (1-10 years after construction) Mid-term (10-30 years after construction) Long-term (30-50 years after construction)
Improvements to Life Safety	The degree to which the alternative improves life safety of populations at risk or affected by flooding, including availability of evacuation routes, reliability of flood infrastructure located in floodplains.	Improvement to life safety gets a high score rated over the 50 year period of analysis.
Wetlands Impacted	An estimate of wetland acres degraded by the alternative	The fewer acres of wetlands adversely impacted, the higher the score
Fish (salmonid) Habitat Affected	An estimate of fish habitat degraded by the alternative	The lower the adverse impacts to fish habitat, the higher the score
Riparian Habitat (Corridor) Affected	An estimate of riparian habitat degraded by the alternative	The lower the acres of riparian habitat adversely impacted, the higher the score
Floodplain Connectivity	An estimate of floodplain increased or decreased by the alternative	The more floodplain connectivity the higher the score
Other considerations	Degree to which a particular plan meets long-range flood risk management objectives for the non-federal sponsor	The better the alternative meets the non-Federal sponsor's objectives, the higher the score
Mitigation Efforts	An estimate of the degree of mitigation efforts needed to offset unavoidable environmental impacts	The fewer mitigation efforts needed, the higher the score
Operations & Maintenance Responsibility	The degree of O&M responsibility to maintain alternative features	The lower the O&M responsibility the higher the score
Real Estate Complexity	The likelihood or ease in acquiring real estate to be acquired	The lower the magnitude of real estate complexity, the higher the score
Planning Objectives Met	How well the alternatives meet the planning objectives	The more effectively of the project objectives are met, the higher the score
External Needs / Risks to Alternative Completeness	Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities.	The more completely the alternative meets the planning objectives, the higher the score

Table 3-10. Measures Evaluation Criteria Categorized by P&G Criteria

P & G Criteria / Alternative Comparison Criteria	Definition	Corresponding Evaluation Criteria
Effectiveness	The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.	• Flood Risk Management • Improvements to Life Safety
Acceptability	The workability and viability of the alternative plan with respect to acceptance by Federal and non-Federal entities and the public and	• Wetlands Adversely Impacted • Fish (Salmonid) Habitat Adversely Affected • Riparian Habitat Adversely Affected

	compatibility with existing laws, regulations, and public policies	• Floodplain Connectivity • Other considerations
Efficiency	The extent to which an alternative is the most cost effective means of alleviating the specified problems and realizing the specified opportunities.	The Corps used a qualitative evaluation of the following criteria as a proxy for construction costs: • Mitigation Efforts • Operations & Maintenance Responsibilities • Real Estate Complexity • Planning Objectives Met
Completeness	The extent to which each alternative plan provides and accounts for all necessary measures and actions to ensure the realization of the planning objectives.	• External Needs/Risks to Alternative Completeness

Evaluation of the Final Array of Alternatives

Each of the three alternative plans in the Final Array of Alternatives was assessed using the evaluation criteria. This assessment was qualitative based on the level of detail for hydraulic and hydrologic engineering, economics, and design in this phase of the Study. The evaluation included a qualitative analysis of each evaluation criterion on a plan by plan basis. The evaluation analysis between each alternative plan and the No Action alternative used a scoring system to distinguish the magnitude of the effects between the alternatives. The scoring methodology is different for each P&G criterion section.

For example, for the *Flood Damage Reduction* criterion, a score of 1 reflected anticipated severe increase in flood risks, while a score of 5 reflected anticipated significantly reduced flood risks. For the Efficiency criteria, however, a score of 1 reflects anticipated significant increase in O&M responsibilities, mitigation efforts, or real estate complexities while a score of 5 reflects no anticipated change in O&M responsibilities, mitigation efforts or real estate complexity. Again, it is important to remember this assessment was qualitative based on the level of detail in this phase of the Study. Examples of other criteria used: improvements to life safety, impact to wetlands, impact to fish habitat, impact to riparian habitat, floodplain connectivity.

In addition, as noted earlier, the Corps used a 1% ACE probability as a starting point for the concept-level design used in evaluation and comparison of the Final Array of Alternatives, This was for all reaches in the Study area except the lower Puyallup River reach, where a conceptual 0.5% ACE was assumed in the base condition and 0.1% ACE at the end of the planning period of analysis. This is based on Pierce County service objectives outlined in the County's Rivers Flood Hazard Management Plan and Comprehensive Plan goals. (Note that the percent ACE probability used for evaluation and comparison of alternatives may not be the same as a design performance with assurance, which will be defined during the feasibility-level design analysis of the TSP – the single plan that moves forward for additional design - as additional design information is available and the TSP is optimized to identify the NED plan which reasonably maximized net benefits for NED and reduces residual risk to life safety. This information will be documented in the final FR/EIS.)

Alternatives were not evaluated and compared using a quantitative cost estimate because the Corps determined this level of detailed cost information would not change the alternative selection. Proxies for cost drivers were used, including O&M responsibilities, mitigation efforts, and real estate complexity.

Based on the evaluation scoring for the 12 criteria, Alternative 2 scored highest among the three alternatives on six criteria, including:

- Flood damage reduction, because sedimentation in the basin is a concern and the levee modification in Alternative 2 would involve levees that would be designed such that they could handle the sedimentation over the 50-year period. By contrast, Alternative 3 involves some frequency of going back periodically to dredge.
- Fish and riparian habitat, because of the proposed setback in the lower Puyallup reach
- Other considerations, because Alternative 2 best addresses the Sponsor objectives for flood risk management
- O&M responsibilities because, although there are a few new levees within the system under this alternative, it would increase the stability of the existing levee system, thereby decreasing the amount of maintenance responsibilities over the planning horizon.
- Completeness, because Alternative 2 has the fewest external requirements, such as permitting or anticipated land acquisition.

In some cases, Alternative 1 (No Action) scored highest, including wetlands impacts, because existing wetlands would remain largely unchanged. Alternative 1 also scored highest for floodplain connectivity because it does not include new levees, as the other two alternatives do. In addition, Alternative 1 scored highest for mitigation effort and for real estate complexity because the alternative would not include a new Federal project so would not require mitigation or real estate acquisition. In the case of wetlands impact, mitigation effort, and real estate complexity, Alternative 2 scored second highest because of the impacts and requirements associated with the dredging measure in Alternative 3 that are not part of Alternative 2.

Alternative 3 did not score highest in any of the criteria.

Comparison of the Final Array of Alternatives

After the three plans were evaluated, they were then compared against each other with emphasis on the outputs and effects that will have the most influence in the decision-making process. The comparison step can be defined as a reiteration of the evaluation step, with the exception that, in this step, each plan is compared against each other and not against the future without-project condition (No Action Alternative) alone. The comparison criteria are the same as the 12 evaluation criteria.

As with the evaluation, this comparison was qualitative and was based on the level of detail of the information available in this phase of the Study process. The comparison analysis between each alternative plan used the scoring totals from each alternative plan's evaluation of significant output and effects as it relates to the P&G criteria. Because the scoring methodology for the evaluation step above was different for each P&G criterion, the scores were then normalized using a multiplier to balance the variability in the scoring methodology.

Below is a summary of the evaluation and comparison process. Detailed tables documenting the evaluation and comparison process, rationales and scoring are included in Appendix A (Plan Formulation).

Effectiveness:

Two criteria were used:

- Flood Damage reduction
- Improvement to Life Safety

No Action: Non-Federal projects under No Action would not be enough to address repetitive damages to existing levee system, sustain flood risk reduction efforts, and are not constructed to provide needed protection within urban areas. Would not reduce flood risks or life safety risks during planning period due to decreased conveyance capacity as result of sediment deposition.

Alternative 2 scored highest because, to evaluate at the 1% ACE probability at the end of the planning period, flood damage reduction at the beginning of the planning period would be greater than 1% ACE at many locations under Alternative 2, resulting in a higher level of flood damage reduction early in the planning period than under Alternative 3. Alternative 3 scored lowest because it would decrease level of flood risk management due to sedimentation and loss of channel capacity; would increase to 1 % ACE with maintenance dredging. Very intensive on the O&M because of the dredging. Both Alternative 2 and Alternative 3 scored equally for improvements to life safety.

In comparison, both Alternative 2 and Alternative 3 would be effective in reducing flood risk. Alternative 2 would provide more flood risk reduction in the early years and decrease in its effectiveness in the latter years, but still meet the 1% ACE probability level that was used for evaluation and comparison. Alternative 3 would provide flood risk management in the initial years and would decrease its level of flood risk management due to sedimentation and loss of channel capacity. However, Alternative 3 would provide the required flood risk management again as designed once maintenance dredging has occurred. Both alternatives improve the reliability of the existing levee system either as part of the levee raise, levee setback, or just an improvement to increase reliability of the structure to reduce flood risks.

Acceptability

Five criteria were used:

- Wetlands Adversely Impacted
- Fish (Salmonid) Habitat Adversely Affected
- Riparian Habitat Adversely Affected
- Floodplain Connectivity
- Other considerations – how well alternative meets Sponsor FRM goals

The No Action Alternative scored lowest because it is not acceptable to the non-Federal Sponsor and study stakeholders due to its inability to reduce flood risks in the Basin.

Alternative 2 would slightly benefit habitat due to the setback levee on the lower Puyallup reach, but would have some negative impact in other areas of project. Alternative 3 scored lower than Alternative 2 due to the impact of dredging on significant resources (ESA listed species), would require a substantially higher magnitude of mitigation, and may impact the Puyallup Tribe's U&A fishing areas. Alternative 3 scored lower than the other two because it also requires permits that may be difficult to obtain to dredge the channel and would have high costs of mainstem dredging maintenance. Alternative 2 and Alternative 3 scored equally on Floodplain Connectivity because floodplain connectivity is a limiting factor to salmon recovery, based on the significant amount of existing flood control structures throughout the study area. Both alternatives would continue this condition.

In comparison, Alternative 3 is less acceptable than Alternative 2 due to its greater adverse impacts to significant resources such as ESA listed species, requires a substantially higher magnitude of mitigation costs, and may have impacts to the Puyallup Tribe's U&A fishing areas. In addition, the non-Federal Sponsor is concerned about the inability to obtain necessary permits to dredge the channel system to manage sedimentation and channel conveyance along with the high costs of routine mainstem dredging maintenance.

The No Action alternative is not acceptable to the non-Federal Sponsor and Study stakeholders due to its inability to reduce flood risks in the Basin.

Efficiency

Four criteria were used:

- Mitigation Efforts
- Operations & Maintenance Responsibilities
- Real Estate Complexity
- Planning Objectives Met

The evaluation did not use a quantitative cost estimate for each alternative and used complexity, requirements, and effort as a proxy for cost. Without developing costs at this stage of the Study, this category considered the magnitude of efforts for each of the main cost drivers to assess efficiency. In addition, each alternative was assessed on how well it addressed each planning objective.

The No Action Alternative would have fewer responsibilities and/or efforts required to reduce flood risks than the other alternatives; however, would not meet the planning objectives of the project. Therefore, it is not efficient. Alternative 2 has real estate complexity, but is more effective in meeting the planning objectives, less O&M and mitigation than Alternative 3. Alternative 3 would have significantly higher O&M than Alternative 2 due to dredging and mitigation responsibilities, which would cause it to be less efficient than Alternative 2.

Completeness

One criterion used:

- External Needs/Risks to alternative completeness

The No Action Alternative is not a complete alternative plan due to dependency on external actions by the non-Federal Sponsor, stakeholders, and other government agencies to reduce flood risk.

Alternative 2 scored higher than Alternative 3. Both are complete plans, are not related to other public or private plans within the Basin, and completely meet the project objectives. However, Alternative 3 has higher implementation risks:

- Alternative 2: Availability of lands owned by the Puyallup Tribe along lower Puyallup River reach and the ability to obtain a permit from the Tribe for any in-water work in lower Puyallup reach.
- Alternative 3: Same as Alternative 2 plus a series of maintenance dredging throughout the planning period. This action would include a permit from the Corps and coordination with Federal resource agencies each time maintenance dredging is conducted. In addition, mitigation would be extensive and availability of sites is limited. The volume of material could add a challenge to finding a placement location.

In comparison, the No Action Alternative has fewer responsibilities and/or efforts required to reduce flood risks than the other alternatives plans; however, it would not meet the planning objectives of the project over the planning period of analysis. Therefore, it is not efficient. Unlike the No Action Alternative, Alternative 2 has significantly higher real estate complexity, but is more effective in meeting the planning objectives. Alternative 3 has significantly higher O&M dredging and mitigation responsibilities than Alternative 2 because of the dredging measure included in Alternative 3, which cause it to be less efficient than Alternative 2 in meeting the planning objectives.

Based on the evaluation and comparison analysis summarized above, Alternative 2 (Levee Modification Alternative) is the recommended TSP, because it cost-effectively meets the flood risk management objectives, has fewer adverse impacts to environmental resources and is more likely to be supported by the sponsor and the public than Alternative 1 or Alternative 3.

3.4 Identifying the NED Range of the TSP

The TSP was further evaluated to determine if elements of the TSP would meet economic justification. Separable areas or elements are defined for the Study as the subdivision of the Study area's flood risk based on hydrologic and hydraulic characteristics and functions with identifiable and distinct economic benefits. In general, components were combined within study reaches, yielding separable elements for the lower Puyallup River, the middle Puyallup River, the upper Puyallup River, the White River, and the Carbon River. A conceptual design was completed at a 1% ACE probability over the planning period of analysis for all features associated with the TSP, for the purposes of evaluating and comparing alternatives during plan formulation. (Recommended scale of features will be based on optimization of the TSP during feasibility-level design analysis and documented in the final FR/EIS). Cost engineering was completed for conceptual designs for features within each reach and economic analysis was completed to determine the economic benefits of each separable element. Economic analysis was completed with the USACE Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) version 1.4 modeling software, a Corps-certified planning model.

For purposes of this analysis, economic justification is generally defined as a benefit-cost ratio (BCR) exceeding 1.0. Preliminary economic analysis based on levee overtopping provided economic justification) for improvements to the upper Puyallup River, the middle Puyallup River, lower Puyallup River, and the White River. Economic justification was not found for improvements to the Carbon River, and the lower Puyallup River reach improvements had shown marginal justification. Marginal justification on the Lower Puyallup is related to higher costs to construct projects in this reach and consideration of damages from the full range of flood events and the existing flood risk infrastructure that exists through this reach. The Lower Puyallup measures address high residual risks to property and life safety associated with larger, less frequent flood events to the largest proportion of population, critical infrastructure, and development in the study area. The results of the first iteration of separable elements analysis is presented in Table 3-11.

Table 3-11. Economic Analysis of Separable Elements, 1st Iteration (Oct 2014 prices, 3.375% discount rate, $1,000s)

Reach	Construction	LERRD	PED, Construction Management	Total Cost (before contingency)	Total Cost w 46% cont (Oct 2014 prices)	Annualized Cost ($1,000)	Equivalent Annual Benefit ($1,000)	Net Benefits ($1,000)	BCR
Lower Puyallup	$118,267	$32,056	$22,471	$172,794	$252,279	$10,948	$12,159	$1,211	1.11
Middle Puyallup	$1,216	$1,206	$231	$2,653	$3,873	161	2,872	2,710	17.79
Upper Puyallup	$5,268	$8,360	$1,001	$14,629	$21,358	890	1,879	989	2.11
White River	$19,246	$10,109	$3,657	$33,011	$48,196	2,009	18,923	16,915	9.42
Carbon River	$13,261	$1,207	$2,520	$16,988	$24,803	1,034	82	-952	0.08
Totals	$157,257	$52,939	$29,879	$240,075	$350,510	$15,042	$35,915	$20,873	2.39

The sponsor noted that the Clear Creek features previously included in the lower Puyallup River reach were being implemented unilaterally on a local level and requested that the Clear Creek features be considered in the future without-project condition rather than as part of the TSP. As a result, the costs of the improvements to lower Puyallup River reach were consequently reduced. The hydraulic analysis and costs were updated, along with economics. Table 3-12 displays the second iteration of results for the separable elements analysis which removes the Carbon River reach and Clear Creek features from the refined TSP. Confidence bounds are presented on the net benefits and benefit-cost ratio, where the 75% confidence level represents the likelihood net benefits will exceed the indicated value 75% of the time and so on. Benefit uncertainty is derived from Monte Carlo simulation in HEC-FDA which considers uncertainties in hydrologic, hydraulic, geotechnical and economic inputs. The low, mid, and high range represent the 50% confidence range (25, 50, and 75%), given the inputs the analysis. In other words, there is greater confidence that net benefits and BCR will exceed the low values and less confident as you move toward the high values, with the best estimate being the mean values. This analysis did not consider uncertainty in the costs, therefore no distribution for costs was developed. Rather, the costs presented include contingency with 80% confidence. The refined TSP results in approximately $24 million in net benefits and a 2.5 benefit-cost ratio based on mean benefit (or EAD reduced) estimates (October 2015 prices, 3.125% discount rate). Figure 3-4 and Figure 3-5 display the residual 1% (1/100) ACE floodplain for the refined TSP Plan base and future conditions, respectively. The population at risk from flooding with project in the residual 1% (1/100) ACE base floodplain is estimated to be 2,100 based on remaining businesses and residential structures subject to flooding and a 2.59 per household population estimate for Pierce County (Census 2010).

Table 3-12. Net Benefits/Benefit-to-Cost Ratio Ranges for the Refined TSP Plan (October 2015 prices, 3.125% discount rate, in $1,000s)

					Annual Net Benefits Confidence			Benefit-Cost Ratio Confidence		
Separable Reach	**Equivalent Annual Benefits (Mean)**	**Annual Costs**	**Annual Net Benefits**	**Benefit-Cost Ratio**	**75% (High)**	**50% (Mid)**	**25% (Low)**	**75% (High)**	**50% (Mid)**	**25% (Low)**
Refined TSP Plan	$39,078	$15,430	$23,648	2.5	$10,954	$19,839	$33,610	1.7	2.3	3.2

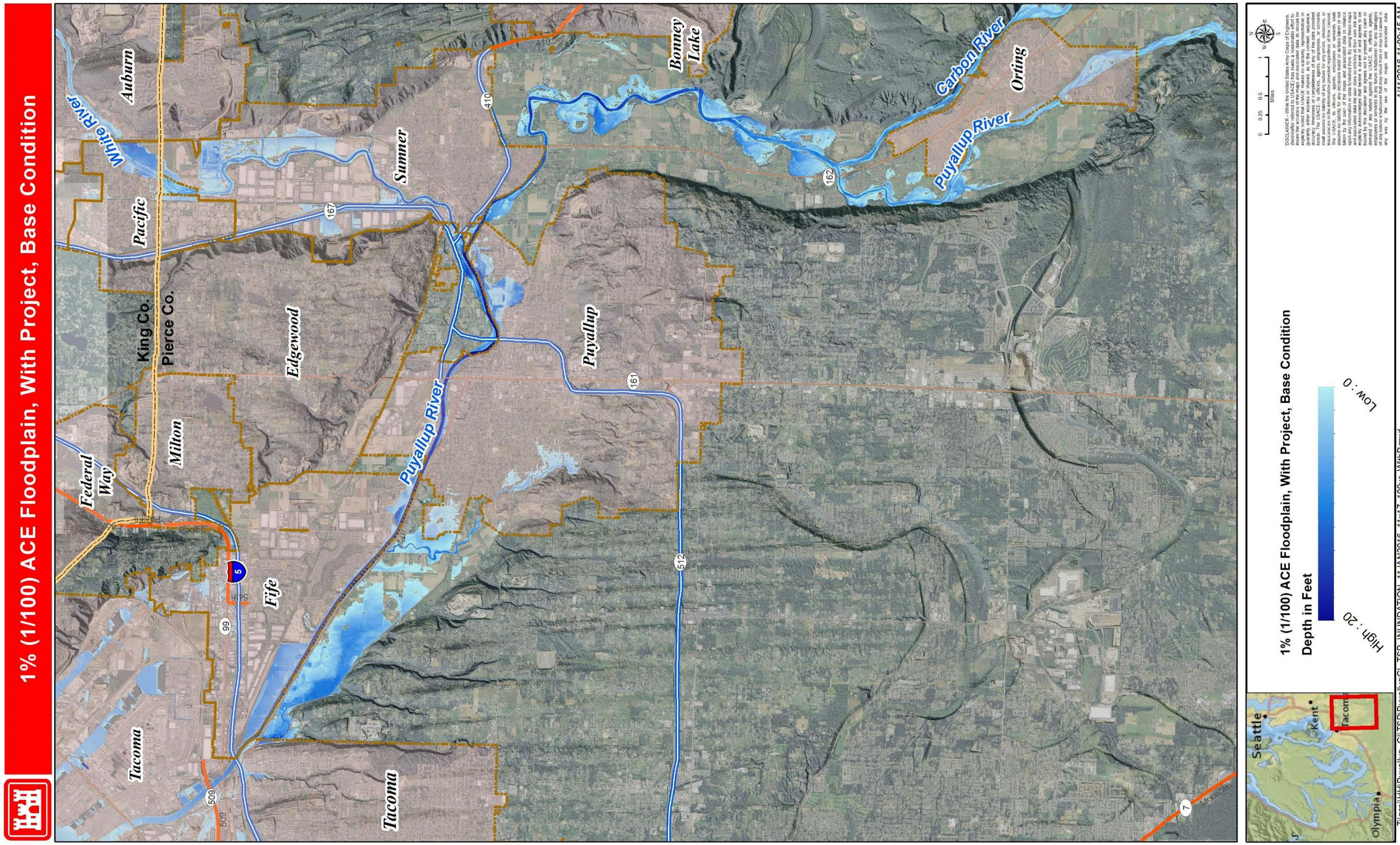


Figure 3-4. Residual 1% ACE Floodplain of the Refined TSP Plan, Base Condition

This page intentionally left blank.

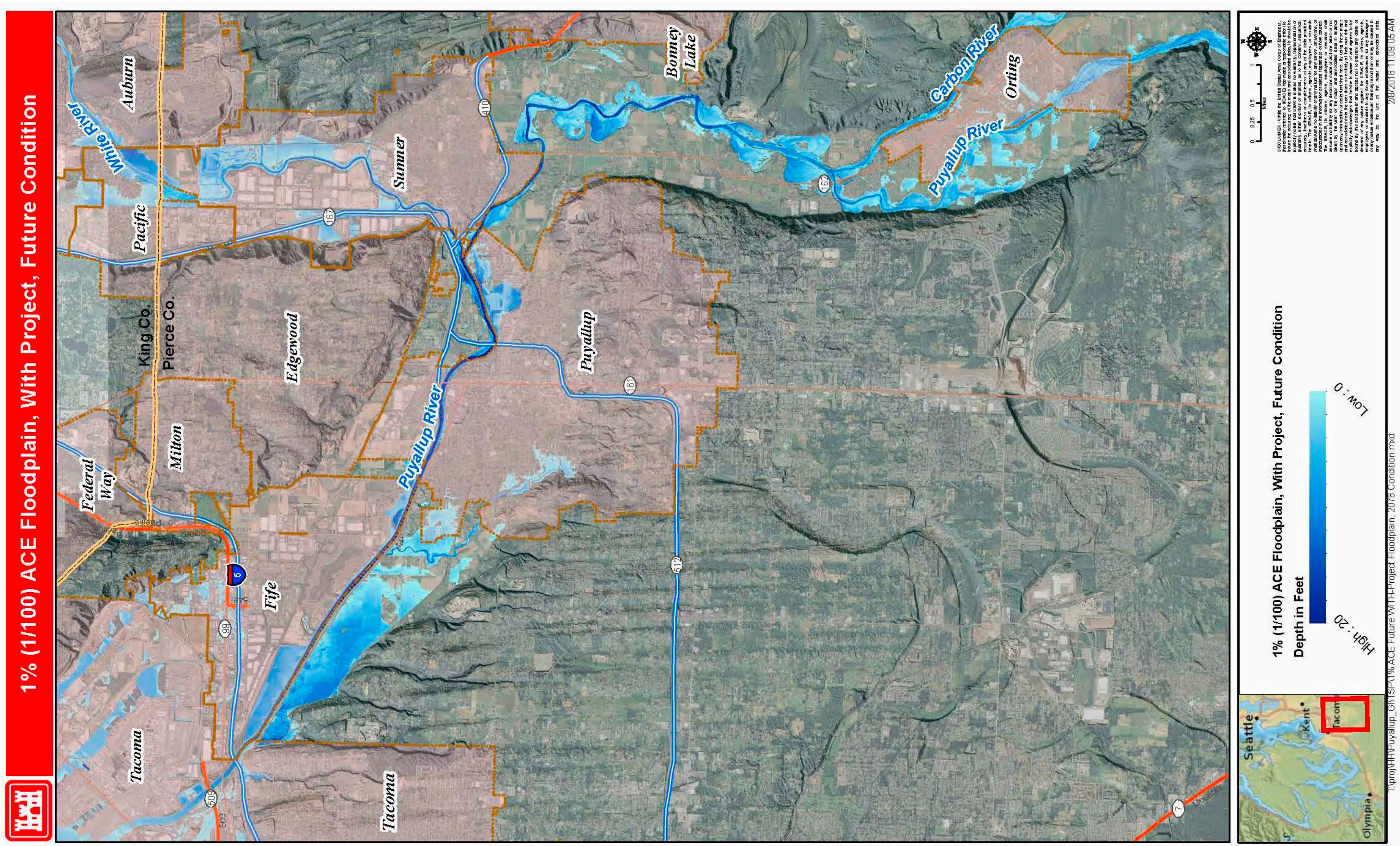


Figure 3-5. Residual 1% ACE Floodplain of the Refined TSP Plan, Future Condition

This page intentionally left blank.

3.4.1 Summary of TSP Measures

A comparison of the TSP (Alternative 2) features associated with the Levee Modification Alternative as it moved through the plan formulation process, leading to identification of the TSP, and reflecting outcomes of subsequent separable elements analysis of the TSP, is included in Table 3-13 below. Table 3-14 summarizes the investment costs and benefits of the refined TSP compared to the No Action alternative.

Table 3-13. Comparison of Features in Alternative 2

Reach	Feature	Initial Array of Alternatives	Final Array of Alternatives	TSP	Notes
Lower Puyallup	Federal Authorized Levee	X	X	X	
	North Levee Road A-Setback	X	X	X	
	River Road Levee Floodwall	X	X	X	
	Lower Puyallup Extension Levee	X	X	X	
	Clear Creek Levee	X	X		Removed from TSP because this will be implemented locally, separate from the Study
Middle Puyallup	Highway 410 Levee/Floodwall	X	X	X	
Upper Puyallup	Jones Levee Improvement	X	X	X	
White River	White River New Levee	X	X	X	
	Property Acquisition	X	X	X	
	MMD Operational Changes	X			Removed before evaluation/comparison of Final Array of Alternatives based on determination that it would be technically infeasible
Carbon River	Lower Carbon River Levee Improvement	X	X		Removed from TSP because not economically justified
	Property Acquisition	X	X		Removed from TSP because not economically justified

Table 3-14. Summary of Costs and Benefits for Refined TSP (Oct 2015 prices, 3.125% discount rate)

	No Action	Alternative 2 (Refined TSP)
Investment Cost		
First Cost	-	$341,144,000
Interest During Construction	-	$30,092,000
Subtotal	-	$371,236,000
Annual Cost		
Interest and Amortization	-	$14,773,000
OMRR&R	-	$600,000
Subtotal	-	$15,373,000
Annual Flood Risk Management Benefits	-	**$39,078,000**
Annual Net Benefits	-	**$23,705,000**
Benefit-to-Cost Ratio (3.125%)	-	**2.5:1**

3.5 Optimizing TSP to Identify NED Plan

Optimization of the TSP to identify the recommended NED plan, to include the rationale for selection and a discussion of the optimization analysis and risks and uncertainties, will be completed during the feasibility-level design analysis as additional detailed information is available, following public, technical, legal, and policy reviews of the DFR/EIS. The outcome of this analysis will be documented in the final FR/EIS. Optimization of TSP will include an evaluation of a range of levee and/or floodwall heights for each of the TSP features to identify the scale which reasonably maximizes net benefits (the difference between annualized benefits and annualized costs over the period of analysis) where benefits are greater than costs, while providing reduced residual risk to life safety and property. It is anticipated that the scale of features, particularly on the lower Puyallup reach, may be reduced based on performance estimates of the current design and the marginal benefit-cost ratio. The optimization will also incorporate sediment transport modelling information in future economic flood damage analysis, and analysis of life safety, including critical infrastructure, environmental justice communities, and evacuation routes, and lands subject to development for Executive Order 11988 as described further in Chapter 5.

This page intentionally left blank

4 Affected Environment and Environmental Consequences*

This chapter evaluates the final array of alternatives carried forward from Chapter 3 (Plan Formulation) as required for the Study, consistent with the Corps Planning process and as required by NEPA. This chapter describes the existing conditions and future without-project conditions (i.e. the No Action Alternative) used for analysis during the Study. Existing conditions are the physical, chemical, biological, and sociological characteristics of the Study area. Characterizing resource conditions is critical for understanding the probable future condition of those resources (i.e. the future without-project condition) and for defining problems and opportunities.

This chapter also provides information on issues relevant to the decision process for selecting the TSP. The analysis investigates the potential for activities associated with the considered alternatives to affect (either adversely or beneficially) the various resources of concern and provides a comparative assessment of each alternative's expected effect on the environment. The assessment of environmental effects is based on a comparison of conditions with and without implementation of the proposed alternatives; in this case, two alternatives were formulated through the screening process and are compared to the No Action Alternative. Effects can be short-term or long-term, and beneficial or adverse. The analysis focused on significant resources, which are those that are likely to have a material bearing on the decision-making process. For the alternatives analysis in this chapter, the spatial scale of analysis focuses on the locations of the proposed features for the alternatives to provide a comparison between the No Action Alternative and the two action alternatives. The Study period of analysis is the 50-year period from 2026 through 2076.

Chapter 3 summarizes the formulation and evaluation of alternatives. The final array of alternatives carried forward for the assessment of environmental consequences in this chapter is:

- Alternative 1: No Action Alternative
- Alternative 2: Levee Modification Alternative
- Alternative 3: Sediment Management with Levee Modification Alternative

All river mile locations, and levee or floodwall lengths and heights for measures during the plan formulation process are approximate and based on professional judgment and/or concept-level design. Actual river miles for measures included in the TSP will be refined during feasibility-level design analysis and documented in the final FR/EIS.

4.1 Resources Analyzed and Resources Screened from Detailed Analysis

Table 4-1 lists the resources analyzed or screened from detailed analysis including a rationale for inclusion or exclusion. Resources were excluded from detailed analysis if they are not potentially affected by the alternatives or do not have a material bearing on the decision-making process.

Table 4-1. Resources Analyzed or Screened from Detailed Analysis

Resource	Included in Detailed Analysis (Y/N)	Rationale for inclusion or exclusion
Hydraulics and Hydrology	Y	Problems identified center on the relationships among hydraulics and hydrology. Proposed alternatives require study of these characteristics.
Geomorphology and Sediment Transport	Y	The proposed alternatives may have effects to geomorphology and sediment transport.
Water Quality and Quantity	Y	The proposed alternatives may have short- and long-term effects to water quality.
Air Quality	Y	Due to the estimated construction activities needed to implement the alternatives, the alternatives may have short term effects to air quality.
Greenhouse Gas Emissions	Y	Required to be analyzed by CEQ guidance (2010).
Climate Change and Sea Level Change	Y	Corps Engineering Regulation 1110-2-8162 requires feasibility studies to consider the sensitivity and adaptability of projects to sea level change. Predicted effects of climate change are described for the alternatives.
Noise	Y	Sensitive receptors would near the location of the alternatives and therefore, short term noise related impacts could occur.
Hazardous, Toxic, and Radiological Waste	Y	The proposed action alternatives would not create a significant hazard to the public or the environment through transport, use, or disposal of hazardous materials; however there are potential HTRW sites near the alignments of the alternatives.
Fish and Wildlife	Y	The proposed action alternatives may have impacts on fish populations in the mainstem river channel. The proposed alternatives also may have short term effects to fish and wildlife during construction.
Wetlands Habitat	Y	The proposed action alternatives may have effects to wetlands in the Study area due to possible fill activities.
Riparian Habitat	Y	The alternatives may adversely affect riparian habitat. .
Aquatic Habitat	Y	One or more of the action alternatives could impact aquatic habitat in the mainstem channel.
Soil Resources	Y	One or more of the proposed alternatives could be affected by the soil types in the area.
Threatened, and Endangered Species	Y	The proposed action alternatives may have impacts on ESA-listed species in the Study area.
Socio-Economics	Y	The alternatives could have effects to socio-economics.
Cultural Resources	Y	The alternatives could adversely affect significant cultural resources
Environmental Justice Communities	Y	Required to be analyzed by presidential executive order.
Aesthetics	Y	The proposed action alternatives may have aesthetic impacts within the Study area.
Land Use, Planning and Zoning	Y	One or more of the alternatives could affect or be affected by land use policies.

Agricultural Resources	Y	Two of the proposed alternatives may have impacts to sizable amounts of agricultural lands and land designated at prime farmland.
Recreation Resources	N	Significant recreation activities (boating, camping, bicycling, hunting, etc.) occur outside the Study area in the upper watershed. Existing recreation facilities within the Study area would remain unaffected by the alternatives. Fishing occurs in the Study area, but the proposed alternatives would not have more than a short term negligible effect on access to recreational fishing.
Public Services and Utilities	Y	Benefits to public services and utilities from reduced flood risk.
Public Health and Safety	Y	Benefits to public health and safety from reduced flood risk.
Transportation and Traffic	Y	The proposed alternatives may cause temporary disruptions to local traffic, and construction vehicles could require additional traffic controls for the duration of work, but not beyond this period.

4.2 Summary of Environmental Consequences

Table 4-2 summarizes the expected consequences on resources analyzed for each of the three alternatives in the final array. The remainder of this section of the report discusses the evaluations that resulted in these expectations.

Table 4-2. Summary Comparison of Environmental Effects of Alternatives, by Resource

Resource	Alternative 1	Alternative 2	Alternative 3
Hydrology and Hydraulics	Conditions are expected to change due to climate alterations; increased runoff and sediment loads in the upper portions of the study area.	Implementation would increase the flood carrying capacity of each river reach. Change to river velocity at flood stages would be less than 1 foot per second.	Implementation benefits to flood risks same as Alternative 2.
Geomorphology and Sediment Transport	Continued sedimentation particularly on the lower Puyallup, upper Puyallup and White rivers.	Increase in transport capacity possible as a result of raised levees with the channel likely remaining confined to its existing planform. Decrease in sediment transport capacity possible at levee setback areas.	Dredging would return depositional reaches of the study area to a historical channel bed condition and alter future sedimentation patterns.
Air Quality and Greenhouse Gases	Increases in air pollution as urbanization	Localized, short-term increases in greenhouse gases and	Localized, short-term increases in greenhouse gases and pollutants related to construction activities.

	increases. Anticipated increase in greenhouse gas emissions	pollutants related to construction activities. No long-term change in greenhouse gas emissions versus the FWOP	No long-term change in greenhouse gas emissions versus the FWOP
Noise	Future growth may change noise levels and types within the study area.	Temporary short-term negative impacts to ambient noise levels from construction equipment. No long-term changes in ambient noise levels	Impacts include short-term construction impacts to noise levels and also increases in underwater noise levels due to dredging. No long-term changes in ambient noise levels
Soils	No significant future changes to soils.	Minimal soil impacts.	Minimal soil impacts from levee and floodwall construction; in-channel negative impacts to channel bed materials from dredging.
Water Quality/Quantity	Overall future water quality is expected to decline largely due to continued development and industrialization. Climate change could result in increased runoff occurring.	Short-term negative impacts to water quality would result from in-water construction activities; removal of riparian vegetation on existing levees and building new structures would minimally contribute to higher water temperatures.	Similar impacts to Alternative 2 for levee and floodwall construction; dredging impacts include short-term decreases to dissolved oxygen and increased turbidity .Negative impacts to water quality will be recurring due to maintenance dredging.
Wetland Habitat and Other Waters of the U.S.	Restoration efforts in the lower basin could improve the extent and quality of wetlands in the future; overall wetland areas are expected to remain largely unchanged.	Construction of new levees and floodwalls would result in a total estimated wetland impact of 7 acres and total impact to Waters of the U.S. of 5 acres.	Construction of new levees, floodwalls and dredging would result in a total estimated wetland impact of 0.34 acres and total impact to Waters of the U.S. of 193 acres.
Riparian Habitat	The existing degraded riparian habitat conditions are expected to continue due to ongoing levee maintenance and impacts from climate change.	Approximately 19.9 miles of riparian habitat could be negatively impacted by this alternative.	Approximately 12.3 miles of riparian habitat could be negatively impacted by this alternative.
Aquatic Habitat	Continued decline in the quantity and quality of aquatic habitat due to	Short-term construction related impacts including loss of shoreline	Impacts similar to Alternative 2, with additional detrimental effects to aquatic habitat due to wide-scale sediment excavation which

	development, limited floodplain connectivity and climate change.	vegetation and turbidity; long-term benefit from levee setback and negative impacts to bank complexity due to new levees and floodwalls.	will cause long-term disruption of aquatic habitat..
Fish and Wildlife	Habitat and species protections would continue; overall long-term habitat and species decline due to climate change, human population and development and repairs to existing flood infrastructure.	Short-term negative construction related impacts such as increased turbidity; beneficial impact on the lower Puyallup due to the levee setback; minimal negative impacts to fish, benthic invertebrates and wildlife because levee alignments minimize inwater work and removal of riparian vegetation at the water's edge.	Terrestrial impacts similar to Alternative 2, with significant negative impacts to fish and benthic invertebrates due to dredging operations which would cause long-term disruption of spawning and rearing habitat in the river Benthic organisms will decrease in species composition and number.
Threatened and Endangered Species	See Fish and Wildlife	See Fish and Wildlife	See Fish and Wildlife
Cultural Resources	Flooding is anticipated to increase in frequency and severity as channel capacity is reduced, which would continue to threaten or damage historic buildings or structures, potentially displace or erode archaeological sites.	Historic properties, including archaeological sites, historic buildings and structures, and other culturally significant resources could be impacted by removal of the existing levees, construction of new or setback levees, or enlarging the footprints or height of existing levees or floodwalls. Proposed actions could indirectly affect significant qualities or values of historic built-environment structures by altering or diminishing the historic setting by introducing new visual or atmospheric	Impacts similar to Alternative 2.

		elements (induced flooding). Removal of structures in high-probability flood zones could impact historic structures.	
Hazardous, Toxic and Radioactive Waste	No change to existing facilities; one potential site could erode during flood events creating a hazard.	Minimal potential impacts except for North Road setback area. Levee design in that reach will have to be evaluated to avoid known contaminated areas.	Minimal potential impacts to existing HTRW sites. Material to be dredged will have to be assessed for contaminants
Land Use, Planning and Zoning	No change to existing land use, planning and zoning within the study area.	Temporary construction related impacts to land owners; increases in flood risk management to certain areas.	Temporary construction related impacts to land owners; increases flood risk management to certain areas.
Agricultural Resources	Risks related to flooding could cause loss of crops and also increases in run-off to the rivers.	Some loss of agricultural land due to implementation of project measures. Some reduction in flood damage to agricultural lands due to project implementation	Some loss of agricultural land due to implementation of project measures. Some reduction in flood damage to agricultural lands due to project implementation.
Socio-Economics	Development will continue in area as the region's population continues to grow.	Increased flood protection not anticipated to change rate of development in the area.	Similar to Alternative 2
Environmental Justice Communities	No direct impacts. Possible negative indirect impacts to low-income and minority populations due to displacement from a large flood event.	No disproportionate impacts to minority and low-income populations. Long-term benefits include increased flood protection to all populations within the protected area.	No disproportionate impacts to minority and low-income populations. Long-term benefits include increased flood protection to all populations within the protected area.
Aesthetics/Visual Resources	Aesthetics within the basin would remain moderate to high with lower aesthetic values in urbanized portions of the study area.	Short-term negative impacts during construction due to equipment operations; long-term negative impacts due to higher existing	Short-term negative impacts during construction due to equipment operations; long-term negative impacts to river views although slightly less than Alternative 2 due to lower levee heights due to dredging.

		levees, new levees and floodwalls restricting views to the river.	
Public Services and Utilities	Existing public service and utilities would continue; infrastructure would remain at risk from flooding	Beneficial impact to lower the risk to public services and utilities.	Beneficial impact to lower the risk to public services and utilities.
Transportation and Traffic	Continued risk of impacts from flood events to existing transportation infrastructure including roadways and rail lines.	Short-term negative impacts to transportation during construction; long-term beneficial impacts to ground transportation and rail lines.	Short-term negative impacts to transportation during construction; long-term beneficial impacts to ground transportation and rail lines.
Public Health and Safety	No change to existing policies and programs such as flood warning systems and public outreach. Flood risk will remain the same except for local flood damage reduction projects being implemented.	Beneficial impact to lower flood risks to the study area as well as implementation of non-structural measures.	Beneficial impact to lower flood risks to the study area as well as implementation of non-structural measures.

4.3 Hydrology and Hydraulics (including Climate Change and Sea Level Change)

See Section 2.7 for a description of existing and historical flood conditions Climate Change, and Sea Level Change.

4.3.1 Alternative 1: No Action

See Section 2.8 for a description of the future without-project condition (i.e. the No Action Alternative).

4.3.2 Alternative 2: Levee Modification Alternative

This alternative would increase the flood carrying capacity of each river reach through the end of the project life in developed areas by raising levees, constructing new levees, and setting back areas of existing levees. This would provide for an increase in level of protection from what they are at the existing (or base year) through the end of the project life (2076). Flood protection would be increased for the Orting area (RM 22.6 to 17.5 on the upper Puyallup River) from around 2-5% annual chance exceedence (ACE) to 1% ACE on the West side of Highway 162, and on the lower Puyallup River (RM 1.5 to 9) from 2% ACE to 0.5% ACE. Areas of the middle Puyallup and lower White Rivers would see an increase in level of protection from 50-5% to 1% ACE. Raising the levees would contain more floodwaters within the channel increasing water surface elevations. With the only levee setback in the project, North Levee Road on the lower

Puyallup River, high flows in the river will be able to access the floodplain area at a 0.5% to 0.2% ACE event. The possible flooding impacts from sea level change would be lessened from the No Action alternative with the raising of levees along the lower Puyallup River.

4.3.3 Alternative 3: Sediment Management with Levee Modification Alternative

The sediment management alternative would provide the same benefit in flood risk management as Alternative 2 through the end of the project life by dredging of the main river channels in the Basin in addition to levee improvements in areas that were not responsive to dredging. Dredging was found to not be effective in achieving project goals in several areas due to backwater. These areas include the Puyallup River near Commencement Bay and near the confluence with the White River. So it was necessary to supplement dredging with the raising of several levees. With this alternative the increase of levee height would not be as great as for Alternative 2. This is further described in the H&H appendices.

4.3.4 Cumulative Effects

The implementation of either alternative could result in a variety of short and long-term impacts. Short-term impacts would primarily involve water quality, particularly the potential for increased turbidity from construction or maintenance activities. Long-term hydraulic and hydrologic impacts for either alternative would be a result of greater flow containment as compared to the No-Action Alternative. Direct changes could include higher in-channel velocities, higher in-channel flow rates, less flood attenuation, and higher water surface elevations at areas where the alternatives include structural measures. The cumulative effect of these changes has the potential to change the hydraulic character of the study area. Higher velocities would be a result of flow confinement at higher flow rates. Reduction in flood attenuation would be the result of reduced river-floodplain interaction, which would keep more water in the river instead of temporarily storing it in adjacent floodplain areas. The greater degree of flow confinement could also create higher flood elevations in areas where the two alternatives do not have measures. This is called transferring risk when an individual measure (such as raising a levee) induces flooding somewhere else in the study area. As of the TSP milestone, the project has accounted for major areas of transferred risk. Buyouts and/or construction of new levees are planned to account for this. Additional refinements are planned based upon sediment modeling to predict future conditions. These impacts from greater flow containment would vary spatially throughout the study area and would generally be more pronounced relative to the size of the flood event. There would be minor differences during frequent events with the differences becoming more pronounced for the larger, less frequent floods.

4.4 Geomorphology and Sediment Transport

See Section 2.7 for existing Geomorphology and Sediment Transport conditions.

Preliminary methods were used to evaluate alternatives to estimate water surface change from observed changes in channel bed material volume over a 25 year window of available data from 1984-2009. Rates of bed material volume change over this period were extrapolated over the period of analysis to design each alternative. This also provided for a relative comparison between existing conditions and future without-project conditions. Feasibility-level design analysis will include updating designs with the results of sediment modeling. This will be documented in the final FR/EIS.

4.4.1 Alternative 1: No Action

See Section 2.8 for future without-project geomorphology and sediment transport conditions.

4.4.2 Alternative 2: Levee Modification Alternative

Raising levees as part of the Levee Modification Alternative is not expected to substantially alter present sedimentation patterns. The North Levee Road setback will not allow the river to migrate out of its present location; only high flows will access the re-connected floodplain areas. Concrete panels buried below the bankline will be left in place.

The consequence of continuing to raise levees in depositional areas is the river channel can become perched above the surrounding floodplain. This would add an additional risk of damages caused by levee failures that would not exist if the channel were dredged to maintain a consistent bed elevation. As levee projects age the risks associated with a perched channel increase. The residual risk after the design life may be much greater than current levels. At this time, the potential for perched channels to develop in depositional areas is being assessed through sediment modeling.

4.4.3 Alternative 3: Sediment Management with Levee Modification Alternative

Dredging localized areas of the river system is, in general, returning the channel bed to a state that existed at some point in history. The effect of this is to create a sediment trap within the river channel that would then fill at some accelerated rate, to return the reach to a similar state that existed before dredging. The tendency may be to trap slightly larger material initially due to the increased trap efficiency. For feasibility level analysis, the existing depositional rate observed over 25 years of data was used to inform estimations of initial and maintenance dredge volume. Because the river is confined between levees, dredging is not likely to produce significant planform change. As mentioned previously, dredging alone was not sufficient to achieve the desired level of flood risk management in several project areas, so it was necessary to supplement with levee modifications. Estimations of dredging frequency on the lower Puyallup River and lower White River is once during the 50 year period of analysis, while the White River near Pacific would be dredged three times and the upper Puyallup River near Orting would be dredged twice for this alternative.

Material removed during dredging would be characterized for physical characteristics and contaminants. If material is suitable it would either used for construction activities or placed in a permitted placement site. Contaminated material would be placed in a site designated for placement of contaminated material.

4.4.4 Cumulative Effects

The historical geomorphic trend for most of the Study area is one of channel aggradation. This would continue for Alternative 2 and for Alternative 3 (between sediment removal events). Overall it is expected that future sediment deposition rates for the No Action Alternative and the selected Alternative 2 would be similar. Specific differences will be determined during feasibility-level design analysis with the results of sediment modeling. Deposition rates for the Alternative 3 may have been greater in some locations as the removal of material can create conditions where the sediment deposition rate is initially accelerated above what it would have been had the material not been removed. The degree of alternative-induced geomorphic changes is highly dependent on the magnitude of flood events that occur during the period of analysis. Higher peak flows and/or more frequent high flows as a result of climate change would be expected to accelerate sediment deposition in many areas.

4.5 Air Quality & Greenhouse Gases

4.5.1 Air Quality

The Puget Sound Clean Air Agency (PSCAA) is the local authority in charge of monitoring air quality for Pierce County and King County. PSCAA tracks six criteria air pollutants that are reported to the EPA. The pollutants include fine particulate matter (PM 2.5 and PM 10), ozone, nitrogen oxide, carbon monoxide, sulfur dioxide, and lead. EPA sets national ambient air quality standards (NAAQS) for these pollutants (PSCAA 2011).

Data provided by PSCAA is aggregated at the county level from monitoring stations throughout the county. PSCAA reports air quality using the EPA-developed standard, called the Air Quality Index (AQI). The AQI is reported on a scale of 0 to 500, 0 being the best and 500 being considered hazardous air quality. The AQI for Pierce County in 2009 was rated as “good” (0 to 50) 78% of the year, “moderate” (51 to 100) for 18% of the year, and “unhealthy for sensitive receptors” (101 to 150) 4% of the year for the reporting year 2009. King County’s AQI measured for 2009 was good 75%, moderate 24%, and unhealthy for sensitive receptors 1% of the year (PSCAA 2011).

The air quality is generally good in the White River and Carbon River sub-basins, but has failed to meet air quality standards in the lower Puyallup River sub-basin and a portion of the upper Puyallup River sub-basin. Since 2000, the AQI results have generally trended toward improved air quality in Pierce County with less days exceeding the air quality standards per year. However, the lower Puyallup River Sub-basin and a portion of the upper Puyallup River Sub-basin experienced levels of fine particulate matter that violates the EPA 24-hour standard in 2006 (PSCAA 2007). The readings in 2006 contributed to an exceedance of the 3-year weighted mean of 15.0 micrograms per cubic meter (µg/m3) for PM 2.5. This exceedance caused EPA to designate the area as nonattainment for PM 2.5.

In 2006, EPA reviewed its policy on NAAQS under the Clean Air Act. The EPA decided to require more stringent standards for fine particulate matter (PM 2.5). As a result of this new standard a portion of Pierce County, including the Puyallup Tribal reservation lands, was determined to be out of compliance for PM 2.5 emissions. The main contributor for not reaching attainment is a combination of wood stoves and outdoor burning, which combine to produce 63% of the fine particulate matter (PSCAA 2007).

In 2008, WDOE working with PSCAA proposed a nonattainment area boundary for PM 2.5 to EPA (Access Washington 2011). The area is referred to as the Wapato Hills to Puyallup River Valley Area. In 2009, the EPA accepted WDOE’s proposed boundary. In October 2014 WDOE submitted a redesignation request and maintenance plan to EPA as a revision to Washington’s State Implementation Plan. The plan shows that the area is meeting the fine particle limit and has the necessary pollution controls in place to meet the limit for the next 10 years. EPA has up to 18 months to approve the plan. When the plan is approved, the area will be redesignated to attainment. (Access Washington 2015)

In addition to preparation of a plan to reach attainment, PSCAA has created the Tacoma-Pierce County Wood Smoke Reduction Program, which offers incentives for residents of Tacoma and Pierce County to replace their wood burning stoves with non-wood forms of heat. Registration into the program is currently available to the public (PSCAA 2015).

The Puyallup Tribe Air Quality Program is also working with PSCAA and EPA to improve air quality on tribal lands. The Puyallup Tribe has adopted its own air quality regulations and follows the Federal Air Rules for Reservations (FARR) policy, which applies to outdoor burning (Puyallup Tribe 2011).

4.5.2 Greenhouse Gases

Earth's atmosphere is changing, the climate system is warming, and the changes are likely due in part to human activities that produce greenhouse gases (GHGs). GHGs include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and some hydrocarbons and chlorofluorocarbons. These compounds create a greenhouse effect when they accumulate in Earth's atmosphere. They act as a layer of insulation, retaining within Earth's atmosphere some of the thermal radiation that originated from the sun.

At the Federal level, GHG is not regulated directly; however, some policies and guidance from the CEQ do provide some direction on how to address greenhouse gases in environmental impact statements. CEQ regulations and guidance further elaborate on how the analysis for GHGs should be formulated with the recognition that not only are there no formal thresholds for GHG emissions analyses, but also of the scientific limitations on how the analyses can be prepared. Specifically, the CEQ guidance states "agencies should recognize the scientific limits of their ability to accurately predict climate change effects, especially of a short-term nature, and not devote effort to analyzing wholly speculative effects." Thus, the following analysis acknowledges to the extent scientifically possible the GHG emissions and sequestration of each alternative.

Estimating the total quantity of GHG that would be produced by each project alternative would require extensive analysis and numerous assumptions about each alternative's final design and construction. Qualitative comparisons, however, can be drawn from comparing the proposed features of each alternative.

4.5.3 Alternative 1: No Action

It is likely that, if approved by the EPA, the plan developed by WDOE would bring the lower Puyallup River and upper Puyallup River sub-basins back within compliance for PM 2.5. This would be seen as an improvement to current air quality conditions. In addition, current measures such as implementing burn bans and incentive programs (although currently not funded) would likely contribute to improved air quality for PM 2.5.

Between 2000 and 2040, the population of King County is expected to increase 42% and the population of Pierce County is expected to increase 23% (PSRC 2009). According to the Federal Highway Administration (FHWA 2009), EPA regulations for vehicle engines and fuels will cause a nation-wide reduction in vehicle emissions of 72% by the year 2050. Therefore, current air quality conditions stemming from vehicle engines and fuels are expected to improve over time.

4.5.4 Alternative 2: Levee Modification Alternative

This alternative would have localized short-term increases in emissions and GHG during the estimated six year construction schedule. Machinery and vehicles employed for the proposed repair work will release emissions including greenhouse gases. Equipment such as dump trucks, and excavators would have mufflers and exhaust systems in accordance with State and Federal standards. Based on similar levee modification projects, this alternative would, most likely, be below or at the *de minimis* thresholds and would be exempted pursuant to 40 CFR § 93.153(c)(2)(ix) from the requirement of a conformity determination.

4.5.5 Alternative 3: Sediment Management with Levee Modification Alternative

Similar to Alternative 2, this alternative would have localized short-term increases in air quality and GHG. In addition to the equipment needed to construct the levee modifications, this proposed alternative would generate emissions from engines operating on the vessels, dredges, and tugboats used to dredge and place sediment. The dredge and tugs may be used for the proposed dredging create emissions of CO_2, N_2O, O_3, CO, $PM_{2.5}$, and sulfur dioxide. This alternative would create more emissions than Alternative 2: Levee Modifications because it would construct all the same levee features as Alternative 2 and would also include mainstem dredging along the lower Puyallup River and upper Puyallup, and White Rivers. As mentioned earlier, the lower Puyallup River and lower White River would be dredged once during the period of analysis while the White River near Pacific would be dredged three times and the upper Puyallup River would be dredged twice. Based on similar levee modification projects, this alternative would, most likely, be below or at the *de minimis* thresholds and would be exempted pursuant to 40 CFR § 93.153(c)(2)(ix) from the requirement of a conformity determination.

4.5.6 Cumulative Effects

Impacts to air quality and GHG would be temporary and would only occur during construction including the dredging activities described in Alternative 3. During construction the emissions generated would be additive to other existing sources of emissions such as vehicles, and industrial activities. In addition to increased urbanization, the proposed project would likely result in a small increase in GHG.

4.6 Noise

Noise is defined as unwanted sound (LaMuth 2008). A number of factors affect how humans perceive sound. These include the loudness, frequencies involved, period of exposure to the noise, and changes or fluctuations in noise levels during exposure. The human ear cannot perceive all pitches or frequencies equally well. Reflecting this fact, measures can be weighted to compensate for the human range of sensitivity. The most common of the weighted measurement units used for assessing construction activities is the A-weighted decibel, or dBA. Zero on the dBA scale is based on the lowest sound that the healthy human ear can detect. Ambient sounds generally range from 30 dBA (very quiet) to 100 dBA (very loud).

The lower Puyallup River sub-basin is characterized by a mix of industrial, commercial, residential, and agricultural land uses. Noise in this area is generated by heavy industrial marine terminals, the interstate freeway, local roadways, railways, manufacturing, and warehouse facilities. This sub-basin generally has higher ambient sound than the rest of the Puyallup River Basin.

In 2000, the Washington State Department of Transportation (WSDOT) conducted noise monitoring along the proposed SR 167 extension from Puyallup to Tacoma to establish the existing condition based on afternoon peak-hour travel conditions. Results showed a range of sound level from 52 dBA to 80 dBA (WSDOT and FHWA 2006).

The upper Puyallup River and Carbon River sub-basins are composed of mainly rural residential and agriculture, with some commercial and industrial land uses mainly in the cities of Sumner and Orting. The White River sub-basin includes the cities of Sumner and Buckley and a portion of the cities of Pacific and Auburn and the Muckleshoot Indian Reservation. This area is generally characterized as rural with low density housing, agricultural, and forestry within unincorporated areas and residential/commercial within incorporated areas. The primary sources of noise generated in these areas are roads, farming activities and industrial/commercial zones in the urban areas.

4.6.1 Alternative 1: No Action

Sources of noise within the project area are expected to change over time. As population growth and urban expansion continue, current land uses and their associated noise generators would be expected to change. For example, ambient noise from agricultural practices may be reduced as a result of conversion to residential or commercial land uses. However, ambient noise from these new uses would then increase, including increased traffic, exterior heat exchangers (ventilation, air-conditioning, etc), outdoor speaker systems, etc. Future growth may also increase noise levels from existing sources, such as increases in noise generated from roadways or rail lines in the study area.

4.6.2 Alternative 2: Levee Modification Alternative

Construction of this alternative would temporarily increase ambient noise levels. Construction would be limited to daylight hours to minimize the impact to nearby noise sensitive receptors such as residences, schools, day care facilities, etc. Noise-related effect to fish and wildlife are analyzed in Section 4.12.

Typical equipment to be used would include excavators, dump trucks, compactors, water trucks, and pickup trucks. Average maximum noise levels at 50 feet from heavy equipment range from 73 to 101 dBA (WSDOT 2013).

No long-term increases in ambient noise are anticipated due to the construction of the project features.

4.6.3 Alternative 3: Sediment Management with Levee Modification Alternative

As with Alternative 2, this alternative would also temporarily increase in ambient noise levels during construction. Construction would be limited to daylight hours to minimize the impact to nearby noise sensitive receptors such as residences, schools, day care facilities, etc. The lower Puyallup River and lower

White River would be dredged once during the period of analysis while the White River near Pacific would be dredged three times and the upper Puyallup River would be dredged twice.

Noise from dredging equipment would be limited to the 16 July to 31 August timeframe, which is the in-water work window to limit fish impacts for the study area, though other out-of-the-water work could occur outside this window. In addition to the equipment noted above for the levee modifications, this alternative would also require the typical equipment for the dredging such as tug boats, work boats, mechanical dredges, barges and survey boats. Dredging in shallower areas may also be done by excavator. Reference sound levels at 50 feet from dredge equipment range from 72 to 87 dBA (Epsilon Associates, Inc. 2006).

Sound travels more than four times faster underwater than in air and absorption is less (World Organization of Dredging Associations 2013). Since sound can be far ranging, the spatial scale of impacts can be quite large. Dredging excavation, vessel transport, and material placement (disposal) generate underwater noise. Factors affecting the impact of underwater noise include the receiver's ability to detect sound, hearing range and sensitivity, and the background sound levels. Local conditions such as water temperature, viscosity, density, water depth and bottom conditions can also influence the impact of the noise.

An investigation carried out on grab dredgers indicates that this activity is relatively quiet with recorded sound levels just above the background levels at approximately 1km from the source (Clarke et al. 2002 *in* Central Dredging Association 2011). Clam shell dredges and trailing suction hopper dredgers are louder (Thomsen et al. 2009 *in* Central Dredging Association 2011). The sound levels were also dependent on the aggregate type being extracted, with coarse gravel generating higher sound levels than sand (Robinson et al. 2011 in Central Dredging Association 2011).

No long-term increases in ambient noise are anticipated due to the construction of the project features or projected maintenance dredging.

4.6.4 Cumulative Impacts

Ongoing land use activities and development will continue to contribute cumulative impacts to noise throughout the Study Area. As development increases and the population in the Study Area continues to grow, ambient noise levels are also likely to continue to increase. During construction and maintenance activities, the noise generated by trucks and machines would be additive to other existing noise generators such as highways, industries, and boats. Impacts to noise would be temporary and would only occur during construction activities.

4.7 Soils

The Pierce County (Zulauf 1979) and King County (Snyder et al. 1973) soil surveys provide mapping of soils throughout the sub-basins. Soils in the eastern, mountainous portion of the watersheds are typically derived from volcanic materials from Mount Rainier. The most recent volcanic events were approximately 500-years ago, the Electron mudflow on the Puyallup River and the Fryingpan mudflow on the White River.

Soils in the upland plateau are commonly derived from underlying glacial and alluvial parent material (Zulauf 1979).

Human influence within the Basin has contributed to substantial modification of the geology and geomorphology throughout the past 150 years. Construction of levees, dams and development within the floodplain has resulted in reductions in habitat function and loss of floodplain connectivity. Levees and river modification occurred largely between 1914 through the 1960's on the rivers within the study area. In addition to flood infrastructure, agriculture, residential, industrial and other development has contributed to modification of the soils and geology.

Major soil types found throughout the upper Puyallup River, lower Puyallup River, and Carbon River sub-basins include Alderwood-Everett, Kapowsin, Indianola, Kitsap, Buckley, Puyallup-Sultan, and Barneston-Scamman-Wilkeson series, as well as Xerochrepts and Alluival soils (Zulauf 1979). Major soil types found in the White River Sub-basin include the Kapowsin, Alderwood-Everett, Puyallup-Sultan, and Buckley series (Snyder et al. 1973; Zulauf 1979).

4.7.1 Alternative 1: No Action

Soils will continue to erode in the Study area due to natural processes and potential human development. Predicted increases in storm events could increase the rate of erosion as soils along steep gradients—especially in the upper Puyallup River sub-basin—become saturated and give way. Human development could exacerbate the erosion effect as soil-stabilizing vegetation is removed. Development is expected to occur mainly in areas where agricultural land would be converted to residential or commercial uses. This is expected mostly to occur in the upper portion of the lower Puyallup River sub-basin and the lower portions of the upper Puyallup River and White River sub-basins.

Tephra (ash and other pyroclastic debris from a volcanic eruption) or lahars from a potential future eruption of Mount Rainier could modify future soil conditions in the study area. USGS has estimated that there is a 1:10 risk of a lahar from Mt Rainier reaching the lowlands in the next 75 years. Tephra from a volcanic eruption of Mount Rainier would significantly alter soils in the Study area. The distribution of tephra following an eruption usually involves the largest boulders (volcanic "bombs") falling to the ground nearest the volcano, with smaller fragments like pumice and ash being distributed the farthest and most broadly. The distribution of tephra after an eruption is strongly dependent on wind direction. Volcanic tephra would alter the chemistry and composition of soils; soils would likely become less permeable and more acidic due to leaching over overlying volcanic ash.

4.7.2 Alternative 2: Levee Modification Alternative

Due to the immediate proximity of levee modifications to the existing structures, significant soil impacts are not expected with this alternative. Levee modifications to raise the height of the levee as well as improve the strength of the structure would be conducted primarily within the existing levee prism. Levee modifications would be conducted in the landward direction to the maximum extent possible. Any impacts would be localized to the existing levee footprint area. For new and setback levees, ground disturbance would be necessary and new structures would confine the channel and have some effect on the floodplain dynamics through the affected area. Temporary impacts due to construction would likely be prevented or minimized through the implementation of best management practices (BMPs).

4.7.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts to soils from levee construction are similar to the Alternative 2. Alternative 3 is designed to deepen the lower Puyallup River by approximately 3 feet for 5.5 miles, the lower White River by 7.5 feet for 3 miles, the White near the town of Pacific by 3.2 feet for 1.1 miles, and the upper Puyallup River by a depth of 2.5 feet for 1.4 miles. Dredging would remove the surface sediments and expose previously existing underlying sediments to the overlaying water. The channel bed would likely be permanently altered and result in channel degradation. Initially, exposed substrate would be re-colonized by opportunistic organisms that prefer newly disturbed substrate. The available organic matter and food sources for benthic invertebrates would be reduced while the newly exposed substrate stabilizes and undergoes recolonization. Through required maintenance dredging to maintain the desired level of flood protection, continued disturbance to channel sediment would occur. The lower Puyallup River and lower White River are expected to be dredged once during the period of analysis while the White River near Pacific would be dredged three times and the upper Puyallup River would be dredged twice. Disposal of material if suitable to upland disposal will occur at permitted disposal sites. Clean material might also be used for construction projects in the Puget Sound area. Material that determined to contain contaminants will be disposed of in an approved site.

4.7.4 Cumulative Impacts

Overall impacts to soils are expected to be insignificant as much of the construction activities would occur within existing infrastructure and landward of the riverbank. Construction related impacts would be cumulative to soil disturbance associated with other construction projects and ongoing levee maintenance within the basin. Setback levees would lower the energy available to transport a given grain size, therefore the material transported past the setback areas would be expected to become finer. Any sediment removal or dredging associated with Alternative 3 would contribute to significant physical changes within the floodplain.

4.8 Water Quality/Quantity

Within the study area, water quality affects both aquatic lifeforms as well as human health, as people utilize the water for drinking water, irrigation, and recreational activities. The water quality data provided in this section was compiled based on a review of Washington State's Water Quality Assessment [303(d)] on-line spatial database (Access Washington 2011c), as well as on a review of the WRIA 10 data of the use designations for fresh waters (Washington Administrative Code [WAC] 173-201A-602). In addition, two water quality studies applicable to the study area were used: *Concentrations of Dissolved Oxygen in the Lower Puyallup and White Rivers, Washington, August and September 2000 and 2001* (Ebbert 2002) and *Puyallup River Watershed Fecal Coliform Total Maximum Daily Load Draft, Water Quality Improvement Report and Implementation Plan* (Mathieu and James 2011).

The Carbon River meets water quality standards and has no listed pollutants (Access Washington 2011c). The upper Puyallup River has been tested for exceedances for pH and bacteria and meets the tested standards for both criteria.

Water quality is impaired in both the lower Puyallup River and White River for several criteria. A section of the lower Puyallup River (RM 3.8 to 5.5) is listed by the EPA for mercury and fecal coliform violations and sections of the White River are listed for fecal coliform, temperature and pH (WDOE 2010). Wastewater and stormwater treatment facilities in the study area have contributed excess nutrients to the basin. Polybrominated diphenyl ethers, endocrine disruptors, fertilizers, pesticides, petrochemicals, polyaromatic hydrocarbons (PAHs), metals and other substances are not effectively removed during the commonly used treatment process (Johnson et al. 2002; Puget Sound Action Team 2007). The lower Puyallup River also has slight impairments from turbidity, lead and dissolved oxygen.

The following describes the pollutant control recommendations in the Study Area (Mathieu and James 2009):

- Clarks Creek was the second largest fecal coliform loading source to the Puyallup River at RM 5.8 (of the sub-basins that exceeded water quality standards).
- The highest fecal coliform counts occurred during the dry season (July to October), for both the Puyallup River and White River. Dry season sources should be addressed first.
- Wet season stormwater delivery of fecal coliform loads to the White River should be reduced below RM 23.8.
- Unexplained increases in fecal coliform concentrations within the following reaches should be investigated:
    - White River RMs 1.4 to 3.3
    - Puyallup River RMs 1.4 to 3.3
    - White River RMs 18.9 to 23.8
    - Puyallup River RMs 10.3 to 12.0

The upper Puyallup River is designated for all water supply uses including: domestic, industrial, agricultural, and stock water. The lower Puyallup is designated for all water supply uses except domestic water from the mouth to RM 1.0. From the mouth to RM 1.0, designated uses include: existing primary contact recreation, secondary contact recreation, wildlife habitat, harvesting, commerce/navigation, boating, and aesthetics (WAC 173-201A-602). From RM 1.0 to the confluence with the Carbon River, the Puyallup River is designated for all water uses as well as primary contact recreation, wildlife habitat, harvesting, commerce/navigation, boating, and aesthetics (WAC 173-201A-602). The lower Puyallup from the mouth to river mile 1.0 has an aquatic life uses designation of rearing/migration only. From river mile one to the Mowich River (approximately RM 45) the aquatic life uses is core summer habitat. The White River, from the mouth to Section 1, Township 20 North, Range 4 East (approximately RM 5) is designated for aquatic life uses for spawning and rearing. From Section 1, Township 20 North, Range 4 East to MMD and continuing upstream to the West Fork of the White River, it is designated for core summer habitat. Upstream of the West Fork, including the West Fork, is designated for char spawning/rearing (WAC 173-

201A-602). The White River is designated for primary contact recreation from the mouth of the White River to MMD. Upstream of the dam it is designated for existing primary contact recreation. The White River is designated for all water supply uses as wildlife habitat, harvesting, commerce/navigation, boating, and aesthetics (WAC 173-201A-602). Downstream of the Snoqualmie National Forest and Mount Rainier National Park, the Carbon River is designated for primary recreation. Other uses for the Carbon River include wildlife habitat, harvesting, commerce/navigation, boating, and aesthetics (WAC 173-201A-602).

4.8.1 Alternative 1: No Action

Continued development and industrialization, especially in the lower reaches of the Study area to accommodate anticipated population growth, may further impact water quality, especially along urban corridors and industrial areas. Changes in stream flows related to climate change may increase pollutant concentrations and temperatures, especially should low summer flow rates result from a lack of snow pack. Existing water quality regulations and the future implications of TMDLs, as well as restoration measures, may work to offset potential water quality impacts throughout the study area. Vegetation maintenance for levee safety diminishes riparian habitat, exacerbating temperature concerns. The levee system will maintain the channelization of the river, exacerbating sedimentation concerns. Overall, future water quality is expected to decline.

4.8.2 Alternative 2: Levee Modification Alternative

Short-term impacts to water quality would be associated with construction of new levees and improvement of existing ones. In-water construction would be limited to the in-water work window to limit fish impacts for the study area, which is 16 July to 31 August. During construction there may be short-term, localized water quality impacts such as increases in turbidity. Impacts to water quality would be minimized through the implementation of BMPs. Also, removal of riparian vegetation to facilitate levee construction efforts would reduce shading and nutrient inputs to the system. The increase in water temperatures may locally reduce dissolved oxygen (DO) levels in the water. Placement of riprap along the riverward slopes would further increase temperatures through thermal retention and light reflection of the rocks. No pollutants would be expected to be introduced to the river from this alternative. Temperature and nutrient inputs would be affected until plantings installed as part of on-site mitigation features become established, approximately 5-10 years. With the exception of the Jones levee, the amount of riparian vegetation removed at the water’s edge will be minimal. See the Riparian Vegetation section for more details.

4.8.3 Alternative 3: Sediment Management with Levee Modification Alternative

This alternative would involve water quality impacts associated with both levee construction activities as described above for Alternative 2 and also from mainstem dredging. This alternative largely includes similar lengths of levee construction and modification as Alternative 2. While levees in Alternative 3 would be shorter in stature and width than in Alternative 2, the impacts discussed above for Alternative 2 are fully relevant to Alternative 3 due to the similarity of construction methods and general geographic extent. The discussion below will therefore focus on the additive impacts of dredging only.

Sediment removal from the channel would have negative short-term water quality impacts on-site and downstream. Impacts include increased suspended sediment leading to increased turbidity and decreased light penetration which could affect energy relations and benthic organisms (OWRI 1995). Dredging by a crane mounted clamshell in the lower Puyallup River and White River would result in pulsed and localized increases in suspended solids to the water column. Dissolved oxygen tends to decline in the vicinity of dredging operations when the suspension of anoxic sediments creates high chemical oxygen demand. Temporary decreases in DO associated with increased suspended sediments are possible in the immediate dredging plume area. It is unlikely that the sediments to be dredged are strongly anoxic because the bulk of the sediment to be dredged has a low percentage of fine materials. The dredged channel areas would tend to concentrate river flow in a narrower area than exists now. The river flow during low flow periods (June-September) may experience slightly increased velocities. Subsequent maintenance dredging events would result in the same negative impacts to water quality over the duration of the dredging period.

4.8.4 Cumulative Effects

Construction activities could result in impacts to water quality including increases in turbidity, temperature associated with vegetation removal and alterations in water flow. BMPs would be implemented to minimize water quality impacts. Construction related impacts would be additive to ongoing levee maintenance and other activities including agriculture, development and resource extraction. Dredging associated with Alternative 3 could permanently alter instream flows and subsurface flow. This could result in degradation to existing spawning areas where hyporheic flows provide cool water temperatures and nutrients required for spawning (Pierce County 2012b). Overall, future water quality would be expected to decline due to the alteration of the channel bed combined with increased development adjacent to the river and maintenance of flood control works. This decrease would partially be ameliorated by setback levees.

4.9 Wetland Habitat and Other Waters of the U.S.

Wetlands in the study area were identified using the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) and the Pierce County and King County wetland databases (USFWS 2011; Pierce County 2009; King County 2011). Figure 4-1 contains wetlands within the study area documented in the NWI and Figure 4-2 contains wetlands in the study area as documented by Pierce County and King County.

Wetlands provide critical habitat functions and are valuable in maintaining and/or enhancing the biological and hydrological landscape. The EPA identifies the benefits of wetlands to protecting and improving water quality, providing fish and wildlife habitat, storing floodwaters, and maintaining surface water flow during dry periods. These beneficial features are considered valuable to the functionality of watersheds worldwide (USEPA 2011).

There has been dramatic loss of estuarine, riverine, and wetland habitat processes and their associated functions throughout the Puyallup River Basin (Kerwin 1999). The *Pierce County Environmental Health Trends* (Pierce County 2008b) suggests that the historic loss and degradation of wetlands can be primarily attributed to the expansion of agriculture and the siting of ports and industrial facilities. The primary drivers for continued loss and degradation of wetlands are urban expansion, forestry and agricultural practices, and the invasion of exotic plants and animals. The same loss and degradation of wetland habitat by land conversion and development has occurred and continues to be an issue throughout King County (King County 2008). Mechanisms for wetland protection include acquisition, planning, mitigation, and disincentives for conversion of wetlands to other land uses (Pierce County 2008b; King County 2008).

In general, NWI maps were developed using aerial photo analysis of vegetation patterns, visible hydrology, and geographic position. Aerial photo interpretation can sometimes result in inaccuracies and can limit the extent of wetlands. This is a common occurrence in areas where human disturbance (e.g., development and agricultural practices) is prevalent.

In addition to the information available through the NWI, Pierce County and King County continually update their wetland inventories to establish more accurate wetland data within the basin, and both counties as a whole. Wetlands as shown in the Pierce and King counties inventories are depicted in Figure 2. The Pierce County inventory was initiated in 1997 and has been developed through analysis of various environmental and hydrological attributes. Soils, elevation contours, and vegetation are reviewed by Pierce County to distinguish potential wetland boundaries. This inventory is commonly referred to as the Buildable Lands Program and is pursuant to the Growth Management Act (GMA). The Pierce County Buildable Lands Program is a collaborative program developed to satisfy the 1997 amendments to the GMA of 1990. The 1997 amendments, commonly referred to as the "Buildable Lands" amendments, require certain jurisdictions to monitor development activities through 5-year periods and conduct housing and employment capacity analysis within that time. The *Buildable Lands Report* (Pierce County 2002) consolidates incorporated and unincorporated land development and monitoring data for all urban areas within Pierce County.

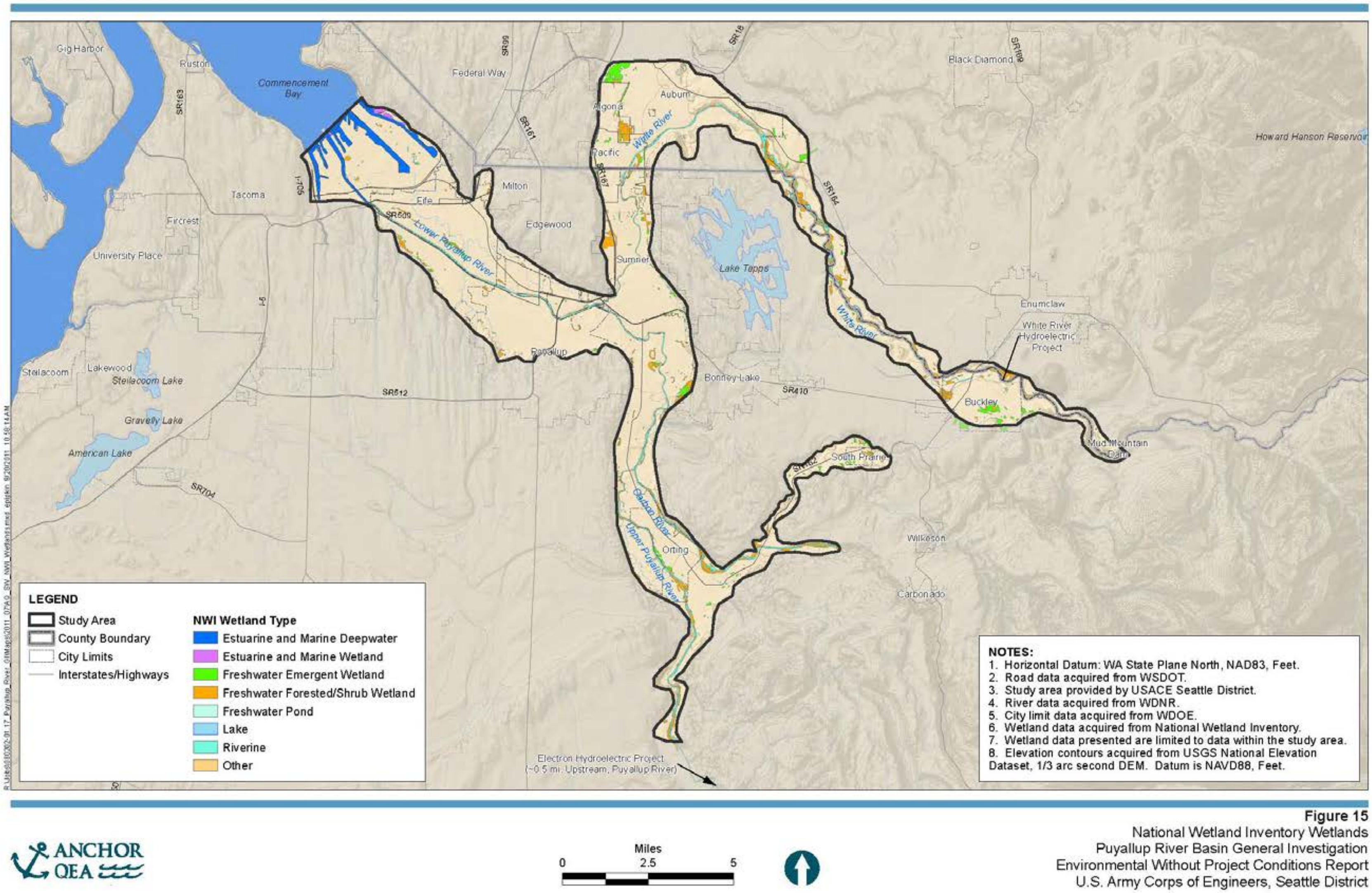


Figure 4-1. NWI Wetlands in Study Area

The Pierce County Wetland Inventory has identified approximately 38,211 acres (4% of land) of wetland habitat including delineated, verified, and unverified (added from aerials or NWI maps) wetlands in Pierce County (Pierce County 2008b). This is comparable to the NWI maps, which document approximately 45,640 acres (4% of land and water) of wetland habitat. Due to the nature of the NWI, wetland classifications are based on aerial photographs rather than wetland science. Therefore, it can be assumed that the 7,500-acre difference between the two databases is approximately the area covered by waterbodies and not palustrine and estuarine wetlands. It should also be noted that the Pierce County Wetland Inventory is conservative by nature and likely understates the area of wetlands by excluding open water wetlands, whereas the NWI maps include this habitat type.

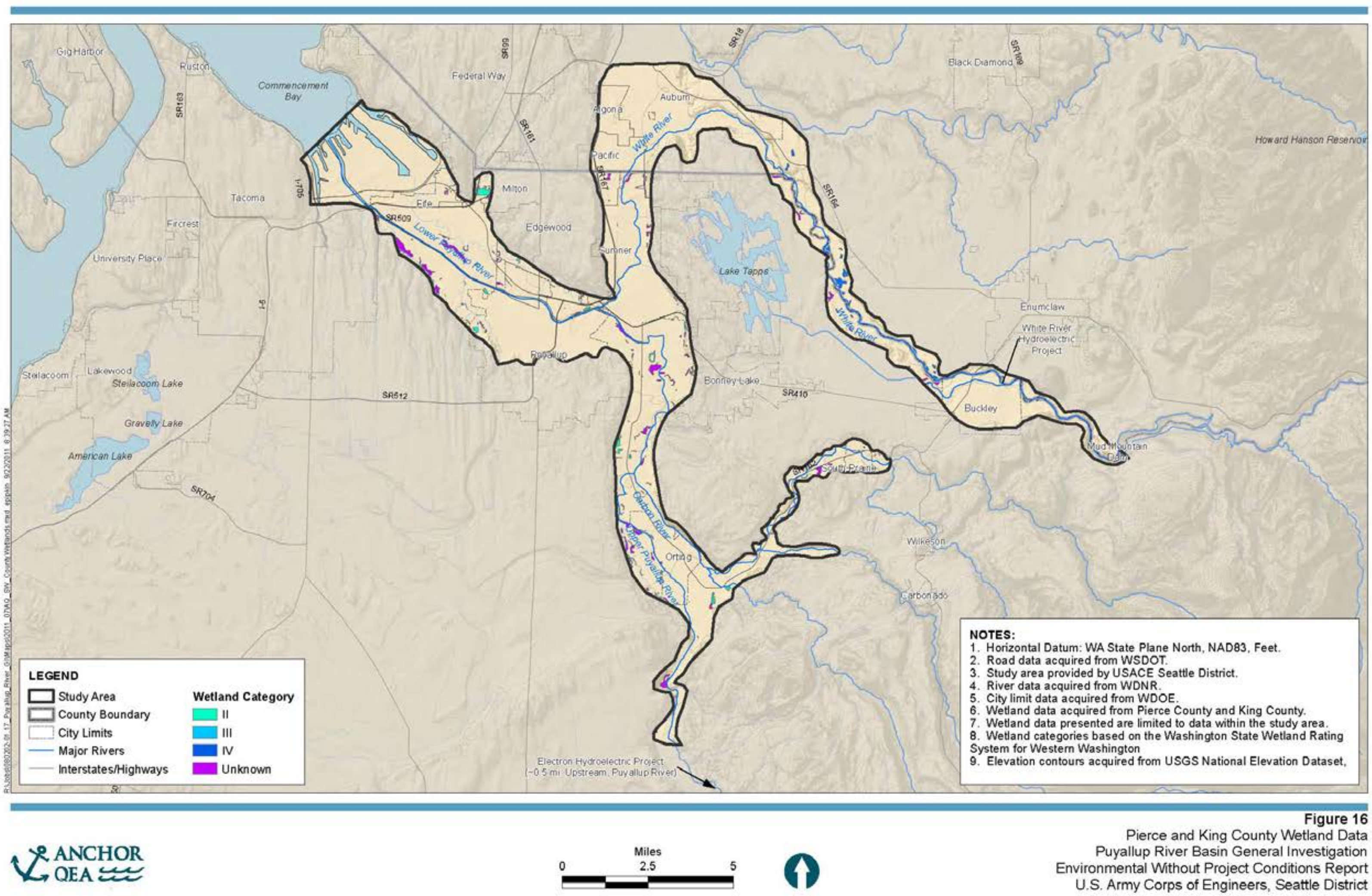


Figure 4-2. Pierce County and King County Wetland Inventories in Study Area

According to the Pierce County Wetland Inventory (Pierce County 2009b), potential wetlands include the following areas: 1) areas within 315 feet of hydric soils, wetlands identified on NWI maps or Pierce County Wetlands Inventory Maps, areas of known flooding, or any other indicators of hydrology such as Washington Department of Natural Resources stream data; 2) areas that possess wetland indicators and any adjacent areas within 315 feet; and 3) areas within the buffer of any wetland previously identified through the wetland review process.

In addition to wetlands identified in the two inventories, acreage figures are included for “other waters of the United States” such as open water and riverine areas. These areas are also regulated under the Clean Water Act.

In addition to wetlands, the Clean Water Act regulates navigable waters and other parts of the surface water tributary system down to the smallest of streams (e.g., tributary that only contains water after a rain event), lakes, ponds, or other water bodies on those streams, and adjacent wetlands (e.g. sloughs, swamps, and some seasonally flooded areas). Jurisdiction is up to the ordinary high water mark in non-tidal systems. These water bodies are referred to as “other waters of the U.S.” in this document.

4.9.1 Alternative 1: No Action

The Commencement Bay portion of the lower Puyallup River sub-basin is nearly fully developed and continued development, dredging, and filling are anticipated to occur. However, some cleanup and associated mitigation/restoration actions are anticipated to occur during the next 50 years. It is anticipated that these actions will result in a slight increase of the extent and quality of estuarine and marine habitat.

Sea level rise will have significant impacts throughout Puget Sound; however, effects within the study area will likely be limited due to extensive flood protection around the Puyallup River. Sea level rise may force saltwater-influenced habitats farther upstream, replacing current freshwater habitats. It is estimated that 3 to 4% of undeveloped upland adjacent to Commencement Bay may be converted to transitional marsh and salt marsh due to sea level rise anticipated over the next 50 years. In addition, Glick et al. (2007) estimated that two thirds of beaches along Commencement Bay may be lost by the year 2100 due to erosion and inundation; it is unknown how much of this will occur by 2076. The beaches would become tidal flats and then convert to estuarine open water with increased sea level rise (Glick et al. 2007).

Wetland areas in the Puyallup River Basin above Commencement Bay are expected to remain relatively unchanged. Current federal, state, and local regulations protect wetlands and require the maintenance of wetland habitat function. Currently planned floodplain restoration projects could also benefit wetland habitat by expanding riparian wetland areas.

4.9.2 Alternative 2: Levee Modification Alternative

The construction of new levees and floodwalls and the raising of existing levees would result in both a direct elimination of wetlands and other waters of the U.S. due to filling or an alteration of the wetland habitat due to vegetation clearing and/or changes in the substrate due to the placement of riprap.

Wetland functions such as shade, fish and wildlife habitat, detrital input, large woody debris recruitment, flood flow attenuation, and water quality improvement would be impacted by the proposed actions.

An initial analysis of impacts to wetlands and Other Waters of the U.S. was conducted by overlaying the proposed project impact zone over the NWI layer and calculating the intersection between those two layers. Acreage impacts for Alternative 2 are listed in Table 4-3. Acreages listed indicate the area of fill in wetlands and other waters of the U.S.. In addition, in the buffer area around the levee footprint the wetland character will be altered by vegetation clearing (15 foot clear zone on each side of the levee prism) or riprap placement but still retain the wetland or other waters of the U.S. characterization. In some cases, wetlands will be converted to other waters of the U.S.

Table 4-3. Alternative 2 Potential Impacts to Wetlands and Other Waters of the U.S., in acres

	Lower Puyallup	Middle Puyallup	Upper Puyallup	White River	Total
ALTERNATIVE 2					
Freshwater Emergent Wetland			0.01	0.18	0.19
Freshwater Forested/Shrub Wetland	2.70		3.98		6.68
TOTAL Wetland Impact					**6.87**
Riverine (Other Waters of the U.S.)	0.26		4.88	0.22	5.36
TOTAL IMPACT	**2.96**		**8.87**	**0.4**	**12.23**

As the project progresses to the feasibility-level design analysis, levee alignments may be readjusted to avoid wetland impacts.

The construction and/or raising of levees will have a direct impact on wetlands crossing the project footprint. Based on an analysis of projected project footprint and existing Pierce and King County Wetland Inventories, the National Wetland Inventory mapping, approximately 7 acres of wetlands could be altered by this alternative, either through filling for levee placement, or vegetation clearing due to the necessary compliance with the Corps' Engineer Technical Letter (ETL) 1110-2-583, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*. Impacts to other waters of the U.S. would total approximately 5 acres.

An initial analysis of impacts to wetlands and Other Waters of the U.S. was conducted by overlaying the proposed project impact zone over the NWI layer and calculating the intersection between those two layers. Acreage impacts for Alternatives 2 are listed in Table 4-3. Acreages listed indicate the area of impact.

The 281 acre setback area on the lower Puyallup River presents an opportunity for providing all mitigation lands, though ideally mitigation will occur in the specific reach where the impact takes place.

4.9.3 Alternative 3: Sediment Management with Levee Modification Alternative

Similar to Alternative 2, the construction and/or raising of levees will have a direct impact on wetlands crossing the project footprint. Based on an analysis of projected project footprint and existing Pierce and King County Wetland Inventories, the National Wetland Inventory mapping, approximately .34 acres of wetlands could be altered by this alternative, either through filling for levee placement, or vegetation clearing due to the necessary compliance with the Corps' ETL 1110-2-583, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*. An initial analysis of impacts to wetlands and Other Waters of the U.S. was conducted by overlaying the proposed project impact zone over the NWI layer and calculating the intersection between those two layers. Acreage impacts for Alternative 3 are listed in Table 4-4. Acreages listed indicate the area of fill in wetlands and other waters of the U.S.. In addition, in the buffer area around the levee footprint the wetland character will be altered by vegetation clearing (15 foot clear zone on each side of the levee prism) or riprap placement but still retain the wetland or other waters of the U.S. characterization. In some cases, wetlands will be converted to other waters of the U.S.

Table 4-4. Alternative 3 Potential Impacts to Wetlands and Other Waters of the U.S., in acres

	Lower Puyallup	Middle Puyallup	Upper Puyallup	White River	Total
ALTERNATIVE 3					
Freshwater Emergent Wetland				0.18	0.18
Freshwater Forested/Shrub Wetland	0.16				0.16
TOTAL Wetland Impact	**0.16**			**0.18**	**0.34**
Riverine (Other Waters of the U.S.)	97.6		36	59	193
TOTAL IMPACT	**99.2**		**36**	**59.18**	**194.38**

A greater impact will occur however due to the alteration of the river substrate due to the proposed dredging. This action will impact approximately 193 acres of Other Waters of the United States. The removal of part of the river substrate will directly harm aquatic life as well as disrupt spawning and rearing habitat. Because of the projected life-cycle for maintenance dredging, the probability of recovery of this habitat is assumed to be low because not enough time will be allowed for the river substrate to recover to pre-dredge conditions.

4.9.4 Cumulative Effects

The cumulative effects of the project are assumed to be additive to the past, present, and future development in the Puyallup basin. The benefits of the proposed setback in Alternative 2, in combination with the other setbacks currently in construction or proposed by the County and other local entities will improve floodplain connectivity and allow for increased wetland/riparian habitat and natural bank formation. In addition, proposed new levees and improvements to existing levees combined with other flood control projects that alter the natural processes in the basin will decrease habitat function.

Effects of Alternative 3 create a long-term change to the characteristics of the river bottom, creating a less diverse landscape. The alteration of the banks, population increases, continued development, climate change impacts, increased frequency of levee repairs, and maintenance dredging in the estuary all contributes to degraded aquatic habitat throughout the study area that would be expected to provide diminishing function in the future.

4.10 Riparian Habitat

WDFW defines riparian habitat as the area beginning at the ordinary high water line and extending to that portion of the terrestrial landscape that directly influences the aquatic ecosystem by providing shade, fine or large woody material, nutrients, organic and inorganic debris, terrestrial insects, or habitat for riparian-associated wildlife (Knutson and Naef 1997). Shading from forested riparian areas maintains cool water temperatures. Plant roots stabilize stream banks to control erosion and sedimentation. Vegetation contributes leaves, twigs, and insects to streams providing important nutrient inputs to the aquatic system. Large trees from functioning riparian habitats fall into the waterway and provide important refuge habitat for juvenile and adult fish. Riparian vegetation, litter layers, and soils filter incoming sediments and pollutants from runoff. Also, approximately 85% of Washington's terrestrial vertebrate species use riparian habitat for essential life activities (Knutson and Naef 1997).

Historically, extensive floodplains were associated with the large river valleys within the Puget Sound region. Floodplains typically included an extensive network of channels and broad wetland and riparian areas, providing important ecosystem functions such as flood storage, energy dissipation, nutrient cycling, and maintenance of other habitat characteristics including storage and transport of large wood (Simenstad 2000). The watershed and its associated riparian habitat have been impacted by historic and current timber harvest practices, as well as ongoing urban development and flood control practices.

Riparian habitat in the Puyallup basin can include a mosaic of shrubland and forest. Red alder (*Alnus rubra*) is the most widespread tree species in this habitat type. Other deciduous broadleaf trees that commonly dominate or co-dominate include black cottonwood (*Populus balsamifera ssp. trichocarpa*), big-leaf maple (*Acer macrophyllum*), and Oregon ash (*Fraxinus latifolia*). Pacific willow (*Salix lucida ssp. lasiandra*) can form woodlands on major floodplains or co-dominate with other willows in tall shrublands. Typical shrubs that frequently dominate underneath a tree layer include salmonberry (*Rubus spectabilis*), salal (*Gaultheria shallon*), vine maple (*Acer circinatum*), red-osier dogwood (*Cornus sericea*), snowberry (*Symphoricarpus albus*) and thimbleberry (*Rubus parviflorus*). Typical understory dominant herbs include slough sedge (*Carex obnupta*), Dewey sedge (*C. deweyana*), Sitka sedge (*C. aquatilis var. dives*), skunk cabbage (*Lysichiton americanus*), coltsfoot (*Petasites frigidus*), and great hedge-nettle (*Stachys ciliata*) (Chappell et al. 2001).

In recent years there has been an influx of non-native, invasive plants. In wetland areas, reed canary grass (*Phalaris arundinacea*) has come to dominate emergent areas and understory of scrub-shrub areas. In addition to reed canary grass in the understory, foreseted systems have also seen an influx of English ivy (*Hedera helix*) and holly (various species). Open, upland fields have seen infestations of Scotch broom (*Cytisus scoparius*) and Himalayan blackberry (*Rubus aremeniacus*). Along riparian areas, Himalayan blackberry can dominate upper levee slopes, along with Japanese knotweed (*Fallopia japonica*), with reed canary grass on the lower slopes.

Riparian vegetation is generally lacking in the lower reaches of the Puyallup River, especially coniferous vegetation, which was historically present. Remaining riparian vegetation is fragmented and less than 5% of riparian areas can be considered functional (Simenstad 2000). From approximately RM 4.0 of the Puyallup River to above the city of Orting, there is a narrow band of riparian vegetation which provides minimal habitat functions (such as shade, detrital inputs and insect drop, large woody debris recruitment). The upper Puyallup River Sub-basin is located predominantly within USFS and private commercial timberland, which has protected a majority of the area from development as compared to urban areas in the lower reaches. However, the watershed is still impacted by historical and current timber harvest practices, reducing the availability and function of riparian areas (Kerwin 1999).

Upstream of RM 8.5, the Carbon River consists of a braided system within a mostly broad and relatively level floodplain. Only limited and restricted development exists so that mature second growth riparian forest provides shade and riparian function to the river. Downstream of RM 8.5, the Carbon River has been disconnected from parts its floodplain through a system of levees. Floodplain areas have been converted to agricultural and developed land behind the levee system (Simenstad 2000). Riparian habitat is more limited, particularly on the left bank in and around the city of Orting.

Above RM 10, the White River is largely unconfined and has well developed riparian habitat. The lower White, where it flows through the communities of Sumner and Pacific, development has limited the amount of riparian forest.

4.10.1 Alternative 1: No Action

Riparian habitat in the lower basin will continue to be impacted by the presence of levees and bank protection projects adjacent to the river bank. Ongoing levee maintenance, i.e. vegetation removal and bank hardening, would be expected to continue or increase in frequency with the increase in floodplain development. These maintenance efforts will continue to fragment and limit riparian function. Loss of riparian vegetation in the Puyallup basin would result in loss of wildlife and fish habitat, higher water temperatures, less organic and nutrient input to the river, and limited LWD recruitment. There are ongoing and future restoration efforts in the Basin that could offset some of these impacts.

Climate change may greatly alter the vegetation communities in the basin. Fewer than 50% of the statistical models in a study conducted by Rehfledt et al. (2006 in Littell et al. 2009) suggest that a climate appropriate for Douglas-fir would exist in the 2060s. Increased winter precipitation and summer drought, longer growing seasons, and warmer temperatures may result in changes in plant species composition and increased pest populations. Invasive species may proliferate and fill previously occupied niches as native species are stressed and displaced by more generalist species. Climate change could also increase the frequency and intensity of flood events. This would be expected to require more frequent levee and revetment repairs and more diligent vegetation management; both actions would further reduce riparian function.

4.10.2 Alternative 2: Levee Modification Alternative

Modifications of the existing levees, and construction of new levees would result in the direct removal of riparian vegetation due to either fill actions from the construction or maintenance of the 15 foot vegetation free zone (VFZ), as required by Corps Levee Maintenance Guidance. Approximately 19.9 miles riparian vegetation of various degrees of quality could be impacted by this alternative. The removal of this vegetation would impact wildlife species that use the riparian corridor, as well as critical habitat for ESA listed species. Removal of vegetation at the river's edge would impact shading, insect drop and nutrient inputs to the river. A total of approximately 1.7 miles of levee would be constructed adjacent to the water's edge resulting in a direct loss of shading and nutrient input to the river. On the Lower Puyallup the existing concrete panels with silt bench and riparian vegetation would be retained.

4.10.3 Alternative 3: Sediment Management with Levee Modification Alternative

The implementation of this alternative would have similar impacts to riparian vegetation as in Alternative 2. However, the extent of the removal of riparian vegetation would be less because of the levees would be shorter (12 8 miles) and less width under this alternative. Approximately 1 acre of riparian forest would be impacted by this alternative. Approximately .5 miles of levee would be constructed adjacent to the water's edge directly impacting shading and nutrient input.

4.10.4 Cumulative Effects

The cumulative effects of the project are assumed to be additive to the past, present, and future development in the Puyallup basin. The benefits of the proposed setback in Alternative 2, in combination with the other setbacks currently in construction or proposed by the County and other local entities would improve floodplain connectivity and allow for increased riparian habitat and natural bank formation. In addition, proposed new levees and improvements to existing levees combined with other flood control projects that alter the natural processes in the basin would decrease habitat function.

Effects of Alternative 3 would create a long-term change to the characteristics of the river bottom, creating a less diverse landscape. In conjunction with the alteration of the banks, population increases, continued development, climate change impacts, increased frequency of levee repairs, and maintenance dredging in the estuary all would contribute to degraded riparian habitat throughout the study area and would be expected to provide diminishing function in the future.

4.11 Aquatic Habitat

The Estuary

Historically, Commencement Bay and the Puyallup River delta included a complex aquatic habitat system of extensive mudflats, subtidal and intertidal shallows, dendritic tide channels, and an extensive transition zone between upland habitats and emergent marsh habitats (Simenstad 2000). In the early 1900s, the intertidal and tideflat areas were channelized and developed into eight waterways. Filling and dredging activities, as well as construction of vertical or steeply sloping bulkheads, and/or over-water structures (Kerwin 1999), were associated with the development and maintenance of these waterways. By 1988, more than 98% of the Puyallup River estuary was modified to accommodate development and industrial uses (Kerwin 1999; Simenstad 2000).

Due to this extensive urban and industrial growth, few natural aquatic habitat areas remain. Those that remain are typically small, isolated, and surrounded by development. However, since the mid-1980s, several mitigation and cleanup related actions were implemented to restore intertidal and subtidal habitats to benefit juvenile salmonids.

Eelgrass (*Zostrea marina and Z. japonica*) and bull kelp (*Nereocystis luetkeana*) dominate the shallow sub-tidal zones of many areas of Puget Sound. They have high ecological value, providing three dimensional habitat for diverse communities of invertebrates, shelter and refugia for commercial species like Dungeness crab and salmon, and a significant source of primary production in nearshore waters. Eelgrass beds function as valuable nursery habitat for both juvenile salmon and rockfish and as foraging grounds for waterfowl and marine birds (Mumford 2007). Commencement Bay includes patchy fringes of eelgrass and kelp, mostly on the western edge of the bay (Ecology 2013).

In 1981, Commencement Bay was placed on the Superfund program's national interim priorities list—the top 115 priority hazardous waste sites in the country. In December of 1983, the Commencement Bay Nearshore/Tideflats site was officially added to the National Priorities List. The "site" included four main areas: the Asarco Smelter site and Ruston/North Tacoma Study Area; Tacoma Tar Pits; and the Tideflats Area. The Federal Authorized Levees are located within the vicinity of the Commencement Bay Nearshore/Tideflats Superfund Site that primarily includes waterway sediments. The impacted waterways do not interact with the location of the Federal Authorized Levees. Remediation of waterway sediments within the superfund site is occurring; sediments continue to be monitored and work is ongoing at upland cleanup sites across the tideflats.

The River

The lower Puyallup River, White River, and Carbon River have experienced substantial urbanization with extensive levees along the Puyallup and White Rivers, cutting off much of the floodplain off-channel habitat (NMFS 2011). The levees also create channel margins along the mainstem rivers that are often devoid of the in-stream complexity like woody debris, backwaters, and vegetation that would provide cover and foraging habitat for aquatic species. A high sediment load was also identified as a significant habitat factor in the Greenwater River and Huckleberry Creek. Poor road management leading to increased runoff was indicated as a large contributor (Pierce County 2012a). Both bank modifications and high sediment loads reduce the quality of substrate for spawning and rearing of fish. Spawning habitat exists from the upper watershed to the lower river below Puyallup.

Electron Hydro LLC operates the Electron Dam, which is located on the upper Puyallup River. The Corps operates MMD, which is located five miles upstream from the city of Buckley on the White River. Cascade Water Alliance operates the White River Hydroelectric Facility, which is located downstream of MMD between Enumclaw and Buckley. The White River hydropower facility is currently not operating for power generation. The Cascade Water Alliance facility diverts up to 1000 cfs (an annual average of approximately

400-450 cfs) from the White River at Buckley and into a canal and flume system into Lake Tapps (Cascade Water Alliance 2008). Aside from upstream fish passage concerns, flow modifications produced by the flow diversion/dam operations and the loss of LWD in the system, largely resulting from snagging operations at MMD, also have negative impacts to the function of the aquatic habitat in the study area.

MMD currently operates under a deviation from the Water Control Manual, releasing 6,000 to 8,500 cfs during typical flood events. The Water Control Manual allows for releases of up to 12,000 cfs during typical flood events. Limiting releases from the reservoir limits movement of the largest bed material typically seen on the White River, leading to predominance of coarser substrate (boulders and cobbles) upstream and finer substrate (cobbles, gravel, and sand) downstream that is more favorable spawning and rearing substrate. Most of the finer sediments (sand/silt/clay) are transported downstream into the lower White and Puyallup at more frequent flows regardless of releases during higher flood events. These lower releases result in slower water habitat during floods that are more suitable to fish.

4.11.1 Alternative 1: No Action

The Estuary

Continued development, dredging, and minor filling are anticipated to occur within the Commencement Bay vicinity. However, some cleanup and associated mitigation and restoration actions are also expected over the next 50 years. It is estimated that 3 to 4% of undeveloped upland adjacent to Commencement Bay may be converted to transitional marsh and salt marsh due to sea level change anticipated over the next 50 years. Sea level change may also force saltwater-influenced habitats farther upstream, replacing current freshwater habitats. In addition, Glick et al. (2007) estimated that two thirds of beaches along Commencement Bay may be lost by the year 2100 due to erosion and inundation; it is unknown how much of this will occur within the life of this project. The beaches would become tidal flats and then convert to estuarine open water with increased sea level change (Glick et al. 2007).

Continued development such as building construction, utility installation, road and bridge construction, and stormwater discharge could substantially alter the land surface, soil, vegetation, and hydrology of the study area, which could adversely impact aquatic habitat. Development can interrupt sediment supply, increase turbidity levels, diminish light availability to eelgrass in the estuary and other aquatic vegetation, alter hydrology and flow characteristics, raise water temperature, and re-suspend pollutants (Phillips 1984 in PFMC 1999).

Current federal, state, and local regulations that protect wetlands and critical habitat for endangered/threatened species are expected to continue protecting these resources from significant impacts. Currently proposed projects by Pierce County and local municipalities to set-back some levees may slightly improve aquatic habitat conditions in the future and reduce the need for frequent maintenance/repairs.

The River

Past and expected future bank stabilization projects using materials such as riprap will continue to degrade the complexity of aquatic habitat for cover, rearing, and spawning in the main channels. Additionally, future and existing channelizing of the river will continue to impede the development of side channels and off-channel sloughs (PFMC 1999).

Continued development such as building construction, utility installation, road and bridge construction, and stormwater discharge could substantially alter the land surface, soil, vegetation, and hydrology of the study area, which could adversely impact aquatic habitat. Development can interrupt sediment supply, increase turbidity levels, diminish light availability to eelgrass in the estuary and other aquatic vegetation, alter hydrology and flow characteristics, raise water temperature, and re-suspend pollutants (Phillips 1984 in PFMC 1999).

Future operations at MMD are assumed to return to the authorized release of 12,000 cfs during typical flood events detailed in the Water Control Manual. An increase in scour and associated bedload movement is expected in the White River as a result of these increased flows. These higher flows would result in increased coarsening of surface material through removal of fines and deposition of coarser material. Areas that used to receive only sand and gravel, for example, may start to see cobbles. These changes in depositional areas may result in a shifting of suitable spawning and rearing habitat, with more suitable habitat moving downstream to areas where a gravel bed channel can be sustained. Impacts would affect salmon species differently, depending on their particular grain size and spawning depth requirements. Finer material (sand/silt) will still be transported to the lower White and Puyallup River regardless of releases during higher flood events at the dam. Short-term declines in slower moving-refuge habitat during such events are also expected as a result of the increased release.

Also, as noted in Section 4.10, climate change may greatly alter the vegetation communities in the basin. Alteration of vegetative communities in the riparian corridor could impact the quality of aquatic habitat. Climate change could also increase the frequency and intensity of flood events. This could require more frequent levee and revetment repairs which would cause repetitive impacts to the aquatic habitat. Increased water temperatures are also possible due to climate change. This could alter the types of aquatic vegetation and aquatic insects that thrive within the study area.

4.11.2 Alternative 2: Levee Modification Alternative

Short-term impacts to aquatic habitat would be associated with construction of new levees and improvement of existing ones. These impacts include elevated turbidity, loss of vegetation from the shoreline, and loss of river bottom with the placement of new rip rap.

Long-term impacts are as follows: Alternative 2 includes a 281 acre setback in the lower Puyallup River. This would increase available aquatic habitat during higher flows, increasing refuge habitat and allow riparian habitat improvements. The lower river, where North River Road setback is proposed, lacks sufficient energy for braiding. This alternative also includes extensive in-place levee modification and new levee construction. There would be a temporary loss of riverbank vegetation and a permanent loss of bank complexity along approximately 1.7 miles of shoreline due to these efforts. In addition riparian vegetation would be removed along the rest of the levee alignment (19.9 miles total) mainly on the landward side of the existing levees or setback from the river bank allowing for a band of riparian vegetation to remain at the river's edge. The existing plants provide benefits to fish by slowing down water, shading the margins of the river, and providing organic input to fuel the food chain. The new levees would create a uniform channel with little room for channel meandering and wood recruitment that creates complex habitat for aquatic species. Impacts from the loss of riparian vegetation and bank complexity would be mitigated by actions such as completing onsite and offsite plantings, setting back levees where possible, and installation of large woody debris. See Section 5.2 for proposed conceptual mitigation.

Other long term impacts associated with this alternative would include changes in hydrology and additions of armor rock to the river banks and river bottom. Inwater work would cover approximately 1.7 miles. Armoring the slopes and toes of the new levees, would further disconnect the river from its floodplain and would keep water within the channel in the urban corridor at higher levels than in the FWOP. The additional water in the system would lead to hydrologic changes including increased velocities (less than 1 foot per second) and water depth over the existing condition, causing a decline in refuge habitat. Increased velocities could change the composition of the river bottom, increasing the typical particle size and potentially lead to scouring of redds. However, with the small predicted change in river velocity during flood phase and the regulation by MMD on the White River, the potential for red scour is low.

The new levees along the White River would occur where there is little to no armoring currently and a more robust, though narrow, riparian habitat exists. Except for a 840 feet on the Lower White River, all levee construction will be out of the water. Armoring at the water's edge including the river bottom adjacent to the banks could have considerable effects on the functions of the local aquatic habitat within this important biodiversity corridor by reducing shading to the river, limiting organic (plant and insect) inputs to the river, and changing the available substrate from native materials to imported rock.

Climate change would exacerbate how this alternative impacts aquatic habitat. More frequent and intense flood events could increase frequency of levee repairs and require the use of larger armor rock for those repairs.

4.11.3 Alternative 3: Sediment Management with Levee Modification Alternative

This alternative includes shorter lengths of levee construction and modification than Alternative 2. While levees in Alternative 3 would be less in length and width than in Alternative 2, the impacts discussed above for Alternative 2 are fully relevant to Alternative 3, but lesser in magnitude, due to the shorter lengths and less inwater work (approximately .5 miles). The discussion below will therefore focus on the additive impacts of dredging only.

Alternative 3 would have detrimental effects to aquatic habitat due to the proposed wide-scale sediment excavation. Impacts to organisms are further described in the Fish and Wildlife Section (4.12). This alternative is designed to deepen the lower Puyallup River by approximately 3 feet for 5.5 miles, the lower

White River by 7.5 feet for 3 miles, the White River near the town of Pacific by approximately 3 feet for 1.1 miles, and the upper Puyallup River by a depth of 2.5 feet for 1.4 miles. Although composition of bed gravels at depth are expected to be similar to existing conditions, the removal of gravels would cause short-term turbidity increases, and could remove or disturb instream roughness elements (such as large woody debris). In-stream sediment removal would also directly alter the channel geometry to create the designed uniform dredge depth, decreasing the variation of micro-topography of the river bottom that provides habitat complexity. Pool-riffle formation, gravel bars, substrate patterns and composition, and hyporheic zones are all likely to be degraded as a result of dredging. Rates of sediment deposition can vary, however the proposed removal would be expected to increase bottom depths until natural sedimentation rates would return the channel to its current depth. The lower Puyallup and lower White Rivers are expected to be dredged once during the period of analysis while the White River near Pacific would be dredged three times and the upper Puyallup River would be dredged twice. This infrequency, particularly on the Puyallup, should allow for the recovery of diversity of benthic habitat in-between dredging events. Removal of sediment could result in changes in channel morphology due to erosion from sediment starvation and coarsening of bed material downstream as gravels are transported downstream without replacement from upstream (Kondolf 1997). In areas where there are levees, bank erosion should be minimal and, assuming that the material is the same four feet down as on the surface, there should still be replacement of gravel from upstream sources.

4.11.4 Cumulative Effects

The cumulative effects of the project are assumed to be additive to the past, present, and future development in the Puyallup basin. The benefits of the proposed setback in Alternative 2, in combination with the other setbacks currently in construction or proposed by the County and other local entities will improve floodplain connectivity and allow for increased riparian habitat and natural bank formation. In addition, proposed new levees and improvements to existing levees combined with other flood control projects that alter the natural processes in the basin will decrease habitat function.

Effects of Alternative 3 create a long-term change to the characteristics of the river bottom, creating a less diverse landscape. In conjunction with the alteration of the banks, population increases, continued development, climate change impacts, increased frequency of levee repairs, and maintenance dredging in the estuary all contributes to degraded aquatic habitat throughout the study area would be expected to provide diminishing function in the future.

4.12 Fish and Wildlife

Pierce County and King County assessed and mapped land to determine which areas provide the greatest biological diversity (King County 2008; Brooks et al. 2004). Sixteen biologically rich areas were identified, known as Biodiversity Management Areas. Biodiversity connectors, continuous strips of undeveloped land within developed areas, were also identified. These connectors improve ecological coherence between populations, combat habitat fragmentation, and provide linkages between core protected areas for species migration. In the study area, the upper Puyallup River and lower Puyallup River sub-basins and portions of the White River Sub-basin have been classified as biodiversity connectors, by the Pierce County

Biodiversity Network and Assessment (Brooks et al. 2004; Figure 4-1). The upstream reach of the White River study area also touches on the Greenwater River Biodiversity Management Area.

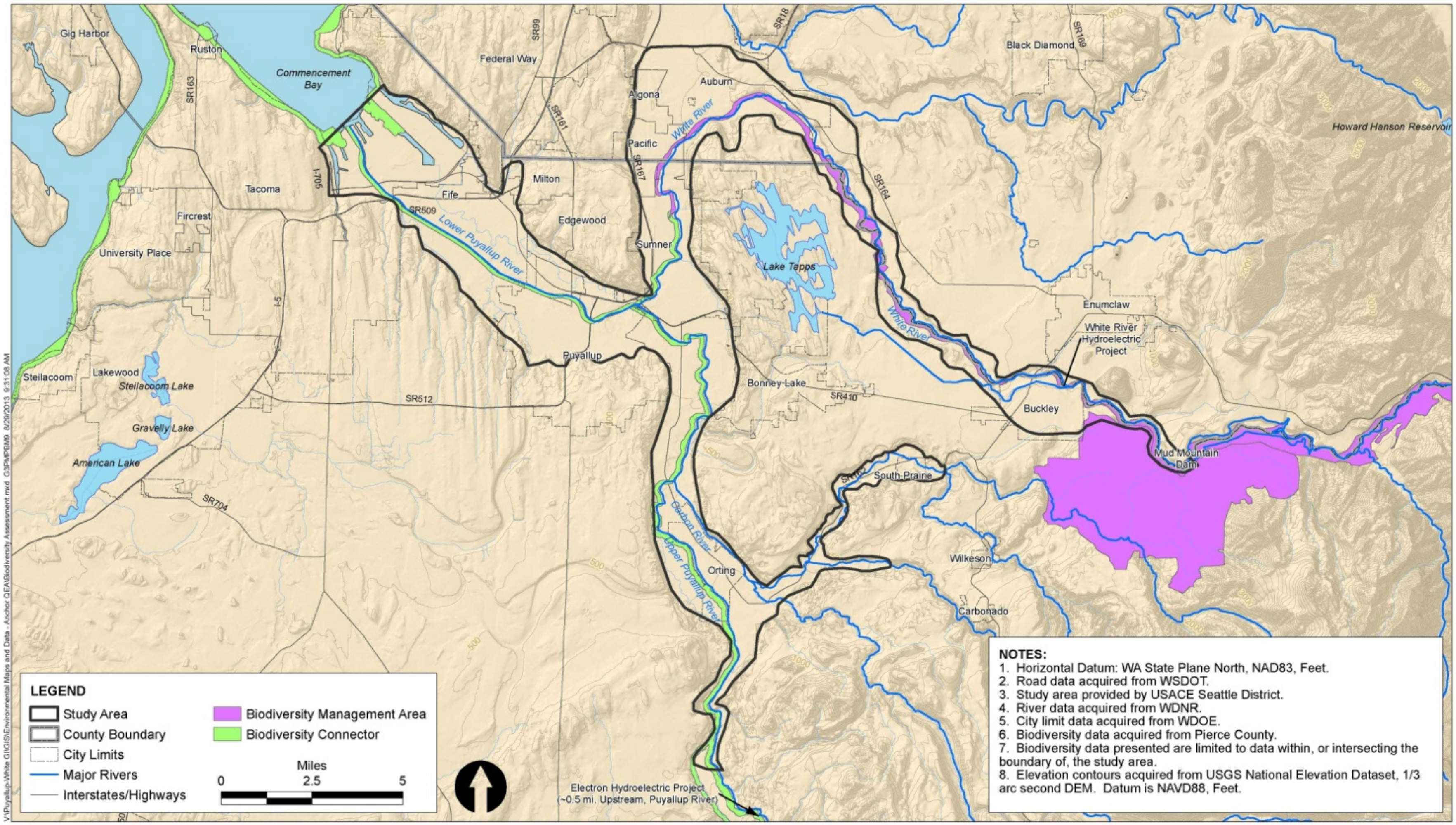


Figure 4-3. Pierce County Biodiversity Assessment Information

Fish

The Puyallup/White watershed contains several species of salmonids, including Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), pink (*O. gorbuscha*), sockeye (*O. nerka*), steelhead/rainbow trout (*O. mykiss)*, cutthroat trout (*O. clarki*), bull trout (*Salvelinus confluentus*) and non-native brook trout (*S. fontinalis*) (Puyallup Tribal Fisheries 2010). Other freshwater and anadromous native fish species known to inhabit coastal and inland waters in the Puget Sound region include mountain whitefish(*Prosopium coulteri*)*,* Pacific lamprey (*Lampetra tridentatus*)*,* river lamprey (*L. ayresi),* Northern pikeminnow (*Ptychocheilus oregonensis),* speckled dace (*Rhinichthys osculus),* three-spine stickleback (*Gasterosteus aculeatus*)*,* Coastrange sculpin (*Cottus aleuticus*)*,* shorthead sculpin (*C. confuses*)*,* starry flounder (*Platichthys stellatus*)*,* and bocaccio (*Sebastes paucispinis*). A variety of non-native fish are found in freshwater including brown bullhead (*Ameiurus nebulosus*), largemouth bass (*Micropterus salmoides)*, bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) (Wydowski and Whitney 2003).

The WDFW Fisheries Management Division assesses and documents Washington's 11 species and subspecies of native salmonids in the Salmon Stock Inventory (SASI). The salmonid runs that exist in the study area, as well as the 1992 and 2002 status of these stocks, are listed in Table 4-5.

Table 4-5 Salmon Stock Inventory, Puyallup River Basin

Stock Name	1992 Status	2002 Status
Puyallup Chinook	Unknown	Unknown
White River (Puyallup) Fall Chinook	Unknown	Unknown
White River (Puyallup) Spring Chinook	Critical	Critical
Puyallup/Carbon Fall Chum	Unknown	Healthy
Puyallup Coho	Depressed	Healthy
White River (Puyallup) Coho	Healthy	Healthy
Puyallup Pink	Healthy	Depressed
Carbon Winter Steelhead	Healthy	Depressed
Mainstem Puyallup Winter Steelhead	Healthy	Depressed
White River (Puyallup) Winter Steelhead	Healthy	Depressed
Table Source: WDFW 2010		

Mainstem salmonid spawning occurs throughout the system with pink and chum salmon spawning in the lower Puyallup. Chinook and steelhead spawning is more likely to occur above the confluence of the Puyallup and White Rivers. Rearing and outmigration of juveniles and sub-adults occurs throughout the river from the headwaters to the lower river. Presence and length of time spent in the river varies by species and life history strategy. Table 4-6 provides a general summary of life cycle timing in the river.

Table 4-6. Life Cycle Timing of Salmonids, Puyallup River Basin

Species	Life Stage	Month																							
		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Chinook	Adult Migration										■	■	■	■	■	■	■	■	■	■	■	■	■		
	Spawning																	■	■	■	■	■			
	Juvenile Outmigration			■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Chum	Adult Migration																				■	■	■		
	Spawning	■	■																				■	■	■
	Juvenile Outmigration					■	■	■	■	■	■														
Coho	Adult Migration													■	■	■	■	■	■	■	■	■	■	■	■
	Spawning																	■	■	■	■	■	■	■	■
	Juvenile Outmigration					■	■	■	■	■	■	■	■	■											
Pink	Adult Migration														■	■	■	■	■						
	Spawning																■	■	■	■	■	■			
	Juvenile Outmigration			■	■	■	■	■	■	■	■	■													
Sockeye	Adult Migration													■	■	■	■	■							
	Spawning																		■	■					
	Juvenile Outmigration							■	■	■	■	■	■												
Steelhead	Adult Migration	■	■	■	■	■	■	■	■	■	■											■	■	■	■
	Spawning					■	■	■	■	■	■	■	■												
	Juvenile Outmigration							■	■	■	■	■	■	■	■										
Bull Trout	Adult Migration				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
	Spawning															■	■	■	■	■					
	Juvenile Outmigration									■	■	■	■	■	■										

The historic loss of estuarine, wetland, and channel habitat has been cited as a significant limiting factor in salmonid recovery within the watershed (Kerwin 1999). Commencement Bay has lost more than 98% of its intertidal and subtidal habitat to development (Kerwin 1999).

The Puyallup River, White River, and Carbon River are contained within levee/revetment systems, which limit the natural meandering and sinuosity of the rivers and prevent floodplain connectivity, which adversely affects salmon recovery. There are several barriers to fish passage in the study area. At the White River diversion at Buckley, the Corps collects adults returning to spawn in a trap-and-haul system and truck then upstream of MMD. Smolts' passage downstream occurs via the river and not through the trap-and-haul system.

Since the construction of the MMD fish trap facility in the late 1930's, pink salmon were only observed at very low numbers in the White River at Buckley one or two years until 2001 when numbers began to increase steadily. This is corroborated by Salmon and Steelhead Stock Inventory (SASSI) distribution maps, which do not list the White River as a primary spawning area. In 2003 the first substantial numbers of pink salmon returned to the Puyallup system. Substantial numbers of pink salmon were seen at the Buckley fish Passage barrier and fish collection facility for Mud Mountain Dam. This increase coincided with the removal of Tacoma Public Utilities pipeline, which acted as a low-head sill in the in the river. It is thought that the removal of the pipeline allowed pink salmon to migrate freely up to MMD trap. That season over 13,000 pink salmon were trapped and hauled upriver. Since then, the number of pink salmon transported from the trap has steadily increased to 33,000 in 2005, 127,000 in 2007, 540,000 in 2009, 622,000 in 2011, and 465,000 in 2013. These numbers do not include a large proportion of pink salmon that are not transported and either spawned immediately below the trap or died prematurely. Only gross estimates, in the range of 100,000-400,000, are available on the non-transported fish. The returning pink salmon are mixed with smaller numbers of migrating bull trout, Chinook salmon and steelhead. The pattern of increasing pink salmon in odd-numbered years in the White River has greatly increased the required operations and maintenance of the fish trap facility, and directly impacts listed species mixed with the returning pinks. The large numbers of fish result in crowding and delay of all fish including ESA listed salmon.

Currently, MMD operates under a deviation from the authorized Water Control Manual, releasing only 6,000 to 8,500 cfs during typical flood events. This results in lower flows than what would be seen if operating at the full release of 12,000 cfs that is authorized. See Section 4.11 (Aquatic Habitat), for details on how current hydrology and sedimentation patterns from dam operations affect fish habitat. In the Puyallup River Basin, the construction of a fish ladder at the Electron Dam in 2000 provided access to more than 30 miles of habitat which had been blocked for over 90 years.

The upper Puyallup River watershed and much of the White River Sub-basin are located predominantly within USFS and private commercial timberland, which has protected these areas from urbanization and development. However, the watershed is impacted by timber harvest including impacts to riparian areas and fine sediment influx from road construction and landslides (Kerwin 1999, Herrera 2007). In addition, practices such as removing riparian vegetation, construction and maintenance of levees and revetments, removal of LWD (Kerwin 1999), and water quality issues adversely impact salmonid production.

Benthic Invertebrates

Benthic invertebrate communities are those species that dwell at the bottom of the streambed. Benthic invertebrate communities typical of rivers in the Puget Lowlands are dominated by stonefly (order Plecoptera), caddis fly (order Trichoptera), common midge (family Chironomidae), mosquito (family Colucidae), and blackfly larvae (family Simuliidae) (Plotnikoff 1992). Aquatic invertebrates are generally accepted as indicators of watershed health.

The Commencement Bay estuarine ecosystem is an abundant resource for benthic and epibenthic (species living just above the bottom of the streambed) invertebrate communities. Overwater structures, as found along the highly developed shoreline, reduce benthic vegetation and decrease densities of epibenthic organisms (Haas et al. 2002, Kerwin 1999). Substrate size and slope are also critical factors that can negatively affect abundance. For example, epibenthic invertebrate abundance decreases on steeply sloped shorelines, particularly where modifications have occurred along the shoreline of the Puyallup estuary and Commencement Bay (Kerwin 1999).

Wildlife

Numerous bird, terrestrial mammal, amphibians and reptiles occur in the diverse habitats available within the study area. The riparian area serves as a migratory corridor for birds and small mammals, as well as a rearing area for species adapted to living adjacent to human habitation.

Bald eagles (*Haliaeetus leucocephalus*) were delisted from the Endangered Species Act (ESA) in 2007 but are still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. They are commonly found along salt- and fresh-waterbodies of Puget Sound and nest in the largest Douglas-fir (*Pseudotsuga menziesii*) or black cottonwood (*Populus trichocarpa*) trees within a stand, often near a water source. In Washington, bald eagles typically breed from April to August. They are known to occur within all sub-basins of the study area, including seven breeding areas and a communal roost.

Marine Mammals

Marine mammals are generally found in the deepwater portions of Commencement Bay. Typical marine mammals known to migrate through Puget Sound include Steller sea lion (*Eumotopias jubatus*), California sea lion (*Zalophus californianus*), Pacific harbor seal (*Phoca vitulina*), killer whale(*Orcinus orca*), gray whale (*Eschrichtius robustus*), Dall's porpoise (*Phocoenoides dalli*), and harbor porpoise (*Phocoena phocoena*). Humpback whales (*Megaptera novaeangliae*) are also known to migrate through Puget Sound, but at much less frequency than the aforementioned species (Tetra Tech et al. 2009). Steller sea lion, Southern Resident killer whale, and humpback whale are listed under the ESA and are discussed in more detail in Section 4.12.

Harbor seals are the most common and widely distributed marine mammal in Puget Sound waters. California sea lions are also common and seasonally migrate through (Jeffries et al. 2000). Seals and sea lions utilize haulout areas, to rest, sunbathe, interact with each other, and regulate body temperature. Two haulout sites are documented in the study area on buoys, floats, and log booms along the northeastern corner of Commencement Bay (WDFW 2013). Dall's porpoise and harbor porpoise live and feed in Puget Sound waters throughout the year; however, it is unlikely that they would be present in the nearshore marine habitats within Commencement Bay due to the high volumes of marine traffic in the area (Tetra Tech et al. 2009).

4.12.1 Alternative 1: No Action

According to studies conducted by the Climate Impacts Group (Vano et al. 2009; see Section 4.3 for more information on Climate Change), climate change will negatively affect plant and wildlife species. In general, as climate changes species ranges will shift to follow suitable climates and potentially could disappear from areas if suitable temperatures are no longer present. Species range shifts will be more likely to occur along natural areas than urban areas.

Water temperatures in rivers and lakes are expected to increase causing a decrease in reproductive success for salmon and other fish species. Thermal migration barriers and an increase in the risk of fish kills at temperatures greater than 70°F are predicted to expand, beginning earlier in the year and lasting longer (Mantua et al. 2009). In some areas lower summer flows will likely also restrict the movement and migration of fish due to insufficient water. Higher projected winter flows could increase scour of redds. Due to existing local, state, and federal regulations that require new stream and river crossings to be fish passable, no new man-made fish passage barriers are expected to occur. Additionally, some existing fish passage barriers are anticipated to be made fish-passable either through restoration efforts or repairs and improvements to infrastructure. Higher flows would also make it more difficult for juvenile salmonids to find refuge due to lack of shallow water, and low velocity habitat. Sea level change may decrease the acreage of estuarine marsh within Commencement Bay and existing tidally influenced freshwater areas of the Lower Puyallup River and, reducing the available habitat for species using those areas.

Increased human population and development is expected to decrease habitat function for many species. Continued development such as building construction, utility installation, and road and bridge construction could substantially alter the land surface, soil, vegetation, and hydrology of the study area, which could adversely impact wildlife through habitat loss or modification. Development along the shore may result in removal of shoreline and riparian vegetation, which could impact aquatic habitat by interrupting sediment supply, increasing turbidity levels and diminishing light availability to aquatic vegetation, altering hydrology and flow characteristics, raising water temperature, and re-suspending pollutants (Phillips 1984 in PFMC 1999).

Repairs to the existing flood protection system in the study area would be expected to continue in the future. These repairs can remove riparian vegetation, reduce recruitment of spawning gravel by eliminating lateral erosion, and impede the development of side channels (PFMC 1999). Pierce County and other local entities are currently proposing projects to set back some of these levees in the area. Each implemented levee setback project will improve local habitat conditions by reconnecting floodplain and allowing the formation of natural vegetated banks.

Future operations at MMD are assumed to return to the authorized release of 12,000 cfs during typical flood events which are detailed in the Water Control Plan. An increase in scour and associated bedload movement is expected in the White River as a result of these increase flows. See Section 4.11 (Aquatic Habitat), for details on how changes in hydrology and bedload movement from higher releases at MMD would affect fish habitat.

4.12.2 Alternative 2: Levee Modification Alternative

Fish

Short-term impacts to fish communities would be associated with construction of new levees and improvement of existing ones. A majority of the work required to improve these levees would be on the landward side and atop the levees. However, some in water work would be necessary to build or fortify levees by adding armor rock to the riverward slopes and toes. It is currently estimated that approximately 1.7 miles of levee would require some inwater construction. The in-water work window to limit fish impacts for the study area is typically from 16 July through 31 August, however there are still many species that are present in the river at this time including:

- Adult migrating Chinook, pink, and sockeye salmon
- Outmigrating juvenile Chinook (ocean and stream type)
- Juvenile stream type Chinook (spring run)
- Steelhead,
- Bull trout
- Juvenile coho
- Resident cutthroat and rainbow trout
- A variety of other resident fish such as sculpin, stickleback, and dace

Impacts from in-water work include elevated turbidity, physical disturbance, and noise that could result in interruption of foraging and migration behavior and elevated stress levels. The following are noise thresholds for salmonids (Hastings 1995 and NMFS et al. 2008):

- 150 dB_{RMS} for harassment for continuous noise for fish of all size
- 187dB cumulative Sound Exposure Level (SEL) for injury of fish ≥ 2 grams[5]
- 183dB cumulative SEL for injury of fish < 2 grams
- 206 dB_{peak} for injury of fish of all sizes

It is unlikely that noise thresholds would be exceeded for the placement of rock since riprap will not be end dumped, and each rock will be individually placed. Typical construction site noise ranges from 73 to 101 dB (WSDOT, 2013) which is below the injury threshold for salmonids.

Long term impacts would derive from changes in vegetation and hydrology, and placement of armor rock due to improvement and construction of levees; all of which impact habitat. The levee modification alternative includes a 281 acre setback in the lower Puyallup River at North River Road. A setback in this reach would be beneficial as it would provide the opportunity for improved riparian vegetation, refuge habitat and recruitment of LWD in an area where these functions are very limited. There would be a temporary loss of riparian benefits to fish caused by the removal of vegetation for these efforts (see

[5] Injury thresholds are based on pile driving (pulsed noise)

Section 4.10). Although the remaining riparian habitat in the project area is limited to sparse narrow bands of young trees and herbaceous vegetation, these existing plants provide benefits to fish by slowing down water, shading the margins of the river, and providing organic input to fuel the food chain. Areas where inwater work is proposed (1.7 miles) proposed would have a permanent loss of mature riparian forest (existing or potential future), since they are likely to be managed under the levee vegetation maintenance program which limits the location, size, and species of trees. The remaining 18.2 miles of new levee and levee improvements would be set back from the river's edge reducing the removal of riparian vegetation at the riverbank and allowing for some more natural bankline. New levees would also reduce habitat complexity provided by channel meandering, erosion, and LWD recruitment.

Armoring the slopes of the new levees, particularly on the White River, will further limit refuge habitat and increase vulnerability to predation.. Impacts from the loss of riparian vegetation and bank complexity would be mitigated by actions such as completing onsite and offsite plantings, setting back levees where possible, and installation of large woody debris. See Section 5.2 for preliminary conceptual mitigation.

The additional water in the system during floods could lead to hydrologic changes including increased velocities and depth over the existing condition. Under existing conditions water spills into the floodplain in the urban corridor during larger flood events. This alternative would keep water within the channel in the urban corridor up to a 1% ACE probability. Because river velocities are predicted to increase by less than 1 foot per second in the larger flood events there is small likelihood that:: 1)some juvenile salmon could be swept out to Commencement Bay before they are physiologically ready and too small, 2) fish being physically damaged by rip-rap, 3) increasing energy demands on fish to maintain swimming positions, 4) juvenile fish having difficulty foraging, and 5) juvenile fish being more vulnerable to predation from decreased shallow water habitat and decreased energy. Some scour of spawning habitat and redds, reduced fertilization success, and difficulty for adults to maintain their position could result from increased depths and velocities in spawning areas though the change over the FWOP would be small. See Section 4.11 (Aquatic Habitat) for details on how changes in hydrology and sediment movement affects fish habitat.

Fish communities in Commencement Bay could also be affected by this alternative. Increased flows and associated sediment loads could be delivered to the Bay because less water would spill into the adjacent floodplain, potentially smothering or eroding fish habitat like tidal channels and eelgrass beds. This could impact juvenile salmonids, forage fish, and other marine fish. Proposed mitigation, including setting back of levees and planting of riparian vegetation, could help to minimize impacts of changes in hydrology and sediment dynamics to fish.

Benthic Invertebrates

Short-term impacts to benthic communities in the river from construction are expected to be minimal as they typically recolonize disturbed areas quickly. Long-term impacts to benthic invertebrates include: 1) changes in hydrology could lead to changes in substrate composition and distribution, and 2) the temporary loss of riparian vegetation would decrease the amount of detrital input. Additional scour and sedimentation could change invertebrate communities to more tolerant taxa like snails and fly larvae and decrease optimal taxa like mayflies, caddisflies, and stoneflies. The loss of detrital input could result in a loss of a food source for many invertebrate taxa. However, impacts from vegetation loss could be mitigated in the long-term by planting benches on levees where the toe can be buried or the water ward areas where levees can be set back. Long-term impacts to benthic invertebrate communities in Commencement Bay could result from additional sediment and flows during flood events (discussed under impacts to fish communities in preceding paragraph).

Wildlife

Wildlife within the urban area is tolerant of human presence, noise, and development. Any mobile wildlife in the vicinity during construction may vacate the area due to the increased activity but would be expected to return soon after activity diminished. Any ground dwelling animals within the footprint during construction could be injured or killed.

As with fish, removal of vegetation for construction would also decrease habitat function for wildlife. However vegetation on existing levees is highly managed to maintain levee integrity and inspectibility. Similarly, construction of the new levee alignments also occurs largely in developed or agricultural lands. Impacts to wetlands (detailed in Section 4.9) could reduce habitat function for wildlife at the construction site, though the inclusion of compensatory mitigation will offset the loss in the study area.

The new levees along the White River would occur where little to no armoring currently exists and more robust, though narrow, riparian habitat exists. Armoring at the water's edge could have considerable effects on the functions of this habitat for wildlife within this important biodiversity corridor.

Surveys for eagle nests would be required prior to construction. Limitations on work to avoid sensitive time periods and a bald and golden eagle permit from USFWS may be needed.

Climate change would exacerbate how this alternative impacts fish and wildlife communities. More frequent and intense flood events would contribute to elevated velocities and scour in the mainstem, as well as sedimentation in the Bay. Shifts in timing of flood events could overlap with juvenile outmigration, particularly as stream temperatures rise and cue shorter incubation periods and earlier emergence. Proposed mitigation for this alternative combined with ongoing restoration efforts in the basin could help alleviate the cumulative effects of climate change, sea level change, and increasing pressure from a growing human population.

4.12.3 Alternative 3: Sediment Management with Levee Modification Alternative

This alternative largely includes shorter lengths of levee construction and modification as Alternative 2. While levees in Alternative 3 would be shorter in stature and width than in Alternative 2, the impacts discussed above for Alternative 2 are fully relevant to Alternative 3 due to the similarity of construction methods, but lesser in magnitude due to shorter length. The discussion below will therefore focus on the impacts of dredging only.

Fish

As noted in the previous section, the in-water work window for the study area to limit fish impacts is typically from 16 July through 31 August, however there are still many species' life stages that are present in the river at this time including Chinook adult migration and juvenile outmigration, pink salmon adult migration and spawning, and steelhead rearing.

Alternatives 3 would have considerable short-term and long-term detrimental effects to all fish species in the area due to the proposed wide-scale sediment excavation. This alternative is designed to deepen the lower Puyallup River for 5.5 miles, the lower White River for 3 miles, the White near the town of Pacific for 1.1 miles, and the upper Puyallup River for 1.4 miles. Although dredging would occur during the established fish window, thus avoiding most salmon life stages, this work would remove the benthic macroinvertebrates that serve as the primary food source for most fish, and would likely kill most of the benthic oriented fish like lamprey, sculpin, and flatfish (in the lower river) present in the lengths of channel that would be dredged. Loss of these fish populations could take many years to recover. Elevated turbidity and noise could result in a behavioral response to flee, delayed migration, and/or physiological damage from gill injuries and noise threshold exceedences for injury in fish. Turbidity monitoring and compliance with the water quality certification should minimize the impacts of turbidity on fish. Noise thresholds for salmonid are discussed in Section 4.6. It is unknown what dredge methods would be used and whether they would exceed these noise thresholds. Substrate, dredges type, and channel morphology all effect underwater noise levels. However as noted in section 4.6.3, shallow water dredging by excavators is in the 72 to 87 dB range which is below the injury threshold for salmonids.

Dredging is proposed in chum, pink, and Chinook spawning habitat. Although dredging would likely occur during the fish window, largely avoiding incubation of redds and emergence of juvenile salmonids, impacts to spawning habitat for future generations is likely due to the destabilization of the channel bed that could take years to stabilize. The depth of dredging would be no greater than four feet, so water depths over spawning habitat would increase no more than four feet. A four foot depth increase would still exclude many areas from spawning until pre-dredging depths return, particularly for chum and pink salmon whose maximum spawning depth are approximately three to four feet (Groot and Margolis 1991). Chinook salmon would be also be affected by increases in depths over spawning grounds, but less so as their maximum spawning depths reach up to up to 22 feet but average about one to two feet (Groot and Margolis 1991). Broad-scale alteration of the river bottom would cause considerable risk that salmon would not be able to find appropriate spawning habitat for one or more years as sediments stabilize. Salmon are known to locate their spawning grounds via olifactory cues (Hasler and Wisby 1951). The exact cue is speculative, but one theory is that it is the substrate. It is unknown how the removal of the top four feet of substrate would affect the homing process. Gravel at the depths achieved by dredging is assumed to be similar to the top layers because the river has been in its current configuration for long enough that it is likely that four feet down was exposed to the same conditions as it is currently. However, in-stream sediment removal directly alters the channel geometry and risks leaving stream morphology unfavorable to salmonids. Pool-riffle habitat, gravel bars, and hyporheic zones are all likely to be degraded by dredging events. Suitable spawning substrate may be temporary lost downstream of the dredging as gravel is transported downstream but not replaced. Eventually, with large channel morphing flood events, the substrate would return to a suitable formation for spawning but there would be a temporary loss of habitat. This loss of spawners could result in a decline in various salmonid populations if alternative spawning habitat is not available in undredged sections of the river.

Benthic Invertebrates

Alternative 3 would have significant negative effects to the aquatic insect populations in the rivers and other benthic organisms in the lower Puyallup. Dredging effectively removes and kills nearly all aquatic insects within the dredged channel, and insects that remain in the channel are subjected to the settling of fine sediments that become suspended during the dredging work (Kondolf et al. 2002). In addition there would be a similar reduction in populations of benthic oriented native fishes such as sculpin and lamprey which are not as mobile as salmonids. Recolonization across the many miles of river would take varying amounts of time depending on species mobility and trophic habits (Mackay 1992). A direct effect of such widespread removal of the benthic macroinvertebrates that dwell among the substrate is that fish remaining in the river would have little to no food source available. Additionally, the young salmon that emerge from redds the following spring will have extremely poor feeding conditions as their primary food sources would not likely have had enough time to recover to previous abundance. Recolonization of invertebrates would come from upstream sources (Gore et al. 1982) and may take 1-3 years (Mackay 1992). Gore et al. (1982) also found that the first invertebrates to colonize a site with densities and diversities similar to reference sites were collector-gatherers and collector-filterers, then scrapers once there is sufficient periphyton, and the predators often arrive last. The infrequency of maintenance dredging should allow for some recovery of benthic communities in between dredging events.

4.12.4 Cumulative Effects

Cumulative effects are assumed to be additive to the past, present, and future development in the Puyallup basin. Changes around the region, such as agricultural and industrial development, have modified the available habitat for species. Future development of the study area is likely to continue to favor species that thrive in close contact with humans, and continue to pressure species that have more specialized needs. Critical area and shoreline regulations now limit the extent of habitat alterations and habitat loss within floodplains. Other laws, such as the Clean Water Act, are also expected to continue to provide protections for important habitat features.

The effects of the proposed levee modifications and new levees in Alternative 2 and Alternative 3 would further degrade the already poor quality habitat conditions; however mitigation efforts would be designed to offset these impacts. The proposed North Levee Road A-Setback Levee in Alternative 2, in combination with the other setbacks currently in construction or proposed by the County and other local entities will improve the floodplain connectivity and allow for increased riparian habitat and natural bank formation.

Short-term and long-term effects of the dredging of Alternative 3 combined with any potential maintenance dredging in the estuary pose a considerable risk to all fish species, and especially to salmon that may not find suitable spawning habitat for an unpredictable number of years. Also, effects to benthic macroinvertebrates would have significant cumulative effects for salmonid species that already face greatly reduced and degraded habitats in the channel, floodplain, and estuary. These potential impacts would be added to the list of events that have caused environmental degradation and the decline of fish populations in the watershed.

4.13 Threatened and Endangered Species

The Corps intends to submit a Biological Assessment (BA) on the preferred alternative and its proposed mitigation to NMFS and USFWS under section 7 of the ESA. This BA will contain an extensive analysis of the project's effects and an associated effects determination of either "*no affect", "may affect but not likely to adversely affect",* or *"may affect and likely to adversely affect"* for each ESA listed species in the project area. NMFS and USFWS will decide, based on the BA, if they concur or do not concur with the Corps affect determinations and may recommend reasonable and prudent measures to minimize impacts to ESA listed species in a Biological Opinion. The analysis presented below is a summary of ESA species occurrence and life history strategies in the Basin, as well as potential impacts resulting from the alternatives:

Listed and proposed endangered and threatened species with the potential to occur in the Study area are listed by sub-basin in Table 4-7.

Table 4-7. Special Status Species with the Potential to Occur within the Study Area

Common Name	Scientific name	Federal Status	Occurrence within Sub-basin			
			Lower Puyallup	Upper Puyallup	Carbon River	White River
Fish						
Puget Sound Distinct Population Segment (DPS) steelhead	*O. mykiss*	Threatened	X	X	X	X
Puget Sound ESU Chinook salmon	*O. tshawytscha*	Threatened	X	X	X	X
Coastal-Puget Sound DPS bull trout	*Salvelinus confluentus*	Threatened	X	X	X	X
Bocaccio	*Sebastes paucispinis*	Endangered	X	-	-	-
Canary Rockfish	*S. pinniger*	Threatened	X	-	-	-
Yelloweye Rockfish	*S. ruberrimus*	Threatened	X	-	-	-
Southern DPS Pacific eulachon	*Thaleichthys pacificus*	Threatened	X	X	X	X
Birds						
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	X	-	-	-
Mammals						

Common Name	Scientific name	Federal Status	Occurrence within Sub-basin			
			Lower Puyallup	Upper Puyallup	Carbon River	White River
Humpback whale	*Megaptera novaeangliae*	Endangered	X	-	-	-
Southern Resident DPS killer whale	*Orcinus orca*	Endangered	X	-	-	-
Table Sources: NMFS 2013f; WDNR 2013; WDFW 2013; USFWS 2013a						

Several other listed species occur within Pierce County, but are not likely to occur in the study area due to lack of habitat and/or specialized habitat requirements that are not met there, and/or lack of tolerance for human activity. Federally listed species in Pierce County but unlikely within the study area:

- Mazama pocket gopher (*Thomomys mazama*) - Threatened
- Canada lynx (*Lynx canadensis*) - Threatened
- North American wolverine (*Gulo gulo luteus*) -, Proposed
- Gray wolf (*Canis lupus*) -, Endangered
- Grizzly bear (*Ursus arctos horribilis*) - Threatened
- Streaked horned lark (*Eremophila alpestris strigata*) - Threatened
- Yellow-billed cuckoo (Coccyzus americanus) –Threatened
- Northern spotted owl (*Strix occidentalis caurina*) - Threatened
- Oregon spotted frog (*Rana pretiosa*) - Proposed
- Taylor's checkerspot (*Euphydryas editha taylori*) - Proposed
- Marsh sandwort (*Arenaria paludicola*) [historic] - Endangered
- Golden paintbrush (*Castilleja levisecta*) [historic] - Threatened
- Water howellia (*Howellia aquatilis*) - Threatened

4.13.1 Fish

Steelhead

The Puget Sound DPS of steelhead is listed as threatened under ESA (Federal Register 2007). Much of the Puyallup basin is proposed critical habitat for the species including the Puyallup, Carbon, and White Rivers, and Commencement Bay. (Federal Register 2013). The Critical habitat proposal excludes Tribal Reservation lands within the lower Puyallup River.

The steelhead in the Puyallup River Basin typically spawn between March and May (NMFS 2005). Spawning occurs in the mainstem Puyallup River, White River, and Carbon River, though the majority of spawning occurs in tributaries. Puget Sound steelhead typically migrate to the ocean after 2 years, with some waiting until 3 years. Outmigration in the Puyallup River system generally occurs between April and July (Berger et al. 2010). Steelhead stay in marine waters for approximately 2 or 3 years before returning to their natal streams to spawn. As noted in section 4.12, there are several barriers to fish passage in the study area which impact steelhead migration. Puyallup River winter-run steelhead show significantly declining trends in natural escapement and natural recruitment (NMFS 2005).

There is one hatchery run within the study area, the Puyallup River hatchery winter-run steelhead. These steelhead are currently acclimated and released from the Voights Creek Hatchery, though Chambers Creek hatchery fish have previously been released within the Puyallup River (NMFS 2005).

Chinook

The Puget Sound ESU of Chinook salmon is listed as threatened under ESA (Federal Register 1999). Much of the Puyallup basin is designated critical habitat for the species including the Puyallup, Carbon, and White Rivers, and Commencement Bay (Federal Register 2013). Critical habitat designations excludesTribal Reservation lands within the lower Puyallup River.

The Puyallup River Basin Chinook occur in all sub-basins of the study area (Shared Strategy Development Committee, 2007). Spawning occurs in the Puyallup River upstream of Sumner, Carbon River, White River, and various tributaries. Two distinct stocks of Chinook are present in the Puyallup River Basin: White River spring and fall Chinook and Puyallup River fall Chinook. White River spring Chinook are the only spring Chinook stock in the Puget Sound region (WDFW et al. 1996 in Marks et al. 2007). White River Chinook spring-run salmon return to freshwater earlier, beginning in late May and spawn from September through mid-October (Shared Strategy Development Committee 2007). Spring Chinook have a high tendency to be stream-type, spending a full year in freshwater before out-migrating. Puyallup River Chinook fall-run salmon begin entering the river in late July and complete spawning by November (Shared Strategy Development Committee 2007). The majority of Chinook salmon in Puget Sound and the Puyallup River leave freshwater within their first year (ocean-type) and spend much of their time in the estuary before migrating to the ocean.

The White River Hatchery for White River spring Chinook is located near Buckley within the study area. It is operated by the Muckleshoot Indian Tribe and was constructed by Puget Sound Energy as part of an agreement with the tribe to mitigate for impacts of the White River Hydroelectric Project (Shared Strategy Development Committee 2007). Both hatchery and natural origin components are included in the ESA listing (Federal Register 1999).

Bull Trout

Bull trout occur in five identified DPS within the contiguous United States, all of which are listed as threatened under the ESA (Federal Register 2010a). Their range includes Oregon, Washington, Idaho, and Montana, and western Canada. The entire study area is within the Coastal-Puget Sound DPS management unit and bull trout are known to occur in all sub-basins of the study area (Streamnet 2013). The Coastal-Puget Sound DPS contains the only anadromous form of bull trout in the United States. As with Chinook, bull trout critical habitat has been designated throughout the study area (Federal Register 2005b, 2010a). Critical habitat designations excludes Tribal Reservation lands within the lower Puyallup River.

Bull trout have more specific habitat requirements than other salmonids and require suitable water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors. Stream channel stability and the maintenance of natural flow patterns are crucial elements of bull trout habitat (USFWS 2004). All life history stages of bull trout are associated with some type of cover, such as LWD, undercut banks, boulders, and pools (USFWS 2004). Migratory bull trout spawn in cold (40 to 46 °F) upstream tributaries in the late summer and early fall and rear there for 1 to 4 years before migrating, usually in the spring, to a river, lake, or estuary/nearshore area (USFWS 2004). Spawning occurs in the late summer and early fall in the upper portion of the Carbon River and in the White River, above the limits of the study area (Streamnet 2013). Foraging and rearing habitat and migration corridors occur throughout the study area.

Boccacio, Yelloweye Rockfish, and Canary Rockfish

Boccacio, yelloweye rockfish, and canary rockfish are all listed as threatened under the ESA. In Puget Sound, boccacio are most frequently found south of Tacoma Narrows (NMFS 2013b). Tacoma Narrows is at approximately the same longitude as Commencement Bay, although it is farther west. There is potential for juveniles of all three species to occur within the Commencement Bay and in the nearshore areas near the mouth of Puyallup River. Rockfish give birth to live larval young which are found in surface waters extending several hundred miles offshore. Larvae and juvenile rockfish remain in open ocean for several months, being passively dispersed by currents (NMFS 2013b, NMFS 2013c, NMFS 2013d). Boccacio juveniles hover over rocky substrate with various understory kelps or sandy bottoms with eelgrass. Adults of these species are found in deeper marine waters outside of the study area. Juvenile canary rockfish settle in tidepools and kelp beds. Yelloweye rockfish adults, sub-adults, and juveniles occupy the shallower areas with rocky substrate. Critical habitat for all three rockfish has been proposed within Commencement Bay, but does not extend into the Puyallup River.

Eulachon

The Pacific eulachon historically ranged from northern California to the Bering Sea in Alaska. Currently, their range extends from the Mad River in Northern California north into British Columbia. Eulachon are small, anadromous fish that typically spend 3 to 5 years in offshore marine waters and return to glacial-fed rivers to spawn in late winter and early spring in tidal portions of the rivers (NMFS 2013e and Federal Register 2010b). In Washington, they are present predominantly in the mainstem Columbia River up to approximately Bonneville Dam. Although established populations are not thought to exist in Puget Sound rivers, the occasional occurrence has been recorded (Federal Register 2010b). There have been recent confirmed occurrences of eulachon in the Puyallup River (Ladley, pers. comm., 2013).

4.13.2 Birds

Marbled Murrelet

Marbled murrelets are small seabirds that feed on fish and invertebrates usually within 2 miles of shore and nest up to 45 miles (SAS 2013) inland in stands of mature and old-growth forest. They have been observed foraging within calm, shallow, coastal waters and bays, including Commencement Bay in the study area (SEI 2013; EVS 1995). Marbled murrelets typically breed between April and July. No suitable breeding habitat is present within the study area, but it is present east of the study area in and around

Mount Rainier National Park. While critical habitat is present for marbled murrelet within Pierce County, it is not present within the study area (USFWS 2013b).

4.13.3 Marine Mammals

Humpback Whale

The humpback whale is listed as endangered under the ESA and also is afforded protection by the MMPA (Federal Register 1970). They occur worldwide; in the North Pacific, they range from California to Russia and also occur in the Bering Sea. They migrate south to wintering destinations off Mexico, Central America, Hawaii, southern Japan, and the Philippines. They frequently occur close to shore and near island habitats for feeding and breeding.

Humpback whales are occasionally observed in Puget Sound and the deep water portions of Commencement Bay. They have a low potential to occur in Commencement Bay and would likely not be found in the lower Puyallup River Sub-basin (Tetra Tech et al. 2009). There are no known occurrences of this species in the Puyallup River Basin according to the WDFW Priority Habitats and Species database (WDFW 2013).

Southern Resident Killer Whale

The orca, or killer whale, is a toothed member of the order Cetacea, which includes whales, dolphins and porpoises. The southern resident population of killer whale was listed as endangered effective February 16, 2006 (Federal Register 2005a). The Southern Resident's customary range is thought to be primarily within Puget Sound, and through and within the Georgia and Johnstone Straits. Southern Residents occasionally migrate as far south as Monterey Bay, California and as far north as the northern Queen Charlotte Islands in Canada (Krahn et al. 2004). Critical habitat has been designated for killer whales, including Puget Sound and Commencement Bay marine waters deeper than 20 feet (Federal Register 2006).

Foraging is known to occur in waters of all depths, and killer whales have been seen to "herd" schools of fish into shallow bays to increase their feeding effectiveness. Occurrence of southern resident killer whales in Commencement Bay is rare (Osborne 2008). Although Southern Resident killer whales do not directly occupy the shallow waters of the Puyallup River, they have a strong feeding preference for salmon (first Chinook then chum). The survival of these whales has been shown to positively correlate with Chinook salmon abundance (Ford et al. 2010). 72.2 percent of the 396 salmon taken by killer whales that were sampled from 1974 to 2004 were Chinook, despite the much higher abundance of the other species (Ford and Ellis 2005). Decline in Chinook and chum abundance, underwater noise, and contaminants are all factors that limit Southern Resident killer whale recovery.

4.13.4 Alternative 1: No Action

Habitat and species protections for the listed species would be expected to continue into the future. The impacts of climate change, increased population, expanded development, and continued bank stabilization efforts on threatened and endangered species will be similar to those discussed above for fish and wildlife in Section 4.12. Listed species may be more sensitive to climate change and other habitat changes due to their low population numbers, limited habitat availability, and population isolation.

4.13.5 Alternative 2: Levee Modification Alternative

4.13.5.1 Fish

Impacts to listed species, particularly steelhead, Chinook, and bull trout, will be largely the same as those discussed for other fish in Section 4.12. These include short-term impacts such as elevated turbidity, physical disturbance, and noise that could result in interruption of foraging and migration behavior and elevated stress levels. Adherence to the in-water work window will minimize impacts during the most sensitive time periods, however there are still listed species present in the river during this time. Long term impacts associated with this alternative include increased temporary and permanent losses of vegetation, disconnection from the floodplain limiting off-channel habitat, increased length of hardened banks in the watershed decreasing habitat complexity and increasing vulnerability to predators, and increased velocities and depths of water in the channel during flood events making it difficult to seek out suitable refuge habitat. Juvenile fish and post spawn bull trout will have the most difficulty with increased velocities. Adult steelhead, being stronger swimmers, would have the least difficulty. Impacts to eulachon would be limited due to the rarity of their occurrence in Commencement Bay.

Juvenile boccacio, yelloweye rockfish, and canary rockfish in Commencement Bay could be affected by this alternative. With more water being kept in the channel during flood events increased flows and associated sediment loads could be delivered to the Bay, potentially smothering or degrading the shallow eelgrass and kelp beds that provide juvenile habitat. Proposed mitigation, including setting back of levees and planting of riparian vegetation, could help to minimize impacts of changes in hydrology and sediment dynamics to fish.

4.13.5.2 Birds

Marbled murrelet may transit the construction area while travelling from foraging grounds to nesting habitat. Construction of the levee raises and the new levee alignments would not be expected to impact marbled murrelet flight routes or timing as the levels of noise and human activity associated with the effort would not be substantially different than typical ambient levels for this urban area. Impacts in Commencement Bay from increased flows or sediment loads during flood events could have minor impacts on murrelets by impacting foraging areas and forage fish.

4.13.5.3 Marine Mammals

No impacts to humpback whales would be expected due to the rarity of their occurrence in Commencement Bay. While no direct impacts to killer whale would be expected from construction, indirect impacts to their primary food source could occur. These would include impacts to salmonids, particularly Chinook, a preferred prey item to which killer whale populations are correlated. Quantifying extent of the impact is complex since they rely on Chinook runs from various rivers, including a substantial proportion from the Fraser River (NMFS 2013f).

4.13.6 Alternative 3: Sediment Management with Levee Modification Alternative

Alternative 3 includes shorter lengths of levee construction and modification than Alternative 2. The impacts discussed above for Alternative 2 are fully relevant to Alternative 3 due to the similarity of construction methods, but lesser in magnitude due to shorter length. The discussion below will therefore focus on the additive impacts of dredging only.

4.13.6.1 Fish

As noted above, impacts to steelhead, Chinook, and bull trout will be largely the same as those discussed for other fish in Section 4.12. Adverse impacts include short-term impacts from noise and turbidity and considerable detrimental effects to the benthic macro-invertebrates and aquatic insect populations that serve as primary food sources and benthic oriented fish. It is assumed that pelagic fish like salmonids would largely avoid the entrainment in the dredge, however juveniles would have more difficulty doing so than adults. Long-term impacts will result from broad-scale alteration of the river bottom habitat for spawning, foraging, and rearing. Chinook and steelhead spawning habitat would be directly affected by the dredging in the Puyallup and Whites rivers; although dredging would not occur during actual spawning. These impacts could last several years after construction, as recovery across the many miles of river would take varying amounts of time depending on species mobility and trophic habits (Mackay 1992). Positive benefits to ESA listed fish from the levee setbacks included in Alternative 2 would not result from this alternative.

Impacts to eulachon would be limited. Impacts of dredging on the three listed rockfish in the nearshore areas around the mouth of Puyallup could result by altering sediment patterns in Commencement Bay, but would be expected to be minimal.

4.13.6.2 Birds

Marbled murrelet passing through the construction area would not be expected to alter flight routes or timing as a result of the dredging as the levels of noise and human activity associated with the effort would not be substantially different than typical ambient levels for this urban area.

4.13.6.3 Marine Mammals

No impacts to humpback whales would be expected due to the rarity of their occurrence in Commencement Bay. Similarly, Stellar sea lions are rare in the area and would not be expected to be impacted.

While no direct impacts to killer whale would be expected from construction, indirect impacts to their primary food source could occur. These would include impacts to salmonids, particularly Chinook, a preferred prey item to which killer whale populations are correlated. Quantifying extent of the impact is complex since they rely on Chinook runs from various rivers, including a substantial proportion from the Fraser River (NMFS 2013f).

4.13.7 Cumulative Effects

As for other fish and wildlife, cumulative effects are assumed to be additive to the past, present, and future development in the Puyallup basin. Changes around the region, such as loss or degradation of habitat, increased predation/competition by non-native species, and past management practices, have lead to the decline of these species. Future development of the study area is likely to continue to favor species that thrive in close contact with humans, and continue to pressure species that have more specialized needs. Regulations to protect and restore these species and their habitats would be expected to continue to be considered in all future projects in the region.

Improvement of fish passage at the Mud Mountain Dam fish passage structure will improve connectivity with the upper watershed potentially increasing salmonid populations in the basin and improve a limiting factor for listed salmonid species. This improvement will partially offset future development impacts.

The extensive modification of the basin, including levees and dams on the river and dredging and fill in the estuary, has decreased the habitat function for listed fish. The proposed setback in Alternative 2, in combination with the other setbacks currently in construction or proposed by the County and other local entities will improve floodplain connectivity in the basin and allow for increased riparian habitat and natural bank formations. However the proposed new levees and improvements to existing levees would further degrade the already poor quality habitat conditions for listed salmonids. Mitigation efforts would seek to offset these impacts.

Short-term and long-term effects of Alternative 3 pose a considerable risk to Chinook and steelhead that may have greater difficulty finding suitable spawning habitat for an unpredictable number of years. Also, effects to benthic macroinvertebrates would have cumulative effects for salmonids that already face greatly reduced and degraded habitats in the channel and floodplain. These potential impacts would be added to the list of events that have caused environmental degradation and the decline of fish populations in the watershed.

4.14 Cultural Resources[6]

General and useful overviews of the prehistory and ethno-history of the Study area are provided in Suttles and Lane (1990), Ruby and Brown (1992), Matson and Coupland (1995), and Ames and Maschner (1999). The history of settlement and development of Tacoma, Pierce County and Puyallup River Basin are provided in Gallacci (2001) and Morgan and Morgan (1983). A general historic overview of the Study area with emphasis on built-environment resources is also provided in the Puyallup Historic Survey Report,

[6] A **cultural resource** is an object or definite location of human activity, occupation, use, or significance identifiable through field inventory, historical documentation, or oral evidence. Cultural resources include prehistoric, historic, archaeological, or architectural sites, structures, buildings, places, or objects and locations of traditional cultural or religious importance to specified social and/or culture groups. Cultural resources include the entire spectrum of objects and places, from artifacts to cultural landscapes, without regard to significance or eligibility for inclusion on the National Register of Historic Places (NRHP), the Washington Historical Register (WHR), or local registers or designations. Cultural resources that are included in, or eligible for inclusion in, the NRHP per the NRHP eligibility criteria at 36 C.F.R. § 60.4 are referred to as **historic properties**. Historic properties may include any prehistoric or historic district, site, building, structure, traditional cultural property or object. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization that meet the NRHP criteria. Federal agencies have specific responsibilities under Section 106 of the National Historic Preservation Act to take into account effects on historic properties.

Puyallup, Washington (BOLA Architecture and Planning, 2007). A brief summary of the prehistory and history of the study area is provided for context.

The record of human settlement and occupation of the southern Puget Lowlands and the Puyallup River Basin extends back at least 12,000 years, although there are few archaeological sites with antiquity greater than 5,000 years. Early prehistoric archaeological sites are characterized by assemblages of stone tools and lithic debitage that indicates the Northwest Coast was settled by peoples from diverse cultural backgrounds and traditions following the retreat of ice from the last glaciation. The prehistory of the region is delineated by various stone tool traditions, which generally are described as an Early Period (prior to 5000 years B.P.), a Middle Period (5,000-1000 years B.P.), and a Late Period (1,000 to 250 years B.P.). The Early Period is characterized by archaeological assemblages containing stone tools of various traditions and cultures and an absence of mollusk shells, which assist in preserving bone or other faunal material. After 5000 years B.P. (Middle Period), large shell middens begin to appear, along with an increased diversity in in artifact assemblages, including artifacts indicating increased specialization in fishing and hunting of sea-mammals. In the Late Period, archaeological assemblages are characterized by artifacts that show an increasing reliance on fisheries (bone tools and shell) and a shift away from the manufacture of chipped stone tools to the use of ground or pecked stone (Carlson 1990; Nelson 1990; Wessen 1985).

Native American tribes with an interest in the area include the Puyallup Tribe of the Puyallup Reservation, Muckleshoot Indian Tribe of the Muckleshoot Reservation, Nisqually Indian Tribe of the Nisqually Reservation, Squaxin Island Tribe of the Squaxin Island Reservation, and Snoqualmie Tribe. The Confederated Tribes and Bands of the Yakama Nation, though not in the immediate area, historically passed through, traded, or lived with extended family in the area, and have an interest in cultural resources in the region. The study area includes the Puyallup Reservation, which was established in 1854 (Ruby and Brown 1994). The Muckleshoot Indian Reservation is nearby, but not located within the study area boundaries. Ethno-historically, native peoples lived in wood-plank houses, some of which were as large as 500 feet long and 40-60 feet wide. They exploited a wide variety of vegetable foods, game and marine resources, catching salmon and freshwater fish, hunting deer and elk, and gathering seasonal berries, nuts, wapato, and camas. They established permanent villages along the Puyallup River Valley which were important trade centers among native tribes (Suttles and Lane 1990). Archaeological sites associated with the ethno-historic period would be expected to exhibit a diverse array of artifacts associated with all facets of daily life, including stone and metal tools, basketry, bone fishing implements and netting. Northwest Coast Indians first encountered Europeans in the late 18th century. In 1833, the Hudson's Bay Company established Fort Nisqually as a trading post, which begins continuous contact with non-Native traders and settlers in the region. The Puyallup River Valley and areas north of it were opened to non-native settlement by the Medicine Creek Treaty, signed on December 26, 1854.

The cities of Tacoma and Puyallup were both founded in the 1870s and are some of Washington's oldest municipalities. Puyallup is located approximately eight miles east of Tacoma in the Puyallup River Valley. Puyallup River Valley contains a significant number of historic properties that reflect its origin as an agricultural settlement dating from the 1850s. Flood control projects in the Puyallup River Basin were begun in the early 20th century with the construction of levees, diversion dams, and channeled tributaries to control the periodic flooding from heavy winter rains and spring snowmelt. After severe floods in 1917 and 1933, the Army Corps of Engineers was charged with constructing a more permanent and robust flood control system, which led to the construction of Mud Mountain Dam and the Puyallup Right and Left Bank Federal Levees in the 1940s and 1950s. Increased flood protection in the Puyallup River Valley created a more stable environment for the development and settlement, and is generally responsible for the increased urbanization of the Puyallup River Valley since 1950 (BOLA Architecture + Planning, 2007).

Study Area and Area of Potential Effect (APE)

The study area establishes the baseline within which impacts to cultural resources will be considered. The study area is defined as the maximum flood inundation damage reach expected from a 0.25% ACE flood event. The Corps has also consulted with the Washington State Historic Preservation Officer (SHPO) and established the area of potential effect (APE) for purposes of consultation in accordance with Section 106 of the National Historic Preservation Act (54 U.S.C. 306108)(NHPA) Documentation is provided in Appendix G (Environmental and Cultural Resources). The APE is the total geographic area or areas within which the undertaking may directly or indirectly cause alterations in the character or use of historic properties eligible for or listed in the National Register of Historic Places (NRHP) per 36 C.F.R. § 800.16(d) of the regulations implementing Section 106. The NRHP eligibility criteria are provided 36 C.F.R. § 60 and further explained in *National Register Bulletin* 15 (How to Apply the National Register Criteria). The APE is influenced by the scale and nature of an undertaking and includes those areas which could be affected by an undertaking prior to, during and after construction.

For purposes of the study, the Corps has established a buffered APE to consider direct and indirect effects. For direct effects, the APE extends to 100 feet around the proposed footprint of new levees, raised levees, setback levees, or any other required construction action, including levee removal, road relocations, staging areas and fill areas, and acquisition and removal of structures. For indirect effects (visual, auditory or atmospheric intrusions), the APE extends to a ¼ mile buffer around new levees, setback levees, floodwalls, or levees that would be raised. Specific to flooding that may be induced from the actions proposed in the alternatives, the Corps has defined a general indirect effects APE that extends to the damage reach boundaries for flood inundation for a 1% ACE flood event (see Appendix G – Environmental and Cultural Resources). Within the study area and APE as defined, the analysis has correlated existing cultural resources data and information gathered through consultation to compare the baseline without the project against the estimated future conditions with the project to determine whether there are known or recorded resources in areas that might be threatened or affected. For the general investigation/feasibility study planning effort, the APE is based on current engineering design and construction plans and would be adjusted accordingly should design or construction plans change.

In considering the APE for indirect effects, the primary focus in identifying potential impacts are: visual intrusions on the historic setting of a historic property which results from raising the height of an existing levee or constructing a new levee or floodwall; induced flooding in new areas as a result of changes to the levee system; increase in the depth of existing flood inundation as a result of changes to the levee system;

increased development or change of use in lands provided protection from future flooding; and new or increased bank erosion resulting from changes to the levee system. Conversely, positive indirect effects to historic properties may result from the measures proposed in the study, including reduced threats to historic properties from flood damage as flood protection levels are increased and less threat of flood inundation to historic properties throughout the basin as a whole.

Level of Effort to Identify Cultural Resources

For general investigation/feasibility studies, identification efforts are scaled to the level of alternative development and refinement. Within the Corps' planning process, feasibility studies emphasize making risk-informed decisions using existing information for planning decisions on overall project feasibility, while phasing detailed field investigations, such as archaeological or built-environment surveys, to post-authorization. Surveys or other intensive field investigations normally would not be conducted without access/right-of-way agreements, which would not be pursued unless the project is authorized and funded. Post-authorization compliance with Section 106 of the NHPA would be governed by a Programmatic Agreement as provided at 36 C.F.R. § 800.4(b)(2) and 800.14(b)(ii).

To identify cultural resources located within the study area and APE for each alternative, the analysis considers existing and available information to determine the location and nature of prehistoric, historic, and built-environment properties. The Corps completed a records and literature review using the *Washington Information System for Architectural and Archaeological Records Data* (WISAARD) which is maintained by the Washington Department of Archaeology and Historic Preservation (DAHP). The information available in the WISAARD online geospatial database and supporting geographic information systems is current through July 2015. The WISAARD includes all cultural resources that have been systematically identified and recorded. The database also includes information about cultural resources surveys and inventories that have been conducted since 1995. WISAARD does not provide a comprehensive list of inventories conducted prior to 1995.

The Corps has also sought information from Indian tribes and other consulting parties regarding cultural resources of interest or concern in the study area. The Corps has specific responsibilities under Section 106 to consult with Indian tribes that attach religious and cultural significance to historic properties which may be located in the APE. For purposes of identifying these properties and other concerns, the Corps has initiated consultation with the Puyallup Tribe of the Puyallup Reservation, Muckleshoot Indian Tribe of the Muckleshoot Reservation, Nisqually Indian Tribe of the Nisqually Reservation, Squaxin Island Tribe of the Squaxin Island Reservation, Snoqualmie Tribe, and the Confederated Tribes and Bands of the Yakama Nation.

It is important to emphasize that the baseline for considering impacts will necessarily change regardless of federal actions proposed in the alternatives. Aside from the federal actions proposed, Pierce County and King County have identified projects that may be constructed before this study is completed and construction is initiated.

Baseline Cultural Resources Summary for the Study Area

The WISAARD identifies 156 cultural resources investigations that have been conducted within or that partially extend into the study area. Most of these investigations are surveys and inventories for archaeological and built-environment properties that were completed to fulfill the requirements of federal or state historic preservation laws or historic preservation planning. Consequently, most of these investigations have been conducted where modern development has been greatest, along the lower Puyallup River and Commencement Bay. In addition, most historic structure inventories and historic register listings are found within urban areas, such as Tacoma and Puyallup. Less attention has been focused on less urban or rural areas, where properties associated with early settlement or agriculture might occur. Seven investigations are identified exclusively as historic structures surveys. These investigations cover less than 0.1 percent of the study area. One hundred and thirty-two of the investigations are identified as general cultural resources survey reports. General survey coverage within the study area for all cultural resource property types is approximately 1.0 percent. A list of cultural resources investigations for the study area is provided in Appendix G (Environmental and Cultural Resources), which also identifies investigations that extend into the APE as defined for Section 106 of the NHPA.

The general baseline information for cultural resources indicates that there are 5,562 recorded properties within the boundaries of the study area. The predominant property type are residential buildings which have been identified in the DAHP Historic Property Inventory (HPI). Information regarding properties included in the HPI often have varying levels of historic information and generally have not been formally surveyed or recorded. Identification and inclusion of many properties in the HPI is based on a screening review of tax accession records using a minimal threshold, usually 50 years of age, as a parameter for inclusion. Of the 5,562 properties in the study area, 5,490 are recorded in the HPI inventory as built-environment properties, such as residential and commercial buildings, barns or other outbuildings, warehouses, wharfs or waterfront structures, bridges, levees, and highway or railroad structures. The remaining 72 properties have been formally recorded or documented and are identified using a Smithsonian trinomial designation. These properties include built-environment or other historic properties listed in the NRHP, as well as historic and prehistoric archaeological sites. Twenty-five properties within the boundaries of the study area are classified as historic archaeological sites. Thirteen properties are classified as prehistoric archaeological sites. A full list of cultural resources that occur within the study area are provided in Appendix G (Environmental and Cultural Resources).

Twenty-five properties have been formally recognized as significant at the local, state or national level by their inclusion in either the National Register of Historic Places (NRHP), the State of Washington Heritage Register (WHR), the Washington Historic Barn Register (WHBR), or the Pierce County Register of Historic Places (PCRHP) (Table 4-8).

Table 4-8. Properties within the Study area listed on the National Register of Historic Places (NRHP), Washington Historic Register (WHR), Washington Historic Barn Register (WHBR), or Pierce County Register of Historic Places (PCRHP)

DAHP Identifier	Property Description	NRHP	WHR	WHBR	PCRHP
PI00099	Ezra Meeker Mansion	X	X		
PI00175	Ryan House	X	X		
PI00219	J. H. Lotz House	X	X		
PI00565	Puyallup Assembly Center		X		
PI00577	Charles W. Orton House	X	X		X
PI00580	Puyallup Tribe Cemetery		X		
PI00580	Cushman Cemetery, Historic Cemetery (ca. 1858)		X		
PI00584	Herbert Williams House	X	X		
PI00587	Sidney Williams House	X	X		
PI00605	Christ Episcopal Church	X	X		
PI00626	Peace Lutheran Church		X		
PI00638	Alderton School	X	X		X
PI00650	Fire Station No. 15	X	X		
PI00653	Fireboat Station	X	X		
PI00654	City Waterway Bridge	X	X		
PI00660	McMillin Bridge	X	X		X
PI00696	Albers Brothers Mill	X	X		
PI00742	M.V. Kalakala (Historic Ferry)*	X	X		
PI00761	Balfour Dock Building	X	X		
PI00803	Schoenbachler Barn			X	
PI00812	Harman Barn			X	
PI00819	Barn			X	
PI00976	Stewart - Brew House		X		
PI01200	Spooner Farms			X	
PI01294	Puyallup Fish Hatchery	X	X		

* The Kalakala has reportedly been dismantled. However, the listing is still maintained in the WISSARD database and is included here to maintain consistency with the database.

Analysis of Impacts

Analysis of impacts for each alternative examines both indirect and direct impacts. The potential for indirect impacts from induced flooding is considered first and separately from other direct and indirect impacts for each alternative. Within the context of Section 106, indirect impacts would include the introduction of visual, auditory, or atmospheric intrusions that generally affect the integrity of location, setting, feeling or association of a property. For example, flood inundation would be considered an atmospheric intrusion that may impact the integrity of a property and would be an indirect consequence of the actions proposed in an alternative. In addition, raising the height of a levee or constructing a new levee or floodwall may introduce a visual intrusion that could indirectly alter the historic setting of a property. Direct impacts are more generally associated with actions that would physically alter or remove the property or its significant characteristics or values, including diminishing the integrity of location, design, materials, and workmanship. For instance archaeological sites that retain significant information values are most likely to be directly impacted by activities that would disturb or destroy artifacts, features, or their interpretive context. Meanwhile, buildings or structures that exhibit characteristics or values of association with famous persons or events, or represent significant periods in architecture or history, are more likely to be directly impacted by alteration or demolition. Where properties are eligible for or listed in the NRHP, such indirect and direct impacts are referred to as “adverse effects” (36CFR800.5). The phrase “adverse effect” (used in the NHPA) and “significant impact” (used in NEPA) are not equivalent terms but are similar in concept. However, adverse effects to properties that are eligible for or listed in the NRHP are not necessarily considered significant impacts under NEPA.

For comparison of the alternatives, a worst case scenario for “potential” impacts is analyzed. Final planning, engineering and design would consider all reasonable measures to avoid or minimize impacts to significant cultural resources to the extent possible. In the event that a significant resource could not be avoided, actions would be taken to minimize and/or mitigate the impacts. Typically, these actions would entail treatment or mitigation that is appropriate to the property’s significant qualities and values. Table 4-9 summarizes the comparison of cultural resources and designated resources in the Study APE.

Table 4-9. Summary of Cultural Resources and Designated Resources (NRHP, WHR, WHBR, PCRHP) in the APE by Alternative

	Cultural Resources			Properties Included in a Historic Register (NRHP, WHR, WHBR, PCRHP)		
Alternative	APE for Direct Effects (100’ Buffer)	APE for Indirect Effects (1/4 Mile Buffer)	Flood Inundation APE	APE for Direct Effects (100’ Buffer)	APE for Indirect Effects (1/4 Mile Buffer	Flood Inundation APE
No Action Alternative	0	0	645	0	0	10
Alternative 2	23	561	331	2	2	7
Alternative 3	13	418	331	1	2	7

4.14.1 Alternative 1: No Action

Impacts from Flood Inundation

Under Alternative 1, cultural resources in the study area and the APE would be continue to be threatened by indirect effects associated with the decline in flood protection to less than a 1% ACE that is projected for the future without a project. The primary threat to cultural resources would be damage from flood inundation. Cultural resources in the study area and the APE would continue to be impacted by periodic flooding, including new areas of induced flooding that would be a consequence of the decline in flood protection to less than a 1% ACE. As the level of flood protection degrades to less than a 1% ACE probability as a result of increased sedimentation and decreased channel capacity, it would be expected that flood impacts to cultural resources within the APE for inundation for a 1% ACE would increase. For this alternative, 645 properties in the APE would continue to be periodically threatened or damaged by flooding (see Appendix G, Environmental and Cultural Resources). Of these, 601 properties are primarily residential or commercial buildings or other structures identified as meeting the minimum fifty year age threshold. Eight buildings or built-environment structures listed on local, state or national registers and two historic cemeteries would be threatened or damaged by flooding (Table 4-10).

Table 4-10. Designated properties within the No-action Alternative threatened by flood inundation

DAHP Identifier	Property Description	NRHP	WHR	WHBR	PCRHP
PI00260	Puyallup Waterway Crossing		X		
PI00580	Puyallup Tribe Cemetery		X		
PI00580	Cushman Cemetery, Historic Cemetery (ca. 1858)		X		
PI00584	Herbert Williams House	X	X		
PI00587	Sidney Williams House	X	X		
PI00660	McMillin Bridge	X	X		X
PI00742	M.V. Kalakala (Historic Ferry)	X	X		
PI00761	Balfour Dock Building	X	X		
PI00803	Schoenbachler Barn			X	
PI00819	Barn			X	

Flooding may impact historic buildings or structures in a variety of ways, including but not limited to undermining foundations and inducing structural weakness, increasing deterioration and reducing integrity of materials and workmanship, affecting exterior paint or masonry, saturating and buckling flooring, and saturating and eroding interior wall surfaces.

Two historic cemeteries would be threatened or impacted by flooding under this alternative, including the historic Puyallup Tribal Cemetery. Twenty historic archaeological sites and eleven prehistoric archaeological sites would also be inundated. Inundation would not necessarily damage a buried archaeological site. However, archaeological sites may be impacted in other ways, including displacement of surface artifacts by receding flood waters and loss of archaeological materials due to wave action or other erosional processes.

Although unrecorded and unevaluated, the levees that channel the river system through the basin are themselves built-environment properties that also meet the minimum age threshold to be considered for the NRHP. The Puyallup Right and Left Bank Federal Levees were completed 1950 and were planned in conjunction with Mud Mountain Dam to afford protection against floods in the Puyallup Basin. The levee system played a critical role in the development of the City of Tacoma and the important shipping industry out of Commencement Bay. Consequently, the levees may be eligible for the NRHP or State and local historic designations for their significant associative values. The Jones Levee is near the town of Orting, Washington, and is believed to have been originally constructed around 1955 by Pierce County to provide protection from flooding. Although the levee system was designed to channel and control existing flood waters, the levees would also be threatened by flood damage through erosion, or by overtopping and breaching.

Direct and Indirect Impacts

There would be no other direct or indirect impacts to cultural resources or historic properties in the study area or the APE under the Alternative 1. The existing Puyallup River flood control system would continue to be managed and maintained, although the existing level of flood protection would continue to decrease as a result of increased sedimentation and channel capacity.

Mitigation

As there is no Federal action, there are no impacts resulting from an action that would affect properties eligible for or listed on the NRHP and there would be no mitigation requirement.

4.14.2 Alternative 2: Levee Modification Alternative

Impacts from Flood Inundation

Under Alternative 2, cultural resources in the study area and the APE would continue to be impacted by periodic flooding, but the frequency and severity of inundation would be less than Alternative 1, based on a 1% ACE. As with the Alternative 1, a primary threat to cultural resources is damage from flood inundation. With this alternative, 331 properties would continue to be periodically threatened or damaged by flooding based on a 1% ACE, which is approximately one-half the number of cultural resources threatened by flooding under the Alternative 1 (see Appendix G, Environmental and Cultural Resources). Three properties (HPI 132011, HPI 104521, and HPI 153919) not currently subjected to flooding would be threatened by flooding in this alternative. Two-hundred ninety-four (294) properties are primarily residential or commercial buildings or other built-environment structures identified as meeting the minimum fifty year age threshold. Five buildings or built-environment structures listed on local, state or national registers would be threatened or damaged by flooding (Table 4-11).

Table 4-11. Designated Properties within APE for Alternative 2 threatened by flood inundation.

DAHP Identifier	Property Description	NRHP	WHR	WHBR	PCRHP
PI00260	Puyallup Waterway Crossing		X		
PI00580	Puyallup Tribe Cemetery		X		
PI00580	Cushman Cemetery, Historic Cemetery (ca. 1858)		X		
PI00660	McMillin Bridge	X	X		X
PI00742	M.V. Kalakala (Historic Ferry – now demolished)	X	X		
PI00803	Schoenbachler Barn			X	
PI00819	Barn			X	

As with the Alternative 1, flooding may impact historic buildings or structures in a variety of ways, including but not limited to undermining foundations and inducing structural weakness, increasing deterioration and reducing integrity of materials and workmanship, affecting exterior paint or masonry, saturating and buckling flooring, and saturating and eroding interior wall surfaces.

Two historic cemeteries would be threatened or impacted by flooding under this alternative, including the historic Puyallup Tribal Cemetery. Seventeen historic archaeological sites and twelve prehistoric archaeological sites would also be inundated in flood events. As for all alternatives, inundation would not necessarily damage a buried archaeological site. However, archaeological sites may be impacted in other ways, including displacement of surface artifacts by receding flood waters and loss of archaeological materials due to wave action or other erosional processes.

Direct and Indirect Impacts

Direct and indirect impacts are examined within the context of the APE as established for purposes of Section 106 of the NHPA. For this alternative, there are 23 cultural resources located within the APE for direct effects and 551 cultural resources are located within the APE for non-flood induced indirect effects (574 total). There are no properties eligible for or listed on the NRHP within the APE for direct or indirect effects not related to inundation. Two properties, identified as the Puyallup Tribe Cemetery and the Historic Cushman Cemetery are located within the APE for both direct and indirect effects. Both properties are listed on the WHR. Although located within the buffered APE for direct effects, neither property would be directly impacted as the actual footprint for levee construction would remain northeast of and not extend beyond East Bay and River Roads.

Of the 574 cultural resources located within the APE for direct and indirect effects, 561 are primarily residential buildings or other built-environment properties which have been identified in the HPI. Eighteen of these properties are located in the APE for direct effects. One historic archaeological site and two prehistoric archaeological sites are located within the APE for direct effects. The properties located within the APE for direct effects are summarized in Table 4-12.

Table 4-12. Cultural Resources located within the Alternative 2 APE for Direct Effects and Designation Status

DAHP ID	PROPERTY NAME	PROPERTY ADDRESS	NRHP	WHR	WHBR	PCRHP
HPI 31973	George Milroy Bridge	Puyallup River Bridge; Pierce County Bridge #18204A				
HPI 55489	Puyallup River Bridge	Bridge No. 509 / 8				
HPI 127924		14017 16TH ST E, SUMNER, WA				
HPI 128005		14001 16TH ST E, SUMNER, WA				
HPI 129904		14009 16TH ST E, SUMNER, WA				
HPI 131038		2 COURT PL, PUYALLUP, WA				
HPI 131039		417 10TH AVCT NE, PUYALLUP, WA				
HPI 135241		413 COURT PL, PUYALLUP, WA				
HPI 135242		421 10TH AVE NE, PUYALLUP, WA				
HPI 308543		599 3RD AVE SE, PACIFIC, WA				
HPI 31970	Fort Malone Historical Marker	N Levee Rd, and Meridian St, Puyallup, WA				
HPI 31971	Riverside Valley Grange	N side Levee Rd, W of 70th Ave E, vicinity of Puyallup, WA				

HPI 338708		603 3RD AVE E, PACIFIC, WA				
HPI 39730	Fort Malone Historical Marker (PC-96-15)	North Levee Road and Meridian St, Puyallup, WA 98424				
HPI 39814		3102 Frank Albert Rd, Fife, WA				
HPI 39815	Christoph House	3206 Frank Albert Rd, Fife, WA				
HPI 536859		1002 E 21ST ST, TACOMA, WA 98421				
HPI 674416	Cleveland Way Pump Station	2223 Cleveland Way, Tacoma, WA 98421				
KI01002	Historic Archaeological Site					
PI00580	Puyallup Tribe Cemetery			**X**		
PI00580	Cushman Cemetery			**X**		
PI00930	Prehistoric Archaeological Site					
PI00967	Prehistoric Archaeological Site					

Within the exception of the two cemeteries, the 21 cultural resources located within APE for direct effects would be threatened by actions proposed in the alternative. The archaeological sites may be damaged or destroyed by construction activities. Buildings and structures within the APE for direct effects are threatened by demolition or removal for construction of the expanded levee footprint for raised levees or the construction of new floodwalls or setback levees. There are two bridges recorded in the HPI that are located within the APE. It is not anticipated that the bridges would be directly impacted by the actions proposed in this alternative.

In addition, there are buildings or structures on land parcels that are threatened by flooding and, depending on the degree of flooding, may be proposed for acquisition and removal. These parcels have not been surveyed for cultural resources. However, a comparison of parcel maps with existing cultural resources data indicate that 53 residential buildings or structures identified in the HPI are located on these parcels. None of the properties is listed on the NRHP or other State or local historic register. These properties would need to be formally recorded and evaluated. If eligible for the NRHP, removal of a property would constitute an adverse effect under Section 106 of the NRHP. Appendix G (Environmental and Cultural Resources) includes a table that identifies properties that occur within the inundation area that may be proposed for acquisition and removal.

The Puyallup Right and Left Bank Federal Levees and Jones Levee are located within the APE and are the subject of actions proposed in this alternative. The actions proposed would either raise, remove or modify the existing levees. The levees have not been evaluated for the NRHP, but there is high likelihood that the levees would be considered eligible under one or more of the NRHP criteria. If determined eligible, then the modification or removal of the existing levees would be an adverse effect under Section 106 of the NRHP.

Other than flooding which has been previously discussed, the most likely indirect impact that could alter the significant characteristics of a property in the APE would be the introduction of modern or incompatible elements (visual intrusion) into the historic setting of a significant cultural resource.

Archaeological sites, whose significance is solely derived from scientific or information values, would generally not be affected by visual intrusions. Built-environment resources, such as residential or commercial buildings, bridges, or other structures, would be the most likely property types to be impacted by the introduction of new elements into the historic setting. There are 561 built-environment properties located within the APE for indirect effects. The existing levee system has also been in place for more than 60 years. As such, the levees have become an integral part of the historic setting, and to some extent, may define and be responsible for allowing the development of the nearby areas. The levees may be part of the historic setting for many properties. It is likely that modification of the current levees by raising the levee height, setting back existing levees, or building levee floodwalls, would introduce a new element into the existing historic setting for many properties. There is insufficient information regarding eligibility and historic setting at this time to determine which properties would be indirectly impacted. However, it is reasonable to conclude that a small number of these properties would be considered significant and eligible for the NRHP and would be adversely affected indirectly by a visual intrusion into their historic setting that would occur with a raised levee, new setback levee, or new floodwall.

Mitigation

The mitigation of adverse effects are described in Section 5.2.4.

4.14.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts from Flood Inundation

The analysis and conclusions are the same as for Alternative 2.

Direct and Indirect Impacts

For this alternative, there 13 cultural resources located within the APE for direct effects and 408 cultural resources are located within the APE for non-flood induced indirect effects (418 total). There are no properties eligible for or listed on the NRHP within the APE. The Cushman Cemetery is located within the APE for both direct and indirect effects. The cemetery is listed on the WHR. Although located within the buffered APE for direct effects, the cemetery would not be directly impacted as the actual footprint for levee construction would remain northeast of and not extend beyond East Bay and River Roads.

Of the 418 cultural resources located within the APE for direct and indirect effects, 408 are primarily residential buildings or other built-environment properties which have been identified by the HPI. Seven of these properties are located in the APE for direct effects. There are also two prehistoric archaeological sites located within the APE for direct effects. The properties located within the APE for direct effects are summarized in Table 4-13.

Table 4-13. Cultural Resources located within the Alternative 3 APE for Direct Effects and Designation Status

DAHP ID	PROPERTY NAME	PROPERTY ADDRESS	NRHP	WHR	WHBR	PCRHP
HPI 131039		417 10TH AVCT NE, PUYALLUP, WA				
HPI 135241		413 COURT PL, PUYALLUP, WA				
HPI 135242		421 10TH AVE NE, PUYALLUP, WA				
HPI 31973	George Milroy Bridge	Puyallup River Bridge; Pierce County Bridge #18204A				
HPI 39730	Fort Malone Historical Marker (PC-96-15)	North Levee Road and Meridian St, Puyallup, WA 98424				
HPI 536859		1002 E 21ST ST, TACOMA, WA 98421				
HPI 55489	Puyallup River Bridge	Bridge No. 509 / 8				
HPI 674416	Cleveland Way Pump Station	2223 Cleveland Way, Tacoma, WA 98421				
HPI 97770	Milwaukee Railroad-Puyallup River Bridge	Puyallup River RR Crossing, Tacoma, WA				
PI00580	Cushman Cemetery			X		
PI00930	Prehistoric Archaeological Site					
PI00967	Prehistoric Archaeological Site					

Within the exception of the Cushman Cemetery, cultural resources located within APE for direct effects may be threatened by actions proposed in the alternative. Archaeological sites may be damaged or destroyed by construction activities. Buildings and structures within the APE for direct effects are threatened by demolition or removal for construction of the expanded levee footprint for raised levees or the construction of new floodwalls or setback levees. There are three bridges recorded in the HPI that are located within the APE. It is not anticipated that the bridges would be directly impacted by the actions proposed in this alternative.

The analysis and conclusions for buildings or structures that would be proposed for acquisition and removal because of the induced flood damage would be the same as for Alternative 2.

The Puyallup Right and Left Bank Federal Levees are located within the APE and are the subject of actions proposed in this alternative. The actions proposed in this alternative would either raise, remove or modify portions the existing levees. The analysis and conclusions are the same as for Alternative 2.

Other than flooding which has been previously discussed, the most likely indirect impact that could alter the significant characteristics of a property in the APE would be the introduction of modern or incompatible elements (visual intrusion) into the historic setting of a significant cultural resource. The analysis and conclusions are similar as for Alternative 2, except there are 408 built-environment properties located within the APE for indirect effects. As with Alternative 2, it is reasonable to conclude that a small number of these properties would be considered significant and eligible for the NRHP and would be adversely affected indirectly by a visual intrusion into their historic setting that would occur with a raised levee, new setback levee, or new floodwall.

The primary threats or impacts for Alternative 3 are the same as for Alternative 2.

Mitigation

Mitigation would be the same as described for Alternative 2 and is described in Section 5.2.4.

4.14.4 Cumulative Effects

Cultural resources, and the subset including historic properties, are non-renewable resources. In the sense that each property is unique, it is difficult to measure cumulative impact or loss. Inevitably, the incremental loss of individual properties increases the value and significance of the remaining properties. Given the nature of the planning study and the broad and incomplete nature of the information available, the cumulative analysis primarily considers impacts within a quantitative context using the baseline information for the study area.

It would be expected that as additional cultural resources investigations are carried out within the study area, new properties would be identified and properties meeting the minimum fifty-year age threshold would continue to increase. In addition, it would be anticipated that the number of properties being formally evaluated for significance and listed on local, state or the national registers would increase as a result of project review in compliance with federal and state historic preservation laws. For properties already recorded and evaluated, it is likely that the number of properties being formally evaluated for significance and listed on local, state or the national registers would increase slightly through a reassessment of cultural resources that takes into account the passage of time, changing perceptions of significance, and the incomplete nature of prior evaluations. In addition, regardless of the actions proposed in this plan, it would be anticipated that cultural resources, especially buildings and structures, would be continue to be threatened or destroyed as a result of on-going development in the region or continued impacts from recurring flood inundation. It is likely that a number of the properties that may be lost would be eligible for the NRHP. Regardless of actions considered in this plan, there has been past and recurring loss of cultural resources over time, and it is expected that there would be some normal cumulative loss of cultural resources extending into the future.

Alternative 1: There would be no direct or indirect impacts resulting from actions proposed in the study. However, damage from periodic flooding is expected to continue to increase over time. Of the 5,562 cultural resources currently identified in the study area, there are 645 cultural resources within the study area that would continue to be threatened or damaged by flooding. This represents about 12 percent of the total cultural resources base currently identified in the study area. Most of these resources are buildings or structures. Twenty-five properties (0.45 percent of the study area base) have been designated as significant and are listed either on the NRHP, the WHR, the WHBR, or PCRHP. Of these, 10 properties (0.17 percent of the study area base), would be threatened or impacted by continued periodic flooding, or 40% of the designated properties in the study area.

Alternative 2: There would be potential direct and indirect adverse effects with this alternative, including periodic flooding. There are 331 cultural resources within the study area that would continue to be threatened or damaged by flooding, which is approximately one-half of the properties that would be threatened in Alternative 1. This represents about 6% of the total cultural resources base currently identified in the study area. Three of these properties are properties that would be threatened or damaged by new flooding that may result with this alternative. Most of these resources are buildings or structures. Seven designated properties (0.12 percent of the study area base), would be threatened or impacted by continued periodic flooding, or 28% of the designated properties in the study area.

There are 574 properties (11 percent of the study area base) located within the direct and indirect APE for non-flood induced impacts. Most of these are residential buildings or structures and would be primarily threatened by visual intrusions into the historic setting. Two properties have been designated as significant and are listed on the WHR. Twenty-three properties (0.41 percent) are located within the APE for direct effects. These properties would be directly threatened or damaged by construction or related activities. There are 53 properties (1 percent) that would be threatened by acquisition and removal due to induced flooding. The existing levees are unrecorded, but are likely eligible for the NRHP. The levees would be completely altered or removed in this alternative.

Alternative 3: There would be potential direct and indirect adverse effects with this alternative, including periodic induced flooding. There are 331 cultural resources within the study area that would continue to be threatened or damaged by flooding. This represents about 6% of the total cultural resources base currently identified in the study area. Three of these properties are properties that would be threatened or damaged by new inundation resulting from the project. Most of these resources are buildings or structures. One designated properties (0.21 percent of the study area base), would be threatened or impacted by continued periodic flooding, or 4% of the designated properties in the study area.

There are 418 properties (7.5 percent of the study area base) located within the direct and indirect APE for non-flood induced impacts. Most of these are residential buildings or structures and would be primarily threatened by visual intrusions into the historic setting. Two properties have been designated as significant and are listed on the WHR. Twelve properties (0.21 percent) are located within the APE for direct effects. These properties would be directly threatened or damaged by construction or related activities. There are 53 properties (1 percent) that would be threatened by acquisition and removal due to induced flooding. The existing levees are unrecorded, but are likely eligible for the NRHP. The levees would be substantially altered in this alternative.

4.15 Hazardous, Toxic and Radioactive Waste

Per ER 1165-2-132, Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects, HTRW includes any material listed as a "hazardous substance" under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq (CERCLA). A database search of EPA Enviro Facts and Washington State Department of Ecology's Integrated Site Information System (Web Reporting) was performed to identify potential HTRW concerns in the immediate area of the Puyallup River GI. The intent was to generally delineate areas that contain confirmed or suspected HTRW releases that may hinder future alternative site selection. The accuracy of the data presented is only as accurate and up-to-date as the retrieved available information. Records may have been added, changed, or deleted since the databases were retrieved.

The purpose of the records review is to obtain and review records that will help identify confirmed or suspected HTRW sites within the project area. This assessment included the presence and character of contamination on lands, including structures and submerged lands in the study area, or external HTRW contamination which could impact, or be impacted by, the Puyallup River Basin GI.

Many sites were identified in the records search to be located near the project area; however only three known or suspected HTRW sites were identified that may affect project alternatives (see below and Appendix H). The majority of sites identified in the search that do not affect project alternatives are Hazardous Waste Generators (HWG), which are regulated by EPA under RCRA to ensure these wastes are managed in a way that protect human health and the environment. Further coordination with the project team and non-Federal sponsor will occur to assure that the three known or suspected sites are avoided or remediated prior to construction.

4.15.1 Alternative 1: No Action

Under the No Action Alternative, existing conditions are not expected to change significantly in the future in the absence of a flood risk management project. The Washington State Department of Ecology will continue to monitor and identify facilities with hazardous waste activities and, as necessary, remediate facilities with reported toxic releases. As projects are remediated, some may be closed by covering, removing, or treating the HTRW materials.

One site under this alternative is suspected to contain HTRW- Pacific Park, at RM 1.7-6.2. In the no action alternative, this site would continue to experience flooding with no changes.

4.15.2 Alternative 2: Levee Modification Alternative

Federal Authorized Levees (RM 0.7 to RM 2.9): There are 18 identified properties located adjacent to the federal authorized levees. . Based on records available none of the properties identified are of concern to the project.

The Federal Authorized Levees are located within the vicinity of the Commencement Bay Nearshore/Tideflats Superfund Site that primarily includes waterway sediments. The impacted waterways do not interact with the location of the Federal Authorized Levees. Remediation of waterway sediments within the superfund site is occurring; sediments continue to be monitored and work is ongoing at upland cleanup sites across the tideflats.

North Levee Road Setback (RM 2.7 to RM 8.1): Of the 34 identified properties located within or adjacent to the North Levee Road setback there is one State Cleanup Site, the Choi Property, that could impact the project. Proposed actions for this alternative include set back of the existing levee which may reveal contamination because the setback will allow this site to be inundated. In the mid-1970s, the Choi Property was filled with materials from a forest industry consisting primarily of wood debris that was mixed with Asarco slag. The depth of the fill was approximately 12 feet below ground surface. This site will be further assessed as the alternative is finalized. If the setback is located such that it will allow flooding of the Choi Property, then additional coordination with the sponsor and possibly additional assessment will be required to assure that the site is avoided or remediated prior to construction.

River Road Levee Floodwall (RM 2.9 to RM 7.2) and Lower Puyallup River Extension Levee (or floodwall) (RM 7.2 to RM 8.6). There are seven properties located adjacent to the River Road levee floodwall footprint. Of the seven properties identified only one property is of concern to the project area.

USG Interiors Inc. is located on the south side of the Puyallup River and is currently used as a storage yard. In 1971, the property was filled with industrial waste from the USG mineral fiber insulation manufacturing plant in Tacoma. The Tacoma plant used ASARCO slag as a manufacturing feedstock. A cleanup was conducted in 1985 to excavate and remove fill from the site. Sampling data associated with that cleanup indicated that residual arsenic remained in soil and groundwater at the site. Soil and sediments within the draft levee project footprint contains arsenic contamination. The final levee alignment will avoid this area or coordination among the team and sponsors will occur to assure that soils disturbed during levee construction are appropriately managed and disposed. Additional assessment may be required at this site to determine the need for cleanup actions. Current levee alignment under this alternative would decrease existing flooding at this site.

White River New Levee (RM 1.7 to RM 6.2) and Property Acquisition (RM 4.6 to RM 5.0): Of the 14 identified properties within or adjacent to the White River new levee footprint and the property acquisition area there is one property of concern- Pacific Park.

A 1985 Abandoned Landfill Study by King County describes the Pacific Park area as "King County refuse dump in the City of Pacific" located on approximately 72 acres on both sides of the Stuck (White) River. The landfill was closed around 1961. In 1966, the City of Pacific was granted permission to use about 21 acres of the abandoned site for park purposes. The landfill was a burning dump and received agricultural, municipal, and household wastes from the surrounding areas. A preliminary assessment by King County Solid Waste department indicated that there are no records showing that hazardous wastes were deposited at this facility. However, the lack of records makes the site suspect and additional coordination with the sponsor will be required to assure that the site is avoided or further assessed prior to construction. Insufficient information is available at this time to determine if potentially contaminated soils would be transported under this alternative.

Highway 410 Floodwall and Levee (Rm 10.7 to RM 11.8): There were two identified properties located adjacent to the floodwall and levee. One is a landfill that was closed in 1976 and still produces methane gas and the other is a hazardous waste generator. Based on records available none of the properties identified contain HTRW and these sites are not of concern to the project.

Jones Levee Improvement (RM 21.3 to RM 22.5) and Flow control structure: There are two properties adjacent to the Jones levee project that were identified in the records search. Based on records available none of the properties identified are of concern to the project.

Lower Carbon River Levee Improvement (RM 0.0 to RM 4.0) and Property Acquisition: There are ten properties adjacent to or in the property acquisition area. Based on records available none of the properties identified are of concern to the project.

4.15.3 Alternative 3: Sediment Management with Levee Modification Alternative

See Alternative 2. In addition, the known HTRW site, USG Interiors, has documented arsenic contamination in the the Puyallup River sediments adjacent to the site due to migration of contaminants via groundwater or surface soil disturbance. Dredged sediments would need to be characterized prior to disposal.

4.15.4 Cumulative Effects

The cumulative effects of the project are assumed to be additive to the past, present, and future development in the Puyallup River Basin. There are no cumulative impacts from HTRW sites identified because all HTRW sites will be avoided or remediated by the sponsor prior to implementation of alternatives.

4.16 Land Use, Planning and Zoning

Within the Study area, land use changes from high density industrial and commercial activity near the Port of Tacoma, to predominantly single-family home areas mixed with commercial and light industrial areas around Puyallup, to rural agricultural areas with residential developments in the upper reaches of the Puyallup River and Carbon River.

The lower Puyallup River is mostly within the city boundaries of Tacoma, Fife, and Puyallup. About one-half of the six-square-mile Port of Tacoma is developed with manufacturing, light industrial, and distribution/wholesale uses; about one-quarter is in public rights-of-way and waterways; and about one-tenth is presently vacant. Major manufacturing and industrial uses include paper manufacturing, container and bulk (shipping) terminals, boat building, chemical processing, oil refining, lumberyards, and wood-product mills. The City of Fife is completely within the Puyallup Tribe's reservation lands. The reservation is one of the most urban Indian reservations in the United States and extends into parts of Tacoma, Puyallup, and Edgewood.

North along the White River are the cities of Sumner, Pacific, Algona, and Auburn. Southeast of Auburn the land is zoned for agriculture with one dwelling unit per thirty-five acres. Sumner is centered on a concentrated downtown area with small-lot residential development with some higher densities along the Puyallup River in the south part of town. To the north of the city downtown is a combined warehouse/industrial district. Approximately 40 percent of Pacific's land area is located in Pierce County, and 60 percent is in King County. The residential portion of Pacific, located within King County, consists mostly of single-family residential. The bulk of the commercial and industrial lands are located in Pierce County.

South along the Puyallup River is the Alderton-McMillin planning area, which is mostly designated by the county as Agricultural Resource Lands. The city of Orting is a rural town with small-lot residential development located between the upper Puyallup and Carbon Rivers. Agricultural lands are active within and around the city. Outside of the cities in the upper Puyallup River and Carbon River, the area is mostly designated as Agricultural Resource Lands.

Most of the land within the floodplain is designated with one of the five Pierce County low-density zoning classifications. However, much of the land area adjacent to the rivers within the study area are within municipalities and are typically zoned for higher density, more intense uses (Pierce County 2012b). The shoreline areas within the study area are regulated through County Shoreline Management Use Regulations consistent with the Washington State Shoreline Management Act of 1971. Critical areas are also protected under the Washington State Growth Management Act. The five types of critical areas are wetlands, areas with critical recharging effect on aquifers for potable water, frequently flooded areas, geologically hazardous areas and fish and wildlife conservation areas.

4.16.1 Alternative 1: No Action

This alternative would have no effect to existing land uses in the project area. Land use patterns would continue to be defined by local zoning, land use ordinances and building codes.

The future of land use in the study area and surrounding region is guided by policies resulting from Washington State's Growth Management Act of 1990. The Act requires cities and counties to develop policies to establish a framework to address planning issues across jurisdictional boundaries. The Puget Sound Regional Council (PSRC) is responsible for coordinating the planning policies of King, Kitsap, Pierce, and Snohomish Counties. In 2009, the PSRC completed the latest long-range growth management, environmental, economic and transportation strategy, known as *Vision 2040,* to guide future employment and population growth for the central Puget Sound region.

A key concept of *Vision 2040* is directing future development into the urban growth area, while focusing new housing and jobs in cities and within a limited number of designated regional growth centers. Regional growth centers are compact urban centers that are intended to accommodate a significant proportion of future regional population and employment growth by concentrating housing, shopping, work, entertainment, civic uses, and other activities. The regional strategy of *Vision 2040* also contains a number of manufacturing/industrial centers, which are existing employment areas with intensive, concentrated manufacturing and industrial land uses that cannot be easily mixed with other activities.

Figure 4-4 shows the urban growth area, designated regional growth centers, and manufacturing/industrial centers for the Study Area and surrounding region. There are currently five regional growth centers designated in Pierce County: Puyallup–Downtown (in the Study Area), Puyallup–South Hill, Lakewood, Tacoma–Downtown (partially in the Study Area), and Tacoma Mall. The currently designated manufacturing/industrial centers are the Port of Tacoma (in the Study Area) and Frederickson. In King County, the city of Auburn Urban Growth Area extends south from the city into the project study area.

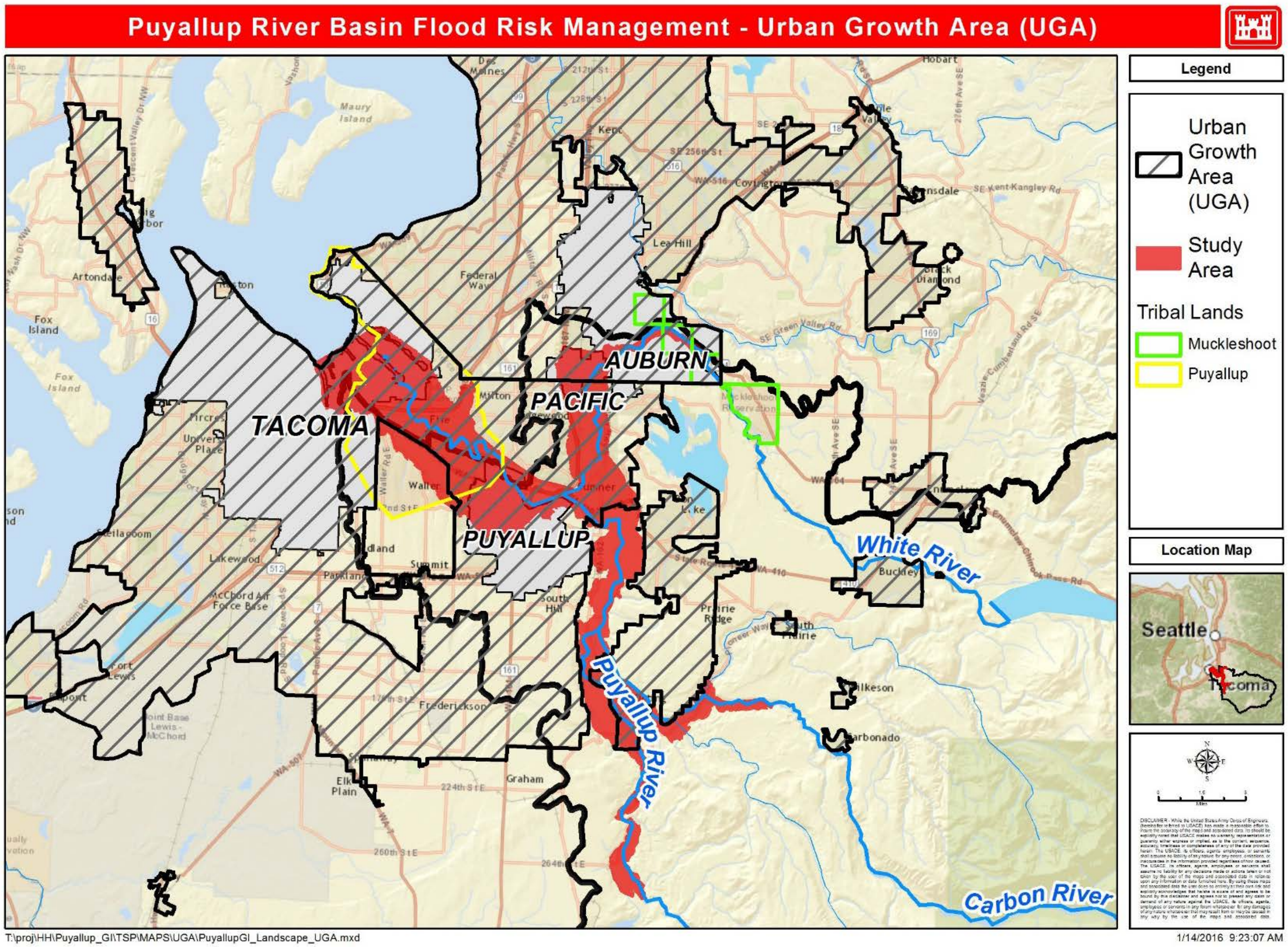


Figure 4-4. Urban Growth Areas Overlay with Study Area (*Source: Adapted from Puget Sound Regional Council, 2009.)*

There are two major developments planned and/or underway in the vicinity of Orting. Tehaleh is a planned community encompassing 4,720 acres of land northeast of Orting. It is planned to include 6,000 new homes, an employment center, and a variety of commercial and civic uses. It represents one of the largest remaining entitled master-planned community developments in the Seattle metro area and is a key component of Pierce County's urban growth plans. The Buttes is a 90-acre development southeast of Orting, between Poplar Creek and the Puyallup River that will ultimately consist of approximately 90 homes. Most of Orting is in the Study Area. Neither development is in the floodplain, however, both are dependent upon services and infrastructure to some extent.

According to the Pierce County Buildable Lands report, Pacific is in the process of transitioning the limited residential areas that are within Pierce County to commercial and industrial uses. The goal is to increase the employment by 200 percent and decrease the population by one-third in order to better balance the population with jobs, creating a more "economically stable community" (Pierce County 2002). Given the projected population increase in the area, intense development pressure will continue in the project area in the FWOP condition.

4.16.2 Alternative 2: Levee Modification Alternative

Temporary impacts to land use would occur during construction, as land owners surrounding the project areas would be disrupted while equipment and personnel access the construction areas. It is assumed that existing zoning and shoreline regulations would remain in effect. Local zoning, policies and shoreline regulations would regulate any development potentially minimizing floodplain development. Intense development pressure would still remain in areas covered by the proposed project.

4.16.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts would be similar to Alternative 2. Existing flood regulations would remain in effect. Intense development pressure would still remain in areas covered by the proposed project.

4.16.4 Cumulative Effects

Additional development restrictions could occur in the future. For example, the 2008 National Marine Fisheries Service Biological Opinion on the National Flood Insurance Program in conjunction with County policy could encourage municipalities to change floodplain policies and permitted land use activities (Pierce County 2012b). These potential changes coupled with critical area and shoreline regulations which are already in place could further limit the extent of habitat alterations and habitat loss within floodplains. Property owners within the floodplain could be subject to additional limitations on allowable development in the future. Intense development pressure and infilling in the area will continue with or without the increased flood protection provided by the proposed project.

4.17 Agricultural Resources

Agricultural habitat is widely distributed at low to mid-elevations (6,000 feet and lower) throughout Washington. It is found among a range of climactic conditions and is common in river valleys such as the Puyallup River Basin. It often occurs adjacent to Westside Lowlands Conifer-Hardwood Forest and other low- to mid-elevation forest and woodland habitats. This habitat is frequently dominant in flat or gently rolling terrain, on well-developed soils such as Puyallup fine sandy loam and sultan silt loam in the study area, in broad river valleys, and in areas with access to abundant irrigation water. Unlike other habitat types, agricultural habitat is often characterized by regular landscape patterns such as squares, rectangles, and circles and straight borders due to landowner boundaries and multiple crops within a region (Chappell et al. 2001).

Agriculture occupies approximately 13,360 acres within the study area, approximately 26.1% of the total land area (51,210 acres) (Chappell et al. 2001). Agricultural habitat occurs throughout the Puyallup River Valley where there is no urban development. It is found surrounding the community of McMillin and City of Orting, from approximately RMs 10 to 22; between the Carbon and Puyallup rivers south of Orting, between the City of Sumner and community of McMillin; and in the central section of the lower Puyallup River Sub-basin, from approximately RMs 4 to 10. Agricultural habitat is found in low-lying areas adjacent to and surrounding the city of Orting, from approximately RMs 4.0 to 8.0. Agricultural habitat is present in low-lying areas around the city of Sumner at approximately RM 2.0, upstream to approximately RM 6.0 and around the city of Buckley from approximately RMs 22.0 to 25.0.

In the Study area, common crops include lettuce, cabbage, radishes, green onions, and hay. Other crops in Pierce County include rhubarb, pumpkin, tulips, and daffodils (Pierce County 2009). Agricultural habitat is not present within the portion of the Study area in King County. Structural diversity is generally low since often only one to a few species of similar height are cultivated. Depending on the intensity of farming or the type of cultivation, agricultural habitat can vary considerable annually in structure; cultivated cropland and modified grasslands are typified by periods of bare soil and harvest whereas pastures are mowed, hayed, or grazed one or more times during the growing season.

The Farmland Protection Policy Act of 1981 was enacted to minimize the extent that Federal programs contribute to the unnecessary and irreversible conversion of prime or unique farmland to non-agricultural uses. U.S. Department of Agriculture's National Resources Conservation Service (NRCS) is responsible for designating prime or unique farmland protected by the Act (2014). Prime farmland, as defined by the act, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forestland, or other land, but it is not urban or built-up land or water areas. Unique farmland is defined by the act as land other than prime farmland that is used for the production of specific high value food and fiber crops, such as citrus, tree nuts, olives, and vegetables.

Based on data accessed from the NRCS, approximately 542,380 acres, or 46%, of the total acreage in Pierce County meet the soil requirements for prime farmland. Unique farmland is not located in the study area. Prime farmland is land that meets the NRCS soil requirements to be designated as prime farmland; however the land may or may not actually be used for crop production.

4.17.1 Alternative 1: No Action

Over time the amount of farmland has been decreasing in the County. As of 2007, approximately 47,677 acres of farm land are in Pierce County which is an approximately 17% decrease in farm land from 2002

(USDA 2007). Between 2007 and 2012, however, the amount of the farm land increased 4% to approximately 49,483 acres (USDA 2012). Overall this trend of farm land decreasing is expected to continue throughout the project life.

4.17.2 Alternative 2: Levee Modification Alternative

This alternative would, most likely, result in some loss of agricultural land in the project area. Approximately 11.2 miles of new levees would be constructed and 8.7 miles of existing levees would be modified. At this phase of the project, the conceptual designs indicate approximately 164 acres of prime farmland would be impacted with the construction of new levees and modification to the existing levees.

4.17.3 Alternative 3: Sediment Management with Levee Modification Alternative

Similar types of impact to agricultural resources would occur from the levee modification features of this alternative as Alternative 2. However, with Alternative 3, the amount of agricultural land lost would be slightly less because the length of new levees and modifications to existing levees would be less than Alternative 2.

4.17.4 Cumulative Effects

Increases in population and development may result in losses of agricultural land and a reduction in the total harvested acres. With both alternatives, cumulative effects would have a slight increase of the general downward trend in farmland acreage. Under Alternative 2, potentially agricultural land would be permanently lost or modified which would contribute to the overall loss of agricultural land. Alternative 3: Sediment Management would result in a smaller amount of loss or modification of agricultural land as Alternative 2.

As mentioned in previous sections of Section 4, climate change could cause more frequent and intense flood events in area. Climate change projections indicate the possibility of increased agricultural pests, invasive plants, and diseases driven by warmer temperatures (Lee and Hamlet 2011). Increases in temperatures in the Pacific Northwest could impact the agricultural base in the County by increasing the number of insect life cycles per year, expanding pest ranges, altered pathogen development rates and modified crop resistance to pathogens (Casola et al. 2005). In addition, degraded quality and/or decreased productivity of some crops could occur due to warmer temperatures alone; however elevated CO_2 levels could increase the net productivity in some crops (Lee and Hamlet 2011). Possible effects from climate change with both alternatives would be the same as those described above.

4.18 Socioeconomics

The Study area lies within both mostly within Pierce County, but also a part of King. King County has the largest county population in Washington because it includes the large cities of Seattle and Bellevue, both of which are located outside the Study area. The portion of the Study area within King County is in south King County, which has a population density far lower than the two main metro centers. Pierce County is the second most populous county in the state because it includes the large urban area of Tacoma. Parts of Tacoma, Fife, Puyallup, Sumner, and Orting lie within the Study area. Both counties have shown consistent population growth since 1940. The period during and after World War II was characterized by increased economic activity mainly due to expansion of The Boeing Company throughout the region.

Table 4-14 shows the 2010 populations for of all of the Study area communities. There are three major cities that lie partially within the Study area: Tacoma, Auburn, and Puyallup. Tacoma, with a population of nearly 200,000 in 2010, is the third largest city in Washington. The city grew rapidly during and immediately after World War II, but then population growth slowed until the 1990s, when efforts were made to revitalize the city center. The next largest city located partially within the Study area is Auburn, which has experienced rapid growth in the past ten years due to annexations that added over 16,000 people. Puyallup experienced steady population growth through the 20th century and also added just over 2,000 residents through annexations in the 2000s.

Bonney Lake experienced rapid growth in the 2000s due to annexations, and had 17,374 residents by 2010. The population of Enumclaw grew rapidly during the 1980s and 1990s and then decreased in the 2000s due to a building moratorium caused by sewage treatment capacity constraints. The remaining communities in the study area had populations of less than 10,000 in 2010. All of these communities have seen population increases during the past several years. Edgewood, which had a population of 9,387 in 2010, has only one year of population data due to its recent incorporation.

Table 4-14. Population by City, County and Study Area Communities, 2010

Place	Population
Washington	6,724,540
King County	1,931,249
Pierce County	795,225
Lower Puyallup	
Tacoma	198,397
Fife	9,173
Edgewood	9,387
Middle and Upper Puyallup	
Puyallup	37,022
Bonney Lake	17,374
Orting	6,746
White River	
Sumner	9,451
Pacific	6,606
Algona	3,014
Auburn	70,180
Enumclaw	10,669
Buckley	4,354

Source: U.S. Census Bureau, 2010.

Table 4-15 shows the housing characteristics of the state, King and Pierce Counties, and study area communities. Densely populated Tacoma accounted for about half of the total housing units of the study area communities in 2010. The percentage of housing units in the study area communities that were occupied in 2010 was slightly higher than in the state as a whole. The median value of an owner-occupied unit was highest in Edgewood ($344,100) and lowest in South Prairie ($191,400) in the 2005 – 2009 period.

Table 4-15. Housing Characteristics in Washington State, King County, Pierce County and Study Area Communities

Place	Number of Housing Units (2010)	Occupied Units (%) (2010)	Median Value of Owner-Occupied Units ($) (2005-2009)
State of Washington	2,885,677	90.8	277,600
King County	851,261	92.7	398,600
Pierce County	325,375	92.2	262,400
Lower Puyallup			
Tacoma	85,786	91.6	235,200
Fife	3,895	93.5	295,500
Edgewood	3,801	94.9	344,100
Middle and Upper Puyallup			
Puyallup	16,171	92.4	282,600
Bonney Lake	6,394	93.7	290,300
Orting	2,361	92.5	241,400
White River			
Sumner	4,279	93.0	273,600
Pacific	2,422	93.7	262,300
Algona	1,018	93.6	221,300
Auburn	27,834	93.6	275,000
Enumclaw	4,420	94.4	268,100
Buckley	1,669	95.3	254,100

Source: U. S. Census Bureau, 2010 Census; American Community Survey, 2010.

Table 4-16 shows housing characteristics in the River Sections in 2010. The area along the White River had the greatest number of housing units, which reflects its relatively large population.

Table 4-16. Housing Characteristics in the Study Area

Place	Number of Housing Units (2010)	Occupied Units (%) (2010)
Lower Puyallup River	11,799	92.4
Middle and Upper Puyallup River	15,094	91.6
White River	24,627	93.6
Source: U. S. Census Bureau, 2010 Census.		

4.18.1 Alternative 1: No Action

The No Action Alternative draws on information presented in the PSRC's 2006 Population, Households and Employment Forecast to estimate the future socioeconomic characteristics of the Study Area and surrounding region. The units used by PSRC are forecast analysis zones (FAZs), which are built up from traffic analysis zones. FAZ boundaries follow census tract boundaries and thereby facilitate the use of census data to build projections (Table 4-17). For the purposes of this study, the FAZs of interest are those in the vicinity of the Study Area. According to the PSRC forecasts, the population will increase within all of the FAZs of interest.

Table 4-17. Puget Sound Regional Council Forecast Analysis Zones (FAZ) and Census Places

Forecast Analysis Zone	Census Places
All of Tacoma	Tacoma minus the Port of Tacoma
Tacoma Central Business District (CBD)	A subarea of Tacoma
Fife Area	Fife plus the Port of Tacoma
Puyallup/Frederickson	Puyallup
Sumner/Bonney Lake	Bonney Lake, Sumner, Edgewood, Orting, South Prairie, Buckley
Auburn Area	Pacific, Algona, Auburn
Enumclaw Area	Enumclaw

Population growth for the All of Tacoma zone appears modest relative to its size, but is considerable considering that most of the land area is developed and population increases will occur through increased density. The growth in the Tacoma CBD, nearly doubling over the next 30 years, reflects the increased density forecasted. The Fife Area's population is expected to continue to grow slowly, as it is expected to remain predominately industrial and commercial. Puyallup/Fredrickson and Sumner/Bonney Lake are projected to experience substantial population growth, with Sumner/Bonney Lake nearly doubling due to plans to accommodate new single-family residential and increased densities near urban centers. The Enumclaw Area is also poised for substantial growth due to planned single-family development and infill. The forecast for the Auburn Area shows moderate growth as most of the added housing will be infill.

The PSRC forecast of the number of households shows the number of households in the FAZs of interest growing faster than the population. This suggests that household sizes will decrease and that there will be a greater need for housing units relative to the population.

4.18.2 Alternative 2: Levee Modification Alternative

Temporary impacts to socioeconomics would occur during construction, as land owners surrounding the project areas would be disrupted while equipment and personnel access the construction areas. It is assumed that existing zoning and shoreline regulations would remain in effect. Local zoning, policies and shoreline regulations would regulate any development potentially minimizing population growth in the floodplain Intense development pressure would still remain in areas covered by the proposed project.

4.18.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts would be similar to Alternative 2. Existing flood regulations would remain in effect. Intense development pressure would still remain in areas covered by the proposed project.

4.18.4 Cumulative Effects

Additional development restrictions could occur in the future which could limit population growth in floodplain areas. For example, the 2008 National Marine Fisheries Service Biological Opinion on the National Flood Insurance Program in conjunction with County policy could encourage municipalities to change floodplain policies and permitted land use activities (Pierce County 2012b). These potential changes coupled with critical area and shoreline regulations which are already in place could further limit the extent of habitat alterations and habitat loss within floodplains. Property owners within the floodplain could be subject to additional limitations on allowable development in the future. Intense development pressure would still remain in areas covered by the proposed project.

4.19 Environmental Justice Communities

Executive Order 12898 on Environmental Justice requires that each federal agency address disproportionately high and adverse health or environmental effects of its programs, policies, and activities on minority and low-income populations. The population groups to be considered in an analysis of environmental justice were defined by the Interagency Working Group on Environmental Justice, which was established by Executive Order 12898 to implement the order's requirements. Low-income populations are defined as those living below the established poverty level. A minority is any individual classified as American Indian, Alaska Native, Asian, Pacific Islander, African American, or Hispanic.

There are high concentration "pockets" of low-income and minority populations throughout the Study Area and surrounding region, but most of these pockets are in the Tacoma area. The large minority area between the White and Green Rivers southeast of the city of Auburn is the reservation of the Muckleshoot Tribe, one of the largest Native American groups in Washington. Another area of relatively high low-income populations is the western side of Auburn. The Muckleshoot Tribe shows moderate concentrations of low-income populations similar to areas outside of Orting and Buckley.

Table 4-18 shows the percentage of each minority group in Washington, King County and Pierce County, and Study area communities in 2010. Asians and Hispanics are the largest minority groups in a number of cities and towns. The Fife Valley has traditionally been a farming area, with many Japanese-Americans owning (and farming) land within the area (WSDOT and FHWA, 2006). However, with the urbanization (zoning and land use changes) of the area, particularly within the city limits of Fife, it has become more difficult economically for the farmers to continue operations in this area. Consequently, many Japanese-American farmers have recently been retiring from farming and leasing or selling their property. Much of the farmland in the area today is leased by farmers who employ anywhere from two to ten farmhands who work on a temporary/seasonal basis. While these temporary farmhands are primarily Hispanic, the Hispanics residing in and around the Study Area are not necessarily associated with farming operations (WSDOT and FHWA, 2006). The communities of Enumclaw, Buckley, Orting, and South Prairie have relatively small minority populations.

Table 4-18. Minority Population Percentage in Washington State, King County, Pierce County, and Study Area Communities, 2010

Place	White	Black or African American	Alaska Native and American Indian	Asian	Native Hawaiian and Other Pacific Islander	Hispanic	Total Minority
State of Washington	77.3	3.6	1.5	7.2	0.6	11.2	27.3
King County	68.7	6.2	0.8	14.6	0.8	8.9	35.0
Pierce County	74.2	6.8	1.4	6.0	1.3	9.2	29.5
Lower Puyallup							
Tacoma	64.9	11.2	1.8	8.2	1.2	11.3	39.3
Fife	55.2	8.2	3.0	15.5	2.7	17.4	51.8
Edgewood	90.4	1.0	0.9	2.5	0.3	4.4	11.8
Middle and Upper Puyallup							
Puyallup	84.4	2.1	1.4	3.8	0.7	6.9	18.9
Bonney Lake	88.8	1.3	1.0	2.4	0.2	6.1	14.4
Orting	87.9	1.5	1.4	1.3	0.5	7.2	15.4
White River							
Sumner	87.3	1.2	1.0	2.4	0.4	10.1	18.2
Pacific	69.2	3.1	1.9	9.0	1.8	15.1	35.2
Algona	67.1	3.3	1.7	11.7	2.0	15.9	38.8
Auburn	70.5	4.9	2.3	8.9	2.3	12.9	34.4
Enumclaw	91.8	0.5	1.0	0.9	0.1	6.6	11.2
Buckley	93.0	0.6	0.8	0.8	0.1	3.1	8.1
Source: U. S. Census Bureau, 2010 Census.							

Note: Total minority population was calculated by taking the Total population and subtracting the 'White Alone' and 'Some Other Race Alone' fields and adding back in the 'Hispanic, White Alone' and 'Some Other Race Alone, Hispanic' fields.

Table 4-19 shows the minority populations in the Study Area River Sections in 2010. The Lower Puyallup has the highest percentage of minorities due to its relatively large Asian and Hispanic populations. The White River has a large Hispanic population and a comparatively large American Indian population. As noted above, part of the Muckleshoot Indian Reservation is in White River. Both the Upper Puyallup and Carbon River have minority populations that are approximately half of that of the state as a whole.

Table 4-19. Minority Population Percentage in Study Area River Sections, 2010

Place	White	Black or African American	Alaska Native and American Indian	Asian	Native Hawaiian and Other Pacific Islander	Hispanic	Total Minority
Lower Puyallup River	74.7	4.2	2.3	7.2	1.2	12.2	30.9
Middle and Upper Puyallup River	87.4	1.2	1.3	2.7	0.4	6.2	15.5
White River	76.1	3.1	4.0	4.3	1.2	12.9	28.6
Source: U. S. Census Bureau, 2010 Census.							

Note: Total minority population was calculated by taking the Total population and subtracting the 'White Alone' and 'Some Other Race Alone' fields and adding back in the 'Hispanic, White Alone' and 'Some Other Race Alone, Hispanic' Fields

4.19.1 Alternative 1: No Action

The No Action Alternative would have no direct impacts related to environmental justice communities. Indirect impacts could include a higher potential for permanent displacement of population due to progressively decreasing levels of flood protection. Existing flood control infrastructure would continue to be maintained. There would likely be disproportionate impacts on low-income residents in a mandatory evacuation due to lack of financial resources. Federal, state and local programs are available to assist all residents in the rebuilding process following a flood event.

4.19.2 Alternative 2: Levee Modification Alternative

Construction impacts would be temporary in nature, but would impact those living near the construction areas. Impacts from noise, dust, and traffic generated by construction would be minimized through construction planning efforts and the implementation of best management practices. Benefits of the project include decreased flood risk to all populations living in or using infrastructure in the protected area. Overall impacts from this alternative would not disproportionately affect low-income and minority populations. There appears to be no correlation between areas of transferred risk and low income and minority populations.

4.19.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts would be similar to those described above for Alternative 2.

4.19.4 Cumulative Effects

Continued development and population increases are expected within the Study Area. Minority populations in the Puget Sound Region increased by 50% between 2000 and 2010 (PSRC 2011). No impacts are expected to disproportionately affect minority or low income populations. The long term benefits of decreased flood risk from both action alternatives will protect the population as a whole, to include minority and low income populations.

4.20 Aesthetics / Visual Resources

The visual character of the environment includes landforms, vegetation, topography, land uses, and historic or cultural resources that together contribute to an observer's overall impression of an area. The visual quality within the study area varies greatly from forests, to open spaces, through agricultural areas, to urban landscapes.

The characterization provides a qualitative assessment that considers vividness, intactness, and unity of aesthetic features. Each sub-basin is given a rating of low, moderate, or high. The ratings are defined as follows:

- Low – provides a minimal contribution or may detract from the overall visual quality of the study area
- Moderate – provides an average contribution with visual quality elements common to the study area
- High – contributes unique visual quality characteristics to the study area

The lower Puyallup River Sub-basin encompasses a range of aesthetic features. From the mouth of the Puyallup River to I-5, views are primarily from the many bridges that cross over the river in this area. The area is characterized by a mix of commercial, industrial, and recreational features. The mouth of the Puyallup River is dominated by views of Commencement Bay, and commercial and industrial activities including marine port terminal operations that use cranes to load and off-load container ships.

Agricultural fields are also found in the area. They offer long views as well as seasonal colors, depending on the crop being planted. Other features include the Puyallup City Center, Western Washington Fairgrounds, commercial areas, some vegetation along the riparian zone of the river, and Mount Rainier. In general, the visual quality of the lower Puyallup River Sub-basin is considered low to moderate due to the numerous manmade features within the sub-basin, coupled with longer views of vegetated bluffs, the river corridor, and agricultural areas.

The upper Puyallup River and Carbon River sub-basins contain several aesthetic resources. These resources primarily include rural/agricultural features, but also some built features around the city of Orting. The unique topography of the sub-basin provides scenic views from many parts of the sub-basins. The dominant views come primarily from the Foothills Regional Trail, SR 410, and SR 162. Views looking east include Mount Rainier, which dominates in several locations. There are also several parks in the sub-basins, including regional trails. These parks provide opens spaces with additional views of open and vegetated areas (Pierce County 2005). In general, the visual quality of the upper Puyallup River and Carbon River sub-basins is considered moderate to high due to the vividness and intactness of the views, including Mount Rainier.

The White River sub-basin has varied topography from a flat floodplain on the valley floor, to gradual slopes up to the surrounding hills. The White River Sub-basin contains many aesthetic resources. The lower portion of the sub-basin is composed mainly of built features, such as roadways and buildings. Views are primarily from surface streets in the city of Sumner and also where SR 410 crosses over the river just upstream from the confluence with the Puyallup River. However, there are also pockets of open space and agricultural areas that allow for longer views of a vegetative environment as well as Mount Rainier. Several parks within Auburn city limits provide unique settings with views of the White River (Auburn 2005). In general, the visual quality of the White River sub-basin is considered moderate to high due to the vividness and intactness of the views.

4.20.1 Alternative 1: No Action

As the human population is expected to increase within the Basin, lands (including some agricultural within designated growth areas) will be converted to residential units based on future land use described in local agency comprehensive plans. This would change the aesthetic values, as some areas are currently in agricultural use. A major highway is planned that will connect SR 167 in Puyallup to I-5 and SR 509 in Fife. The connection will occur along the lower Puyallup River Valley and would alter the current aesthetics of the area by replacing the existing land use (agricultural, commercial, and residential) with a raised highway. Outside of the designated growth areas, the land use is generally rural agricultural with low density housing or forestry. The current uses are anticipated to remain relatively unchanged and therefore aesthetics are expected to remain moderate to high.

4.20.2 Alternative 2: Levee Modification Alternative

Temporary impacts from construction would result in impacts to visual quality due to the presence of construction equipment. Impacts would be greatest in the upper portions of the study area where human activity is typically lower. These impacts would not be significant because construction would be limited duration between several weeks to several months. Views to the river will be permanently obstructed through areas of new levees and floodwalls, however, these are proposed in areas where human-made visual elements are prominent and infrastructure has already modified the landscape. Riparian vegetation planted riverward of the setback levee would enhance the natural aesthetic of the river corridor. Mitigation features including plantings, associated with levee and floodwall construction would also improve the aesthetic view of a purely armored structure.

4.20.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts to aesthetics are similar to those described for Alternative 2 for levee and floodwall construction. During dredging the dredge, barges and equipment would be visible from the shore and from the water. No permanent impacts to aesthetics would result from dredging; however throughout the project life maintenance dredging would result in additional visual disturbances during each dredge cycle.

4.20.4 Cumulative Effects

Existing Pierce County development regulations and Shoreline Management Regulation require that development minimize obstructions to view corridors and scenic vistas such as Mt. Rainier or waterbodies.

The cumulative impacts of the proposed flood risk management efforts along with existing infrastructure and proposed development would maintain the aesthetic and visual resources throughout the study area.

4.21 Public Services and Utilities

As the Basin includes multiple urban centers as well as rural residential areas there are seven schools, medical centers, emergency responders (two fire stations and one police station) and utility services throughout the area. Refer to Table 2-11 for critical facilities located within the floodplain by river reach. Major utility service is prevalent throughout the Study Area including electrical, water, waste management, and wastewater utility services. Tacoma Power provides electrical service to the Tacoma portion of the study area and the Town of Fife. Tacoma Power generates electricity from several dams, none of which are in the study area. Puget Sound Energy (PSE) provides electrical service to the areas east of Tacoma from Puyallup to Enumclaw. Electron Hydro LLC operates a relatively small hydroelectric power plant on the Puyallup River at Electron.

Tacoma Water provides water service to most of the study area and surrounding region including Tacoma, Fife, Puyallup, and Bonney Lake, either directly or through reselling to local utilities. The Green River Watershed is the primary water supply source. Tacoma Water also draws on 24 wells. The main well field is located southwest of the study area in south Tacoma. Public services in the Study Area also include a number of local, state and federal parks which contain trails, boating access, and other recreational features.

Cascade Water Alliance operated the diversion flume at the Buckley diversion. This flume provides water supply to the Lake Tapps area. Cascade Water Alliance has water rights to divert up to 1000 cfs.

There are five wastewater treatment plants (WWTP) in the study area. Pierce County's Chambers Creek Regional WWTP serves portions of the study area and is located east of Tacoma in University place, outside of the study area.

4.21.1 Alternative 1: No Action

The existing public services and utilities are expected to continue to provide services within the study area. Infrastructure within the floodplain, including these resources, would remain at risk of damage from flood events.

4.21.2 Alternative 2: Levee Modification Alternative

This alternative would reduce the risk of flooding through proposed flood risk management improvements to existing levees and construction of new levees. Overall this alternative would reduce the risk to public services and utilities including one police station, two fire stations, three WWTP's and seven schools, and would therefore have a beneficial effect. For any services and utilities outside of the floodplain this alternative is not anticipated to change the existing condition.

4.21.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts to public services and utilities would be largely the same as those described for Alternative 2. There are utilities located below the channel bottom in the lower Puyallup River. Dredging activities would need to be designed and coordinated with local municipalities and utility providers to ensure that no detrimental effects occur.

4.21.4 Cumulative Effects

The existing public services and utilities are expected to expand and become more heavily used as development of the area continues. Both of the action alternatives increase protection for utilities and services in the Basin.

4.22 Transportation and Traffic

The Study area contains an extensive transportation network that connects both regional centers and international markets.

Roads

Figure 4-5 shows the traffic volumes for I-5 and other highways in and around the Study Area. I-5, the Pacific Northwest's primary north-south corridor, runs through the project area. I-5 has the highest traffic volumes in the study area with an Average Daily Traffic Count (ADTC) ranging from 154,000 to 179,000 vehicles. State Route (SR) 167, commonly referred to as the "Valley Freeway," is a four-lane separated freeway with ADTC ranges from 75,000 to 91,000 on this section. The portion of SR 167 that connects Sumner to Tacoma is a four-lane highway on the banks of the lower Puyallup known as "River Road" where its ADTC ranges from 25,000 to 99,000. SR 410 connects Yakima to the Puget Sound and has ADTC from 19,000 to 50,000.

Further out of the urban areas, SR 162 connects Sumner to Orting with an ADTC ranging from 17,000 to 20,000. SR 164 connects Auburn to Enumclaw while passing through the Muckleshoot Reservation with an ADTC ranging from 9,400 to 17,000.

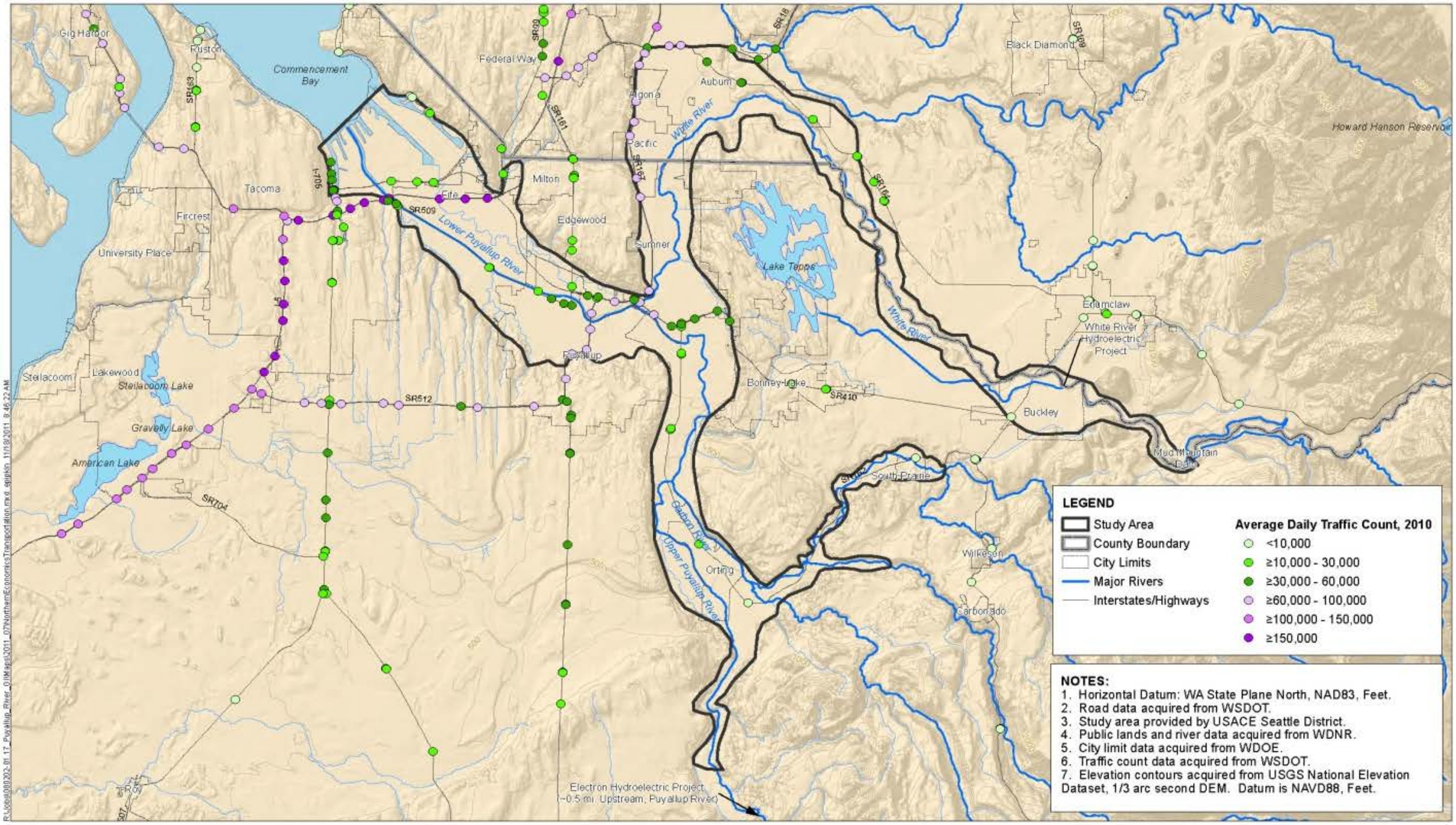


Figure 4-5. Traffic Volumes within Study Area

Air

The Seattle-Tacoma International Airport (SeaTac) is the main airport for the region and is located about 15 miles north of the Study Area. Over 33 million passengers used the airport in 2012, making it the 15th busiest airport in the U.S (Port of Seattle 2013).

Adjacent to the Study area, just east of Orting and south of Puyallup, is Thun Field, a small aircraft airport with approximately 90,000 take-offs and landings in 2012 (WSDOT 2012). Auburn Municipal Airport is just north of downtown Auburn, with approximately 170,000 take-offs and landings per year (Auburn Municipal Airport 2013).

Rail

Both freight and passenger trains run through the study area. The Union Pacific Railroad and BNSF Railway are the two most prominent interstate freight lines through the area to service the Port of Tacoma. Several smaller shorter rail systems also exist to move freight locally from the port, including Tacoma Rail, Puget Sound and Pacific Railroad, and Meeker Southern.

Amtrak Cascades provides regional passenger rail service that connects Portland, Oregon to Vancouver, British Columbia. Additionally Amtrak runs the Coast Starlight train which connects Seattle to Los Angeles. Both of these trains stop at the Tacoma Station. Commuter rail service, known as the Sounder Commuter Rail, connects much of the Study area to Tacoma and Seattle. The Sounder line starts in Lakewood and travels to Everett. Stations in the Study area include stations in Tacoma, Puyallup, Sumner and Auburn.

Water

The Port of Tacoma is the only seaport in the Study area. The Puyallup River is navigable up to RM 3 (USACE 2008) and some industries use the river to transport goods.

4.22.1 Alternative 1: No Action

Under the No Action alternative, large flood events that affect transportation infrastructure would continue to occur and climate change could increase the frequency of these events. Transportation impacts due flood events include damage to infrastructure, such as from streambank erosion or channel migration, and closure of transportation systems and roadways due to inundation.

In addition to creating an inconvenience, the transportation interruptions negatively impact the local and regional economy. Interruptions could also adversely affect public safety by impeding access for fire, police, and emergency services.

Pierce County completed an economic analysis for their Flood Hazard Management Plan that modeled expected travel delays due to flooding (Pierce County 2010b). The study concluded that a 4% ACE to 1.1% ACE probability flood would produce minimal additional travel delay. For a 1% ACE probability event, the model results predicted an increase of almost 147,000 hours (about 43 percent or larger) over the baseline of 338,320 hours that drivers spend driving on the County road network each day.

Besides impacts to roadways, rail lines can also be impacted by flooding. Rail lines in the lower Puyallup are below the 1% ACE probability flood level on the north and south sides of the river and would require closure if inundated. Rail segments close to the river but which are not designed to function as a levee could fail during flooding. Temporary closure of intermodal yards that are either inundated themselves or have their connecting rail lines overtopped by flood waters could affect two of the Port of Tacoma yards.

4.22.2 Alternative 2: Levee Modification Alternative

This alternative provides long-term benefits to ground transportation in the area by protecting critical roadways and rail lines from flooding.

No negative impacts to rail or air traffic would occur as a result of this alternative. Water surface elevations would be expected to increase during flood events due to more water being confined to the channel. This is not expected to impact navigability of the first three miles of the Puyallup River.

With this alternative, there would be short term construction related impacts to vehicular traffic. During construction activities, vehicles and equipment associated with the project could disrupt local traffic due to merging, turning, and traveling together. Traffic controls would be used as needed to ensure public safety. Construction-related vehicles, mainly dump trucks, would add to the existing traffic over the construction period. The numbers and locations of vehicles would vary depending on the specific construction activities occurring during the different phases of the construction. There could be lane closures along local roads as work is being completed. The floodwall construction on River Road is likely to require lane closures. As this is a high traffic road, this could cause lengthy traffic delays. These lane closures would be short term, occurring only during the construction period. Once construction of the alternative was complete, roads would reopen and impacts from additional traffic would not occur.

No permanent impacts to traffic throughout for River Road are anticipated, however the view of the river would be obstructed after construction was complete (see Section 4.19 Aesthetics/Visual Resources for more information). During large flood events, transportation corridors will remain operational due to the increased flood protection.

4.22.3 Alternative 3: Sediment Management with Levee Modification Alternative

This alternative also provides long-term benefits to ground transportation in the area by protecting critical roadways and rail lines from flooding. As above, no impact to rail or air traffic would occur as a result of Alternative 3. Water surface elevations would be expected to increase less than Alternative 2 due to the addition of dredging, and navigability of the first three miles of the Puyallup River would not change.

Proposed dredging begins at RM 3.1. Presence of dredging equipment in the river could temporarily impact boat traffic, but would not be expected to block traffic due to sufficient width of the channel. This impact would be short term in any single location as equipment would complete dredging in one site and slowly move through the proposed work area. Construction related traffic impacts would be the same as for Alternative 2. Once construction of the alternative was complete, roads would reopen and impacts from additional traffic would not occur.

4.22.4 Cumulative Effects

The local transportation system is expected to expand and become more heavily used as development of the area continues. Each alternative would decrease flood risk to transportation. However flooding can impact a wide area of the transportation network. While increased usage of the transportation network would have no substantive effect on the probability that flooding would occur, it does mean that the impacts of floods on the transportation system, when they occur, could become more severe in the future.

4.23 Public Health and Safety

Pierce County and local municipalities work together in numerous ways to protect public health, safety and welfare in relation to flood hazards. Zoning is one method by which a county or a municipality legally controls the use of property and physical configuration of development within its jurisdiction. Regulations can protect undeveloped lands for flood storage, and establish land use practices in flood hazard areas to prevent development from causing or exacerbating flooding that would endanger lives, property, or public resources.

Pierce County works with several Federal agencies to reduce and manage flood risks. The County works with the FEMA to map flood risks for the Puyallup, Carbon, White, and Mashel Rivers and South Prairie Creek. Flood maps show communities their flood risk and allow communities and individuals to make informed decisions in their land use planning. Pierce County has a joint agreement with the USGS to monitor river stage and flow at USGS gages on major rivers in the County. This allows for real-time information to support river modeling efforts, to update flood mapping, and to improve water resource management. Pierce County also participates in the Corps' Levee Rehabilitation and Inspection Program, as authorized under PL 84-99. The PL 84-99 program includes emergency response activities and rehabilitation of levees damaged by floods. Routine repair and preventive maintenance activities on levees are completed by Pierce County and local municipalities.

Flood education and outreach programs to property owners, including annual flood bulletins, are ongoing. Pierce County monitors National Weather Service (NWS) flood information to support response activities. They also coordinate with the various dam operators, and King County regarding reservoir levels, inflows, and release rates that affect the magnitude and timing of downstream flood flows. This information is incorporated into flood warnings and disseminated to local jurisdictions and the public through the Pierce County Emergency Operations Center under the guidelines of the County's Comprehensive Emergency Management Plan (Pierce County 2010a). Pierce County also provides sand bags and sand to fire districts and public works departments for use during floods, conducts annual flood emergency exercises, updates the standard guidance and protocols for emergency flood hazard response, and provides technical assistance to property owners on elevation and flood-proofing of structures.

As described in Section 2.7.3 Existing Flood Risk Management, the Basin consists of 28 levee segments currently in the Corps' NLD. This includes 26 non-federal levees and two federally owned and operated levees on the lower Puyallup River.

As mentioned in Section 2.7.4 Existing Economics Conditions, most of the existing critical facilities within the 1% ACE floodplain are located within the Lower Puyallup, however several schools exist within both the Upper Puyallup and Carbon River floodplains. Critical facilities consist of public service facilities such as police stations, fire stations, and wastewater treatment facilities. Approximately 35,000 people are at risk from flooding in the 1% ACE event who either live or work in the floodplain. During flood events, some roads within the Basin have been temporarily closed, affecting emergency response services.

4.23.1 Alternative 1: No Action

The above programs would be expected to continue with the No Action Alternative. The public health and safety services such as fire departments and flood risk management are expected to continue and those services located in the 1% ACE floodplain would remain at risk of damage from flood events (Figure 2.7). Additionally, climate change is predicted to cause changes in rainfall, temperatures, and snowmelt. This may lead to increased flooding in the area (see Section 4.3 for more information on Climate Change) possibly increasing the risk for public health and safety.

4.23.2 Alternative 2: Levee Modification Alternative

This alternative would reduce to risk of flooding up to a 1% ACE event within the areas of Lower Puyallup River, Sumner, and Pacific more than the No Action Alternative and therefore would have an overall beneficial effect to public health and safety (Figure 3-3). The areas in the Basin that would remain at risk for flooding would have similar impacts to public health and safety as the No Action Alternative (Figure 2.7). However with implementation of nonstructural measures such as relocations, elevating homes, developing evacuation routes and plans, these risks to the public would be reduced.

4.23.3 Alternative 3: Sediment Management with Levee Modification Alternative

Impacts of Alternative 3 would be the same as those discussed above for Alternative 2.

4.23.4 Cumulative Effects

The cumulative impacts of the proposed flood risk management efforts along with local improvements to levees, warning systems, public outreach, etc. are expected to continue to provide important protections for public health and safety.

5 Description of the Tentatively Selected Plan

5.1 Description of the TSP

The TSP would modify the existing levee system to manage flood risk by setting back levees, increasing existing levee heights, improving existing levee reliability, constructing new levees, or through property acquisition on the Puyallup River and White River. The proposed levee modifications would be the primary flood protection feature within this alternative and would work with other flood risk management features to increase channel capacity and reduce flood risk within the project area. The TSP includes approximately 11.2 total miles of new levee and/or floodwall construction and approximately 8.7 total miles of modification to existing features, including levee setbacks. Actual levee alignments, river mile locations, and alternative measures will be refined during feasibility-level design analysis and documented in the final FR/EIS. Table 5-1 describes TSP features, followed by Figure 5-1, which shows the location of the TSP features. As noted earlier, all river mile locations, and levee or floodwall lengths and heights for measures during the plan formulation process are approximate and based on professional judgment and/or concept-level design. River miles, heights and other characteristics of measures included in the TSP will be refined for the recommended plan during feasibility-level design analysis, based on additional information from sedimentation modeling, geotechnical and utility survey data, comments received on the DFR/EIS during public, technical, and legal and policy reviews, and will be documented in the final FR/EIS. In addition, nonstructural measures - such as relocations or elevating structures - may be included, as needed, during feasibility-level design analysis of the TSP.

Table 5-1. TSP Feature Descriptions

Reach	Feature	Approximate Location[7]	Federal Levee?	New Feature or Modification	Notes
Lower Puyallup (RM 0.0 – RM 10.3)	Federal Authorized Levee	Left bank and right bank: 2.1 miles total. • Right bank 0.7 mi from RM 2.0 to 2.7; • Left bank 1.4 mi from RM 1.5 to 2.9.	Yes	Modification	FAL location is RM 0.7 to RM 2.7 on right bank and RM 0.7 to RM 2.9 on left bank. TSP would raise levees in place on both banks.
	North Levee Road A-Setback	Right bank: 5.4 miles. Setback from RM 2.7 to end of North Levee Road at RM 8.1.	No	Modification	Levee would be setback from RM 2.7 to RM 4.2 (Frank Albert Road) approximately 1,000 ft, from RM 4.2 to RM 6.0 approximately 80-100 ft, from RM 6.0 to RM 7.1 approximately 600 ft, and from RM 7.1 to RM 8.1 approximately 80-100 ft. The setback levee alignment is approximately 32,000 linear feet with approximate levee heights ranging from 6 to15 feet. This feature proposes to setback and raise the levee to safely convey the 1% ACE elevation plus three feet of residual height. The proposed levee modification would manage flood risks to residential, commercial and industrial properties.
	River Road Levee Floodwall	Left bank: 4.3 miles (RM 2.9 to RM 7.2).	No	New	This floodwall would reduce risks to the transportation corridor and residential, commercial and industrial structures, where space is limited. The floodwall height would range from 4-8 feet, with the average of about 6 feet.
	Lower Puyallup Extension Levee	Left bank: 1.4 miles (RM 7.2 to RM 8.6).	No	New	The new extension levee would be 7,200 feet and would incorporate about 1,100 feet of the existing River Road Levee. The levee height would vary between 8-13 feet. In areas where the levee is 8 feet tall, there would be about 3.5 feet of additional fill placed on the existing berm.
Middle Puyallup (RM 10.3 – RM 17.4)	State Route 410	Left bank: 1.1 miles (Levee section between RM 10.7 and 11.0; floodwall	No	New	Combination of new levee and floodwall; would provide protection to adjacent SR 410 and residential properties. Levee and floodwall

[7] All river miles are estimates at the concept level for this DFR/EIS. River mile locations will be refined during feasibility-level design analysis and documented in the final FR/EIS.

	Levee/Floodwal l	between RM 11.0 and 11.8).			height would vary between 6-12 feet to provide 3 feet of residual height from the 1% ACE flood elevation.
Upper Puyallup - (RM 17.4 – RM 28.6)	Jones Levee Improvement	Right bank: 1.2 miles (RM 21.3 to RM 22.5).	No	Modification	Modification to levee in place; would increase levee heights approximately 1.5 feet to 6.5 feet and improve riverside erosion protection; would also include a flow control structure design as a preventative measure that would reduce repetitive erosion damage to the Ford Levee.
White River (Puyallup River RM 10.3 / White River RM 0.0 to RM 29.6)	Pacific Park Levee	Right bank: 1.0 miles (RM 5.5 to 6.5)	No	New	New levee; would provide protection to adjacent commercial and residential properties. Levee would vary between 7-10 feet to provide 3 feet of residual height from the 1% ACE flood elevation.
	Butte Ave. Levee	Right bank: 0.7 Miles (RM 4.8 to RM 5.5)	No	New	New levee; would provide protection to adjacent commercial and residential properties. Levee would vary between 1-8 feet to provide 3 feet of residual height from the 1% ACE flood elevation.
	Lower White River Levee	Right bank: 2.7 miles (RM 1.7 to RM 4.4)	No	New	New levee; would provide protection to adjacent commercial and residential properties. Levee would vary between 4-13 feet to provide 3 feet of residual height from the 1% ACE flood elevation.
	Property Acquisition	Left bank: RM 4.6 to RM 5.0	NA	New	This non-structural measure proposes acquiring approximately 35 acres of property, consisting of 14 parcels that have experienced repetitive flood impacts and are at risk to additional adverse flood impacts.
Approximate Total miles new construction:	**11.2**				
Approximate Total miles modification to existing features:	**8.7**				

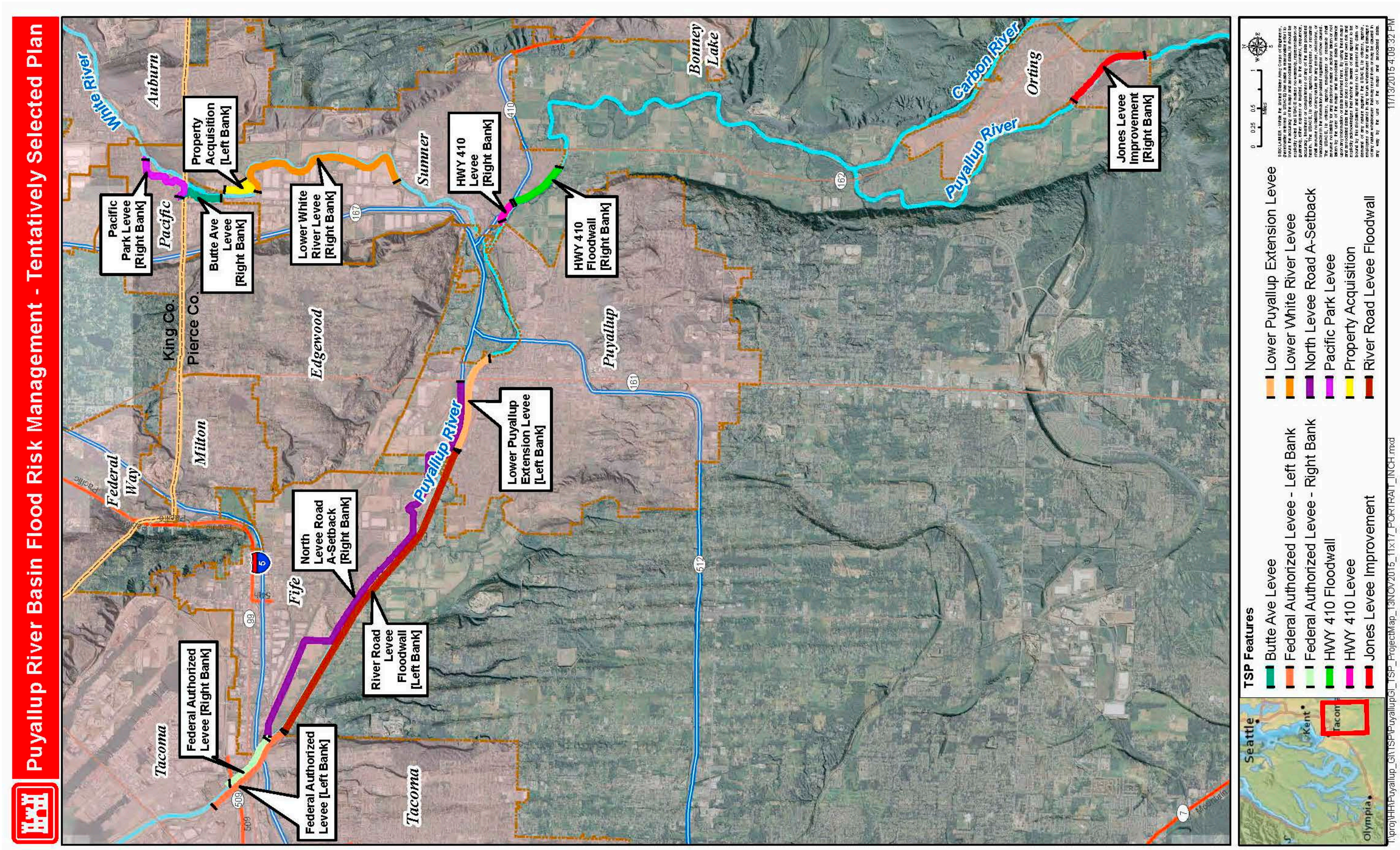


Figure 5-1. TSP Features

This page intentionally left blank

5.2 Mitigation for Adverse Environmental Effects*

NEPA requires that agencies identify and include in the action all relevant and reasonable mitigation measures that could reduce negative effects of the Federal action. Implementation of the TSP would involve raising and constructing levees, constructing floodwalls and non-structural measures with construction activities in the aquatic environment and in close proximity to other ecological resources. Through the analysis of effects, certain adverse effects were identified as summarized in Table 4-2 Summary of Environmental Consequences in Chapter 4. Construction designs would include practices that avoid and minimize adverse effects of the proposed alternative. For the DFR/EIS, proposed mitigation measures are conceptual at this point and will be further developed during feasibility-level design analysis using an approved model. This information will be documented in the final FR/EIS.

Levee modification will result in the direct loss of wetland riparian habitat along the river either through the direct filling of wetlands or other waters of the U.S., or alteration of the vegetation or topography reducing or changing the functions those habitats supply. The proposed alignment will seek to avoid impacts to these habitats. However, in many instances avoidance of wetland and riparian areas is not possible. Therefore development of mitigation lands is required for the project. Fill in wetlands other waters of the U.S. will be mitigated according to CWA guidance. In addition, mitigation for project impacts will follow guidance under ESA since critical habitat will be impacted by the proposed project.

For impacts to wetlands and riparian areas, the most widely accepted mitigation would be onsite and off-site plantings, development off channel habitat, reconnecting floodplain/wetland areas, and installation of LWD structures in the river system. The potential to use onsite riverbank plantings and LWD is limited because of the potential impact on hydraulic conductivity and compliance with current Corps of Engineers Levee Vegetation requirements. At best, any riverbank plantings on levees will provide local shade but will never be allowed to reach maximum heights due to levee vegetation restrictions. Levee plantings should provide some refuge from predators and high water velocity, terrestrial insect fall, and organic input aiding in production of benthic invertebrates.

An approximately 281 acre setback area would be created on the right bank in the lower Puyallup River. These lands could potentially be used for mitigation of wetland and other waters of the U.S. impacts, as well as impacts to riparian areas.

For the lower Puyallup River, required mitigation for the wetland and riparian impacts could be mitigated in this area along with retaining the relatively mature riparian vegetation on the existing silt bench at the river's edge. Moving upstream, greater riparian and wetland impacts occur on the upper Puyallup reach. The White River levee alignment is actually setback from the river and avoids disruption of riparian and wetland areas to most extent.

For the purposes of mitigation planning, a preliminary estimate of riverbank area directly impacted was used for developing initial mitigation costs. With the retention of the trees on the silt bench in the lower river and the alignment of the White River levee avoiding the majority of riparian impacts, approximately

32 acres of edge habitat/wetland would be directly impacted. Based on best professional judgment approximately 96 acres of mitigation land would be required for this alternative.

The mitigation areas would be developed by:

1. Removing existing levees
2. Placement of a new setback levee to provide at least an equal level of flood risk management
3. Planting suitable riparian vegetation in the setback area
4. Placing LWD structures in the setback area
5. Excavation of side-channels to reconnect the floodplain to the river.

Based on similar setback levee projects in the area, the cost per acre is approximately $155,000 per acre. Mitigation costs for Alternative 2 could range from $5,000,000 to $15,000,000. If the setback area on the Lower Puyallup is used for a mitigation site, the cost of mitigation will be reduced since the setback levee is already an FRM component of the project.

This preliminary mitigation estimate will be adjusted as more detailed designs are developed for the TSP, and mitigation requirements are evaluated through the use of an environmental model. Any revisions will be detailed in the Final FR/EIS.

5.2.1 Standard Practices to Mitigate Negative Effects of Construction

Specific measureable and enforceable mitigation measures would be developed for the project based on the specific impacts of the project. The TSP designs and construction timing would include the following standard measures.

- In-water work would be scheduled to occur during designated periods as established by WDFW (16 July to 31 August) per WAC 220-110-271 and work windows designated by NMFS or USFWS per ESA consultation. The more restrictive work window will apply.
- The Corps would conduct surveys for eagle nests and limit construction activities during breeding/nesting season or obtain the necessary Bald Eagle Protection Act permit.
- Construction contractors would be required to prepare Environmental Protection Plans (EPP) for each site for approval by the Corps.
- Traffic alterations would be designed to minimize impediments, with the shortest and least disruptive detours possible, and in coordination with the relevant transportation agency.
- Timing of construction will follow local noise ordinances.

5.2.2 Conceptual Mitigation Measures for Effects to Wetland Habitat

- Wetland delineations would be conducted to determine the extent and function of wetlands affected by the TSP during the feasibility level design analysis; then
- To minimize this potential impact, the project footprint would be reduced and/or the alignment shifted to maximum extent possible; and either
- To rectify any remaining effects, onsite wetland habitat would be restored or;

- To compensate for any remaining impacts, off-site mitigation would be developed as no wetland mitigation banks exist within the study area.

5.2.3 Conceptual Mitigation Measures for Effects to Threatened and Endangered Species, Fish, and Aquatic and Riparian Habitats

Section 7 consultation under ESA will establish conservation measures to reduce the level of impact to ESA listed species. In most cases these measures will cover the mitigation needed under NEPA to reduce project impacts to a non-significant level.

- To minimize impacts, the project footprint would be reduced and/or the alignment shifted to the maximum extent possible; and
- To compensate for any remaining impacts, a combination of some or all of the following options could be implemented:
  - Planting along a levee bench per ETL 1110-2-583,
  - Planting of riparian vegetation per ETL 1110-2-583,
  - Setting back a levee,
  - Installing habitat weirs,
  - Anchoring LWD,
  - Constructing an off-site mitigation project such as a side channel or restoring habitat

5.2.4 Conceptual Mitigation Measures for Effects to Cultural Resources

The primary threats or impacts for Alternative 2 include damage to historic buildings or structures from induced flooding, demolition of historic buildings or structures resulting from acquisition and removal of properties subject to severe flooding, alteration or removal of the existing levee system, and alteration or diminishment of the historic setting by the introduction of new visual elements into the historic setting of a historic property. The Corps would continue to explore and refine the design and engineering for the actions proposed to avoid or minimize impacts where possible. For purposes of Section 106, the Corps would execute a programmatic agreement (PA) as provided at 36 C.F.R. § 800.4(b)(2) and 36 C.F.R. § 800.14(b) of the regulations implementing Section 106. The PA would provide a binding process and stipulations by which the Corps would continue to refine and document the APE, identify historic properties in the APE, evaluate properties using the Criteria of the National Register of Historic Places, and assess the effects of the undertaking on historic properties. Where historic properties would be adversely affected, the Corps would continue to consult with the SHPO, Advisory Council on Historic Preservation (ACHP), Indian tribes, and other consulting parties on the resolution or appropriate mitigation of the adverse effect. The PA would be completed and executed among the consulting parties prior to the Record of Decision on the final FR/EIS.

The mitigation of adverse effects are usually tailored to the specific significant characteristics and values that qualify a historic property for inclusion on the NRHP and the nature of the adverse effect. There is no single required mitigation measure for a specific effect, but there are conventional approaches to the treatment or mitigation of adverse effects that are generally considered appropriate. The actual treatment or mitigation of the adverse effects would be determined in consultation with the SHPO, ACHP, Indian tribes and other consulting parties in the manner that would be stipulated in the PA. The range of conventional mitigation options that are often considered are described below:

- Archaeological sites that are significant for their information values are often mitigated by recovering significant or scientific information through archaeological excavation, scientific study, and curation of artifacts. Mitigation may also include interpretative products, such as scientific and public--oriented publications or presentations, or the exhibition and interpretation of artifacts in a museum or travelling exhibit.
- Built-environment properties (buildings and structures) or culturally significant properties (traditional cultural properties) that would be directly affected by physical alteration or destruction of their significant values would have mitigation tailored to the significant characteristics and values as derived from their NRHP significance criteria. For properties significant for their association with significant events or persons important in history (NRHP Criteria A and B), mitigation may include: intensive documentation of the property; preparation of scholarly publications or presentations; exhibition or interpretation about the property and its associations with the events or person in historical museums or other public settings, and; preparation of documentary videos or photographic documentation about the property.
- For properties significant under NRHP Criteria C for their association with the works of a master, or embody the distinctive characteristics of a type, period or method of construction, or represent a significant and distinguishable entity whose components may lack individual distinction (a historic district), mitigation may include: intensive historical documentation of the property; documentation of the property using the formats required by the Historic American Buildings Survey or the Historic American Engineering Record; completion of formal nominations to the NRHP; preparation of scholarly publications or presentations; exhibition or interpretation about the property in historical museums or other public settings which inform how the property represents the works of a master or embodies a type, period or method of construction represented in a historic district, and; preparation of documentary videos or photographic documentation about the property.

5.2.5 Best Management Practices to Protect Water Quality

The proposed construction activities would involve, by necessity, some in-water work and areas of ground disturbance. Protecting water quality from storm water runoff and in-water turbidity would require implementation of best management practices (BMP) to avoid excessive runoff and elevated turbidity in the receiving water body. It is important to avoid excessive pulses of sediment during the construction phase that are more than what the surrounding aquatic life can easily tolerate. The construction contractor will prepare a Stormwater Pollution Prevention Plan (SWPPP), which includes a Temporary Erosion and Sedimentation Control Plan, approved by a Corps staff biologist. Construction contractors would be required to obtain a Construction Stormwater Permit under Section 402 of the Clean Water Act. The SWPPP would be developed in accordance with the Washington State Department of Ecology Western Washington Stormwater Manual. Standard construction stormwater BMPs can be incorporated into site designs, operational procedures, and physical measures on site. The following are some examples of frequently used BMPs:

- Minimize area of ground disturbance and vegetation clearing,
- Use the site's natural contours to minimize run-off and erosion,
- Construction each site in portions to not expose an entire site at one time,
- Stabilize erodible surfaces with mulch, compost seeding, or sod,
- Use features such as silt fences, gravel filter berms, silt dikes, check dams and gravel bags for interception and dissipation of turbid runoff water,
- Where possible, isolate in-water work sites with supersacks, cofferdams or other materials to reduce turbidity impacts,
- Place rocks individually, no end dumping of rocks for toe and riverward face armoring would occur,
- Vegetable based hydraulic fluids will be used in construction equipment,
- All construction equipment will be cleaned before use in or adjacent to water,
- Fueling of equipment will occur away from water in a confined area,
- Spill response kits will be kept onsite and construction workers will be adequately trained in use of the kits.

5.2.6 Best Management Practices for Minimization of Effects of Greenhouse Gas Emissions

There are no legal requirements to mitigate for GHG emissions; however, BMPs are available for fuel and material conservation during construction. Such BMPs include the following:

- Maximize use of construction materials that are reused or that have a high percentage of recycled material content, such as recycled asphalt pavement, concrete and steel,
- When deconstructing levees in the setback areas, levee material will be reused in the new levees if suitable,
- Obtaining construction materials and equipment from local sources or vendors to minimize energy use for shipping and transport,
- Encouraging construction personnel to carpool or use a crew shuttle van,
- Turning off equipment when not in use to reduce idling,
- Maintaining equipment in good working order to maximize fuel efficiency,
- Routing truck traffic through areas where the number of stops and delays would be minimized, and using off-peak travel times to maximize fuel efficiency,
- Scheduling construction activities during daytime hours or during summer months when daylight hours are longest to minimize the need for artificial light,
- Implementing emission-control technologies for construction equipment,
- Using ultra low sulfur (for air quality) and biodiesel fuels in construction equipment,
- Using warm mix asphalt or cool pavement rather than hot mix asphalt,
- Using renewable energy produced onsite or offsite. For example, using solar-powered generators to supply electricity for field offices and construction lighting.

5.3 Summary of Economic, Environmental and Other Social Effects of the TSP*

Corps policy establishes four accounts to facilitate the evaluation and display of the effects of the recommended plan. These accounts are National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). These four accounts encompass all significant effects of plan implementation, including economic, socioeconomic, and environmental effects that must be considered in water resources planning. Effects of the recommended plan in the four evaluation accounts are displayed in Table 5-2.

Table 5-2. Summary of Accounts for Economic, Environmental and Other Social Effects of TSP

Evaluation Account	TSP: Levee Modification Alternative
NED Account	The national economic development (NED) account displays changes in the economic value of the national output of goods and services. The current design of the TSP provides an estimated $39.1 million in equivalent average annual benefits, with mean net benefits of $23.7 million and a mean benefit-cost ratio of 2.5 (ranging from 1.7 to 3.2 with a 75%-25% confidence bound) at the October 2015 price level and 3.125 percent discount rate. The feasibility-level analysis will consider various scales of TSP features to determine scales which reasonably maximize net benefits. The results of this analysis, including project performance estimates, will be presented in the final report.
RED Account	The regional economic development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output and population. This will be analyzed as part of feasibility-level design using RECONS and presented in the final report.
EQ Account	See the summary in Section 4.2 and in Section 5.3.1.
OSE Account	The other social effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts. The population at risk from flooding with project in the residual 1% (1/100) ACE floodplain is estimated to be 2,100, a reduction of at least 33,800 from 34,900 people from the 1% ACE floodplain without a project based on residential structures subject to flooding and a 2.59 per household population estimate for Pierce County (Census 2010) and direct jobs of approximately 4,400 from industrial lease tenants at the Port of Tacoma. Life safety, floodplain population, environmental justice communities, critical infrastructure, and potentially developable acreage will be analyzed as part of feasibility-level design and presented in the final report.

5.3.1 Environmental

The following sections summarize the analysis provided in Chapter 4 on the potential environmental effects from implementation of the TSP.

5.3.1.1 Unavoidable Adverse Environmental Effects

To facilitate the construction of all of the proposed flood risk management measures of the TSP, some adverse environmental effects, while only temporary, could occur within the project area. The following list summarizes adverse environmental effects that are more fully described in Section 4:

- Temporary, minor, and localized degradation of water quality from increases in turbidity during in-water work

- Greenhouse gas emissions from construction equipment would combine with the global accumulation of greenhouse gases
- Temporary disturbance to fish and aquatic insects through increased turbidity and construction activity in the water
- Temporary clearing of upland and riparian vegetation for access and staging areas
- Temporary and localized disruptions to traffic caused by construction vehicle access to worksites
- Loss of wetland and riparian areas
- Continued simplification of the riparian and aquatic habitats in the urban corridor
- Permanent reduction of refuge habitat for fish including ESA-listed species

5.3.1.2 Irreversible and Irretrievable Commitment of Resources

NEPA requires that environmental analysis include identification of "any irreversible and irretrievable commitments of resources which would be involved in the preferred alternative should it be implemented." This clause refers to the use of nonrenewable resources and the effects that the use of these resources have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable period. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored because of the action (e.g., extinction of a species or the disturbance of a cultural site).

The TSP would result in an irreversible use of fossil fuels to execute the construction of the project. Machinery types were estimated during the cost estimate work for the alternatives analysis. The proposed Federal action is designed to have minimal irreversible and irretrievable commitment of resources. All construction effects are assumed to be short-term reductions in fish, aquatic insect, and plant resources, which would recover their abundances in a relatively short period.

5.3.1.3 Relationship Between Short-Term Uses and Long-Term Productivity

NEPA requires that an EIS consider the relationship between short-term uses of the environment and the impacts that such uses may have on the maintenance and enhancement of long-term productivity of the affected environment (40 CFR Section 1501.16). This section compares the short- and long-term environmental effects of the proposed project. For the TSP, "short-term" refers to the temporary phase of construction of the proposed project, while "long-term" refers to the 50-year period of analysis of the proposed project and beyond. Section 4 of this document evaluates the direct, indirect, and cumulative effects that could result from the alternatives.

Short-term impacts caused by the project would be similar for any of the construction alternatives. These impacts would occur during and immediately after construction and would generally result in adverse effects. The long-term impacts that would occur over the life of the project would result in overall detrimental effects to riparian habitat. The alternative would address levee deficiencies that currently threaten property and public safety. Flooding in the event of a levee failure would result in extensive flooding and potential loss of life. However the construction of 16.6 miles of new levee and the modification of 3.3 miles of existing levee would reduce riparian cover, and directly alter approximately

1.7 miles of riverbank. Creation of setback areas would increase off-channel and flooded riparian habitat which is absent from the lower Puyallup and White River systems.

5.3.1.4 Areas of Controversy and Unresolved Issues

NEPA requires disclosure of controversial issues to the decision-maker. The following major issues were identified during public scoping and outreach efforts for this project.

- Aquatic habitat protection
- Alternatives Selection
- Management of Mud Mountain Dam
- Economic Development and Risk
- Sediment management

Table 7-1 details these concerns as well as the other comments received during the scoping process.

5.4 Design and Construction Considerations

The study team has taken a common sense and risk-based approach to the level of design developed in the feasibility phase. The information presented in the DFR/EIS includes a conceptual level of design. The various technical appendices to the DFR/EIS provide the conceptual level designs developed at this point in the Study, for use in plan formulation and evaluation. The Corps will develop a feasibility-level design before completion of the Study, which is a more detailed level than the TSP described in the DFR/EIS. The study team has identified the necessary studies and data collection to be performed during the feasibility-level design analysis to manage specific risks and uncertainties as well as meet the requirements outlined in Corps planning and engineering guidance for feasibility studies, including ER 1105-2-100 (Planning Guidance Notebook) and ER 1110-2-1150 (Engineering and Design for Civil Works Projects; USACE 1999b). The completed feasibility-level design will be presented in the final FR/EIS, which will have a public notification period of at least 30 days prior to the signature of the Record of Decision. The Final Feasibility Plan and. The detailed design presented in the final FR/EIS will take into account comments received during the public review of the DFR/EIS.

5.5 Real Estate Considerations

There are two components of real estate acquisitions that would be required to support the TSP:

353.3 acres of unimproved lands located within all three reaches of the Study area as well as 73.62 acres of improved lands located within the lower Puyallup River and White River reaches. A total of 319 parcels would be impacted by the project. Current land uses of all properties required to support the project are residential, agricultural and one commercial timber facility.

Tribal interests in proposed project lands will be identified in order to determine the level of interaction and further communication required between the two federally recognized tribes located within the Study area. The two tribes are the Muckleshoot Tribe and the Puyallup Tribe.

One of the largest risks to the proposed project is the number and types of Uniform Relocation Assistance (P.L. 91-646) mandated relocations that may be required as a result of the project. A number of parcels and improvements would be inundated in the Pierce County North Levee Road Setback area as well as the White River King and Pierce County portions of the Study area.

Utility/Facility Relocations will be further refined during feasibility level design. An initial assessment of utilities that could be impacted includes electrical, water/sewer and other utilities within the Study Area. The Government, after consultation with the non-Federal sponsor, shall determine the utility and displaced persons/farms/business relocations necessary for construction, operation, and maintenance of the Project, including those necessary to enable the borrowing of material or the disposal of dredged or excavated material.

Due to the preliminary nature of the proposed projects, title reports were not secured. A thorough title analysis will be conducted during PED to identify Third Party Interests that may impede the proposed projects. The non-Federal sponsor will be required to present a legal opinion as to the disposition of any Third Party interests. All property interests acquired in support of the proposed project must take priority over any competing third party real estate interests that could defeat or interfere with the construction, operation and maintenance of the project.

An HTRW analysis will be used to determine whether valuation methods must be adjusted to reflect contamination. For the purposes of this REP, it is assumed that the property will be delivered clean of contaminant levels that would endanger the project. HTRW PDT member concurs with that approach.

Real Estate requirements will be revised during PED.

5.6 Cost Estimate and Economics

Based on October 2015 price levels, the estimated project first cost is $341,144,000. (Project first cost refers to the cost estimate that includes, among other things, preconstruction engineering and design costs, construction costs, lands, easements, right-of-way, relocation, and disposal (LERRD) values, and contingencies.) The fully-funded cost estimate is $380,030,000. Estimated average annual costs are $15.4 million including interest during construction based on a 3.125% interest rate, a period of analysis of 50 years, and construction ending in 2025 (estimated 66 month construction duration), and annual operations and maintenance estimated at less than $600,000 per year. The total average annual flood damage reduction benefits would be $39.1 million with net benefits of $23.7 million a benefit-cost ratio of 2.5 to 1 as shown in Table 5-3. Table 5-4 outlines the project first costs and cost share of the TSP. The estimated Federal cost share is $221,744,000, and the estimated non-Federal cost share is $119,400,000.

Table 5-3. Cost and Benefit Summary of the TSP Plan

Cost and Benefit Summary of TSP (October 2015 price level)	
Interest Rate (Fiscal Year 2016)	3.125%
Interest Rate, Monthly	0.26%
Construction Period, Months	66
Period of Analysis, Years	50
Estimated Cost (Oct 2015 price level)	$341,144,000
Interest During Construction	$30,092,000
Investment Cost	$371,236,000
Average Annual Cost	
Amortized Cost	$14,773,000
OMRR&R	$600,000
Total Annual Cost	$15,373,000
Average Annual Benefits	$39,078,000
Net Benefits	$23,705,000
Benefit-Cost Ratio (3.125%)	2.5

Table 5-4. Summary of TSP Cost Estimate and Cost Sharing Responsibilities ($1,000, Oct 2015 price levels)

MCACES Account[1]	Account	Federal	Non-Federal	Total
1	Lands and Damages		$103,263	$103,263
6	Fish and Wildlife	$19,361		$19,361
8-19	Construction[2]	$180,540		$180,540
30	Planning, Engineering and Design	$23,988		$23,988
31	Construction Management	$13,993		$13,993
	Cash Contribution/Reimbursement	($16,137)	$16,137	$0
	Total First Cost (TSP)	$221,744	$119,400	$341,144
	Percentage	65%	35%	100%

[1] Micro Computer-Aided Cost Engineering System (MCACES) is the software program and assorted format used by USACE
[2] Account 08 - Roads, Railroads & Bridges; Account 11 - Levees & Floodwalls; Account 19 - Buildings, Grounds & Utilities

5.7 Monitoring and Adaptive Management*

The Corps' Implementation Guidance for Section 2039 of the 2007 WRDA (P.L. 110-114) defines monitoring as "the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits" (USACE 2009a). Even the most strategically planned mitigation actions can yield unexpected results. Monitoring includes documenting and diagnosing these results especially in the early, formative stages of a project, providing information useful for taking corrective action. In this way, monitoring reduces the risk of failure and enables effective, responsive management of mitigation actions.

A Monitoring and Adaptive Management Plan provides a conceptual plan for evaluating the effectiveness of proposed mitigation actions and for developing corrective actions if mitigation is not meeting performance metrics. A similar monitoring protocol will be followed those used in monitoring restoration projects in Puget Sound and the Pacific Northwest (Heitke et al. 2010, Crawford and Rumsey 2011).

Compliance monitoring provides data to evaluate whether projects were built to design, and effectiveness monitoring provides data to determine whether projects are meeting project objectives. The Corps will use decision criteria to evaluate project performance for the degree of success, or for the need for corrective actions. Details and uncertainties will be addressed in the preconstruction, engineering, and design phase, and a detailed monitoring and adaptive management plan, including a detailed cost estimate, will be included in the final FR/EIS.

5.8 Risk and Uncertainty

Risk and uncertainty is fundamental to all water resource planning and communication. This study incorporated risk management framework principles and risk-informed planning into its plan formulation process.

- Risk analysis and communication was used following ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, and Engineering Manual (EM) 1110-2-1619, *Risk-Based Analysis for Flood Risk Management*.
- Uncertainty was captured through cost engineering's mandatory center of expertise (MCX) cost and schedule risk analysis to establish cost contingencies. Risks to project cost and schedule were documented in a risk register.
- Risks were assessed and managed throughout the study process, in coordination with the Corps' Vertical Team.
- Specific risk and uncertainty remaining includes the extent of potential induced and transferred flood risk resulting from confined flood flows associated with new or modified levees to areas in the floodplain. To minimize and mitigate these uncertainties, more detailed hydraulic modeling of the TSP will be conducted during the feasibility-level design analysis to better understand the flood risks associated with the specific features of the TSP to other areas in the floodplain. Nonstructural measures such as elevating homes, relocations, developing evacuation routes and plans, as well as structural measures can be evaluated on an incremental basis during the feasibility-level design analysis to reduce induced and/or residual flood risks once the risk is better understood. This additional evaluation will be conducted as part of optimization of TSP features for NED to reasonably maximize benefits relative to cost and will be documented in the final FR/EIS.
- Future Without-Project Construction: Pierce County and King County have identified projects that may be constructed before the Study will be completed and construction is initiated. A potential funding source has been identified for some of these projects, but these projects are not fully funded for construction at this time. If funding falls through on these projects, there is a risk to having to modify the TSP. Other County projects where funding was certain have been identified and included in the future without-project analysis of the Study. The Corps will continue to work closely with the County as the TSP is refined and detailed design analysis is conducted after the Agency Decision Milestone (ADM) to ensure assumptions on projects to be constructed by the County are still accurate.

5.9 Executive Order 11988

Executive Order (EO) 11988 (May 24, 1977) requires a Federal agency, when taking an action, to avoid short and long term adverse effects associated with the occupancy and the modification of a floodplain. The agency must avoid direct and indirect support of floodplain development whenever floodplain siting is involved. In addition, the agency must minimize potential harm to or in the floodplain and explain why the action is proposed. Additional floodplain management guidelines for EO 11988 were also provided in 1978 by the Water Resources Council.

Corps implementation guidance in Engineering Regulation (ER) 1165-2-26 (March 30, 1984), states the following in Paragraph 6:

EO 11988 has as an objective the avoidance, to the extent possible, of long-and short-term adverse impacts associated with the occupancy and modification of the base floodplain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative. Under the Order, the Corps is required to provide leadership and take action to:

- Avoid development in the base flood plain unless it is the only practicable alternative;
- Reduce the hazard and risk associated with floods;
- Minimize the impact of floods on human safety, health and welfare; and
- Restore and preserve the natural and beneficial values of the base floodplain.

General procedures to implement Executive Order 11988 include eight steps as outlined and evaluated for the Puyallup River Basin Flood Risk Management Feasibility Study.

1. Determine if the proposed action is in the base floodplain (1% ACE).
2. If the action is in the floodplain, identify and evaluate practicable alternatives to locating in the base floodplain.
3. Provide public review.
4. Identify the impacts of the proposed action and any expected losses of natural and beneficial floodplain values.
5. Minimize threats to life and property and to natural and beneficial floodplain values. Restore and preserve natural and beneficial floodplain values.
6. Reevaluate alternatives.
7. Issue findings and a public explanation.
8. Implement the action.

Screening of measures and alternatives for this Study considered impacts to the floodplain and minimizing induced development. The feasibility-level design analysis and optimization of TSP features for National Economic Development (NED) will include evaluation and documentation of the eight-step process to comply with the EO. The approach will include an evaluation of potentially developable land in the floodplain for the No Action Alternative and refined NED Plan. Economic drivers such as population projections and development demand will also be considered as part of this analysis. Impacts to life safety, evacuation routes and critical infrastructure will also be documented in support of this analysis in the final FR/EIS.

5.10 Residual Risk

As the TSP is refined during feasibility-level design analysis and NED optimization, more information will be communicated with regard to residual risk (i.e. the risk that remains with implementation of the recommended plan). This communication will include a discussion of levee performance, remaining or residual flood damage potential, and flood inundation estimates. The residual risk analysis will include an evaluation of population at risk, life safety, critical infrastructure, evacuation routes and economic damages of the No Action and refined plan recommendation. This will be documented in the final FR/EIS.

5.11 Plan Implementation Requirements

5.11.1 Non-Federal Sponsor

Pierce County, Washington is the cost-sharing non-Federal sponsor of the Study and has provided a letter reaffirming the County's support of the preliminary TSP and further study work, including development of feasibility-level designs and cost estimates. The Corps will request a letter of intent before completion of the feasibility study, and non-Federal sponsor self-certifications of financial capability prior to execution of a design agreement (DA) to complete design and project partnership agreement (PPA) for construction.

5.11.2 Institutional Requirements

The schedule for project implementation is dependent on project authorization. After Congress authorizes the project, the project would be eligible for construction funding. The project would be considered for inclusion in the President's budget based on national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal partner to fund its share of the project cost, and the budget constraints at the time of funding.

After Congress appropriates Federal construction funds, the Corps and the non-Federal sponsor would enter into a DA and eventually a PPA. The DA would define the Federal and non-Federal responsibilities for completion of final designs for the project. The PPA would define the Federal and non-Federal responsibilities for implementing, operating and maintaining the project.

5.11.3 Operation and Maintenance (O&M) Considerations

After completion of construction and the monitoring and adaptive management period for any required mitigation, the non-Federal sponsor(s) will assume O&M responsibility for the entire project footprint, including vegetation free zones beyond the levee toe. The non-Federal sponsor is responsible for all long-term project operations, maintenance, repairs, replacements, and rehabilitations following completion of construction, including inspection and periodic maintenance. O&M activities include operations and maintenance of new and modified levees and new floodwalls. O&M costs have been estimated for the TSP. At this time it is assumed that the TSP will require maintenance estimated to be approximately $600,000 per year or less with O&M activities focusing on semi-annual inspections and reports, proper operation and maintenance of culverts and floodwall closures, and periodic levee maintenance activities to include repair and replacement of damaged or deficient components. Levee maintenance responsibilities would include:

- Vegetation maintenance according to ETL 1110-2-583 or approved vegetation variance
- Promote the continued growth of sod cover
- Repair of erosion damage and displaced riprap
- Correction of unusual settlement
- Repair of depressions and rutting
- Animal control program and effective implementation of plans

Floodwall O&M would include regular inspections and periodic maintenance to clear weep holes, remove problem vegetation, and repair any other noted deficiencies.

A detailed O&M manual will be developed during the Pre-construction Engineering and Design (PED) phase that follows completion of the feasibility phase of the project.

This page intentionally left blank

6 Compliance with Environmental Statutes

This chapter provides documentation of how the TSP (agency preferred alternative) complies with all applicable Federal environmental laws, statutes and executive orders.

6.1 Federal Laws

6.1.1 American Indian Religious Freedom Act

The American Indian Religious Freedom Act of 1978 (AIRFA) (42 U.S.C. 1996) establishes protection and preservation of Native Americans' rights of freedom of belief, expression, and exercise of traditional religions. Courts have interpreted AIRFA to mean that public officials must consider Native Americans' interests before undertaking actions that might impact their religious practices, including impact on sacred sites. The Corps will coordinate with the Tribes during feasibility to avoid impacts to religious practices and sacred sites.

6.1.2 Archaeological Resources Protection Act

The Archaeological Resources Protection Act of 1979 (ARPA) (16 U.S.C. §470aa-470mm; Public Law 96-95 as amended) establishes the requirements to protect archaeological resources and sites on public and Indian lands and to foster increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals. The Act established civil and criminal penalties for the destruction or alteration of cultural resources. Prior to conducting archaeological investigations on either Puyallup or Muckleshoot Tribal lands, the Corps will attain a permit or its regulatory equivalency from the Tribe.

6.1.3 Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (16 U.S.C. §668-668c) applies to Corps civil works projects through the protection of bald and golden eagles from disturbance. Construction activities associated with the proposed actions have potential to disturb bald and golden eagles due to the presence of heavy machinery and elevated noise levels. The Corps will develop an eagle monitoring plan, and will minimize construction effects by surveying each site for nests and roosts prior to and during construction, and, if nests and/or roosts are nearby, will coordinate with USFWS.

6.1.4 Clean Air Act

The Clean Air Act (CAA) as Amended (42 U.S.C. §7401, et seq.) prohibits Federal agencies from approving any action that does not conform to an approved State or Federal implementation plan. Three agencies have jurisdiction over air quality in the project area: EPA, WDOE, and the Puget Sound Clean Air Agency. The EPA sets standards for concentrations of pollutants in outdoor air and the State establishes regulations that govern contaminant emissions from air pollution sources.

Based on similar levee modification projects, this alternative would, most likely, be below or at the *de minimis* thresholds and would be exempted pursuant to 40 CFR § 93.153(c)(2)(ix) from the requirement of a conformity determination.

6.1.5 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972 as amended (16 U.S.C. §1451-1464) requires Federal agencies to carry out their activities in a manner that is consistent to the maximum extent practicable with the enforceable policies of the approved State Coastal Zone Management Program. The aim of the act is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone." The delegated authority for review of consistency in Washington State is WDOE. In compliance with State law, King and Pierce Counties have developed their own Shoreline Master Programs under the State Shoreline Management Act. The Corps expects to be fully consistent with the enforceable policies of both the King and Pierce County Shoreline Master Programs. In addition under Washington's Program, federal activities that affect any land use, water use or natural resource of the coastal zone must comply with the enforceable policies within the six laws identified in the Program document. The six state laws are:

- Shoreline Management Act (including local government shoreline master programs)
- State Environmental Policy Act (SEPA)
- Clean Water Act (CWA)
- Clean Air Act (CAA)
- Energy Facility Site Evaluation Council (EFSEC)
- Ocean Resource Management Act (ORMA)

The Corps will submit the CZMA Consistency Determination to WDOE for their review at the same time as submission of all of the documents required for Clean Water Act Section 401 review. WDOE's concurrence with the CZMA Consistency Determination is contingent upon receipt of a 401 Water Quality Certification. The Corps expects to be substantively consistent with the enforceable polices of each county's Shoreline Master Program. The Corps has initiated coordination with the Department of Ecology and will prepare a CZMA Consistency Determination for each site according to the relevant county or local code. The Corps will continue coordination with WDOE throughout PED to ensure the project meets requirements for 401 certification as a prerequisite for WDOE concurrence on the CZMA Consistency Determination.

6.1.6 Endangered Species Act

The Endangered Species Act (ESA) (16 U.S.C. §1531-1544), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat upon which they depend. Section 7(a) requires that Federal agencies consult with the NMFS and USFWS, as appropriate, to ensure that proposed actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their critical habitats. The Corps is coordinating with NMFS and USFWS to ensure the protection of those threatened and endangered species under their respective jurisdictions and to anticipate potential negative effects that may result from the project. The Corps will prepare a Biological Assessment based on the 35% level of design. The Biological Assessment will analyze the effects on listed species of all elements of the proposed action (not likely to adversely affect vs. likely to adversely affect). The Corps will submit this document to

NMFS and USFWS for their consideration. ESA consultation will be complete prior to the issuance of the final FR/EIS.

6.1.7 Farmland Protection Policy Act

The Farmland Protection Policy Act (7 U.S.C. § 4201 et seq., 7 CFR 658) was authorized to minimize the unnecessary and irreversible conversion of farmland to nonagricultural use due to Federal projects. This Act protects Prime and Unique farmland, and land of statewide or local importance. The Farmland Protection Policy Act protects forestland, pastureland, cropland, or other land that is not water or urban developed land. The Farmland Protection Policy Act requires a Federal agency to consider the effects of its action and programs on the Nation's farmlands. This Act is regulated by the NRCS. The NRCS is authorized to review Federal projects to see if the project is regulated by the Farmland Protection Policy Act and establish what the farmland conversion impact rating is for a Federal project. The Corps will provide the NRCS with project maps and descriptions to assess impacts on Prime and Unique farmlands. NRCS uses a land evaluation and site assessment system to establish a farmland conversion impact rating score on proposed sites of federally funded and assisted projects. The Corps will then work with NRCS to determine ways to avoid or minimize impacts if the amount of conversion of prime and unique farmlands exceeds recommended allowable limit.

6.1.8 Federal Water Pollution Control Act

The Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.) is more commonly referred to as the Clean Water Act (CWA). This act is the primary legislative vehicle for Federal water pollution control programs and the basic structure for regulating discharges of pollutants into waters of the United States. The CWA was established to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." The CWA sets goals to eliminate discharges of pollutants into navigable waters, protect fish and wildlife, and prohibit the discharge of toxic pollutants in quantities that could adversely affect the environment.

Section 401 – Any project that involves placing dredged or fill material in waters of the United States or wetlands, or mechanized clearing of wetlands, requires a water quality certification from the State agency as delegated by the EPA. For the lower Puyallup River, the delegated authority is the Puyallup Tribe. The remainder of the study area including Middle & upper Puyallup and White Rivers, the delegated authority is WDOE. When the site-specific construction drawings and contract are prepared, the Corps will provide these and all other necessary documentation for the Puyallup Indian Tribe and WDOE to certify that the action will not violate established water quality standards. In the interim the Corps will coordinate with WDOE and PTI to assure that the project designs and mitigation formulation are consistent with each agency's regulatory policies. The Corps anticipates receiving a letter from WDOE and from the Puyallup Tribe of Indians with assurance that the project sites can be certified under Section 401.

Section 402 – The National Pollutant Discharge Elimination System (NPDES), controls discharges into waters of the United States. NPDES permits contain industry-specific, technology-based, and/or water-quality-based limits, and establish pollutant monitoring and reporting requirements. EPA has established a program to address stormwater discharges. These regulations require that facilities or construction sites with stormwater discharges from a site that is one acre or larger apply for an NPDES permit. Permits would be obtained from the Puyallup Tribe for any work within the Puyallup Tribe Reservation and from the EPA for all other area. Stormwater discharge permits will provide the relevant authority for discharges from the project sites during construction.

Section 404 – The Corps administers regulations under Section 404(b)(1) of the CWA, which establishes a program to regulate the discharge of dredged and fill material into waters of the U.S., including wetlands. The Corps will evaluate potential project-induced impacts subject to these regulations during feasibility-level design and provide a public notice to solicit comments on the project design and evaluation under the Section 404 of the Clean Water Act. The 404(b)(1) evaluation of the TSP is in Appendix G (Environmental and Cultural Resources).

6.1.9 Federal Water Project Recreation Act

In the planning of any Federal navigation, flood control, reclamation, or water resources project, the Federal Water Project Recreation Act, as amended (16 U.S.C. 460(l) (12) et seq.) requires that full consideration be given to the opportunities that the project affords for outdoor recreation and fish and wildlife enhancement. The Act requires planning with respect to development of recreation potential. Projects must be constructed, maintained, and operated in such a manner if recreational opportunities are consistent with the purpose of the project. With the proposed project, effects to recreation would be negligible. In addition, the proposed project would not restrict future recreation opportunities.

6.1.10 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) of 1934 as amended (16 U.S.C. §661-667e) provides authority for the USFWS involvement in evaluating impacts to fish and wildlife from proposed water resource development projects. It requires that fish and wildlife resources receive equal consideration to other project features. It requires Federal agencies that construct, license, or permit water resource development projects to consult with the USFWS, NMFS, and State resource agencies regarding the impacts on fish and wildlife resources and measures to mitigate these impacts. Section 2(b) requires the USFWS to produce a Coordination Act Report (CAR) that describes fish and wildlife resources in a project area, potential impacts of a proposed project, and recommendations for a project. The CAR includes the USFWS positions and recommendations. A CAR pursuant to FWCA has been completed for the project and is in Appendix G. As noted in the CAR, most of the USFWS recommendations are directed towards landuse and policy actions that are not in the jurisdiction of the Corps of Engineers. Policy changes with regard to the PL84-99 Program are also beyond the scope of this study. The Corps will continue to coordinate with USFWS on project design to avoid impacts to riparian areas, as well as minimizing temperature impacts. As noted above, ESA consultation will be conducted during the NEPA process.

6.1.11 Hazardous, Toxic and Radiological Waste Laws

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) is designed to clean up sites contaminated with hazardous substances; remediating abandoned hazardous waste sites, by establishing legal liability, as well as a trust fund for cleanup activities. CERCLA, called "Superfund," provides broad Federal authority to clean up releases or threatened releases of hazardous substances that may endanger public health or the environment. The law authorized the EPA to identify parties responsible for contamination of sites and compel the parties to clean up the sites. Where responsible parties cannot be found, EPA is authorized to clean up sites itself, using a special trust fund. In 1986, the Superfund Amendments and Reauthorization Act (SARA) addressed cleanup of leaking underground storage tanks (USTs) and other leaking waste storage facilities. The amendments established a trust fund to pay for cleanup of leaking UST sites where responsible parties cannot be identified.

The Resource Conservation and Recovery Act (RCRA) gives the EPA the authority to control hazardous waste from "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA sets forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. In 1984, Congress expanded the scope of RCRA with the enactment of Hazardous and Solid Waste Amendments. The amendments strengthened the law by covering small quantity generators of hazardous waste and establishing requirements for hazardous waste incinerators, and the closing of substandard landfills. In general, CERCLA applies to contaminated sites, while RCRA's focus is on controlling the ongoing generation and management of particular waste streams. RCRA, like CERCLA, has provisions to require cleanup of contaminated sites that occurred in the past.

The Toxic Substances Control Act (TSCA) of 1976 provides EPA with authority to require reporting, record-keeping, and testing requirements, and restrictions relating to chemical substances and/or mixtures. Certain substances are generally excluded from TSCA, including, among others, food, drugs, cosmetics, and pesticides. TSCA addresses the production, importation, use, and disposal of specific chemicals including polychlorinated biphenyls (PCBs), asbestos, radon, and lead-based paint.

No Confirmed and Suspected Contaminated Sites directly impact the preferred alternative and therefore do not present a concern for HTRW. During feasibility-level design it will be necessary to continue coordination regarding HTRW sites to ensure levee alignments do not encounter sites with confirmed and suspected contamination. Furthermore, the sponsor is required to abate any HTRW that will impact the project in compliance with applicable laws. Construction activities associated with the Puyallup GI will also comply with applicable laws.

6.1.12 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §1801 et. seq.) requires Federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The objective of an EFH assessment is to determine whether the proposed action(s) “may adversely affect” designated EFH for relevant commercial, federally managed fisheries within the proposed action area. EFH includes those waters and substrate necessary for fish spawning, breeding, feeding, or growth to maturity. The assessment describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action. During the feasibility-level design analysis, the Corps would prepare an effects analysis addressing EFH, which would be provided to NMFS within the Biological Assessment required under ESA Section 7. EFH exists in the project area for salmon species, and for groundfish in the lower portion of the project area. Although habitat disturbance may have temporary adverse effects to designated EFH, the conservation measures that the Corps will include as part of the proposed site design to address ESA concerns should be adequate to avoid, minimize, or otherwise offset potential adverse impacts to the EFH.

6.1.13 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (16 U.S.C. §703-712) as amended protects over 800 bird species and their habitat, and commits that the U.S. will take measures to protect identified ecosystems of special importance to migratory birds against pollution, detrimental alterations, and other environmental degradations. EO 13186 directs Federal agencies to evaluate the effects of their actions on migratory birds, with emphasis on species of concern, and inform the USFWS of potential negative effects to migratory birds. Impacts to migratory bird habitat would be investigated during the feasibility-level design analysis to determine whether any negative effects will occur. The Corps will coordinate appropriate mitigation with USFWS if needed.

6.1.14 National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 U.S.C. §4321 et seq.) commits Federal agencies to considering, documenting, and publicly disclosing the environmental effects of their actions. NEPA-required documents must provide information regarding the proposed action and alternatives, the environmental impacts of the alternatives, appropriate mitigation measures, and any adverse environmental impacts that cannot be avoided if the agency implements the proposal. Agencies are required to demonstrate that decision makers have considered these factors prior to undertaking actions, which is exhibited in signing a Record of Decision for Environmental Impact Statements such as this one. This DFR/EIS is a primary step towards achieving NEPA compliance for the proposed project. Before preparing this document, the Corps published a Notice of Intent to prepare an EIS in the Federal Register on 23 September 2011, and held a public scoping meeting 6 October 2011 (see Appendix G). Following the final version of the FR/EIS, the Chief of Engineers will sign a Record of Decision as well as the Corps-required Chief's Report.

6.1.15 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) requires that Federal agencies, prior to approving an undertaking, take into account the effects of their actions on historic properties. The implementing regulations for Section 106 are published in 36 C.F.R. § 800. The regulations describe the process by which an agency complies with Section 106. The regulations emphasize a process of consultation with various parties to identify, evaluate and consider effects on historic properties. Consulting parties include the ACHP, the State Historic Preservation Officer (SHPO), Indian tribes, State and municipal governments, and organizations or individuals with a specific interest in the undertaking.

In general, the agency moves through the consultation process in several steps. These include: identifying and documenting the APE, identifying cultural resources in the APE and evaluating properties using the Criteria of the National Register of Historic Places, assessing the effects of the undertaking on historic properties, taking steps to avoid or mitigate adverse effects. Where adverse effects are identified, the agency must resolve the effect in consultation with the consulting parties. The resolution of adverse effect is normal codified in a Memorandum of Agreement among the parties. A signed and executed memorandum of agreement (MOA) concludes Section 106 for undertakings that have an adverse effect.

Where alternatives under consideration consist of corridors or large land areas, or where access to properties is restricted, an agency may use a phased process to conduct identification and evaluation and may defer final identification and evaluation of historic properties if it is specifically provided for in a programmatic agreement (PA) executed pursuant to 36 C.F.R. § 800.14(b). In such cases, the Section 106 consultation process should establish the likely presence of historic properties within the area of potential effects for each alternative through background research or appropriate level of field investigation. As specific aspects or locations of alternatives are refined, the agency can proceed with completing identification and evaluation of historic properties in accordance with the stipulations of the programmatic agreement governing the undertaking.

For this Study, the Corps initiated formal consultation with the Washington SHPO (Washington Department of Historic Preservation) by letter dated December 10, 2015. In that letter, the Corps defined and documented the APE for the undertaking as required at 36 C.F.R. § 800.4(a)(1). In this initial consultation, the Corps also notified the SHPO that the Corps proposed to phase and defer identification and evaluation as provided in the regulations and requested to enter consultation on a programmatic agreement.

The Corps also is in the process of identifying and notifying other consulting parties who might be interested in consulting on the Study and participating in the PA, including the ACHP, the Puyallup Tribe of the Puyallup Reservation, Muckleshoot Indian Tribe of the Muckleshoot Reservation, Nisqually Indian Tribe of the Nisqually Reservation, Squaxin Island Tribe of the Squaxin Island Reservation, Snoqualmie Tribe, Confederated Tribes and Bands of the Yakama Nation, Historic Preservation Commissions of certified local governments, and other government agencies and members of the public with a demonstrated interested in cultural, historical or social components of the Puyallup River Flood Risk Management General Investigation and Feasibility Study. The PA would provide a process to continue identification and evaluation of historic properties as the TSP is refined and proposed actions are approved and funded, determining effects on historic properties, and addressing post-review discoveries of archaeological sites and inadvertent discoveries of human remains. The PA may also consider identifying best management practices or standard treatments of certain properties or effects, and the manner in which the Corps will conclude its Section 106 responsibilities for these individual actions.

6.1.16 Native American Graves and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) (Public Law 101-601; 25 U.S.C. §3001-3013) describes the rights of Native American lineal descendants, Indian tribes, and Native Hawaiian organizations with respect to the treatment, repatriation, and disposition of Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony, referred to collectively in the statute as cultural items, with which they can show a relationship of lineal descent or cultural affiliation. If cultural items protected under NAGPRA are discovered during pre-construction cultural resource investigations or during construction, the Corps will halt work and follow the procedures outlined in the Act.

6.2 Executive Orders

6.2.1 Executive Order 11988, Protection of Floodplains

Executive Order (EO) 11988 requires Federal agencies to provide leadership and take action to (1) avoid development in the base 1% ACE event) floodplain, unless such development is the only practicable alternative; (2) reduce the hazards and risk associated with floods; (3) minimize the effect of floods on human safety, health and welfare; and (4) restore and preserve the natural and beneficial values of the base floodplain. To comply with EO 11988, Corps policy is to formulate projects which, to the extent possible, avoid or minimize significant effects associated with use of the without-project floodplain, and avoid inducing development in the existing floodplain unless there is no practicable alternative. Compliance with the executive order is addressed in Chapter 5 (*Description of the Tentatively Selected Plan*).

6.2.2 Executive Order 11990, Protection of Wetlands

EO 11990 entitled Protection of Wetlands, dated May 24, 1977, requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction and to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this EO. In addition, Federal agencies shall incorporate floodplain management goals and wetlands protection considerations into its planning, regulatory, and decision making processes. The preferred alternative would have adverse effects to wetlands. During the feasibility level design analysis, a wetland delineation would be conducted to determine the extent and function of wetlands affected. To offset those impacts, the project footprint would be minimized and alignment adjusted to the greatest extent possible and both on and off-site mitigation would be investigated and developed commensurate for the impacts.

6.2.3 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

EO 12898, dated February 11, 1994, requires Federal agencies to consider and address environmental justice by identifying and assessing whether agency actions may have disproportionately high and adverse human health or environmental effects on minority or low-income populations. Disproportionately high and adverse effects are those effects that are predominantly borne by minority and/or low-income populations and are appreciably more severe or greater in magnitude than the effects on non-minority or non-low income populations. The Corps has analyzed the potential effects of the alternatives on communities in the Puyallup River Basin and found that no adverse effects would occur to protected communities. Refer to Section 4.19 for further details.

6.2.4 Executive Order 13007, Indian Sacred Sites

EO 13007 requires agencies of the executive branch of the federal government to accommodate access to and use of Indian scared sites located on federal lands by Indian religious practitioners, and to avoid disturbances to sacred sites. The Corps will coordinate with Tribes in the area to assure that disturbances to sacred sites are avoided, and during the design phase to assure that access to sacred site is retained.

6.2.5 Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks

EO 13045 requires Federal agencies to identify and assess environmental health risks and safety risks that may disproportionately affect children and ensure that policies, programs, activities and standards address disproportionate risks to children that result from environmental health or safety risks. Places that children generally gather include schools, parks, recreational facilities and day care centers. During the Feasibility phase, the Corps will analyze the potential effects of the alternatives on children in the Puyallup River Basin to assure that children are not disproportionately impacted by the proposed action.

6.2.6 Executive Order 13175, Consultation and Coordination with Indian Tribal Governments

EO 13175, requires agencies to be guided by three fundamental principles: 1) uphold the unique legal relationship with Indian tribal governments as set forth in the U.S. Constitution, treaties, statutes, EOs and court decisions, 2) recognized the right of Indian tribes to self-government and continue to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, tribal trust resources and Indian tribal treaty, 3) recognizes the right of Indian tribes to self-government and supports tribal sovereignty and self-determination. The Corps has a government-to-government consultation policy to facilitate the interchange between decision makers to obtain mutually acceptable decisions. In accordance with this Executive Order, the Corps will continue to engage in regular and meaningful consultation and collaboration with the tribes in the Basin throughout the course of the study.

6.3 Treaties

Treaties with the Tribes are the supreme law of the land, superior to State laws, and equal to Federal laws. The Federal trust responsibility to Native American Tribes is a protection and preservation of land and certain rights for them. The trust responsibility is derived from the special relationship between the U.S. and Native American Indian Tribes, first defined by U.S. Supreme Court Chief Justice John Marshall in Cherokee Nation v. Georgia, 30 U.S. 1 (5 Pet.) (1831). Later, in Seminole Nation v. United States, 316 U.S. §286 (1942), the Supreme Court noted that the U.S. "has charged itself with moral obligations of the highest responsibility and trust" toward Native American Indian Tribes. The scope of the Federal trust responsibility is broad and incumbent upon all Federal agencies. The U.S. government has an obligation to protect tribal land, assets, resources, and rights, as well as a duty to carry out the mandates of Federal law with respect to Indian Tribes.

In the mid-1850s, the United States entered into treaties with nearly all of the Native American tribes in the territory that would become Washington State. These treaties guaranteed the signatory tribes the right to "take fish at usual and accustomed grounds and stations . . . in common with all citizens of the territory" [U.S. v. Washington, 384 F. Supp. 312 at 332 (WDWA 1974)]. The Boldt I decision resolved that the Treaty tribes had the right to take up to 50 percent of the harvestable anadromous fish runs passing through those grounds, as needed to provide them with a moderate standard of living. Over the years, the courts have also held that this right comprehends certain subsidiary rights, such as access to their "usual and accustomed" fishing grounds. More than de minimis impacts to access to usual and accustomed fishing area violate this treaty right [Northwest Sea Farms v. Wynn, F.Supp. 931 F.Supp. 1515 at 1522 (WDWA1996)]. In U.S. v. Washington, 759 F.2d 1353 (9th Cir 1985) the court indicated that the obligation to prevent degradation of the fish habitat would be determined on a case-by-case basis.

The tribes in the Puyallup Basin have been involved throughout the scoping process for this Study; consultation will continue through feasibility and design Efforts to avoid and minimize impacts to important fisheries have been and will continue to be developed as the designs are further refined. Additionally a mitigation package will be developed for any unavoidable impacts to wetlands and ESA listed species/critical habitat. These mitigation efforts would also benefit other non-listed but important traditional fisheries within the Tribes' U&A fishing areas.

7 Summary of Public Involvement, Review Process and Consultation

Input from stakeholders, agencies, tribes, and the public is integral to define flood risk management opportunities, objectives, constraints, and to develop the range of alternatives to be analyzed for feasibility and environmental compliance. Public involvement activities and agency coordination are summarized in this chapter.

7.1 Public Involvement Process

Corps Planning Policy and NEPA emphasize public involvement in government actions affecting the environment by requiring that the benefits and risks associated with the proposed actions be assessed and publicly disclosed. In accordance with NEPA public involvement requirements (40 CFR 1506.6) and Corps Planning Policy (ER 1105-2-100), opportunities were presented for the public to provide oral or written comments on potentially affected resources, environmental issues to be considered, and the agency's approach to the analysis. Efforts to involve the public included a public scoping meeting, soliciting relevant information from the public, holding a number of informal public meetings, and explaining procedures of how interested parties can get information on the planning process.

7.2 Public Scoping Meeting

Scoping is a critical component of the overall public involvement program to solicit input from affected Federal, State, and local agencies; tribes; and interested stakeholders. The scoping process provides early and open means to determine the scope of issues (problems, needs, and opportunities) to be identified and addressed during the Study. The Study scoping process was conducted jointly with Pierce County. The Corps conducted a public outreach effort as part of scoping, including official notifications, display ads, and the mailing of postcards to the project mailing list, including Puyallup River basin landowners.

A federal Notice of Intent (NOI) was published in the Federal Register on 23 September 2011 with a comment period through 24 October 2011. The Corps mailed a postcard announcing the scoping period and public meeting to residents, stakeholders, and relevant agency and tribal contacts on the Corps project list. Postcards were received approximately two weeks prior to the meeting. Print display advertisements were placed in the Tacoma News Tribune on September 24, 2011 and in the Puyallup Herald on September 28, 2011 - approximately two weeks prior to the meeting. The Corps e-mailed an electronic newsletter to relevant agency and tribal contacts for distribution to respective e-mail lists.

The public scoping meeting was held October 6, 2011, in Fife, Washington. The scoping meeting provided an overview of the study, identified the project purpose and need, identified preliminary measures and described the NEPA process. A total of 13 communications were submitted during the comment period: one comment form submitted during the scoping meeting, six verbal comments given during the scoping meeting, one mailed comment form, and five e-mail comments. Each communication was analyzed and categorized into the themes listed in Table 7-1 below; many included multiple comments regarding different elements of the study.

Table 7-1. Public Scoping Meeting Comment Summary

Category	Number of Comments	Key Concerns
Adaptive management and monitoring	1	Development of a plan to ensure the success of mitigation measures and provide management flexibility to incorporate new research and information.
Air quality and emissions	1	EIS should contain an analysis of emissions from construction, vehicle use, and equipment use.
Alternative selection/analysis	5	Comments specifically asked that the study analysis include or address: maintenance, replacement, or additional installation of structural flood mitigation measures, utilization of non-structural measures; importance of natural process and habitat restoration; prioritization of environmental benefits and mitigation of environmental impacts; channel maintenance and construction; sediment management; digging or dredging; economic development techniques.
Aquatic habitat protection and restoration	9	Recognizing adverse impacts of existing structural flood mitigation measures on aquatic habitat; requesting prioritization of future flood risk mitigation techniques that provide aquatic habitat restoration; importance of healthy aquatic habitat was cited to have biological, water quality, economic, and cultural significance to the Puyallup River Basin and its residents.
Climate change	2	Climate change effects relevant for this study include changes in hydrology, weather patterns and precipitation rates; the EIS should discuss project alternatives in relation to climate change mitigation strategies.
Cultural and historic resources	3	Follow Section 106 of the National Historic Preservation Act, but not allow attention to Section 106 review to cause analysts to give insufficient consideration to other kinds of cultural resources; the efforts must be made to respect tribal cultural interests, values and modes of expression; common tribal issues of concern include: reservation lands, trust and treaty resources, grave and burial sites, off-reservation sacred sites, hunting, fishing and gathering areas and historic properties and other cultural resources.
Cumulative and indirect impacts	1	Comment includes the EPA issued guidance on how they are to provide comments on the assessment of cumulative impacts and the elements required for an adequate cumulative effects' analysis.
Economic development/risk	5	Potential economic development opportunities resulting from flood risk mitigation included job creation, rising property values, investment opportunity, and an increase in residential population; concerns for protection of certain existing buildings and residents; potential economic benefit from purchasing real estate from property owners in the flood-prone riparian zone.

Endangered species	2	Comment on preventing any breach of sewage into the river assists ESA listed fish; EIS should identify ESA listed species and designated critical habitat within the project area, identify impacts the project would have to ESA listed species and coordinate/consult with the USFWS and NMFS.
Environmental justice	2	Compliance with EO 12898 and following Council on Environmental Quality guidance on addressing Environmental Justice in the environmental review process; respect tribal cultural interests, values, and modes of expression.
Flooding	2	Suggestion of a channel diversion that runs from the Puyallup to before MMD; consideration of USGS work on sediment inputs to the system during the analysis of project alternatives.
Human health and protection	2	Protection of the existing infrastructure already in place for example hospital, bridge, or housing development; human life and employment centers would get a priority in terms of protection; important to have preventative flood wall projects as a priority.
Mud Mountain Dam	5	Dam mentioned as a topic to be addressed in the study; comments discussed harms to and potential impacts on aquatic and vegetative habitat; risks involved with the dam's operations; benefits the dam offers to the community.
NEPA process/EIS	3	The EIS needs to have a purpose and need statement that should be stated as a positive outcome that is expected; special efforts must be taken to avoid disproportionate adverse environmental impacts on Tribes and allow for their full participation in the NEPA process.
Non-structural measures	2	The study should consider alternatives that would use levee setbacks and non-structural measures and not limit consideration of these measures to sites below the Meridian Street Bridge in Puyallup; costs of maintaining structural measures should be compared to the costs for implementing non-structural measures; prioritize non-structural measures where floodplain development is relatively limited and in conjunction with any structural measures to be employed.
Project funding and timeline	3	Comments stressed the importance of having a plan fully funded and implemented as soon as possible; requests to accelerate the study.
River channel maintenance	4	Comments tended to identify specific alternatives for flood risk mitigation, ranging from dredging to construction of a channel between Puyallup and MMD.
Sediment management	5	Suggested sediment management as a potential alternative for flood risk management in the basin. Noted sediment concerns, including soil composition, buildup, high levels of aggradation and increased localized deposition of sediment. Sediment concerns harmfully impact aquatic species, vegetation, and flooding and any future sediment management methods should minimize any environmental effects.

Structural measures	4	Many comments included various structural measures to mitigate flood risk. Suggestions included construction and maintenance of drain pipes, drain ports, tide gates, pumping, flood walls and levees.
Transportation	1	Every type of transportation is impacted, including roads to get freight to the airports.
Tribal consultation	8	Many comments discussed the topic of tribal consultation throughout the EIS process. Mentioned legal requirements for government-to-government Tribal consultation; issues respecting the Tribes' cultural, environmental, and economic concerns including hunting, fishing and gathering areas. The Muckleshoot Indian Tribe Fisheries Division asked for close collaboration with the Corps throughout the NEPA process.
Vegetation habitat and management	3	Comments included the importance of large woody debris in the channel as well as riparian vegetation next to the river; discuss structural measures or flood control facilities to be enrolled in the Corps P.L. 84-99 program and how that relates to vegetation maintenance; prepare a vegetation management plan to address noxious weeds/exotic plants that occur in the project corridor.
Water quality/contamination	3	Comments included the EIS must meet the requirement of the CWA, disclose information regarding Total Maximum Daily Load allocations, water quality standards, pollutants of concern, and 303(d) listed waters should not be further degraded; watershed or aquatic habitat restoration activities should be considered to compensate for past impacts to water resources.

7.3 DFR / EIS Public Review

The public comment period, during which any person or organization may comment on the DFR/EIS, is mandated by State and Federal laws. For this study, the DFR/EIS public comment period will formally run for 45 days beginning in February 2016 and ending in March 2016. The Corps and County will host one public meeting in the study area during the public review period. Comments will be accepted during the public meeting and via mail, fax or email. The Corps will consider all comments received during the comment period. The complete list of comments on the DFR/EIS and the Corps' responses will be included as an appendix to the final FR/EIS.

7.4 Agency and Tribal Government Consultation and Coordination Process

The Corps is consulting and/or coordinating with appropriate Federal, State and local interests, environmental groups and other interested parties.

7.4.1 Federal Agencies

The Corps is coordinating with USFWS in compliance with the Fish and Wildlife Coordination Act. NEPA regulations encourage agencies to formally agree to cooperating agency status, thus ensuring their expertise will be applied when formulating feasible alternative plans. As noted in Section 0, FEMA is a cooperating agency for this study.

7.4.2 State Agencies

The Corps is coordinating with the WDFW, WDOE and Washington SHPO to seek input on this project.

7.4.3 Indian Tribes

The Corps has engaged in formal and informal consultation with the Puyallup Tribe of Indians and Muckleshoot Indian Tribe throughout the Study. Tribal consultation will continue throughout the feasibility phase, preconstruction engineering and design, and construction in accordance with Executive Order 13175 Consultation and Coordination with Indian Tribal Governments. In addition, the Corps will continue to consult with the tribes with regard to Section 106.

7.5 Additional Coordination and Consultation

The following Federal and State agencies, federally recognized tribes, and non-governmental organizations have been involved during the feasibility study:

- U.S. Environmental Protection Agency
- Federal Emergency Management Agency
- National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- Washington Department of Fish and Wildlife
- Washington Department of Transportation
- Puyallup Tribe of Indians
- Muckleshoot Indian Tribe
- Squaxin Island Tribe
- Snoqualmie Tribe
- Yakama Nation
- Nisqually Indian Tribe

7.6 Peer Review Process

In 2010, the Corps developed the Review Plan for the study (USACE 2010b), which the Corps FRM Planning Center of Expertise (FRM-PCX) endorsed and the Corps' Northwestern Division approved. Peer review for the study was designed to meet all pertinent Corps policies (e.g. Engineering Circulars [EC] including EC 1165-2-214 (USACE 2012)). This plan requires external review of the project's technical reports as well as the draft and final FR/EIS. The study has adhered to this guidance and completed District Quality Control (DQC) and Agency Technical Review (ATR) on feasibility phase deliverables. This DFR/EIS will undergo DQC, ATR, and Independent External Peer Review (IEPR). Once complete, DQC, ATR, and IEPR reports will be included in the final FR/EIS. The IEPR report will also be posted to the Corps web site for public access and transmitted to Congressional committee.

8 Recommendation

The following text is draft, and will be included in the final FR/EIS, pending public review, policy review, technical reviews, and subsequent comments and revisions:

I have considered all significant aspects of this project, including environmental, social and economic effects; and engineering feasibility. I recommend that the tentatively selected plan for flood risk management for the Puyallup River Basin project area as generally described in this report be authorized for implementation as a Federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. The estimated first cost of the recommended plan is $341,144,000. Operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) expenses are estimated to be approximately $600,000 per year at this time. The Federal portion of the estimated first cost is $221,744,000. The non-Federal sponsors' portion of the required 35% cost share of total project first costs is $119,400,000. The non-Federal partner shall, prior to implementation, agree to perform the following items of local cooperation:

a. Provide the non-federal share of total project costs, including a minimum of 35 percent but not to exceed 50 percent of total costs of the NED Plan, as further specified below:

1. Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide, during construction, a contribution of funds equal to 5 percent of total costs of the NED Plan;

3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the project;

4. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total costs of the NED Plan;

b. Shall not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal obligations for the project, unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project;

c. Not less than once each year, inform affected interests of the extent of protection afforded by the flood risk management features;

d. Agree to participate in and comply with applicable federal flood plain management and flood insurance programs;

e. Comply with Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), which requires a non-federal interest to prepare a flood plain management plan within one year after the date of signing a project partnership agreement, and to implement such plan not later than one year after completion of construction of the project;

f. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood risk management features;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of flood risk management the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. For so long as the project remains authorized, OMRR&R of the project, or functional portions of the project, including any mitigation features, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government;

j. Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

k. Hold and save the United States free from all damages arising from the construction, OMRR&R of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

m. Comply with all applicable federal and state laws and regulations, including, but not limited to Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;

o. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, OMRR&R of the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-Sb), and Section l03G) of the WRDA 1986, Public Law 99-662, as amended (33 U.S.C. 2213G)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

The recommendations contained herein reflect the information available at this time and current departmental policies governing the formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national civil works construction program or the perspective of higher levels within the executive branch. Consequently, the recommendations may be modified before they are transmitted to Congress for authorization and/or implementation funding. However, prior to transmittal to Congress, the State of Washington, interested Federal agencies, and other parties will be advised of any significant modifications in the recommendations and will be afforded an opportunity to comment further.

JOHN G. BUCK
Colonel, Corps of Engineers
District Commander

9 List of Preparers*

The following individuals participated in the preparation of this integrated FR/EIS:

Name	Education/Experience	Responsibility
U.S. Army Corps of Engineers		
Lynn Wetzler	M.P.A.; 7 years experience	Project Manager
Donald Kramer	M.P.A., M.U.P. Public Administration and Urban Planning; 6 years experience	Plan Formulation
Keely Brown	M.P.A., M.S.P. Public Administration and Urban and Regional Planning; 11 years experience	Plan Formulation
Michael Scuderi	B.A., M.A., PhC. Geography ; 32 years experience	Environmental Coordinator; Wetland Riparian Habitat
Amanda Ogden	B.S. Sustainable Resource Sciences, M.S. Forest Soils; 7 years experience	Environmental Coordinator
Charyl Barrow	B.S. Economics; 8 years experience	Economics
Karah Haskins	B.S., Earth and Space Science, 5 years experience	HTRW
Deborah Johnston	M.S. Marine Sciences; 26 years experience	HTRW
Rolla Queen	M.A. Anthropology / Historic Preservation; 37 years experience	Cultural Resources
Danielle Storey	M.A Anthropology; 14 years experience	Cultural Resources
Bobbi Jo McClain	M.S. Environmental Forest Biology; 13 years experience	Wildlife, Wetland Habitat, Endangered Species
Chemine Jackels	M.S. Biological Sciences (with focus on fish and aquatic biology); 11 years experience	Fish and Invertebrates, Aquatic Habitat, Endangered Species
Hannah Hadley	B.A. Anthropology; 10 years experience	Agriculture, Air Quality
Lee Ford	B.S. Civil Engineering; PE; 9 years experience	Technical Lead and Civil Design
Patrick Wheeler	B.S. Civil Engineering; PE; 12 years experience	Hydrology & Hydraulics
Brendan Comport	M.S. Civil Engineering; PE; 5 years experience	Hydrology & Hydraulics
Michael Gonia	B.S Civil Engineering; PE; 5.5 years experience	Geotechnical Design
Alan Heninger	MEng Civil Engineering; PE; 5 years experience	Structural Engineering
Antonio Rodriguez	B.S. Civil Engineering; Certified Cost Consultant; 6 years experience	Cost Engineering
Doris Cope	MBA, M.S. Advanced Management, 5 Years Cost Share Experience	Real Estate
Diane Hintz	B.S. Industrial Engineering; 20 years experience	Real Estate
Scott Campbell	M.S. Geographic Information Systems and Remote Sensing; 11 years experience	GIS Development
Lisa Hansen	B.A. Sales & Marketing Education; 15 years experience	Technical Editor
Pierce County		
Harold Smelt		Surface Water Management
Helmut Schmidt		Surface Water Management
Randy Brake		Surface Water Management

10 References

Access Washington. 2011a. Nonattainment Areas in Washington, in: Air Quality. Washington State Department of Ecology; Olympia, Washington. Accessed: August 31, 2011. Available at: http://www.ecy.wa.gov/programs/air/Nonattainment/Nonattainment.htm.

Ames, K.M. and H.D.G. Maschner. 1999. People of the Northwest Coast: Their Archaeology and Prehistory. Thames and Hudson, Ltd., London, 1999.

Auburn (City of Auburn). 2005. Parks, Recreation and Open Space Plan 2005. Auburn Parks and Recreation; Auburn, Washington.

Auburn Municipal Airport. 2013. Airport Master Plan. Accessed 15 October 2013. Online at: http://www.centurywest.com/aviation-planning-projects/auburn-municipal-airport-airport-master-plan/.

Berger, A., R. Conrad, and J. Paul. 2010. Puyallup River Juvenile Salmonid Production Assessment Project 2010. Puyallup Tribal Fisheries Department; Puyallup, Washington.

BOLA Architecture and Planning. Puyallup Historic Survey Report, Puyallup, Washington. Seattle, Washington, 2007.

Brooks, K., K.M. Dvornich, M. Tirhi, E. Neatherlin, M. McCalmon, and J. Jacobson. 2004. Pierce County Biodiversity Network Assessment: August 2004. Report to Pierce County Council. Pierce County, Washington, 146 pp.

Carlson, R.L. 1990. Cultural Antecedents. In Handbook of North American Indians Vol. 7, edited by Wayne Suttles, Smithsonian Institution, Washington DC, 1990

Cascade Water Alliance. 2008. Fact Sheet on White River Management Agreement and Related Settlement Agreements between Cascade Water Alliance and the Muckleshoot and Puyallup Tribes. Accessed 17 October 2013. Online at: http://cascadewater.org/pdf/watersupply/PressRelease2008-06.pdf.

Casola, J.H., J.E. Kay, A.K. Snover, R.A. Norheim, L.C. Whitley Binder, and the Climate Impacts Group. 2005. Climate Impacts on Washington's Hydropower, Water Supply, Forest, Fish, and Agriculture. Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, October.

Central Dredging Association. 2011. CEDA Position Paper: Underwater Sound in Relation to Dredging. www.dredging.org.

Chappell, C.B., R.C. Crawford, C. Barrett, J. Kagan, D.H. Johnson, M. O'Mealy, G.A. Green, H.L. Ferguson, W.D. Edge, E.L. Greda, and T.A. O'Neil. 2001. Wildlife Habitats: Descriptions, Status, Trends and System Dynamics, in: D. H. Johnson, T. A. O'Neil (Eds), Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, pp. 22-114.

Council on Environmental Quality (CEQ). 2010. Federal Greenhouse Gas Accounting and Reporting, Final Guidance. 75 FR 63823.

Crawford, B.A. and S.M. Rumsey. 2011. Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead listed under the Federal Endangered Species Act. National Marine Fisheries Service, NW Region, 160pp.

Czuba, J.A., Magirl, C.S., Czuba, C.R., Curran, C.A., Johnson, K.H., Olsen, T.D., Kimball, H.K., and Gish, C.C. 2012. Geomorphic analysis of the river response to sedimentation downstream of Mount Rainier, Washington: U.S. Geological Survey Open-File Report 2012-1242, 134 p.

David Evans & Associates, 1991. Commencement Bay Cumulative Impact Study Vol. 1: Assessment of Impacts and Volume 2: Restoration/Mitigation Options. Bellevue, Washington.

Duncan, J.M., 2000, *Factors of Safety and Reliability in Geotechnical Engineering*, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 126, No. 4.

Ebbert, J.C. 2002. Concentrations of Dissolved Oxygen in the Lower Puyallup and White Rivers, Washington, August and September 2000 and 2001. US Geological Survey, Water-Resources Investigations Report 02-4146, 40pp.

Ecology. 2013. Coastal Atlas Map. Accessed 18 October 2013. Online at: https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx.

ECONorthwest. 2007. Economic Connections Between the King County Floodplains and the Greater King County Economy. Eugene, Oregon.

Epsilon Associates, Inc. 2006. Hudson River PCBs Superfund Site, Phase 1 Final Design Report, Attachment J – Noise Impact Assessment. Prepared for General Electric Company. Accessed: 11 October 2013. Online at: http://www.epa.gov/hudson/pdf/2006_03_21%20Phase%20I%20FDR%20ATTACHMENT%20J.pdf.

EVS. 1996. Commencement Bay Damage Assessment Studies: Hylebos Waterway Data and Data Analysis Report. Prepared for Commencement Bay Natural Resource Trustees. EVS Environment Consultants; Seattle, Washington. February 1996.

Federal Register. 1970. List of Endangered Foreign Fish and Wildlife, Title 50 CFR Part 17. Federal Register 35, No. 233, 18319-18322.

Federal Register. 1999. Endangered and Threatened Species: Threatened Status for Three Chinook Salmon Evolutionarily Significant Units (ESUs) in Washington and Oregon, and Endangered Status of One Chinook Salmon ESU in Washington; Final Rule, Title 50 CFR Part 17. Federal Register 65, No. 56., 14308-14328.

Federal Register. 2005a. Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales, Title 50 CFR Part 224. Federal Register 70, No. 22, 69903-69912.

Federal Register. 2005b. Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho; Final Rule; Title 50 CFR Part 226, Docket No. 030716175–5203–04; I.D. No. 070303A. Federal Register 70, No. 170, 52630-52858.

Federal Register. 2006. Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale, Final Rule, Title 50 CFR Part 226, Docket No. 060228057–6283–02; I.D. 022206D. Federal Register 71, No 229, 69054-69070.

Federal Register. 2007a. Endangered and Threatened Species: Final Listing Determination for Puget Sound Steelhead, Final Rule, Title 50 CFR Part 223. Federal Register 72, No. 91, 26722-26735

Federal Register. 2010a. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States; Final Rule. Title 50 CFR Part 17. Federal Register 75, No. 200, 63898-64070.

Federal Register. 2010b. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Population Segment of Eulachon; Final Rule. Title 50 CFR 223. Federal Register 75, 13012-13024.

Federal Register. 2013. Endangered and Threatened Wildlife and Plants; Proposal to designate critical habitat for lower Columbia River coho salmon and Puget Sound steelhead; request for comments. Title 50 CFR Part 226. Federal Register 78, No. 9, 2725-2796.

Ford, J.K.B., G.M. Ellis, and P.F. Olesiuk. 2005. Linking prey and population dynamics: did food limitation cause recent declines of 'resident' killer whales (*Orcinus orca*) in British Columbia. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Report no. 2005/042. 27 p.

Ford, J. K. B., B. M. Wright, G. M. Ellis, and J. R. Candy. 2010. Chinook salmon predation by resident killer whales: seasonal and regional selectivity, stock identity of prey, and consumption rates. DFO Canadian Science Advisory Secretariat Research Document 2009/101.

Gallacci, C.D. 2001. The City of Destiny and the South Sound: An Illustrated History of Tacoma and Pierce County. Heritage Media Corp., Carlsbad, California, 2001.

GeoEngineers, Inc. 2008. Levee Setback Feasibility Analysis: Puyallup River Watershed. Redmond, Washington.

Glick, P., J. Clough, and B. Nunley, 2007. Sea-level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon. National Wildlife Federation; Reston, Virginia.

Gore, J.A. 1982. Benthic invertebrate colonization: source distance effects on community composition. Hydrobiologia. 94: 183-193

Hasler, A.D. and W.J. Wisby. 1951. Discrimination of stream odors by fishes and its relation to parent stream behavior. American Naturalist. 85:223-238.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life Histories. Vancouver: UBC Press.

Haas, M.E., C.A. Simenstad, J.R. Cordell, D.A. Beauchamp and B.S. Miller. 2002. Effects of Large Overwater Structures on Epibenthic Juvenile Salmon Prey Assemblages in Puget Sound, Washington. Research Report, Research Project Agreement T1803, Task 30. Report No. WA-RD 550.1, 114pp.

Hastings, M.C. 1995. Physical effects of noise on fishes. Inter-noise 95, the 1995 International congress on noise control Engineering Vol 2: 979-984

Heitke, J.D., E.A. Archer, B.B. Roper. 2010. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes.

Herrera (Herrera Environmental Consultants, Inc.). 2007. Reach Analysis: White River, Pierce County, Washington. Prepared for the Washington Department of Transportation. Herrera Environmental Consultants, Inc.; Seattle, Washington.

Jeffries, S.J., P.J. Gearin, H.R. Huber, D. L. Saul, and D. A. Pruett. 2000. Atlas of Seal and Sea Lion Haulout Sites in Washington. Washington Department of Fish and Wildlife, Wildlife Science Division, and National Marine Fisheries Service, National Marine Mammal Laboratory; Olympia and Seattle, Washington. February 2000.

Kerwin, John. 1999. Salmon Habitat Limiting Factors Report for the Puyallup River Basin (Water Resource Inventory Area 10). Washington Conservation Commission; Olympia, Washington.

King County. 2002. Comprehensive Emergency Management Plan. Seattle, Washington.

King County. 2004. Historical Channel Locations of the White River. RM 5- RM28. Seattle, Washington.

King County. 2006. King County Flood Hazard Management Plan. Seattle, Washington.

King County. 2008. King County Biodiversity Report. Prepared by the Local Action for Biodiversity Group and King County, Seattle, Washington. 2008.

King County (website). 2011. King County Geographic Information Services Center (KCGIS): Sensitive Area Ordinance Wetland Areas Geodatabase. Accessed: September 1, 2011. Available at: http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=sao_wetland.

Knutson, K. L., and V. L. Naef. 1997. Management recommendations for Washington's priority habitats: riparian. Wash. Dept. Fish and Wildl., Olympia. 181pp.

Kondolf, G.M. 1997. Application of the Pebble Count: Reflections on Purpose, Method, and Variants. Journal of the American Water Resources Association, Vol. 33, No. 1, 1997, pp. 79-87.

Kondolf, G.M., M. Smeltzer, and L. Kimball. 2002. Freshwater Gravel Mining and Dredging Issues. White paper prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation. Center for Environmental Design Research, Berkeley, CA.

Krahn, M.M., M.J. Ford, W.F Perrin,P.R. Wade, R. P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitao, M.E. Dalheim, J.E. Stein, & R. S. Waples. 2004. 2004 status review of southern resident killer whales (Orcinus orca) under the Endangered Species Act. U.S. Dept. Commerce. NOAA Technical Memo. NMFS-NWFSC 62, 73pp.

Ladley, Russ. 2013. Puyallup Tribe. Email conversation on 27 March 2013.

LaMuth, Jackie. 2008. The Invisible Environment Fact Sheet Series: Noise. Publication: CDFS-190-08. Ohio State University Extension; Columbus, Ohio.

Lee, Se-Yeun and A. F. Hamlet. 2011. Skagit River Basin Climate Science Report, a summary report prepared for Skagit County and Envision Skagit Project by the Department of Civil and Environmental Engineering and The Climate Impacts Group at the University of Washington.

Leopold, L., Wolman, M.G., and Miller, J.P. 1964. Fluvial processes in geomorphology: San Francisco, W.H. Freeman and Company, 522 p.

Littell, J.S., E.E. Oneil, D. McKenzie, J.A. Hicke, J.A. Lutz, R.A. Norheim, and M.M. Elsner. 2009. Forest Ecosystems, Disturbances, and Climatic Change in Washington State, USA. In: Littell, J.S., et al. (Eds), Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate. University of Washington Climate Impacts Group; Seattle, Washington.

Mackay, R.J. 1992. Colonization by lotic macroinvertebrates: a review of processes and patterns. Canadian Journal of Fisheries and Aquatic Sciences 49:617-628

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. In: Littell, J.S., et al. (Eds), Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate. University of Washington Climate Impacts Group; Seattle, Washington.

Marks, E.L., R.C. Ladley, B.E. Smith, and T.G. Sebastian. 2007. 2006-2007 Annual Salmon, Steelhead, And Bull Trout Report: Puyallup/White River Watershed Water Resource Inventory Area 10. Puyallup Tribe of Indians Fisheries Division; Puyallup, Washington.

Mastin, M.C., A.S. Gendaszek, and C.R. Barnas, 2010. Magnitude and Extent of Flooding and Selected River Reaches in Western Washington. Scientific Investigations Report 2010-5177. U.S. Geological Survey; Washington, D.C. Prepared in cooperation with the Federal Emergency Management Agency.

Mathieu, N. and C. James. 2011. Puyallup River Watershed Fecal Coliform Total Maximum Daily Load – Water Quality Improvement Report and Implementation Plan. Publication Number 11-10-040.

Matson, R.G., and G. Coupland. The Prehistory of the Northwest Coast. Academic Press, San Diego, 1995.

Mays, L. W., 2005. Water Resources Engineering, John Wiley & Sons, Inc.

Morgan, M. and R. Morgan. 1983. South on the Sound: An Illustrated History of Tacoma and Pierce County. Windsor Publications, Woodland Hills, California, 1983.

Mumford, T.F. 2007. Kelp and Eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2005. Summary of Scientific Conclusions of the Review of the Status of Puget Sound Steelhead. July 26, 2005.

NMFS. 2011. 2011 Implementation Status Assessment. Prepared by Lighthouse Natural Resource Consulting, Inc. Online at: http://www.nwr.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/puget_sound/chinook/implement-rpt.pdf. Accessed 20 Sept 2013.

NMFS. 2013b. Bocaccio (Sebastes paucispinis). Online at: http://www.nmfs.noaa.gov/pr/species/fish/bocaccio.htm. Accessed 13 August 2013.

NMFS. 2013c. Canary Rockfish (Sebastes pinniger). Online at: http://www.nmfs.noaa.gov/pr/species/fish/canaryrockfish.htm. Accessed 13 August 2013.

NMFS. 2013d. Yelloweye Rockfish (Sebastes ruberrimus). Online at: http://www.nmfs.noaa.gov/pr/species/fish/yelloweyerockfish.htm. Accessed 13 August 2013.

NMFS. 2013e. Pacific Eulachon/Smelt (Thaleichthys pacificus). Online at: http://www.nmfs.noaa.gov/pr/species/fish/pacificeulachon.htm. Accessed 13 August 2013.

NMFS. 2013f. Species under the Endangered Species Act (ESA). In: Office of Protected Resources. Accessed: August 30, 2013. Updated: August 13, 2013. Available at: http://www.nmfs.noaa.gov/pr/species/esa/.

NMFS, U.S. Fish and Wildlife Service, Federal Highway Administration, Ca Department of Transportation, CA Department of Fish and Game, OR Department of Transportation, and WA Department of Transportation. 2008. Memorandum: Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving. Accessed online at: http://www.wsdot.wa.gov/NR/rdonlyres/4019ED62-B403-489C-AF05-5F4713D663C9/0/InterimCriteriaAgreement.pdf

National Park Service. National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation. U.S. Government Printing Office, Washington, D.C., 1997.

Navin, M.P., Vroman, N.D., Schwanz, N.T., and Farmer, B.M. 2011. *Development of Risk Assessment Methods with Regard to Internal Erosion for Corps of Engineers Levees*, Proceedings from ICOLD workshop, Czech Republic.

Nelson, C. M. Prehistory of the Puget Sound Region. In Handbook of North American Indians Vol. 7, edited by Wayne Suttles, Smithsonian Institution, Washington DC, 1990

Northern Economics. 2011. *Socioeconomics of the Puyallup River Basin General Investigation Study Area.* Bellingham, Washington.

Osborne, R.W. 2008. The Whale Museum, Southern Resident Killer Whale Sighting Compilation 1990-2008.

PFMC (Pacific Fishery Management Council). 1999. Appendix A: Identification and Description of Essential Fish Habitat, Adverse Impacts, and Recommended Conservation Measures for Salmon. Amendment 14 to the Pacific Coast Salmon Plan. Portland, Oregon. August 1999.

Pierce County. 2002. Pierce County Buildable Lands Report: A Monitoring and Evaluation Analysis of Urban Growth and Development Capacity for Pierce County and its Cities and Towns. Funding provided by the Washington State Department of Community Trade and Economic Development. September 2002.

Pierce County. 2005. Mid-Puyallup Basin Plan. Pierce County Public Works and Utilities Water Programs Division; University Place, Washington.

Pierce County. 2008a. Pierce County Flood Risk Assessment, Pierce County Public Works & Utilities Water Programs Division. Tacoma, Washington.

Pierce County. 2008b. Pierce County Environmental Health Trends 2008. Tacoma | Pierce County Health Department.

Pierce County. 2009. County Wetland Inventory. Prepared by the Pierce County Department of Planning and Land Services. Plot Date: September 16, 2009.

Pierce County. 2010b. Rivers Flood Hazard Management Plan Economic Analysis. Final Report. Prepared by Entrix, Inc., for Pierce County Public Works and Utilities, Surface Water Division, Tacoma, Washington. October 2010.

Pierce County. 2012a. Salmon Habitat Protection and Restoration Strategy. Accessed 17 October 2013. Online at: http://www.co.pierce.wa.us/documentcenter/view/4029.

Pierce County. 2012b. Pierce County Flood Hazard Management Plan EIS. Accessed 24 July 2014. Online at: http://www.piercecountywa.org/Archive.aspx?AMID=118.

Pierce County. 2013. Pierce County Flood Hazard Management Plan, Pierce County Public Works & Utilities Water Programs Division. Tacoma, Washington.

Plotnikoff, Robert W. 1992. Timber/Fish/Wildlife Ecoregion Bioassessment Pilot Project. Publication No. 92-63. Washington Department of Ecology, Environmental Investigations and Laboratory Services Program, Watershed Assessments Section; Olympia; Washington.

Port of Seattle. 2013. About the Port Website. Accessed 15 October 2013. Online at: http://www.portseattle.org/About/Pages/default.aspx.

Port of Tacoma. 2014. Economic Impact. Accessed 25 January 2016. Online at: http://portoftacoma.com/sites/default/files/POT_EconomicImpactsOnePager2014.pdf.

PSCAA (Puget Sound Clean Air Agency), 2007. Fine Particulate Matter Non-Attainment Area Recommendation for the Tacoma Area. Puget Sound Clean Air Agency; Seattle, Washington.

PSCAA. 2011a. 2009 Air Quality Data Summary. Puget Sound Clean Air Agency; Seattle, Washington.

PSCAA (website). 2011b. Tacoma Pierce County Wood Smoke Reduction Program. Puget Sound Clean Air Agency; Seattle, Washington. Accessed: September 1, 2011. Available at: http://www.pscleanair.org/programs/community/woodstove.replacement/.

PSRC (Puget Sound Regional Council). 2009. Vision 2040: The Growth Management, Environmental, Economic, and Transportation Strategy for the Central Puget Sound Region. Adopted April 24, 2008. Amended May 28, 2009.

PSRC. 2011. Puget Sound Trends. Online at: http://www.psrc.org/assets/6085/trend-d9.pdf. Accessed 24 July 2014.

Ruby, R.H., J.A. Brown. 1992. A Guide to the Indian Tribes of the Pacific Northwest. University of Oklahoma Press, Norman, Oklahoma, 1992.

SAS (Seattle Audubon Society, website). 2013. BirdWeb. Seattle Audubon Society; Seattle, Washington. Accessed: August 30, 2013. Available at: http://www.birdweb.org/birdweb.

Saucier, C., Howard, I., and Tom Jr., J., 2009, *Levee Breach Geometries and Algorithms to Simulate Breach Closure*, Southeast Region Research Initiative (SERRI) Report (70015-001), Mississippi State.

Shared Strategy Development Committee, 2007. Puget Sound Salmon Recovery Plan. Prepared for National Marine Fisheries Service. Shared Strategy for Puget Sound; Seattle, Washington. January 19, 2007. Volumes I and II.

Simenstad, Charles A., 2000. Commencement Bay Aquatic Ecosystem Assessment – Ecosystem-Scale Restoration for Juvenile Salmon Recovery. SoF-UW-2003. Prepared for City of Tacoma, Washington Department of Natural Resources, and U.S. Environmental Protection Agency. School of Fisheries, University of Washington; Seattle, Washington.

Snyder, D.E., P.S. Gale, and R.F. Pringle, 1973. Soil Survey of King County Area, Washington. U.S. Department of Agriculture, Soil Conservation Service in cooperation with the Washington Agricultural Experiment Station; Washington, D.C.

StreamNet. 2013. Fish Distribution. Accessed: August 27, 2013. Available at: http://q.streamnet.org

SEI (Sustainable Ecosystems Institute). 2013. Endangered Species: Marbled Murrelet. Accessed: August 30, 2013. Available at: http://www.sei.org/murrelet.html.

Suttles, W. and B. Lane. 1990. Southern Coast Salish. In Handbook of North American Indians Vol. 7, edited by Wayne Suttles, Smithsonian Institution, Washington DC, 1990.

Tetra Tech. 2008. Lower Puyallup River Flood Protection Investigation: Without Project Condition Analysis. Seattle, Washington.

Tetra Tech, Northwest Hydraulic Consultants, ESA Adolfson, and Shannon & Wilson, 2009. Lower Puyallup River Flood Protection Investigation: Without-Project Analysis. Prepared for Pierce County Public Works and Utilities Surface Water Management. Tetra Tech; Seattle, Washington. June 2009.

USACE. 2002. General Investigation Reconnaissance Study, Puyallup/White River Watershed, Washington. Seattle District.

USACE. 2008. Navigable water of the U.S. in Washington State. Accessed 15 October 2013. Online at: http://www.nws.usace.army.mil/Portals/27/docs/regulatory/permit%20guidebook/Navigable_Waters_of_the_US_in_WA_State.pdf

USACE. 2009a. *Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System Final Report of the Interagency Performance Evaluation Task Force, Volume VIII – Engineering and Operational Risk and Reliability Analysis*, June 2009.

USACE. 2009b. Mud Mountain Dam: White and Puyallup Rivers Channel Capacity Study. Seattle District.

USACE. 2010a. *Natomas Post-Authorization Changes Report*, Sacramento District.

USACE. 2010b. *Review Plan, Puyallup River Basin, Pierce County, Washington General Investigation*, Seattle District.

USACE. 2010c. Mud Mountain Dam Upstream Fish Passage, Vol 1, Post-Authorization Change Decision Document Mud Mountain Dam, White River, Washington. Seattle District.

USACE. 2010c. Puyallup River, WA, Reconnaissance Report. Seattle District.

USACE. 2012. ER 1165-2-214, *Water Resources Policies and Authorities – Civil Works Review*.

USACE. Unpublished. *Columbia River Treaty 2014/2024 Review Program Phase 2A Flood Risk Assessment Report, Appendix F, Levee Analysis*, Unpublished.

USDA (United States Department of Agriculture), National Agricultural Statistics Service. 2007 Census of Agriculture, Pierce County Profile, Washington. 2007. http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Washington/cp53053.pdf. Accessed 8 Jan 2016.

USDA, National Agricultural Statistics Service. 2012 Census of Agriculture, Pierce County Profile, Washington. 2012. http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Washington/cp53053.pdf. Accessed 8 Jan 2016.

U.S. Environmental Protection Agency (USEPA). 2011. Wetlands. Accessed: August 14, 2011. Updated: July 8, 2011. Available at: http://water.epa.gov/type/wetlands/index.cfm.

USGS. 2012. Geomorphic Analysis of the River Response to sedimentation Downstream of Mount Rainier, Washington; Open File Report 2012-1242.

USGS. 1995. Debris Flow, Debris, Avalanche, and Flood Hazards At and Downstream from Mount Rainier, WA.

USGS. 1997. Water quality in the Lower Puyallup River Valley and Adjacent Uplands, Pierce County, Washington (Water-Resources Investigations Report 86-4154). Tacoma, Washington.

U.S. Department of the Interior. YEAR. Channel and Floodplain Changes, 1931 to 2005, for a Section of the Puyallup River (RM 21.3 to RM 25.2), Pierce County, Washington. Report No. 86-68330-2009-01, Prepared by Lucille A. Piety. Denver, Colorado.

USFWS (U.S. Fish and Wildlife Service). 2004. Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (Salvelinus confluentus) Volume I (of II) Puget Sound Management Unit. Portland, Oregon. 389 + xvii pp.

USFWS. 2011. National Wetlands Inventory. Updated: August 19, 2011. Accessed: July 27, 2011. Available at: http://www.fws.gov/wetlands/.

USFWS. 2013a. Listed and proposed endangered and threatened species and critical habitat; candidate species; and species of concern in Pierce County. Accessed: August 28, 2013. Updated April 24, 2013. Available at: http://www.fws.gov/wafwo/speciesmap/PierceCounty042413pdf.pdf.

USFWS. 2013b. Critical Habitat Portal. U.S. Fish and Wildlife Service Environmental Conservation Online System; Washington, D.C. Accessed: August 28, 2013. Available at: http://criticalhabitat.fws.gov/crithab/.

U.S. Senate. 1936. Report on Puyallup River, Washington. USACE, Seattle District, 1936; Senate Committee Report, 74th Congress, 2nd Session. Washington, DC.

Vano, J.A., N. Voisin, L. Cuo, A.F. Hamlet, M. McGuire Elsner, R.N. Palmer, A. Polebitski, and D.P. Lettenmaier. 2009. Climate change on water management in the Puget Sound region, Washington, USA, in: Littell, J.S., et al. (Eds), Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate. University of Washington Climate Impacts Group; Seattle, Washington.

WDFW (Washington Department of Fish and Wildlife). 2013. Priority Habitat and Species. Accessed: August 29, 2013. Available at: http://wdfw.wa.gov/mapping/phs/.

WDNR (Washington Department of Natural Resources, website). 2013. GIS Data Set for Rare Plants and Ecological Communities, in: Reference Desk of Washington Natural Heritage Program. Accessed: August 27, 2013. Available from: http://www1.dnr.wa.gov/nhp/refdesk/gis/index.html.

WSDOT (Washington State Department of Transportation). 2012. Pierce County-Thun Field, 2012 Airport Economic Profile. Accessed 15 October 2013. Online at: http://www.wsdot.wa.gov/aviation/AllStateAirports/Puyallup_PierceCoThunField.htm

WSDOT. 2013. Advanced Training Manual Version 02-2031 for Biological Assessment Preparation. Accessed: 11 October 2013. Available at: http://www.wsdot.wa.gov/NR/rdonlyres/448B609A-A84E-4670-811B-9BC68AAD3000/0/BA_ManualChapter7.pdf

WSDOT and FHWA (Washington State Department of Transportation and Federal Highway Administration). 2006. Tier II Final Environmental Impact Statement, SR 167 Puyallup to SR 509. Cities of Puyallup, Fife, Edgewood, Milton, and Tacoma, Washington.

Wessen, G. 1985. A Resource Protection Planning Process Identification and Evaluation for Prehistoric Archaeological Resources in the Southern Puget Sound Study Unit. Ms. on file, Office of Archaeology and Historic Preservation. Olympia, Washington, 1985.

WRCC (Western Regional Climate Center, website). 2011. Climate of Washington. Desert Research Institute: Western Regional Climate Center; Reno, Nevada. Accessed: August 2, 2011. Available at: http://www.wrcc.dri.edu/narratives/WASHINGTON.htm.

World Organization of Dredging Associations. 2013. WODA Technical Guidance on Underwater Sound from Dredging. Guidance Paper.

Zulauf. A.S., 1979. Soil Survey of Pierce County Area, Washington. U.S. Department of Agriculture, Soil Conservation Service in cooperation with the Washington Agricultural Experiment Station; Washington, D.C.