Appendix A

Plan Formulation

Puyallup River Basin

Flood Risk Management Feasibility Study

Department of the Army
Seattle District, US Army Corps of Engineers

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Plan Formulation Appendix

Contents

List of Tables

1 Prior Studies, Reports and Existing Water Projects

The following is an annotated list of reports that informed this Study. A full list of references used in the DFR/EIS is documented in the References chapter of the main DFR/EIS document.

1.1 U.S. Army Corps of Engineers Reports

Puyallup River Basin Flood Risk Management - Report on the 79th Meeting of the USACE Committee on Channel Stabilization, Seattle, Washington – 16-18 September 2014, USACE, December 2014. This report documents the Seattle District consultation with the USACE Channel Stabilization Committee in 2014 on a range of issues in the Basin, including several specific issues related to the general investigation Study. Committee recommendations informed the scope of effort for sedimentation modeling and analysis to be conducted for the feasibility-level design analysis during the Study.

Report on Puyallup River, Washington. USACE, Seattle District, 1936; Senate Committee Report, 74th Congress, 2nd Session. The report to Congress submitted by the Chief of Engineers served as the basis for the initial implementation of flood risk management by the Corps within the Puyallup Basin. The recommendation was designed to complement existing flood risk management projects constructed by the Intercounty Improvement Commission (a King County-Pierce County partnership). The recommendation consists of construction of a dam and reservoir near Mud Mountain on the White River; flood-channel enlargement, construction of levees, revetments and bridge alterations through Tacoma, Washington on the lower Puyallup; and construction of bank protection on the upper Puyallup River. MMD was designed to limit flows during floods to 50,000 cfs in the lower Puyallup, the design capacity of the recommended flood-channel enlargement. This project was authorized for construction under the 1936 Flood Control Act and constructed in subsequent years without local cooperation (per Section 2, 1938 Flood Control Act).

General Investigation Reconnaissance Study, Puyallup/White River Watershed, Washington. USACE, Seattle District, December 31, 2002. The 2002 Puyallup / White River Watershed Reconnaissance Study was a preliminary analysis in accordance with the guidelines of Section 905(b) of the 1986 WRDA (Public Law 99-662) to determine if there was a Federal interest in conducting a General Investigation. The Study found there is a Federal interest in pursuing a detailed Feasibility Study in order to address local basin needs for ecosystem restoration and flood risk management. Pierce County was initially identified as the non-Federal sponsor. However, the Reconnaissance Report was not approved due to lack of non-Federal participation.

Mud Mountain Dam: White and Puyallup Rivers Channel Capacity Study, USACE, Seattle District, 2009. The intent of the Channel Capacity Study was to provide MMD water managers with updated channel capacity information for the White and Puyallup Rivers and will assist in determining short-term operational plans at MMD and to alert emergency personnel to potential trouble spots. The study area included RM 0 to 11 of the White River with special interest in the City of Pacific reach RM 5.0 to 6.3. On the Puyallup River, the study covers RMs 0 to 10, from the White River confluence to the mouth.

Mud Mountain Dam Upstream Fish Passage Project, FY 2015 Design and Execution Document, USACE Seattle District, 2015. This document describes the recommended fish passage facility design, construction/life cycle cost estimates and the anticipated schedule for completion of a fish passage facility at MMD. The document focuses on the Barrier Structure at the Buckley Site, the fish trap and haul facility

to be constructed at the Buckley location, and fish release sites upstream of MMD, as required for ESA compliance.

Puyallup River, WA, Reconnaissance Report, USACE, Seattle District, February 5, 2009 (NWD approved April 2010). The purpose of the Reconnaissance Study was to investigate flood risks within the Puyallup River Basin and to determine a Federal interest in continuing a feasibility-level evaluation of flood risk management. The Reconnaissance Study identified significant flood risks in the Puyallup River Basin and resulted in the finding that there is a Federal interest in continuing the study into the feasibility phase.

1.2 Pierce County Reports

Lower Puyallup River, North Levee Setback Hydraulic Modeling, Draft report, November 2014. The purpose of this report, prepared by Northwest Hydraulic Consultants, was to provide the County guidance to inform the feasibility-level design for the general investigation Study with regard to flood risk management in the lower eight miles of the Puyallup River through an evaluation of flood risk management measures.

Pierce County Rivers Flood Hazard Management Plan 2013. The purpose of this plan is to recommend regional policies, programs and projects to reduce risks to public health and safety; reduce public infrastructure and private property damage; reduce maintenance costs; and, improve habitat conditions, while protecting and maintaining the regional economy. The Flood Plan addresses the range of resource and policy issues facing local governments, resource managers, tribes, property owners and businesses and recommends specific actions that Pierce County and its partners can take to address river flooding and channel migration risks.

Lower Puyallup River Flood Protection Investigation: Without Project Condition Analysis. Tetra Tech, prepared for Pierce County. June 2008. This analysis determined existing and 50-year future conditions of the lower Puyallup River floodplain. The objective of the study was to address significant flood-related issues affecting communities along the lower Puyallup River; in addition, to assist in reducing the mapped floodplain area. Analyses in the report include: hydrology, preliminary geotechnical investigation of levees, sediment transport and deposition, hydraulic analysis, and economic analysis. The report concluded that sediments accumulating along the river bottom have raised river water levels so that the tops of the levees are no longer at least 3 feet above the required 1% ACE probability water levels as required for federal accreditation.

Levee Setback Feasibility Analysis: Puyallup River Watershed. GeoEngineers Inc, prepared for Pierce County. June 19, 2008. This report presents the results of a Levee Setback Feasibility Analysis for the Puyallup, Carbon and White Rivers in Pierce County, Washington. The study evaluated 32 setback projects that would best establish dynamic channel forming process, recapture lost flood storage and restore salmon habitat. The report includes a prioritization strategy for a total of 32 sites in the project area, including 20 sites on the Puyallup River, six sites on the Carbon River and six sites on the White River. Based on the evaluation criteria and assigned weighting values, the top site for each watershed were identified - South Fork on the Puyallup River, Alward Road on the Carbon River, and county line on the White River.

Pierce County Flood Risk Assessment, Pierce County Public Works & Utilities Water Programs Division, March 2008. This document is an assessment of flood hazard risk in unincorporated Pierce County, Washington. This Risk Assessment contains the raw data that can be used to measure the net benefit of

actions that will reduce flood risk, be compared against the cost of the no action, and determine if the action is cost effective. This assessment determines risk based on two components: 1) the probability that an event will occur and 2) the impact the event will have on people, property, and the economy. Risk Assessment is the process of measuring the potential impacts to these components from a single- and multiple –natural hazards.

Historical Channel Locations of the White River. RM 5- RM28, King County, WA, October 19, 2004. This report used geographic information systems (GIS) to map White River historical channel locations from the King County line upstream to MMD, utilizing aerial photographs between 1931 and 2000, and General Land Office plat maps from 1867-1891. LiDAR (i.e. remote sensing) mapping of historical channel zones indicates that the White River has occupied nearly its entire floodplain in the recent past; how many years removed from the present is not known without field study. It is also likely that a large portion of the floodplain channels detectable by LiDAR imagery remain active currently. This in turn would imply that the White River, when defined as the river and its floodplain sloughs, at present occupies nearly its entire floodplain.

1.3 King County Reports

2013 King County Flood Hazard Management Plan Update and Progress Report, November 2013. This plan amends the 2006 King County Flood Hazard Management Plan for the Community Rating System. The National Flood Insurance Program's Community Rating System requires an update every five years to King County's Flood Hazard Management Plan. This update to the 2006 King County Flood Hazard Management Plan reflects new information on hazards, vulnerabilities, accomplishments, and proposed actions.

King County Flood Hazard Management Plan. King County. Seattle, Washington. 2006. Flood impacts in King County are far ranging and pose significant threats to public safety and regional economic vitality. This document includes a 10-year action plan which identifies and prioritizes construction, repair and maintenance actions for flood risk management facilities and related projects throughout King County. Projects in the plan include levee and revetment repairs, levee setbacks, acquisition of repetitive loss properties and other at-risk homes, completion of technical mapping and analyses to better understand the location of areas at risk from flooding, and reconnection of rivers and streams with their floodplains to increase floodplain capacity and improve natural conveyance processes.

Economic Connections Between the King County Floodplains and the Greater King County Economy. ECONorthwest. Eugene, Oregon. October 2007. The report addresses the regional economic benefits related to implementing the countywide 2006 King County Flood Hazard Management Plan. The analysis indicates that there is substantial economic interaction between the floodplains and the rest of King County, and suggests there are economic benefits to King County of protecting the floodplain. Because the floodplain region employs many people who live elsewhere in King County, the benefits of flood hazard management accrue beyond the floodplain areas, to the entire King County economy. A one-day shutdown of economic activity in the King County floodplain areas would result in at least $46 million in foregone economic output in King County.

Comprehensive Emergency Management Plan, King County, December 2008. This update to the 2002 King County Comprehensive Emergency Management Plan reflects King County government's organizational changes and National Incident Management System (NIMS) elements. It provides a

framework for countywide disaster mitigation, prevention, preparedness, response, and recovery activities, detailing authorities, functions, and responsibilities to establish a cooperative plan of action for county departments.

1.4 Other Relevant Reports

Geomorphic Analysis of the River Response to sedimentation Downstream of Mount Rainier, Washington; Open File Report 2012-1242. U.S. Geological Survey (USGS), 2012. USGS completed this study the geomorphology of rivers draining Mount Rainier to identify sources of sediment to the river network, identify important processes in the sediment delivery system, assess current sediment loads in rivers draining Mount Rainier, and assess how rates of sedimentation might continue into the future using published climate-change scenarios.

Channel Conveyance Capacity, Channel Change, and Sediment Transport in the Lower Puyallup, White, and Carbon Rivers, Western Washington; Scientific Investigations Report 2010-5240. U.S. Geological Survey (USGS), 2010. USGS was solicited to complete survey and survey interpretation of river cross-sections and sediment analysis for the major tributaries in the Puyallup River basin. The report compares cross-sections from 2009 with river cross-sections from 1984, identifies aggradation (i.e. deposition of material) within the river bed and the effect on stage-discharge relationships.

Socioeconomics of the Puyallup River Basin General Investigation Study Area. Northern Economics. Bellingham, Washington. November, 2011. Northern Economics was contracted by the Corps to complete an inventory of socioeconomic data for the study area. The report contains information related to demographics, employment, housing, and transportation data for existing and projected future forecasts for the region.

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, U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. This report analyzed the changes in the river channel and adjacent floodplain caused by placement of restrictive levees, erosion and/or setback levees. The study used historical photographs from 1931-2005. Past photographs indicate that, by 1970, restrictive levees were in place along the entire study section. However, prior to 1931 and 1940 the river corridor was mostly free of human features. Restrictive levees eliminated large areas of the historical channel migration zone (HCMZ) and the adjacent floodplain. Measurements indicate that generally, the HCMZ and adjacent floodplain in these sections expanded to values between pre-levee and leveed conditions. There are also indications of lack of channel stability in areas where levees were allowed to erode or setback. In general, it is not known if the river will recover to pre-levee conditions, as this is dependent not only on conditions within the studied segment but also upstream and downstream segments. The study also concludes that it is also unclear if removal of levees, rather than progressive natural erosion, would speed the recovery process.

Debris Flow, Debris, Avalanche, and Flood Hazards At and Downstream from Mount Rainier, WA. US Geological Survey. 1995. This report discusses debris flows and avalanches from Mount Rainier volcano and the subsequent downstream associated flow risks within the Puyallup River Basin. The report states Mount Rainier presents the most severe flow risks of any volcano in the U.S., with flows sometimes travelling as far as Puget Sound Lowland. The report presents three case histories to illustrate subpopulations of flows with known magnitudes and frequencies, and associated risks.

Commencement Bay Cumulative Impact Study Vol. 1: Assessment of Impacts and Volume 2: Restoration/Mitigation Options. Results of urban and industrial use over time have caused a cumulative effect on the Commencement Bay's aquatic resources. Volume One identifies historic impacts to aquatic resources in the Bay, establish a current baseline of these resources to assist in developing future projects to manage these limited resources in light of the competing uses. Volume Two documents restoration or mitigation options in the Bay area, emphasizing the need to maintain biodiversity by using a landscape approach. Volume Two includes restoration options but is not a restoration plan.

Water quality in the Lower Puyallup River Valley and Adjacent Uplands, Pierce County, Washington (Water-Resources Investigations Report 86-4154). U.S. Geological Survey, Tacoma, WA: 1987. This study was conducted to determine the quality of ground and surface water within and adjacent to the lower Puyallup River valley. Generally, the water is suitable for most typical uses; however, development in the area has led to some degradation of water quality in small streams and of shallow ground water. The study was prepared in cooperation with the Puyallup Tribe of Indians, which plans to increase ground water usage at its existing fish hatchery and a proposed hatchery.

2 Final Array of Alternatives Evaluation/Comparison

The Final Array of Alternative Plans was evaluated and then compared using criteria 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 Corps applied quantitative hydraulic analysis to characterize the future without-project and future with-project conditions for the final array of alternative plans, and used qualitative metrics and hydraulic engineering for evaluation, comparison and selection of a tentatively selected plan (TSP). This process also included development of the concept-level design of the TSP, completion of preliminary cost engineering and economic analysis, separable elements analysis to identify economically-justified features of the TSP, and screening based on quantitative economic justification.

Table 2-1 through Table 2-4 summarize the evaluation of the two action alternatives exclusively against the No Action alternative. Each alternative plan was assessed using the significant effects and outputs criteria or evaluation criteria. This assessment was qualitative based on the level of detail for hydraulic, hydrologic, economic, engineering and design, and applied 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. Each table includes a description of the scoring system used to evaluate the alternative plan against the No Action Alternative.

This process is summarized in Chapter 3 of the main DFR/EIS report.

Table 2-1. Alternatives Evaluation for Effectiveness

			ALTERNATIVES EVALUATION ANALYSIS								
			Alternative 1: No Action			Alternative 2: Levee Modification			Alternative 3: Levee Modification w/ Sediment Management		
			(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)
EFFECTIVENESS	**ALTERNATIVES EVALUATION CRITERIA**	**SCORE DEFINITION**	**1 = severe increase in flood risks , 2 = increase flood risks , 3 = no change/maintains the same flood risks throughout the planning horizon, 4 = reduces flood risks, 5 = significantly reduces flood risks**								
	Flood Damage Reduction	Short term (1-10 years after construction)	3	2	2	5	5	5	4	4	4
	The higher the reduction of flood risk the higher the score	mid-term (10-30 years after construction)	2	1	1	4	4	4	3	3	3
		long term (30-50 years after construction)	1	1	1	4	4	4	4	4	4
		Evaluation Analysis	The No Action Alternative would not generally reduce flood risks in the study area. There are projects currently planned along the Upper Puyallup River (Calistoga Levee) and along the White River (Countyline Levee) that will provide localized flood risk reduction. However, general flood risk is expected to increase in the future due to loss of channel capacity from sediment deposition. Sediment deposition in the study area is the main driver of increased flood risk in the future. Alternative analysis assumed MMD operation per the Water Control Plan.			Alternatives were evaluated and compared at a 1% ACE probability at the end of the 50-year planning period of analysis. Sediment deposition is the main driver of future conditions changes. To achieve a 1% ACE probability at the end of the planning period of analysis, flood risk reduction at the beginning of the planning horizon would be greater than 1% ACE at many locations under Alternative 2 resulting in a higher level of flood risk reduction early in the planning period of analysis than under Alternative 3. Future sediment deposition volumes are based on historic trends. Alternative analysis assumed MMD operation per the Water Control Plan.			Alternatives were evaluated at a 1% ACE probability over the 50-year planning horizon via maintenance dredging to address the anticipated future loss of channel capacity due to sediment deposition. Dredging alone in many areas does not provide a 1% ACE risk management. Therefore, dredging is supplemented with levee modifications (raises and new levees in those areas where levees do not currently exist) where needed. Future sediment deposition volumes are based on historic trends. This alternative would significantly reduce flood risks within the Basin. Alternative analysis assumes MMD operation per the Water Control Plan.		
		SUBTOTAL (Short-, mid-, and long-term scores were each weighted. Short-term score x 10, mid-term score x 20 and long-term score x 20. Total weighted score was divided by 50year period of analysis, rounded to the nearest whole one-tenth)	1.8	1.2	1.2	4.2	4.2	4.2	3.6	3.6	3.6
	Improvement to Life Safety	**Improvement to life safety gets a high score (Rated over the 50-year period of analysis)**	2	2	2	4	4	4	4	4	4
		Evaluation Analysis	The No Action Alternative does not provide significant improvements to public safety, except for areas protected by the Countyline Levee setback along the White River and the Calistoga Levee along the Upper Puyallup River. Over the planning horizon, sedimentation in these areas are expected to reduce channel capacity and reduce the benefit of flood measures in the without project condition.			By modifying the levees in the Upper Puyallup reach, setting them back in the lower Puyallup reach and constructing new levees in the system would provide a significantly improved public safety and reduction in population at risk over the period of analysis. Improved reliability of levee systems would allow for greater availability of emergency evacuation routes and less flooding of structures including residences, as well as critical infrastructure including			This alternative would improve public safety and reduce the population at risk over the period of analysis. Greater channel capacity of the rivers associated with sediment management and selective levee improvements would reduce flooding to urbanized areas. The increased capacity of the river and improved reliability of select levees would allow for greater availability of emergency evacuation routes and less flooding of structures including residences, as well as critical		

						schools, emergency services, human and health services, and major roadways designated as evacuation routes.			infrastructure including schools, emergency services, human and health services, and major roadways designated as evacuation routes.		
	TOTAL EFFECTIVENESS	**3.8**	**3.2**	**3.2**	**8.2**	**8.2**	**8.2**	**7.6**	**7.6**	**7.6**

Table 2-2. Alternatives Evaluation for Acceptability

		ALTERNATIVES EVALUATION ANALYSIS								
		Alternative 1: No Action			Alternative 2: Levee Modification			Alternative 3: Levee Modification w/ Sediment Management		
	SCORE DEFINITION	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)
ACCEPTABILITY	**ALTERNATIVES EVALUATION CRITERIA**	**1= Highly Detrimental, 2 = Slightly Detrimental, 3 = No Change, 4= Slightly Beneficial, and 5 = Highly Beneficial**								
Wetlands Impacted	**The fewer acres of wetlands adversely impacted, the higher the score**	4	4	4	2	4	2	1	1	1
	Evaluation Analysis	The No Action Alternatives assumes that the wetland areas in the Puyallup River Basin above Commencement Bay are expected to remain relatively unchanged from its existing condition. 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. 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.			Alternative 2 would slightly benefit wetlands through the setback of the right bank of the lower Puyallup River, slightly degrade wetlands on the White River and degrade wetlands throughout the rest of the study area based on the footprint of proposed actions and the higher amount of wetlands present in the upper watershed areas. Preliminary review of mapped wetlands (Pierce County and King County inventories) indicates few wetlands are in alignment. There would be impacts to Other Waters of the U.S. (below OHW) for riverward work being done.			Alternative 3 would have similar negative effects as Alternative 2 throughout the study area on wetlands through modification of existing levees. Dredging would result in significant impacts to Other Waters of the U.S..		
Fish (Salmonid) Habitat Affected	**The lower the adverse impacts to fish habitat, the higher the score**	2	2	2	2	3	2	1	1	1
	Evaluation Analysis	The No Action Alternative assumes that water temperatures in rivers and lakes are expected to increase, particularly during the summer, causing a decrease in reproductive success for the fish and salmon species. Increased human population and development is expected to decrease habitat function for many of the species in the study area. An increase in agriculture could potentially increase run-off into the rivers as vegetated cover is removed and soils are disturbed multiple times per year. 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 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 aquatic vegetation, altering hydrology and flow characteristics, raising water temperature, and re-suspending pollutants.			Alternative 2 would slightly benefit fish habitat through the setback of the right bank of lower Puyallup River, but this is balanced by the loss of edge cover due to construction, degraded fish habitat through new levee construction on the White River as well as the rest of the Study area through levee modification and new levee segments.			Alternative 3 would significantly degrade fish habitat throughout the study area through the removal of sediment within the channel. All areas of the study area contain fish habitat (spawning, rearing, and holding). Proposed dredge areas are in spawning "Hotspots" identified by Pierce County in 2013 Flood Control Plan. Pink and Chum salmon spawning hotspot in the Lower Puyallup dredging area; Steelhead and Chinook spawning hotspot in the Pacific dredging area; Chinook spawning hotspot in the Puyallup River dredge area. Lower levels of spawning for various salmonid species occur in other parts of the study area.		
Riparian Habitat (Corridor) Affected	**The lower the acres of riparian habitat adversely impacted, the higher the score**	2	2	2	1	4	2	2	2	2
	Evaluation Analysis	Riparian habitat in the lower basin would 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 would 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			Alternative 2 would slightly benefit riparian habitat through the levee setback opening up ~281 acres of riverward land. Recognizing that many of the projects identified would occur in areas where riparian habitat is already limited or poor quality , Alternative 2 would likely result in further decline of riparian habitat throughout the rest of the study area; mitigation actions could compensate for these impacts.			Alternative 3 would degrade riparian habitat, particularly in areas where there are in-channel vegetated gravel bars / islands. Overall less impact to riparian areas versus alternative 2 due to smaller levee length		

		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 could also increase the frequency and intensity of flood events.								
Floodplain Connectivity	**The more floodplain connectivity the higher the score**	2	2	2	2	4	2	2	3	2
	Evaluation Analysis	The No Action Alternative includes the Puyallup, White, and Carbon rivers contained within levee systems, which limit the natural sinuosity of the rivers and prevent floodplain connectivity, adversely affecting salmon recovery. This condition is expected to continue to be a limiting factor to habitat availability/quality.			Floodplain connectivity is a limiting factor to salmon recovery based on the significant amount of existing flood control structures throughout the study area. Alternative 2 would perpetuate this condition in the Lower Puyallup, slightly degrade through the rest of the Puyallup / Carbon and degrade through the new levees on the White.			Floodplain connectivity is a limiting factor to salmon recovery based on the significant amount of existing flood control structures throughout the study area. Alternative 3 would perpetuate this condition in the lower Puyallup and degrade through the rest of the study area.		
Other considerations	**The better the alternative meets the non-Federal sponsor's flood risk management objectives, the higher the score**	1	1	1	4	4	4	2	2	2
	Evaluation Analysis	This alternative does not satisfy non-Federal sponsor. This alternative does not provide the assistance the sponsor needs in developing a comprehensive flood risk management solution along the Puyallup River and its main tributaries.			This alternative satisfies the sponsor's need to reduce flood risks within the Puyallup River Basin.			This alternative reduces the flood risks within the Basin; however, the alternative is not as favorable to the sponsor due to the dredging impacts to ESA listed species in the Puyallup River and its tributaries. The environmental impacts associated with this alternative require subsequent permitting actions that may be highly challenging for the non-Federal sponsor to achieve. The sponsor is further concerned about O&M costs and frequency needed to maintain the channel.		
TOTAL ACCEPTABILITY		**11**	**11**	**11**	**11**	**19**	**12**	**8**	**9**	**8**

Table 2-3. Alternatives Evaluation for Efficiency

		ALTERNATIVES EVALUATION ANALYSIS								
			Alternative 1: No Action			Alternative 2: Levee Modification			Alternative 3: Levee Modification w/ Sediment Management		
		SCORE DEFINITION	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)
EFFICIENCY	ALTERNATIVES EVALUATION CRITERIA		1 = Significant increase in O&M responsibilities, mitigation efforts or real estate complexities 2 = Moderate increase in O&M responsibilities, mitigation efforts or real estate complexities 3 = Marginal increase in O&M responsibilities, mitigation efforts or real estate complexities 4 = Negligible increase in O&M responsibilities, mitigation efforts or real estate complexities 5 = No change in O&M responsibilities, mitigation efforts or real estate complexity								
	O&M Responsibility	The lower the O&M responsibility to manage flood risks the higher the score	2	2	2	4	4	4	1	1	1
		Evaluation Analysis	Under the No-Action Alternative, existing flood risk management system would continue to require maintenance to ensure reliability of the structures and to provide the needed level of flood risk management. It is anticipated for O&M needs to increase as flood risks increase. Due to the increasing rate of sedimentation and increased development within the floodplain, there would be a significant requirement for the sponsor to increase its flood risk projects. Unfortunately, due to local government funding limitations, not all existing structures would be modified in the timeframe and to the level of protection as needed. Existing levees may not receive the needed level of maintenance without support from other agencies. The ability for the sponsor to provide the needed O&M without initial Federal action to increase the reliability of its existing flood management system within the planning timeframe would continue to be challenging for the sponsor.			This alternative includes a series of levee improvements that would provide the needed flood risk management and manage (or contain) the increasing sediment deposition within the river system. Although there are a few new levees within the system, this alternative further increases the stability of the existing levee system thereby decreasing the amount of maintenance responsibilities over the planning horizon. In addition, the existing levees in PL 84-99 would continue to require maintenance and rehabilitation as needed by non-Federal entities.			This alternative also includes levee modifications that increase channel conveyance and levee stability. A key measure of this alternative is initial construction dredging and subsequent maintenance dredging. Litigation has resulted in a moratorium on dredging in the reach that is part of this alternative. In addition, it may be challenging for the sponsor to obtain the required permits from the Federal agencies to conduct the maintenance work due to potential impacts to ESA listed species. Further, the Puyallup Indian Tribe owns lands within the lower Puyallup River riverbed and those lands adjacent to the river channel. The sponsor would have to obtain a permit from the tribe to conduct O&M within this reach. Maintenance dredging is anticipated to occur within the lower Puyallup River – 1 time, lower White reach – 1 time, White River at City of Pacific – 3 times, and the Upper Puyallup reach – 2 times, over the planning timeframe. The frequency of the maintenance dredging could be a challenging responsibility for the sponsor.		
	Mitigation Efforts	The lower amount of mitigation needed, the higher the score	5	5	5	2	3	2	1	1	1
		Evaluation Analysis	Because the No Action Alternative assumes there is no proposed Federal action, no mitigation would be required.			Mitigation was determined based on the scores for the above environmental criteria and likely scope of the mitigation required for both wetland and riparian / salmonid habitat impacts. Alternative 2 would provide the only slight benefit (self-mitigating) area with the levee setback on the lower Puyallup, however the rest of their study area would likely require mitigation for in-water work impacts, wetland impacts (potentially avoided / minimized once we refine alignments), and loss of existing riparian vegetation to accommodate levee modifications. The White River alignment based on the intersection of the 100 ft. buffer and the existing vegetation has small impacts, therefore a more positive score. The setback on the lower Puyallup works as mitigation land.			The mitigation required for both short and long term impacts from dredging would require significant efforts to mitigate (likely off-site projects TBD). Alternative 3 would have similar wetland and riparian impacts to Alternative 2 but at a smaller scale due to the smaller levee footprint proposed. However, there will be an impact to approximately 195 acres of riverine habitat that cannot be avoided. Based on discussions with Pierce County, King County and Tribal biologists, full mitigation of impacts of sediment management would be difficult. Due to the major disruption of the aquatic environment and long-term effects of the dredging, between a 4 to 1 and 6 to 1 mitigation ratio is recommended. The only feasible mitigation option is creation of off-channel habitat which has a direct connection to the river. This off-channel mitigation would take the same form as the off-channel mitigation described for Alternative 2. Between 784 and 1196 acres of off-channel habitat would be required for mitigation. Finding this much available acreage in the Puyallup basin would be difficult. Given the average cost of $155,000 per acre for mitigation development, between $87,000,000 and $131,000,000 would be required for the mitigation action.		

Real Estate Complexity	**Higher scores are a magnitude of higher likelihood or ease of acquiring the real estate necessary to implement the project.**	5	5	5	3	1	4	3	1	3
	Evaluation Analysis	The No Action Alternative assumes that a Federal project is not constructed and real estate complexity would be relative to the projects undertaken by the Sponsor. Due to the funding limitations (without Federal dollars) and diminished project scope, the Sponsor would not seek to acquire the magnitude of real estate that would be required under a cost-share project with the federal government.			Real Estate is available or could be made available utilizing various acquisition strategies for the project, including for levee setbacks, raises, and new levees. Real Estate on the upper Puyallup River is generally less urban and less developed and therefore is likely cheaper and easier to acquire than that on the lower Puyallup River. The lower Puyallup River is generally more urban and developed, and includes tribal ownership, especially along the river banks, and therefore is likely to be more expensive and difficult to acquire. Utilities are also more prevalent in the densely populated/urban areas. Willingness of landowners, and the ability to relocate utilities will ultimately determine the difficulty and costs associated with acquisition.			Federal regulatory jurisdiction only covers the lower 3 river miles of the lower Puyallup River. The Puyallup Indian Tribe (Tribe) retains control of the remaining portions of the Puyallup River. Navigational servitude could be applied to the lower 3 miles of the Puyallup River for dredging features of the project only. Maintenance dredging and O&M efforts would require permits for each separate action from the Department of Natural Resources and the Tribe for the rest of the Puyallup River and the White River. There is a high likelihood that support for dredging and permit acquisition will become increasingly difficult and unlikely to obtain. As a result, there is a high uncertainty and risk associated with dredging and O&M activities along the Puyallup and Carbon Rivers. The White River has similar project features as Alternative 2 and therefore real estate availability is assumed to be the same.		
Meets Planning Objectives		**1 = meets no objectives, increase in flood risks** **2 = meets at least 1 planning objective , but there is an increase in flood risks** **3 = meets all planning objectives but, maintains the same flood risks throughout the planning horizon,** **4 = meets all planning objectives, and slightly reduces flood risks throughout the planning horizon** **5 = meets all planning objectives, and significantly reduces flood risks**								
	The better accomplishment of objectives the higher the score	**2**	**1**	**1**	**5**	**5**	**5**	**5**	**5**	**5**
		The No Action Alternative would not generally reduce flood risks and meet any of the planning objectives throughout the planning timeframe. There are projects currently planned along the upper Puyallup River (Calistoga Levee) and along the White River (Countyline Levee) that will provide localized flood risk management. However, in general flood risk is expected to increase in the future due to loss of channel capacity from sediment deposition. The No Action Alternative features in the middle and upper Puyallup River and the Carbon River meet only Objective #5: Optimize use of natural floodplain for conveyance and storage within the Puyallup River Basin.			Alternatives were evaluated at a 1% ACE probability at the end of the 50-year planning horizon and will provide capacity for forecasted sediment deposition. This alternative analysis assumes Mud Mountain Dam operation per the Water Control Plan to assist in managing flood risks within the system. All objectives are met in the alternative.			Alternative was evaluated at a 1% ACE probability over the 50-year planning horizon via maintenance dredging to address the anticipated future loss of channel capacity due to sediment deposition. Dredging alone in many areas does not provide a 1% ACE protection. Therefore, dredging is supplemented with levee modifications (raises and new levees in those areas where levees do not currently exist) where needed. Alternative analysis assumes Mud Mountain Dam operation per the Water Control Plan to assist in managing flood risks within the system. All objectives are met in this alternative.		
TOTAL EFFICIENCY		**14**	**11**	**13**	**14**	**13**	**15**	**10**	**8**	**10**

Table 2-4. Alternatives Evaluation for Completeness

ALTERNATIVES EVALUATION ANALYSIS											
			Alternative 1: No Action			Alternative 2			Alternative 3		
			(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	(Lower Puyallup)	(White River)	(Carbon, Middle Puyallup, and Upper Puyallup)	Levee Modification w/ Sediment Management (Lower Puyallup)	Levee Modification w/ Sediment Management (White River)
COMPLETENESS	External Needs/Risks to Alternative Completeness	The more complete the project the higher the score	1 = Incomplete project, dependent on external needs/risks 2 = Partially complete, meets some of the planning objectives, but is dependent on external needs/risks 3= Complete project with significant external project needs/risks 4= Complete project but moderate external project needs/risks 5 = Complete project with minimal external project needs/risks								
		Evaluation Analysis	The No Action Alternative is not a complete alternative due to its dependency upon external flood risks management actions. This project will need to seek additional investments by the non-Federal sponsor and or other stakeholders and government agencies to fulfill the project objectives within the planning timeframe.			This alternative is complete. However, this alternative would require availability of lands to purchase for the setback levees, levee raises, and new levees as a part of the project. The Puyallup Indian Tribe owns lands along the lower Puyallup River that would be required property for a levee setback. In addition, this alternative would require a permit from the Puyallup Indian Tribe for any in-water works; since the tribe also owns the lower Puyallup reach riverbed. None of these features are outside of the scope of the alternative plan; however, its external needs are moderate. In addition, mitigation requirements are not yet defined.			This alternative is complete but would require purchase of lands for levee raises, new levees, and a permit from the Puyallup Indian Tribe for the dredging works and any in-water works. In this alternative, dredging alone along the lower Puyallup River would not be feasible without a levee component. In addition, for this alternative to remain complete throughout the planning period of analysis, maintenance dredging would be required to maintain the level of flood risk management. This alternative would require a permit from the Corps of Engineers and coordination with Federal resource agencies each time maintenance dredging is conducted. None of these features are outside of the scope of the alternative plan; however, its external needs would be significant. Material removed during dredging would need to be characterized for physical characteristics and contaminants to determine appropriate placement location. Maintenance dredging would be necessary. In addition, mitigation would be extensive and availability of sites is limited. Volume of material could add challenge to finding a location.		
	TOTAL COMPLETENESS		**1**	**1**	**1**	**5**	**4**	**5**	**4**	**3**	**3**

2.1 Comparison of the Final Array of Alternatives

Table 2-5 below summarizes the comparison of the three alternatives based on the Evaluation Analysis described above. The P&G Criteria were used to compare each alternative plan's significant outputs and effects. This comparison was qualitative and was based on the level of detail for hydraulic, hydrologic, economic, engineering and design, and engineering cost estimates, applied 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 described in the table below, to balance the variability in the scoring methodology.

Table 2-5. Comparison of Final Array of Alternatives

ALTERNATIVES COMPARISON ANALYSIS									
	Alternative 1: No Action			Alternative 2: Levee Modification			Alternative 3: Sediment Management with Levee Modification		
	Carbon, Upper Puyallup, Middle Puyallup Rivers	Lower Puyallup	White River	Carbon, Upper Puyallup, Middle Puyallup Rivers	Lower Puyallup	White River	Carbon, Upper Puyallup, Middle Puyallup Rivers	Lower Puyallup	White River
P&G CRITERIA									
Effectiveness	Effectiveness is the extent to which an alternative plan alleviates the specified problems, achieves the specified opportunities, and attains the planning objectives. Another factor that can impact the effectiveness of an alternative is whether there is substantial risk and uncertainty associated with the alternative. The overall Study problems and objectives support reducing flood risks and improving life safety within the Basin. The No Action alternative includes Pierce County and King County projects to reduce flood risk and manage flood impacts. However, the efforts applied are not enough to address the problem of repetitive damages to the existing levee system, sustain the flood risk reductions efforts, and are not constructed to provide the needed protection within urban areas. The No Action alternative would continue to lose conveyance capacity due to sediment deposition and therefore will not reduce flood risks within the planning period of analysis. 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. 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. The No Action alternative would not reduce life safety impacts due to the continual decrease in conveyance capacity within the riverine system. Alternative 2 and 3 would adequately reduce impacts to loss of life and improve public safety throughout the planning timeframe.								
Total Effectiveness	3.8	3.2	3.2	8.2	8.2	8.2	7.6	7.6	7.6
Normalized Score Total Score* [normalized max possible score (30)/max possible score (10)]	11.4	9.6	9.6	24.6	24.6	24.6	22.8	22.8	22.8
Acceptability	Acceptability is the workability and viability of the alternative plan with respect to acceptance by the Federal and non-Federal entities and the public and compatibility with existing laws, regulations, and public policies. The alternative must be implementable meaning that the alternative is feasible from technical, environmental, economic, financial, political, legal, institutional, and social perspectives. Acceptability also considers the extent to which the alternative addresses the non-Federal sponsor's flood risk management objectives. When assessing each alternative plan as it relates to Federal environmental laws and policies, it is clear that 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 impact the Puyallup Tribe's Usual & Accustomed 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. The most acceptable alternative to the resource agencies and the non-Federal sponsor is Alternative 2 because it would have less impact ESA listed species within the system and provides additional riparian habitat.								
Total Acceptability	**11**	**11**	**11**	**11**	**19**	**12**	**8**	**9**	**8**
Normalized Score Total Score*[max possible score (30) / normalized max possible score (30)]	**11**	**11**	**11**	**11**	**19**	**12**	**8**	**9**	**8**
Efficiency	Efficiency is the extent to which an alternative plan is the most cost-effective at alleviating the specified problems and meeting objectives. 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 – real estate, operations & maintenance, and mitigation. In conjunction, each alternative was assessed on how well it addressed each planning objective. These criteria helped evaluate each alternative's magnitude of efficiency. 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 which cause it to be less efficient than Alternative 2 in meeting the planning objectives.								
Total Efficiency	**14**	**11**	**13**	**14**	**13**	**15**	**10**	**8**	**10**

Normalized Score Total Score* [normalized max possible score (30)/max possible score (20)]	**21**	**16.5**	**19.5**	**21**	**19.5**	**22.5**	**15**	**12**	**15**
Completeness	Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. The criteria looked at the level of completeness for each alternative in addition to identifying any foreseen external needs or risks that could impact project implementation. The No Action alternative is not a complete alternative plan due to its dependency upon external flood risk management actions by non-Federal sponsor, stakeholders and other government agencies to reduce flood risk. Alternative 2 and Alternative 3 are complete plans, are not related to other public or private plans within the Basin, and completely meet the project objectives. However, both of these alternatives include some risks towards implementation. Risks for Alternative 2 include availability of lands owned by the Puyallup Tribe along the lower Puyallup River reach and the ability to obtain a permit from the Tribe for any in-water works along this reach as well. Risks to implementation of Alternative 3 include the same as Alternative 2 along with a series of maintenance dredging throughout the planning horizon. This action would include a permit from the Corps and coordination with Federal resource agencies each time maintenance dredging is conducted.								
Total Completeness	**1**	**1**	**1**	**5**	**4**	**5**	**4**	**3**	**3**
Normalized Score Total Score* [normalized max possible score (30)/max possible score (5)]	**6**	**6**	**6**	**30**	**24**	**30**	**24**	**18**	**18**
TOTAL (Total Score Max = 120)	**53.4**	**47.1**	**49.1**	**86.6**	**87.1**	**89.1**	**69.8**	**61.8**	**63.8**

Based on the evaluation and comparison analysis, 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.