DRAFT HFCCP Summary Report

APPENDIX I

1.0 PROJECT HISTORY

1.1 Introduction

Climate change in Washington State may be contributing to higher aggradation rates in the Puyallup River system in Pierce County, including the White and Carbon rivers, all of which originate on Mount Rainier as glacial meltwater (Czuba, et.al., 2012). Erosion and transport of sediment into the Puyallup River system has resulted in sediment aggradation within leveed channels. This situation contributes to reduced channel capacity, levee and revetment overtopping, tributary backwater flooding, channel migration problems, flooding of structures and infrastructure, public safety issues, and the need for emergency action during and after large flood events. Large volumes, literally millions of cubic yards of sediment, in the glacial valleys and from feeder bluffs along the river (personal communication, Fantello 2019), ranging in size from boulders to silt-sized particles, are available for transport. The amount of material moved is highest during extreme storms, including rain-on-snow events.

Large flooding events in 2006 and 2009 brought about a heightened level of concern about the increasing amounts of accumulated sediment and associated flooding. One question repeatedly asked by citizens in Pierce County following these large flood events has centered on dredging as a possible solution. Many long-time residents remember channel dredging as a flood control method. Indeed, mining sand and gravel from river bars and floodplains was commonplace starting as early as the 1930s. Most of the gravel mining appears to have occurred between the 1970s and the early 1990s (Collins, 1995). Rule changes to Section 404 of the Clean Water Act in 1993 expanded the regulation to include "mechanized clearing, ditching, channelization, and other excavation activities" of floodplains, giving the U.S. Army Corps of Engineers (USACE) jurisdiction over dredging activities.

Numerous studies throughout the 1970s through the 1990s documented the effects of wood and gravel removal on aquatic habitat (Bull, 1974; Bowen, 1986; Collins and Dunne, 1989; and Collins, 1995, among others). In general, wood and varying substrate provide complex hydraulics, which creates habitat for a wide range of species and age classes. Removal of sediment and wood simplify channels and eliminates suitable habitat conditions for native fish species. Throughout the 1990s and early 2000s, a growing number of salmonid species were listed under the Endangered Species Act (ESA) as threatened or endangered, including several species/populations in the Puyallup Watershed. Common among the reasons for population declines was acknowledgement of degraded habitat conditions. Because the USACE is required to consult with federal fish and wildlife agencies (U.S. Fish and Wildlife Service [USFWS] and National Marine Fisheries Service [NMFS] or National Oceanic and Atmospheric Administration [NOAA] Fisheries) under Section 7 of the ESA, authorization of potential habitat degrading activities (e.g. dredging) became increasingly difficult. Often, dredging was not feasible where ESA-listed species are present. As a result, dredging/large-scale sediment removal from stream and river channels for flood control essentially ceased in Washington state (although floodplain mining has continued in some circumstances).

However, there are potentially several reasons for removing sediment from a river system. A primary consideration is reducing flood impacts to the built environments that exist on many of the floodplains in urban and suburban settings. Billions of dollars are spent annually across the nation to mitigate and recover

from flood damages. Targeted removal of sediment could provide a temporary reduction in the damages associated with moderate flooding, while other longer-term flood reduction plans are developed.

Sediment aggradation can lead to frequent overtopping of levee systems and subsequent degradation and failure of the protection from flooding they were designed to provide. While it can be argued that we should remove the levees and let the rivers return to a more natural condition, the fact is that we have already allowed development to occur on many of our floodplains. The economic and social impacts of abandoning flood protection measures where such development exists would be astronomical. Future land use planning could, to some extent, reduce the infrastructure located immediately adjacent to our rivers and allow some re-occupation of historic floodplains, however that will take decades to accomplish and some intermediate strategies (such as sediment removal) may be necessary in the interim.

Following the 2009 flooding, state- and federal-level elected officials met with Pierce County citizens, tribes, agencies, the Pierce County Sustainability Council, Master Builders of Pierce County and county officials to discuss the flooding issues; a Flood Plan Advisory Committee was convened to advise Pierce County on the revision of an existing Flood Hazard Management Plan. Numerous public meetings were held to gather input for the process. Out of those discussions grew the political will to test sediment removal as one potential "tool in the toolbox" for flood mitigation. This concept was different from previous maintenance because it was not wholesale dredging. Project staff made sure this point was clearly explained to residents, agency staff, tribes and elected officials. The concept was targeted removal of sediment for localized flood relief – especially to reduce levee damage.

Several distinct study efforts resulted from this commitment. They include: 2011 Pilot Study, Phase 1; 2012 Pilot Study, Phase 2; 2014-2015 Sediment Management as a Risk Reduction Tool (SMRRT) Project Data Gaps Analysis; 2015-2016 SMRRT Project Reach Selection; and 2015-2016 SMRRT Project Site Selection. An overview, findings and lessons learned for each of these efforts is provided below. Figures and tables referenced in this summary report with their original numbers and are provided as an appendix under report-specific tabs. Figure 1 (GeoEngineers, et al. 2016a) shows the Regional Setting and Watershed for the Puyallup River system.

1.2. 2011 Pilot Study, Phase 1

1.2.1 Overview

The purpose of the pilot project was to study the effectiveness of removing entire, or portions of, gravel bars that threaten existing levees, revetments and riverbanks to protect public infrastructure, critical facilities and private property from flood risk. Another purpose of the study was to study approaches of removing gravel to minimize impacts to the natural environment, especially to ESA-listed fish species and enhance river habitat.

The first step in developing and testing a gravel bar removal project was to develop reach selection criteria methods and references. Pierce County provided initial reach selection work to the consultant team and worked with the consultant team to identify twelve reaches for consideration. A memorandum dated May 27, 2011 (GeoEngineers, Inc.) evaluated twelve reaches on the Puyallup, White and Carbon rivers identified by Pierce County (Pierce County Public Works, Possible Gravel Removal Locations, 2009).

The initial selection of the twelve reaches was based on an evaluation of the three rivers included in the study. The study entailed the analysis of cross sections, 2010 USGS study, mapping changes of the channel

profile, identifying historical gravel removal locations, gravel bar analysis and channel changes from historical aerial photos, identified (at a high level) critical infrastructure at risk, life line arterials at risk, levee damage records, risk analysis and other elements.

The project team consisted of Pierce County staff, Parametrix and GeoEngineers. Selection criteria for the 2011 evaluation included:

- Social/Site:
    - **Critical Infrastructure at Risk** (Low, Medium, High);
    - **Levee Infrastructure at Risk** (Low, Medium, High);
    - **Land Use at Risk** (Residential, Commercial, Industrial); and
    - **Property Value at Risk** ($); Site Access (Poor, Fair, Good).
- Geomorphic:
    - **Geomorphic Classification** (Single/Confined, Braided/Confined);
    - **Transport Regime** (Transport, Deposition, Aggradation, Erosion);
    - **Long-term Bar Growth** (Low, Moderate, High);
    - **Topographic Steering** (Low, Moderate, High); and
    - **Future Channel Response** (Low, Moderate, High).
- Hydraulic:
    - **Height of Levee Overtopping** (list);
    - **Flood Reduction Potential** (Low, Moderate, High)
- Biologic:
    - **Biologic Usage** (Low, Moderate, High); and
    - **Primary Habitat Quality** (Low, Moderate, High)

Site prioritization was based on a qualitative assessment of the criteria, with greater emphasis placed on two to five elements from each field (see bolded selection criteria above). Four reaches were ranked highest, including Reach 6 (Puyallup River near Orting), Reach 7 (upper Puyallup River), Reach 10 (upper Carbon River) and Reach 12 (White River near the Pierce/King County line). Reaches 6 and 7 were selected for additional evaluation. The Phase 1 reaches are shown in Figure 1 (GeoEngineers, 2011).

Pierce County staff reached out to the Puyallup Tribe and Muckleshoot Tribe natural resources staff for assistance. The Puyallup Tribe provided unpublished fish utilization data.

1.2.2. Lessons Learned

Adding the following tasks could have made this pilot more successful.

- Complete a scientific data analysis and evaluation to determine the reaches for consideration, rather than incorporating infrastructure considerations at this phase. Given the primary purpose of the study, it is understandable the initial list of reaches would be based on locations of levee damages and other county concerns. However, reaches characterized in a different manner by independent scientific evaluation may have resulted in a different list than those selected by the project team. For instance, if the primary purpose of the pilot study was simply to demonstrate whether gravel removal is effective at reducing flood flow elevations, then different sites may have been prioritized.
- The study concluded that the biologic criteria used for reach selection were not effective at distinguishing differences among reaches. Identifying alternative biologic criteria, such as spawning areas, juvenile rearing areas and tributary confluence zones, could have fostered a more effective reach selection process for a demonstrative pilot project.
- Coordinate with resource management agencies from the beginning of the project through completion. Effectively define project goals and progress with these stakeholders as early as possible. It may be possible to find a common cause with these agencies and tribal staff, such as habitat improvement, that would offset objections to permitting the project.

1.3. 2012 Pilot Study, Phase 2

1.3.1 Overview

Phase II focused on identifying two or three gravel bars from each of Reaches 6 and 7 for detailed modeling and quantitative analyses, with the intent of determining the bars posing the greatest risks to adjacent levee(s) and infrastructure. Six candidate gravel bars were selected in consultation with Pierce County staff and assigned alphabetical labels from A to F (GeoEngineers, 2012). The candidate gravel bars were identified based on previous geomorphic studies conducted by GeoEngineers, subcontracted by Parametrix, involving Puyallup River channel and gravel bar behavior, records of previous levee damage and institutional knowledge provided by Pierce County staff.

Six selection criteria were chosen to evaluate and qualitatively assess gravel bars A through F:

- **Channel Form:** Channel form at each gravel bar site was characterized in terms of the number and alignment of the main stem channel(s) within the levee-confined corridor.
- **Bar Forms and Current Condition:** Gravel bar forms were characterized in terms of gravel bar location within the high flow corridor, bar type and dimensions.
- **Long/Short-term Bar Development:** Changes in the location, shape and size of the gravel bars were evaluated from 1965, which is the approximate year levee construction was completed, up to the present. Gravel bar stability and growth were used as a measure of topographic steering and channel migration.
- **Sediment Supply and Transport:** Sediment transport through each reach was obtained primarily from the Phase I reach assessment, and review of recent imagery and field observations. Visual changes in gravel bar size and shape observed over the course of the aerial photographic record

(1965 to 2011) and changes in bed elevations from 1984 to 2009 published in the 2010 USGS study (included in the draft 2011 GeoEngineers memorandum) were used to determine whether channel performance was primarily transport- or response (deposition)-dominant.

- **Bar Steering/Flow Deflection:** Gravel bar steering, defined as the deflection of flow around gravel bars was evaluated. Stable gravel bar forms (as defined for this project) had greater capacity to gently or abruptly deflect high stage flows against levees on a repetitive and consistent basis, for longer time periods. Gravel bars with higher steering potential were ranked as a higher priority for gravel removal.
- **Levee Condition:** Levee damage and repair records were evaluated for the previous five years in the vicinity of each gravel bar, with higher incidence of damage being higher priority.

The Phase II study recommended gravel bars B and F for further analysis. Both bars met the criteria for selection and presented significant consistent risks to levees from flow deflection over the long term. Both gravel bars were subject to gravel replenishment and were sufficiently large to allow for gravel excavation well away from the active channel. In addition, both gravel bars were well positioned to capture large volumes of gravel that would eventually move downstream, where it could further increase the risk of damage to levees and infrastructure. Implicit in this scenario is sediment supply to downstream reaches would be temporarily reduced and flood risk also mitigated.

Consultation with the resource management agencies resulted in the project team adopting an initial approach of selecting gravel bars with higher steering effects. However, later input from stakeholders and resource management agency staff indicated a lack of support for the premise that hydraulic steering effects of gravel bars caused significant impacts to levees. Stakeholders and resource management agency staff held the position that the levees themselves were/are the primary driver of gravel bar growth and any related hydraulic effects. In addition to this position, certain stakeholders and resource management agency staff were concerned about significant impacts to fish habitat that had not yet been considered by the study team, such as biological usage and habitat quality. None of the agencies was willing to propose a viable, permittable alternative strategy for removing gravel from the channel.

1.3.2. Lessons Learned

After the second phase of the pilot project, the following lessons are identified:

- All members of the team need to support the project goals and needs. During this phase, some county staff attempted to discourage the project during conversations with the tribes and regulatory staff. Establishing clear roles and responsibilities and adhering to strict communication protocols within the project team may have helped when messaging the project to outside entities.
- As long as a project complies with regulations and standard of practice, the project proponent should not be unduly influenced by agencies that oppose the project for subjective reasons. For example, Pierce County decided to not follow through with the pilot project because resource agency feedback assumed the project would be detrimental to habitat, even though no analysis was conducted to address that assumption.
- Representatives of NOAA Fisheries, WDFW and the USACE had said that the project did not comply with existing regulations because any gravel removal would be a detriment to fish habitat. Instead of conducting a gravel removal project from within the OHWM, another project option to explore

with the agencies may have been to harvest gravel within the floodplain, but outside of the OHWM. However, this may have been counterproductive, given that the failing or compromised levees appeared to be the problem. Alternatively, it may have been possible to complete a project if it could be demonstrated that the habitat enhancement would exceed any impacts of sediment removal.

- Early quantitative methods, e.g. 2D numerical modeling, could have been helpful in demonstrating hydraulic conditions for stakeholder consideration; however, given the number of sites costs may have been prohibitive at this stage.

1.4. 2014-2015 SMRRT Project Data Gaps Analysis

1.4.1. Overview

Despite the failure of the gravel bar steering approach to permitting a sediment removal pilot project, there was still political will to evaluate whether limited sediment removal could help mitigate flood impacts. This is reflected in the Pierce County Rivers Flood Hazard Management Plan (PCRFHMP), which modified the 1991 Puyallup River Comprehensive Flood Control Management Plan, and was published and adopted in February 2013. Among other flood hazard reduction strategies, the plan recognized Comprehensive Sediment Management and Gravel Removal Project Policies #11 and #12. Policy #11 states that "Comprehensive sediment management in Pierce County shall be informed by channel monitoring and technical sediment transport studies and consider the variable nature of sediment transport to achieve a balance between flood risk reduction and ecological health." Policy #12 states that "Pierce County may remove gravel from rivers for flood hazard or channel migration protection purposes when:

a. It can be demonstrated that gravel accumulation poses a flood risk as defined in General Policy #2;

b. Hydraulic and sediment transport studies conclude gravel removal has a benefit of flood or channel migration risk reduction;

c. It is in a demonstrated area of gravel accumulation;

d. It is part of a comprehensive flood hazard management reach-scale strategy;

e. Biologic studies determine that gravel removal does not, with mitigation, result in a net loss of ecological function; and

f. All proper approvals have been secured."

Therefore under the authority of the PCRFHMP, Pierce County chose to explore the possibility of targeted sediment removal as a flood risk reduction tool with initiation of a reach-scale pilot project to study the "effectiveness of removing entire, or portions of, gravel bars that threaten existing levees, revetments and river banks to protect public infrastructure, critical facilities, and private property from flood risks."

The SMRRT project subsequently was conceived in 2014 as a pilot project to test whether targeted sediment removal was a feasible strategy to aid in reducing flooding and flood damages during moderate flooding events. The project was intended to determine if sediment removal could be permitted and used as an effective, short-term flood risk reduction tool in instances where the river is leveed on both sides and valuable property, critical infrastructure and/or public safety was at risk. Another scenario to consider for using this approach was an interim risk-reduction tool while longer-term flood reduction projects were being

designed, permitted and constructed. Pierce County established a steering committee to provide technical direction and oversight for the pilot project.

The goals of the project were to:

- Estimate the effectiveness of sediment removal as a method for localized flood hazard risk reduction during a moderate[1] event in the Puyallup River Basin.
- Avoid, minimize or mitigate for potential adverse impacts to habitat and other resources from sediment removal.
- Design a sediment removal project that satisfies Goals 1 and 2 above and can be submitted for permits and approvals.
- Conduct a sediment removal project at a selected site; and monitor the effectiveness of sediment removal with respect to localized flood risk reduction during a moderate flood event.

At the time the SMRRT project was initiated, the assumption by the Pierce County steering committee and project team was that an Environmental Impact Statement (EIS) would be required for permitting the pilot project because of potential environmental impacts and stakeholder concerns.

The project began with a data needs assessment and gaps evaluation. The project team consisted of Pierce County staff, and the prime consultant GeoEngineers, Inc. (geomorphology; fisheries disciplines; and Geographic Information Systems [GIS] and database management), with subconsultants Northwest Hydraulic Consultants (NHC) (hydraulics and sediment disciplines), David Evans and Associates (social and land use disciplines) and EnviroIssues (public relations/communications). Additionally, Pierce County staff contracted an attorney from K&L Gates, who had extensive experience with environmental permitting on complex projects and who was a previous NOAA Fisheries employee with familiarity of the Services processes to assist with developing the permitting strategy for the project.

Identification of potentially significant data gaps was the initial step during development of the SMRRT project execution plan. The SMRRT project had two primary components with respect to data needs: 1) technical studies and supporting data for selecting the best site(s) for sediment removal and to support development of extraction, mitigation and monitoring plans; and 2) support development of the discipline reports for inclusion in the EIS.

The team produced a Data Gaps Analysis Report for the SMRRT Project (GeoEngineers, et al. 2015). Available data regarding geomorphic, hydrology/hydraulics, and fisheries conditions, as well as social and infrastructure considerations in the Puyallup River basin were reviewed to determine whether existing data sources were adequate for project design and permitting; whether identified gaps could be reasonably filled considering project schedule and budget; and if alternative existing data could be used.

The data gaps evaluation was divided into two categories: 1) the scientific technical disciplines including geomorphology, hydrology/hydraulics and fisheries science, and 2) other NEPA EIS disciplines the team evaluated as being relevant to permitting agencies for the project including Cultural Resources, Economic

[1]"Moderate" would be defined at the site level because it is based on Pierce County's Level of Service at each site.

Elements, Environmental Justice, Land Use, Hazardous Materials, Social, Transportation, Wetlands, Wildlife Habitat Conservation Areas, Visual Quality, and Geology/ Soils/Groundwater.

The technical discipline approach to identifying data gaps is summarized in Table 3 (GeoEngineers, et al. 2015). Each of the three technical disciplines evaluated the data available by developing critical criteria for siting and designing a pilot sediment removal project. The criteria were weighted relative to a low priority, medium priority or high priority scale of 1 to 3, respectively. The available data then were designated as either adequate for project purposes or additional data would be required/desired.

The NEPA EIS disciplines used a similar approach of prioritizing. The data gaps analyses are summarized in Table 4 (GeoEngineers, et al. 2015).

The most notable technical data gaps included: the current reach-scale geomorphic data (post-2008 to 2014); updated reach-and site-scale hydraulic models; updated sediment bedload trends; and absence of habitat typing, quantification and empirical data associated with habitat availability and fish use in the mainstem areas.

The team evaluated risks to the project if missing data were not attainable, along with an opinion of the likelihood of attaining the missing data in time for implementation in the selection and design process. The team concluded that, generally, high risk data gaps could be filled by direct data collection, compilation and analysis, provided that the project schedule allowed.

A cost estimate for filling the identified data gaps developed by the team proved to be excessive compared to the budget available for the project, and the team was asked to consider whether the available data were sufficient for the purposes of designing a pilot project to evaluate the feasibility of sediment removal as a tool to reduce flooding while enhancing fish habitat. The steering committee and the technical team concluded that while collecting additional data is always preferred, existing information, coupled with site-specific data acquisition at two final candidate reaches, would be adequate to complete the project, and constitute use of best available science. The team concluded that most of the gaps could be filled with reach- or site-specific surveys/observations at the appropriate times during the site selection and design processes. The one exception may have been empirical fish use data, especially for the mainstem river channels as a result of river turbidity, safety and fish use timing. Likewise, the EIS discipline evaluation concluded that data gaps associated could be filled by the team largely during project design. Thus, the identified data gaps did not represent fatal flaws to project completion.

1.4.2 Public and Agency Outreach /Communications

The project team identified that strong communication strategies for both internal and external audiences were important to the success of the project. The complexity of the subject matter necessitated clear, concise messaging and strong, ongoing interagency coordination. The plan recognized that sediment removal was a topic of interest to many jurisdictions, partner agencies, elected officials, other stakeholders, and Pierce County constituents. The project team developed several communication goals for implementation later in the project development. Pierce County's project lead was sensitive to internal issues of the previous project and did not want to expand the technical group or external communications until a promising plan for a pilot project was developed. Therefore, the control of messaging and communication outside the project team was identified as a critical success factor.

Identified communication objectives during this phase of the project included:

a. Highlight Pierce County's responsibility to protect public safety and infrastructure by addressing potential flood risks associated with the Puyallup, Carbon and White rivers.
b. Articulate the project's potential benefits and tradeoffs within the broader context of floodplain management. Highlight opportunities where multiple benefits can be achieved (e.g., reduce flood risk, protect public safety, and improve habitat).
c. Share accurate project information with stakeholders (and proactively correct misinformation).
d. Avoid surprising elected officials and other key decision-makers who may hear feedback from constituents about the project.
e. Collect public and stakeholder input at appropriate project milestones to inform key county decisions.
f. Support completion of permitting processes.

The project team prepared a detailed communications plan to help guide and implement communication tools, tactics, key messaging, and strategies during this phase. The plan also included a detailed audience analysis to identify those groups that would be most interested in project information and developments. The communications plan served as a living document that was revisited and updated as needed to account for new project developments and new information.

The communication tools that the project team implemented at this phase included a project website and a project fact sheet. The Pierce County project manager offered and provided project presentations to the Northwest Regional Floodplain Management Association and the Surface Water Management Advisory Board.

1.4.3 Lessons Learned

- A complete data gaps analysis is essential for a sediment removal project. Knowing what data is available will inform the project approach, help establish the project duration and budget, and identify technical stakeholders (internal and external) that should be consulted during project development.
- A data gaps analysis should include a delineation of reaches based on the goals and objectives of the project. In the case of the SMRRT project, it may have been prudent to reevaluate the reaches identified during the earlier project phase to verify that the previously selected reaches meet the revised/new goals and objectives for the project. The effort that a re-delineation entails will be dependent on the budget available.
- Early in the sediment removal pilot project reboot may have been a good time to coordinate with resource management agencies and tribal staff, keeping them more involved with setting project goals, providing information that may not be readily available to the public (such as private fish utilization data), and discussing the overall permitting approach and strategy. However, only limited fish utilization data was made available in the previous phases (Phases 1 and 2). Finding a strategy that provides large benefits to habitat may be a way to garner cooperation from stakeholders with proprietary fish utilization data.

- An alternative approach would have been to have the USACE, USGS or a university lead the project, with Pierce County staff and consultants collaborating to frame the research questions and overall direction of the study. At this stage of a sediment removal project for flood risk reduction, one could consider structuring the project as a scientific study, if funding was available and knowing that the project schedule might be lengthened. The study would include geomorphic and hydraulic analyses of riverbed aggradation, gravel bar growth, and the corresponding hydraulic and geomorphic response. These evaluations would be followed by analyses of the effects of gravel removal on corresponding hydraulic and geomorphic characteristics. For example, what is the location and quantity of gravel removal required to reduce water surface elevations over a reach of interest? This would involve a significant effort in applying a 2D hydraulic model over a significant portion of the river, then filtering based on the model results combined with the geomorphic analysis. If the studies conclude that gravel removal can be effective at achieving stated goals, then the subsequent phase of a project could focus on developing a permittable, on-the-ground project.

- Once the data gaps have been identified, the budgetary requirements of attaining the data to fill the gaps must be determined and whether the available budget is sufficient or the approach needs to be refined. The existing budget may not be adequate to acquire all the data that is desirable; such as using hydraulic 2D model results as a filter. If the goals are not being achieved, then re-evaluate the goals and redefine as necessary.

1.5. 2015-2016 SMRRT Project Reach Selection

1.5.1 Overview

Site selection began with a reach-scale evaluation of twelve reaches previously identified by Pierce County and their consultants during earlier phases of work (GeoEngineers, May 27, 2011; GeoEngineers, April 13, 2012; and Todd Essman, Pierce County Surface Water Management [SWM], personal communication) (see Section 1.2.1.). The project team remained the same as in the data gaps phase of the SMRRT project.

The goal of the reach-scale selection was to re-evaluate the previously selected reaches from the 2011 Phase 1 pilot study, and to narrow the number of reaches under consideration from twelve to six, then ultimately to two finalist reaches.

Selection criteria were developed as a collaborative effort between Pierce County staff and the consultant team. Four main categories were selected for consideration (Geomorphology, Hydraulics and Sediment, Fisheries, and Social and Land Use) in narrowing the number of reaches under consideration. Each Category was assigned three to six criteria. A basis for selection value (low priority, medium priority, high priority) was developed for each criterion with a numerical value (i.e., ranking) assigned to each ranging from 1 to 3, respectively. Each criterion ranking was then assigned to each of the twelve reaches, based on the data available and site reconnaissance conducted by the team. Raw scores were tabulated for each reach and summarized in Table 1 (GeoEngineers, et al. 2016a).

In order to remove any inadvertent bias to the numerical scoring resulting from the number of criteria assigned to each category (i.e. those categories with more criteria vs. those with fewer criteria), the scores were normalized; the raw score for each category was divided by the total number of possible points for that category, for each reach. For example, the Fisheries selection category had five criteria, corresponding to a total possible reach score of fifteen; summed criteria scores within the Fisheries category for each

reach were then divided by fifteen, resulting in a selection category score on a scale of 0.0 to 1.0. The normalized score for each reach is presented in Table 2 (GeoEngineers, et al. 2016a). The twelve reaches then were scored and ranked as depicted in Table 3 (GeoEngineers, et al. 2016a), and the highest ranking six reaches were chosen for additional evaluation.

Subsequently, the same process was repeated for the remaining six reaches in order to select the top two candidates for further evaluation. The selection criteria were generally the same but refined to add detail to help the selection process. The same prioritization tiers for high, medium and low were used to score each criterion. However, two criteria for Fisheries resources were eliminated because the data available could not improve the resolution of salmonid habitat restoration potential or vegetation density on bars for the final ranking. Including those criteria would have been redundant from the initial filtering from twelve to six reaches. Raw and normalized scores were summarized in Tables 4 and 5 (GeoEngineers, et al. 2016a) for each of the six reaches. The reaches were ranked as presented in Table 6. Based on the final scores, the highest-ranking reaches were the "Old Cannery" or P1, and "Sportsman" or P2 reaches, each on the Puyallup River at River Mile (RM) 10.2 to 10.5 and 13.9 to 14.4, respectively (see Figures A-1 through A-3, GeoEngineers, et al. 2016a, for the locations of the top two reaches).

In general, Reach P1 is located at the confluence of the Puyallup and White rivers, and is bounded by the City of Puyallup on the left (south) bank and the City of Sumner and unincorporated Pierce County on the right (north) bank. The area is moderately urbanized, with the City of Sumner wastewater treatment plant located immediately north of the river. The Linden Avenue Bridge crosses the Puyallup River just upstream of this reach. Overtopping of the levees and revetments had been the primary cause of flood damage in this reach, with backwater effects that inundated a large area south of the river within the City of Puyallup during floods. Historically, damage to the levees and revetments has not been pervasive during flood events.

Reach P2 is bisected by the 96th Street East Bridge. This reach on the Puyallup River is entirely within unincorporated Pierce County. The Sportsman Club property and a small residential cluster are the primary developed properties in this reach. Land use is primarily undeveloped rural open space and agricultural. Damages to levees and revetments had been high to moderate in the previous 15 years, along with moderate occurrences of overtopping resulting in flooding.

Conclusions for each finalist reach for each discipline are summarized below.

Reach P1: In summary, reach P1 achieved a normalized combined score of 0.81 for criteria from the categories that were ranked, and was the most favorable for implementation of a sediment removal project because of the following:

> **Geomorphology:** The apparent long-term stability of the reach and the hydraulic characteristics indicated that a well–designed SMRRT Project in this reach would not likely induce channel instability. Persistent long-term gravel bar growth over decadal time scales was expected in this reach as a result of the abrupt change in channel alignment near the White River confluence, the channel constriction caused by the Linden Avenue Bridge, and the presence of levees on both banks.
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> **Hydraulics and Sediment:** This reach is a source control to the lower Puyallup River. A sediment removal project would reduce sediment volume in this reach and immediately downstream. The

reach is immediately downstream of a bridge, and without sediment removal the riverbed is predicted to increase in elevation by 0.65 foot within 25 years, which may impact the bridge. The gravel bar in this reach likely would re-grow within 10 years of sediment removal as a result of geomorphic conditions that encourage alternate gravel bar formation. Constriction caused by the bridge also is a factor in sediment deposition but is minor when compared to the larger geomorphic-forcing mechanisms.

Fisheries: This reach is the only one of the six candidate reaches that is a non-ESA fish species spawning reach. No or low channel complexity and poor habitat conditions for native salmonids make this a well-suited reach for sediment removal because of fewer potential impacts to salmon and salmon habitat. This provided greater opportunity to implement any mitigation for potential impacts. This reach also presents an opportunity to improve historically degraded habitat.

Social and Land Use: Population density is relatively high in this reach, with commercial and light industry properties, and high traffic volumes on the roads. When major flooding occurs, impacts can be extensive, affecting transportation corridors, impacting critical infrastructure (Sumner wastewater treatment plant and underground sanitary sewer lines), and damaging private properties and economic centers.

Reach P2: Reach P2 achieved a normalized combined score of 0.75 for criteria from the categories that were ranked, placing this reach in the number two position:

Geomorphology: Persistent long-term gravel bar growth over decadal time scales was expected in this reach, because of the 96th Street East Bridge channel constriction and expansion, additional channel constrictions and expansions located upstream near RM 14.5 and downstream near RM 13.8, and the presence of levees on both banks.

Hydraulics and Sediment: This reach is an area of sediment storage and bed aggradation, with the highest average bed elevation increase from 1984 to 2009 of the six-candidate reaches. A bridge in the middle of the reach creates a local constriction, which causes accumulation of gravel over time. It was estimated that it would take about 14 years for the bed to rebuild the current level if sediment was removed to the 1984 bed elevation.

Fisheries: Winter steelhead spawn in this reach, but not Chinook salmon. Fish use in a small unnamed tributary is neither documented nor presumed. This reach lacks habitat complexity and has potential for mitigation relative to fisheries.

Social and Land Use: A bridge is located within this reach and is at risk during flooding. The population density in this reach is moderate, and local residents can be stranded because of water over roadways during flooding. The past costs to Pierce County resulting from damages to revetments and levees during floods are high, especially in proportion to per river mile cost.

Some information on how each category was evaluated is provided below.

1.5.2 Geomorphology

The geomorphic assessment for reach selection was based on readily available data identified in the Data Gaps Analysis Report (GeoEngineers, et al., 2015) and information from Pierce County. Collectively,

this information included reach-by-reach geomorphic characteristics for twelve candidate reaches identified by Pierce County. The information available for the twelve reaches was reviewed with Pierce County in order to determine the geomorphic reach and site selection criteria to be used throughout the reach and subsequent site selection process. These criteria also were used to guide the information collection objectives for a two-day reach reconnaissance with representatives of Pierce County, which culminated in the selection of six candidate reaches.

Transitioning from twelve to six reaches required the application of the following prioritization and site selection criteria:

- **G1: Subbasin sediment yield (relative)** from the Carbon, Puyallup and White subbasins (Czuba, et al., 2012) was used as an indicator of spatial differences in the quantity of sediment available within the system.
- **G2: Stream power (relative)** along the Carbon, Puyallup and White rivers was used as an indicator of spatial differences and temporal changes in geomorphic function.
- **G3: Channel confinement within the valley** along the Carbon, Puyallup and White rivers was evaluated at the valley, reach and site scales.
- **G4: Planform pattern**(s) within the Carbon, Puyallup and White rivers were summarized according to the valley confinement and observations of planform characteristics.
- **G5: Long-term bar growth** along the Carbon, Puyallup and White rivers was used as an indicator of spatial differences and temporal changes in geomorphic function.
- **G6: Future channel response** potential resulting from the Project was characterized as low (indicating little to no expected change in channel form, type or behavior), moderate (some expected change in channel form, type or behavior), or high (significant expected change in channel form, type or behavior).

Transitioning from six-to-two reaches required the application of additional prioritization and site selection criteria. For each criterion, the basis for selection criteria values was determined through exploratory data analysis among all reaches. For example, average stream power was calculated for each reach, and the range in values among all reaches was used to differentiate reaches as low, medium or high priority.

- **G1: Sub-basin sediment yield (relative).** The sediment yield criterion values from the twelve-reach evaluation were used again for the six-reach evaluation.
- **G2a: Stream power (lb/sq ft sec) avg for 20y Q and G2b: Stream power change from upstream.** Two stream power criteria were evaluated based on the results from hydraulic modeling. Model output for the 20-year recurrence interval discharge was used to evaluate average specific stream power within each reach, and the specific stream power trend from upstream reaches to the reach of interest.
- **G3a: Channel confinement index (avg HCOT:Active Channel Width) and G3b: Locations of abrupt channel construction or alignment changes.** The evaluation of channel confinement used two criteria. A confinement ratio was developed in order to identify long-term changes in channel confinement within each reach. The ratio of the historic channel width to the 2015 channel width

was used to evaluate long-term changes in channel confinement. The second criteria evaluated the number and location of abrupt channel constriction or alignment changes.

- **G4: Planform pattern.** The planform patterns within the Carbon, Puyallup and White rivers were used again for the six-reach evaluation.
- **G5a: Average bar area (acres) 1998-2015 and G5b: Bar area growth factor (2015:1998).** The evaluation of long-term gravel bar growth used two criteria. The long-term average gravel bar area was based on data from 1998, 2008 and 2015. These same data were used to calculate the gravel bar area growth factor, which is the ratio between the 2015 gravel bar area and the 1998 gravel bar area.
- **G6: Future channel response.** Predicting future channel behavior was based on an integration of information from the geomorphic analyses described above, as well as results from the hydraulics and sediment analyses.

1.5.3. Hydraulics and Sediment

Selection criteria for the "Hydraulics and Sediment" category was developed to evaluate dynamic river processes at appropriate spatial scales using existing information and data. Criteria were weighted using low, moderate and high rankings, or priorities.

Selection criteria chosen for the twelve-to-six reach filter included:

- **H1: Average level of protection (return interval Q),** as determined by reach-averaged flood conveyance capacity;
- **H2: Minimum level of protection (return interval Q),** as determined by the minimum flow magnitude at which floodplain overtopping begins;
- **H3: Prior flood location.** Frequency of area flooding as documented by Pierce County records from 1990 to 2015;
- **H4: Potential flood reduction.** Qualitative assessment of flood risk reduction if project(s) were implemented; criterion was eliminated because it was based on a previous Pierce County study and duplicated a "social" criterion already being considered by Pierce County;
- **H5: Recent (decadal) hydraulic change (max within reach).** Maximum change in channel conveyance capacity as calculated by comparison of 1984 and 2009 channel surveys; and
- **H6: Recent (decadal) hydraulic change (avg within reach).** Reach-averaged change in channel conveyance capacity as calculated by comparison of 1984 and 2009 channel surveys.
- **S1: Recent (decadal) bed elevation change.** Change in average bed elevation as calculated by comparison of 1984 and 2009 channel surveys;
- **S2: Transport regime.** Reach transport regime defined as either supply, transport or storage;
- **S3: Typical sediment storage period.** Sediment storage period calculated over a 10-year timeframe;
- **S4: Longitudinal pattern in grain-size distribution;** and
- **S5: Longitudinal change in sediment transport capacity.**

Selection criteria codes use for the selection of the two finalist reaches were refined and expanded to use available quantitative data.

Refined or new criteria for the six-to-two reach filter included:

- **H1: 2008 level of protection; WSEL-Bank EL for 10 yr/50/yr/100 yr.** Level of protection as defined as the elevation difference between the 2008 bank level and 10-year flood level, computed using the existing HEC-RAS hydraulic model;
- **H2: Change in level of protection, 1984-2008 DQ at R/10 yr.** Change in estimated 10-year flood discharges computed in 1988 and 2008;
- **H3: Change in level of protection, 1990-2008, DWSEL for 10 yr RI Flow.** Change in computed 10-year water surface elevations measured at USGS gage stations in 1990 to 2008;
- **H4: Potential flood reduction.** Potential flood risk reduction if project(s) were implemented using the existing HEC-RAS hydraulic model; and
- **H5: Potential flood risk if nothing is done.** Estimated flood risk if the no action option was implemented based on current aggradation rates, past changes in bed level, and predicted future bed level changes.
- **S1: Bed elevation change (ft), 1984-2009.** Change in average bed elevation as calculated by comparison of 1984 and 2009 channel surveys;
- **S2: Response time to rebuild channel after project, yrs.** Calculated response time for channel to aggrade to pre-project levels where the project was implemented;
- **S3: 25-yr average aggradation at site.** Comparison of normalized aggradation rates over a 25-year period;
- **S4: Change in bed elevation (ft) if no project over 25 yrs.** Estimated change of bed levels if the no action option was implemented; and
- **S5: Ratio of sediment supply to transport capacity.** Ratio of estimated sediment supply to computed transport rate.

1.5.4. Fisheries

The fisheries assessment was based on readily available data identified in the Data Gaps Analysis Report (GeoEngineers, et al. 2015). In planning and preparation for scoping the study, Pierce County determined that incorporating fish habitat use would be an important consideration for selecting sediment removal sites for a pilot project. To protect valuable fish resources, the team needed to understand the habitats available, what habitats are being used and when they are being used, and potential impacts that could result from sediment removal. Overall, the approach focused on the following objectives to help inform site selection:

- Evaluation of known ESA-listed salmonid spawning habitat use areas;
- Identification of suitable nursery juvenile rearing habitat areas (e.g. low-velocity/off-channel habitat);
- Estimation of salmonid habitat restoration potential; and
- Identification of key areas where impacts could have considerable detrimental impacts to fish populations.

To narrow the focus from twelve candidate reaches to six, the team conducted the reach prioritization process on the twelve-candidate project reaches using the five fisheries-specific selection criteria (and priorities), summarized below:

- **F1: ESA-listed salmonid spawning habitat use**
- **F2: Proximity to tributary confluence**
- **F3: Nursery juvenile rearing habitat presence**
- **F4: Salmonid habitat restoration potential**
- **F5: Vegetation density on bars**

To narrow the site selection from six-to-two reaches, three fisheries prioritization selection criteria were used in a manner similar to the previous prioritization step from twelve to six reaches. Because this stage of evaluation was based on available data only, and field work was not conducted, the team attempted to reduce subjective judgment by eliminating selection criteria F4 (salmonid habitat restoration potential) and F5 (vegetation density on gravel bars). In the evaluation from twelve to six reaches step, criterion F4 was based primarily on professional judgment. Because no additional data would be available at this step and it was not specifically tied to minimizing habitat impacts, it was the team's professional opinion that this criterion would not provide any more resolution to the prioritization from six-to-two reaches. Likewise, F5 was not used because in the absence of additional field data collection methods and results would have been the same as the previous step. The three selection criteria used in this step (and priority levels) are summarized below.

- **F1: ESA-listed salmonid spawning habitat use**
- **F2: Proximity to tributary confluence**
- **F3: Nursery juvenile rearing habitat presence (i.e., low velocity/off-channel habitat)**

1.5.5. Social and Land Use

Social

Selection criteria for the "Social" category were evaluated for the potential benefits of reduced flood risk to the local population and the infrastructure used by the population. Criteria were weighted using low, moderate and high rankings, or priorities.

Selection criteria chosen for the twelve-to-six reach filter included:

- **SO1: Population benefited from reduced flooding of structures** using 2010 census data and 2014 planimetric data;
- **SO2: Population benefited from reduced flooding of roads (road closures.);** and
- **SO3: Property value changes.**

The selection criteria for the six-to-two reach filter process also were refined and expanded to use available quantitative data. The criteria used in the selection process for twelve-to-six reach filter used qualitative information to make screening decisions regarding the potential benefits that a sediment removal project may have on structures (SO1), roads (SO2) and property values (SO3). The refined criteria used to select two final reaches used SO1 and SO2 but expanded upon them. Criterion SO3, as previously defined, was dropped as a screening criterion and replaced with new measurable criteria to better inform the selection process.

In the selection of two finalist reaches, Code SO1 focused on the population and population density located within the 1 percent chance (i.e., 100-year floodplain); criterion SO2 focused on private structures located within the 1 percent chance floodplain; and criterion SO3 focused on the impacts to roads from flooding based upon Average Daily Traffic (ADT) volumes. New criterion SO4 attempted to account for the potential impact to economic centers along the candidate reaches.

Selection criteria chosen for the six-to-two reach filter included:

- **SO1: Population Density;**
- **SO2: Population Benefitting from Reduced Flooding of Structures (SF);**
- **SO3: Population Benefitting from Reduced Flooding of Roads (ADT); and**
- **SO4: Impact to Employment Centers.**

Land Use

Selection criteria were created for the "Land Use" category to qualitatively evaluate the flood risk to critical facilities and infrastructure as well as the flood risk associated with levees and revetments. Critical facilities are those that are essential to a community's resiliency and sustainability, and for this study were defined as the community's ability to quickly and efficiently respond to floods, recover from floods, meet the needs of its citizens, and rebuild after floods. All facilities evaluated are within the 100-year floodplain, as defined by Pierce County 2014 GIS data. Details of the selection criteria and applied weighting are presented in Appendix E of the Reach Selection Report (GeoEngineers, et al. 2016a).

Selection criteria chosen for the twelve-to-six reach filter included:

- **L1: Critical Facilities and Infrastructure Risk;**
- **L2: Levee/Revetment Damages (locations);**
- **L3: Levee/Revetment Damages (per river mile).** Normalized to account for reaches of differing length);
- **L4: Flooding – Frequency** (previous 15 years); and

- **L5: Flooding – Locations** (previous 15 years but accounting for numbers of locations where washouts or overtopping occurred).

Selection criteria used for the selection of the two finalist reaches were refined and expanded to use available quantitative data. Criterion L1 continued to focus on Critical Facilities; however, the focus shifted to those specific facilities that are at risk of flood damage. Criteria L2 and L3 were added to account for potential flood impacts to public roads and private properties. Criteria L4, L5, L6 and L7 remained the same as those used in the twelve-to-six reach filter, but two new criteria (L8 and L9) were added to inform the decision-making process regarding the estimated cost to the county to restore flood-damaged levees and revetments (see Table E-2, GeoEngineers, et al. 2016a).

Refined or new criteria for the six-to-two reach filter included:

- **L1: Critical Facilities Risk;**
- **L2: Public Infrastructure Risk (roads);**
- **L3: Private Property Risk ($);**
- **L8: Flooding - Past Costs to Pierce County ($)**; and
- **L9: Flooding - Past Costs to Pierce County ($/RM).**

Scoring results for the top six reaches are summarized in Table E-2 (GeoEngineers, et al., 2016a).

1.5.6 Public and Agency Outreach/Communications

During this phase of the project, the communications plan was revisited and updated to reflect the reach selection process. In addition, the project website content was updated to reflect the completion of the data gap analysis, as well as the site selection criteria that the team was developing. Because much of the selection process involvement was limited to the technical team, little public outreach occurred during this phase. Some outreach did occur in 2016 regarding the two final sites. However, Pierce County did not receive any substantive feedback because most regulatory agencies wanted to first know more about the final site selection. The unique characteristics of the final site would be more applicable to the permitting process and their regulatory purview.

1.5.7 Lessons Learned

At the reach selection stage of the SMRRT project, the following lessons are identified:

- Careful consideration should be given to the weighting process that is selected to develop cumulative scores for each reach. The project goals and/or permitting strategy for your project will influence the category selections and how weights are assigned to each category. In the SMRRT project, while all categories were important, some may have been more critical to the success of the project and, therefore, deserved more influence in the scoring. For example, it is possible that a different reach would have been chosen if a higher weighting were given to hydraulic benefit. The difficulty with weighting categories is that there is an inherent potential to introduce bias into the scoring based on what someone perceives to be more important.

- Coordination with regulatory agencies and tribal natural resources/fisheries staff to refine the project approach for reach selection may have proved beneficial. This may have created more support for the project and final site selection.

1.6. 2015 - 2016 SMRRT PROJECT SITE SELECTION

1.6.1. Overview

As summarized in Section 1.5.1, the two finalist reaches for the SMRRT Project selected during the reach-scale selection phase were the P1 (Old Cannery) and P2 (Sportsman) reaches of the Puyallup River.

Both the P1 and P2 reaches are at least partially confined by levees. Flood control measures other than sediment removal had been identified, and at least partially implemented, at or near Reach P1, including a levee setback along the river's left bank at the Lynden Golf Course, which at the time was at conceptual design, and a flood wall at the City of Sumner wastewater treatment plant. At P2, levee setback likely is not viable because of the bridge restriction; but a specific setback project was not defined in 2016, and would have taken several years to fund and implement once identified.

The project team for the final site selection remained the same as during the reach selection phase. Additional modeling and analysis were completed for these two reaches, in order to select a final reach best suited to achieve the goals of the SMRRT Project.

In the site selection phase, the technical team used the "categories" (i.e., Hydraulics and Sediment, Geomorphology, Fisheries Resources, and Social and Land Use) previously used in the Reach-scale Selection phase. Additionally, analysis by three new disciplines were added to aid in the selection of the recommended final site: Hazardous Materials; Wetlands and Wildlife Habitat; and Geology, Soils and Groundwater. These disciplines were added because of the potential for these disciplines to impact project permitting and cost.

This site selection phase included collecting additional data, sediment transport and hydraulic modeling, habitat impacts analysis, and documenting existing baseline environmental conditions.

At this phase, permitting the project was expected to include acquisition of State and Federal permits and would need to comply with State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA) processes. It was anticipated that the level of analysis for the permitting process might take the form of a joint NEPA/SEPA EIS. Appropriate discipline reports would be completed and assembled for submission as a draft EIS for agency review and for public comment. The final EIS would then be published once the comments had been addressed.

The site selection process was initiated by completing bathymetric (i.e., river section) surveys to develop one-dimensional (1D) hydraulic models for both reaches. The survey results were combined with 2010 LiDAR data provided by Pierce County to develop base maps for each reach for the hydraulic, sediment, geomorphology and fisheries resources analyses.

Next, a two-day field reconnaissance was conducted by representatives of the team in November 2015 to document existing conditions. The reconnaissance formed the basis for developing two conceptual

sediment removal scenarios for each reach, incorporating hydraulics, sediment transport, geomorphic and fisheries resources considerations.

Subsequently, steady-state 1D HEC-RAS hydraulic models were constructed for existing conditions for each reach to aid with site selection evaluations. The 1D HEC-RAS model suggested a significant water elevation increase following sediment removal. This was interpreted to represent an artifact of 1D simplification of hydraulic computations. Therefore, a two-dimensional (2D) model for each sediment removal alternative (two alternatives for each reach) was constructed using Sedimentation and River Hydraulics 2D hydraulic model (SRH-2D). Each alternative was evaluated using several flood flows to simulate post-sediment removal flow elevations, inundation areas and areas of levee overtopping. Cross sections were constructed for pre- and post-sediment removal conditions to evaluate sediment transport responses, estimate the effectiveness of sediment removal for reducing flooding, and estimate the time required for sediment accrual to return to pre-sediment removal conditions.

The bathymetric surveys, available data obtained during reach-scale selection and results from the 1D and 2D hydraulic models were evaluated for geomorphic impacts and considerations, and to qualitatively evaluate future channel responses to each sediment removal alternative for the two finalist reaches.

Fisheries resource considerations compared juvenile rearing habitat availability (depth and velocity only) for ESA-listed Chinook salmon and steelhead species between existing conditions and both sediment removal alternatives during low-flow and moderate-flow flood events.

The Social and Land Use selection assessment compared pros and cons of reducing flood events at each of the two reaches, P1 and P2, based on the criteria, such as population density, development, critical infrastructure and past flood damages, as determined during the Reach-scale Selection phase of the project

Hazardous Materials considerations used land use data from Pierce County zoning information and aerial photograph interpretation from post 1940; Pierce County outfall information and the origin of discharges to the river; and known contaminated, hazardous waste or other sites of environmental interest adjacent to each reach.

Wetlands and Wildlife Habitat evaluations used data from available wetland and wildlife databases to identify the number of mapped wetlands and wildlife habitat areas, areal extent of wildlife habitat areas, and vegetated riparian width within each reach.

The Geology, Soils and Groundwater considerations relied on available geology, soil and groundwater data to assess the relative degree of adjacent material in each reach to provide more sediment, and the potential for construction activities to affect regional groundwater flow.

Each of the analyses described above resulted in identifying positive and negative attributes for sites P1 and P2. A resulting Pro vs. Con analysis was conducted based on the results of the discipline analyses. The Pro vs. Con factors are presented by discipline in Table 1of the Site Selection Report (GeoEngineers, et al., 2016b) and described below. Reach P1 ranked higher than P2 in almost every category. The only category that P2 ranked higher for was hazardous materials, which could be mitigated by planning for appropriate disposal of the sediment removed.

Summaries of each discipline analysis are provided below.

1.6.2. Geomorphology

The geomorphic assessment for site selection was based on readily available data, as described in the Reach-scale Selection Report (GeoEngineers, et al., 2016a), and information from Pierce County. This information included reach-by-reach geomorphic characteristics for twelve candidate reaches identified by Pierce County. The information available for the two finalist reaches was reviewed with Pierce County and site selection criteria to be used throughout the site selection process (GeoEngineers, et al., 2016b). These criteria also were used to guide the information collection objectives for the two-day geomorphic survey of the two finalist reaches.

Geomorphic surveys were completed for each of the two final candidate reaches on November 5 and 6, 2015, to observe the existing planform patterns and associated physical characteristics. This assessment included mapping and characterizing the river channel and adjacent surfaces in the selected reaches for existing conditions, including:

- Morphological bedform transitions (e.g., pool, riffle, run, side-channel);
- Locations, dimensions, and controlling factors of depositional gravel bar features;
- Riverbank materials, conditions, locations and dimensions of active adjustment;
- Large wood material, including individual pieces and logjams, within the active channel and riverbanks;
- Riparian conditions; and
- Adjacent land uses.

The results from sediment transport modeling and two-dimensional hydraulic modeling of the two finalist reaches provided additional information to evaluate the geomorphic processes and potential future channel response. Collectively, all this information was used to evaluate the geomorphic selection criteria for reaches P1 and P2.

The evaluation of geomorphic selection criteria suggested that reach P1 would be more suitable for a SMRRT project than reach P2. The existing conditions at P1 indicated more bed material available for removal, and a neutral long-term sediment transport regime that would be better for long-term sediment management. The evaluation of historic, existing and potential future conditions indicated greater long-term channel stability at P1, including under the modeled sediment removal alternatives.

1.6.3. Hydraulics and Sediment

Hydraulic impacts of conceptual level alternatives were evaluated using the SRH-2D hydraulic model to capture the complex hydraulics at sites P1 (Old Cannery) and P2 (Sportsman). Two alternative sediment removal options were considered for each site. Under Alternative 1, gravel bars in the reach would be excavated to an elevation 0.5 foot above the water surface during the median summer flow. In Alternative 2, in addition to gravel bar surface lowering, a second channel would be excavated through the gravel bar that is equal to the adjacent channel thalweg elevation.

Three flow scenarios were modeled for each alternative corresponding to the median summer, approximate 1.5-year, and the 10-year events. On average, water surface elevations were reduced through the project

sites for each alternative for all flows modeled. There were a few localized incidences where water surface elevations were increased because of the proposed excavation. Alternative 2 provided the greatest reduction in water surface elevations at both proposed project sites.

Sediment transport at both locations was evaluated by examining temporal changes to cross-section geometry. The sediment transport modeling results indicated that the amount of deposition occurring at Site P1 would lead to a slower re-growth of the gravel bars in that reach when compared to Site P2.

1.6.4. Fisheries

Findings from the prior reach prioritization steps resulted in two final candidate reaches. In this step, the project team conducted a Pro vs. Con analysis to compare the two reaches relative to fish and their associated habitats. Methods for analysis at this step included collecting field data (November 5 and 6, 2015) and interpretation of SRH-2D model results relative to fish habitat suitability. In general, the November 2015 observations included identifying areas where suitable spawning and rearing habitat for ESA species might exist, which were used to ground-truth model results.

The hydraulic model was developed for both existing conditions and two conceptual proposed conditions at each reach. For the existing and conceptual proposed conditions, models at each reach were run at two flow conditions to represent a low-flow condition and moderately high-flow condition (P1: low-flow = 1,175 cubic feet per second (cfs), high-flow = 11,800 cfs; and P2: low-flow = 1,175 cfs, high-flow = 11,900 cfs). Juvenile rearing areas for ESA-listed steelhead and Chinook salmon were estimated by overlaying velocity and depth results for each flow. Suitable conditions for steelhead and Chinook salmon were combined and identified where flow velocity was between 0.46 and 1.99 feet per second and depth was greater than 1.5 feet (WDFW 2004). Model runs were not conducted for spawning habitat because substrate size and distribution are critical for that analysis and those data were not collected or available.

Results - Reach P1

Based on visual observations of reach P1, the team concluded that very little juvenile rearing habitat is available, largely owing to the relatively high velocities associated with a single-thread channel and lack of cover. Existing condition model results support field observations. Suitable juvenile rearing habitat comprises approximately 11 percent of the channel area throughout the reach at 1,175 cfs and approximately 2 percent of the channel area at 11,800 cfs.

In conceptual Alternative 1, estimated juvenile rearing habitat availability decreases from existing conditions at both flows. At 1,175 cfs, availability decreases by less than 1 percent and at 11,800 cfs, availability decreases by approximately 19 percent.

In conceptual Alternative 2, estimated juvenile rearing habitat availability increases from existing conditions at both flows. At 1,175 cfs, availability increases by approximately 66 percent and at 11,800 cfs, availability increases by approximately 25 percent.

Results - Reach P2

Similar to Reach P1, Reach P2 has very little juvenile rearing habitat for ESA-listed species, largely owing to the relatively high velocities associated with a single-thread channel and lack of cover. Existing condition model results support our field observations. Suitable juvenile rearing habitat comprises approximately 5 percent of the channel area at 1,175 cfs and approximately 1 percent of the channel area at 11,900 cfs.

In conceptual Alternative 1, estimated juvenile rearing habitat increases by nearly 3 percent at 1,175 cfs and decreases by approximately 45 percent at 11,900 cfs.

In conceptual Alternative 2, estimated juvenile rearing habitat increases by approximately 148 percent at 1,175 cfs and decreases by nearly 13 percent at 11,900 cfs.

Conclusions for Fisheries

The two alternatives evaluated for each reach showed mixed results in terms of potential habitat losses and gains. In Reach P1, Alternative 1 estimated habitat availability decreases at both flows, while habitat availability increased at both flows in Alternative 2. In the two alternatives evaluated for Reach P2, habitat availability increased at low flows but decreased at higher flows.

From a fish habitat perspective, Reach P1 seemed to be the reach where habitat impacts would be the least and could potentially have a net benefit if Alternative 2 was selected. Both alternatives in Reach P2 showed a considerable decrease in juvenile rearing habitat at higher flows so negative impacts might be unavoidable.

Although model analysis didn't specifically evaluate spawning habitat, previous analysis shows documented steelhead spawning in Reach P2. Our field observations identified conditions in Reach P2 appeared to be well-suited for steelhead spawning. Therefore, it is probable that sediment removal in that reach could reduce spawning habitat availability. Comparatively, previous analysis phases suggest that ESA-listed species had not been documented spawning in Reach P1 and field observations only identified one small location that appeared to be suitable for spawning. Therefore, the risk to spawning habitat of a project involving sediment removal seemed much smaller for Reach P1 compared to Reach P2.

1.6.5. Social and Land Use

In preparation for screening the selected six reaches to the final two, the screening criteria were refined to include additional details to better inform the screening process. The screening criteria previously used to reduce the reaches from six reaches to two were left unchanged. However, in this phase these criteria were used to compare and contrast the pros and cons of reaches P1 (Old Cannery) and P2 (Sportsman). This analysis provided a method that produced a clear choice for selecting the final candidate (i.e., P1), based on a comparison of Social and Land Use categories for the two reaches. A table summarizing the analysis is shown below (Table D-1 of the Site Selection Report, GeoEngineers, et al., 2016b).

TABLE D-1. SITE SELECTION

	Site P1 Pros	Site P1 Cons		Site P2 Pros	Site P2 Cons
1	High priority critical infrastructure at risk.	Low occurrence of levee damages along reach.	1	High occurrence of levee damages along reach.	No high priority critical infrastructure at risk.
2	High population impacted.	Low cost of past flood damages to levees.	2	Moderate number of flooding locations along reach.	Low value of private property at risk.
3	Moderate value of private property at risk.		3	High cost of past flood damages to levees.	Moderately low population impacted.
4	High number of flooding locations along reach.		4		Very low square footage of structures in 100-year floodplain.
5	Moderately high square footage of structures in 100-year floodplain.		5		Moderate impact to traffic caused by flooding.
6	High impact to traffic caused by flooding.		6		Moderate to Low impact on commuters and economy.
7	High impact on commuters and economy.		7		No significant roads impacted by flooding. Alternative routes available.
8	Lifeline corridor impacted by flooding.				

Notes:

Blue: Land Use Criteria

Green: Social Criteria

Based upon an analysis of the pros and cons of each site for the Social and Land Use criteria, Site P1 had more pros than cons. Site P1 had more pros in both criteria categories than Site P2. Further, Site P1 had a greater range of benefits than Site P2. Therefore, based upon the Social and Land Use criteria, Site P1 was the better candidate for the next phase of the Project.

1.6.6. Hazardous Materials

An additional category included as part of project site selection was the potential for the presence of hazardous materials in sediment. The hazardous materials category was included in site selection based on the premise that the presence of hazardous materials in sediment could increase the required level of effort and corresponding cost for sediment removal permitting and reuse and/or disposal of the material. The evaluation performed as part of project site selection included an assessment of potential sources of hazardous materials to the two candidate reaches.

The evaluation included a review of:

- Land use type and density in proximity to the candidate reaches;
- Discharges into and in proximity (i.e., upgradient) of the candidate reaches; and
- Identification and assessment of contaminant sources including known hazardous waste sites in proximity to the candidate reaches.

The rationale for the parameters that were evaluated is that the likelihood of sediment contamination increases with increasingly intensive land use, with a greater number of outfall discharges and with increasing numbers of contaminant sources in proximity to the project sites. The following sections summarize information obtained and reviewed to evaluate the potential for the presence of hazardous materials in sediment at the two potential project reaches (i.e., P1 and P2). Generally in this phase, site selection was conducted as a pros vs. cons analysis. However, a "scoring" or ranking approach used during the analysis for Hazardous Materials was used in this project phase; this discipline had not been previously scored since it was added to the site selection phase.

Surrounding Land Use

Land use zoning information for the area encompassing the two reaches was obtained from Pierce County and reviewed. Additionally, aerial photographs provided in Environmental Data Resources reports (EDR) and on Google Earth also were used to evaluate land use in the area of the two reaches. Reaches were scored based on the prevalent adjacent land use: "low" for urbanized land use, "medium" for rural and agricultural use, or "high" for undeveloped land.

Presence of Outfalls

Information concerning drainage and outfalls in proximity to the two reaches was obtained from Pierce County. Drainage information included maps of stormwater collection infrastructure (catch basin, pipes, culverts, open channels, etc.) in proximity to each reach and outfall information included the number of outfalls, the origin of discharges contributing to the outfalls (e.g. "roads," "agriculture", etc.) and outfall pipe size (i.e., pipe diameter). Information that supported a lower score (i.e., "low") included a larger number of outfalls with contributions from higher intensity activities/sources (ex. roads, parking, etc.). Information that supported a higher score (i.e., "medium"), included a lower number of outfalls with contributions from drainage with a lower likelihood of sources (ex. oxbow/wetland). Information that would support the highest score (i.e., high) would be no outfalls being present in or within one-half mile upgradient of the reach.

Presence of Contaminant Sources

EDR reports were obtained that summarized known contaminated, hazardous waste, and other sites of environmental interest adjacent to or in proximity to, each reach. The EDR reports identified sites up to a one-mile radius from each reach. Information that supported a lower score (i.e., "low") included a relatively high number of sites, in proximity to the reach. Information that supported a higher score (i.e., "medium") included a relatively lower number of sites in proximity to the reach. Information that would support the highest score (i.e., high) would be no known contaminated, hazardous waste, and other sites of environmental interest adjacent to or in proximity to the reach.

Scoring/Results for Hazardous Materials

Each reach was scored based on the criteria identified above and discussed below. Land use zoning information, outfalls and known contaminated, hazardous waste, and other sites of environmental interest were tabulated and presented in figures provided in Appendix E for each reach (GeoEngineers, et al. 2016b).

Review of land use information and historical aerial photographs for the areas adjacent to and upgradient of each reach indicated that land surrounding reach P1 had been developed for decades and was an increasingly dense urban area. Land surrounding reach P2 had been developed for decades as agricultural land with interspersed residential development. The presence of hazardous materials in sediment was more likely for reach P1 than P2, based on surrounding land use.

The reaches were evaluated based on the number of outfalls and the origin of the discharges contributing to the outfalls. Outfalls were included for evaluation if they were located within the reach or within one-half mile upgradient of the reach end. There were 19 outfalls mapped in or within one-half mile upgradient of reach P1 that ranged in size from 12 inches to 42 inches in diameter with discharges originating from roads and parking lots, agriculture, wetlands, trails and a wastewater treatment plant. There were two outfalls mapped in or upgradient of reach P2 that were 60 and 64 inches in diameter originating from oxbows/wetlands. The presence of hazardous materials in sediment was identified to be more likely at reach P1 than P2 based on the number and discharges from outfalls.

The reaches were evaluated based on the number and general type of sites identified in the EDR reports. Only those sites located in areas that appeared to have the potential to contribute drainage or groundwater discharge to the reaches or contribute drainage or groundwater discharge within one-half mile upgradient of the reach ends, were included for evaluation. The amount of information for each site varied and that best professional judgment was used in assessing potential for contaminant contribution. Based on the evaluation, there were approximately 19 sites with the potential to contribute contamination to reach P1. Based on the evaluation, there were approximately eleven sites with the potential to contribute contamination to reach P2. The presence of hazardous materials in sediment was more likely for reach P1 than P2, based on the presence of potential contaminant sources.

Based on the evaluation performed for the hazardous materials category, Reach P2 scored higher (lower likelihood of contaminated sediment), based on the information that was reviewed and scoring that was performed. The hazardous materials category was the only one in which Reach P2 scored higher than P1.

1.6.7. Wetlands and Wildlife

Wetlands and wildlife were added to the project in this phase as an additional screening tool. Occurrence and distribution of wetlands and wildlife habitats were considered during this phase specifically to evaluate potential temporary or permanent impacts of the project on regulated sensitive habitats that may be located on the margins of the channel, within adjacent riparian buffers, and/or at upland access routes and staging areas. These areas could be impacted as a result of modifications to the banks of the channel and/or during site access and construction. Impacts to sensitive habitats can have permitting implications and may require costly habitat mitigation. This evaluation was independent of, and did not consider, potential impacts to aquatic habitats associated with the river, such as fish habitat, nor did it consider riverine wetlands that are within the banks of the river.

Evaluation of wetlands and wildlife habitat impacts was based primarily on definitions available from Pierce County Code Title 18E, which regulates wetlands and Fish and Wildlife Habitat Conservation Areas (FWHCAs), as well as data available from the USFWS National Wetlands Inventory (NWI), and the Washington Department of Fish & Wildlife (WDFW) Priority Habitats and Species (PHS) Inventory. Field assessments were not completed as part of this evaluation. Instead, the published map data available from the above sources were used.

Two criteria were identified by which to evaluate each type of habitat, which included:

- Wetland criteria:
    - W1: Presence of wetland habitat
    - W2: Potential for on-site wetland mitigation
- Wildlife criteria:
    - VW1: Wildlife habitat presence/occurrence
    - VW2: Characteristics of native vegetation

Occurrence of wetland (W1) and wildlife (VW1) habitats used a 300-foot buffer around each project site, which constituted the "review area" and was intended to provide for analysis of the potential to impact habitats proximal to each project site as a result of construction access routes, staging or other site work outside of the river itself. Available spatial data for each type of habitat was input into a Geographic Information System (GIS), which was used to identify the proportion of the review area covered by the habitat type and the quantity of wetland units located immediately at or adjacent to anticipated construction areas based on preliminary designs. To evaluate the potential for on-site wetland mitigation (W2), we quantified the number of non-riverine wetlands within the review area, which could potentially be used as mitigation sites, the number of wetland and wetland-adjacent areas that appeared to have degraded baselines based on aerial imagery, and presence or absence of non-riverine hydrology that might support wetland conditions at a mitigation site. Characteristics of riparian vegetation (VW2) was assessed by identifying the typical width of the intact riparian vegetation corridor adjacent to the river throughout each site, the connectivity of the riparian habitats within each site to habitat areas beyond the site, and the subjective quality of on-site riparian vegetation based on a review of site photographs.

Like the Hazardous Materials analysis, the Wetlands and Wildlife analysis had not been conducted during the SMRRT project reach selection phase, therefore, scoring was conducted during this site selection phase. Each site was rated as Low, Medium or High with respect to specific thresholds identified for each criterion, which were presented in detail in the Site Selection Report (GeoEngineers, et al. 2016b). Reach P1 scored higher than P2 for criterion W1, whereas the reverse was true for criterion W2. It was noted that the results of these two analyses are inversely correlated with each other: where wetlands are present and, therefore, more likely to be impacted by construction activities, there also is more likely to be ample opportunity to complete wetland mitigation, which requires existing degraded wetlands and available wetland hydrology. For prioritization purposes, which are based on the consequences of environmental permitting for the Wetland Category, it was decided that avoiding (or minimizing) wetland impacts at a site with limited mitigation potential was preferable to incurring more wetland impacts at a site with ample mitigation potential. Consequently, criterion W1 was weighted more heavily than criterion W2. As a result,

Reach P1 received a higher overall priority classification than Reach P2 for the wetland category. Reach P1 also was rated higher than P2 for both wildlife habitat criteria.

These results indicated that, based on the data reviewed, project construction activities and site access at Reach P1 was less likely to have an adverse effect on non-riverine wetlands and non-fish wildlife species that could occupy habitats adjacent to the river. This evaluation was based on limited site-specific data and, because of project budget, did not include a site reconnaissance to verify or delineate jurisdictional wetland habitats or occurrence of wildlife habitats.

1.6.8. Geology, Soils and Groundwater

The three related criteria of geology, soils and groundwater were evaluated together for reach selection because they could mutually contribute either beneficial or detrimental impacts to the project. The most favorable site would have a large accumulation of loose gravel with sand in an area with easy access, minimal geologic hazards and low groundwater levels.

The Data Gaps Analysis (GeoEngineers, et al. 2015) identified five selection criteria to apply to the geology, soils and groundwater category:

- GSG1 – Geologic Units Mapping
- GSG2 – Soils Units Mapping
- GSG3 – Groundwater Flow Patterns for the Basin
- GSG4 – Erosion Hazard Areas
- GSG5 – Landslide Hazard Areas

Mapped geologic units that indicated favorable conditions included Quaternary alluvium (Qal) and glacial deposits, specifically Vashon-age glaciation recessional (Qvr) and advance outwash (Qva) units. The mapping of these glaciofluvial materials in the floodplain and adjacent terraces of each reach indicate long-standing fluvial process activity and persistent sediment accumulation. Mapped units that indicate unfavorable conditions include the presence of bedrock.

Again, for this discipline added at this phase of the project, each reach geology criterion was designated as low, medium or high, with the high designation assigned if mapped units in the reach are dominantly alluvium and outwash deposits. The presence of till or lahar reduced the score to medium. A bedrock-dominated reach was given a low designation.

The USDA Soil Conservation Service soils unit mapping for each reach was reviewed specifically for the severity of erosion hazard rating. Existing soils with high erodibility characteristics were ranked as high (generally granular soils), while low erodibility soils were ranked as low (generally cohesive soils).

Conditions for encountering the least amount of groundwater in granular soils, a losing reach, are judged to be most favorable and ranked the highest. A gaining reach received the medium ranking because granular soils are still present, but more groundwater must be managed. Artesian conditions were lowest ranking because large volumes of water under artesian pressure would be the most difficult to manage during project implementation.

Areas mapped as steep slopes in the project reaches include riverbanks and levees. Each project reach was ranked as having a low, medium or high soil erosion hazard based on the presence of steep slopes (>20 percent) and highly erodible soils.

Landslide hazard areas were obtained from Pierce County GIS. Criteria for this evaluation identified landslide hazards in areas with long valley slopes of native, non-alluvial soils. Steep slopes that comprised only stream banks within the alluvial plain are not considered landslide hazard areas unless they had known, recent movement. Areas with a high landslide risk received a low ranking, a moderate risk received a medium ranking, and the lowest risk received a high ranking.

Both reaches were evaluated using the criteria listed above. The reaches scored almost identically, with minor differences in the geologic units mapping (P1: Old Cannery was slightly preferred) and Landslide Hazard (P2: Sportsman was slightly preferred). In summary, the Geology, Soils and Groundwater analysis did not show preference for one reach over the other because the geologic setting of the two reaches is very similar.

1.6.9. Agency Outreach

Once the final reach was selected, Pierce County engaged regulatory agencies and tribes, including NOAA Fisheries, USGWS, USGS, WDFW, Ecology, USACE, Muckleshoot Indian Tribe, Puyallup Tribe, and Flood Control Zone District to share final outcomes of the reach selection process. At this stage, Pierce County and regulators examined the proposed final reach and identified that the potential for sediment removal activities at P1 would likely result in limited habitat disruptions and, in fact, presented the opportunity to potentially increase habitat and complexity in an area where little currently existed.

No substantive public outreach was conducted during this phase because Pierce County first wanted to be able to provide more details about the design and permit process, timed more closely to the SEPA public comment period.

1.6.10. Summary of Results

The Geomorphic discipline analysis indicated that nearly all of the geomorphic criteria were more favorable for sediment removal at P1, primarily because of the relatively stable site conditions, more bed material available for removal, and a neutral long-term sediment transport regime that would be better for long-term sediment management. The evaluation of historic, existing and potential future conditions indicated greater long-term channel stability at P1, including under the modeled sediment removal alternatives.

P1 also was the preferred site to assist in improving flood conveyance. Alternatives at both P1 and P2 sites improved flood conveyance and provided increased sediment storage capacity, but the analyses showed P1 having greater potential for long-term benefits. The reduction in flood levels at P1 had greater potential to reduce known flooding of infrastructure (e.g. storm drains). Sediment analyses show that P2 is currently eroding and as these conditions were expected to continue, flood levels would naturally drop. Conversely, P1 is experiencing moderate aggradation and loss of flood conveyance capacity.

From a Fisheries Resources perspective, P1 was best site for sediment removal primarily because there were no potential ESA-listed spawning impacts anticipated for the reach, and the potential for habitat uplift at P1 was more favorable.

Social and Land Use concluded that P1 was preferable because of the higher population density, more critical infrastructure and greater development would benefit more from flood reduction than the more rural and agricultural P2.

Hazardous Materials was the only category that favored reach P2 for a sediment removal project, because there were fewer sources of potential contamination and, therefore, a lower risk of encountering contaminated sediment during a sediment removal project.

The Wetlands and Wildlife Habitat categories analysis projected a lower likelihood of negative impacts if conducted in Reach P1. Reach P2, had potential mitigation opportunities for improving wetlands and wildlife habitat, but the potential improvements could negatively impact fish resources. The potential habitat benefits resulted from off-channel areas such as side channels and sloughs, but water levels in post-sediment removal scenarios would decrease in moderate and low-flow conditions such that fish stranding was probable. The technical team decided that having fewer impacts initially (P1) was preferable to having to complete extensive mitigation (P2), especially when the overall potential benefit was uncertain.

The Geology, Soils and Groundwater analysis did not show preference for one reach over the other because the geologic setting of the two reaches is very similar.

Based on the site selection Pros vs. Cons analysis and the Project team's best professional judgment, reach P1 (Old Cannery, Puyallup River) was selected as most suitable for the SMRRT Project. A sediment removal project at this location had the highest potential to successfully reduce local flood hazards, offered the best monitoring opportunities, and resulted in fewer overall impacts to habitat.

1.6.11. Lessons Learned

After completing the site selection, the following lessons were identified:

- It would have been good to compare the benefit of projects at both P1 and P2 sites to a No Action scenario some years in the future. This may have strengthened the case for selection of one site over the other.
- Consider looking at longer reaches for gravel extraction and/or implementing extraction at several locations for a more pronounced reduction in flood elevations.
- Extend the hydraulic/sediment model further up and downstream. This would help establish what effects the gravel extraction had on channel stability and flood risk at other locations.
- Work more closely with resource agency, tribal staff and other stakeholders early on to develop project success/screening criteria. For instance in the SMRRT project, minor increases in water surface elevations identified at this stage were unable to be hydraulically mitigated in subsequent design phases. Reach P1 sites may have been disqualified and others become apparent earlier in the site selection process, based on this factor alone.
- An in-field wetland assessment at both sites could have helped with critical areas considerations for site selection.
- EDR packages (provided in Appendix E of the Site Selection Report [GeoEngineers, et.al. 2016b]) were obtained for each of the proposed project sites. EDR packages provide information from review of government records and historical sources for properties/sites within a specified radius

around the two candidate reaches. As stated above, the EDR identified 19 sites with the potential to contribute contaminants to the P1. However, a historical landfill site located directly adjacent to the project area was not identified in the government records and historical sources reviewed to prepare the EDR for P1. The historical landfill site subsequently was identified after selection of P1 as the project site.

- Use consistent messaging and goals for the project objectives. At this phase, the project reach to be selected was the best fit to achieve project goals, which included receiving permits and the ability to monitor effectiveness and/or longevity.

1.7. 2017 HABITAT AND FLOOD CAPACITY CREATION PROJECT (HFCCP)

1.7.1. Introduction

Following completion of the SMRRT site selection (GeoEngineers, et al., 2016b), Pierce County's project manager began to conduct outreach meetings and correspondence with various stakeholders. The primary stakeholders consulted during this period of time included WDFW, the USACE, USFWS, NOAA Fisheries, and the Muckleshoot and Puyallup tribes' technical staff. The meetings were intended to provide an introduction to the concept of pilot study progress made to date and solicit input.

The tribes were interested in the design details but questioned why Pierce County would choose to spend the money testing the concept vs. spending the money on already recognized and preferred flood mitigation methods such as levee setbacks. Pierce County explained the project goals and explained this tool would be used where setbacks are not feasible and that an adaptive monitoring and management plan would be implemented to measure the impacts of the pilot study.

USACE staff were consulted regarding the potential permitting path for the pilot project, specifically with regard to whether an Individual Permit and the potential need for an EIS would be needed. The team also inquired about the possibility of a preliminary review of the available plans to ascertain potential concerns that the agencies might have prior to project design for the selected site. However, the USACE's position was a review would not occur until the design for the project was submitted as a Joint Aquatic Resources Permit Application (JARPA) package.

During a meeting between the Pierce County project manager and a NOAA Fisheries representative, NMFS suggested that Pierce County might consider permitting the project under a Nationwide 27 approach, as a habitat enhancement or restoration project. After consideration, Pierce County decided to pursue the project as a combination habitat improvement project with an added potential benefit of flood reduction under a Nationwide 27 permit application. The consultants agreed that the approach could potentially work and the design and permitting concept for the project was modified. The design would focus on habitat enhancement.

Under a Nationwide Permit strategy, an EIS would not be required. However, discipline reports would be completed and used for local permitting and State Environmental Policy Act (SEPA) review, and would be provided to the USACE and WDFW, as applicable, for their reviews. The technical documents would depend on the design elements selected for the project, so an iterative design process was undertaken. As the design progressed, workspace and access considerations dictated additional technical studies to address wetlands, the potential for contamination of the sediment to be removed (which had been previously

screened during the final site selection process), noise, cultural resources, etc. Unaffected discipline elements also were documented in a report.

1.7.2. Basis of Design Report

In the last stage of the SMRRT project, the project team synthesized the habitat and flood capacity creation goals into 75 percent level plans, the design of which is documented in a Basis of Design (BOD) report (NHC and GeoEngineers, 2017). The design process optimized habitat creation with flood reduction using numeric and physical hydraulic modeling tools. Table 3-1 in the BOD reports the range of flows modeled for habitat and flooding analyses. NHC developed a scaled (1:180 horizontal and 1:90 vertical) physical model of the project area that was used primarily to evaluate impacts of various configurations of large woody material (LWM) structures on water surface elevations and provide additional data regarding project resiliency and lifespan. The physical model proved to be a useful outreach and stakeholder engagement tool in conceptualizing channel grading and in-channel configuration of LWM.

The project team considered options for incorporating wood structures into the design for habitat elements, including dolos/wood combinations. Dolosse are large concrete structures resembling “jacks” with large wood incorporated. The dolosse would have provided ballast (weight and resistance to movement of the large wood) for the habitat structures. The use of dolosse was rejected because of the potential to trigger an USACE Individual Permit. Instead, the project proposed to install over ninety LWM structures, ballasted with boulders and log piles, to provide habitat functions for fish species, as well as bank and channel stability. Habitat enhancement is achieved in part through increasing access to complex channel environments and cover via LWM structures. Section 6 of the BOD report described improvements in quality and quantity of habitat created in the project area for both steelhead and Chinook salmon.

The design proposed to remove over 40,000 cubic yards of material from the channel from two subareas, or locations, in P1. In general, the project appeared to show a net hydraulic benefit for moderate flood events, with decreases in water surface elevations by up to one foot indicated in some locations and reductions in the floodplain’s wetted area. However, the project location at the confluence of the White and Puyallup rivers created complex hydraulic conditions that caused localized in-channel water surface level increases, which could have possibly triggered additional permitting requirements through the Conditional Letter of Map Revision and Letter of Map Revision (CLOMR/LOMR) process (Section 8, BOD).

Project resiliency was estimated based on numerical and physical modelling of sediment transport through the reach. Because of the uncertainty of future hydrologic events and upstream sediment supply, the rate at which the excavated channel bars could reform were estimated to be from about two to five years. Over

that time, it is not expected that deposition within the existing gravel bars would have substantial impacts to overall reach morphology.

1.7.3. Sediment Characterization

After selection of P1 as the project site, sediment characterization was performed to support permitting and evaluation of the sediment to be removed for reuse and/or disposal. Sediment characterization was performed in accordance with the Dredged Material Management Office (DMMO) and Dredged Material Evaluation and Disposal Procedures User Manual (User's Manual, DMMO 2016). The User's Manual requires sampling based on the specific design for the sediment removal, including aerial extent, depth and volume of sediment to be removed.

A sampling and analysis plan was prepared, reviewed and approved by the DMMO based on the initial design that included removal of sediment from two locations at the project site, which had an estimated volume of approximately 10,000 cubic yards. Sediment sampling activities were completed in accordance with the DMMO-approved SAP to evaluate sediment conditions within the P1-Downstream and P1-Upstream project sub-areas.

Additionally, a historical landfill area was identified upland of the project site and sampling was needed to characterize the soil and groundwater between the project site and historical landfill since the landfill could be or have been a source of contaminants to the material to be removed. Supplemental sampling and analysis of soil and groundwater between the project site and landfill was performed.

Subsequently, as the project design advanced, a portion of the project (P1 – Downstream project area) was revised to expand the proposed sediment removal area and volume. The volume of sediment to be removed for the 75% design was estimated at 17,000 cubic yards (an increase of 7,000 cubic yards from the earlier design). As a result, additional sediment characterization was necessary to meet the minimum DMMP sampling requirements. Therefore, an addendum to the sampling and analysis plan was prepared describing the additional sampling and analysis to be performed to characterize the additional sediment to be removed as part of the revised design. The sampling and analysis plan addendum was approved by the DMMO, but supplemental sampling was not performed as the project was not completed.

1.7.4. Other Discipline Reports

At this phase of the project, draft documents prepared for site design and anticipated permit application packages included: Critical Areas Report; cultural resources inventory; Dredged Material Characterization Sampling and Analysis Plan Report and addendum; a fisheries report; a biological assessment; a transportation and noise discipline report; a landfill characterization memorandum, and a monitoring plan.

The project team explored alternative sediment disposal options, including reuse for habitat enhancement projects, resale as aggregate, or sending to a landfill for disposal or cover (depending on the level of contamination). When the tribal staff were approached, they indicated that they would not accept the replacement of any removed sediment back into the Puyallup River system.

1.7.5. Cost-Benefit Analysis

Historically, "sediment management" often meant dredging channels to enhance flood flow capacity (late 1800's to mid-1980s) which was predicated on the prevailing engineering philosophy of channelizing river systems to quickly convey flood water out of the drainage basin. As sediment accrued in lower gradient

reaches of the river, channel capacity was reduced. In order to re-establish the capacity necessary to prevent flooding, the most expedient engineering solution was to simply remove the sediment periodically.

The engineering strategy outlined above was intended to protect farmland and urban areas, and effectively allowed subsequent development of floodplains for suburban and urban housing, commerce and supporting purposes. Floodplains with leveed channels have become increasingly converted to housing and commercial development because the flat land of the floodplain is easy to build on. An unintended consequence is the built environment is becoming increasingly vulnerable to flood damages, not only to houses and businesses, but also to critical infrastructure such as highways, bridges, hospitals, emergency services, etc. Consequently, flood-damages, emergency response, and insurance premiums have become more costly in response to our past land use practices.

Sediment removal may become a consideration for floodplain managers when moderate floods potentially can place lives at risk, impact critical infrastructure, interfere with commerce or cause an avulsion through an area of high consequence. The presumption is that wholesale removal of sediments from a river is not tenable for any number of reasons, including potential impacts to endangered species habitat, possible negative channel response, etc.

Paramount among the potential reasons for considering sediment removal is to reduce the risk of potential for loss of life during moderate flood events. Fatalities occur each year in the United States as motorists and pedestrians attempt to navigate floodwaters or are simply swept up in floods. Most government agencies require a cost-benefit assessment as one step in the project justification process, and sediment removal projects can cost significant sums of money to permit and implement, especially when endangered species are present. While it is a (relatively) simple procedure to estimate roadway repair costs, commerce impacts from closed arterials, or emergency services, it is not easy to place a dollar value on a human life.

A cost-benefit analysis was conducted (unpublished) to address feedback from the steering committee and stakeholders throughout the SMRRT project and HFCCP that questioned the benefit of completing a temporary sediment removal project for the amount of money that was spent since project inception, to determine if it was worthwhile to continue – especially because 1) the net flood reduction modeled to result from the project was relatively small, and 2) the project benefit duration was estimated to be only between 5 and 10 years, or until the gravel bars aggraded to previous elevations.

The method that was chosen for the analysis is typical for stream habitat restoration projects in Washington State, and follows the guidelines in Cramer (2012, Chapter 5), *Stream Habitat Restoration Guidelines*. The relative benefits and costs were evaluated for two alternatives: 1) implementation of the HFCCP; and 2) No Action.

To evaluate benefits, first, the project team identified selection criteria to be used to evaluate the effectiveness of each alternative at achieving the HFCCP objectives. These criteria were consistent with those from the reach- and site-selection project phases. The project team assigned a weighting value to each criterion, based on its relative level of importance toward achieving the overall project objectives. Secondly, the project team rated each alternative for how effective it is at achieving the selection criteria.

Costs were estimated for implementation/construction of the HFCCP. The No Action costs were to include flood damages to public infrastructure, commercial and residential property, and costs of road closures

resulting from flooding. However, the data for estimating these costs either are very limited, unavailable or not applicable to the project reach.

Based on benefit ratings only, conducting the HFCCP is nearly twice as effective at achieving the project goals as the No Action alternative. This conclusion of the HFCCP benefit rating relative to the No Action benefit rating seemed circular, however, since the HFFCP project was specifically designed to achieve project goals. The cost comparisons portion of the analysis was not meaningful with the available data, and the project team felt that it was unlikely that costs associated with moderate flooding under existing conditions would exceed the cost to complete the HFCCP.

As mentioned earlier, some potential benefits/costs are difficult or impossible to assign a dollar value, such as assigning a value to a human life. Considerations such as these rendered the cost/benefit assessment incomplete.

1.7.6. Agency Communications

Pierce County continually engaged in conversations with regulatory agencies and tribes to provide ongoing project updates and share the additional project focus applied to the enhancement of habitat along the preferred reach. These meetings provided the opportunity for Pierce County to share information, as well as answer questions and receive feedback on permitting strategies and anticipated project implementation.

1.7.7. Public Outreach/Communications

To account for the new objectives that were incorporated into the scope of the HFCCP project, the communications plan, including key messages, were updated in fall 2016 to reflect the project's dual focus of creating new habitat and mitigating flood risk.

In addition to updates to communication planning, the project team also created a summary report that covered the background of the HFCCP and shared the story of the reach selection process. This summary report was developed to be approachable for a wide variety of stakeholders. It worked to showcase how the project evolved over the years, and demonstrated how sediment removal could create new, more complex habitat in areas where none existed or was degraded. This summary report was reviewed by the Pierce County internal steering committee, shared with interested stakeholders, and made available on the project website.

To supplement the summary report, the team also refreshed the project fact sheet to reflect the additional HFCCP goals.

The project summary report was updated in fall 2017 to showcase project design at P1, as well as the findings and anticipated impacts included within each discipline report. This updated version of the report also highlighted future, unfunded project work that was, at the time, anticipated to occur through 2019.

Briefings with the project manager were available to interested groups and stakeholders, including steering committees and advisory boards, throughout the HFCCP phase. Information presented at these briefings often included review of updated project goals, the reach selection process, and the characteristics of the final selected reach. In addition to these briefings, Pierce County staff also shared an email update with all interested stakeholders that highlighted the new habitat opportunities the preferred site provided. Pierce

County staff met with the cities of Sumner and Puyallup to prepare for local permit application submittals and to clarify SEPA lead agency roles. Pierce County staff also held an agency and tribal briefing prior to permit submittal in fall 2017, where they provided a project update, preview of the permit application submittal materials, and key findings from the environmental analyses. These meetings were intended to brief the agencies prior to their receipt of permit applications.

1.7.8. Lessons Learned

Physical Model

The physical model provided value in several aspects of the project including:

- The team hosted three separate workshops with the physical model: one for the technical team, one for the tribes and regulatory agencies, and one for the Pierce County steering committee, other interested agencies, and the Flood Control Zone District. The model allowed stakeholders to visualize the project and quickly test ideas that they had to improve conditions or to see the effects of changes to the proposed project design.
- The physical model demonstrated that many small LWD structures could be installed within the project reach with very little resulting increase in water surface elevations. Demonstrating that relationship would have been less efficient with a numerical model. The hydraulics and channel response associated with habitat structures is complex and requires many simplifying assumptions to evaluate in a 1D or 2D numerical model. Whereas, physical modeling allows for less "simplification" of geometry, roughness features, etc. and provides for quicker and less expensive evaluation of various alternatives that require changes to geometry, roughness, and obstructions.
- The numerical and physical models predicted similar channel response to the proposed sediment extraction, specifically aggradation patterns. This provided more confidence with respect to results from the numerical model, which was used to quantify long-term rates of aggradation and to estimate how long before aggradation returned the project site to previous existing conditions (i.e., estimate project longevity from a sediment removal perspective only).

Hydraulic Modeling

The Site Selection Report (GeoEngineers, et al., 2016b) identified localized increases in water surface elevations at Site P1. Hydraulic evaluation of coarse concept level designs is indicative of likely outcomes, but hard to rely upon to make go/no-go decisions. Be aware that no-rise permitting constraints may become evident in the project design phase, once 2D is in progress. At that point, the site either may need to be abandoned, or the design modified significantly.

Sediment Characterization

The DMMO requires specific sampling based on the specific design for the sediment removal including aerial extent, depth and volume of sediment to be removed. Since the design changed significantly after the initial sampling and analysis plan had been developed and approved, and sampling and analysis had been performed, an addendum to the sampling and analysis plan was required. The addendum needed to be prepared, reviewed and approved and supplemental sampling, analysis and reporting completed. The additional work could have extended the project duration and did increase project costs substantially. Therefore, if possible, it is most efficient if the sediment characterization work can be performed based on the final design.

Agency Communications and Permitting Approach

As with earlier phases of the project, agency communications require careful thought:

- The team conducted the entirety of the study using readily available data for fisheries and, because of political sensitivity, did not reach out to state, federal or tribal agencies during the reach and site selection project phases. From a fish population and habitat use perspective, interviewing agency scientists that are intimately familiar with the project area could have been useful in informing selection criteria, obtaining unpublished and/or anecdotal data and provided means for generating support for the project.
- Changing the project name to include "habitat creation" late in the process wasn't convincing: agency and tribal staff still viewed the project as a sediment removal project that included habitat as an afterthought. Having "creation" and "restoration" in the project name and goals from the initial stages of the project would have likely garnered and maintained more support for the project.
- In retrospect and with a project focus on habitat restoration, there may have been other reaches where habitat enhancement may have been more favorable. If this had been prioritized in an early phase (and an NWP 27 approach was anticipated), a different finalist site may have been selected. One example is reach P2, where juvenile rearing conditions for native salmonids are relatively poor but spawning has been documented consistently. In this reach there are several locations where off-channel rearing habitat could have been improved/restored. A focus on improving juvenile rearing habitat would have been complementary to the spawning use.
- Incorporating habitat benefit may have reduced the overall flood reduction benefit of the project, which might have been offset by implementing the project over a longer reach.
- Approaching the project from an NWP 27 permitting perspective may prove to conflict with the original intent of the pilot project. An NWP 27 authorization includes maintenance requirements for the habitat elements of the project. Maintaining the habitat elements of the P1 design might have interfered with evaluating the longevity of the flood reduction benefit as originally envisioned for the project.
- Engineered river restoration project elements, including dolosse or piles, are used elsewhere in the Puyallup River system because they typically result in longer project lifespan and project benefits. Use of dolosse for the HFCCP may have extended the longevity of project benefits but would have triggered a USACE Individual Permit, which would have led to a longer and more costly permitting process. If Pierce County had not already spent a considerable amount of money and time on the project, switching to dolosse may have been a feasible path forward during this phase. It also may have achieved more support for the project, both internally and externally.

1.8. END OF THE HFCCP

Completion of the 75% design plans and BOD Report allowed the discipline reports to be finalized in preparation for submission for permits. The Pierce County and technical teams were prepared to move ahead with permit applications, and a new budget for 2018 was developed and submitted to Pierce County for review.

At about the same time, Pierce County hired a new tribal liaison and the project management team began to coordinate outreach to the Puyallup and Muckleshoot tribes. The Tribal Relations Manager requested some time to establish relationships with, and ask for input from, the tribes prior to submitting permit documents. Early conversations with tribal technical staff determined that any decision/commitment from the tribes would need to come from tribal elders. In addition, the Puyallup Tribe was hosting the Tribal Canoe Journey, which required significant commitment from tribal elders. The preparations for the celebration delayed conversations between the liaison and tribal elders. Pierce County staff approached the USACE in summer 2018, explaining the situation and requesting that they provide an informal review of the draft JARPA package and provide an opinion on whether the current design would qualify for a Nationwide 27 permit. In fall 2018, the USACE project manager assigned to the HFCCP project provided a preliminary opinion that the project would not qualify for coverage under a Nationwide Permit 27, and that an Individual Permit would be necessary. This meant for the project to proceed an alternatives analysis, a cumulative effects analysis, and an identification of a representative site would be required. It also meant additional on-site and/or off-site mitigation likely would have been required.

The project team evaluated the probable level of effort, time and budget requirements for completing the Individual Permit process for the HFCCP compared to a Nationwide Permit 27. The project manager approached the steering committee for consideration of continued funding to complete the permitting. After reviewing the request, Pierce County placed the project on the inactive list with the idea that if additional funds and support came to fruition in the future, the project could be resurrected.

2.0 WRAP UP

Czuba et al. (2012) assumed that the rivers draining Mt. Rainier are in a “general state of sediment surplus”, and “future aggradation rates will be largely governed by the underlying hydrology that transports sediment downstream.” With climate change predictions of increased hydrologic activity and runoff, aggradation rates in the following century also may increase.

Evaluation of theoretical overtopping conditions using stage-discharge measurements at USGS gages indicates flood conveyance at the Puyallup River at the Puyallup gage has generally decreased from a maximum of 57,800 cfs to 48,100 cfs, or about 15%, from 1987 to 2010 (Czuba, et al., 2010). Average bed elevations show a trend of moderate aggradation along the lower Puyallup River from 1984 to 2009 Czuba, et al. 2010). During this same period, increases in average bed elevations generally range from 1 to 2 feet along the lower 10 miles of river, but increase to 2 to 4 feet just downstream of the White River confluence.

Detailed review, conducted by NHC, of repeat river surveys indicates that the significant changes to bed elevation downstream of the White River are caused more from aggradation in vegetated overbanks, i.e. benches between levees, rather than of the main channel bed. This observation complicates the perceived interaction between flood conveyance, sediment transport, channel aggradation, and river management. Material aggrading in the overbank benches is likely fine sand and silts, trapped by vegetation, but can still have a significant impact on flood conveyance. In this case, it’s almost more of a lateral, rather than vertical, effect. Still, removal of material upstream, e.g., at the Old Cannery site (Reach P1), may provide benefits by limiting downstream deposition that would otherwise reduce flood conveyance. The magnitude of this reduction for a one-off gravel removal, estimated to be 40,000 CY; however, is likely relatively small compared to the total sediment available. In contrast, revisiting management options of vegetation and

sedimentation on interior levee benches may provide more significant opportunities to increase flood conveyance. Given riparian habitat regulations and structural requirements for certified levees this could also be difficult. Additionally, given the preference for increasing vegetative shade along the riverbanks, removal of those features may be objectionable to tribes and other habitat advocates.

In contrast, upstream of the White River confluence, sedimentation within the Puyallup system is generally varied and spatially complex and becomes more so when forecasting into the future. Czuba, et al. (2012) suggested locations where sediment management would be most effective. These locations are generally upstream of high population centers and point to the benefits of controlling supply delivered to downstream reaches. These benefits, however, are long-term investments that may take decades to realize. Furthermore, an understanding of basin-wide management versus addressing acute problem reaches needs to be recognized. In places where sediment removal has been successful (e.g., Cowichan and Vedder rivers in British Columbia, Canada, and the Cedar River, Renton, Washington), significant, spatially acute, ongoing aggradation has been directly correlated with reduced flood capacity (McLean, et. al. 2013; NHC 2009a; NHC 2009b; NHC 2014; NHC 2015; USACE 1997). The necessity of these sediment removal measures has been easier to demonstrate and permit. In a basin-wide program, benefits of sediment removal could be achieved, but would be less apparent and more difficult to demonstrate.

Given the uncertainty with predicting future geomorphic conditions and correlation with flood hazards, the suggestion of Czuba, et al. (2012) to establish a monitoring program (e.g., level loggers or hydrophones) to measure relative changes in flood levels and sediment transport over time may be the best way to evaluate future trends and implication to flood hazards. In the event that a site-specific sediment removal project, performed individually or as part of a basin-wide program, cannot be completed, government and communities may need to consider other engineered or policy options, both near- and short-term, for flood risk reduction and/or assume the risk of impacts to life and property as a result of changes in basin land use, climate variability, and sediment transport in the river system.

When viewed in hindsight, some key learnings in the evolution of the sediment removal pilot project stand out:

- This project was sponsored by local officials trying to be responsive to citizen input. Early in the process, the sponsors needed to be informed of the long timeline and high cost of initiating this kind of study. Project staff need to recognize that the level of support from the sponsors may change as other priorities occur. In the case of the Puyallup River system, there have not been flood events as damaging since 2009; fighting flooding damage has likely dropped in priority.
- Getting good and useful permitting advice from the agencies to steer the project from the get-go was critical. The resource management agencies initially indicated they would support an approach of selecting gravel bars with high steering effects for sediment removal. However, during a meeting in Phase 2, the resource management agencies were of the opinion the levees were the primary driver of gravel bar growth and related hydraulic effects. Further, they were concerned that fish habitat had not yet been considered. This ended the initial pilot project.
- The project may have been received more favorably by the resource agencies and tribal staff if the project were combined with other flood hazard reduction techniques as part of the total project; for example, gravel removal combined with levee setback. However, the demonstrable effects of sediment removal portion of the project could be indistinguishable from the larger combined project, possibly diminishing the benefit of testing the pilot project concept.

When planning a similar project, consider the following comments:

Regulatory Support and Permitting Strategy

- If sediment removal is to occur, it should be included in a basin flood hazard management plan or other planning document. The flood hazard management plan should spell out that levee setbacks may occur in areas where feasible, but in areas where they are not feasible, sediment removal with habitat enhancement may be an option to address flooding and protection of infrastructure.
- Consulting legal counsel from the outset of the project, even prior to engaging stakeholders to identify potential legal pitfalls, should be considered before initiating and throughout project design.
- Devise a project that complies with regulations and codes. Further, ask the regulators why a project cannot be permitted when codes, regulations and laws indicate that a project is permittable. Legal counsel may need to be engaged to take on this fight.
- Assuming the project elements are allowed by regulation and code, engage tribes, agencies, stakeholders and constituents as early as possible to begin sharing information and identifying challenges and opportunities associated with permitting and project implementation. Early engagement needs to clearly explain the project need, goals and other drivers to set accurate and realistic project expectations within the community.

Stakeholder Engagement

- To gain approval of stakeholders, the project team may need to be willing to amend the scope or nature of the project to better align with the stakeholder priorities. For instance, creating additional habitat either in the project area or elsewhere within the river system may be needed in conjunction with the flood risk reduction component.
- Articulate project goals as comprehensively as possible and as early as possible within the project. Sharing consistent goals throughout the life of the project could help the effort feel more cohesive and help to ensure that the project scope and benefits are widely understood by tribes, agencies, and stakeholders.
- Set up strategies and resources for effectively sharing accurate project goals and information with internal audiences, elected officials, and agency partners. These resources could include fact sheets, project briefs and other messaging, staff briefings, and other strategies as appropriate. Having a robust resource toolkit could help to keep project staff, partners and others aware of the best information. These materials and strategies also can be helpful in actively engaging new staff, partners and elected officials with strong influence over the project outcome, throughout the lifecycle of the project as turnover occurs and as new people engage.
- Rather than evaluating possible sediment removal measures on a system-wide basis, it may be more economical to focus on distinct sub-reaches with known sedimentation and flood problems. Whether demonstrated through a monitoring program or based on widespread public observation or shared stakeholder goals, focusing on an acute problem will be more manageable from an implementation and design standpoint, as well as more likely to gain stakeholder approval.

Project Considerations and Execution

- Scientific selection of the project site that best fits the project goals is a defensible method for a pilot project. However, for this to be a useful tool for flood risk reduction, the "best" reach may be one that is selected for other reasons, such as past damages, threatened lifeline infrastructure or economics, instead of meeting the most project goals. Although the SMRRT Project weighted reach selection land use/social and other disciplines equally, there may be reasons to weight certain criteria more heavily depending on the goals, opportunities and funding for each project.
- It may be worth considering sediment removal where setbacks have already occurred, but the river has not yet occupied the newly opened floodplain area. Removal of floodplain sediments outside ordinary high water, but inside of the new setback area, may be easier to permit and the removal could yield multiple benefits including the creation of off-channel habitat and providing storage volume for transported sediment. Floodplain sediment removal could lower flood elevations and potentially reduce downstream flooding potential, as well.
- Establishing a baseline monitoring program at a known problem site, or sites, could provide multiple benefits. First, collected field data and direct observation of sedimentation and flooding patterns are especially valuable since the processes are complex and difficult to model. Monitoring also can identify important trends that could be used to demonstrate whether sedimentation is, in fact, responsible for observed flooding. Such information could be useful to support, or conversely, oppose public perception that sedimentation is the root cause of flooding, as other factors may be at work. Regardless, baseline monitoring could be a cost-effective means to identify problem reaches, as well as provide design insight once a site is selected.
- Before starting a project, have an idea of what threshold triggers, or minimum threshold goals, are desired; e.g., minimum 1 foot of flood reduction or, alternatively, maintenance of existing flood capacity. As part of the iterative process of site selection, compare the sites relative to these goals as the project progresses.
- Be cognizant throughout the project that there will be upstream and downstream impacts to sediment movement, habitat and flooding. Those need to be considered during project design so that there are no adverse impacts elsewhere resulting from your project.
- By nature, a sediment removal project will have a period of effectiveness, after which the gravel bars will reestablish. The post-construction monitoring plan must be developed to account for the expected duration of positive effects. This period of positive effects also could be used to quantify a net ecological benefit portion of the cost-benefit analysis. Developing a monitoring plan with clear, measurable criteria to determine level of effectiveness is essential.

It is our opinion that with the right advocates, both internally and externally, political support, and enough funding and time, removing sediment from river systems in Pierce County or any other jurisdiction in Washington State is feasible and permittable.

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List of Attachments:
Attachment 1. Excerpts from Reach Selection Criteria Methods Memo
Attachment 2. Excerpts from Data Gaps Analysis Report
Attachment 3. Excerpts from Reach-scale Selection Report
Attachment 4. Excerpts from Site Selection Report

Attachment 1

Excerpts from Reach Selection Criteria Methods Memo

GeoEngineers

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Memorandum

To:	Stephanie Miller, Parametrix
From:	Mary Ann Reinhart, LG; Leif Embertson, PE, GeoEngineers
Date:	March 22, 2011
File:	0497-109-00
Subject:	Reach Selection Criteria Methods and References Puyallup Gravel Extraction Pilot Project Pierce County, Washington

GeoEngineers, Inc. is pleased to present this technical memorandum (Memo) regarding the results of a qualitative geomorphic, hydraulic/hydrologic, and biologic evaluation regarding the Gravel Extraction Pilot Project for the Puyallup, Carbon and White River in Pierce County, Washington. The services described in this Memo were completed in general accordance with Tasks 3.0 and 4.0 of our sub-consultanting agreement with Parametrix, dated August 4, 2010.

The purpose of the Pilot Project is to identify and removal gravel bars that currently direct stream flow against stream banks, and potentially cause damage to nearby levees. The primary objective of the Pilot Project may be thought of as a means of protecting levees, public infrastructure, and private property.

The work presented here represents the first of several phases comprising the "Gravel Extraction Pilot Project". Phase I was tasked with evaluating, comparatively, reaches comprising the three river channels, and selecting from them two or three reaches posing the greatest risk to levees, as well as the physical channel and gravel conditions offering the greatest benefit from gravel removal.

Reaches selected in Phase I will enter into Phases II and III, wherein more rigorous analyses will be conducted in concert with completion of the Environmental Impact Statement analyses. The ultimate goal of Phases II and III is the identification and successful permitting for the removal of gravel from one or more specific bars (in a selected reach) by mechanical methods. Studies to be performed in the later phases will include more focused and robust geomorphic analyses, two-dimensional hydraulic modeling, sediment transport modeling, additional flood modeling, focused biologic assessments, including local species utilization and habitat quality studies for specific areas with the selected reaches, and impact analyses regarding gravel removal.

To accomplish the goal of Phase I, twelve reaches on the Puyallup, White and Carbon Rivers were identified for evaluation by the County and are shown in Figure 1, attached to this memorandum. A reach data sheet was developed for each identified reach and is included within a summary table, also attached to this memorandum. The reach data sheets and summary table were developed to aid in comparing key characteristics of each potential reach, and ultimately identify those reaches that best meet the County's goals for protecting levees and infrastructure. Categories for the site selection matrix were presented to the County for review on July 19, 2010 and further discussed during a meeting on October 13, 2010.

For the purposes of this project, gravel may be removed in two way, by bar scalping, which removes gravel from above the summer low-flow water surface and extending upwards toward the bank at a 2 percent slope and consistent with WAC 220-110-140 (7); and gravel removal from below the low-flow water surface. Gravel bar scalping would remove only the highest points within the river channel normally created by low

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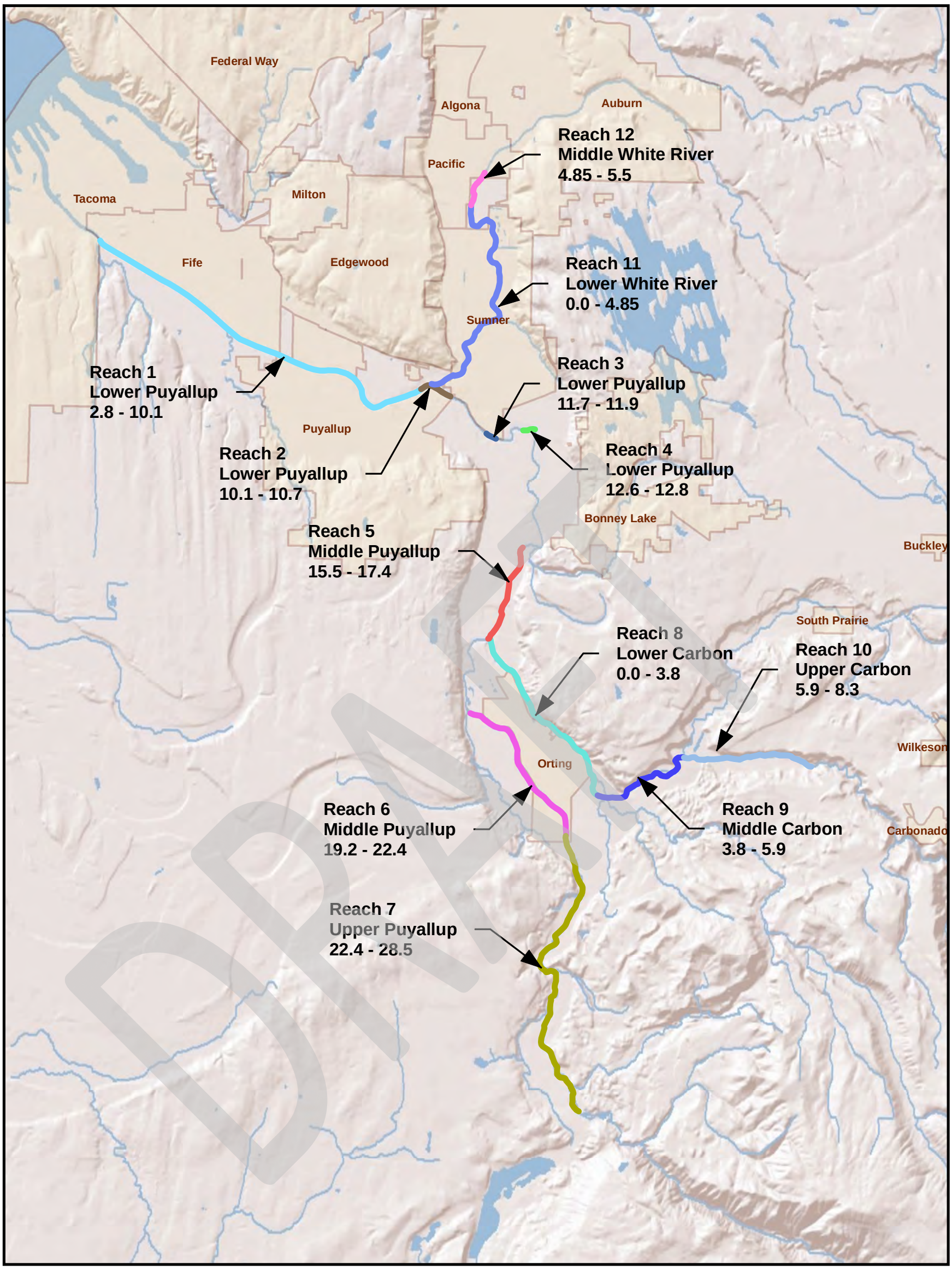

Legend

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Reach 6
- Reach 7
- Reach 8
- Reach 9
- Reach 10
- Reach 11
- Reach 12

2 0 2
Miles

N W E S

Notes:
1. The locations of all features shown are approximate. 2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication. 3. It is unlawful to copy or reproduce all or any part thereof, whether for personal use or resale, without permission.
Data Sources: Shaded relief, ESRI; Cities, Department of Ecology State Plane Washington South FIPS 4601 (Feet), North American Datum 1983. North arrow oriented to grid north.

Project Reach Locations

Puyallup River Pilot Project
Pierce County, WA

GeoEngineers

Figure 1

Office: BAM Path: P:\0\0497109\GIS\MXD\Gravel Extraction Locations.mxd Map Revised: 09/17/2010 MLT

Attachment 2

Excerpts from Data Gaps Analysis Report

Sediment Management as a Risk Reduction Tool (SMRRT Project)

Data Gaps Analysis Report

Prepared for:
Pierce County Public Works
Surface Water Management
2702 South 42nd Street, Suite 201
Tacoma, Washington 98409

Attention: Annette Pearson

Prepared by:
GeoEngineers, Inc.
8410 154th Avenue NE
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July 31, 2015

enviroissues

GeoEngineers

David Evans and Associates Inc.

Historical Research Associates, Inc.

nhc northwest hydraulic consultants

Table 3

Technical Discipline Data Gaps Summary Table

Selection Criteria for Reach, Site and Design Selection Process

Sediment Management as a Risk Reduction Tool (SMRRT) Project

Puyallup River Basin - Puyallup, Washington

Selection Category	Selection Criteria Code	Selection Criteria Description	Basis for Selection Criteria Value			Data Needed	Available Data	Data Gaps
			1 = Low Priority	2 = Medium Priority	3 = High Priority			
Fisheries Resources	F1	ESA listed salmonid spawning habitat use	Documented Spawning	Presumed and/or modeled presence	No spawning	Maps showing known or presumed spawning locations	WDFW spawning ground survey data, SWIFD mapping, Salmonscape mapping, Pierce County Rivers Flood Hazard Management Plan (Appendix H), Marks et al. (2011, 2012, 2013)	adequate for project purposes
	F2	Proximity to tributary confluence	≤ 200 meters	200-500 meters	>500 meters	GIS mapping with buffer distance from tributary mouths throughout the watershed	GIS mapping-needs to be analyzed and generated	Generate maps showing buffers around tributary mouths
	F3	Nursery juvenile rearing habitat presence (i.e. low velocity/off-channel habitat)	High	Moderate	Low	Habitat type mapping to identify and quantify mainstem rearing areas	Marks et al. (2011, 2012, 2013), SWIFD mapping, Salmonscape mapping	Detailed habitat mapping not adequate for project purposes
	F4	Salmonid habitat restoration potential	Low	Moderate	High	Model data and professional opinion from basin experts on restoration potential	Waldo et al. (2013), Mobrand Biometrics (2004), Marks et al. (2011, 2012, 2013)	adequate for project purposes
	F5	Vegetation density on bars	High	Moderate	Low	Mapping of vegetated bars throughout mainstem parts of the watershed	None available	Aerial survey desktop analysis combined with field verification
Geomorphic	G1	Subbasin sediment yield (relative)	Low	Moderate	High	Sediment load, drainage area, geology	Czuba et al., 2012; public and Pierce County GIS data	None
	G2	Stream power (relative)	High	Moderate	Low	Slope (historic & contemporary), water discharge	GeoEngineers (2003, 2008, 2010, 2011); Czuba et al. (2010, 2012); public and Pierce County GIS data	None
	G3	Channel confinement within the valley	Confined	Partly confined	Unconfined	Geology, elevation, aerial photos and maps (historic & contemporary)	GeoEngineers (2003, 2008, 2010, 2011); Czuba et al. (2010, 2012); public and Pierce County GIS data	Data from approximately 2008 to present
	G4	Planform pattern	Single thread	Transitional	Multi-thread	Geology, elevation, channel slope, water discharge, bed load grain size, aerial photos and maps (historic & contemporary)	GeoEngineers (2003, 2008, 2010, 2011); Czuba et al. (2010, 2012); public and Pierce County GIS data	Data from approximately 2008 to present
	G5	Long-term bar growth	Low	Moderate	High	Geology, elevation, channel slope, water discharge, bed load grain size, aerial photos and maps (historic & contemporary)	GeoEngineers (2003, 2008, 2010, 2011); Czuba et al. (2010, 2012); public and Pierce County GIS data	Data from approximately 2008 to present
	G6	Future channel response	Low	Moderate	High	Geology, elevation, channel slope, water discharge, bed load grain size, aerial photos and maps (historic & contemporary); reach- and site-scale hydraulics, sediment transport competency and capacity, channel geometry/elevation, bed material grain size distributions, channel boundary characteristics, planform patterns and processes, large wood quantity and function	GeoEngineers (2003, 2008, 2010, 2011); Czuba et al. (2010, 2012); public and Pierce County GIS data	Data from approximately 2008 to present; reach- and site-scale data from hydraulics & sediment analyses, and geomorphic surveys

Hydraulic	H1	Channel capacity up to top of bank	>100-year return interval	>5-year return interval AND <100-year return interval	< 5-year return interval	1D hydraulic model simulations	Czuba et al. (2010) model (to be corrected for datum bust at bridges)	corrected model elevations at bridges
	H2	Level of protection (return interval Q)	>100-year return interval	>5-year return interval AND <100-year return interval	< 5-year return interval	1D hydraulic model simulations, flow-frequency analysis throughout basin	Czuba et al. (2010), NHC (2012)	none
	H3	Prior flood hazard location	no	yes	yes	damage data	documented flooding problems (PC-RFHMP), documented damages (PC {Todd's}-damages map), inspection records	none
	H4	Potential flood hazard location	no	yes	yes	visible bank erosion and damage data	historical air-photo comparison, documented flooding problems (PC-RFHMP), documented damages (PC {Todd's}-damages map), inspection records	none
	H5	Recent (decadal) hydraulic change	<1 foot in WSEL at 20-year	>1 foot AND < 3 feet in WSEL at 20-year Q	>3 ft in WSEL at 20-year Q	Compare the 2009 USGS model results with previous model (FEMA, PC) results	previous model and channel capacity work by USGS (Prych, 1988 and Czuba, 2010) to be updated with new surveys	none for Phase 2 Basin Scale, new survey for Reach Scale
Sediment	S1	Recent (decadal) bed elevation change	<6 inches in average elev.	>1 foot in average elev.	>3 feet in average elev.			
	S2	Transport regime	Supply	Transport	Storage			
	S3	Typical sediment storage period	<1 year	>1 years AND <10 years	>10 years			

Notes

1. Selection criteria may be different among the different stages of reach, site and design selection; i.e., some criteria may be applied at the reach scale only, while different criteria may be applied at the design selection stage.
2. The "Basis for Selection Criteria Value" and the scoring (1 to 3) are provided as example only; the scoring/weighting and corresponding basis will be developed based on data analysis during Phase 2 of SMRRT Project in 2015.
3. These selection criteria will be applied at each 0.2 RM section of the Carbon, Puyallup and White rivers.

Table 4

NEPA Discipline Data Gaps Summary Table

Selection Criteria for Reach, Site and Design Selection Process

Sediment Management as a Risk Reduction Tool (SMRRT) Project

Puyallup River Basin - Puyallup, Washington

Selection Category	Selection Criteria Code	Selection Criteria Description	Basis for Selection Criteria Value			Data Needed	Available Data	Data Gaps
			1 = low priority	2 = medium priority	3 = high priority			
Cultural Resources	C1	Cultural Resource identified	NRHP eligible	Not evaluated	Not NRHP eligible	Archaeological site forms	WISAARD data from DAHP	None
	C2	Cultural resource study performed	No	N/A	Yes	Cultural Resource reports	WISAARD data from DAHP	None
	C3	Traditional Cultural Property identified	Yes	Not reviewed	No	Traditional Cultural Property locations	Some available in CR reports	Discussion with Tribes
	C4	Risk for identifying unrecorded cultural resources	Yes	Not reviewed	No	Predictive/Risk data	WISAARD data from DAHP	None
	C5	Within CMZ	No	within the last 100 years	Within the last 50 years	Channel Migration Zone (GIS)	Pierce County/GeoEngineers GIS	None
Economic Elements	Multiple	Flood Hazard Profile, Vulnerability Analysis and Impact Resulting from Flood and Channel Migration Hazards	Not reviewed	Not reviewed	Not reviewed	To be determined	Risk assessment in the PCRFHMP	Passage of time between completion of the Risk Analysis and the use of it in this project
Environmental Justice	EJ1	Proximity to minority populations	Adjacent to site	Within affected area	None	Current Census Data	Pierce County GIS	None
	EJ2	Proximity to low-income populations	Adjacent to site	Within affected area	None	Current Census Data	Pierce County GIS	None
Land Use	L1	Proximity to park property	Adjacent to site	Within affected area	None	Park Boundary Maps (GIS)	Pierce County GIS	None
	L2	Proximity to resource lands/farmland	Adjacent to site	Within affected area	None	Land Use Maps (GIS)	Pierce County GIS	None
	L3	Land use change	High probability	Low probability	None	Phase 2 hydraulic evaluation	To be developed by team	None
	L4	Land use plan consistency	Inconsistant - special approval required	Minor inconsistancies	Consistent	Comprehensive Plan	PC Comprehensive Plan	None
	L5	Critical facilities and infrastructure risk	No facilities	Medium profile facility	High profile facility	Location of critical facilities (GIS)	Pierce County GIS	None
Hazardous Materials (Contaminated Sediments)	HM1	Proximity to contaminated sites	Adjacent to site	>1/4 mile, <1/2 mile	>1/2 mile	Report/studies of sites	To be identified	None known
	HM2	Proximity to outfalls (stormwater, point sources, etc.)	Adjacent to site	>1/4 mile, <1/2 mile	>1/2 mile	Documentation of outfall locations and discharge type	To be identified	None known
	HM3	Proximity to urbanized areas	Urbanized	Agricultural	Undeveloped	Landuse information	To be identified	None known
	HM4	Grain size/deposition	Silt and sand	Sand and gravel	Gravel and cobbles	Existing studies of sediment type	To be identified	None known
	HM5	Prior sediment removal activities	>1/2 mile	>1/4 mile, <1/2 mile	At proposed site	Documentation of past activities	To be identified	None known
Social	SO1	Population benefited from reduced flooding of structures	Low	Moderate	High	Phase 2 hydraulic evaluation	To be developed by team	None
	SO2	Population benefited from reduced flooding of roads (road closures)	Low	Moderate	High	Phase 2 hydraulic evaluation	To be developed by team	None
	SO3	Property value changes	Decreases	No change	Increases	Economic Analysis	To be developed by team	None
Transportation	T1	Traffic impacts from increased truck traffic	High	Moderate	Low	Typical construction and on-site vehicle traffic projections	To be developed by team	None
	T2	Impacts to recreation and navigation in the river	High	Moderate	Low			
	T3	Impacts from traffic and dredging noise	High	Moderate	Low	Peak hour and daily traffic counts	To be obtained through thrid party once sites are selected	None
	T4	Reduction of road closure due to flooding	Low	Moderate	High	Road Closure records	Pierce County maintenance records	None
Wetlands	W1	Presence of wetland habitat	High	Medium	Low	Wetland occurrence/distribution	NWI, PHS and Pierce County maps	Field verification/delineation
	W2	Potential for wetland mitigation opportunities	Low	Medium	High	Existing wetland occurrence/distribution, potential sources of hydrology, and baseline conditions	Floodplain and hydrography geo-data, as well as NWI, PHS and County mapping	Field verification and baseline conditions assessment
	W3	Presence of wetland buffers	High	Medium	Low	Wetland occurrence/distribution, wetland classification	NWI, PHS and Pierce County maps	Field verification and classification

Wildlife Habitat Conservation Areas	VW1	Habitat present for non-salmonid species	High	Medium	Low	Species/habitat maps	PHS and CH maps, species report	Field verification
	VW2	Native vegetation present	High	Medium	Low	Aerial photographs, direct observations	Publicly available imagery	Field assessment
	VW3	Within access routes to removal sites	High	Medium	Low	Design plans	TBD	
Visual Impacts	VI1	Vegetation Removed	Trees	Shrubs	None	Project Design	To be developed by team	None
Geology, Soils, Groundwater	GSG1	Geologic units mapping	Bedrock	Till/lahar deposits	Recessional/advance/ alluvial deposits	Distribution of units with lateral and vertical contacts located and accurate to about 10 feet	USGS quadrangles, 1:100,000 to 1:24,000 scale	Field verification and mapping for reach and site scale assessment
	GSG2	Soils units mapping	Low erodibility hazard	Moderate erodibility hazard	Severe to very severe erosion hazard	Regional mapping of soil units with erodibility index	USDA Web Soil Survey	None
	GSG3	Groundwater flow patterns for basin	Low permeability units/deep groundwater aquifers	Shallow groundwater, losing reaches	Shallow groundwater, gaining reaches	Potentiometric surface map of basin		
	GSG4	Steep slopes	Steep slopes adjacent to river, low erosion potential	Steep slopes adjacent to channel, moderate erodibility	Steep slopes adjacent to river, high erodibility	Topographic maps	Pierce County GIS	Field verification for site scale assessment
	GSG5	Landslide	Low potential	moderate potential	High potential, known landslides	Landslide maps, aerial photographs and/or LiDAR	Pierce County GIS	LiDAR or field verification for site scale assessment

Notes

1. Selection criteria may be different among the different stages of reach, site and design selection; i.e., some criteria may be applied at the reach scale only, while different criteria may be applied at the design selection stage.
2. The "Basis for Selection Criteria Value" and the scoring (1 to 3) are provided as example only; the scoring/weighting and corresponding basis will be developed based on data analysis during Phase 2 of SMRRT Project in 2015.
3. These selection criteria will be applied at each 0.2 RM section of the Carbon, Puyallup and White rivers.

Attachment 3

Excerpts from Reach-scale Selection Report

Sediment Management as a Risk Reduction Tool (SMRRT) Project

Reach-scale Selection Report

Prepared for:
Pierce County Public Works
Surface Water Management
2702 South 42nd Street, Suite 201
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Attention: Angela Angove

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January 29, 2016

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nhc
northwest hydraulic consultants

Table 1

Evaluation of Selection Criteria for Twelve Reaches

SMRRT Project

Puyallup River Watershed - Pierce County, Washington

Selection Category	Selection Criteria Code	Selection Criteria Description	Basis for Selection Criteria Value			Assigned Value of Selection Criteria to Reaches and River Mile Extent (P=Puyallup, C=Carbon, W=White)											
						P1	P2	P3	P4	P5	P6	P7	C1	C2	C3	C4	W1
			1 = Low Priority	2 = Medium Priority	3 = High Priority	10.2 - 10.5	13.9 - 14.4	16.0 - 16.5	17.0 - 17.5	21.5 - 21.9	22.3 - 24.4	25.7 - 28.5	0.1 - 3.1	3.4 - 3.8	4.2 - 5.9	6.0 - 8.3	3.8 - 4.8
Fisheries Resources	F1	ESA listed salmonid spawning habitat use	Documented Spawning	Presumed and/or modeled presence	No spawning	3	1	1	2	1	1	1	1	1	1	1	1
	F2	Proximity to tributary confluence	≤ 200 meters	200-500 meters	>500 meters	1	3	2	1	3	3	2	2	1	1	1	3
	F3	Nursery juvenile rearing habitat presence (i.e. low velocity/off-channel habitat)	High	Moderate	Low	3	3	3	2	1	1	1	3	2	2	3	1
	F4	Salmonid habitat restoration potential	Low	Moderate	High	1	2	3	2	1	1	2	2	2	2	2	1
	F5	Vegetation density on bars	High	Moderate	Low	3	3	3	2	2	2	2	2	2	1	2	2
Geomorphic	G1	Subbasin sediment yield (relative)	Low	Moderate	High	2	2	2	2	2	2	2	1	1	1	1	3
	G2	Stream power (relative)	High	Moderate	Low	1	3	3	3	3	2	2	2	2	2	2	1
	G3	Channel confinement within the valley	Confined	Unconfined	Partly confined	1	3	3	3	3	3	1	1	3	3	2	1
	G4	Planform pattern	Multi-thread	Single-thread	Transitional	2	2	3	3	1	1	1	3	1	1	1	2
	G5	Long-term bar growth	Low	Moderate	High	1	2	2	2	1	3	3	2	2	3	3	1
	G6	Future channel response	High	Low	Moderate	2	3	3	3	2	1	1	1	1	1	1	2
Hydraulic	H1	Average Level of protection (return interval Q)	>100-year return interval	10-year to 100-year return intervals	< 10-year return interval	3	3	3	2	1	1	1	2	2	1	1	3
	H2	Minimum Level of protection (return interval Q)	>100-year return interval	10-year to 100-year return intervals	< 10-year return interval	3	3	3	3	2	2	3	3	3	3	2	3
	H3	Prior flood location	<5 years	5 to 10 years	>10 years	1	2	2	2	3	3	3	2	2	3	3	1
	H4	Potential flood reduction	Low	Moderate	High	1	2	2	2	2	1	1	2	2	1	1	3
	H5	Recent (decadal) hydraulic change (Max within reach)	<20%	20% to 50%	>50%	2	1	1	1	1	1	3	2	3	3	3	3
	H6	Recent (decadal) hydraulic change (Ave within reach)	<10%	10% to 20%	>20%	3	1	1	1	1	1	3	1	3	1	1	3
Sediment	S1	Recent (decadal) bed elevation change	<6 inches in average elev.	>1 foot in average elev.	>3 feet in average elev.	2	3	1	2	2	3	3	1	2	2	2	2
	S2	Transport regime	Supply	Transport	Storage	2	2	3	3	2	3	3	1	3	3	2	3
	S3	Typical sediment storage period	<1 year	>1 years AND <10 years	>10 years	1	1	2	2	2	3	3	1	2	3	3	3
	S4	Longitudinal Pattern in Grainsize Distribution	No downstream fining	Gradual downstream fining	Abrupt downstream fining	1	2	2	1	1	2	3	2	3	2	3	3
	S5	Longitudinal change in sediment transport capacity	Increasing downstream	Slowly decreasing downstream	Abruptly decreasing downstream	1	2	1	3	1	3	3	1	1	1	3	2
Land Use	L5	Critical facilities and infrastructure risk	No facilities	Medium profile facility	High profile facility	3	1	2	2	2	1	1	3	3	2	3	2
		Levee/Revet Damages (Locations)	<10	10 - 20	>20	1	2	1	1	2	2	3	3	2	3	3	1
		Levee/Revet Damages (per/River Mile)	<10	10 - 20	>20	1	3	2	1	3	1	2	1	3	2	3	1
		Flooding - Frequency	<2x's	2 - 3x's	>4x's	2	2	2	2	1	2	3	3	2	2	3	1
		Flooding - Locations	<5	5 - 10	>10	3	2	1	2	1	1	3	2	1	1	3	2
Social	SO1	Population benefited from reduced flooding of structures	Low	Moderate	High	3	2	2	1	3	1	1	2	2	1	1	3
	SO2	Population benefited from reduced flooding of roads (road closures)	Low	Moderate	High	3	1	1	2	2	1	1	2	2	2	2	3
	SO3	Property value changes	Decreases	No change	Increases	3	2	2	2	3	2	2	3	3	2	2	3
					Reach Total	**59**	**64**	**62**	**60**	**55**	**54**	**63**	**57**	**62**	**56**	**63**	**63**

Table 2

Normalized Scores for Twelve Reaches

SMRRT Project

Puyallup River Watershed - Pierce County, Washington

Selection Category	Selection Criteria Code	Selection Criteria Description	Basis for Selection Criteria Value			Assigned Value of Selection Criteria to Reaches and River Mile Extent (P=Puyallup, C=Carbon, W=White)											
						P1	P2	P3	P4	P5	P6	P7	C1	C2	C3	C4	W1
			1 = Low Priority	2 = Medium Priority	3 = High Priority	10.2 - 10.5	13.9 - 14.4	16.0 - 16.5	17.0 - 17.5	21.5 - 21.9	22.3 - 24.4	25.7 - 28.5	0.1 - 3.1	3.4 - 3.8	4.2 - 5.9	6.0 - 8.3	3.8 - 4.8
Fisheries Resources	F1	ESA listed salmonid spawning habitat use	Documented Spawning	Presumed and/or modeled presence	No spawning												
	F2	Proximity to tributary confluence	≤ 200 meters	200-500 meters	>500 meters												
	F3	Nursery juvenile rearing habitat presence (i.e. low velocity/off-channel habitat)	High	Moderate	Low	0.73	0.80	0.80	0.60	0.53	0.53	0.53	0.67	0.53	0.47	0.60	0.53
	F4	Salmonid habitat restoration potential	Low	Moderate	High												
	F5	Vegetation density on bars	High	Moderate	Low												
Geomorphic	G1	Subbasin sediment yield (relative)	Low	Moderate	High												
	G2	Stream power (relative)	High	Moderate	Low												
	G3	Channel confinement within the valley	Confined	Unconfined	Partly confined	0.50	0.83	0.89	0.89	0.67	0.67	0.56	0.56	0.56	0.61	0.56	0.56
	G4	Planform pattern	Multi-thread	Single-thread	Transitional												
	G5	Long-term bar growth	Low	Moderate	High												
	G6	Future channel response	High	Low	Moderate												
Hydraulic	H1	Average Level of protection (return interval Q)	>100-year return interval	10-year to 100-year return intervals	< 10-year return interval												
	H2	Minimum Level of protection (return interval Q)	>100-year return interval	10-year to 100-year return intervals	< 10-year return interval												
	H3	Prior flood location	<5 years	5 to 10 years	>10 years												
	H4	Potential flood reduction	Low	Moderate	High	0.72	0.67	0.67	0.61	0.56	0.50	0.78	0.67	0.83	0.67	0.61	0.89
	H5	Recent (decadal) hydraulic change (Max within reach)	<20%	20% to 50%	>50%												
	H6	Recent (decadal) hydraulic change (Ave within reach)	<10%	10% to 20%	>20%												
Sediment	S1	Recent (decadal) bed elevation change	<6 inches in average elev.	>1 foot in average elev.	>3 feet in average elev.												
	S2	Transport regime	Supply	Transport	Storage												
	S3	Typical sediment storage period	<1 year	>1 years AND <10 years	>10 years	0.47	0.67	0.60	0.73	0.53	0.93	1.00	0.40	0.73	0.73	0.87	0.87
	S4	Longitudinal Pattern in Grainsize Distribution	No downstream fining	Gradual downstream fining	Abrupt downstream fining												
	S5	Longitudinal change in sediment transport capacity	Increasing downstream	Slowly decreasing downstream	Abruptly decreasing downstream												
Land Use	L5	Critical facilities and infrastructure risk	No facilities	Medium profile facility	High profile facility												
		Levee/Revet Damages (Locations)	<10	10 - 20	>20												
		Levee/Revet Damages (per/River Mile)	<10	10 - 20	>20	0.67	0.67	0.53	0.53	0.60	0.47	0.80	0.80	0.73	0.67	1.00	0.47
		Flooding - Frequency	<2x's	2 - 3x's	>4x's												
		Flooding - Locations	<5	5 - 10	>10												
Social	SO1	Population benefited from reduced flooding of structures	Low	Moderate	High												
	SO2	Population benefited from reduced flooding of roads (road closures)	Low	Moderate	High	1.00	0.56	0.56	0.56	0.89	0.44	0.44	0.78	0.78	0.56	0.56	1.00
	SO3	Property value changes	Decreases	No change	Increases												
					Reach Mean	**0.68**	**0.70**	**0.67**	**0.65**	**0.63**	**0.59**	**0.69**	**0.64**	**0.69**	**0.62**	**0.70**	**0.72**

Table 3

Ranking of Twelve Reaches Based on Selection Criteria

SMRRT Project

Puyallup River Watershed - Pierce County, Washington

River	Reach Extent (RM)	Reach Number	Reach Code	Reach Name	Normalized Reach Score	Rank
White	3.8 - 4.8	White-1	W1	Sumner Link Trail	0.72	1
Carbon	6.0 - 8.3	Carbon-4	C4	Alward	0.70	2
Puyallup	13.9 - 14.4	Puyallup-2	P2	Sportsman	0.70	3
Carbon	3.4 - 3.8	Carbon-2	C2	Foothills-Downstream	0.69	4
Puyallup	25.7 - 28.5	Puyallup-7	P7	High-Champion	0.69	5
Puyallup	10.2 - 10.5	Puyallup-1	P1	Cannery	0.68	6
Puyallup	16.0 - 16.5	Puyallup-3	P3	McMillin	0.67	7
Puyallup	17.0 - 17.5	Puyallup-4	P4	Bowen-Parker	0.65	8
Carbon	0.1 - 3.1	Carbon-1	C1	Confluence-Bridge St.	0.64	9
Puyallup	21.5 - 21.9	Puyallup-5	P5	Soldiers Home	0.63	10
Carbon	4.2 - 5.9	Carbon-3	C3	Foothills-Upstream	0.62	11
Puyallup	22.3 - 24.4	Puyallup-6	P6	Ford	0.59	12

Table 4

Evaluation of Selection Criteria for Six Reaches

SMRRT Project

Puyallup River Watershed - Pierce County, Washington

Selection Category	Selection Criteria Code	Selection Criteria Description	Basis for Selection Criteria Value			Assigned Value of Selection Criteria to Reaches and River Mile Extent (P=Puyallup, C=Carbon, W=White)					
						P1	P2	P3	P4	C2	W1
			1 = Low Priority	2 = Medium Priority	3 = High Priority	10.2 - 10.5	13.9 - 14.4	16.0 - 16.5	17.0 - 17.5	3.4 - 3.8	3.8 - 4.8
Fisheries Resources	F1	ESA-listed salmonid spawning habitat use	>1 species	1 species	No spawning	3	2	2	2	1	1
	F2	Proximity to tributary confluence	Documented fish bearing	Modeled fish bearing	No trib/use	3	3	1	2	3	3
	F3	Nursery juvenile rearing habitat presence (i.e. low velocity/off-channel habitat)	High (>25% sc length)	Moderate (10-25% sc length)	Low (<10% sc length)	3	3	3	3	1	1
Geomorphic	G1	Subbasin sediment yield (relative)	Low	Moderate	High	2	2	2	2	1	3
	G2a	Stream power [(lb/sqft sec) avg for 20y Q]	>10	5 - 10	<5	2	1	2	2	1	3
	G2b	Stream power change from upstream	Increasing	Unchanged	Decreasing	1	1	3	1	2	3
	G3a	Channel confinement index (avg HCOT:Active Channel Width)	<2	2 - 3	>3	1	2	3	3	2	1
	G3b	Locations of abrupt channel constriction or alignment changes	1	2	>2	2	1	1	3	1	3
	G4	Planform pattern	Multi-thread	Single-thread	Transitional	2	2	3	3	1	2
	G5a	Average bar area (acres) 1998-2015	<5	5 - 10	>10	2	1	3	3	3	2
	G5b	Bar area growth factor (2015:1998)	<1	1 - 1.5	>1.5	1	2	2	1	3	3
	G6	Future channel response	High	Low	Moderate	2	1	3	1	1	2
Hydraulic	H1	2008 Level of protection: WSEL-Bank El. For 10 YR / 50 YR / 100 YR	(WSEL-Bank El) <0	0< (WSEL-Bank El) <2 for 10 YR	(WSEL-Bank El) >2 for 10 YR	2	3	3	2	1	3
	H2	Change in Level of Protection, 1984-2008 DQ at RI 10 YR**	$\Delta Q < 0$	$1\% < \Delta Q < 19\%$	$\Delta Q \geq 20\%$	3	3	2	2	3	1
	H3	Change in Level of Protection, 1990-2008, DWSEL for 10 YR RI Flow**	$\Delta < 0$	$0 \leq \Delta < 0.49$	$\Delta > 0.5$	3	3	1	1	2	3
	H4	Potential flood reduction	Low	Medium	High	3	2	2	2	1	3
	H5	Potential flood risk if nothing is done	Low	Medium	High	3	3	1	3	1	3
Sediment	S1	Bed elevation change (ft), 1984-2009	$\Delta < 1.0$	$1.1 < \Delta < 2.0$	$\Delta > 2.1$	3	3	1	2	1	3
	S2	Response time to rebuild channel after project, yrs*	Time < 1 year	1 < time < 10	Time > 10	2	3	1	2	1	3
	S3	25 year average aggradation at site yd3/0.1 mile/yr	$yds^3 < 500$	$500 < yds^3 < 1{,}000$	$yds^3 > 1{,}000$	2	3	1	2	1	3
	S4	Change in bed elevation (ft) if no project over 25 yrs	$\Delta < 0$	$0 \leq \Delta < 0.49$	$\Delta > 0.5$	3	3	2	2	1	2
	S5	Ratio of sediment supply to transport capacity	Ratio < 1.0	Ratio = 1.0	Ratio > 1.0	1	1	3	1	3	3
Land Use	L1	Critical Facilities Risk	None, underground sanitary sewer	Bridges, child care (0.2%)	Wastewater treatment plant, water main, bridges	3	2	3	3	3	1
	L2	Public Infrastructure Risk (roads)	Low volume, inconvenience, re-route, low population	Moderate volume, stranding potential, moderate population	High volume, lifeline roads, high population	3	2	3	3	1	1
	L3	Private Property Risk ($)	<$50M	$50M, but <$100M	>$100	2	1	1	1	1	3
	L4	Levee/Revetment Damages (locations)	<10	10 - 20	>20	1	2	1	1	2	1
	L5	Levee/Revetment Damages (per river mile)	<10	10 - 20	>20	1	3	1	2	3	1
	L6	Flooding - Frequency	<2x's	2 - 3x's	>4x's	2	2	2	2	2	1
	L7	Flooding - Locations	<5	5 - 10	>10	3	2	2	2	1	2
	L8	Flooding - Past Costs to County ($)	<$300K	$300K, but <$750K	>$750K	1	3	1	2	3	2
	L9	Flooding - Past Costs to County ($/RM)	<$300K	$300K, but <$750K	>$750K	3	3	1	2	3	2
Social	S01	Population Density	<150 people	150 but < 500 people	> 500 people	3	2	2	1	3	1
	S02	Population Benefitting from Reduced Flooding of Structures (SF)	<500KSF	500>SF, but <1MSF	>1MSF	2	1	1	1	1	3
	S03	Population Benefitting from Reduced Flooding of Roads (ADT)	<2,000	2,000, but <10,000	>10,000	3	2	2	2	1	1
	S04	Impact to Employment Centers	Low Density	Moderate Density	High Density	3	2	1	1	1	3
					Reach Total	**79**	**75**	**66**	**68**	**60**	**76**

Notes:

*Assuming the sediment removed equals the volume accumulated since 1984 and the transport rate equals the average from 2005-2009.

** Measured at gage closest to the site, as reported by USGS

Table 5

Normalized Scores for Six Reaches

SMRRT Project

Puyallup River Watershed - Pierce County, Washington

Selection Category	Selection Criteria Code	Selection Criteria Description	Basis for Selection Criteria Value			Assigned Value of Selection Criteria to Reaches and River Mile Extent (P=Puyallup, C=Carbon, W=White)					
						P1	P2	P3	P4	C2	W1
			1 = Low Priority	2 = Medium Priority	3 = High Priority	10.2 - 10.5	13.9 - 14.4	16.0 - 16.5	17.0 - 17.5	3.4 - 3.8	3.8 - 4.8
Fisheries Resources	F1	ESA listed salmonid spawning habitat use	>1 species	1 species	No spawning	1.00	0.89	0.67	0.78	0.56	0.56
	F2	Proximity to tributary confluence	Documented fish bearing	Modeled fish bearing	No trib/use						
	F3	Nursery juvenile-rearing habitat presence (i.e. low-velocity/off-channel habitat)	High (>25% sc length)	Moderate (10-25% sc length)	Low (<10% sc length)						
Geomorphic	G1	Subbasin sediment yield (relative)	Low	Moderate	High	0.56	0.48	0.81	0.70	0.56	0.81
	G2a	Stream power [(lb/sqft sec) avg for 20y Q]	>10	5 - 10	<5						
	G2b	Stream power change from upstream	Increasing	Unchanged	Decreasing						
	G3a	Channel confinement index (avg HCOT:Active Channel Width)	<2	2 - 3	>3						
	G3b	Locations of abrupt channel constriction or alignment changes	1	2	>2						
	G4	Planform pattern	Multi-thread	Single-thread	Transitional						
	G5a	Average bar area (acres) 1998-2015	<5	5 - 10	>10						
	G5b	Bar area growth factor (2015:1998)	<1	1 - 1.5	>1.5						
	G6	Future channel response	High	Low	Moderate						
Hydraulic	H1	2008 Level of protection: WSEL-Bank El. For 10 YR / 50 YR / 100 YR	(WSEL-Bank El) <0	0< (WSEL-Bank El) <2 for 10 YR	(WSEL-Bank El) >2 for 10 YR	0.93	0.93	0.60	0.67	0.53	0.87
	H2	Change in Level of Protection, 1984-2008 DQ at RI 10 YR**	$\Delta Q < 0$	$1\% < \Delta Q < 19\%$	$\Delta Q \geq 20\%$						
	H3	Change in Level of Protection, 1990-2008, DWSEL for 10 YR RI Flow**	$\Delta < 0$	$0 \leq \Delta < 0.49$	$\Delta > 0.5$						
	H4	Potential flood reduction	Low	Medium	High						
	H5	Potential flood risk if nothing is done	Low	Medium	High						
Sediment	S1	Bed elevation change (ft), 1984-2009	$\Delta < 1.0$	$1.1 < \Delta < 2.0$	$\Delta > 2.1$	0.73	0.87	0.53	0.60	0.47	0.93
	S2	Response time to rebuild channel after project, yrs*	Time < 1 year	1 < Time < 10	Time > 10						
	S3	25 year average aggradation at site yd3/0.1 mile/yr	$yds^3 < 500$	$500 < yds^3 < 1,000$	$yds^3 > 1,000$						
	S4	Change in bed elevation (ft) if no project over 25 yrs	$\Delta < 0$	$0 \leq \Delta < 0.49$	$\Delta > 0.5$						
	S5	Ratio of sediment supply to transport capacity	Ratio < 1.0	Ratio = 1.0	Ratio > 1.0						
Land Use	L1	Critical Facilities Risk	None, underground sanitary sewer	Bridges, child care (0.2%)	Wastewater treatment plant, water main, bridges	0.70	0.74	0.56	0.67	0.70	0.52
	L2	Public Infrastructure Risk (roads)	Low volume, inconvenience, re-route, low population	Moderate volume, stranding potential, moderate population	High volume, lifeline roads, high population						
	L3	Private Property Risk ($)	<$50M	$50M, but <$100M	>$100						
	L4	Levee/Revetment Damages (locations)	<10	10 - 20	>20						
	L5	Levee/Revetment Damages (per river mile)	<10	10 - 20	>20						
	L6	Flooding - Frequency	<2x's	2 - 3x's	>4x's						
	L7	Flooding - Locations	<5	5 - 10	>10						
	L8	Flooding - Past Costs to County ($)	<$300K	$300K, but <$750K	>$750K						
	L9	Flooding - Past Costs to County ($/RM)	<$300K	$300K, but <$750K	>$750K						
Social	S01	Population Density	<150 people	150 but < 500 people	> 500 people	0.92	0.58	0.50	0.42	0.50	0.67
	S02	Population Benefitting from Reduced Flooding of Structures (SF)	<500KSF	500>SF, but <1MSF	>1MSF						
	S03	Population Benefitting from Reduced Flooding of Roads (ADT)	<2,000	2,000, but <10,000	>10,000						
	S04	Impact to Employment Centers	Low Density	Moderate Density	High Density						
					Reach Mean	**0.81**	**0.75**	**0.61**	**0.64**	**0.55**	**0.73**

Notes:

*Assuming the sediment removed equals the volume accumulated since 1984 and the transport rate equals the average from 2005-2009.

** Measured at gage closest to the site, as reported by USGS

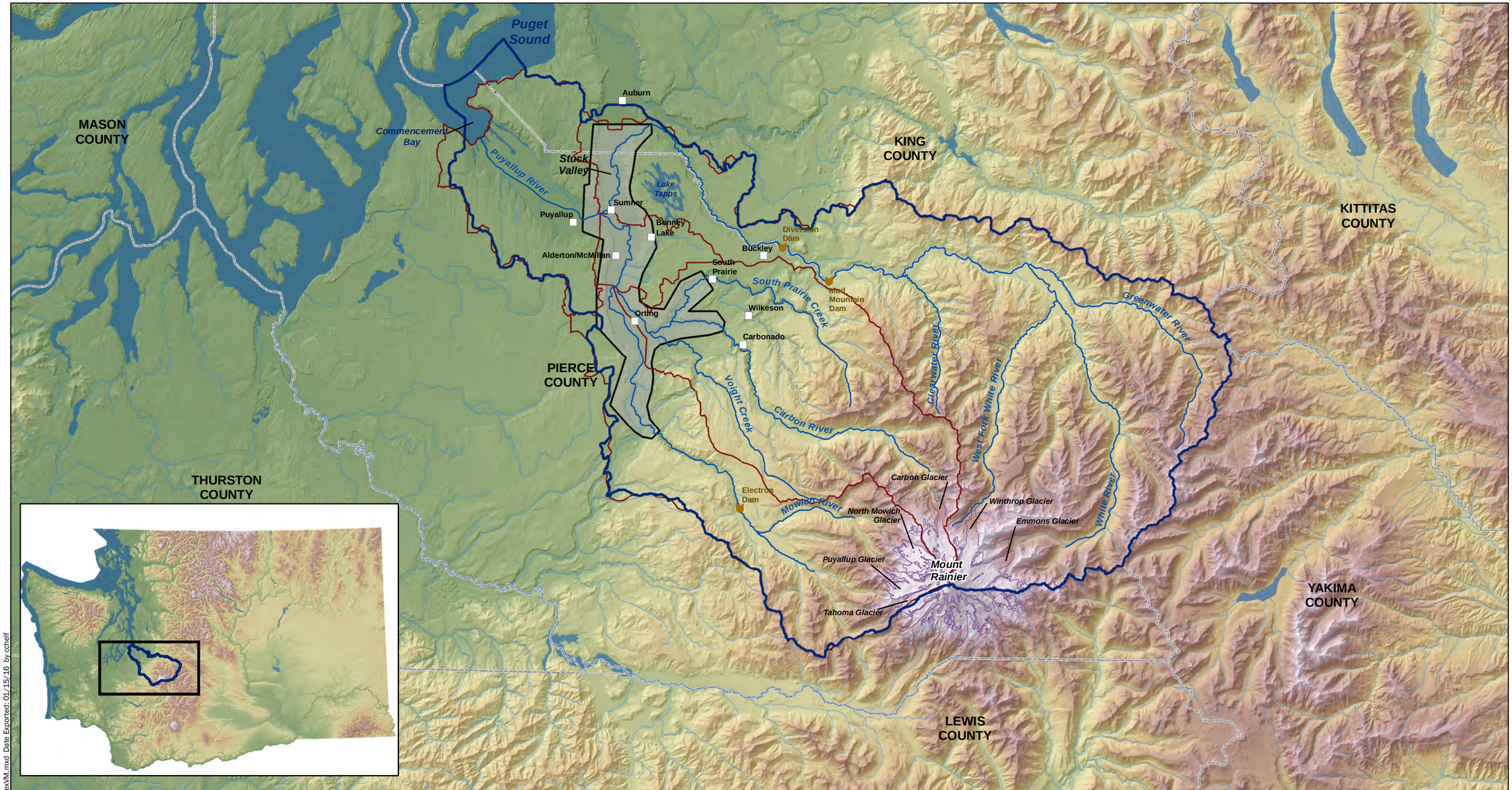
Table 6

Ranking of Six Reaches Based on Selection Criteria

SMRRT Project

Puyallup River Watershed - Pierce County, Washington

River	Reach Extent (RM)	Reach Number	Reach Code	Reach Name	Normalized Reach Score	Rank
Puyallup	10.2 - 10.5	Puyallup-1	P1	Cannery	0.81	1
Puyallup	13.9 - 14.4	Puyallup-2	P2	Sportsman	0.75	2
White	3.8 - 4.8	White-1	W1	Sumner Link Trail	0.73	3
Puyallup	17.0 - 17.5	Puyallup-4	P4	Bowen-Parker	0.64	4
Puyallup	16.0 - 16.5	Puyallup-3	P3	McMillin	0.61	5
Carbon	3.4 - 3.8	Carbon-2	C2	Foothills-Downstream	0.55	6



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: USGS, Pierce County, WSDOT, WAECY, WADNR

Projection: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet

Legend

- City
- Approximate Dam Location
- Project Area
- County Boundary
- Puyallup River Watershed Boundary
- Major River
- Other River
- Modifed Puyallup River Sub-Basin
- Glacier
- Water

Elevation
14417 Feet
-14 Feet

N W E S

4 0 4
Miles

Regional Setting and Watershed Map

Pierce County SMRRT Project
Pierce County, Washington

GEOENGINEERS

Figure 1

P:\0\0497109\GIS\05\MXD\049710905_ComplexVM.mxd Date Exported: 01/15/16 by cchelf

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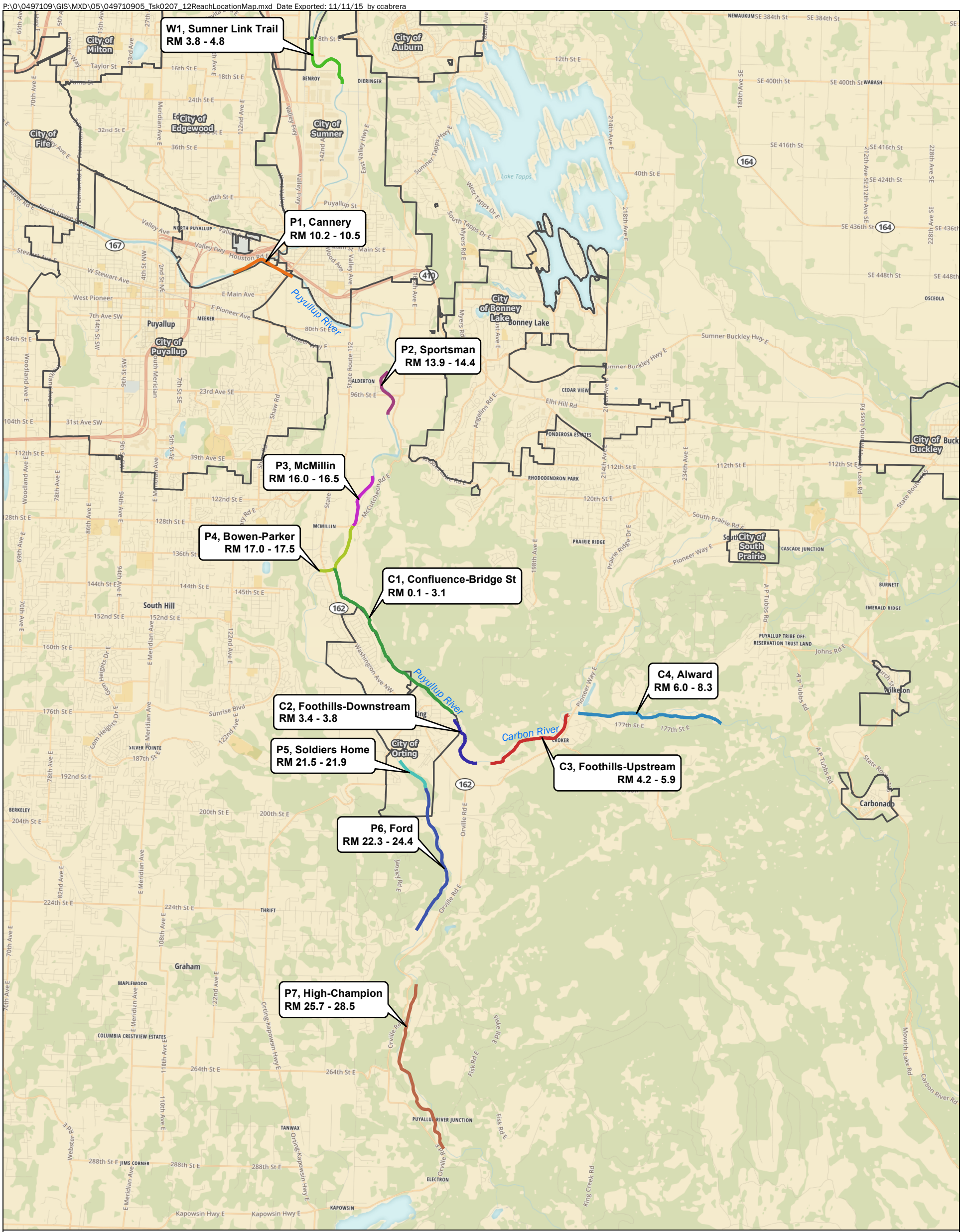

Legend

- City Limits
- Candidate Reaches
  - C1, Confluence-Bridge St
  - C2, Foothills-Downstream
  - C3, Foothills-Upstream
  - C4, Alward
  - P1, Cannery
  - P2, Sportsman
  - P3, McMillin
  - P4, Bowen-Parker
  - P5, Soldiers Home
  - P6, Ford
  - P7, High-Champion
  - W1, Sumner Link Trail

N W E S

1.5 0 1.5

Miles

Notes:

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Data Source: City limits from Pierce County, Washington GIS.
Base map from ESRI ArcGIS Data Online.

Projection: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet

Twelve Candidate Reaches

SMRRT Project
Puyallup River Basin
Pierce County, Washington

GeoEngineers

Figure A-1

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Legend

● River Miles

The channel between the end River Mile (RM) markers is the approximate extent of study reach evaluation. The actual project reach is shorter than this study reach (the project reach RMs are indicated in the title block).

N W E S

700 0 700

Feet

Reach P1, Cannery, RM 10.2 - 10.5

SMRRT Project
Puyallup River Basin
Pierce County, Washington

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Figure A-2

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial (July, 2013) from ESRI ArcGIS Online.

Projection: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet

P:\0\0497109\GIS\MXD\05\049710905_Tsk0207_ReachCandidate_P2.mxd Date Exported: 01/12/16 by ccabrera

Legend

● River Miles

The channel between the end River Mile (RM) markers is the approximate extent of study reach evaluation. The actual project reach is shorter than this study reach (the project reach RMs are indicated in the title block).

N W E S

300 0 300

Feet

Reach P2, Sportsman, RM 13.9 - 14.4

SMRRT Project
Puyallup River Basin
Pierce County, Washington

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Figure A-3

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial (July, 2013) from ESRI ArcGIS Online.

Projection: NAD 1983 HARN StatePlane Washington South FIPS 4602 Feet

Attachment 4

Excerpts from Site Selection Report

Sediment Management as a Risk Reduction Tool (SMRRT) Project

Site Selection Report

Prepared for:
Pierce County Public Works
Surface Water Management
2702 South 42nd Street, Suite 201
Tacoma, Washington 98409

Attention: Angela Angove

Prepared by:
GeoEngineers, Inc.
8410 154th Avenue NE
Redmond, Washington 98052

May 13, 2016

GeoEngineers

nhc
northwest hydraulic consultants

Table 1

Site Selection Analysis

Sediment Management as a Risk Reduction Tool (SMRRT) Project
Pierce County, Washington

Site	Hydraulics and Sediment Transport		Geomorphology		Fisheries		Social and Land Use		Hazardous Materials		Wetlands and Wildlife		Geology, Soil and Groundwater	
	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons
P1	Net bed elevation has increased 2.2 ft since 1977.	Net increase in bed elevation 0.8 ft less over 38 years than at Site P2.	Average bar area (acres) 1998-2015 - 7.7 acres. More available bed material.	Stream power is increasing upstream to downstream along the reach, indicating the potential for reduced channel stability.	In Alternative 2, Juvenile rearing habitat availability increases (66% at 1,175 cfs and 24.7% at 11,800 cfs).	In Alternative 1, slight decrease in juvenile rearing habitat availability (-0.1% at 1,175 cfs and -19.2% at 11,800 cfs).	**High priority critical infrastructure at risk.**	Low occurrence of levee damages along reach.		Surrounding land use includes more development over decades for P1; more likely than P2 to have presence of hazardous materials in sediment.	Mapped wetland areas present within the review area are not located at or immediately adjacent to anticipated construction areas based on preliminary alternative designs. Wetlands are located on the opposite bank and/or further upland than the existing levee.	Two non-riverine wetlands with potentially degraded baseline conditions have lmited potential for wetland mitigation; therefore less opportunity for mitigation than at P2.	Based on relative likelihood of adjacent material to provide more sediment (i.e., steeper slopes, landslide hazards, erodible soils), both reaches rank about the same.	
	Reach in a near equilibrium indicating natural rates of erosion would not reduce bed elevation in the future.	Post project flooding will remain at 10-year flow.	**Channel confinement index (avg HCOT:Active Channel Width) - average 1.9. Channel has occupied less of the valley floor, indicating long-term stability.**		**No potential ESA spawning impacts.**		Moderate value of private property at risk.	Low cost of past flood damages to levees.		More outfalls in or upgradient of P1, from parking lots, roads, agricultural properties and wastewater treatment plant; more likely than P2 to have presence of hazardous materials in sediment.	Only one wildlife habitat (general habitat area) near P1, with 20.9% of review area covered; therefore less potential short-term impacts during construction at P1.		Based on the potential impact to affect regional groundwater from construction activities, both reaches rank about the same.	
	Project could decrease water surface elevations by up to 0.5 foot at the 10-year flow.	Site currently does not overtop the banks until 10-year flow.	Relative shear stress effects from SMRRT project - lower. SMRRT project alternatives result in less shear stress changes, suggesting potential for channel stability.				**High number of flooding locations along reach.**			Approx. 19 sites that may have the potential to contribute or have contributed contamination to the reach.	Vegetated riparian width estimated average of 151 feet, with subjectively low riparian habitat quality; therefore, project would impact riparian habitat less at P1 than at P2.			
	Comparative project life greater than at Site P2.	Sediment volume to extract for a project is larger than at Site P2.	**Long-term sediment transport regime - neutral. Suggests better channel stability.**				**Lifeline corridor impacted by flooding.**							
			Average sediment transport capacity, 20-yr return interval event - 4,500 tons/day. Suggests better long-term sediment regime.				High population impacted.							
			Stream power [(lb/sqft sec) avg for 20y Q] - averages 5.0 lb/ft sec. Stream power is lower in P1, suggesting more channel stability.				Moderately high square footage of structures in 100yr floodplain.							
			Bar area growth factor (2015:1998) - 0.96. Suggests better long-term sediment regime.				High impact to traffic as a result of flooding.							
			Long-term bar bar pattern suggest bar formation will continue after SMRRT project.				**High impact on commuters and economy.**							
			Future channel response - moderate. Suggests better potential channel stability.											

Site	Hydraulics and Sediment Transport		Geomorphology		Fisheries		Social and Land Use		Hazardous Materials		Wetlands and Wildlife		Geology, Soil and Groundwater	
	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons
P2	Net bed elevation has increased 3 ft since 1977.	Post project flooding will remain at 10-year flow.	Long-term bar bar pattern suggest bar formation will continue after SMRRT project.	Stream power [(lb/sqft sec) avg for 20y Q] - averages 12.6 lb/ft sec. Stream power is higher in P2, suggesting less channel stability.	Increases juvenile rearing habitat in both alternatives at low-flow conditions (2.6% at 1,1175 cfs and 148.4% all 11,900 cfs).	Juvenile rearing habitat decreases in both alternatives at higher flows (-45.1% at 1,175 cfs and -12.8% at 11,900 cfs).	High occurrence of levee damages along reach.	No high priority critical infrastructure at risk.	Surrounding land use has been primarily agricultural for decades, with a few exceptions, therefore less likely than P1 to have hazardous materials in sediment.	Several non-agricultural uses and sports gun range adjacent to reach.	Five non-riverine wetlands with potentially degraded baseline conditions have potential for wetland mitigation.	Mapped wetlands that are present within the review area are located at or immiately adjacent to anticipated construction areas based on preliminary alternative designs. Therefore, more potential for wetland impacts compared to P1.	Based on relative likelihood of adjacent material to provide more sediment (i.e., steeper slopes, landslide hazards, erodible soils), both reaches rank about the same.	
	Net increase in bed elevation over 38 years 0.8 ft greater than at Site P1.	Comparative project life lower than at Site P1.		Channel confinement index (avg HCOT:Active Channel Width) - average 2.5. Channel has occupied more of the valley floor, indicating long-term instability.		Steelhead have been documented spawning in this reach and gravel removal could negatively impact spawning habitat.	Moderate number of flooding locations along reach.	Low value of private property at risk.	Only two outfalls and the origin of discharges are wetland/oxbow; therefore low likelihood of hazardous materials in sediment.	Approx. 11 sites that may have the potential to contribute or have contributed contamination to the reach.		Three wildlife habitat areas (including two waterfowl concentration and one old growth inventory areas) near P2, with 46.4% of review area covered; therefore more likely that a project could have short-term impacts during construction.	Based on the potential impact to affect regional groundwater from construction activities, both reaches rank about the same.	
	Would decrease water surface elevations by up to 1.5 foot at the 10-year flow.	**Reach is erosional indicating natural rates of erosion will reduce bed elevation in the future.**		Relative shear stress effects from SMRRT project higher. SMRRT project alternatives result in larger shear stress changes, suggesting potential for channel instability.			High cost of past flood damages to levees.	No significant roads impacted by flooding. Alternative routes available.	Less likely than P1 to have contaminant sources adjacent to reach because fewer known or potential contaminant sources.			Vegetated riparian width estimated average of 360 feet, with subjectively medium riparian habitat quality; therefore, project would potentially impact more riparian habitat at P2.		
	Site currently overtops the banks at the 2-year flow.			Long-term sediment transport regime - erosional. Suggests worse channel stability.				Moderately low population impacted.						
	Sediment volume to extract for a project is less than at Site P1.			Average sediment transport capacity, 20-yr return interval event - 1,140 tons/day. Suggests worse long-term sediment regime.				Very low square footage of structures in 100yr floodplain.						
				Average bar area (acres) 1998-2015 - 3.75 acres. Less available bed material.				Moderate impact to traffic as a result of flooding.						
				Bar area growth factor (2015:1998) - 1.12. Suggests worse long-term sediment regime.				Moderate to Low impact on commuters and economy.						
				Stream power is increasing upstream to downstream along the reach, indicating the potential for reduced channel stability.										
				Future channel response - high. Potential future channel response is high, suggesting potential channel instability.										

Summary

Geomorphology: More available bed material, more channel stability and better long-term sediment regime make P1 preferable.

Hydraulics and Sediment: Based upon an analysis of the pros and cons of each site for the sediment criteria, P2 has one more pro than P1. Most of the criteria are near equal between the sites. Site P2 has a significant Con - sediment transport and repeat cross section analysis shows it to be naturally erosional in recent years.

Fisheries: Juvenile rearing habitat increases at P1/Alt. 2 (at both flow scenarios) and P2 both alternatives at low flow; there are no potential ESA spawning impacts at P1. Site P1 is preferable for fisheries in comparison to P2 because potential impacts are less and habitat uplift is more probable.

Social and Land Use: Based upon an analysis of the pros and cons of each site for the Social and Land Use criteria, P1 has more pros than cons. P1 has more pros in both criteria categories than P2. P1 has a greater range of benefits than P2.

Hazardous Materials: P2 has fewer potential sources of contaminants adjacent to the reach with a less-developed surrounding land use, and fewer outfalls with the potential to contribute contaminants directly to sediment.

Wetlands and Wildlife: P2 is preferable to minimize impacts to wetlands and has more potential for wetland mitigation; however, wetland impacts at P1 might be avoidable or minimized. P1 is preferable to minimize impacts to potential wildlife habitats as a result of fewer mapped habitat areas, a narrower existing native riparian buffer, and lower riparian habitat quality.

Geology, Soils and Groundwater: Criteria for both reaches rank about the same.

Conclusion

Based on comparison of the pros and cons for the two reaches, and professional judgment, the team has concluded that Reach P1 is the most favorable reach for the sediment removal pilot study. P1 is the most stable of the two reaches, will provided approximately 10 years of benefit before aggrading to existing conditions, flood elevations will be significantly reduced and the reduction in flood elevations will not negatively impact habitat, and significant benefits to infrastructure will result.