Volume I

Pierce County
Rivers Flood Hazard Management Plan

Adopted February 19, 2013
Ordinance 2012-53s
PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

February 2013
PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

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Special Acknowledgments

The Pierce County Rivers Flood Hazard Management Plan benefitted extensively from the planning approach, science, and content of the King County Flood Hazard Management Plan (King County 2007) and the analysis of flood mitigation alternatives in the Upper Yakima River Comprehensive Flood Hazard Management Plan (Yakima County Flood Control Zone District 2007).
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EXECUTIVE SUMMARY

ES.1 INTRODUCTION AND PURPOSE

In the 20 year period between 1991 and 2011, the total cost of the river management program and estimated damages to public and private infrastructure and property in Pierce County, resulting from flooding and channel migration exceeded $155 million (Table ES.1). During this same time frame, the population, property values, advances in science and engineering, and our understanding of the importance of natural riverine process have grown significantly. Political and societal pressure is growing for the development of a plan which provides meaningful and long lasting solutions for river management and flood protection in Pierce County. The Pierce County Rivers Flood Hazard Management Plan (the “Flood Plan” or “Plan”) outlines how Pierce County will address and manage flooding and channel migration hazards on the major rivers, large tributaries and associated floodplains within Pierce County for the next 20 years.

Table ES 1 - Total Cost of Flood Damages and River Management Program in Pierce County (1991-2010)a

<table>
<thead>
<tr>
<th>Type of Funding or Program</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEMA (Stafford Act) Emergency Assistance Funds to public entities for infrastructure and property damage</td>
<td>$38,877,189</td>
</tr>
<tr>
<td>FEMA (Stafford Act) Individual Assistance to private property owners</td>
<td>$7,217,257</td>
</tr>
<tr>
<td>NFIP Flood Insurance Claims</td>
<td>$6,752,264</td>
</tr>
<tr>
<td>U.S. Army Corps of Engineers funding through PL 84-99 Program</td>
<td>$13,343,309</td>
</tr>
<tr>
<td>Acquisition and buyout of properties and structures (including federal HMGP, state, and local REET sources and SRFB funds)</td>
<td>$25,430,088</td>
</tr>
<tr>
<td>Pierce County SWM River Improvement Fund</td>
<td>$28,133,773</td>
</tr>
<tr>
<td>Pierce County REET River Improvement Fund</td>
<td>$35,337,748</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td><strong>$155,091,628</strong></td>
</tr>
</tbody>
</table>

a This does not include state and federal infrastructure damages, unreimbursed private property damage, lost business output, agricultural damages, environmental damages, and unrepaired flood facility damages.


1 Riverine - Of or produced by a river

2 Floodplain – The total area subject to inundation by the base flood including the flood fringe and floodway. The low area adjoining a stream or river channel that overflows at times of high river flow.
The Flood Plan replaces the 1991 Puyallup River Comprehensive Flood Control Management Plan. It includes for the first time flood hazard mitigation planning for the Nisqually, Greenwater, and Mashel rivers and South Prairie Creek, along with the Puyallup, Carbon and White rivers. Like its predecessor, the Flood Plan was developed to meet the requirements of the Washington Administrative Code (WAC 173-145) related to Comprehensive Flood Control Management Plans, Revised Code of Washington (RCW 86.12 flood control by counties), and the Community Rating System guidance for floodplain management planning under the National Flood Insurance Program.

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

Since the adoption of the 1991 Puyallup River Basin Comprehensive Flood Control Management Plan, the regulatory and environmental landscape has changed dramatically. The Clean Water Act and Endangered Species Act requirements now call for updated and creative approaches to river and floodplain management. Climate change is a growing concern. Trends are showing a change in flood frequency and magnitude and glacial melting is exposing more sediment to downstream transport that has the potential to increase flood risks in the near- and long-term future.

This Flood Plan was developed using the best available technical information, an inclusive stakeholder and public-involvement process, and a multi-disciplinary team of Pierce County staff and supporting consultants. Complex economic, social, and cultural conditions in the watershed; federal, state, and local regulations; and, existing legal agreements (e.g., Tribal, Corps of Engineers) were considered as part of Flood Plan development. The recommendations found within the Flood Plan have the support of Pierce County staff and the Flood Plan Advisory Committee. That Committee was made up of 26 individuals representing a wide range of property owners, business interests, floodplain cities and towns, tribal, state and federal representatives.

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3 Mitigation – Avoiding, rectifying, minimizing, reducing, compensating for, or eliminating probable significant adverse impacts to a natural resource or environment.

4 Sediment – Solid material settled from suspension in a liquid.

5 Watershed – The region drained by or contributing water to a stream, lake, or other body of water.
ES.2 GOALS AND OBJECTIVES

In developing the Flood Plan, Pierce County and the Flood Plan Advisory Committee developed a set of Goals and Objectives the Flood Plan should achieve. The goals describe broad outcomes and provide direction and focus towards the end results. The Plan Objectives are a more specific statement, of actions that the Advisory Committee agreed would move the Plan towards attainment of the Plan’s Goals. The Goals of the Flood Plan are:

1. Reduce risks to life and property from river flooding and channel migration;
2. Identify and implement flood hazard management\(^6\) activities in a cost-effective and environmentally-sensitive manner;
3. Support compatible human uses, economic activities, and improve habitat conditions in flood-prone and channel migration areas; and
4. Develop a long-term and flexible funding strategy for river flood hazard management.

The Objectives of the Flood Plan (in no particular order) are:

1. Evaluate the risks to public safety and existing development (e.g., critical facilities, infrastructure, and structures) in flood-prone and channel migration hazard areas;
2. Examine alternatives to reduce risk to life and property, while reducing economic and environmental impacts of flood hazard management actions and programs;
3. Regulate new development in flood-prone and channel migration hazard areas to minimize risks to life, property, and habitat, and strive for consistency of regulations among affected local governments;
4. Identify current and establish future “Levels of Service” for existing and new flood risk reduction facilities;
5. Maintain, repair and modify necessary existing flood risk reduction facilities in a cost-effective manner that makes the facilities less susceptible to future damage, reduces impacts on aquatic\(^7\) and riparian\(^8\) habitat, and ensures consistency with public law (PL) 84-99, or similar federal, tribal and state laws and programs;
6. Identify repetitive-loss properties and properties needed for future flood risk reduction facilities;

\(^6\) Flood Hazard Management – A comprehensive approach to flood control issues that encompasses both flood control management and floodplain management and uses both structural and nonstructural methods of reducing flood hazards. Flood hazard management is not limited to areas within the floodplain but can extend to the entire watershed.

\(^7\) Aquatic – Pertaining to water

\(^8\) Riparian – The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems that mutually influence each other. Riparian habitat begins at the ordinary high water mark and includes riparian areas of wetlands that are directly connected to the stream course; it may include the entire extent of the floodplain.
EXECUTIVE SUMMARY

Pierce County Public Works & Utilities
ES-4
www.piercecountywa.org/water

Surface Water Management

Prioritize projects and programs based on the level of risk, benefit, cost-effectiveness over the life of the plan or facility, and adverse effects on habitat;

Provide for the participation of stakeholders in the assessment of acceptable risks, evaluation and ranking of alternatives, natural resource management issues and development of recommendations;

Coordinate among Pierce County departments, other agencies and governments (cities, tribes, adjacent counties) to seek consistency in flood hazard management and flood disaster response and recovery;

Implement a County-wide public education and outreach program to improve flood awareness that includes actions people can take to reduce risks (e.g., flood insurance, flood proofing);

Identify possible funding sources for implementing the recommended flood hazard management activities;

Examine the connections between flood hazard management, river corridors, salmon recovery, aquatic and riparian habitat, water quality, open space, public access and agricultural resources to take advantage of efficiencies in addressing multiple objectives;

Remove or modify existing flood risk reduction facilities to protect, restore, or enhance critical riparian or instream habitat that benefits threatened or endangered species;

Identify important riparian, aquatic, fish and wildlife habitat;

Protect and enhance natural systems that prevent flooding;

Adaptively manage implementation to learn from successes, develop long-term cost-effective approaches and reduce the need for costly solutions;

Incorporate a science-based approach in developing and evaluating alternatives and to monitor implementation;

Increase our understanding and incorporate information about climate change (including potential increases in rainfall, glacial retreat and changes in sediment transport) into flood hazard management decision-making; and

Cooperate with regional agencies in maintaining a network of accurate stream flow and weather gauges, and water quality data.

ES.3 PLANNING AREA DESCRIPTION

The geographic scope of the Pierce County Rivers Flood Hazard Management Plan includes the floodplains of the two major river systems in Pierce County (Puyallup and Nisqually Rivers),

Stream – A channel of perennial or intermittent flowing water.
their major tributaries, and streams with historical peak flows exceeding 5,000 cubic feet per second\(^\text{10}\) (cfs). Figure ES.1 outlines the planning area covered by the Flood Plan. Not included in the plan are rivers and streams that either:

- Lack flood risk reduction facilities operated and maintained by Pierce County;
- Are segments partly or wholly located within adjacent county jurisdictions; or
- Have little or no Pierce County maintained infrastructure or developed areas.

The Puyallup River and Nisqually River watersheds include forests, national parks, and wilderness areas in the upper watersheds; rural and agricultural uses in the mid to lower basin\(^\text{11}\) areas; and urban areas dispersed throughout the lower Puyallup watershed near the river mouth. To capture the full impact of the river systems, the Flood Plan also includes the areas adjacent to these rivers in the 100-year floodplain, which includes unincorporated Pierce County, as well as portions of the cities of Tacoma, Fife, Puyallup, Sumner, Orting, and Pacific, and the towns of South Prairie and Eatonville.

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\(^{10}\) **Cubic feet per second (cfs)** – Cubic feet per second. Units assigned to the volume of water that flows past a fixed point in a stream channel, drainage outlet, or other water flow path every second; equivalent to 449 gallons per minute (gpm).

\(^{11}\) **Basin** – A geographic and hydrologic sub unit of a watershed, shortened reference to drainage basin.
The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.
ES.4 PLAN DEVELOPMENT

Development of the Pierce County Rivers Flood Hazard Management Plan was lead by the Pierce County Public Works and Utilities Department, Surface Water Management (SWM) Division. A Pierce County Project Team made up of representatives from SWM, Transportation Planning, Emergency Management, Planning and Land Services, Economic Development, Government Relations, and Parks and Recreation Services helped to guide development of the Plan. An internal Steering Committee (composed of the SWM Management Team) reviewed all elements of the Flood Plan prior to broader external review.

Extensive stakeholder involvement was conducted throughout the planning process. During May to July 2009, interviews were held with external parties including cities, tribes, agencies, the Pierce County Sustainability Council, and Master Builders of Pierce County to seek input on issues and concerns related to flooding in Pierce County. In August 2009, notification was sent to all postal customers in Pierce County (including residential and business addresses) informing them about the planning process and inviting their input through a survey. Over 1300 responses to the survey were received.

In December 2009, a Flood Plan Advisory Committee (Advisory Committee) was convened to advise Pierce County on development of the Flood Plan and provide technical and other input on many of the Plan’s elements, including: goals and objectives; guiding principles; problem definitions; evaluation of alternatives; plan recommendations; capital projects; and, implementation. The Advisory Committee consisted of 26 members representing cities, counties, tribes, state and federal agencies, business, environmental and agricultural interests, floodplain residents and citizens outside of the planning area. The Advisory Committee met 18 times between December 2009 and June 2011. The Advisory Committee agreed upon the goals and objectives (Chapter 1.4), guiding principles (Chapter 1.5) and policies (Chapter 3) that laid the foundation for development of the plan. The Advisory Committee agreed upon programmatic recommendations (Chapter 4), commented on capital projects (Chapter 5), and agreed upon plan implementation and funding (Chapter 6).

A series of public open houses and meetings were held at three distinct phases of the project. Open houses were held in March and November 2010 and June 2011 at three to four locations around the County to seek: (1) input on issues, concerns, and problem identification, (2) perspectives on management strategies, plan alternatives, and options, and (3) comments on draft plan recommendations. An Elected Officials Workshop was held in September 2010 to inform elected officials about the plan and seek input on management strategies, levels of protection, and floodplain development regulations.

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12 Programmatic – Relating to a plan or procedure for dealing with some matter, e.g., regulations, policy guidelines, site design standards, operational policies and procedures, technical assistance, enforcement, and public outreach and educational programs.
ES.4.1 Guiding Principles and Policies

Guiding principles (Chapter 1.5) and policies (Chapter 3) inform development of the programmatic and capital improvement recommendations in the Plan. The guiding principles are the facts, scientific foundation, and broad philosophy that serve as a frame of reference for developing new flood hazard management policies, evaluating flood risks, identifying the range of management alternatives, and developing recommendations.

All proposed policies are written to be consistent with Pierce County’s flood hazard regulations and other local, state, and federal regulations. Some policies were developed from related policies contained within the Comprehensive Plan for Pierce County, Washington. Other policies will revise policies in the Utilities Element of the Comprehensive Plan. The policies contained within this Flood Plan encourage cooperative and consistent floodplain management among towns, cities, counties, and special districts as advocated by Chapter 86.12 RCW. Actions taken by one jurisdiction can have adverse effects upon neighboring jurisdictions. Filling of the floodplain in one area frequently transfers the flood hazard risk to other areas and other jurisdictions and their citizens. Consistent approaches to flood hazard management across jurisdictions can reduce such adverse affects. Some of the key policies proposed in the Flood Plan are highlighted below:

Project policy #5 – Flood and Channel Migration Risk Reduction Goals – This policy proposes four “flood protection levels” for levees that would be applied to different river reaches\(^{13}\) based on the recommended reach management strategy. The four flood protection levels are:

a. 200-year design, plus three feet of freeboard\(^{14}\);

b. 100-year design, plus three feet of freeboard;

c. Maintenance of 2009 conveyance capacity; and

d. Maintenance of existing levee\(^{15}\) configuration (“prism”).

Additionally, two erosion protection levels are proposed for revetments\(^{16}\):

a. Channel migration prevention design, and

b. Channel migration resistance design.

Project policies #11 and 12 – Comprehensive Sediment Management and Gravel Removal – Policy #11 states that “Comprehensive sediment management in Pierce County shall be informed by channel monitoring and technical sediment transport studies and consider the highly variable nature of sediment transport to achieve a balance between flood risk reduction

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\(^{13}\) **Reach** – A segment of a stream channel where the cross-section, slope, and roughness of the channel are constant. Simulation of the flow in streams is done by dividing the stream channel into reaches.

\(^{14}\) **Freeboard** - Additional height of a levee above the design height to provide a factor of safety in the design.

\(^{15}\) **Levee** – A flood-control structure designed to protect an area from flooding. Levees are often rated by the level of protection they offer. Pierce County currently does not have any levee certified to provide 100-year flood protection per FEMA criteria.

\(^{16}\) **Revetment** – A flood-control structure that reduces erosion along a riverbank.
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.

Floodplain Land Use policy #1 – Consistent Regulatory Standards – Pierce County supports consistency in flood hazard regulations across jurisdictions. Cities and towns should adopt policies and regulations that are consistent with Pierce County critical area regulations for flood hazard areas, and regulate according to the best available data, such as updated flood studies.

Funding policy #1 – Regional Funding – New or expanded regional funding sources should be identified and secured to meet the need for enhanced or expanded flood and channel migration hazard management projects, maintenance, and programs. An example of this would be the formation of a Flood Control Zone District.

ES.5 PROBLEMS AND PROPOSED SOLUTIONS

ES.5.1 Flooding and Channel Migration Problems

Nearly 250 flooding and channel migration problems for each sub-planning area were identified by Pierce County staff, cities, tribes, the Advisory Committee, other stakeholders, and the public. An empirical, criteria-driven evaluation was completed for those problem areas that reflected the following flooding and channel migration conditions:

- Levee/revetment overtopping or breaching,
- Tributary backwater\(^\text{17}\) flooding,
- Public safety/emergency evacuation,
- Channel migration problem areas,
- Flooding of structures and infrastructure,
- Sediment/gravel bar accumulation

\(^\text{17}\) Backwater – Stream water, obstructed by some downstream hydraulic control that is slowed or stopped from flowing at its normal, open-channel flow condition.
The problem evaluation was completed to prioritize limited resources for the development of solutions for a subset of highly ranked problems. Criteria used to evaluate flood and channel migration problems included:

1. **Existing land use of affected area (Consequences)** – This criterion gave different weights to different types of land uses affected by flooding, including critical facilities, public infrastructure, commercial/industrial uses, residential, resource lands, and recreational lands.

2. **Severity of potential flood or channel migration impact** – This criterion was intended to evaluate the type and magnitude of the impacts irrespective of the scale at which the impact occurred. This included public safety problems; severe, moderate or minor infrastructure or property damage, and inconvenience flooding or channel migration.

3. **Spatial area of impact (consequences and severity)** – This criterion describes the scale of the problem. Is the problem over a large area or in a manner that will affect a large number of people, or is it largely localized? Categories were regional (large scale impacts), severe (city center, large neighborhoods), moderate (numerous structures or roads impacted) and localized (affects a few homes or businesses).

4. **Frequency of flood or channel migration occurrence** – This criterion is used to describe how often the flood or channel migration event occur (i.e., a channel migration event is any significant landward bank erosion\(^{18}\)). Categories were: 1) three or more occurrences in the past 20 years; 2) two occurrences; 3) one occurrence; or 4) has not occurred (but would likely occur in a 1 percent annual chance flood).

Additional floodplain management considerations were taken into account as part of problem identification and evaluation process, but lacked sufficient data to support an empirical, criteria-driven evaluation:

- Facility maintenance and repair needs,
- Inconsistent floodplain development regulations across jurisdictions,
- Fish habitat problem areas, and
- Public access issues.

### ES.5.2 Programmatic Recommendations

The Plan includes programmatic recommendations and non-structural actions to reduce the associated risks of flooding and channel migration problems along the major rivers and streams in Pierce County (Chapter 4). The recommendations include programs such as mapping of risks, technical assistance, public education and outreach, flood warning\(^{19}\) and emergency response,

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\(^{18}\) **Erosion** – Detachment of soil or rock fragments by water, wind, ice and gravity.

\(^{19}\) **Flood Warning** - A warning issued by the NWS to warn of river flooding which is imminent or occurring. A flood warning is issued when a river first exceeds its flood stage, and it may be reissued if a new river forecast for a forecast point or reach is significantly higher than a previous forecast.
monitoring, facility maintenance, sediment and wood management, as well as land use and regulations to reduce future risks (see Table ES.2). Some programmatic recommendations bear directly on capital projects such as river management strategies, levels of protection, the levee setback program, and roads and bridges. Recommended programs address the goals, objectives, applicable policies, and problems found in the Flood Plan.

Each of the programmatic recommendations provides a description of the issue being addressed, as well as background and other supporting information. Recommendations are numbered and apply either “flood plan-wide” (FPW), or to a specific river system (e.g., Puyallup River (PR)). The specific recommendation language was agreed upon by the Flood Plan Advisory Committee.

<table>
<thead>
<tr>
<th>Table ES 2 – Programmatic Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information/Mapping/Technical Assistance</strong></td>
</tr>
<tr>
<td><strong>FPW #1</strong></td>
</tr>
<tr>
<td><strong>FPW #2</strong></td>
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<tr>
<td><strong>FPW #3</strong></td>
</tr>
<tr>
<td><strong>FPW #4</strong></td>
</tr>
</tbody>
</table>

| **Land Use/Regulatory/Acquisition/Structure Elevation** |
| **FPW #5** | Consistent Floodplain Development Regulations | These recommendations address consistency of floodplain and flood hazard area regulations between Pierce County and cities/towns; regulation based on best available data; zero rise and compensatory storage regulations; establishment of a regulatory working group to support consistency and assess residual flood risks and appropriate regulations behind certified levees. *(Pierce County, cities/towns)* |

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20 **Compensatory Storage** – New excavated storage volume equivalent to the flood storage capacity eliminated by filling or grading within the floodplain. For any fill placed below the base flood elevation, an equal volume will be removed from the
## EXECUTIVE SUMMARY

### PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

**Table ES 2 – Programmatic Recommendations**

<table>
<thead>
<tr>
<th>FPW #</th>
<th>Program Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPW #6</td>
<td><strong>Urban Growth Area Expansion</strong>&lt;br&gt;This recommendation extends the current prohibition on expansion of Urban Growth Areas into the 100-year regulatory floodplain of the Flood Plan planning area. <em>(Pierce County, cities/towns)</em></td>
</tr>
<tr>
<td>FPW #7</td>
<td><strong>Agricultural Land Uses and Activities</strong>&lt;br&gt;These recommendations address review of and amendments to Pierce County code to enable agricultural practices in floodplains, including removal of sediment deposited by floods, construction of flow-through non-residential agricultural structures, promoting the leasing of publicly held floodplain lands suitable for agriculture, and allowing composting when accessory to on-site agriculture. <em>(Pierce County, public)</em></td>
</tr>
<tr>
<td>FPW #8</td>
<td><strong>Floodplain Acquisition and Home Buyouts</strong>&lt;br&gt;These recommendations address identification and evaluation of floodplain properties for home buyouts or property acquisition; outreach with floodplain property owners; pursuit of federal and state grant funding, coordination with other agencies, and local funding for proactive floodplain acquisition. <em>(Pierce County, cities/towns, public)</em></td>
</tr>
<tr>
<td>FPW #9</td>
<td><strong>Home/Structure Elevation and Floodproofing</strong>&lt;br&gt;These recommendations address technical assistance provided to floodplain property owners; identification of areas needing targeted outreach; and pursuit of grant funding to support an elevation program. <em>(Pierce County, public)</em></td>
</tr>
</tbody>
</table>

**River Channel Management**

<table>
<thead>
<tr>
<th>FPW #10</th>
<th><strong>River Channel Monitoring</strong>&lt;br&gt;These recommendations address monitoring of river channel(^{21}) conditions including river stage and flow, cross-sections, conveyance capacity, sedimentation trends, topography (LiDAR), aerial photos during floods, and project-specific monitoring to evaluate project effectiveness. <em>(Pierce County, other agencies)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>FPW #11</td>
<td><strong>Management of Large Woody Material</strong>&lt;br&gt;These recommendations address the repositioning, relocation and removal of large woody material(^{22}) in Pierce County rivers posing imminent threat, LWM removal when threatening bridge piers and public infrastructure; working with resource agencies and tribes to identify rivers segments that function naturally; and obtaining approvals and coordinating with agencies in emergency and non-emergency situations. <em>(Pierce County, other agencies)</em></td>
</tr>
<tr>
<td>PR#1/ WR#1/ CR#1</td>
<td><strong>Sediment Management and Gravel Removal</strong>&lt;br&gt;These recommendations address the approach for sediment management and gravel removal, including use of technical data and studies; pursing levee setback projects as the preferred means to manage floodplain at the same elevation as the placed fill. In addition, the excavated area must be hydraulically connected to the floodway through its entire depth (that is, it must drain out).</td>
</tr>
</tbody>
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\(^{21}\) **Channel** – Natural or artificial waterway long enough to periodically or continuously contain moving water. It has a definite bed and banks that serve to confine water.

\(^{22}\) **Large woody material (LWM)** – Any piece of woody material, generally 12 inches or larger in diameter, that intrudes into a stream channel or nearby (e.g., logs, stumps or root wads) and that functions to form pools, regulate sediments, disperse stream energy, create channel complexity, stabilize channels, provide instream organic matter, and provide cover for fish.
### Table ES 2 – Programmatic Recommendations

<table>
<thead>
<tr>
<th>Facility Repair/Maintenance</th>
<th>FPW #12 Facility Repair &amp; Maintenance – PL 84-99 Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>These recommendations address Pierce County’s participation in the Corps of Engineers’ PL84-99 program for emergency response activities and rehabilitation of flood risk reduction facilities; engaging in review of levee maintenance standards; maintaining program eligibility while pursuing bio-engineering designs; notifying, coordinating with and seeking input from resource agencies and tribes in implementation. (Pierce County, Corps of Engineers, resource agencies, tribes)</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Facility Repair/Maintenance</th>
<th>FPW #13 Annual Repair and Maintenance Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>These recommendations address Pierce County’s repair and maintenance program for flood facilities, including routine repair and maintenance, evaluating options for long-term capital solutions, implementation of the Puyallup River vegetation management program, update of the County’s operations, repair and maintenance manual, and working with resource agencies and tribes to obtain programmatic approval of annual, repair and maintenance activities. (Pierce County, resource agencies, tribes)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Flood Hazard Education and Flood Preparedness, Flood Warning and Emergency Response</th>
<th>FPW #14 Flood Education and Outreach Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>These recommendations address consistency of education and outreach activities with the CRS program; outreach to floodplain property owners through the annual flood bulletin; promotion of all aspects of the County’s flood hazard management program; promotion of flood preparedness and purchase of flood insurance; internal and external coordination and collaboration. (Pierce County, cities/towns, public)</td>
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<table>
<thead>
<tr>
<th>Flood Hazard Education and Flood Preparedness, Flood Warning and Emergency Response</th>
<th>FPW #15 Flood Warning and Evacuation System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>These recommendations address regional coordination and communication before and during flood events with the National Weather Service, Pierce County’s River Watch program, Tacoma Public Utilities and Corps of Engineers (dam operators); and developing technical tools and mapping to improve river flooding forecasts to help guide evacuation decisions. (Pierce County, cities/towns, other agencies, public)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Flood Hazard Education and Flood Preparedness, Flood Warning and Emergency Response</th>
<th>FPW #16 Emergency Response and Flood Fighting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>These recommendations address regional coordination of response and recovery services during and after flood events through the Emergency Operations Center; coordination with cities, towns, tribes, state and federal agencies; documenting all costs associated with response activities; sand bagging support; flood emergency exercises; and periodic updating of guidance and protocols. (Pierce County, local jurisdictions, other agencies, public)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous/Other</th>
<th>FPW #17 Incidental Take Authorization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>These recommendations address Pierce County SWM seeking incidental take authorization for its activities that affect species listed as threatened or endangered under the federal Endangered Species Act (ESA). (Pierce County, other agencies)</td>
</tr>
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<table>
<thead>
<tr>
<th>Miscellaneous/Other</th>
<th>FPW #18 Adaptive Management</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>These recommendations address the use of adaptive management(^{23}) as a component of plan implementation, including evaluation and assessment of project and program performance, cost, and</td>
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\(^{23}\) Adaptive Management - A systematic approach for continually improving management policies and practices by learning from the outcomes of operational programs.
<table>
<thead>
<tr>
<th>FPW #19</th>
<th>Climate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>These recommendations address development of an approach to incorporate information about climate change, including predicted changes in precipitation patterns, future peak flows, and sediment transport into future project designs and program implementation; and working with regional experts. (Pierce County, other agencies)</td>
<td></td>
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<table>
<thead>
<tr>
<th>FPW #20</th>
<th>Habitat and Riparian Areas Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>These recommendations address the restoration of fish habitat and riparian areas as part of advance mitigation for flood management projects, for circumstances where mitigation cannot be accomplished onsite; working with resource agencies and tribes to identify sites for mitigation; and allocating funds to a mitigation account to acquire property and construct advance mitigation projects. (Pierce County, cities/towns, other agencies)</td>
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<table>
<thead>
<tr>
<th>FPW #21</th>
<th>Public Access to Rivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>These recommendations address public access to rivers, including passive use, shoreline access points, and multi-purpose trails; identifying opportunities for improved public access; recommending appropriate levels of future public access; and educating the public regarding restrictions on public access. (Pierce County, cities/towns, public)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>FPW #22</th>
<th>Minimizing Water Quality Impacts of Flooding</th>
</tr>
</thead>
<tbody>
<tr>
<td>These recommendations address the management of pollutant sources in floodplains subject to flooding, and potential water contamination, including storage of hazardous chemicals, wastes, pesticides, and fertilizers; leveraging of existing resources focused on stormwater and source control; and limitations, inspections, operations and maintenance for on-site sewage systems within 100-year floodplains. (Pierce County and cities/towns)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>FPW #23</th>
<th>Coordination with Other Jurisdictions, Tribes and Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>These recommendations address coordination with other jurisdictions in flood plan implementation, including cities/towns, counties, tribes, state and federal agencies; and coordinating with local governments adjacent to and across the river from proposed capital projects. (Pierce County, cities/towns, tribes, other counties)</td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>PR#2/WR#2</th>
<th>Inter-County River Improvement Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>These recommendations address collaborating with King County to renew the Inter-County River Improvement Agreement to address necessary maintenance and capital project needs, responsibilities and funding for the Lower White and lower Puyallup Rivers (the original agreement is due to expire in 2013). (Pierce and King counties)</td>
<td></td>
</tr>
</tbody>
</table>

### Capital Projects

<table>
<thead>
<tr>
<th>FPW #24</th>
<th>River Reach Management Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation proposes four management strategies (levels of protection) for levees, two management strategies for revetments, and two non-structural strategies to address flood and channel migration risk reduction goals for different river reaches in the planning area; and encourages promotion of agriculture, recreation and open space as the most compatible land uses in the floodplain. (Pierce County and cities/towns)</td>
<td></td>
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<table>
<thead>
<tr>
<th>FPW #25</th>
<th>Levee and Revetment Setback Program</th>
</tr>
</thead>
</table>
| These recommendations address updating the levee and revetment inventory map; updating the Setback
Table ES 2 – Programmatic Recommendations

<table>
<thead>
<tr>
<th>FPW #26</th>
<th>Additional Capital Project Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>This recommendation addresses the need to complete further analysis and develop solutions for Tier 2 problem areas for flooding and channel migration that could not be addressed in the Flood Plan due to resource and time constraints. <em>(Pierce County)</em></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FPW #27</th>
<th>Transportation – Roads and Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>These recommendations address the need to examine transportation infrastructure design issues, including road designs accounting for compensatory storage, zero-rise, and elevation above BFE requirements; bridge designs considering scour(^{25}), freeboard above BFE, assessment of future peak discharge flows and backwater effects, and passage of large woody material; conducting a cost benefit analysis for roads and bridges with high associated flood and erosion protection costs; and designing future roads and bridges (and replacements) to accommodate planned levee and revetment setback projects. <em>(Pierce County, cities/towns, WSDOT)</em></td>
<td></td>
</tr>
</tbody>
</table>

The costs of implementing the programmatic recommendations vary due to the number of full-time equivalents to implement a program element, lump sum costs, and whether costs are annual, one-time, or for example, once every five years or during/following a flood event. Table ES.3 summarizes the programmatic costs (see also Appendix J).

Table ES 3 – Estimated Programmatic Costs

<table>
<thead>
<tr>
<th>Type of Programmatic Action</th>
<th>Staff (FTE(^a)/year)</th>
<th>Annual cost (based on FTE/year)</th>
<th>Annual Lump Sum (LS)</th>
<th>One-time LS or FTE</th>
<th>LS every 5 years</th>
<th>Total (annual; one-time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information/Mapping/Technical Assistance</td>
<td>1.2</td>
<td>$144,000</td>
<td>$0</td>
<td>$960,000</td>
<td>$0</td>
<td>Annual: $144,000 One-time: $960,000</td>
</tr>
<tr>
<td>Land Use/Regulatory/Acquisition/Elevation</td>
<td>0.7</td>
<td>$84,000</td>
<td>$0</td>
<td>$27,000</td>
<td>$0</td>
<td>Annual: $84,000 One-time: $27,000</td>
</tr>
<tr>
<td>River Channel Management</td>
<td>0.2(^b)</td>
<td>$24,000</td>
<td>$63,000</td>
<td>$350,000 - $470,000</td>
<td>$265,000 - $315,000</td>
<td>Annual: $87,000 One-time: $350,000 - $470,000 Every five years: $265,000 - $315,000</td>
</tr>
<tr>
<td>River Management Facility Repair and Maintenance</td>
<td>2.2</td>
<td>$264,000</td>
<td>$1,455,000 - $2,505,000</td>
<td>$252,400</td>
<td>$0</td>
<td>Annual: $1,719,000 - $2,769,000 One-time: $252,400</td>
</tr>
<tr>
<td>Education, Flood Preparedness, Flood</td>
<td>0.95</td>
<td>$114,000</td>
<td>$35,000</td>
<td>$105,000 - $115,000</td>
<td>$30,000</td>
<td>Annual: $149,000</td>
</tr>
</tbody>
</table>

\(^{24}\) **Setback Levee** – A levee that is set away from the river in a manner to allow the river channel to migrate in the areas between levees. Setback levees in Pierce County include the Soldiers Home and Ford Levees on the Puyallup River.

\(^{25}\) **Scour** – Process by which floodwaters remove soil around objects that obstruct flow, such as a levee, the channel or a stream.
Table ES 3 – Estimated Programmatic Costs

<table>
<thead>
<tr>
<th>Type of Programmatic Action</th>
<th>Staff (FTE/year)</th>
<th>Annual cost (based on FTE/year)</th>
<th>Annual Lump Sum (LS)</th>
<th>One-time LS or FTE</th>
<th>LS every 5 years</th>
<th>Total (annual; one-time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning and Emergency Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination, Adaptive Management, and Multiple Benefits</td>
<td>0.6</td>
<td>$72,000</td>
<td>$100,000</td>
<td>$325,000 - $545,000</td>
<td>$0</td>
<td>Annual: $172,000 One-time: $325,000 - $545,000</td>
</tr>
<tr>
<td>Capital Project Planning</td>
<td>0.0</td>
<td>$0</td>
<td>$0</td>
<td>$185,000 - $275,000</td>
<td>$40,000 - $60,000</td>
<td>One-time: $185,000 - $285,000 Every five years: $40,000 - $60,000</td>
</tr>
<tr>
<td>Total</td>
<td>5.85</td>
<td>$702,000</td>
<td>$1,653,000 - $2,703,000</td>
<td>$2,184,400 - $2,504,400</td>
<td>$335,000 - $405,000</td>
<td>Annual: $2,355,000 - $3,405,000 One-time: $2,204,400 - $2,574,400 Every five years: $335,000 - $405,000</td>
</tr>
</tbody>
</table>

a FTE= Full Time Equivalent
b Other costs included as part of capital projects

ES.5.3 Capital Projects

The capital improvement projects recommended within the Flood Plan address flooding and channel migration problems which have been identified for each river reach in Chapter 5. Each section of Chapter 5 provides a list of problems identified for the river reach and a description of recommended capital project solutions. The project descriptions provide a general overview of each project. Projects were selected after the completion of an initial feasibility analysis, permitting considerations, assessment of benefits, and project cost estimates. The cost estimates are for capital expenditures only and are preliminary, based on 2011 costs at planning design level (approximately 15 percent design level) and the information available at the time. For many of the projects multiple options were considered, however alternatives also had to be compared and filtered to be consistent with the policies and programmatic recommendations in the plan. Of the remaining alternatives only those which provided the most benefit for the least project cost were recommended for inclusion in the Plan. Initial project analysis for each project was completed by multi-disciplinary teams of Pierce County staff. The estimates and descriptions provided are a starting point for further project development as the Flood Plan is implemented. Additional design and engineering will be required for each project as they are developed and will be included within the Capital

---

26 Capital Improvement Project. - A capital improvement project is a constructed project facility such as a road improvement, flood or stormwater control facility that is generally of a durable nature. Capital improvement projects may be considered assets rather than as expenses for accounting purposes.
Improvement Element of the Pierce County Comprehensive Plan. The total estimated cost of the 32 capital projects is between $350.8 and $396.4 million (Table ES.4).

Preliminary prioritization of capital projects was carried out by scoring the projects based on eight criteria, as follows:

1. Existing land use of affected area (consequences)
2. Severity of potential flood or channel migration impact
3. Spatial area of impact (consequences and severity)
4. Frequency of flood or channel migration occurrence
5. Project effectiveness
6. Benefit-cost analysis\(^{27}\) of project
7. Multiple project benefits
8. Partnerships and opportunity

Scoring was based on a 10-point scale for all criteria except existing land use of the affected area, which was a 20-point maximum, based on the two predominant land uses (see Appendix B). The maximum score was 90 points and the range of total scores was 33 to 66 (see Table ES 4).

### Table ES 4 – Proposed Capital Improvement Projects

<table>
<thead>
<tr>
<th>CIP#</th>
<th>Project Name/Location</th>
<th>Preferred Solution(s)</th>
<th>Score</th>
<th>Estimated Cost (2011 $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP1</td>
<td>Tacoma Wastewater Treatment Plant Flood Wall Left bank(^{28}) (RM 2.9-3.1)</td>
<td>Construct flood wall and storm drain backwater retrofit</td>
<td>65</td>
<td>$5,200,000</td>
</tr>
<tr>
<td>LP2</td>
<td>Clear Creek Acquisition/Levee Left bank (RM 2.9 and backwater area)</td>
<td>Acquiring floodplain properties and construct a levee along Clear Creek</td>
<td>53</td>
<td>$36,000,000 - $55,000,000</td>
</tr>
<tr>
<td>LP3</td>
<td>Oxbow Lake Flooding/Sewer Lift Station Protection Right bank(^{29}) (RM 5.0 and backwater area)</td>
<td>Elevate sewer lift station</td>
<td>51</td>
<td>$410,000</td>
</tr>
<tr>
<td>LP4</td>
<td>North Levee Road Setback Levee Right bank (RM 2.8-8.15)</td>
<td>Construct setback levee landward of N. Levee Road</td>
<td>61</td>
<td>$104,000,000</td>
</tr>
</tbody>
</table>

\(^{27}\) Benefit-Cost Analysis (BCA) – A quantitative procedure that assesses the desirability of a hazard mitigation measure by taking the long-term view of avoided future damages as compared to the cost of a project. The outcome of the analysis is a benefit-cost ratio, which demonstrates whether the net present value of benefits exceeds the net present value of cost.

\(^{28}\) **Left Bank** - The land area to the left, adjacent to the river channel, looking downstream.

\(^{29}\) **Right Bank** - The land area to the right, adjacent to the river channel, looking downstream.
## Table ES 4 – Proposed Capital Improvement Projects

<table>
<thead>
<tr>
<th>CIP#</th>
<th>Project Name/Location</th>
<th>Preferred Solution(s)</th>
<th>Score</th>
<th>Estimated Cost (2011 $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP5</td>
<td>Puyallup Wastewater Treatment Plant Flood Wall</td>
<td>Construct flood wall</td>
<td>60</td>
<td>$2,500,000-$3,500,000</td>
</tr>
<tr>
<td>LP6</td>
<td>Tiffany’s Skate Inn/Riverwalk Flood Wall</td>
<td>Construct flood wall, and close road at underpass during flood events</td>
<td>44</td>
<td>$4,500,000</td>
</tr>
<tr>
<td>LP7</td>
<td>Puyallup Executive Park</td>
<td>Construct flood wall and establish evacuation plan</td>
<td>48</td>
<td>$160,000</td>
</tr>
<tr>
<td>LP8</td>
<td>Linden Golf Course Oxbow Setback Levee</td>
<td>Construct setback levee, side channel habitat. Phase II would remove 14 acre landfill</td>
<td>TBD</td>
<td>$43,000,000</td>
</tr>
<tr>
<td></td>
<td>Middle Puyallup River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP1</td>
<td>Rainier Manor/Riverwalk/Rivergrove and SR-410 Flood Wall and Levee</td>
<td>Construct a flood wall</td>
<td>55</td>
<td>$11,000,000</td>
</tr>
<tr>
<td>MP2</td>
<td>McCutcheon Road &amp; 96th Street E. Road Barricade</td>
<td>Close road with immovable barricade during flood events and conduct post-flood repair</td>
<td>50</td>
<td>$50,000</td>
</tr>
<tr>
<td>MP3</td>
<td>116th Street E. Point Bar Gravel Removal</td>
<td>Remove 13,700 CY gravel</td>
<td>33</td>
<td>$220,000</td>
</tr>
<tr>
<td>MP4</td>
<td>McCutcheon Road &amp; 128th Street E. Levee Setback</td>
<td>Construct setback levees on both left and right banks.</td>
<td>50</td>
<td>$12,500,000</td>
</tr>
<tr>
<td></td>
<td>Upper Puyallup River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UP1</td>
<td>Calistoga Setback Levee</td>
<td>Construct setback levee and reconnect 46 acres of floodplain</td>
<td>66</td>
<td>$8,000,000-$12,000,000</td>
</tr>
<tr>
<td>UP2</td>
<td>Ford Levee Setback Reach Gravel Removal</td>
<td>Remove 36,000 CY gravel and construct up to 12 engineered log jams</td>
<td>35</td>
<td>$900,000</td>
</tr>
<tr>
<td>UP3</td>
<td>Neadham Road Flooding/Channel Migration Protection</td>
<td>Construct levee and engineered log jams (phase 1); acquire floodplain properties and abandon roadway (phase 2)</td>
<td>49</td>
<td>$8,100,000</td>
</tr>
<tr>
<td>UP4</td>
<td>Orville Road Revetment at Kapowsin Creek</td>
<td>Property acquisition and demolition, removal of remnant levee and construction of engineered log jam/dolotimber revetment</td>
<td>50</td>
<td>$1,500,000</td>
</tr>
<tr>
<td>UP5</td>
<td>Orville Road Channel Migration Protection</td>
<td>Construct revetment and install engineered log jams; secondary option (and possible long-term solution) is relocation of Orville Road</td>
<td>49</td>
<td>$17,300,000-$38,000,000</td>
</tr>
<tr>
<td>UP6</td>
<td>Puyallup River/Orville Road Revetment and Riparian Habitat Restoration</td>
<td>Acquire floodplain properties, construct setback revetment along Orville Road, and install engineered log jams</td>
<td>50</td>
<td>$3,700,000</td>
</tr>
</tbody>
</table>
### Table ES 4 – Proposed Capital Improvement Projects

<table>
<thead>
<tr>
<th>CIP#</th>
<th>Project Name/Location</th>
<th>Preferred Solution(s)</th>
<th>Score</th>
<th>Estimated Cost (2011 $)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lower White River</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LW1</td>
<td>State Street Flood Wall or Emergency Access Left bank (RM 0.2-0.3)</td>
<td><em>Multiple Solutions:</em> Construct flood wall or acquire a nearby property and provide emergency access off SR-410 Traffic Ave. exit</td>
<td>53</td>
<td>Up to $2,000,000</td>
</tr>
<tr>
<td>LW2</td>
<td>Lower White River Flood Protection Right and/or left bank (RM 1.8-4.9)</td>
<td><em>Multiple Solutions:</em> Acquire floodplain properties, construct new levees, construct setback levees, and/or construct setback revetments (<em>Project to be completed in multiple phases</em>)</td>
<td>TBD</td>
<td>$28,627,000</td>
</tr>
<tr>
<td>LW3</td>
<td>Butte Avenue Levee/Berm Right bank (RM 4.9-5.5)</td>
<td>Construct a berm and levee</td>
<td>45</td>
<td>$1,700,000</td>
</tr>
<tr>
<td><strong>Upper White River</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Greenwater River</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Carbon River</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Carbon Confluence Setback Levee Left bank (RM 0-0.4)</td>
<td>Construct setback levee</td>
<td>45</td>
<td>$5,300,000</td>
</tr>
<tr>
<td>C2</td>
<td>Carbon Levee Bank Stabilization/Flow Deflection and Coplar Creek Backwater Improvements Left bank (RM 3.2-4.9)</td>
<td><em>Multiple Solutions:</em> Construct engineered log jams and box culvert for Coplar Creek</td>
<td>48</td>
<td>$2,700,000</td>
</tr>
<tr>
<td>C3</td>
<td>Alward Road Floodplain Acquisition Left bank (RM 6.0-6.4)</td>
<td>Acquire flood-prone properties</td>
<td>47</td>
<td>$1,200,000</td>
</tr>
<tr>
<td>C4</td>
<td>Alward Road Floodplain Acquisition and Setback Levee Left bank (RM 6.4-8.3)</td>
<td>Acquire floodplain properties and construct setback levee</td>
<td>56</td>
<td>$29,600,000</td>
</tr>
<tr>
<td>C5</td>
<td>Upper Carbon/Fairfax Road Bank Stabilization Left bank (RM 22.4-24.0)</td>
<td>Construct engineered log jams</td>
<td>48</td>
<td>$1,500,000</td>
</tr>
<tr>
<td><strong>South Prairie Creek</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP1</td>
<td>South Prairie Floodplain Acquisition Right bank (RM 1.6-3.5)</td>
<td>Acquire floodplain properties</td>
<td>53</td>
<td>$570,000</td>
</tr>
<tr>
<td>SP2</td>
<td>South Prairie Fire Station Flood Protection Left bank (RM 6.0)</td>
<td>Extend existing flood berm and install backflow prevention valve</td>
<td>50</td>
<td>$27,000</td>
</tr>
<tr>
<td><strong>Middle Nisqually River</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MN1</td>
<td>McKenna Area Floodplain Acquisition Right bank (RM 21.6-22.0)</td>
<td>Elevate existing residential structures and acquire flood prone properties</td>
<td>45</td>
<td>$10,900,000</td>
</tr>
<tr>
<td><strong>Upper Nisqually River</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UN1</td>
<td>Nisqually Park Levee Protection Right bank (RM 64.3-64.9)</td>
<td>Construct engineered log jam structures adjacent to existing levee</td>
<td>50</td>
<td>$2,000,000-$4,000,000</td>
</tr>
<tr>
<td>UN2</td>
<td>Upper Nisqually/Mt. Rainier National</td>
<td>Construct engineered log jam</td>
<td>61</td>
<td>$2,500,000-</td>
</tr>
</tbody>
</table>
Table ES 4 – Proposed Capital Improvement Projects

<table>
<thead>
<tr>
<th>CIP#</th>
<th>Project Name/Location</th>
<th>Preferred Solution(s)</th>
<th>Score</th>
<th>Estimated Cost (2011 $)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Park Revetment Retrofit/ELJs Right bank (RM 64.9-65.3)</td>
<td>structures adjacent to existing levee/revetment</td>
<td></td>
<td>$3,500,000</td>
</tr>
<tr>
<td></td>
<td>Mashel River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>SR-161 Mashel River Bridge Scour and Slope Repair Left bank (RM 5.2-5.3) and right bank (RM 5.5)</td>
<td>Construct bank roughening log structures</td>
<td>52</td>
<td>$2,000,000-$2,500,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Project Costs</td>
<td></td>
<td></td>
<td>$350,864,400-$396,364,000</td>
</tr>
</tbody>
</table>

ES.6 PLAN IMPLEMENTATION AND FUNDING

Pierce County faces significant challenges in the years ahead. The aging system of flood risk reduction facilities, many of which were built in the 1960s or earlier, were built to a lower level of protection than what is now required to protect transportation, commercial, and residential structures. Many of these systems were designed to protect a less populated unincorporated area which has now incorporated into heavily populated cities and towns. Failure of these facilities could have significant and adverse impacts on public safety, public infrastructure, and private property along the rivers. In some areas, the dynamic nature of rivers, increases in sediment transport, channel migration, and more frequent and intense high flows are resulting in rising river beds, reduced river channel conveyance capacity, and increased flood risks.

Insufficient funds exist for proposed levee or revetment setbacks to increase flood conveyance capacity and reduce downstream sediment transport, or for flood walls to protect critical facilities such as wastewater treatment plants. In addition, the environmental requirements resulting from the Endangered Species Act, Clean Water Act, and other legislation has significantly increased the difficulty and cost of maintaining flood risk reduction infrastructure.

ES.6.1 Plan Implementation

This Flood Plan and its proposed policies, projects, and programs are based on a premise that major-river flooding in Pierce County has regional impacts as well as localized impacts. Long term solutions require regional collaboration, partnerships, and funding. A regionally-focused approach to implementation offers the best opportunity for success in addressing flooding and channel migration risks.

Pierce County, in its regional role of providing services to reduce river flooding and channel migration risks, will provide leadership and build upon its long history of coordinating and partnering with local jurisdictions, tribes, state and federal agencies, and the public to reduce flood risks. Plan implementation will result in multiple public benefits, including reduction in

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30 Conveyance Capacity – A term generally referring to the maximum capability of the physical drainage system to safely transport water.
flooding and channel migration risks, the protection of roads and other critical infrastructure, that support regional safety and economic viability, enhancement of aquatic habitat, and open space protection within floodplains.

Plan implementation will be guided by ongoing flood risk assessments, economic analyses, and development of river reach management strategies that tailor capital projects and programs to meet the targeted levels of service identified for the river reaches within which problem areas are located. Structural (e.g., levees and revetments) and non-structural (e.g., acquisition and floodplain development regulations) solutions will be implemented to maximize benefits and reduce risks. Changing conditions with our rivers and improved understanding of project effectiveness for flood risk reduction facilities, sediment management, and overall floodplain management will identify future implementation actions. New data, mapping, studies, innovative project designs, and monitoring information will play an important role. Informed decision making will ensure that limited resources are directed to addressing the most significant risks in the rivers and floodplains of Pierce County.

The rate of project implementation depends on the level of funding and relative priorities, considering extent and severity of flooding conditions, project effectiveness, benefit-cost analysis, funding sources, and other considerations. The sequencing of project implementation will vary due to factors such as availability of funds, completion of other projects or activities on which a project relies, cooperation from private landowners, and new information or emerging issues.

**ES.6.2 Funding**

One of the four goals of the Flood Plan is to “develop a long-term and flexible funding strategy for river flood hazard management” (see Section 1.4). This Plan recommends that a new county-wide funding source be established to ensure equitable funding for ongoing implementation of the flood plan, as well as to support system-wide consistency and continuity of flood control\(^{31}\) maintenance, operations, and improvements.

Current sources of funding include the Pierce County Surface Water Management Fund, which is paid by residents within unincorporated Pierce County, and Real Estate Excise Tax (REET), which is a 0.25 percent tax on property rates throughout the county. Other sources of funds include designated federal and state funds that are limited and conditionally available in declared flood disasters and through grants. Over the past 20 years (1991-2011) the amount of local funds in total, together with some federal and state funds, expended by Pierce County SWM on river programs, maintenance and operations, capital projects and acquisitions has exceeded $155 million. This averages out to about $7.7 million year over the past 20 years for all maintenance and construction for flood protection on the Puyallup and Nisqually river systems.

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\(^{31}\) **Flood Control** – Physically controlling a river or stream by structural means such as dikes and levees, which separate people and property from damaging floodwater.
Pierce County’s current funding levels do not provide sufficient funding to address the existing needs for flood risk reduction facilities, including maintenance, repair, and capital needs. Existing dedicated funding sources must be enhanced in order for Pierce County to provide adequate flood and channel migration zone hazard services and implement preventive projects and programs to reverse the trends of declining levels of protection.

**ES.6.2.1 Potential New and Enhanced Local Funding**

RCW 86.15.025 gives the Pierce County Council the authority to establish either countywide or basin-level flood control zone districts (FCZD) that create additional opportunities for new, dedicated funding sources. A FCZD is a special purpose district (government agency) established to specifically address flooding issues. The purpose of the FCZD is to construct, operate, and maintain flood control projects to reduce flooding and channel migration risks. Funding for a FCZD can be initiated through a levy based on total assessed value of taxable property within the district’s designated boundaries or through the imposition of fees. A FCZD was created by Pierce County Council Ordinance 2011.95S on April 3, 2012.

RCW 86.12.010 gives the Pierce County Council the authority to establish a county tax for a river improvement fund (e.g., flood control maintenance account). Washington State law allows it to be assessed up to $0.25 per $1000 of assessed value. The River Improvement Fund levy is limited, because the levy competes with other mandatory and essential services that are also funded by levies, and together they cannot exceed statutory levy limits.

RCW 36.89 allows Pierce County the authority to assess surface water management service charges for managing surface water. Pierce County provides surface water management services in unincorporated Pierce County that are funded by an annual surface water management service charge assessed on residential and commercial properties. The SWM Utility service charge, which is paid by residents in unincorporated Pierce County, helps fund a variety of ongoing County projects and programs including flood management, levee repairs, preventing water pollution, salmon recovery, and drainage system construction and maintenance. The SWM service charge could be increased to specifically pay for additional flood management programs and capital projects.

Many cities and towns in the Puyallup and Nisqually watersheds also have storm water fees for residents within their jurisdictions. These city surface water management charges could also be increased to specifically pay for additional flood management programs and capital projects within their boundaries.

Local governments within Pierce County, including cities and towns could jointly fund implementation of the Flood Plan through development of an Interlocal Agreement (ILA), as authorized by RCW 39.34 (Interlocal Cooperation Act). The local jurisdictions would agree on the regional flood management services to be provided by Pierce County and the equitable

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*Channel Migration Zone (CMZ)* – The area within the lateral extent of likely stream channel movement due to stream bank destabilization and erosion, rapid stream incision, and shifts in location of stream channels. The CMZ is approximated by evidence of channel locations in the last 100 years, but is not be strictly bounded by that criterion alone. The area within which a river channel is likely to move over a period of time is referred to as the channel migration zone.
funding share. Individual ILAs would be developed between Pierce County and all participating jurisdictions.

The Washington State Legislature may be asked by stakeholders in Puget Sound to create the authority to establish a watershed investment district with taxing authority to support watershed investments to improve watershed health, including salmon habitat, flood protection, and water pollution control. This would allow independent districts to be formed on a watershed resource inventory area (WRIA) basis.

**ES.6.2.2 Future Funding**

Future funding of plan implementation is being determined in a separate process carried out by the Pierce County Council. The initiation of the Pierce County Flood Control Zone District is being evaluated with input from cities, special purpose districts and other stakeholders.
CHAPTER ONE
INTRODUCTION

Between 1991 and 2011, the total cost of the river management program and estimated damages to public and private infrastructure and property in Pierce County, resulting from flooding and channel migration, exceeded $155 million (Table 1.1). During this same time frame, the population, property values, advances in science and engineering, and our understanding of the importance of natural riverine process have grown significantly. Political and societal pressure is growing for the development of a plan which provides meaningful and long lasting solutions for river management and flood protection in Pierce County. The Pierce County Rivers Flood Hazard Management Plan (the “Flood Plan” or “Plan”) outlines how Pierce County will address and manage flooding and channel migration hazards on the major rivers, large tributaries, and associated floodplains for the next 20 years.

The Flood Plan replaces the 1991 Puyallup River Comprehensive Flood Control Management Plan and expands its scope to include the Nisqually, Greenwater, and Mashel rivers and South Prairie Creek. Like its predecessor, the Flood Plan was developed to meet the requirements of Washington Administrative Code (WAC 173-145) related to Comprehensive Flood Control Management Plans, Chapter 86-12 RCW (flood control by counties), and FEMA’s Community Rating System guidance for floodplain management planning under the National Flood Insurance Program.

<table>
<thead>
<tr>
<th>Type of Funding or Program</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEMA(^{b}) (Stafford Act) Emergency Assistance Funds to public entities for infrastructure and property damage</td>
<td>$38,877,189</td>
</tr>
<tr>
<td>FEMA (Stafford Act) Individual Assistance to private property owners</td>
<td>$7,217,257</td>
</tr>
<tr>
<td>NFIP(^{b}) Flood Insurance Claims</td>
<td>$6,752,264</td>
</tr>
<tr>
<td>U.S. Army Corps of Engineers Funding through PL 84-99 Program</td>
<td>$13,343,309</td>
</tr>
<tr>
<td>Acquisition and Buyout of properties and structures (including federal HMGP(^{b}), state, and local REET(^{a}) sources and SRFB funds)</td>
<td>$25,43,088</td>
</tr>
<tr>
<td>Pierce County SWM River Improvement Fund(^{c})</td>
<td>$28,133,773</td>
</tr>
<tr>
<td>Pierce County REET River Improvement Fund(^{c})</td>
<td>$35,337,748</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td>$155,091,628</td>
</tr>
</tbody>
</table>

\(^{a}\) This does not include state and federal infrastructure damages, unreimbursed private property damage, lost business output, agricultural damages, environmental damages, and unrepaired flood facility damages.

\(^{b}\) FEMA: Federal Emergency Management Agency; NFIP: National Flood Insurance Program; HMGP: Hazard Mitigation Grant Program; REET: Real
1.1 PURPOSE OF THE PLAN

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

Since the adoption of the 1991 Puyallup River Basin Comprehensive Flood Control Management Plan, the regulatory and environmental landscape has changed. The Clean Water Act and Endangered Species Act requirements now call for updated and creative approaches to river and floodplain management. Climate change is a growing concern. Trends are showing a change in flood frequency and magnitude and glacial melting is exposing more sediment to downstream transport that has the potential to increase flood risks in the near- and long-term future.

The Flood Plan was developed using the best available technical information, an inclusive stakeholder and public-involvement process, and a multi-disciplinary team of Pierce County staff and supporting consultants. It considered complex economic, social, and cultural conditions in the watershed; federal, state, and local regulations; and, existing legal agreements (e.g., Tribal, Corps of Engineers). The recommendations found within the Flood Plan have the support of Pierce County staff and the Flood Plan Advisory Committee.

1.2 GEOGRAPHIC SCOPE

The geographic scope of the Pierce County Rivers Flood Hazard Management Plan includes the floodplains of the two major river systems in Pierce County (Puyallup and Nisqually Rivers), their major tributaries, and streams with historical peak flows exceeding 5,000 cubic feet per second (cfs). 5,000 cfs is the threshold at which a channel migration zone for a river or stream may be established. Table 1.2 and Figure 1.1 outline the planning area covered by the Flood Plan:
### Table 1.2 Planning Area

**Puyallup River System (Lower, Middle and Upper)**

<table>
<thead>
<tr>
<th><strong>Puyallup River</strong></th>
<th>From Commencement Bay at RM 0 to Champion Bridge at RM 29</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lower Puyallup</strong></td>
<td>Commencement Bay at RM 0 to the confluence of the White River at RM 10.3</td>
</tr>
<tr>
<td><strong>Mid-Puyallup</strong></td>
<td>Confluence of the White River at RM 10.3 to the confluence of the Carbon River at RM 17.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>White River</strong></th>
<th>From its confluence with the Puyallup River at RM 0 to the King/Pierce County boundary at RM 5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper White</strong></td>
<td>Near the community of Greenwater from RM 44.4 to RM 50.5</td>
</tr>
<tr>
<td><strong>Greenwater River</strong></td>
<td>From its confluence with the White River at RM 0 to RM 4.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Upper Puyallup</strong></th>
<th>Confluence of the Carbon River at RM 17.4 to Champion Bridge at RM 29</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbon River</strong></td>
<td>From its confluence with the Puyallup River at RM 0 to RM 8.4 near the intersection of Alward Rd. and 245th Ave E</td>
</tr>
<tr>
<td><strong>South Prairie Creek</strong></td>
<td>From its confluence with Carbon River at RM 0 to RM 6.4 at the Town of South Prairie</td>
</tr>
</tbody>
</table>

**Nisqually River System (Middle and Upper)**

<table>
<thead>
<tr>
<th><strong>Nisqually River</strong></th>
<th>From the McKenna area to Mt. Rainier National Park</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Middle Nisqually</strong></td>
<td>McKenna area between RM 21.3 to RM 26</td>
</tr>
<tr>
<td><strong>Mashel River</strong></td>
<td>From the confluence with Nisqually River at RM 0 to the Town of Eatonville at RM 6.8</td>
</tr>
<tr>
<td><strong>Upper Nisqually</strong></td>
<td>From the community of Elbe at RM 50.5 to Mt. Rainier National Park at RM 65.8</td>
</tr>
</tbody>
</table>

Not included in the plan are rivers and streams that either:

- Lack flood risk reduction facilities operated and maintained by Pierce County;
- Are segments partly or wholly located within adjacent county jurisdictions; or
- Have little or no Pierce County maintained infrastructure or developed areas.

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33 Confluence – The location where two streams meet.
The Puyallup River and Nisqually River watersheds include forests, national parks, and wilderness areas in the upper watersheds; rural and agricultural uses in the mid to lower basin areas; and urban areas dispersed throughout the lower Puyallup watershed near the river mouth. To capture the full impact of the river systems, the Flood Plan also includes the areas adjacent to these rivers in the 100-year floodplain, which includes unincorporated Pierce County, as well as portions of the cities of Tacoma, Fife, Puyallup, Sumner, Orting, and Pacific, and the towns of South Prairie and Eatonville.
The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.
1.3 PLANNING PROCESS AND STAKEHOLDER INVOLVEMENT

Development of the *Pierce County Rivers Flood Hazard Management Plan* was led by the Pierce County Public Works and Utilities, Surface Water Management (SWM) Division. A Pierce County Project Team made up of representatives from SWM, Transportation Planning, Emergency Management, Planning and Land Services, Economic Development, Government Relations, and Parks and Recreation Services guided development of the Plan. An internal Steering Committee (composed of the SWM Management Team) reviewed all elements of the Flood Plan prior to broader external review.

Extensive stakeholder involvement was conducted throughout the planning process. During May to July 2009, interviews were held with external parties including cities, tribes, agencies, the Pierce County Sustainability Council, and Master Builders of Pierce County to seek input on issues and concerns related to flooding in Pierce County. In August 2009, notification was sent to all postal customers in Pierce County (including residential and business addresses) informing them about the planning process and inviting their input through a survey. Over 1300 responses to the survey were received.

In December 2009, a Flood Plan Advisory Committee (Advisory Committee) was convened to advise Pierce County on development of the Flood Plan and provide technical and other input on many of the Plan’s elements, including: goals and objectives; guiding principles; problem definitions; evaluation of alternatives; plan recommendations; capital projects; and, implementation. The Advisory Committee consisted of 26 members representing cities, counties, tribes, state and federal agencies, business, environmental and agricultural interests, floodplain residents and citizens outside of the planning area. Over 50 percent of the members of the committee live or work in the floodplains covered by this Plan. (See Appendix C for a list of Advisory Committee members and their affiliations). The Advisory Committee met 18 times between December 2009 and June 2011.

The scope of work for the Flood Plan was developed by the Pierce County Project Team and presented to the Advisory Committee at the second committee meeting in January 2010. The Advisory Committee agreed upon goals and objectives (Chapter 1.4), guiding principles (Chapter 1.5) and policies (Chapter 3) that laid the foundation for development of the plan. The Advisory Committee agreed upon programmatic recommendations (Chapter 4), and commented on capital projects (Chapter 5) and plan implementation and funding (Chapter 6).

A series of public open houses and meetings were held at three distinct phases of the project. Open houses were held in March and November 2010 and June 2011 at three to four locations around the County to seek: (1) input on issues, concerns, and problem identification, (2) perspectives on management strategies, plan alternatives, and options, and (3) comments on draft plan recommendations. An Elected Officials Workshop was held in September 2010 to inform elected officials about the plan and seek input on management strategies, levels of protection, and floodplain development regulations. Figure 1.2 depicts the flood planning process, including the project team, steering committee, Flood Plan Advisory Committee, public review process, as well as the review and adoption process.
1.4 GOALS AND OBJECTIVES

Goals describe broad outcomes that the Flood Plan should achieve as agreed upon by the Flood Plan Advisory Committee. The Goals provide direction and focus towards the end results. The Plan Objectives are more specific statements of action that the Committee agreed would move the Plan towards attainment of the Plan’s Goals.

The Goals of the Flood Plan are:

1. Reduce risks to life and property from river flooding and channel migration;
2. Identify and implement flood hazard management activities in a cost-effective and environmentally-sensitive manner;
3. Support compatible human uses, economic activities, and improve habitat conditions in flood-prone and channel migration areas; and
4. Develop a long-term and flexible funding strategy for river flood hazard management.

The Objectives of the Flood Plan (in no particular order) are:
CHAPTER 1: INTRODUCTION

1. Evaluate the risks to public safety and existing development (e.g., critical facilities, infrastructure, and structures) in flood-prone and channel migration hazard areas;

2. Examine alternatives to reduce risk to life and property, while reducing economic and environmental impacts of flood hazard management actions and programs;

3. Regulate new development in flood-prone and channel migration hazard areas to minimize risks to life, property, and habitat, and strive for consistency of regulations among affected local governments;

4. Identify current and establish future “Levels of Service” for existing and new flood risk reduction facilities;

5. Maintain, repair and modify necessary existing flood risk reduction facilities in a cost-effective manner that makes the facilities less susceptible to future damage, reduces impacts on aquatic and riparian habitat, and ensures consistency with public law (PL) 84-99, or similar federal, tribal and state laws and programs;

6. Identify repetitive-loss properties and properties needed for future flood risk reduction facilities;

7. Prioritize projects and programs based on the level of risk, benefit, cost-effectiveness over the life of the plan or facility, and adverse effects on habitat;

8. Provide for the participation of stakeholders in the assessment of acceptable risks, evaluation and ranking of alternatives, natural resource management issues and development of recommendations;

9. Coordinate among Pierce County departments, other agencies and governments (cities, tribes, adjacent counties) to seek consistency in flood hazard management and flood disaster response and recovery;

10. Implement a County-wide public education and outreach program to improve flood awareness that includes actions people can take to reduce risks (e.g., flood insurance, flood proofing);

11. Identify possible funding sources for implementing the recommended flood hazard management activities;

12. Examine the connections between flood hazard management, river corridors, salmon recovery, aquatic and riparian habitat, water quality, open space, public access and agricultural resources to take advantage of efficiencies in addressing multiple objectives;

13. Remove or modify existing flood risk reduction facilities to protect, restore, or enhance critical riparian or instream habitat that benefits threatened or endangered species;

14. Identify important riparian, aquatic, fish and wildlife habitat;

15. Protect and enhance natural systems that prevent flooding;
Adaptively manage implementation to learn from successes, develop long-term cost-effective approaches and reduce the need for costly solutions;

Incorporate a science-based approach in developing and evaluating alternatives and to monitor implementation;

Increase our understanding and incorporate information about climate change (including potential increases in rainfall, glacial retreat and changes in sediment transport) into flood hazard management decision-making; and

Cooperate with regional agencies in maintaining a network of accurate stream flow and weather gauges, and water quality data.

1.5 GUIDING PRINCIPLES

Guiding principles are the facts, scientific foundation, and broad philosophy agreed upon by the Flood Plan Advisory Committee that guided development of plan recommendations and capital projects. These principles serve as a frame of reference for evaluating flood risks, identifying the range of management alternatives, and developing recommendations. Together, the goals and objectives, and guiding principles also provided a basis for the development of the flood plan policies presented in Chapter 3.

1. River flooding and channel migration are natural processes that continually form and alter river valleys and the floodplain landscape. Rivers transport water, sediment, and woody material that may threaten public safety and infrastructure in flood prone areas. Biological productivity and diversity are sustained by natural riverine processes, such as flooding, that create and alter aquatic habitats that sustain fish and wildlife species.

2. Actions in the upland and upstream portions of watersheds impact flooding, channel migration, and water quality within the river corridor. Sources of sediment and pollution from human activities like logging and urbanization also impact water quality and habitat.

3. Flood damage creates financial costs, both public and private. Effective flood hazard management can reduce long-term damage costs. Public infrastructure, such as roads, utilities, levees, revetments and dams, and private improvements such as homes, businesses and structures located in the floodplain, are vulnerable to flood damage. As the budgets of federal, state, and local governments tighten, the amount of funding available for flood hazard management is reduced.

4. A river and its valley floor, including adjacent floodplains, floodways, and potential channel migration areas, constitute a corridor through which floodwaters flow and within which opportunities exist for various and compatible land uses, including agriculture, recreation and open space. Floodplains are subject to inundation during flooding events, varying in magnitude from the 2-year to 100-year event or larger, depending on the river system and floodplain conditions.
(5) **Future development within Pierce County, including cities and unincorporated areas if guided away from flood-prone areas, can reduce future risks to life and property.** Adverse impacts of development both inside and outside the floodplain can be minimized by development practices that reduce future risks through appropriate regulation and land use, open land preservation and acquisition, multi-objective planning, relocation or elimination of high hazard structures, prohibiting unacceptable encroachments, and establishing ongoing maintenance practices that preserve and enhance environmental functions.

(6) **Beneficial functions of floodplains and rivers can be achieved by restoring, preserving, and enhancing natural processes** – even if these flood-prone and environmentally sensitive areas are not subject to development in the future, past degradation of them needs to be remedied through restoration and enhancement actions.

(7) **The levels of funding for floodplain management should meet demand** within Pierce County (both incorporated and unincorporated areas) to ensure that necessary infrastructure maintenance and improvements meet citizen’s expectations and willingness to pay.

(8) **Protecting and working with, rather than trying to control, natural riverine processes** generally will reduce flood risks to people and property in a less costly manner than traditional structural approaches to flood hazard management, while also benefiting native fish and wildlife and preserving aesthetic landscapes.

(9) **Communication with and involvement of a diverse groups of citizens and stakeholders and public and private landowners is vital** in developing a responsible, effective flood hazard management plan.

(10) **Assume personal and public responsibility** – we need to revive our ethic of land and water stewardship. The County needs a framework that will foster localized responsibility for flood risk, water-related resources, and wise use of flood-prone lands. Private property rights should be respected when providing flood protection.

(11) **Leadership and cooperation among affected governments and public agencies (counties, cities, tribes, and resource agencies) is essential** for the success of long-term flood hazard management.

(12) **Advances in technical information and an evolving understanding of flood risks call for an adaptive management approach to implementing the flood hazard management plan.** Our knowledge and levels of understanding of risk will change over time – e.g., changing flood maps, new data, etc. We need to learn from approaches and actions that are most effective in achieving the goals and objectives, and then adjust management actions to reflect the latest information.

(13) **Education regarding riverine processes, flooding and preparedness can raise public awareness and reduce future flood damages and costs.**
1.6 PLANNING AUTHORITY AND FRAMEWORK

Pierce County is authorized by Chapter 86.12 Revised Code of Washington (RCW) to adopt a comprehensive flood hazard management plan for a river basin. The code specifies that the County shall develop the flood plan with the full participation of officials from the cities, towns, or special districts in the planning area, and appropriate state and federal agencies. The flood plan was developed using the 10-step planning process outlined in the Community Rating System (CRS) of FEMA’s National Flood Insurance Program (NFIP) (FEMA 2006) allowing the County the ability to seek coverage under section 510 of the CRS guidance. A more complete description of the NFIP and CRS programs can be found in Chapter 2 and Appendix D.

The flood plan also includes the six elements of the Comprehensive Flood Management Plan specified in Chapter 173-145 WAC to maintain eligibility for Flood Control Account Assistance Program funding, and Chapter 86.26 RCW (State Participation in Flood Control Maintenance). Table 1.3 summarizes some of the regulatory requirements affecting plan development. A more detailed summary of the federal state and local regulations, laws, policies, and programs which influence the Flood Plan may be found in Appendix D.

<table>
<thead>
<tr>
<th>Table 1.3 – Regulatory Requirements Affecting Flood Plan Development</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RCW 86.12 Flood Control by Counties</strong></td>
</tr>
<tr>
<td>1) Designate areas susceptible to periodic flooding (e.g., channel migration zone, floodway)</td>
</tr>
<tr>
<td>2) Establish comprehensive approach to flood control protection/improvements</td>
</tr>
<tr>
<td>a) determine the need for flood control improvements to protect structures and infrastructure</td>
</tr>
<tr>
<td>b) establish the level of flood protection</td>
</tr>
<tr>
<td>c) identify alternatives to in-stream flood control work</td>
</tr>
<tr>
<td>d) identify areas where flood waters could be directed during a flood</td>
</tr>
<tr>
<td>e) identify sources of revenue sufficient to finance flood control protection and improvements</td>
</tr>
<tr>
<td>3) Establish land use regulations that preclude location of structures and improvements in critical portions of areas subject to periodic flooding</td>
</tr>
<tr>
<td>4) Establish restrictions on construction activities in areas subject to periodic flooding</td>
</tr>
<tr>
<td>5) Establish restrictions on land clearing activities and development practices that exacerbate flooding</td>
</tr>
<tr>
<td><strong>WAC 173-145 Flood Control Assistance Account Program Administration</strong></td>
</tr>
<tr>
<td>1) Determine the need for flood control work, including:</td>
</tr>
<tr>
<td>a) watershed description</td>
</tr>
<tr>
<td>b) types of flood problems</td>
</tr>
<tr>
<td>c) specific problem areas</td>
</tr>
<tr>
<td>d) flood damage history</td>
</tr>
<tr>
<td>e) potential flood damages</td>
</tr>
<tr>
<td>f) goals and objectives</td>
</tr>
</tbody>
</table>
CHAPTER 1: INTRODUCTION

PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

Table 1.3 – Regulatory Requirements Affecting Flood Plan Development

- g) applicable regulations – shoreline management, zoning and flood hazard ordinances
- 2) Alternative flood control work, including potential measures of instream flood control work and alternatives
- 3) Identification and consideration of impacts of instream flood control work on following resources:
  - a) fish resources
  - b) wildlife resources
  - c) scenic/aesthetic resources
  - d) navigation
  - e) water quality
  - f) hydrology
  - g) recreation
- 4) Area of coverage of the comprehensive plan shall include the area of 100-year floodplain
- 5) Conclusion and proposed solutions:
  - a) evaluation of problems and needs
  - b) evaluation of alternative solutions
  - c) recommended actions with proposed measures for resource losses
  - d) action priorities
- 6) Certification by Washington State Community Trade & Economic Development (WSCTED) regarding emergency management and operations

Community Rating System (10 Planning Steps)

- 1) Organize to prepare plan – establish committee
- 2) Involve the public – public comments on plan during drafting and before approval
- 3) Coordination with other agencies
- 4) Assess the hazards (e.g., flood hazards, repetitive loss areas)
- 5) Assess the problem
- 6) Set goals
- 7) Review possible activities:
  - a) preventive activities (e.g., zoning, floodplain regulations)
  - b) property protection activities (e.g., flood insurance, acquisition)
  - c) plan review activities
  - d) emergency services activities
  - e) structural actions (e.g., levees, flood storage)
  - f) public information activities (outreach)

34 Repetitive Loss - Homes or structures that have received more than $1,000 of flood insured damage two or more times in the last ten years will appear on the National Flood Insurance Program (NFIP) repetitive loss database and receive higher priority for certain types of buyout.
1.7 RELATIONSHIP TO PIERCE COUNTY PLANS AND AGREEMENTS

Numerous Pierce County plans, polices, and agreements informed the development of the Flood Plan. A brief overview of some of these plans, policies, and agreements are provided with a complete listing and summary found in Appendix D.

1.7.1 Pierce County Comprehensive Plan, Community Plans and Environmental Regulations

The Pierce County Comprehensive Plan was developed and adopted in 1995 in response to the requirements of the Growth Management Act and is codified in Title 19A of the Pierce County Code. The Comprehensive Plan addresses ten elements of the natural and built environment: Land Use, Rural, Economic Development, Environment and Critical Areas, Housing, Transportation, Utilities, Capital Facilities, Community Plans, and Essential Public Facilities. The Land Use Element, Environment and Critical Areas Element, Utilities Element and Capital Facilities Element include policies regarding flood control for major rivers in Pierce County. Where the Flood Plan departs from the policies within the Comprehensive Plan, future updates, and amendments of the Comprehensive Plan will be necessary.

Consistency with the Pierce County Community Plans (Title 19B), Critical Areas (Title 18E) and the Shoreline Master Program (Title 20) is required for projects contained within the Flood Plan. Flood Plan projects may be subject to special requirements (e.g., setbacks or buffers35), design standards, and mitigation measures contained within these Chapters of the Comprehensive Plan, depending upon their location within the county and shoreline environment.

1.7.2 Surface Water Management Basin Plans

Surface water management within unincorporated Pierce County is guided by a series of ten basin specific plans which address flooding of the regulated flood plain within the watershed for tributaries and other water bodies, identify existing conditions which affect storm drainage and surface water, forecasts future drainage conditions, and identify potential solutions for the streams and tributaries not included within the Flood Plan. These basin specific plans are used to develop capital improvement projects, maintenance and repair projects, property acquisition, and program schedules and budgets.

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35 Buffer – A tract or strip of land that separates one type, category, or use of land from another. Buffers typically serve to provide a defined area between a more intensive use of land and a land use that is less intensive. Buffers are typically referenced by the associated critical area such as wetland buffer, riparian buffer, etc.
Basin specific plans are:

- Clover Creek Basin
- Clear Creek and Clarks Creek Basin
- Gig Harbor Basin
- Hylebos Basin
- Key Peninsula Basin
- Mid-Puyallup Basin
- Muck Creek Basin
- Nisqually Basin (in adoption process)
- Upper Puyallup/Carbon River Basin (in development)
- White River Basin (in adoption process)

1.7.3 Pierce County Natural Hazard Mitigation Plan (PCNHMP)

In 2000, Congress passed the Disaster Mitigation Act of 2000 that requires local governments to have federally approved natural hazard mitigation plans in order to be eligible for future pre- and post-disaster mitigation funds. The overriding goal is to reduce risk and ultimately reduce the cost of disaster recovery.

The Pierce County Natural Hazard Mitigation Plan identifies each department or division’s role in providing services and its capabilities to protect and preserve Pierce County. The plan identifies Pierce County’s “critical infrastructure”, their locations, and the mitigation strategies necessary to protect these assets and services. The overall goals of the plan are:

- Protect Life and Property
- Ensure Continuity of Operations
- Establish and Strengthen Partnerships for Implementation
- Protect the Environment
- Increase Public Preparedness for Disasters
- Promote a Sustainable Economy

The Pierce County Department of Emergency Management is responsible for coordinating the development of the Pierce County Natural Hazard Mitigation Plan which includes the divisions and agencies of Pierce County Government. This Pierce County Natural Hazard Mitigation Plan is part of the larger Region 5 Hazard Mitigation Plan that includes the mitigation planning of all

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36 Hazard Mitigation – Action taken to reduce or eliminate long-term risk to people and property from hazards such as floods, earthquakes and fires.
other governments and local jurisdictions within Pierce County. As part of the adoption process
the Pierce County Rivers Flood Hazard Management Plan will need to be incorporated by
reference into the Pierce County Natural Hazard Mitigation Plan.

1.7.4 Inter-County River Improvement Agreement

The Inter-County River Improvement Agreement is a 105 year agreement approved in 1914 to
settle a legal dispute between Pierce and King Counties surrounding the diversion of flow of the
White River from King County into the Stuck River (lower White River) in Pierce County. A more
complete synopsis may be found in Appendix D. The Agreement jointly funds the Inter-County
River Improvement Fund for maintenance and flood control purposes on the lower White, and
lower Puyallup rivers. Since the 1980s, Pierce and King Counties have largely funded necessary
maintenance and capital needs on their respective sides of the county line. Because the
Agreement is due to expire at the end of 2019, a new agreement will need to be negotiated.

1.7.5 Settlement Agreement between the Puyallup Tribe of Indians and
the Federal Government, State of Washington, Local
Governments of Pierce County and Private Interests

In 1990, a Settlement Agreement was reached between the Puyallup Tribe of Indians, local
governments in Pierce County, the State of Washington, the United States of America, Port of
Tacoma, and certain private property owners. Key provisions of this agreement that affect
flood hazard management planning, include: (1) numerous additions to the tribe’s land base
including the submerged lands below the ordinary high water mark\(^{37}\) (riverbed) within the
Puyallup River within the 1873 survey area (approximately RM 1.4 to RM 7.2); (2) provisions for
substantial restoration of the fishery resource, allowing for future development while lessening
impacts on fisheries; (3) resolution of conflicts over governmental jurisdiction; and (4)
establishment of a consultation process. A more complete summary may be found in Appendix
D.

1.7.6 Vegetation Management Agreement with Puyallup Tribe of Indians

Adopted in 1985, the Puyallup River Vegetation Management Program was an agreement
between Pierce County and the Puyallup Tribe to settle a legal dispute about vegetation on the
County’s flood control facilities. The United States District Court issued a stipulation that
acknowledged the vegetation management program and enabled the lawsuit to be cancelled.
The Agreement specifies allowable vegetation removal for maintenance activities, sediment
berm, and gravel removal, and levee and revetment reconstruction in the Puyallup River Basin.
Recommendations in the Flood Plan must be consistent with this agreement or recommend
specific changes to this Agreement for consideration by the two parties to the agreement.

\(^{37}\) Ordinary High Water Mark (OHWM) – The mark on all lakes, streams, and tidal water that can be found by examining the
bed and banks and determining where the presence and action of waters has marked upon the soil a character distinct from
that of the abutting upland, in respect to vegetation. In any area where the ordinary high water mark cannot be found, the
ordinary high water mark adjoining fresh water shall be the line of mean high water.
1.8 MAJOR STUDIES SUPPORTING PLAN DEVELOPMENT

Three studies were undertaken as part of this planning effort to inform development of the Flood Plan.

- **Geomorphic Analysis of the Fluvial Response from Sedimentation**\(^{38}\) *Downstream of Mount Rainier, WA* (by the U.S. Geological Survey)
- **Changes in Sediment Volume in Alder Lake, Nisqually River Basin, Washington, 1945-2011**
- **Rivers Flood Hazard Management Plan Economic Analysis**, 2010 (by Entrix, Inc.)
- **Pierce County Rivers Flood Hazard Management Plan Risk Assessment**, February 2012 (by URS)

The *Channel-Conveyance, Channel Change, and Sediment Transport* study examined sediment transport and its effect on flow conveyance in the lower drainage basin of the Puyallup River system. River cross sections were surveyed at 156 locations and compared with similar data collected in 1984. Between 1984 and 2009, aggradation\(^{39}\) totals (measured by changes in average channel elevation) were as much as +7.5, +6.5, and +2 feet on the Puyallup, White, Carbon Rivers, respectively (Czuba et al. 2010). The changes in average channel elevation within the study area are shown in Figure 1.3.

Channel conveyance capacity is the volume of water conveyed in the river channel before bank overtopping occurs. The most significant decrease in channel conveyance capacity associated with sediment deposition was between RM 19.7 and RM 21.5 on the upper Puyallup River near Orting, and between RM 2.3 and RM 5.8 on the lower White River, downstream of the Pierce-King County line. A hydraulic model\(^{40}\) and bedload transport component were used to analyze river-management options. The model showed that setback levees would provide greater flood protection than gravel-bar scalping after initial project construction and for some time thereafter. The greatest benefit from setback levees comes from a substantial increase in effective channel-conveyance area (Czuba et al. 2010).

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\(^{38}\)**Sedimentation** – The process of settling and depositing suspending matter carried by runoff, usually occurring by gravity when the velocity of the surface water is reduced below the point at which it can transport the suspended material.

\(^{39}\)**Aggradation** – A progressive buildup or raising of the channel bed due to sediment deposition. Permanent or continuous aggradation is an indicator that a change in the stream’s discharge and sediment characteristics is taking place.

\(^{40}\)**Model** – Models are conceptual and mathematical descriptions or analogies used to help visualize something that cannot be directly observed. Models provide frameworks that organize concepts, data, and information into a system of inferences that can be presented as mathematical descriptions of situations or conditions.
Figure 1.3 Change in average channel elevation between 1984 and 2009 in the Puyallup, White and Carbon rivers.
The Geomorphic Analysis of the Fluvial Response from Sedimentation Downstream of Mount Rainier, WA analyzed sedimentation in the Puyallup, Carbon, White, and Nisqually rivers downstream of Mt. Rainier. The USGS\(^{41}\) analyzed sediment budgets, the transport of sediment downstream, and tools for predicting future trends. Glacial retreat on Mt. Rainier is exposing excess sediment to transport downstream. There have been 51 documented debris flows on Mt. Rainier from 1926-2006. The largest was Kautz Creek, tributary to the Upper Nisqually River, in 1947. Stream gauges have shown increased peak flows on the Nisqually and Carbon Rivers in recent decades. There are also higher freezing levels and more precipitation falling as rain.

Evidence suggests that more sediment has been released from Mount Rainier since 1996, but the rivers will meter the delivery of this additional sediment to lowland reaches. In other words, the river systems draining Mt. Rainier are largely transport limited (i.e., even though more sediment is available upstream, the rivers ability to move it further downstream is limited by the river flow). Downstream sediment transport and deposition are governed by stream power. Stream power, slope, and width are the major factors affecting sediment transport potential. Sediment deposition occurs where there is a change in slope (flattening), increased river width, and lower stream power. Reaches along each of the four river systems where deposition is most significant were identified. The estimated range of sediment transport on the Upper Nisqually River to Alder Lake is 0.71 to 1.39 million tons per year. The estimated annual White River sediment load at Auburn is 746,000 tons per year. This information can be used to help inform sediment management decisions.

The Rivers Flood Hazard Management Plan Economic Analysis focused on the 100-year floodplains of the two river systems, its tributaries, and the large streams within the Planning Area. The report examined (1) existing socioeconomic conditions, (2) flood impacts to regional economic activity, (3) property damage, (4) transportation impacts, (5) wastewater treatment plant impacts, and (6) recreation impacts related to closures of Mt. Rainier National Park and Crystal Mountain. Pierce County faces the threat of significant impacts from flooding with potential flood related losses in excess of $725 million from a 100-year or larger flood (Entrix 2010). Over 21,000 people live in the floodplain in 9,340 homes. Businesses located within the flood plain provide 11,800 jobs. There are three wastewater treatment plants serving 216,000 people located in the floodplain.

The study summarizes a range of estimates of economic impacts that were quantified, with both a low and high estimate, as follows:

- Property damage is estimated to be between $199 and $520 million
- Loss of business revenue from disruption or closure ranges from $13 to $46 million, depending on the number of days of closure
- Delays in transportation network caused by road and rail closures are estimated to be between $12.6 and $19.3 million

\(^{41}\) USGS (United States Geological Survey) – Agency within the federal Department of the Interior responsible for collecting and distributing stream flow data for the nation.
• The estimate of losses in agricultural output ranges between less than $1 to $20 million
• Flood damage at wastewater treatment plants is estimated to be between $3 and $128 million
• Lost revenue and income due to closures of Mt. Rainier National Park and Crystal Mountain Ski Resort is estimated to be between $1 and $14 million
CHAPTER TWO
MAJOR RIVER FLOODING IN PIERCE COUNTY

The planning area for the Pierce County Rivers Flood Hazard Management Plan includes the floodplains of the rivers of the Puyallup River and Nisqually River systems. This chapter focuses on flooding within these river systems. Topics include the unique nature of the glacial-fed rivers of Mt. Rainier, a brief overview of the river watershed characteristics, floodplain characteristics, costs and impacts of flooding, results from the risk assessment, floodplain management history in Pierce County, and the County’s participation in the National Flood Insurance Program’s Community Rating System.

2.1   PIERCE COUNTY RIVER SYSTEMS

2.1.1   Mount Rainier’s Glacial-fed Rivers

The rivers of Pierce County behave differently than many other rivers in Western Washington. With a few exceptions, the major river systems of Pierce County originate from glaciers on the slopes of Mt. Rainier. Over millennia, the glaciers formed from accumulating snow that became compacted and eventually turned into glacial ice. As the glaciers moved down slope, they eroded the terrain, picking up rocks and gravel, grinding the bedrock into smaller rocks and fine sediment called glacial silt. Glaciers act much like a conveyor belt carrying rock and sediment from the top of the glacier to the bottom where it deposits in terminal moraines. The unconsolidated soil and rock which fall off the side of a glacier as it moves is called a lateral moraine. This sediment is then available for transport downstream. Glacial rivers carry up to 13 times (USGS 2012) more sediment than non-glacially fed rivers; they run turbid (cloudy) part of the year and carry and deposit sediment downstream.

2.1.2   Puyallup River System

The Puyallup River and its two main tributaries, the White River and Carbon River, drains a watershed of approximately 1,040 square miles and flows from the glaciers of Mount Rainier with an elevation of 14,410 feet to Commencement Bay and Puget Sound. The Puyallup River runs through the cities of Tacoma, Fife, Puyallup, Sumner, and Orting, and large areas of unincorporated Pierce County. The Puyallup Tribe of Indians owns the river bed within the 1873 survey area from approximately RM 1.4 to RM 7.2. The lower reaches of the Puyallup River were historically straightened with levees and revetments for flood control purposes. Mud Mountain Dam on the White River at RM 29.6 provides storage of up to 106,000 acre-feet of water to reduce flooding on the lower Puyallup River and to a lesser extent the lower White River.

The White River drains an area of approximately 475 square miles. It flows about 75 miles from its source on the Emmons Glacier on the northeast side of Mount Rainier to its mouth at the City of Sumner. The river has several tributaries including Huckleberry Creek, Greenwater River and Clearwater River. It flows through the community of Greenwater, the Muckleshoot Indian
CHAPTER 2: MAJOR RIVER FLOODING IN PIERCE COUNTY

The Greenwater River lies in northeastern Pierce County and enters the White River at RM 44.6. The headwaters of the Greenwater River are on Castle Mountain in the Cascades (elevation of 6700 feet) and it flows northwest for 21 miles to the community of Greenwater. The drainage basin is approximately 75 square miles. The Greenwater River forms the boundary between King County (north of the river) and Pierce County (south of the river) upstream of its confluence with the White River.

The Carbon River drains an area of 230 square miles that originates on the north face of Mt. Rainier at the Carbon Glacier. It flows 33 miles downstream joining the Puyallup River below the City of Orting at RM 17.4. This plan concentrates on the lower 8.4 miles of the Carbon River. Most of this segment of the river is within unincorporated Pierce County, but the left bank of the lower 3.5 miles flows along the City of Orting. Above RM 11.0, the river is contained within steep canyon walls up to the community of Fairfax at RM 17.5. Between RM 0.0 and RM 8.3, the channel corridor lies in a relatively narrow trough-like valley.

South Prairie Creek lies in the center of the Puyallup River Basin, east of the City of Orting. South Prairie Creek has a drainage basin of 90 square miles and ranges in elevation from 285 feet above sea level to 5,933 feet at the summit of Pitcher Mountain. This plan concentrates on the lower floodplain area of South Prairie Creek (RM 0 - RM 6.4), extending from the Town of South Prairie to the confluence with the Carbon River at RM 5.9. There are no Pierce County levees along lower South Prairie Creek, but there are isolated rock riprap revetments and earthen berms that have been constructed by agricultural and residential landowners and transportation agencies, such as near SR-162 Bridge crossings of the creek.

2.1.3 Nisqually River System

The Nisqually River drains a watershed of approximately 760 square miles. The river originates from the Nisqually glacier on the south slope of Mount Rainier with an elevation of 14,411 and flows 78 miles to the estuary at the Nisqually National Wildlife Refuge before flowing into Puget Sound. There are two major tributaries to the Nisqually River, the Mashel River, and Muck Creek. Nearly 58 percent of the Nisqually River watershed lies in Pierce County, with the remainder in Thurston County (16 percent) and Lewis County (26 percent). There are two dams on the Nisqually River, the first at RM 42.4 (LaGrande Dam) and the second at RM 44.2 (Alder Dam). Alder Dam forms the 3000-acre Alder Lake. The two dams are part of the Nisqually Hydroelectric Project owned and operated by Tacoma Power. According to Tacoma Power, the dams provide incidental reduction of flood flows, but there are no flood control requirements noted in the operating agreement (Nisqually Watershed Characterization, 2008).

The Mashel River is the largest tributary to the Nisqually River and drains an area of approximately 85 square miles. The headwaters of the Mashel River begins near Mount
Rainier, flows through the Town of Eatonville, and joins the Nisqually River at approximately RM 41.4, one mile downstream of La Grand Dam. Over 40 percent of the Mashel River sub-basin has slopes greater than 30 percent. Elevations range from 460 feet at its mouth to 4,845 feet on the flanks of Mount Rainier.

2.1.4 River Conveyance Capacity for Water and Sediment

The conveyance capacity of a river is determined by the channel width, channel depth, and water velocity. The relationship with flow is shown in the following equation:

\[ \text{River Flow (cubic feet per second)} = \text{Water Velocity} \times (\text{Channel Width} \times \text{Channel Depth}) \]

The ability of a river channel to carry floodwaters is increased if any of the three factors (channel width, depth, or velocity) are increased. The river’s velocity and volume of water, the slope of the river channel, and the size and quantity of rock and sediment available determine the ability of the river to transport sediment. The faster and greater the volume of water, the larger the submerged rocks and overall sediment quantity can be moved. As channels flatten out and the water moves slower, the river can carry less material, resulting in deposition of rock and sediment (Department of Ecology 2007). The inherent nature of a glacial river system is to balance its load of rock and sediment with its steepness and the volume of water it carries.

When steep river channels meet broad, flat, valley floors, flow velocities decrease, and the ability of rivers to move sediment is reduced. This reduced ability to transport sediment results in the deposition of sand and gravel in the river channel (also known as aggradation). Under natural conditions, an unconfined river channel can migrate or flow around the deposited sediment and choose a new path. In confined rivers, between two levees or revetments, the channel cannot migrate and deposited sediment will usually lead to reduced flood conveyance capacity and greater potential to erode banks, including levees and revetments.

2.1.5 Effects of Sediment and Wood on River Flooding and Channel Migration

River channels in Pierce County provide for the conveyance of water, wood and sediment (cobbles, gravel, and fine material) and habitat for various fish and animal species. Water, sediment, and wood form a dynamic interaction within the river channels described as the “three rivers concept” (Wald 2009). Just as water flows from the upper reaches of a watershed downstream to the mouth of the river, sediment and wood also “flow” from various sources down the river channel and eventually discharge at the mouth of the river, or deposit along its reaches (Locke et al. 2008). This interaction affects river management, maintenance, and habitat formation.

Many rivers contain islands and gravel bars that accumulate sediments behind woody debris and log jams left after a previous flood or high water event (Figure 2.1) while serving as

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42 **sub-basin** – A drainage area that drains to a watercourse or water body named and noted on common maps and which is contained within a basin; a basin or area that is part of a larger drainage basin or area.
important habitat features. While it may take only days for water to move the length of a river, mobile sediment and wood may take years (or decades) to progress downstream from one reach to another, moving primarily during high flow events.

The transport of sediment and wood and the resulting habitat is a natural riverine process. However, the accumulation of sediment and large woody debris in river channels can create an impediment to flood flow conveyance, raise water surface elevations during flooding, and sometimes redirect flows in a way that increases channel migration risks (King County 2007).

A recent study of the Puyallup River system (USGS 2010) indicates that increases in average channel bed elevations were significant in some locations between 1984 and 2009 (see Table 2.1 and Figure 2.2).

Between RM 17.7 and RM 21.4 on the Puyallup River, the net volume of deposition was approximately 429,000 cubic yards (cy) of sediment, or 17,200 CY per year. Between RM 21.5 and RM 25.7 on the Puyallup River (from the Calistoga Bridge to the USGS gauging station upstream of Orting), the net volume of deposition was approximately 907,000 cy of sediment, or 36,300 cy per year.

The largest net volume of deposited sediment in the White River was between the Lake Tapps return flow at RM 3.9 and R Street Bridge in Auburn at RM 7.6, with approximately 547,000 cy of sediment or 21,900 CY per year.
Table 2.1 – Sediment accumulation from 1984 to 2009
(change in mean bed elevation)

<table>
<thead>
<tr>
<th>River</th>
<th>River Miles</th>
<th>Change in bed elevation (1984-2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puyallup River</td>
<td>RM 9.1 - 10.1</td>
<td>2 - 3.5 feet accumulation</td>
</tr>
<tr>
<td>Puyallup River</td>
<td>RM 14.2</td>
<td>3.8 feet accumulation</td>
</tr>
<tr>
<td>Puyallup River</td>
<td>RM 18.9 - 21.5</td>
<td>1.6 - 4.0 feet accumulation</td>
</tr>
<tr>
<td>Puyallup River</td>
<td>RM 22.6 - 24.8</td>
<td>2.3 - 7.5 feet accumulation</td>
</tr>
<tr>
<td>White River</td>
<td>RM 4.9 - 6.4</td>
<td>3.1 - 6.5 feet accumulation</td>
</tr>
</tbody>
</table>

The most significant decrease in channel conveyance capacity associated with this sediment deposition was between RM 19.7 and RM 21.5 on the upper Puyallup River and between RM 2.3 and RM 5.8 on the lower White River (see Figure 2.3).
Surface Water Management

River channel modification, and specifically the selective removal of sediment and large woody material, can improve conveyance capacity and provide effective flood risk reduction (to a degree) in some instances, but it usually is only a temporary measure that must be done routinely to maintain its effectiveness. This can make in-channel river maintenance costly over time and give a false sense of security, because the period of effectiveness can be quite short when there are subsequent sediment and wood transport events. In-channel river maintenance can also directly impact other beneficial uses such as aquatic habitat conditions.

Figure 2.3 - Simulated channel conveyance capacity for 1984 (dashed line) and 2009 (solid line) for (a) lower White River and (b) upper Puyallup River (USGS 2010).
and salmonid spawning and rearing. Finally, it is difficult to get authorization from permitting agencies, including the Washington State Departments of Ecology, and Fish and Wildlife, the U.S. Army Corps of Engineers, National Marine Fisheries Service, and U.S. Fish and Wildlife Service, and support from the Puyallup, Muckelshoot, and Nisqually tribes.

### 2.2 FLOODING AND FUTURE TRENDS

Throughout recorded history, flooding has been a natural characteristic of the climate, topography, and hydrology of Pierce County. In the relatively short time since European settlement began in the 1800’s, the floodplains of Pierce County have been developed extensively. From the late 1800s into the middle part of the 1900s, this development mostly focused on agriculture, with concentrations of development in some cities and towns. There was also extensive development of the Port of Tacoma at the mouth of the Puyallup River. These low-lying areas, especially the fertile river valleys, have flooded periodically.

In December 1893, the gauge near Buckley on the White River measured a flow of 28,000 cfs, the highest flow ever recorded on the White River at this gauge (Pierce County 1991). However, it was not until the great flood of 1906 that major changes occurred on the White River. These changes resulted in the permanent diversion of the White River from the Green River into the Stuck River (Figure 2.4), the straightening of the rivers and the construction of levees on both sides to reduce the risk of flooding in the lower Puyallup. Construction of revetments along the rivers in the early to middle 1900s helped reduce bank erosion and channel migration, allowing agriculture to become a thriving industry in the river valleys.

Data on the flow and stage has been collected for the Puyallup River since 1914 (USGS Station 12101500). The largest floods between 1914 and 1965 are shown in Table 2.2. The largest flow on record (57,000 cubic feet per second (cfs)) occurred in 1933, and lead to the construction of Mud Mountain Dam for flood control, substantially reducing flood risks in subsequent decades.

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow Rate (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1917</td>
<td>40,500</td>
</tr>
<tr>
<td>January 1919</td>
<td>36,500</td>
</tr>
<tr>
<td>December 1921</td>
<td>35,600</td>
</tr>
<tr>
<td>November 1932</td>
<td>37,800</td>
</tr>
<tr>
<td>December 1933</td>
<td>57,000</td>
</tr>
<tr>
<td>October 1934</td>
<td>39,500</td>
</tr>
</tbody>
</table>

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43 **Hydrology** – The science of the behavior of water in the atmosphere, on the surface of the Earth, and underground.
The largest floods between 1977 and 2009 are shown in Table 2.3. Five of the largest floods since construction of Mud Mountain Dam in 1948 occurred in the 20 years from 1990 to 2010.

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow Rate (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1977</td>
<td>40,600</td>
</tr>
<tr>
<td>January 1984</td>
<td>37,100</td>
</tr>
<tr>
<td>November 1986</td>
<td>43,800</td>
</tr>
<tr>
<td>January 1990</td>
<td>44,800</td>
</tr>
<tr>
<td>November 1990</td>
<td>41,900</td>
</tr>
<tr>
<td>February 1996</td>
<td>46,700</td>
</tr>
<tr>
<td>November 2006</td>
<td>39,700</td>
</tr>
<tr>
<td>January 2009</td>
<td>48,200</td>
</tr>
</tbody>
</table>

The flooding of February 1996 was the worst that Pierce County has faced. Estimates by the Corps of Engineers indicate that Puyallup River flows into the lower valley would have exceeded 75,000 cfs. All of Pierce County’s major rivers reached flood stage or above. Along the Puyallup River system 10,000 linear feet of levee was partially damaged and 20,000 linear feet completely destroyed. During the same storm event, the Nisqually River also had an unprecedented recorded flow. The amount of water released from the Alder and La Grande reservoirs to prevent damage to the dams exceeded the capacity of the river channel. The flow at McKenna was estimated at 50,000 cfs. Throughout the county, surface water flooding occurred and sandbagging continued for weeks.

Since 1962 there have been 15 Presidential Disaster Declarations that included flooding in Pierce County. These declarations do not include the many flood responses that Pierce County has responded to that do not qualify as a federal disaster.

### 2.2.1 Flood Management History in Pierce County

Early records indicate that basic flood protection work in Pierce County, particularly with the Puyallup River basin, began with arrival of European settlers in the 1850s, increasing by the late...
1800s (Pierce County 1991). Most of this work was to stabilize the course of the rivers. Prior to 1906, the White River flowed north through Auburn and King County, draining into Elliott Bay. During periods of high flood waters, a portion of the White River flowed south via the Stuck River into the lower Puyallup River. During a large flood on November 14, 1906, a debris jam blocking the White River channel near Auburn resulted in diversion of most of the flood waters into Pierce County. In January 1914, Pierce and King counties signed a 105-year Inter-County River Improvement Agreement to settle legal disputes that had arisen from changes to the flow of the White River following the large November 1906 flood event. The counties agreed that for the public interests of their respective residents, the flow of the White River would be confined permanently to the Stuck River, which flows into the lower Puyallup River and into Commencement Bay. Revetments were constructed along the lower White River and levees were constructed along the lower Puyallup River (Figure 2.5).

Figure 2.4 - The flood of 1906 led to the construction of a diversion dam in 1916 to permanently divert the White River south to Commencement Bay. (Graphic courtesy of King County)
By 1931, most of the Puyallup River valley and surrounding hills had been harvested for timber and the valley was cleared for agriculture northward of RM 23.8 near the old Ford farm on Orville Road (GeoEngineers, 2003). In the 1930s and 1940s, rip rapped levees and revetments were constructed to prevent migration of river channels through agricultural lands.

The approach to river management changed in the 1960s. In the early 1960s, Washington State made substantial money available for new construction of levees for flood control (Dave Lewis, personal communication, 2010). The Corps of Engineers encouraged narrowing and straightening of the rivers to keep sediment and debris moving though the system. Extensive portions of the middle and upper Puyallup River and Carbon River were straightened and confined with levees and revetments, decreasing channel width to an average of 250 feet (GeoEngineers 2003). Levees and revetments were designed to prevent sediment sources on ravine hillsides from entering the mainstem channels, thereby increasing transport capacity through the system. The new levees changed land use practices in many areas adjacent to the river. Seasonal and residential developments now occupy portions of the historical zone of channel occupation. The conversion of lands from rural to suburban land use started in the 1970s and continued into the 2000s with conversion of large tracts of farmland (formerly floodplain) to residential, commercial, or industrial development.

The narrowing and straightening of the channels was expected to keep river velocities high and keep sediment and wood moving downstream through the system. Unfortunately, sediment deposition did occur in low-gradient reaches, leading to a heavy focus on gravel removal from within the rivers from the mid-1960s through the mid-1980s. In some instances, river management through gravel removal efforts were marginally successful in controlling erosion and flooding, but they incurred high costs for channel maintenance and flood damage repair, and caused environmental and habitat alteration.


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44 Gradient (of stream) – Degree of inclination of a stream channel parallel to stream flow; it may be represented as a ratio, fraction, percentage or angle.
That plan recognized many of the problems associated with traditional approaches to flood control as practiced from the 1960s through the 1980s. The plan expressed the County’s preference for non-structural measures to reduce future risks, including substantial regulation of floodplain development, public education and outreach, flood warning, flood proofing of existing structures, and acquisition of properties highly susceptible to repetitive flooding. The plan also included structural projects, including levees and revetments, ring levees, setback levees and channel widening, and in-channel measures including gravel and debris removal, vegetation management and streambank protection. Until now, the 1991 Plan has been the County’s blueprint for Puyallup River management.

Significant floods in the 1990s, including the large 1996 flood, forced a serious re-thinking of river confinement. In 1998, Pierce County completed its first levee setback project on the right bank of the Puyallup River between RM 23.4 – RM 25.0, reconnecting 125 acres of floodplain to the river. In 2006, a second levee setback project was completed on the left bank between RM 21.5 and RM 22.4, reconnecting 67 acres of floodplain. The 2008 Puyallup River Levee Setback Feasibility Study (GeoEngineers 2008) evaluated 32 potential sites for setback levees in the Puyallup, White, and Carbon River systems.

2.3 FLOOD HAZARDS AND IMPACTS

2.3.1 Types of Flood-Related Hazards

Major flood events in Pierce County result in two types of flood hazards: flooding and channel migration. Flooding consists of overbank flow or levee overtopping that inundates the floodplain in areas not normally covered by water. Such flooding can cause minor to severe damage. The extent of damage is dependent on the depth, velocity, and duration of flooding, the amount of sediment, wood, and debris carried by floodwaters, along with the extent and type of development in the floodplain.

Channel migration results from bank erosion caused by high peak flows and erosive velocities. Sediment deposition and river avulsions\(^{45}\) can lead to rapid, lateral migration of the river across the floodplain. When floodwaters recede, the river often remains in its new channel. Channel migration can threaten areas that are outside the current floodplain. This can occur when a channel migrates laterally across the valley floor, or when property on a higher bank is undermined by erosive flood flows. Channel migration can cause minor to severe damage, depending on the structures or infrastructure affected, and the rate of channel migration. It is possible for a structure to be outside the floodplain, but still be within a channel migration zone (see Figure 2.6).

\(^{45}\) Avulsion – The rapid abandonment of a channel with the formation of a new channel.
Figure 2.6 – Depicts the danger of channel migration zone (graphic courtesy of King County)
2.3.2 Flood and Channel Migration Hazard Mapping

Flooding and channel migration potential are mapped by FEMA and Pierce County as a means to identify risks. Flood hazard mapping is carried out by plotting estimated flood elevations generated in a hydraulic analysis onto a topographic map of the river valley. Typically, flood hazard mapping maps the extent of water inundation for the one percent annual chance flood (100-year flood event or base flood), and the 0.2 percent annual chance flood (500-year flood event). FEMA’s National Flood Insurance Program (NFIP) established the 100-year standard for floodplain mapping as a minimum standard for regulatory and insurance purposes.

Flood hazard studies and associated mapping provide critical baseline information for flood hazard management and flood risk reduction. This information is then used to inform land-use decisions, regulate existing and proposed floodplain development, and to evaluate and design flood hazard management projects. If maps are outdated and no longer reflect actual floodplain conditions, there is high likelihood that land use decisions and new development will be allowed that put property and people in flood-prone areas, which increases risk. Inaccurate maps can also put unnecessary building restrictions on some parcels that are mapped as flood prone, but are not in a floodplain. As of the publication of this document, updated floodplain maps (Preliminary DFIRM) have not yet been finalized by FEMA for the Puyallup, Carbon, White, and Mashel rivers and South Prairie Creek. However, these preliminary maps are the best available data and are being used to regulate floodplain development in unincorporated Pierce County.

Mapping of the special flood hazard areas (SFHA) was updated by FEMA and preliminary digital flood insurance rate maps (DFIRMs) were issued in 2005 for many of the sub-planning areas (SPAs) as shown in Table 2.4. The extent of increase in SFHA was significant for several SPAs, including the lower Puyallup, upper Puyallup, and Carbon rivers. In particular, the lower Puyallup River experienced an increase of over 300 percent due to the de-accreditation of the levees. When flood mapping was undertaken in 1987, the lower Puyallup levees met federal regulations for accreditation as 100-year levees. However, more recent sediment deposition along the river bed and increases in the estimate of the one percent annual chance flood from 36,800 to 48,000 cfs have raised river water levels so that the levees no longer meet the three feet freeboard requirement for predicted 100-year water levels, which is one of the requirements for federal certification.

Changes in estimates of the one percent annual chance flood and channel conveyance capacity have also affected the increase in floodplain extent in the upper Puyallup and Carbon River reaches, with increases of 40 percent in affected acres. New mapping has not yet occurred for

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46 **100-Year Flood** – The flood having a one percent chance of being equaled or exceeded in any given year. Also referred to as the Base Flood, Special Flood Hazard Area, or One Percent Chance Flood.

47 **Flood Hazard Areas** – In Pierce County Code, flood hazard areas are defined as the floodplain: areas of land within floodplains that are subject to a 1 percent or greater chance of flooding in any given year. Such areas include, but are not limited to, streams, rivers, lakes, coastal areas, wetlands, and the like. In areas where the base flood elevation has not been determined FEMA, zones B and/or X (shaded) are also regulated as flood fringe.
the upper White, Greenwater, and Nisqually Rivers, so the current floodplain mapping remains in effect from the 1987 FEMA map.

<table>
<thead>
<tr>
<th>Sub-planning Area</th>
<th>2009 FEMA Special Flood Hazard Areas (pDFIRM) (Acres)</th>
<th>1987 Flood Hazard FEMA (Acres)</th>
<th>Change (Acres)</th>
<th>Change % from Previous</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPA 1 Lower Puyallup River (RM 0-10.3)</td>
<td>4,494</td>
<td>1,247</td>
<td>3,247</td>
<td>260</td>
</tr>
<tr>
<td>SPA 2 Middle Puyallup River (RM 10.3-17.4)</td>
<td>1,153</td>
<td>1,124</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td>SPA 3 Upper Puyallup River (RM 17.4-29)</td>
<td>2,562</td>
<td>1,730</td>
<td>832</td>
<td>48</td>
</tr>
<tr>
<td>SPA 4 Lower White River (RM 0-5.5)</td>
<td>1,043</td>
<td>1,365</td>
<td>-322</td>
<td>-24</td>
</tr>
<tr>
<td>SPA 5/SPA 6 Upper White River (RM 44-51) and Greenwater River (RM 0-4)</td>
<td>572</td>
<td>552</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>SPA 7 Carbon River (RM 0-8)</td>
<td>1,317</td>
<td>931</td>
<td>386</td>
<td>41</td>
</tr>
<tr>
<td>SPA 8 South Prairie Creek (RM 0-6.2)</td>
<td>469</td>
<td>459</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>SPA 9 Middle Nisqually River (RM 21-26)</td>
<td>886</td>
<td>404</td>
<td>482</td>
<td>119</td>
</tr>
<tr>
<td>SPA 10 Upper Nisqually River (RM 50.5-66)</td>
<td>1,114</td>
<td>967</td>
<td>147</td>
<td>15</td>
</tr>
<tr>
<td>SPA 11 Mashel River (RM 0-6.8)</td>
<td>213</td>
<td>197</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13,823</td>
<td>8,976</td>
<td>4,847</td>
<td>54</td>
</tr>
</tbody>
</table>

Channel migration zone (CMZ) studies and maps provide critical baseline information necessary to understand the effects of potential river migration hazards in river valleys. The CMZ refers to the geographic area where a stream or river has been and is susceptible to channel erosion or channel occupation (WSDOE 2003). CMZ delineations help reduce risks to communities by making homeowners and potential home buyers and builders more aware of risks. While the lower segments of the major rivers in Pierce County are confined by levees and revetments, there are many river segments that still are subject to potential future channel migration. Levees and revetments on major rivers continue to be damaged by erosion associated with channel migration.

The CMZ maps identify severe, moderate, and low Migration Potential Areas (MPAs) within the channel migration zone. In preparing these studies and maps, Pierce County used information on historical channel locations (primarily aerial photography), geology, basin hydrology, current channel conditions, sediment transport, composition of bank and bed material, potential avulsion sites, and channel migration rates to characterize the channel migration zones.

48 **Channel Erosion** – The widening, deepening, and headward cutting of small channels and waterways due to erosion caused by moderate to large floods.
Because of the risks to public safety and the high cost associated with construction and maintenance of flood risk reduction facilities, the County’s approach in severe channel migration hazard areas is to restrict development. To address concerns about channel migration, geomorphic evaluations, channel migration zone analyses, and CMZ mapping have been carried out on sections of five of the major rivers systems as follows:

- Puyallup River from River Mile (RM) 10.0 to RM 28.8
- White River from RM 0.0 to RM 5.5
- Carbon River from RM 0.0 to RM 8.3
- South Prairie Creek from RM 0.0 to RM 5.8, and
- Upper Nisqually River from approximately RM 50.5 to RM 68.6.

Of the three classifications of CMZ, Pierce County regulates only the severe CMZ areas, which have the highest risk of being occupied by a river. These areas are deemed high hazard and high-risk for life, safety and damage to buildings and other property improvements. Table 2.5 shows the severe CMZ acreage within each SPA.

<table>
<thead>
<tr>
<th>Sub-Planning Area</th>
<th>Severe CMZ Area (Acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPA 1 Lower Puyallup River</td>
<td>75</td>
</tr>
<tr>
<td>SPA 2 Mid Puyallup River</td>
<td>1,047</td>
</tr>
<tr>
<td>SPA 3 Upper Puyallup River</td>
<td>1,325</td>
</tr>
<tr>
<td>SPA 4 Lower White River</td>
<td>216</td>
</tr>
<tr>
<td>SPA 5 Upper White River</td>
<td>NA</td>
</tr>
<tr>
<td>SPA 6 Greenwater River</td>
<td>NA</td>
</tr>
<tr>
<td>SPA 7 Carbon River</td>
<td>999</td>
</tr>
<tr>
<td>SPA 8 South Prairie Creek</td>
<td>183</td>
</tr>
<tr>
<td>SPA 9 Middle Nisqually River</td>
<td>NA</td>
</tr>
<tr>
<td>SPA 10 Upper Nisqually River</td>
<td>1,830</td>
</tr>
<tr>
<td>SPA 11 Mashel River</td>
<td>NA</td>
</tr>
</tbody>
</table>

*a CMZ ha not yet to be determined for these rivers*

### 2.3.3 Flood Hazard Risk Assessment

A risk assessment identifies and describes the flood hazards likely to affect a planning area, and generally contains two major planning components: a hazard profile and a vulnerability analysis. A hazard profile describes the location, history, extent, and probability of flood event...
hazards. The vulnerability analysis examines the extent of exposure that may result from a flood hazard event, including population, critical facilities, and infrastructure land use, parcels and structures, repetitive loss properties and NFIP-insured properties. An overall summary of the Pierce County Rivers Flood Hazard Management Plan Risk Assessment, 2012 (see Appendix E) is provided below for the eleven sub-planning areas of the rivers and tributaries included within the flood plan:

- There are a total of 7,535 structures within the eleven sub-planning areas, with a total assessed value of improvements of $1.2 billion. Table 2.6 shows the breakdown for parcels, structures, and improvement values within the planning area.

- There are at least 14 identified critical facilities located within the 100-year mapped floodplain. These include one police station, two fire stations, and three wastewater treatment plants (WWTPs) in the Lower Puyallup River sub-planning area (SPA), eight schools in the Lower Puyallup, Upper Puyallup and Carbon River SPAs and one nursing home in Middle Nisqually River SPA.

- Since 1978, at least $6.7 million in reported flood insurance claims have been disbursed for all sub-planning areas, $9.2 million in incorporated areas and $5.6 million in unincorporated Pierce County. Of all sub-planning areas, the Lower Puyallup River and Middle Puyallup River SPA have the highest reported number of claims.

- As of August 31, 2010, only 18 percent of structures in incorporated areas of the SPAs had a flood insurance policy in place, while only 16 percent of structures had policies in unincorporated Pierce County. With more than 80 percent of the structures un-insured, flood insurance as a means to provide site-specific property protection for “at-risk” properties is significantly under-utilized. Nationwide approximately 49 percent of single-family homes in special flood hazard areas (SFHAs) are covered by flood insurance from the NFIP (Rand, 2010).

- As of August 31, 2010, a total of 65 identified repetitive loss properties exist within the 11 SPAs, 18 in incorporated areas and 47 in unincorporated Pierce County.

- A total of 17 properties were previously considered repetitive loss properties, but have since been mitigated (i.e., purchased and removed from the floodplain). The mitigated properties are all located within unincorporated areas of the Lower Puyallup River SPA. The unmitigated repetitive loss properties are located primarily in the Lower Puyallup River, Middle Puyallup River, and South Prairie Creek SPAs. Of the unmitigated repetitive loss properties, approximately 90 percent have active flood insurance policies in force.

- Of the 48 unmitigated repetitive loss properties, seven are severe repetitive loss properties. Five of the severe repetitive loss properties are located in the Middle Puyallup River SPA, and one is located in the Lower Puyallup River SPA, and one is located in the Middle Nisqually River SPA.
• Approximately 24 percent of the total SPAs constitute residential land use, while approximately 30 percent constitute vacant land. As shown in Table 2.6, the remaining 46 percent of land use is made up of resource lands (including agriculture), commercial, industrial, public, and other designations.

• Approximately 21,195 people live in the Planning Area as of 2009. This population represents three percent of the total Pierce County population of 805,400 people.
## Table 2.6 – Parcel Data by Sub-Planning Area

<table>
<thead>
<tr>
<th>Sub-Planning Area</th>
<th>Parcels in the 100-Year Floodplain&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Vacant Parcels in the 100-Year Floodplain</th>
<th>Vacant Parcels in the 100-Year Floodplain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ac.</td>
<td>Land Value&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Structures</td>
</tr>
<tr>
<td>Lower Puyallup River (RM 0.0 – RM 10.3)</td>
<td>INC 1939 2294</td>
<td>$865.7 2436</td>
<td>$715.9 280</td>
</tr>
<tr>
<td>Middle Puyallup River (RM 10.3 – RM 17.4)</td>
<td>INC 172 64</td>
<td>$13.7 225</td>
<td>$17.4 17</td>
</tr>
<tr>
<td>Upper Puyallup River (RM 17.4 – RM 29.0)</td>
<td>INC 1129 784</td>
<td>$94.6 1442</td>
<td>$145.4 72</td>
</tr>
<tr>
<td>Lower White River (RM 0.0 – RM 5.5)</td>
<td>INC 156 942</td>
<td>$151.0 157</td>
<td>$157.3 52</td>
</tr>
<tr>
<td>Upper White River (RM 44.0 – RM 51.0) &amp; Greenwater River (RM 0.0 – RM 4.0)</td>
<td>INC 0 0</td>
<td>$0.0 0</td>
<td>$0.0 0</td>
</tr>
<tr>
<td>Carbon River (RM 0.0 – RM 8.0)</td>
<td>INC 236 186</td>
<td>$22.7 212</td>
<td>$32.3 73</td>
</tr>
<tr>
<td>So. Prairie Creek (RM 0.0 – RM 6.2)</td>
<td>INC 18 20</td>
<td>$2.0 51</td>
<td>$1.0 6</td>
</tr>
<tr>
<td>Middle Nisqually River (RM 21.0 – RM 26.0)</td>
<td>INC 0 0</td>
<td>$0.0 0</td>
<td>$0.0 0</td>
</tr>
<tr>
<td>Upper Nisqually River (RM 50.5 – RM 66.0)</td>
<td>INC 0 0</td>
<td>$0.0 0</td>
<td>$0.0 0</td>
</tr>
<tr>
<td>Mashel River (RM 0.0 – RM 6.8)</td>
<td>INC 10 13</td>
<td>$0.5 3</td>
<td>$0.2 2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>INC 3660 4303</strong></td>
<td><strong>$1150 4526</strong></td>
<td><strong>$1070 502</strong></td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>5153 9837</strong></td>
<td><strong>$1315 7536</strong></td>
<td><strong>$1190 729</strong></td>
</tr>
</tbody>
</table>

<sup>1</sup>Includes vacant parcels. Parcels with 50% or more of the parcel area within the 100-year floodplain were considered within the floodplain.

<sup>2</sup>Assessed values are in the millions of dollars.

Source: Pierce County Tax Parcels; Pierce County, 2010.
2.3.4 Flood Damages and Impacts

Loss of life and damage to public infrastructure and private property are the most visible impacts of flooding and channel migration in Pierce County. There are numerous indirect impacts such as decrease of property values and business losses. Since 1991, there has been no loss of life in Pierce County from flooding, but there have been numerous boat or helicopter emergency rescues as summarized in Table 2.7.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Number and Type of Rescues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Nisqually River – McKenna</td>
<td>Numerous evacuations; town declared off-limits by sheriff</td>
</tr>
<tr>
<td></td>
<td>Puyallup and Carbon Rivers – Orting Valley (177th/Alward Rd.; 226th St. Ct. E; Neadham Rd.)</td>
<td>Over 80 emergency rescues; many evacuations in addition to this number</td>
</tr>
<tr>
<td></td>
<td>South Prairie Creek</td>
<td>Helicopter rescue</td>
</tr>
<tr>
<td>2006</td>
<td>96th and McCutcheon</td>
<td>Approx. 15 rescued by boat</td>
</tr>
<tr>
<td></td>
<td>128th and McCutcheon</td>
<td>Approx. 35 rescued by boat</td>
</tr>
<tr>
<td></td>
<td>177th St. E./Alward Rd.</td>
<td>Three people rescued by helicopter</td>
</tr>
<tr>
<td>2009</td>
<td>96th and McCutcheon</td>
<td>Nine evacuations by boat</td>
</tr>
<tr>
<td></td>
<td>128th and McCutcheon</td>
<td>Unknown number of evacuations by two boats</td>
</tr>
<tr>
<td></td>
<td>29th and River Road</td>
<td>One evacuation by boat</td>
</tr>
<tr>
<td></td>
<td>35th and 50th and River Rd.</td>
<td>Eight rescues by boat</td>
</tr>
<tr>
<td></td>
<td>Gay Rd. and River Rd.</td>
<td>Unknown number of evacuations – no boats</td>
</tr>
</tbody>
</table>

Source: Pierce County Sheriff's Office

Major floods in Pierce County have resulted in significant property damage. Some flood events have better documentation than others. The total cost over time is not known because available records are incomplete or missing, and some damage is never reported. When a major flood occurs, exceeding the capacity of local and state resources to respond, the governor of Washington can request a disaster declaration. When a federal disaster declaration is made, federal funding may then be available to repair public infrastructure.

The flooding of February 1996 was the worst that Pierce County faced in modern times. Public agencies were the hardest hit in total damages initially reported to the Department of Emergency Management. Total cost for Pierce County, cities, towns, fire districts and other jurisdictions was estimated to be over $40 million, broken down into FEMA categories, as follows:

- Category A – Debris Clearance ($3.2 million);
- Category B – Protective Measures ($0.2 million)
- Category C – Road Systems ($19.7 million)
- Category D – Water Control (Flood Management) Facilities ($15.4 million)
- Category E – Public Buildings and Equipment ($0.2 million)
- Category F – Public Utilities ($1.1 million)
- Category G – Parks and other ($0.25 million)

Over 1,300 people in Pierce County requested assistance in the form of a Small Business Association loan or Individual and Family Grant. The estimated private property damage exceeded $5.4 million. Flooding throughout Washington was so severe that the President declared the state a disaster area on February 9 without the normal assessment, request, and consideration process (Memo from W. Lokey to County Executive Sutherland, Feb. 29, 1996).

Table 2.8 provides a summary of documented damage costs for large flood events in the last 20 years, including emergency assistance funds to local governments and public entities authorized under Section 404 of the Stafford Disaster Relief Act, total Individual Assistance (IA) funds to private parties in Pierce County, and Corps of Engineers funding for emergency response and PL 84-99 following the disaster declarations. In addition to the $59.4 million summarized in Table 2.8, there have been property and structure buyouts and acquisitions totaling $27,766,887 in the floodplains of the Puyallup, Carbon, White, and Nisqually rivers and South Prairie Creek since 1990. Sources of funds include federal Hazard Mitigation Grant Program funds, Washington state FCAAP funds, Pierce County REET and SWM funds, and Salmon Recovery Funding Board funds. This table does not show the millions of dollars of damage costs paid directly to private land owners or un-reported damage.

<table>
<thead>
<tr>
<th>Year</th>
<th>Disaster</th>
<th>Stafford Act Obligated Funds in Pierce County</th>
<th>Total Individual Assistance (IA) from FEMA in Pierce County</th>
<th>Corps of Engineers Funding (Emergency Response and PL 84-99 repairs and rehabilitation)</th>
<th>Disaster Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 1990</td>
<td>WA DR 852</td>
<td>N/A</td>
<td>N/A</td>
<td>$350,000</td>
<td>$350,000</td>
</tr>
<tr>
<td>Nov.-Dec. 1995</td>
<td>WA DR 1079</td>
<td>$386,830</td>
<td>$30,241</td>
<td>$2,500,000</td>
<td>$2,917,071</td>
</tr>
<tr>
<td>Feb. 1996</td>
<td>WA DR 1100</td>
<td>$18,760,197</td>
<td>$3,543,262</td>
<td>$3,500,000</td>
<td>$25,803,459</td>
</tr>
<tr>
<td>Dec. 1996 – Feb. 1997</td>
<td>WA DR 1159</td>
<td>$6,527,150</td>
<td>$830,501</td>
<td>$2,000,000</td>
<td>$9,357,651</td>
</tr>
<tr>
<td>Nov. 2006</td>
<td>WA DR 1671</td>
<td>$8,472,418</td>
<td>$1,284,246</td>
<td>$1,064,900</td>
<td>$10,821,564</td>
</tr>
<tr>
<td>Jan. 2009</td>
<td>WA DR 1817</td>
<td>$4,730,594</td>
<td>$1,529,007</td>
<td>$3,928,409</td>
<td>$10,188,010</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$38,877,189</strong></td>
<td><strong>$7,217,257</strong></td>
<td><strong>$13,343,309</strong></td>
<td><strong>$59,437,755</strong></td>
</tr>
</tbody>
</table>

*Not including damages to state or federal facilities*
2.4 PIERCE COUNTY PARTICIPATION IN THE NFIP COMMUNITY RATING SYSTEM

The National Flood Insurance Program (NFIP) was created in 1968 to address the rising cost of taxpayer funded disaster relief. The goal of the program is to decrease the amount of money the federal government pays in post-flood disaster relief by encouraging jurisdictions to reduce the risk to property owners through floodplain mapping, regulations, education and other programs. The NFIP is administered by the Federal Insurance Administration, which is part of the Federal Emergency Management Agency.

The NFIP provides the financial backing for flood insurance policies within participating communities, making them more affordable to private property owners. There is an incentive for jurisdictions to adopt standards that exceed the minimum standards of the NFIP by reducing the cost of flood insurance premiums within jurisdictions with higher standards. The NFIP makes available affordable flood insurance to communities that adopt approved floodplain management regulations that meet or exceed FEMA standards.

While participation in the NFIP is technically not required under federal law, it is highly impractical for Pierce County and other local governments to not participate in the program. This is because most federally-backed mortgage loans require the purchase of flood insurance and non-participating communities are not eligible for that insurance. Also, local jurisdictions are generally not eligible for federal assistance pursuant to Presidential Declared Disasters without being a NFIP participating community and having a good standing in the program. To continue flood insurance coverage, and be eligible for federal assistance, the County must remain in the NFIP and maintain and enforce minimum floodplain management regulations.

FEMA created the Community Rating System (CRS) as a reward for communities that do more than meet minimum NFIP requirements by taking actions to minimize flood losses and promote public awareness of flood hazards. Community participation in the CRS is voluntary. The CRS offers reduced insurance rates based upon the class rating of a community. The CRS contains ten classes. “Class 1” gives the greatest insurance premium reduction of 45 percent. A “Class 10” community receives no premium reduction. Pierce County entered the program in 1995 and was the first county in the nation to earn a “Class 5” rating and has continued to strive for even better ratings. Pierce County currently holds a “Class 2” rating, one of only three communities in the nation, which results in a premium reduction of 40 percent. Two cities in Pierce County also participate in the CRS program. The City of Fife entered the CRS program in 2006 and currently has a Class 5 rating, resulting in a 25 percent discount. The City of Orting entered the program in 2008 and has a Class 6 rating, resulting in a 20 percent discount.

Table 2.9 shows a breakdown of Pierce County’s 2011 CRS credit. Pierce County continues to strive to improve its program and rating under the CRS program. This will be aided by implementation of the Pierce County Rivers Flood Hazard Management Plan.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Maximum Possible Points⁵</th>
<th>Average Points Earnedᵇ</th>
<th>Pierce County Points Earnedᶜ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation Certificates</td>
<td>162</td>
<td>69</td>
<td>112</td>
</tr>
<tr>
<td>Map Information Service</td>
<td>140</td>
<td>138</td>
<td>140</td>
</tr>
<tr>
<td>Outreach Projects</td>
<td>380</td>
<td>90</td>
<td>238</td>
</tr>
<tr>
<td>Hazard Disclosure</td>
<td>81</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Flood Protection Information</td>
<td>102</td>
<td>24</td>
<td>95</td>
</tr>
<tr>
<td>Flood Protection Assistance</td>
<td>71</td>
<td>53</td>
<td>64</td>
</tr>
<tr>
<td>Additional Flood Data</td>
<td>1346</td>
<td>86</td>
<td>559</td>
</tr>
<tr>
<td>Open Space Preservation</td>
<td>900</td>
<td>191</td>
<td>232</td>
</tr>
<tr>
<td>Higher Regulatory Standards</td>
<td>2740</td>
<td>166</td>
<td>1495</td>
</tr>
<tr>
<td>Flood Data Maintenance</td>
<td>239</td>
<td>79</td>
<td>199</td>
</tr>
<tr>
<td>Stormwater Management</td>
<td>670</td>
<td>98</td>
<td>540</td>
</tr>
<tr>
<td>Floodplain Management Planning</td>
<td>359</td>
<td>115</td>
<td>219</td>
</tr>
<tr>
<td>Acquisition and Relocation</td>
<td>3200</td>
<td>213</td>
<td>300</td>
</tr>
<tr>
<td>Flood Protection</td>
<td>2800</td>
<td>93</td>
<td>95</td>
</tr>
<tr>
<td>Drainage System Maintenance</td>
<td>330</td>
<td>232</td>
<td></td>
</tr>
<tr>
<td>Flood Warning Program</td>
<td>255</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Levee Safety</td>
<td>900</td>
<td>198</td>
<td></td>
</tr>
<tr>
<td>Dam Safety</td>
<td>175</td>
<td>66</td>
<td>63</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>14,850</strong></td>
<td><strong>2,023</strong></td>
<td><strong>4,459</strong></td>
</tr>
</tbody>
</table>

⁵ Maximum possible points based on 2006 CRS Coordinator’s Manual
ᵇ Average points earned are based on communities’ scores as of May 1, 2005
ᶜ Blanks indicated that Pierce County did not seek credit for these activities
CHAPTER THREE
FLOOD HAZARD MANAGEMENT POLICIES

This chapter contains flood hazard management policies, which along with the goals and objectives provide a framework for the river management strategies, programmatic and capital improvement recommendations in this Plan. The 1991 Puyallup River Basin Comprehensive Flood Control Management Plan, the comprehensive flood plan for Pierce County, does not contain policies. Therefore, all policies contained within the Pierce County Rivers Flood Hazard Management Plan are new. They were developed and analyzed in consultation with the Flood Plan Advisory Committee. All policies strive to be consistent with Pierce County’s flood hazard regulations and other local, state, and federal regulations. Some policies are developed from related polices contained within the Comprehensive Plan for Pierce County, Washington (Comprehensive Plan) (see Chapter 1).

Other policies will revise policies in the Utilities Element of the Comprehensive Plan. The policies contained within this Flood Plan encourage cooperative and consistent floodplain management among towns, cities, counties, and special districts as advocated by Chapter 86.12 RCW. Actions taken by one jurisdiction can have adverse effects upon neighboring jurisdictions. Filling of the floodplain in one area frequently transfers the flood hazard risk to other areas and other jurisdictions and their citizens. Consistent approaches to flood hazard management across jurisdictions can reduce such adverse effects.

The policies that follow are written to reflect the level of discretion local governments have in making floodplain management decisions. Use of the term ‘shall’ or ‘will’ implies that the policy is to be interpreted as mandatory or nondiscretionary. The use of ‘should’ or ‘may’ in a policy indicates guidance and a greater level of discretion in making decisions based on the policy.

Policies in this chapter are divided into five categories within the following subsections: 3.1 General; 3.2 Project; 3.3 Floodplain Land Use; 3.4 Flood Warning andEmergency Response; and, 3.5 Funding.

3.1 GENERAL POLICIES

1. Geographic Scope – Pierce County will coordinate and provide regional flood hazard management services on major rivers, including the Puyallup, White, Carbon and Nisqually Rivers, and tributaries with historical peak flows over 5000 cubic feet per second (Greenwater and Mashel rivers, South Prairie Creek).

2. Flood and Channel Migration Risks – The natural processes of flooding and channel migration become risks when human development is located within flood hazard areas. Flood and channel migration risks, and the consequences that would result, are generally prioritized in the following order: (1) threats to public safety; (2) impacts to the local and regional economy; (3) damage to public infrastructure; and, (4) damage to private structures.
3. River and Flood Hazard Management Approach – Pierce County will implement projects and programs for river and flood hazard management that result in multiple benefits, including the following non-prioritized objectives:
   a. Meet site and reach-specific flood and channel migration risk reduction needs;
   b. Achieve quantifiable benefits that exceed total costs of projects and programs, including long-term maintenance costs;
   c. Avoid creation of new flood and channel migration risks;
   d. Balance natural processes of river migration and flooding with protection of productive agricultural lands;
   e. Protect and improve aquatic and riparian habitat and ensure consistency with the Endangered Species Act and salmon recovery programs; and
   f. Leverage flood hazard management revenues through partnerships with other agencies and stakeholders.

4. Inter-County River Improvement Agreement – Pierce County should collaborate with King County to renew the Inter-County River Improvement Agreement to address flood hazard management activities for the lower White and lower Puyallup River systems.

5. Inter-Governmental Coordination and Cooperation – Pierce County’s flood and channel migration hazard management activities will be planned and implemented in close cooperation with cities, counties, tribes, state and federal agencies (e.g., resource agencies, public agencies with infrastructure), and salmon recovery lead entities.

6. Climate Change – Project design and program management should reflect best available science regarding the anticipated changes in precipitation patterns and associated changes in flood flows and sediment transport as a result of climate change.

3.2 PROJECT POLICIES

Projects can be structural, non-structural, or a combination of the two. The following project policies guide the project cycle, from initial concept through design and construction, to post-project monitoring and adaptive management. Structural projects consist primarily of maintaining, repairing, relocating, retrofitting, and new construction or setback of revetments, levees, and associated structures. Non-structural projects include property acquisition, elevation of flood-prone homes, sediment, and large wood management, and the removal of existing structures that no longer serve a flood management purpose. Although regulations are non-structural, they are addressed in sub-section 3.3 Floodplain Land Use Policies.

1. Prioritizing Flood Hazard Risks – Pierce County should prioritize actions to address flood and channel migration risks using the following criteria in order of importance:
   a. The consequences that will result if no action is taken. Consequences should be prioritized as identified in General Policy #2 and in terms of probability of occurrence and severity;
   b. Legal responsibility and authority, as determined by a contractual relationship, between Pierce County and another agency or person(s) to maintain a flood risk reduction facility;
c. Urgency, as measured by how quickly an action needs to be taken in order to prevent a risk from growing worse; and
d. Readiness of the project in terms of funding, partnerships, resolved property issues, or permitting.

2. Property Acquisition – Property acquisition for flood risk reduction projects should be on a willing-seller basis. However, as risks are identified and prioritized there will be circumstances when a compelling public interest makes condemnation necessary.

3. Easements\textsuperscript{49} – New or additional easements necessary to construct, maintain, repair, or retrofit a flood protection facility should be sufficient to meet applicable Pierce County design and construction standards and federal and state technical guidelines.

4. Management of Pierce County Properties – Pierce County will manage its public lands and easements within flood hazard areas in accordance with the policies in this Plan. Public access to publicly-owned flood risk reduction facilities should be allowed on a case-by-case basis provided that such access does not interfere with the performance of any infrastructure and after evaluating issues such as public value, cost, and public safety.

5. Flood and Channel Migration Risk Reduction Goals – Flood risk reduction facilities designed to contain floodwaters (e.g., levees), or reduce channel migration (e.g., revetments) should be designed to be consistent with the adopted river reach management strategy. Four flood protection levels for levees include:
   a. 200-year design, plus three feet of freeboard;
   b. 100-year design, plus three feet of freeboard;
   c. Maintenance of existing (2009) conveyance capacity; and
   d. Maintenance of existing levee prisms.

Two erosion protection levels for revetments include:
   c. Channel migration prevention design, and
   d. Channel migration resistance design.

Deviations from the level of protection shall be approved by the manager of the Surface Water Management Division.

6. Facility Design and Maintenance Objectives – Pierce County should construct new flood risk reduction facilities and maintain, repair or replace existing facilities in such a way as to achieve each of the following:
   a. Minimize maintenance costs over the life cycle of the facility;
   b. Ensure that flood or channel migration risks are not transferred to other sites; and
   c. Protect and improve aquatic and riparian habitat.

\textsuperscript{49} Easement – The legal right to use a specified piece of land for a particular purpose.
CHAPTER 3: FLOOD HAZARD MANAGEMENT POLICIES

7. **River Management Facility Setbacks** – Pierce County will identify opportunities to set back existing river management facilities farther from the river edge and associated buffers to increase flood conveyance and storage, reconnect previously disconnected floodplain, improve aquatic habitat, and allow natural riverine processes to occur.

8. **Pierce County Sponsored Projects** – Pierce County sponsored projects located in flood hazard areas shall be consistent with policies in the Pierce County Rivers Flood Hazard Management Plan and meet or exceed the standards adopted in the Pierce County Code to implement those policies.

9. **Adaptive Management** – Flood hazard management projects shall be monitored to assess the degree to which they function relative to their stated purpose, performance goals and objectives. Adaptive management principles shall be used to manage projects over time, identify needed changes, and inform the design and implementation of future projects.

10. **Large Woody Material** – Naturally occurring accumulations of large woody material may be repositioned, relocated, or removed for flood hazard management purposes if one or more of the flood and channel migration risks in General Policy #2 above is present, all reasonable flood and channel migration risk reduction alternatives have been considered, and there is an imminent threat. Repositioning, relocation, or removal of large woody material should be done in a manner that does not create new flood or channel migration risks, and be accomplished using techniques that result in the least disturbance to the river channel and aquatic habitat while preserving the function of the large woody material.

11. **Comprehensive Sediment Management** – Comprehensive sediment management in Pierce County shall be informed by technical sediment transport studies and consider the highly variable nature of sediment transport to achieve a balance between flood risk reduction and ecological health.

12. **Gravel Removal** – 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.

13. **Levee Certification** – Pierce County should seek accreditation and certification of new 100- and 200-year levees, or re-certification of existing levees, through FEMA and the Army Corps of Engineers.
3.3 FLOODPLAIN LAND USE POLICIES

This sub-section contains policies to guide land use planning and development regulations in floodplains and channel migration hazard areas.

Pierce County floodplains contain a complex matrix of lands governed by Pierce County, cities, and towns. Because the actions of one jurisdiction has the potential to adversely affect the frequency, duration, or magnitude of flood hazards in downstream, upstream or adjacent jurisdictions, the policies in this section are intended to promote greater consistency of regulations across floodplain jurisdictions.

1. **Consistent Regulatory Standards** – Pierce County supports consistency in flood hazard regulations across jurisdictions. Cities and towns should adopt policies and regulations that are consistent with Pierce County critical area regulations for flood hazard areas, and regulate according to the best available data, such as updated flood studies.

2. **National Flood Insurance Program** – Pierce County and cities and towns with floodplains should participate and maintain good standing in the National Flood Insurance Program and its Community Rating System in order to better protect public safety, reduce the risk of flooding and channel migration hazards to existing public and private property, and achieve flood insurance premium discounts.

3. **Urban Growth Area Expansion** – Prohibit expansion of urban growth areas into 100-year floodplains of any river or river segment within the geographic scope of this flood plan, except as allowed by RCW 36.70A.110.

4. **Development in the Floodway** – Prohibit new residential and non-residential structures within the FEMA floodway, severe channel migration zone (CMZ) floodway, and deep and fast flowing water (DFF) water floodway, except as allowed by PCC 18E.70.040. Definitions for these floodways should be consistent across jurisdictions.

5. **Zero-Rise** – The placement of structures or fill is allowed in the floodplain only if they would not cause an increase in elevation of the 100-year flood by more than 0.001 foot.

6. **Compensatory Storage** – Preserve the existing flood storage volume of the floodplain by replacing floodplain storage volume that is eliminated by structures or fill by excavating to provide live storage volume equal to or greater than that which is displaced. Options to achieve this could include removal or relocation of existing structures and associated fill, or by setting back levees. Provide the live storage

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50 **Deep and Fast Flowing Water** – A combination of water depth and/or velocity, as shown in the graph in Pierce County Code Section 18E.70, that can be dangerous to walk or drive through and can cause structural failures. For the purposes of Title 18, Pierce County considers deep and/or fast-flowing water to be a floodway area.

51 **Fill** – Earth, sand, gravel, rock, asphalt, or other solid material placed to raise the ground elevation or to replace excavated material.
7. **Critical Facilities** – Locate critical facilities outside of the 500-year floodplain unless no feasible alternative exists. If no feasible alternative exists, elevate critical facilities to or above the higher of the 500-year flood elevation\(^{52}\) or 3 feet above the 100-year base flood\(^{53}\) elevation and locate as to allow for planned future levee setbacks.

### 3.4 FLOOD WARNING AND EMERGENCY RESPONSE POLICIES

The policies within this sub-section provide guidance to Pierce County’s coordination of emergency response and recovery activities, communication of important flood information to public and private audiences, and coordination between government agencies, jurisdictions, and other entities in conjunction with a flood event.

1. Pierce County should provide regional flood information and notification services during flood events supplemental to the National Weather Service.
2. Pierce County will coordinate regional flood emergency response and recovery services during and after flood emergencies through the Emergency Operations Center and Pierce County Emergency Management Department.
3. Before and during expected flood events Pierce County may provide sand bags and sand when available to Pierce County fire districts and city and town public works departments. Citizens may request them from the individual fire district or city/town public works departments. Property owners are responsible for placing sandbags and cleaning up sandbags after the flood event, and meeting any regulations relating to sandbagging activity.
4. Pierce County will coordinate with the National Weather Service, cities and towns, police and fire departments, and other entities as needed (e.g., Army Corps of Engineers, Mt. Rainier National Park, Tacoma Public Utilities, tribes and the military) to improve flood warning and emergency evacuation procedures.

### 3.5 FUNDING POLICIES

The policies within this sub-section provide funding guidance for Pierce County’s flood risk reduction projects and programs. Funds are typically provided from a variety of sources, including Surface Water Management fees, Real Estate Excise Tax, and other leveraged state

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\(^{52}\) **Flood Elevation** – Height of flood waters above an elevation datum plane.

\(^{53}\) **Base Flood** – The flood having a one percent chance of being equaled or exceeded in any given year, also referred to as the “100-year flood.” The base flood surface water elevation is measured in feet above mean sea level and referenced to the National Geodetic Vertical Datum of 1929 (or the most current vertical datum accepted by Pierce County).
and federal grant and disaster assistance funds. New or expanded regional funding sources are discussed in more detail in chapters 4 and 6.

1. **Regional Funding** – New or expanded regional funding sources should be identified and secured to meet the need for enhanced or expanded flood and channel migration hazard management projects, maintenance, and programs. An example of this would be the formation of a Flood Control Zone District.

2. **Fiscal Management** – Pierce County and partner jurisdictions and agencies should ensure that adequate funds for annual maintenance and operations, capital projects, and contingency funds are budgeted to meet program needs.

3. **Grant Funding** – Pierce County, cities/towns in Pierce County, and other local government agencies should identify, evaluate, and coordinate grant fund sources to determine their suitability and assess consistency with the goals and objectives of this plan, and apply for grants to leverage local sources of funding for flood risk reduction projects.
## Programmatic Recommendations

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## Programmatic Recommendations

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CHAPTER FOUR
PROGRAMMATIC RECOMMENDATIONS

This chapter focuses on programmatic recommendations and non-structural actions to reduce the associated risks of flooding and channel migration problems along the major rivers and streams in Pierce County. Once adopted, these recommendations will become the goals, policies, and objectives used to implement the Flood Plan. The recommendations include programs such as mapping of hazards, technical assistance, public education and outreach, flood warning and emergency response, monitoring, facility maintenance, sediment and wood management, as well as land use and regulations to reduce future risks. Some programmatic recommendations bear directly on capital projects such as river management strategies, levels of protection, the levee setback program, and roads and bridges. Recommended programs address the goals, objectives, policies of Chapter 3, and problems found in the Flood Plan, including:

- **Flood Hazard Information, Mapping, and Technical Assistance.** This includes: (1) floodplain and channel migration zone mapping, (2) flood insurance rate maps, and (3) providing technical assistance on floodplain information to internal and external customers. Also included is participation in the National Flood Insurance Program’s Community Rating System.

- **Regulations and Management of Land Uses.** This includes: (1) achieving greater consistency of flood hazard area regulations between Pierce County, cities and towns, (2) limiting expansion of Urban Growth Areas into the 100-year regulatory floodplain, (3) supporting agricultural activities in the floodplain, (4) acquiring floodplain properties to remove flood-prone structures, or prevent new flood risks, and (5) structure elevation or floodproofing of commercial structures to reduce future flood risks.

- **River Channel Management.** This includes: (1) monitoring of river channel conditions, (2) managing large woody material, and (3) sediment management and gravel removal.

- **Flood Risk Reduction Facility Repair and Maintenance.** This includes: (1) participating in the USACE of Engineers’ public law (PL) 84-99 program for emergency response activities and rehabilitation of facilities, and (2) routine repair and maintenance, including vegetation management.

- **Flood Education, Flood Warning and Emergency Response.** This includes: (1) flood education and outreach, and flood preparedness, (2) flood warning and evacuation system, and (3) emergency response and flood fighting.

- **Coordination, Adaptive Management, and Multiple Benefits.** This includes: (1) achieving incidental take authorization, (2) incorporating adaptive management

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54 **Floodproof** – Structural provisions or adjustments to nonresidential buildings for the purpose of eliminating flood damages to those structures, including their utilities and contents.
principles in implementation, (3) planning for climate change, (4) incorporating habitat and riparian areas mitigation, (5) improving public access to rivers, (6) minimizing water quality impacts from flooding, (7) coordinating with other jurisdictions, tribes and agencies, (8) renewing the Inter-County River Improvement Agreement.

- **Implementation of Capital Projects** (see also Chapter 5). This includes: (1) establishment of river reach management strategies and levels of protection, (2) enhancing the levee and revetment setback program, (3) performing additional capital project analysis, and (4) incorporating road and bridge design improvements to reduce flood risks.

Each of the programmatic recommendations is presented with a description of the problem being addressed, as well as background and other supporting information. Recommendations are numbered and apply either “flood plan-wide” (FPW), or to a specific river system (e.g., Puyallup River (PR)). The specific recommendation language was agreed upon by the Flood Plan Advisory Committee. Use of the term ‘shall’ or ‘will’ implies that the recommendation is to be interpreted as mandatory or nondiscretionary. The use of ‘should’ or ‘may’ in a recommendation indicates guidance and greater level of discretion for that recommendation.

The costs of implementing the programmatic recommendations vary due to the number of full-time equivalents to implement a program element, lump sum costs, and whether costs are annual, one-time, or for example, once every five years or during/following a flood event. The estimated total cost annually is between $2.3 and $3.4 million with additional one time project costs varying between $2.2 and 2.5 million. See Section 6.4 and Appendix J for more detail.
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS

PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

4.1 FLOOD HAZARD INFORMATION, MAPPING AND TECHNICAL ASSISTANCE

4.1.1 Floodplain Mapping

**Problem Description**

Flood hazard studies and associated mapping provide critical baseline information for flood hazard management and flood risk reduction. Modeling of watershed hydrology and river channel hydraulics is the essential first step in characterizing river channel conditions, delineating flood hazard areas, and developing floodplain maps. This information is then used to inform land-use decisions, regulate existing and proposed floodplain development, and to evaluate and design flood hazard management projects.

If maps are outdated and no longer reflect actual floodplain conditions, there is a high likelihood that land use decisions and new development will be allowed that put property and people in flood-prone areas. Inaccurate maps can also put unnecessary building restrictions on parcels that are mapped as flood prone, but are not in a floodplain.

Generating updated hydrologic and hydraulic information is very expensive, necessitating decisions about which river systems are higher priority areas, the type of modeling needed, and degree of change since previous updates.

**FPW #1 – Floodplain Mapping**

**Recommendations**

1. FEMA should approve the countywide preliminary Digital Flood Insurance Rate Maps (DFIRM) completed under the Map Modernization Program. Communities in the floodplain should adopt the updated maps upon approval and publication by FEMA.

2. FEMA and Pierce County should update flood studies and floodplain maps for the Nisqually, lower and upper White and Greenwater rivers using updated hydrologic and hydraulic information, channel, and topographic data, and incorporated into the DFIRM.

3. Pierce County should periodically, but not less than once every 10 years, evaluate the need for flood study updates on each system, including changes in channel and floodplain conditions and changes in watershed hydrology and development (public and private projects). Pierce County should notify FEMA and Ecology that a revision to the flood study and maps is needed when inaccuracies are identified or if hydrologic and hydraulic characteristics have significantly changed, making existing mapping outdated.

4. Upon publishing of updated DFIRM maps by FEMA and adoption by local governments of revised floodplain maps, property owners located in the mapped floodplain should be alerted about new maps.

5. Pierce County should take a central role in the review, approval, and publication of all map amendments including FEMA’s letters of map change (LOMC) process.

6. Pierce County should continue as a Cooperating Technical Partner (CTP) in FEMA’s cost-sharing program for floodplain mapping.
Supporting Information

4.1.1.1 Flood Hazard Mapping

Flood hazard mapping is created by plotting estimated flood elevations generated in a hydraulic analysis onto a topographic map of the river valley. Typically, flood hazard mapping maps the extent of water inundation for the one (1) percent annual chance flood (100-year flood event or base flood), and the 0.2 percent annual chance flood (500-year flood event). Federal Emergency Management’s (FEMA) National Flood Insurance Program (NFIP) established the 100-year standard for floodplain mapping as a minimum standard for regulatory and insurance purposes.

Another significant component of a flood hazard analysis is mapping of the FEMA floodway. The FEMA floodway is the river channel and that portion of the adjoining floodplain that is necessary to contain and discharge the base flood flow without increasing the base flood elevation by more than one foot. This establishes the outer boundary of the FEMA floodway, which is typically the deep and rapidly moving water within a floodplain that is most hazardous. Figure 4.1 shows a typical cross section of the floodplain, floodway, and Base Flood Elevation (BFE).

![Figure 4.1 – Floodplain, floodway and base flood elevation cross-section](image)

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55 **Floodway** – The channel of a river and the adjacent land areas that must be reserved in order to convey and discharge the base flood without cumulatively increasing the water surface elevation by more than one foot, those areas designated as deep and/or fast-flowing water, and Channel Migration Zones where detailed CMZ studies have been adopted by Pierce County. No filling or development is allowed in the floodway.

56 **Base Flood Elevation (BFE)** – The water surface elevation, measured in feet, above the mean sea level for the base flood and referenced to a vertical datum accepted by Pierce County (North American Vertical Datum of 1988 – NAVD88 or National Geodetic Vertical Datum of 1929 – NGVD29); the elevation which is the basis of the insurance and floodplain management requirements of the National Flood Insurance Program.
4.1.1.2 FEMA Map Modernization Program

FEMA’s flood map modernization program was a multiyear initiative directed at improving and updating the Nation’s flood hazard identification maps. The Map Modernization Program sets goals to reduce the age of flood maps, produces digital maps for high priority areas, develops flood maps for previously unmapped communities, and encourages states and communities to share the costs of flood mapping. Cost sharing occurs through FEMA’s Cooperating Technical Partner (CTP) Program, which also incorporates the community’s local knowledge and data into the mapping, resulting in more accurate and representative information. Pierce County joined the CTP program in September 1999 and has undertaken remapping on several rivers in the County.

FEMA intends to complete map modernization efforts in Pierce County by 2011. Updated maps were generated from data and information that reflects more recent USGS gauging data, topographic mapping data, as well as changes in stream bed conditions, and watershed development. Although Pierce County received more federal funding for FEMA’s map modernization program than all other counties in Region X, it has not been enough to complete mapping in all areas with identified needs. Of the seven major rivers in the flood plan planning area, maps are being updated with new detailed studies as follows:

- Puyallup River (downstream of Electron/ RM 29.5) (see Figure 4.2 for an example near Orting),
- White River (downstream of county line / RM 5.5)
- Carbon River (downstream of 177th St. E./ RM 8.3)
- South Prairie Creek (downstream of eastern city limit/RM 6.2), and
- Mashel River (from Little Mashel River upstream 2.3 miles including Eatonville)

In Pierce County, flood insurance mapping studies on the major rivers were carried out by Northwest Hydraulics Consultants, Inc. under contract with FEMA. For each of these studies, new topographic mapping, river channel cross-section data, and hydrologic and hydraulic analyses were used to provide the best available technical information.

The results of these studies and draft floodplain maps represent the best available technical data and information for areas which are not covered by an updated FEMA map. Pierce County code provides for use of this best available technical data and information in the absence of an adopted FEMA map when regulating development.
4.1.1.3 Future Mapping Needs

The Nisqually, Greenwater, and upper White rivers are not included in those systems being updated for Flood Insurance Studies as part of the map modernization program. The Nisqually River was last mapped over 24 years ago as part of the 1987 FEMA study in Pierce County. Since the last maps were created several large flood events occurred in 1996, 2006, and 2009. These floods resulted in damage to areas outside the FMEA mapped areas. Flood map updates are needed for both the Elbe/Ashford area in upper Nisqually and the McKenna area in middle Nisqually.

![Figure 4.2 – Example of floodplain in (dark blue) and floodway (light blue hatched) near Orting.](image)

To update the flood hazard mapping, ground surveys should be carried out to obtain cross-sections within the main channel of the river; key hydraulic features (e.g., bridge crossings, grade breaks) should be surveyed; and LiDAR data covering the floodplain should be used for topography. Hydrologic and hydraulic models should be updated using additional USGS gauge information and other channel and floodplain characteristics noted above. The lower portion of the Greenwater River and the upper White River should also be mapped to identify the 100-year floodplain. Similar data should be collected, as noted for the Nisqually River.

4.1.2 Channel Migration Zone Mapping and Regulation

Problem Statement

Pierce County experiences two major types of hazards associated with flooding: flood inundation and channel migration. Floodplain maps published by FEMA show inundation areas, but there is no equivalent map developed by FEMA for areas at risk of channel migration. Channel migration zone (CMZ) maps are needed for Shoreline Master Plan and ESA compliance.
The CMZ refers to the geographic area where a stream or river has been and is susceptible to channel erosion and/or channel occupation (Rapp and Abbe 2003). CMZ delineations help reduce risks to communities by making homeowners and potential home buyers and builders more aware of risks. Risk is also reduced by regulations guiding development in and along river systems away from areas at severe risk of channel erosion. CMZ delineations can provide guidance in reducing degradation and loss of critical aquatic and riparian habitats, helping assure that the river landscape is not permanently degraded or disconnected from the river by development. Because alluvial channels are rarely static, rivers and streams naturally migrate within their valleys. Preserving a wider river corridor eliminates pressure on the County to perform expensive, sometimes futile, efforts to eliminate or reduce the natural channel migration process.

### FPW #2 – Channel Migration Zone Mapping and Regulation

#### Recommendations

1. Pierce County should adopt the channel migration zone (CMZ) studies and maps for South Prairie Creek (2005) and upper Nisqually River (2007) areas.
2. Pierce County should map CMZ hazards on the Greenwater River, upper White, middle Nisqually, and Mashel Rivers. Upon completion, these CMZ maps should be adopted.
3. Pierce County should continue to regulate the severe channel migration zone of adopted CMZ maps the same as FEMA floodways (PCC 18E.70)
4. Pierce County should develop a process to evaluate levees and revetments to assess the level of resistance the facility provides against channel migration.
5. CMZ mapping should be revised and adopted to reflect significant changes in risks as they are identified. Changes in risk could include decreased risk based on an evaluation of a levee or revetment that limits channel migration or an increased risk based on new geomorphic or geological information that was not known at the time of the original study.
6. The cities and towns along the Puyallup, White, and Carbon Rivers, and South Prairie Creek should adopt the existing CMZ maps and regulate severe channel migration zones as floodway.
7. Pierce County should pursue a mechanism for notifying existing and potential future property owners about channel migration hazards.

### Supporting Information

#### 4.1.2.1 Channel Migration Zone Mapping

Channel migration zone studies and maps provide critical baseline information necessary to understand the effects of potential river migration on hazards in river valleys. While most of the major rivers in Pierce County are confined by levees and revetments, there are many river reaches that still are subject to potential future channel migration. Levees or revetments on major rivers continue to be damaged by erosion associated with channel migration. Because of the risks to public safety and the high cost associated with construction and maintenance of flood risk reduction facilities, the County’s approach in severe channel migration hazard areas is to restrict development. Channel migration hazard mapping and the adoption of land-use...
regulations to prevent development in these areas reduces risks associated with migrating river channels and can lead to improved environmental health.

Issues related to channel migration and associated development restrictions have proven confusing and unpopular to citizens who reside within mapped CMZ areas. In 2009 a Citizen Advisory Committee was convened by the County Council to make recommendations about CMZ mapping, regulations, and notification. Surface Water Management staff assisted the committee with technical information and administration. The committee developed recommendations, included as Appendix I, and SWM staff developed a Staff Report, also included as Appendix I, which supported some but not all of the recommendations.

Elements of three of the Citizen Advisory Committee’s recommendations were supported by SWM:

1. Existing levees and revetments should be evaluated to determine which facilities provide sufficient resistance to channel migration to warrant revisions to the CMZ mapping.
2. Property owners living near rivers should be notified of CMZ-related regulation changes.
3. Channel migration hazards should be noted on a property’s permanent record through notice on the Assessor-Treasurer’s website or other means.

4.1.2.2 Channel Migration Zone Studies in Pierce County

To address concerns about channel migration, geomorphic evaluations and channel migration zone analyses, and CMZ mapping have been carried out on sections of five of the major rivers systems as follows:

- Puyallup River from River Mile (RM) 10.0 to RM 28.8
- White River from RM 0.0 to RM 5.5
- Carbon River from RM 0.0 to RM 8.3
- South Prairie Creek from RM 0.0 to RM 5.8, and
- Upper Nisqually River from about RM 50.5 to RM 68.6

The CMZ mapping identifies severe, moderate, and low Migration Potential Areas (MPAs) within the CMZ (see Figure 4.3). The approach to identifying the CMZ boundaries and the three MPAs (severe, moderate, low) involve four major elements: (1) data collection and review, (2) geographic information system data preparation, (3) geomorphic evaluation, and (4) CMZ and MPA delineation. In preparing these studies and maps, Pierce County used information on historical channel locations (primarily aerial photography), geology, basin hydrology, current channel conditions, sediment transport, composition of bank and bed material, potential avulsion sites, and channel migration rates to characterize the channel migration zones.

Pierce County identifies three levels of risk, the severe, moderate, and low CMZs, and regulates the severe CMZ as a floodway under Title 18E.70. For example, the severe CMZ on the Puyallup
River is where the river could migrate in five years. Title 18E.70.020 (Flood Hazard Areas) notes that CMZs on regulated watercourses (South Prairie Creek, Carbon, Puyallup, White, Greenwater, Nisqually, and Mashel rivers) will be regulated when CMZ studies are completed, accepted and adopted by Pierce County, except for the lower Puyallup River (downstream of the confluence with the White River), where the default CMZ shall be the regulated FEMA floodway.

The CMZ maps for the Puyallup, White, and Carbon Rivers were completed and accepted in 2003 and adopted by the Pierce County Council in 2005. The severe CMZ for these three rivers are regulated as a floodway. The CMZ maps in South Prairie Creek and upper Nisqually River were completed and accepted in 2005 and 2007, respectively, but have not been adopted. Severe CMZs in these areas are not being regulated. The upper White, lower and middle Nisqually, Greenwater, and Mashel rivers CMZs have not been studied or mapped.

![Figure 4.3](image_url)

**Figure 4.3** – Severe, moderate and low channel migration zone potential in the Alderton-McMillan reach of the Puyallup River.
4.1.3 Technical Assistance on Floodplain Information

Problem Description
Knowledge of flood hazard and channel migration risks is critical for landowners and property developers to make informed decisions about new construction. In addition, local jurisdictions and other agencies with infrastructure need better information to make informed decisions. Without technical assistance, there is a higher risk of decisions being made without updated or complete information.

FPW #3 – Technical Assistance on Floodplain Information

<table>
<thead>
<tr>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pierce County Public Works and Utilities, Surface Water Management Division (SWM) should continue a high level of technical training for staff to remain subject matter experts and a regional resource for local communities in flooding and channel migration issues.</td>
</tr>
<tr>
<td>2. Pierce County SWM and Planning and Land Services will provide information and technical assistance to help public and private entities, and local jurisdictions make land use decisions that minimize flood-related risks.</td>
</tr>
<tr>
<td>3. Pierce County SWM should participate in the assessment and review of repairs or new construction of roads, bridges, regional trails, parks and other public infrastructure that may be adversely affected by river and flood hazards to ensure that regulations are interpreted correctly. Flood hazard policies and information should be used to inform the project design and construction methods associated with repair or improvements to these facilities.</td>
</tr>
<tr>
<td>4. Pierce County SWM will work with those involved in the use and management of agricultural, recreational, and open space lands in floodplains and river corridors to ensure that land uses remain compatible with the natural storage and conveyance of flood waters.</td>
</tr>
</tbody>
</table>

Supporting Information

4.1.3.1 Floodplain Technical Assistance and Consultation
Pierce County SWM and Planning and Land Services can help public and private entities make informed land use decisions to reduce flood- and channel migration zone-related risks with a range of technical assistance and consultation. This includes sharing expertise in hazard identification techniques, interpreting flood hazard data, maps, and regulations and by reviewing and coordinating planning and design efforts that are adversely affected by flood hazard areas.

Pierce County has worked closely with FEMA, USGS, and consultants to expand the coverage and improve the accuracy of flood- and channel migration zone-related studies and maps that delineate flood hazards and channel migration zones along the major rivers in Pierce County. Sharing this knowledge with other jurisdictions in Pierce County, agencies, tribes and private individuals can reduce the public cost of flooding and channel migration zone impacts and improve the consistency in the management of flood hazards. Completed and published flood
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS

and channel migration zone studies and maps are located at Pierce County SWM and on the SWM website.

4.1.3.2 Review and Coordination in Flood Hazard Areas and Multiple Beneficial Uses

Functioning river and floodplain systems provide vital ecosystem services and values to society including but not limited to: recreational opportunities, clean water, wildlife habitat, scenic values, and clean air. Portions of Pierce County’s rivers and floodplains also support a variety of land uses and human activities with varying degrees of compatibility and associated risks. For example, roads and bridges are often unavoidably located within flood hazard areas. Residential, commercial, and industrial developments historically occurred in flood hazard areas, particularly in the lower Puyallup River, lower White River, and Orting areas. Agricultural uses, open space and trail corridors are also common in floodplain valleys and along rivers. In the absence of human activities and land uses, rivers and floodplains support habitat forming processes for aquatic and terrestrial fish and wildlife, some of which are protected by state and federal endangered species legal mandates. To minimize impacts from human activities and land uses to the natural functions of rivers and floodplains, it is often desirable to consult and coordinate in decisions related to zoning, planning, and design in flood hazard areas to maximize overall benefits in a cost-effective manner. This ensures that public safety is achieved and beneficial public uses and values are preserved to the greatest extent possible for current and future generations.

4.1.3.3 Roads and Bridges

Many state highways and some arterials cross or parallel rivers in floodplain valleys. Sometimes roads are built atop river levees such as along River Road and North Levee Road adjacent to the lower Puyallup River. In other cases, roads parallel the rivers such as Orville Road along the upper Puyallup River. When the roads are built too close to the rivers, the natural process of bank erosion and channel migration can threaten or undermine the road, requiring extensive armoring of the stream banks and ongoing maintenance. Where feasible consideration should be given to setting back the levee or revetments, and in some instances alignment of the road itself, to achieve more conveyance capacity, extend project design life, and improve aquatic and riparian habitat.

Technical assistance can be provided to help design for flood conveyance, changes in channel conditions and bridge clearance requirements. The approaches of bridges and mid-span bridge piers can adversely impact flood conveyance, overtopping of levees and stream banks, and the passage of woody debris during flood events. This can lead to increased flooding and backwater conditions that threaten upstream uses. Design of new or replacement roads and bridges should consider these conditions and look for opportunities to minimize future flooding and channel migration concerns by designing the facilities to accommodate riverine processes. Design of road and bridge projects should be reviewed with these considerations in mind.

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Ecosystem – A biological community together with the chemical and physical environment with which it interacts.
4.1.3.4 Residential, Commercial and Industrial Development

The construction of residential, commercial, and industrial structures in the floodplain put people and properties at risk during flood events. Many such structures already exist and new development may occur in floodplains and floodways, if allowed by local governments. Because these developments can affect the people who use them, as well as upstream and downstream properties and other floodplain functions, it is important that new or improved structures be designed to minimize flood risk while protecting other important uses of the floodplain and river corridor. Technical assistance to private property owners can include review of new development proposals, provision of information about specific flood hazards on private parcels, and guidance or review of private bank stabilization projects.

4.1.3.5 Agriculture, Recreation, and Open Space Uses in Floodplains

Agricultural, recreational, and open space land uses are often the most compatible uses in floodplains. They contain fewer structures at risk. Additionally, these land uses can often be managed to maintain the flood storage and flow conveyance capacity of floodplains. Partial flooding of agricultural property may occur frequently, and can be accommodated as part of the seasonal pattern of farming activities. Conversely, excessive flooding and sediment deposition can make farming less viable in some areas. Because farming is common in the middle and upper Puyallup and Carbon River valleys and South Prairie Creek, river and floodplain management decisions must balance the needs of agricultural activities with actions which reduce flood hazards while improving floodplain storage capacity for floodwaters.

Many parks, golf courses, and regional trails in flood hazard areas experience occasional flooding, which can cause temporary impacts and result in maintenance needs. However, these areas can also serve an important flood hazard mitigation function by providing a relatively safe temporary storage location for flood waters during flood events. Coordination between jurisdictions, departments, and agencies is important to ensure that compatible recreational uses and activities in floodplains are well designed to meet both recreational and flood hazard management needs. Open space lands also provide opportunities for improving the flood storage and conveyance capacity of the river system through levee setback projects and other river and floodplain reconnection actions. Additional public benefits associated with managing open spaces to maximize flood risk reduction outcomes include: the provision of passive recreational opportunities, scenic and aesthetic values, preservation of aquatic and riparian habitat, and restoration of river and floodplain habitat for the recovery of threatened or endangered species.

4.1.4 Flood Insurance and the Community Rating System

Problem Description

Standard homeowners or business insurance do not cover flooding. High risk areas for flooding, mapped as the 100-year floodplain have a one percent annual chance of flooding, equating to a 26 percent chance of flooding over the life a 30-year mortgage. Other areas may flood more frequently, leading to an even higher risk.
The cost of federal flood insurance and the lack of knowledge about the NFIP may limit some homeowners from purchasing flood insurance. The NFIP’s Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from community actions and activities which are performed each year.

Flood insurance as a means to provide site specific property protection for “at-risk” properties is underutilized within Pierce County. Less than 10 percent of the properties within a FEMA designated floodplain have a flood insurance policy. This is well below the national average. Only three communities in Pierce County (unincorporated Pierce County and the cities of Fife and Orting) participate in the CRS program, which leads to lower insurance rates in those communities.

### FPW #4 – Flood Insurance and the Community Rating System

#### Recommendations

1. Pierce County and floodplain cities and towns should participate and maintain good standing in the National Flood Insurance Program (NFIP) to ensure the availability of subsidized flood insurance in their communities. Floodplain communities should participate in the NFIP’s Community Rating System (CRS) in order to better protect public safety, reduce the risk of flooding and channel migration hazards to existing public and private property, and achieve flood insurance premium discounts. Floodplain communities should strive to achieve a CRS rating of Class 5 or better.

2. Pierce County residents and businesses located in the mapped 100-year floodplain should be encouraged to purchase flood insurance through the NFIP.

#### Supporting Information

**4.1.4.1 NFIP and Community Rating System Program**

The National Flood Insurance Program (NFIP) was created in 1968 to address the rising cost of taxpayer funded disaster relief. The NFIP provides the financial backing for flood insurance policies within participating communities, making them more affordable to private property owners. The NFIP makes available flood insurance to communities that adopt approved floodplain management regulations that meet or exceed FEMA standards. It should be noted that the NFIP is voluntary. However, there are consequences that a community suffers should they choose not to participate in the NFIP. This includes non-eligibility of flood insurance in the community and federal assistance in the case of disasters.

Unincorporated Pierce County is currently a Class 2 community, resulting in flood insurance policies receiving a 40 percent discount for those policy holders that reside within the FEMA
Special Flood Hazard Area \(^{58}\text{(SFHA)}\). Policy holders residing outside of the SFHA, a 10 percent discount is given for communities having a CRS Class Rating between 1 and 6; and a 5 percent discount given for communities having a Class Rating between 7 and 9. The City of Fife entered the CRS program in 2006 and currently has a Class 5 rating, resulting in a 25 percent discount. The City of Orting entered the program in 2008 and has a Class 6 rating, resulting in a 20 percent discount.

4.1.4.2 Flood Insurance Participation

The number of homeowners and citizens purchasing flood insurance is low in Pierce County. The lack of public knowledge about flood hazards may result in a lack of understanding of the magnitude of flood risks that an individual property owner faces, thereby limiting participation in the flood insurance program. Greater promotion of the flood insurance program, education about flood risks, and awareness about the flood insurance discounts available in some communities should increase participation.

In recent years there has been an increase in the purchase of flood insurance in mapped 100-year floodplain areas. All homeowners in these areas with mortgages from federally regulated or insured lenders are now required to buy flood insurance. However, this only applies to approved and adopted FEMA maps, which are now over 20 years old (mostly dating to 1987). When the new FEMA maps are approved, substantially more residential and commercial structures will require flood insurance.

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\(^{58}\) Special Flood Hazard Area – Term used by FEMA to describe areas with a 1 percent or greater chance of flooding in any given year. Such areas are required to be regulated by communities participating in the NFIP, and structures in a Special Flood Hazard Area are required to purchase flood insurance.
4.2 REGULATIONS AND MANAGEMENT OF LAND USES

4.2.1 Consistent Flood Plain Development Regulations

Problem Description

Actions in one jurisdiction can adversely affect the frequency, duration, or magnitude of flood hazards in downstream, upstream, or adjacent jurisdictions. Flood hazard development regulations are the basic regulatory tool to practice sound flood hazard management related to new development and redevelopment.

A 2010 analysis of flood hazard regulations for counties and cities within the Puyallup and Nisqually River watersheds indicates significant differences across the 16 categories evaluated (see Appendix D). The analysis revealed variable approaches to the manner in which jurisdictions regulated development within floodplain environments. Specifically, individual jurisdictions had different approaches to regulating development in the floodplain, including: the manner in which data informed permit decisions, compensatory storage requirements, placement of critical facilities, and elevating above the base flood elevation (BFE). The inconsistency across jurisdictions results in development with varied levels of flood hazard risks, increased flood risk in adjoining jurisdictions, and confusion for developers working in multiple jurisdictions. In keeping with a principal goal of reducing flooding risks and making reach management strategies viable, jurisdictions within the planning area should seek greater consistency of floodplain development regulations. More consistent regulations will enhance Community Rating System benefits, such as reducing flood insurance rates within cities, improve regional coordination of flood services, and enable reach management strategies to be more effective. Resources for levee maintenance repair and construction activities will also be more efficiently allocated, given a reduced need for reactionary levee construction after floodplain development.

FPW #5 – Consistent Floodplain Development Regulations

Recommendations

1. Cities and towns in the planning area of the Flood Plan should adopt policies and regulations that are consistent with 2011 unincorporated Pierce County critical area regulations for flood hazard areas, including regulating based on the best available data, such as updated flood studies. Regulations should address development in the floodway, zero-rise, compensatory storage and critical facilities (see policies in Chapter 3). Other important considerations include locating development out of the floodplain as feasible, elevating above the base flood elevation, substantial damage and improvement calculations, and non-residential flood-proofing.

2. A regulatory working group should be established to support development of more consistent regulations across jurisdictions and to meet the goals and objectives of the Flood Plan. The

59 Substantial Damage – Damage to a structure for which the valuation for the reconstruction or restoration work exceeds 50 percent of the valuation of the existing structure prior to receiving damage.
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS

Pierce County Public Works & Utilities 4-17 www.piercecountywa.org/water

Surface Water Management

FPW #5 – Consistent Floodplain Development Regulations

<table>
<thead>
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<th>Recommendations</th>
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<tr>
<td>group should promote a regional discussion about residual flood risks and appropriate development regulations behind certified levees.</td>
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<tr>
<td>3. Pierce County will provide technical assistance to cities and towns within the planning area of the Flood Plan, in support of aligning their flood hazard regulations with unincorporated Pierce County critical area regulations for flood hazard areas.</td>
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</table>

Supporting Information

4.2.1.1 Management of Floodplain Development

The most effective way to reduce risks and costs associated with flood hazard areas and channel migration zones is to minimize land uses and human activities that are incompatible with such river-related hazards. Land uses and human activities that put people and property at risk from flood and channel migration zone hazards include residential, commercial and industrial development, critical facilities, and roads that serve as emergency transportation routes. Flood risks can directly affect developed properties or adversely affect neighboring properties.

An important issue in the management of floodplain development is the data utilized to determine flood risk and the applicability of regulations. As noted in FPW #1, flood insurance studies and FIRMs have been updated for most of Pierce County’s major rivers in the past seven years, but the FEMA maps have not yet become effective and therefore are not required to be adopted by local jurisdictions. Some, but not all, jurisdictions use this best available data for regulating floodplains and floodways. Because of the long process of updating floodplain maps, all jurisdictions should use best available data for development regulation.

4.2.1.2 Flood Hazard Areas and Channel Migration Zone Regulations

Implementation of flood hazard area and channel migration zone regulations are one of the most effective ways to reduce future risks and property losses. Pierce County Code Chapter 18E.70 (Flood Hazard Areas) is a section of the critical areas development regulations that are the primary tool, along with comparable city codes, for regulating land use in the floodplain.

The Washington State Growth Management Act (GMA) requires the protection of five types of critical areas: wetlands, critical aquifer recharge areas, frequently flooded areas, geologically hazardous areas, and fish and wildlife conservation areas. Frequently flooded areas as

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60 Critical Areas – Wetlands, flood hazard areas, fish and wildlife habitat areas, aquifer recharge areas, and geologically hazardous areas.

61 Aquifer – A saturated permeable material (often sand, gravel, sandstone, or limestone) that contains and carries groundwater and acts as a water reservoir.

62 Conservation – Includes protection, maintenance, and restoration of habitat characteristics to support the species of interest.
defined by GMA are the same as “flood hazard areas” in the Pierce County Code and city municipal codes entitled for example, “flood damage prevention,” “flood damage protection,” or “flood control.” Flood hazard areas along rivers in Pierce County include floodplains and floodways (FEMA regulatory floodway, deep and/or fast flowing water floodway, and channel migration zone floodway).

Pierce County and other jurisdictions use the FEMA standard for determining flood hazard areas. Pierce County uses the following data sources to determine a flood hazard area:

- FEMA Flood Insurance Studies (including preliminary studies)
- FEMA Flood Insurance Rate Maps (including preliminary maps)
- FEMA Letter of Map Change (LOMC)
- Critical Area reports and maps
- Channel migration zone maps and studies
- Historical flood hazard information
- Site specific flood studies

4.2.1.3 Development within the Floodplain or Flood Fringe

The standards contained in Pierce County Code Chapter 18E.70 (Flood Hazard Areas) are intended to minimize public and private losses due to flood conditions in flood hazard areas and provide criteria necessary for regulated activities located within flood hazard areas. Due to potential inaccuracies in floodplain mapping Pierce County requires a careful site specific review, and sometimes a survey to map the floodplain boundary, when any regulated activity is proposed within 300 feet of a mapped flood hazard area. This is intended to ensure that the proposed activity is in fact in or out of the flood hazard area.

Pierce County regulates floodplain and flood fringe63 development in all areas subject to inundation by the base flood. When Pierce County concludes that a proposed project for a regulated activity cannot be located outside of a flood hazard area, a zero-rise analysis may be required to determine and ensure that no increase in the base flood elevation or flow conveyance reduction will occur as a result of the development. When development is permitted and designed to achieve the zero-rise standard, it must also meet the following requirements:

- Compensatory Storage – new excavated storage volume shall be equivalent to the flood storage capacity eliminated by filling or grading within the flood fringe; equivalent shall mean that the storage removed shall be replaced by equal live storage volume between corresponding one-foot contour intervals that are hydraulically connected to the floodplain through their entire depth.

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63 flood fringe – The area subject to inundation by the base flood, but outside the limits of the floodway, and which may provide needed temporary storage capacity for flood waters. Structures in fringe areas in Pierce County must be elevated at least 2 feet above the 100-year flood elevation.
• Flow Conveyance – new conveyance capacity shall be equivalent to existing conveyance capacity.

• Erosion Protection – development shall be protected from flow velocities greater than two feet per second through the use of bio-engineering methods, or hard armoring if necessary.

• Lowest floor of structures must be elevated a minimum of two feet above the BFE, with the exception of commercial structures where dry flood-proofing is also allowed.

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**Figure 4.4** – Fill in the floodplain can raise the base flood elevation and cause flooding to occur in new areas.

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**Hard Armoring** – The use of large rock and/or human-made materials to protect property from shoreline erosion. Such techniques include cement/concrete bulkheads, steel structures, rock wall revetments, and rock gabion structures. Hard armoring typically does not use or integrate any soft armoring or soil bioengineering techniques.
4.2.1.4 Development within the Floodway

A floodway is an extremely hazardous area due to the depth and/or velocity of floodwaters which carry debris, potential projectiles, and have severe erosion potential. The following areas are regulated by Pierce County as floodways:

- Floodway defined by FEMA and shown on the Flood Insurance Rate Map
- Deep and/or Fast Flowing Water Floodway
- Channel Migration Zone Floodway

Any development, encroachment, filling, clearing, grading, new construction, and substantial improvement is prohibited within the floodway, except in specific circumstances such as agricultural activities, structures that do not require a building permit and repairs, reconstruction, replacement, and improvements to existing structures that do not have any associated fill and are not substantial improvements (i.e. improvements values are less than 50 percent of the pre-work value).

The FEMA defined floodways are mapped as part of the FIRMs with a goal of retaining a path for floodwater that does not increase the base flood elevation by more than one foot and is on all major river systems with detailed flood studies. The detailed flood studies were limited to populated areas so upper reaches of the rivers, typically in forest land with isolated pockets of development, remain unstudied. From 2002 to 2005, FEMA developed many new detailed flood studies and floodways including: Puyallup River, Carbon River, White River and a short reach of the Mashel River near Eatonville. On the right bank of the lower six miles of the Puyallup River, a floodway was not mapped during the re-study even though considerable flow was shown to leave the channel. Rather after the de-accreditation of the lower Puyallup River levees, FEMA gave the communities a ten-year time period to build a flood control structure that would prevent the broad inundation of Fife and the Port of Tacoma region.

The Nisqually, upper White, and Greenwater rivers were mapped in the late 1970s and due to poor existing topography, the entire floodplain was mapped as floodway. In the recent FEMA remapping all references to the 1970s Nisqually River detailed study and floodway were removed from the FIRM because the flood of record greatly exceeded the previous mapped floodplain limit and there have been significant changes in the river. FEMA has begun scoping a new detailed flood study for the Nisqually River.

The Deep and/or Fast Flowing (DFF) Water Floodway are areas where persons and or property can be exposed to great risks during the one percent Annual Chance Flood. The DFF is defined as water moving at least three feet per second or water at least three feet in depth or a combination of the two, which is plotted in PCC Title 18E Figure 70-9. The genesis for the DFF Floodway came from the 1988 US Department of Reclamations study on Dam Failures and downstream hazards which calculated the depths and velocities that are dangerous to structures and a person tying to walk through the flow. The three feet of depth and three feet...

65 Topography – The shape or configuration of the land, represented on a map by contour lines or relief shading.
of velocity are also referenced in WAC 173-158-76, establishing minimum criteria for rebuilding in a floodway. Pierce County has regulated the DFF Floodway since joining the NFIP in 1987, and the burden of providing the data is placed on the permit applicant. In 2008, the County commissioned an independent study to establish the DFF floodway limits using data from the latest detailed flood studies. The contractor was able to map the DFF floodway on 125 river miles on 19 rivers and streams.

4.2.2 Urban Growth Area Expansion

Problem Description

The 100-year floodplains of Pierce County’s major rivers have a high probability of flooding, resulting in risks to public safety and property damage. Currently 75 percent of floodplains located within the study area of this plan are in urban land uses and 25 percent is resource lands, public facilities and open space. If currently zoned resource lands, public facilities or open space areas located in the 100-year floodplain are converted to more urban land uses, more people and property associated with higher density land uses will be put at risk. This recommendation proposes limitations on expansion of urban growth areas (UGA) into river floodplains in the study area of the Pierce County Rivers Flood Plan. RCW 36.70A.110 established the threshold of 1000 cubic feet per second (cfs) mean annual flow and several rivers and reaches in the plan are below this threshold.

Effective June 2010, Chapter 19A.30.010 (Comprehensive Plan – Urban Growth Areas) of the Pierce County Code was amended to prohibit the expansion of the UGA into the 100-year floodplains of rivers or river segments above 1000 cfs of mean annual flow. In Pierce County (per the Department of Ecology) this includes: (1) the Puyallup River, below the confluence with the Carbon River, (2) the Nisqually River below the confluence with Mineral Creek, and (3) the White River below the confluence with the Greenwater River. However, significant floodplains included in this plan are not covered. Urban growth areas existing along the Carbon River, Greenwater River, Mashel River, Nisqually River, South Prairie Creek, and the upper Puyallup River could be expanded or new urban growth areas created in the floodplain without this change.

FPW #6 – Urban Growth Area Expansion

Recommendation

1. Pierce County and applicable jurisdictions should expand the prohibition on expansion of urban growth areas into the 100-year floodplains to include all rivers in the Pierce County Rivers Flood Plan. Exceptions should be allowed as per RCW 36.70A.110.
Supporting Information

4.2.2.1 Urban Growth Area Expansion

This recommendation proposes that the prohibition on expansion of UGAs into the 100-year floodplain be expanded to include: (1) Puyallup River up to River Mile (RM) 29, (2) Carbon River from its mouth at the Puyallup River up to RM 8.4, (3) South Prairie Creek from its mouth at the Carbon River up to RM 6.4 at the Town of South Prairie, and (4) Mashel River from its mouth at the Nisqually River up to RM 6.8 at the Town of Eatonville.

Exceptions to the expansion of UGAs in 100-year floodplains would apply, as per RCW 36.70A.110. Examples include: (1) where public facilities already exist within the floodplain and the expansion of an existing public facility is only possible on the land to be included in the UGA and located within the floodplain, and (2) the land is owned by a jurisdiction planning under this chapter or the rights to development of the land have been permanently extinguished.

Pierce County Surface Water Management should work with Planning and Land Services to revise Chapter 19A.30.010 to implement the recommendation through a Comprehensive Plan amendment. The jurisdictions of Eatonville, Orting and South Prairie are adjacent to floodplain not covered by RCW 36.70A.110 and should modify their local ordinance to implement this recommendation.

4.2.3 Agricultural Land Use and Activities

Problem Description

Agricultural land uses in the floodplain are identified as one of several potential compatible land uses in the guiding principles of this plan. Raising crops and livestock can co-exist with occasional inundation of pastures and agricultural fields. This depends on the ability of farmers to quickly take action to prevent losses and to repair damage so agricultural activities can resume after floods. Several problems exist that make farming difficult in the floodplain:

- Floods can deposit several inches of sand and other inorganic sediment over productive soils. Excavation of sediment triggers a requirement to secure a site development permit. These permits are expensive and time-consuming.
- Agriculture relies on farm support structures for storage of equipment and materials. Current regulations do not allow construction of new structures in a floodway. In the lower Puyallup the floodway has been identified with the de-accreditation of the levee to provide flood protection.
- Pierce County SWM currently leases agricultural lands that it owns. Few farmers know of the program. Information on County-owned land potentially suitable for agricultural use is not in a format that gives farmers easily accessible information about sites.
- Composting crop residue is a traditional agricultural practice. It transforms vegetable matter into a beneficial soil amendment that reduces the need for chemical fertilizers and pesticides. Pierce County flood hazard area regulations treat compost as fill, which
is prohibited in a floodway and subject to showing zero-rise and compensatory storage requirements in the flood fringe.

**FPW #7 – Agricultural Land Use and Activities**

**Recommendations**

1. Pierce County should amend regulations to authorize farmers to quickly and inexpensively remove sediment deposited by floods from productive agricultural land.

2. Pierce County should amend development regulations to allow construction of flow-through nonresidential agricultural structures per the flood fringe standards (such as pier and pile) in the floodway of the lower Puyallup River downstream of Clarks Creek, excluding the Clear Creek floodway.

3. Pierce County should identify publicly owned floodplain lands suitable for agricultural use and work with the agricultural community to improve and promote the current leasing program.

4. Pierce County should amend development regulations to allow composting in floodways and floodplains when accessory to on-site agriculture. Composting activities should be sited in such a location as to comply with fish and wildlife habitat area requirements.

**Supporting Information**

**4.2.3.1 Agricultural Land Use in Floodplains**

Agricultural lands are traditionally located within the broad, flat floodplains and valleys of major rivers. Farms often include land in the floodplain as well as in the floodway. The reasons agriculture occurs in floodways and floodplains are many. Agricultural properties contain fewer structures likely to be damaged by flooding and agriculture can help maintain the flood storage and flow conveyance capacity of floodplains. Partial flooding of agricultural property is common and can be accommodated as part of the seasonal pattern of farming activities. Conversely, excessive flooding and sediment deposition can make farming unviable in some areas. Farming is common in the lower, middle, and upper Puyallup River and Carbon River valleys and South Prairie Creek and this plan strives to balance the needs of agricultural activities with flood hazard management principles and floodwater storage needs.

Like other land uses, filling in an unincorporated Pierce County floodplain requires consideration of the adverse effects on adjoining areas. Standards include compensatory storage for floodwater when filling or constructing in a floodplain. County regulations prohibit fill and new structures in floodways.

**4.2.3.2 Farm Support Structures in Lower Puyallup Floodplain and Floodways**

The County’s development regulations prohibit the construction of new structures in a floodway except for structures that do not require a building permit (Pierce County Code 18E.70.040, B Replacement of an Existing Structure). Structures are defined in Pierce County Code 18.25 as anything that is constructed in or on the ground or over water, including any edifice, gas or liquid storage tank, and any piece of work artificially built up or composed of
parts and joined together. Outside paving does not require a permit, nor do accessory buildings used as green houses, tool and storage sheds, and similar one-story buildings when the floor area does not exceed 200 square feet. Shade cloth structures constructed for nursery or agricultural purposes do not require a building permit. Retaining walls less than four feet in height do not require a permit.

Regulations for the flood fringe allow new structures when meeting certain requirements, such as having the first horizontal member above the base flood elevation (BFE) and having areas below BFE constructed to allow the passage of floodwater, such as pier and pile construction. Piles are mechanically driven or jetted deep into the ground. Piers are vertical structural members that are supported entirely by concrete footings. Both must be embedded sufficiently below the expected depth of erosion to remain stable during floods. These standards can be applied to the lower Puyallup floodway and allow non-residential agricultural buildings with low risk of creating adverse conditions for adjoining areas.

4.2.3.3 Leasing of Floodplain Land for Agricultural Use

Pierce County Surface Water Management has purchased significant floodplain land in the major river valleys over the past 20 years as a means to eliminate flood risk properties to ensure compatible activities in floodplains. The County is expected to continue floodplain acquisition through state and federal grants and other fund sources over the next 20 years. Some of this land is suitable for agriculture. Since 2007 SWM has also leased some of these lands in the floodplain and floodway for agricultural use.

The agricultural lease program can be promoted to increase the amount of land in agricultural production. SWM can evaluate floodplain lands for soil type, inundation frequency, water availability, electricity availability, zoning, and other features of sites pertinent to agriculture. Results of the evaluation can be shared on the County’s website. SWM also can work with the agricultural community to improve the current leasing program.

4.2.3.4 Agricultural Composting

Composting vegetable matter is important to sustainable crop farming. WAC 173-350-220, Composting facilities, governs agricultural composting. Several levels of agricultural composting are exempt from having to secure a solid waste handling permit, including composting of vegetable matter when all compost is used on-site. “Agricultural composting” means composting of agricultural waste as an integral component of a system designed to improve soil health and recycle agricultural wastes. It is conducted on lands used for farming. Vegetable matter is referred to as a “Type 1 feedstock” and defined as source-separated yard and garden wastes, wood wastes, agricultural crop residues, wax-coated cardboard, pre-consumer vegetative food wastes, other similar source-separated materials that the jurisdictional health department determines to have a comparable low level of risk in hazardous substances, human pathogens, and physical contaminants. However, whether exempt from a solid waste handling permit or not, agricultural composting must meet certain standards. Surface water and ground water must be protected, nuisance odors and vector attraction controlled, and an annual report filed with the local health department.
The concern with composting in a floodway or floodplain stems from its association with fill. Compost is not fill when it is spread across a field, it is a soil conditioner that breaks down into dust. Compost when being produced is in a transitional state. Storage on a pad or container is temporary. Clarification in the County Code that compost not be considered fill will remove an obstacle to productive agriculture.

### 4.2.4 Floodplain Acquisition and Home Buyouts

#### Problem Description

Much of the funding available for acquisition of floodplain property or flood-prone structures is limited to federal and state grants, and limited local funds to provide grant match or support property acquisition for capital projects. Federal and state grants for hazard mitigation are closely tied to specific eligibility criteria and rigorous benefit-cost analysis. Some grants are only available as a result of Presidential Disaster Declarations. The demand for funding is significantly greater than available funding for property acquisition in frequently flooded areas or areas at risk of channel migration. Floodplain property acquisitions are different from home buyouts in that they typically are proactive rather than reactive.

#### FPW #8 – Floodplain Acquisition and Home Buyouts

<table>
<thead>
<tr>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pierce County should identify properties that are potential candidates for home buyouts or property acquisition based on an evaluation of flood or channel migration risks, project and economic feasibility, and planned capital projects for river management facilities. Pierce County should continue to update this list of properties after significant flood or channel migration events occur. As warranted or as funds become available, Pierce County should conduct outreach to property owners to inform them about flood risks and potential for buyouts to assess possible interest. Property acquisition should be on a willing-seller basis; however, as risks are identified and prioritized there will be circumstances when a compelling public interest makes condemnation necessary.</td>
</tr>
<tr>
<td>2. Pierce County, cities and towns in Pierce County and other local government agencies should continue to seek federal and state grants to assist property owners in flood-prone and repetitive loss areas and to enable buyouts or acquisitions.</td>
</tr>
<tr>
<td>3. Pierce County should set aside some local funding for proactive floodplain acquisition where grants are not likely to be applicable and development regulations are not likely to be restrictive enough.</td>
</tr>
</tbody>
</table>

#### Supporting Information

There are three types of acquisition projects that reduce flood hazard risks: (1) home buyouts to remove people and structures from flood hazard and channel migration hazard areas, (2) open space acquisition in flood hazard areas to prevent development and preserve the floodplain’s capacity to support floodwater conveyance and storage, and (3) acquisition of
lands to facilitate construction of flood risk reduction facilities (e.g., levee setback projects). It should be noted that there can be some overlap in these categories.

4.2.4.1 Home Buyouts and Property Acquisition

Pierce County has acquired many repetitive loss properties and other flood-prone homes using federal, state grants and local funds. Acquisition of homes and properties are based on fair market value appraisals by a qualified independent MAI (Members Appraisal Institute) third party appraiser. Structures on a site are typically demolished and fill material present may be removed to improve the floodplains storage/conveyance capacity. Many acquired houses are offered to the Community Development Low Income Housing Program.

Open space acquisition in flood hazard areas is another tool that may be used to prevent property development. While floodplain regulations limit development in flood hazard areas, they fall short of outright prevention of development and often consume a lot of staff time accommodating an owner trying to get improved use out of their property. New development in flood hazard areas, while significantly restricted, may still have costly consequences in terms of public safety and property damage if flood conditions change or new mapping indicates the floodway or floodplain has changed.

4.2.4.2 Acquisitions for Capital Projects and Property Management

Another category of floodplain acquisitions is purchase of property to facilitate construction of flood risk reduction facilities such as setback levees. Such projects can increase flood storage and conveyance, reduce damaging high flow velocity, reconnect the river to the floodplain, and restore natural riverine processes. There are also benefits for open space, riparian and off-channel habitat, and sediment deposition.

Acquisitions can be fee simple land purchases, or drainage or conservation easements. In some cases, condemnation (acquisition through eminent domain authority) may be need to be used when a negotiated agreement cannot be reached or a parcel is critical to complete a planned capital project.

4.2.4.3 Grants and Cost-Share Funding

The primary sources of funding to implement flood damage and mitigation projects include: the Federal Emergency Management Agency (FEMA), State of Washington Department of Ecology (WDOE), Community Development Block Grants (CDBG) and Real Estate Excise Tax (REET). Specific programs offered by FEMA include Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL). Programs offered by WDOE include the Flood Control Assistance Account Program (FCAAP). Community Development Block Grants are typically made available following a Presidential Declared Disaster and are administered by local jurisdictions.

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The following is a description for each of the funding programs listed above:

- **Hazard Mitigation Grant Program (HMGP).** The HMGP awards grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. Cost share for this grant is 75 percent federal, 12.5 percent state and 12.5 percent local.

- **Pre-Disaster Mitigation (PDM).** The PDM program provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. Cost share for this grant is 75 percent federal and 25 percent local. The State does not cost share in PDM grants.

- **Flood Mitigation Assistance (FMA).** The FMA program was created as part of the National Flood Insurance Reform Act of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP). FEMA provides FMA funds to assist states and communities in implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. Cost share for this grant is 75 percent federal and 25 percent local. The State does not cost share in FMA grants.

- **Repetitive Flood Claim (RFC).** The RFC grant program provides up to $10 million nationwide annually for FEMA to assist states and communities in reducing flood damages to insured properties that have had one or more claims to the NFIP. Cost share for this grant is 100 percent federal and no local cost share is required.

- **Severe Repetitive Loss (SRL).** The SRL grant program provides funding to reduce or eliminate the long-term risk of flood damage to SRL structures insured under the NFIP. An SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and: (a) that has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or (b) for which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building. For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period. Cost share for this grant is 75 percent federal and 25 percent local. Local jurisdictions that have an adopted repetitive loss plan strategy qualify for federal share increases to 90 percent with 10 percent local share.

- **Community Development Block Grants (CDBG).** The objective of the CDBG program is to assist communities in rehabilitating substandard dwellings and expanding economic opportunities, primarily for low-to-moderate-income families. Following a Presidential declared disaster, CDBG funds may be used for long-term needs such as acquisition,
reconstruction, and redevelopment. These funds are typically administered by local jurisdictions. Local cost share for CDBG varies and is dependent upon the disaster declaration and amount of funds available.

- **Washington Department of Ecology Flood Control Account Assistance Program (FCAAP).** RCW 86.26.050 provides that counties and other municipal corporations responsible for flood control maintenance may apply to Ecology for financial assistance for the preparation of comprehensive flood control management plans and for flood control capital and maintenance projects. The purpose of the plans is described in RCW 86.26.105. Ecology determines priorities and allocates available funds from the FCAAP among those counties applying for assistance, and adopts rules establishing the criteria by which those allocations are made. State cost sharing varies between 50 and 80 percent, depending upon the type of project applied for. The remainder is the local share.

### 4.2.5 Home/Structure Elevation and Flood Proofing

**Problem Description**

Acquisition of all flood-prone homes in Pierce County is not feasible due to high costs, societal reasons, available grants, and benefit/cost requirements that limit eligibility. For some homes, elevation or floodproofing of the structure may be the preference of the property owner or the most cost effective option to reduce the risks and costs of future flood damages. Homeowners often need technical assistance to understand options, make decisions about necessary elevation levels, and support with permitting.

Pierce County can apply for FEMA Hazard Mitigation Assistance (HMA) grants to assist homeowners with elevation of homes in flood-prone areas. The financial matches to these grants are often be paid by the homeowners.

<table>
<thead>
<tr>
<th>FPW #9 – Home/Structure Elevation and Floodproofing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommendations</strong></td>
</tr>
<tr>
<td>1. Pierce County will provide technical assistance to homeowners or land owners interested in pursuing elevation of structures and commercial property owners interested in floodproofing of structures in special flood hazard areas.</td>
</tr>
<tr>
<td>2. Pierce County, cities and towns should identify flood prone areas that may be suitable for a home elevation program. Once identified, local governments should work with those communities to pursue FEMA Hazard Mitigation Grant Program funding to help support home elevations for identified areas.</td>
</tr>
</tbody>
</table>
Supporting Information

4.2.5.1 Home Elevation Considerations

Home elevation projects involve assisting property owners with technical assistance for raising the finished floor of a home at least one to two feet above the 100-year BFE, substantially reducing the threat of future damage. This also ensures compliance with state and county regulations. Elevation projects are appropriate where structures are subjected to ponding water in the floodplain with low velocity floodwaters. Elevation projects do not completely remove the flood risk, but there is considerably less flood damage to the structure. Elevation projects are not a viable alternative in areas subject to high-velocity flows, bank erosion or channel migration hazard areas.

Structure elevations are generally not recommended when existing structures are close to being classified as substantially damaged and are located in a mapped floodway (based on Channel Migration Zone, Deep and/or Fast Water and/or FEMA Floodway). This is because once a project reaches substantial damage it is required to meet current code and current code does not allow structures to be substantially improved in a floodway. In Pierce County, substantial damage occurs when a structure has suffered damages which equal or exceed 50 percent of its value. Damages are cumulative and tracked on a five-year cycle. It should be noted that the costs to elevate an existing structure are not counted toward the cumulative improvement but any improvements not related to the elevation would be counted.

Access problems to and/or from an elevated structure during flood events is another important issue to consider when deciding if home elevation is an appropriate strategy. Emergency services may have limited access due to floodwater inundation over the roadway. In many instances, residents may not be able to drive to or from their homes during flood events, resulting in safety risk to residents if emergency response personnel cannot access flooded areas.

Figure 4.5 - Home elevation in the McKenna vicinity of the Nisqually River
4.2.5.2 Floodproofing of Commercial Structures

Pierce County Code does not allow floodproofing of residential structures. However, commercial structures can be floodproofed to prevent floodwaters from entering the structure during flood events. This might involve waterproof coatings, impermeable membranes, or a floodwall built of masonry or concrete (see Figure 4.5). Doors and other openings must be equipped with permanent or removable shields.

Floodproofing may reduce the risks to a structure and contents, and it may be less costly than other retrofitting options, but there are also disadvantages. These include the need for ongoing maintenance, leakage of flood proofing materials, and installation of removable shields that require human intervention just before the flood occurs.
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS  

PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

4.3  RIVER CHANNEL MANAGEMENT

4.3.1  River Channel Monitoring

Problem Description

Real-time information on river flows and stage during flood conditions are critical to inform citizens, emergency personnel, and agencies in making evacuation and emergency response decisions. Flow and stage data also support future modeling efforts and updating of flood mapping.

River channel conditions along the rivers included in this plan are dynamic, and there can be perception that river bed elevations are increasing. Without definitive information from monitoring, it is difficult to differentiate between actual aggradation or erosion of the river bed and qualitative observations. Moreover, some sediment deposition may represent long-term trends towards rising bed elevations, whereas in other areas, a more temporary pulse of sediment may be moving through the river system.

Past capital projects, including levee/revetment construction and repairs, levee setback projects and gravel removal projects have had little or no quantitative monitoring, with the exception of annual conditional assessments. Without better information it is not possible to track project outcomes with respect to water surface elevation reductions, changes in sediment transport, and habitat quality. Ongoing monitoring would provide the SWM Division with the information needed learn how projects are performing and how future projects may be designed more effectively.

FPW #10 – River Channel Monitoring

Recommendations

1. Pierce County SWM should continue its joint agreement with the USGS to monitor river stage and flow at USGS gauges on major rivers in Pierce County. A new gauge should be added on the Carbon River in the Orting vicinity.

2. Pierce County SWM should work with the USGS and other partners to monitor long-term changes in river channel conditions on a 5-year recurring basis, including river channel cross-sections, flood conveyance capacity, and sediment transport and deposition on the Puyallup, Carbon, lower White, and upper Nisqually rivers.

3. Pierce County should update LiDAR mapping of the entire river planning area on a 5-year cycle.

4. Pierce County SWM should carry out more frequent monitoring of selected cross-sections on the Puyallup, Carbon, and lower White rivers, building on the cross-sections surveyed between 1996 and 2008 to monitor the dynamic nature of aggradation and degradation.\(^{67}\)

5. Pierce County SWM should carry out project-specific monitoring to evaluate the effectiveness of the following project types: (a) gravel removal, (b) levee and revetment setbacks, (c) engineered log jams, and

\(^{67}\) Degradation – The lowering of the streambed or widening of the stream channel by erosion; the breakdown and removal of soil, rock and organic debris.
FPW #10 – River Channel Monitoring

Recommendations

placement of large woody material, and (d) facing and toe rock repairs. Monitoring will vary by project type, but should include consideration of water surface elevations (stage), sediment erosion and deposition, hyporheic flow, and habitat elements (such as vegetation, off-channel and wetland development, redd and fish presence monitoring, and large woody material).

6. Pierce County SWM should take aerial photos of the extent of flooding along mainstem river corridors (Puyallup, Carbon, White, South Prairie, and upper Nisqually Rivers) during major flood events, using aircraft coordinated through Pierce County Department of Emergency Management.

Supporting Information

4.3.1.1 Stream Flow Monitoring

The USGS monitors 13 gauges in the planning area on the Puyallup and Nisqually river systems for river flow and/or stage that are used for flood tracking and response. Three are located in the Nisqually basin and 10 are located in the Puyallup basin. Altogether, there are a total of 26 gauges, supported by Pierce County, King County, Puget Sound Energy, Tacoma Power, and the cities of Auburn and Puyallup.

These gages provide critical flow modeling and floodplain mapping information during flood events, for flood planning purposes, and for overall water resource management. It is recommended that an additional gauge be added on the Carbon River in Orting near Bridge Street to provide flow and stage information nearer to urban areas. The only existing gauge on the Carbon River is at Fairfax at River Mile 16.1, over 12 miles upstream of Orting.

4.3.1.2 Cross-Section and Sediment Monitoring

Information collected for monitoring channel changes are important for flooding, channel migration, and natural resource management. Channel changes can be monitored over time to determine potential developing risks associated with flooding and channel migration. The data collected through monitoring may be used to facilitate management actions targeting flood conveyance and sediment management USGS performed a study in 2009-10 to evaluate the flood-conveyance capacity and sedimentation trends of the Puyallup River system (see Figure 4.6 and 4.7). The study examined how conveyance capacity and mean river bed elevations changed between the 1984 and 2009. Findings from the USGS study (2010) indicated that the 25-year change in mean bed elevation varied from -3 feet to +7 feet.

Puyallup River

- RM 2.8 – RM 12.0 (possible cross sections: P26, P34, P42, P53, P58, P64, P72 & P74)
- RM 12.0 – RM 17.4 (possible cross sections: P83, P87 & P103)
- RM 17.4 – RM 21.3 (possible cross sections: P118, P119 & P120) – selected due to proximity to City of Orting (dense population and infrastructure).
• RM 21.3 – RM 25.3 (possible cross sections: P133, P137 P139 & P145)
• RM 25.3 – RM 27.2 (possible cross sections: P152, P158 & P162) – at wide points along the reach; these spots may act as a gravel sink due to reduced energy potential).

Carbon River
• RM 5.9 – RM 8.4 (possible cross sections: C34, C35 & C36) – downstream of active valley wall on right bank and upstream of zone of hydraulic influence from the SR 162 bridge).

White River
• RM 4.8 – RM 5.5 (possible cross sections: W67 & W69B) – dynamic nature of gravel bars and greatest accumulation along the White River in Pierce County.

LiDAR data from 2004 and 2010 along the river corridor have been useful in monitoring river channel changes and trends of aggradation or degradation of sediment. This facilitates the determination of river bed digital elevations in areas without main- or side-channel flow. This plan recommends that LiDAR data be collected every five years along the riverine corridors to help determine changes in bed elevation and support development of project actions, including gravel removal, capital projects, and continued maintenance and repair operations.

4.3.1.3 Project-Specific Monitoring

Project-specific monitoring may be carried out to evaluate project effectiveness or to meet specific permit requirements. Project monitoring may be qualitative (e.g., observations, photo points) or quantitative (e.g., reduction in water surface elevation, change in hyporheic flows, cross-section monitoring, length/area of side channel or wetland development, pieces of large woody material deposited).

Project effectiveness monitoring should focus on monitoring of representative project types such as levee/revetment setback projects, gravel removal projects, engineered log jams or woody material placement, and levee/revetment repair and rehabilitation projects. Effectiveness monitoring provides the basis for determining whether project outcomes are achieved and how project designs can be improved for future implementation. Each monitoring component must have specific elements identified within a monitoring plan in order to produce meaningful results.

Many of the planned activities (gravel removal, levee construction, and repair) have the potential to affect subsurface, hyporheic flows. The hyporheic flows are important for water quality, riparian vegetation, and food production for fish. Monitoring of project effects on the hyporheic flows is recommended. This is an emerging science but methods will most likely involve well monitoring.

68 Side Channel – The portion of the active channel that does not carry the bulk of the stream flow. Side channels may carry water only during high flows, but they are still considered part of the active channel.

69 Effectiveness Monitoring – The evaluation of whether an action achieved the desired effect. For example, in a sediment reduction project, effectiveness monitoring would determine whether sediment supply was actually reduced.
4.3.1.4  Aerial Photos during Flood Events

Aerial photos were taken from aircraft by SWM along the major river corridors during the 1995, 1996, 2006 and 2008 floods. Coverage included the Puyallup, Carbon, and White Rivers and South Prairie Creek. WSDOT took aerial photos along the major rivers during January 2009 flood event. These aerial photos have proven invaluable for analyzing the locations of river levee/revetment overtopping and damages, the extent of riverine floodplain flooding, and specific flooding of building and roads. Aerial photos should be taken during future flood events with extensive flooding of floodplains, structures, and infrastructure.

4.3.2  Management of Large Woody Material

Problem Description

In addition to flood waters and a large sediment load, Pierce County rivers carry an abundance of large woody material (LWM) during high flow events. These typically originate from landslides or stream bank erosion upstream or from previously deposited wood in the stream channel or floodplain. Along river reaches passing through moderately to heavily developed uplands and floodplains, wood accumulations can cause problems during flood events when log jams form or increase in size, or if woody material lodges on or adjacent to obstructions such as bridge piers or levees. This can contribute to lost capacity in the river channel, raising water surface elevations and worsening flooding, or it can result in greater risk of channel migration and river avulsion. Specific flood related risks that can result from woody material accumulations include damage to bridge footings, erosion of stream banks, backwater flooding and channel migration.

Wood also plays a major role in habitat and channel forming processes, stabilizing stream channels, accumulating sediment, and physical habitat formation that benefits salmon and other species. During the last century, logging, wood salvage, forest conversion, and flood control efforts all contributed to a great reduction of large wood in Pierce County rivers. The extent of wood removal and the methods used to remove wood from river channels contributed to the degradation of fish and wildlife habitat, including habitat for species listed as threatened under the Endangered Species Act.

FPW #11 – Management of Large Woody Material

Recommendations

1. Pierce County SWM should continue its current approach to management of woody material in river channels, which includes field investigations to evaluate flood-related, public safety and public infrastructure risks. If a Pierce County team of engineers and biologists determines that there is an imminent threat and all reasonable flood and channel migration risk reduction alternatives have been considered, naturally occurring accumulations of large woody material may be repositioned, relocated, or removed for flood hazard management purposes. Repositioning, relocation, or removal of large woody material should be done in a manner that does not create new flood or channel migration risks, and be accomplished using techniques that result in the least disturbance to the river channel and aquatic habitat.
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS

Pierce County Public Works & Utilities

Surface Water Management

FPW #11 – Management of Large Woody Material

Recommendations

2. Removal of large woody material from mid-channel bridge piers by Pierce County, WSDOT, cities, and private railroads should be done in a manner that does not create new flood or channel migration risks, and be accomplished using techniques that result in the least disturbance to the river channel and aquatic habitat. Whenever possible, wood removed from these facilities should be used for habitat restoration or enhancement projects.

3. Pierce County should seek opportunities to reposition or relocate large wood into engineered log jams (ELJ) on a pro-active basis to protect infrastructure, deflect flows, and enhance habitat, thus reducing the potential for build-up on bridges and other infrastructure during flood flows.

4. Pierce County should work with resource agencies and tribes to identify river segments that largely function naturally and where large woody material poses little or no threat to public safety or public infrastructure. Pierce County should not reposition, relocate, or remove large woody material in these areas provided the woody material does not pose an imminent threat to flood risk reduction facilities.

5. Pierce County will obtain approval from permitting agencies and coordinate with resource agencies and tribes prior to repositioning, relocation, or removal of large woody material in both emergency and non-emergency situations.

Supporting Information

From the early 1900s to the 1960s, wood material was trapped in cable nets and removed from the river either by hauling and/or burning. Private harvest of wood for use as firewood was also common. Up to the 1980s, removal of wood from Pierce County rivers was still common as a flood control and maintenance measure. Wood was routinely removed and or cut-up from above the water line and within the river where it had lodged on critical man-made structures or improvements (Pierce County 1991).

Since the listing of Chinook salmon and revision of Pierce County LWM management practices in the mid-1990s, in-channel wood accumulations have increased significantly. In-channel LWM is known to promote the formation of quality fish habitat, thus requiring a balance between flood risk reduction and LWM management.

In recent years, Pierce County has relocated LWM within the channel to maintain its benefits during future high flows or removed large woody material where the wood posed an imminent flood threat to infrastructure or public safety. The woody material should be managed in a way to reduce flood risks and maintain habitat value, and in accordance with permitting rules and regulations. Mitigation or compensation for impacts of woody material removal may be necessary. If the woody material does not pose an imminent flood risk to infrastructure or public safety, it should be monitored to see if conditions worsen. This approach allows serious threats to be addressed while avoiding adverse impacts on the aquatic habitat.

4.3.2.1 Risks to Public Infrastructure

Levees or revetments, bridge piers and abutments/approaches are the most common types of public infrastructure threatened by accumulation of LWM. The LWM which directs flow into
the levee or revetment may induce scour of toe rock or erosion of facing rock. This same type of flow diversion may also induce scour of or build up on bridge piers.

4.3.2.2 Repositioning of Large Wood

The repositioning or placement of wood into ELJs can help protect levees and other infrastructure as well as provide habitat benefits. Well positioned ELJs help to dissipate energy, deflect the river away from a road, levee, or revetment, and help protect river banks. Using wood in this fashion makes our rivers abundant supply a resource. A pro-active program which features some wood collection and placement into stable jams in the summer, prior to the wood becoming a problem in the winter can reduce the potential for build up on bridges, as well as secure this loose wood into habitat forming structures. This would help reduce the emergency reaction mode during winter flooding.

4.3.3 Sediment Management and Gravel Removal

Problem Description

Pierce County rivers carry a heavy sediment load due to their origin on Mount Rainier and associated basin geology. When steep river channels meet broad, flat, valley floors, flow velocities decrease, and the ability of rivers to transport sediment is reduced. This reduced ability to transport sediment results in the deposition of sand, gravel, and cobbles in the river channel. Under natural conditions, an unconfined river channel can migrate or flow around the deposited sediment, re-establishing a new path or paths. In confined rivers, between two levees or revetments, channel migration is unnaturally constrained. In both cases, deposited sediment can result in reduced flood conveyance capacity, increased bed elevations, and increased potential for erosion and overtopping of levees and revetments.

Figure 4.6 Gravel bars on (left) Puyallup River near Orting, and (right) White River near Pacific
A recent study of the Puyallup River system (USGS 2010) indicates that increases in average channel bed elevations were significant in some locations between 1984 and 2009 (see Table 4.1 and Figures 4.7).

### Table 4.1 – Sediment accumulation from 1984 to 2009 (change in mean bed elevation)

<table>
<thead>
<tr>
<th>River</th>
<th>River Miles</th>
<th>Change in bed elevation (1984-2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puyallup River</td>
<td>RM 9.1 - 10.1</td>
<td>2 - 3.5 feet accumulation</td>
</tr>
<tr>
<td>Puyallup River</td>
<td>RM 14.2</td>
<td>3.8 feet accumulation</td>
</tr>
<tr>
<td>Puyallup River</td>
<td>RM 18.9 - 21.5</td>
<td>1.6 - 4.0 feet accumulation</td>
</tr>
<tr>
<td>Puyallup River</td>
<td>RM 22.6 - 24.8</td>
<td>2.3 - 7.5 feet accumulation</td>
</tr>
<tr>
<td>White River</td>
<td>RM 4.9 - 6.4</td>
<td>3.1 - 6.5 feet accumulation</td>
</tr>
</tbody>
</table>

Between RM 17.7 and RM 21.4 on the Puyallup River (from the Carbon River confluence to Calistoga Bridge), the net volume of deposition was approximately 429,000 cubic yards (CY) of sediment, or 17,200 CY per year. Between RM 21.5 and RM 25.7 on the Puyallup River (from the Calistoga Bridge to the USGS gaging station upstream of Orting), the net volume of deposition was approximately 907,000 CY of sediment, or 36,300 CY per year.

The largest net volume of deposited sediment in the White River was between RM 3.9 and RM 7.6 (from the Lake Tapps return flow upstream to R Street Bridge in Auburn), with approximately 547,000 CY of sediment or 21,900 CY per year.

Figure 4.7 (a) and (b) showing change in average channel elevation between 1984 and 2009 for the Puyallup and White Rivers, respectively.
The most significant decrease in channel conveyance capacity associated with this sediment deposition was between RM 19.7 and RM 21.5 on the upper Puyallup River and between RM 2.3 and RM 5.8 on the lower White River (see Figure 4.8 a and b).

Figure 4.8 – Simulated channel conveyance capacity for 1984 (dashed line) and 2009 (solid line) for (a) upper Puyallup River and (b) lower White River
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS  PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

PR #1 / WR #1 / CR #1 – Sediment Management and Gravel Removal

Recommendations

1. Comprehensive sediment management in Pierce County shall be guided by technical sediment transport and biological studies, analysis of resource and habitat impacts, and consider the dynamic nature of sediment transport.

2. Pierce County should pursue levee setback projects as the preferred means to manage downstream sediment transport (see also FPW#26). Levee setbacks promote sediment deposition by allowing channel migration, increasing channel length, decreasing gradient and promoting braiding of the river. This may offer opportunities to include sediment management at locations outside the active river channel thereby minimizing or eliminating adverse biological impacts.

3. Pierce County gravel removal projects should comply with project policy #12. In addition, gravel removal project should demonstrate a benefit-cost ratio greater than 1.0 over the expected duration of the benefit.

4. Pierce County should evaluate alternative approaches to gravel removal to determine relative benefits in terms of flood risk reduction, effectiveness, habitat impacts, duration of benefits, and costs. The NMFS National Gravel Extraction Guidance should be used as a guiding document.
   a. Pierce County should consider gravel removal in locations where gravel deposition has modified the direction of the river channel in a way that creates a high risk of levee overtopping or levee/revetment erosion, and where substantial numbers of people, floodplain structures, and infrastructure are at risk. In these cases, gravel removal should be evaluated for use on an interim basis until a longer term, more comprehensive and sustainable solution can be implemented.
   b. Pierce County should consider gravel removal where site conditions indicate persistent gravel deposition, access to the site is available, adverse effects on fish habitat can be minimized and properly mitigated, and significant amounts of gravel can be removed to reduce sediment transport downstream and reduce flood risk potential.

5. Pierce County will monitor locations of gravel removal (including upstream and downstream areas), before and after gravel removal and during at least two significant sediment transport events, to assess sediment accumulation, assess project effectiveness, analyze the duration of benefits, and evaluate the effects of gravel removal on salmonid habitat. An analysis of the cost and feasibility of gravel removal should be summarized.

6. Pierce County, in conjunction with a sediment management working group, should develop a plan to guide sediment management and gravel removal at strategic locations on a reach scale to reduce flood and channel migration risks, while achieving no net loss of ecological function.

Supporting Information

Gravel and sediment management in river channels typically involves in-channel deepening or dredging, or gravel bar scalping. Historically, in-channel dredging consisted of removal of vegetation, large wood, sand, gravel and other alluvial deposits from below the surface of the water and channel bed to increase channel capacity by lowering the stream bed elevation (Pierce County 1991). This was common practice from the 1930s until the mid-1980s. By the late 1980s to early 1990s, gravel removal had shifted to consist mostly of gravel bar scalping. This was due to increasing concerns about impacts of gravel removal operations on the
degradation of salmon habitat and channel bed head-cut effects, including effects on spawning and rearing areas. These concerns also resulted in changes in state law (see below).

Gravel bar scalping removes accumulated gravel above the elevation of average low water. Gravel bar scalping is most effective when performed during times of low water to maximize the quantity removed. Gravel bars are typically excavated beginning at a pre-determined distance and elevation from the water’s edge and sloping upward towards the levee or revetment at a two percent grade (Pierce County 1991). Along straighter portions of the river, the gravel bar is sometimes sloped upward towards the levee or revetment to approximately midpoint then excavated on a slope downward towards the levee, creating a shallow side channel along the toe of the levee (Pierce County 1991). A head cut protection buffer at the upstream end of the gravel bar is usually required as well. This head-cut protection area and distance is approximately one-third the length of the bar being scalped. These sediment maintenance measures were last used by Pierce County in 1995 and by private contractors in 1998.

4.3.3.1 Gravel Removal and the Washington Administrative Code (WAC 220-110-140)

New restrictions governing gravel removal in rivers and streams became effective in Washington State in 1994 (WAC 220-110-140), including the following:

- Gravel removal projects shall incorporate mitigation measures as necessary to achieve no-net-loss of productive capacity of fish and shellfish habitat.
- Gravel removal from a watercourse shall be limited to removal from exposed bars and shall not result in a lowering, over time, of the average channel cross-section profile through the project area or downstream.
• Additional removal of bed material, including removal from wetted portions of the channel, may be authorized where the project is an integral part of a comprehensive flood control plan approved by the department.

Other restrictions address issues such as the excavation zone, pre- and post-project channel cross-section surveys, stockpiling, and protection of the upstream end of the gravel bar.

4.3.3.2 Pierce County Pilot Gravel Removal Project

In 2009, Pierce County initiated a Pilot Gravel Removal Project. The Pilot Project is intended to (1) select one or two sites where gravel accumulations threatened public safety and welfare and (2) secure the necessary permits to remove the gravel bars. Pierce County identified 12 sites with sediment accumulations that threatened significant public infrastructure, private property, and public safety. The 12 sites were characterized in terms of biological, geomorphic, and hydraulic reach descriptions. These conditions were summarized into a Reach Conditions Existing Conditions Summary Table and used to select the top two sites.

Site selection characteristics include: (1) critical infrastructure at risk, (2) levee infrastructure at risk, (3) land use(s) at risk, (4) property value at risk, (5) site access, (6) geomorphic classification (single-thread confined or braided confined), (7) transport regime (whether the gravel bar is growing in size, lessening in size, or moving location), (8) long-term bar growth, (9) topographic steering effects due to gravel bars, (10) future channel response, (11) frequency of levee overtopping, (12) flood reduction potential, (13) biologic usage of the affected area, and (14) habitat quality of the affected area.

The Pilot Gravel Removal Project is the basis for Recommendation #3. It has a more immediate term benefit, removing specific gravel accumulations that endanger public safety and welfare.

4.3.3.3 Rivers Flood Plan Gravel Removal Projects

The Flood Plan gravel removal projects focus on two sites (116th Street East point bar gravel removal and Ford levee setback reach gravel removal). The purpose for gravel removal is to manage the volume of sediment transport downstream at strategic locations where gravel removal has fewer impacts on habitat and occurs in areas of demonstrated gravel accumulation. Large woody material entrained in areas of gravel removal would be relocated or repositioned to provide habitat benefits.

For the 116th Street bar, the upstream end or “head” (approximately 30 percent of the gravel bar) would be left in place. Gravel removal of the downstream 70 percent of the bar would result in approximately 13,700 cubic yards (CY) of material removed. Placement of large woody material in the head cut protection area is proposed, to mitigate for potential impacts to fish habitat as part of the gravel removal.

The Ford levee reach has the greatest demonstrated deposition of sediment based on the USGS study. The project targets removal of 36,000 CY of material from a gravel bar located between RM 24 and RM 24.4 along the right bank. Relocation of large wood on the gravel bar into engineered log jams along the setback levee and to reinforce an existing log jam at the head of
the gravel bar are proposed. For more detail on these projects, see Chapter 5 (section 5.3.10.2).

4.3.3.4 River Channel Monitoring

Changes in sediment transport and gravel accumulation can be tracked over time. Data can help to identify risks of flooding, the potential for flood risk reduction from gravel removal and the potential duration of benefit. The USGS study (2010) provides good baseline information for certain cross-sections on average channel elevations, current flood-conveyance capacity and sedimentation trends of the Puyallup River system (see Figure 4.6 and 4.7), including the Puyallup, Carbon and White rivers. Cross-sections were measured every 1000-2000 feet from the top of bank across the river bed to the opposite top of bank.

During past gravel removal operations in the 1980s-1990s, no quantitative information was available or generated on the effectiveness or duration of gravel removal benefits and the benefit was inconclusive. Such information is essential in determining the cost-effectiveness of gravel removal as a sediment management technique.

For example, modeling results from the USGS study show a water surface elevation reduction for gravel removal of up to 0.8 feet (based on approximately 52,000 CY of sediment removed) within the Calistoga reach (RM 20.7 to RM 21.5) (see blue line in Figure 4.10). However, the duration of the benefit in water surface reduction was not conclusive.

![Figure 4.10 – Initial change in water-surface elevation for different river-management options, including gravel bar scalping, setback levee, and combined](image)

The Flood Plan recommends monitoring of pre-construction channel conditions, as-built cross-sections where gravel removal occurred, and annual cross-sections for five to ten years and at least two significant sediment transport events after construction. This monitoring should be coordinated with USGS and Pierce County cross-section surveys noted in FPW#10. Information
on the magnitude and duration of elevated flow conditions for the flood season should be analyzed to relate potential gravel transport events to changes in bed elevations in the area of gravel removal. The specific monitoring design should be developed to answer the following questions:

1. What is the amount and rate of sediment deposition in the area of gravel removal post project?
2. How are sediment transport, scour, and deposition affected by wet season flow conditions?
3. What are the upstream and downstream effects from the gravel removal on channel configuration, levees and/or revetments, and habitat?

### 4.3.3.5 Long-term Sediment Management and Gravel Removal Plan

Given that historical levels of sediments entering the river systems are likely to continue and may increase in the future, it is imperative that Pierce County develop a long-term plan to guide sediment management, including gravel removal. This should be based on costs, benefits, and effectiveness of alternative approaches to gravel removal, monitoring data, as well as evaluation of other management strategies for reducing flood and channel migration risks.

### 4.3.3.6 Levee Setback Projects as a Sediment Management Tool

Levee setback projects have many benefits, including reducing water surface elevations, reconnecting floodplains, restoring natural riverine processes, and enhancing sediment deposition. For the Calistoga example noted above, sediment deposition following levee setback construction was found to be more than twice the volume of the gravel bar scalping option based on simulated cumulative bed volume change (USGS, 2010). Thus, levee setback projects offer an opportunity to manage downstream sediment transport and can include a sediment removal component to promote long-term sediment control.
4.4  FLOOD RISK REDUCTION FACILITY REPAIR AND MAINTENANCE

4.4.1 Facility Repair and Maintenance - U.S. Army Corps of Engineers PL 84-99 Program

Problem Description

Pierce County owns, operates, and maintains 39.76 miles of flood risk reduction facilities that are eligible for federal funding assistance and federal flood response assistance under Public Law (PL) 84-99 along several Pierce County river systems. These facilities are needed to reduce flood risk to public and private property and infrastructure. Adequate functioning of these facilities requires costly and ongoing maintenance and repair. To assist local governments, in 1944 Congress passed PL 84-99, which authorized the USACE to respond to natural disasters, including fighting floods and rescue operations, or in the repair or restoration of any flood control work damaged, threatened or destroyed by a flood. The federal program administered by the USACE known as the “Rehabilitation and Inspection Program” (RIP) helps a local sponsor (such as Pierce County) to offset the costs associated with maintaining flood reduction facilities, by providing 80 percent federal funding. This enables the repair and rehabilitation of damaged facilities at the request of the local sponsor to ensure flood control works continue to provide reliable protection to people’s lives, communities, and improved property.

<table>
<thead>
<tr>
<th>FPW #12: Facility Repair and Maintenance – PL 84-99 Program</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommendations</strong></td>
</tr>
<tr>
<td>1. Pierce County should continue to utilize the wide array of federal assistance offered through the PL 84-99 program of the U.S. Army Corps of Engineers for emergency response activities and rehabilitation of flood risk reduction facilities.</td>
</tr>
<tr>
<td>2. Pierce County should continue to engage in the current national review of levee maintenance standards that affect PL 84-99 eligibility and advocate for standards which are mutually compatible with flood control and preservation of fish habitat.</td>
</tr>
<tr>
<td>3. Pierce County should work with the USACE of Engineers to maintain eligibility for its PL84-99 facilities, while pursuing acceptable bio-engineering designs, as feasible.</td>
</tr>
<tr>
<td>4. Pierce County should continue to notify resource agencies and tribes regarding requests for assistance under PL 84-99. Pierce County should coordinate with and seek input from resource agencies and tribes when proposed alternatives are being developed by the USACE, and as mitigation is being developed.</td>
</tr>
<tr>
<td>5. Pierce County should encourage the USACE to consult with resource agencies when implementing emergency response or rehabilitation actions.</td>
</tr>
</tbody>
</table>
Supporting Information

4.4.1.1 Flood Control and Coastal Emergency Act (PL 84-99)

The USACE has authority under PL 84-99, for emergency management activities. Under PL 84-99, the Chief of Engineers is authorized to undertake activities including disaster preparedness, advance measures, emergency operations (flood response and post flood response), and rehabilitation of flood control works threatened or destroyed by flood. All flood fighting, prevention activities, and rehabilitation projects require a Cooperation Agreement (CA) signed by the public sponsor. The CA is a contract between the USACE and the local sponsor which clarifies the details of proposed work.

- **Disaster Preparedness**: Disaster preparedness and flood fight training are necessary for project inclusion in the USACE Rehabilitation and Inspection Program. PL 84-99 establishes an emergency fund to prepare for emergency responses to natural disasters, for flood fighting and rescue operations, and for rehabilitation of flood control works and protection of structures. Funding for USACE emergency response under this authority is provided by Congress through the annual Water Resources Development.

- **Advance Measures**: PL 84-99 allows for “advance measures” assistance to prevent or reduce flood damage conditions of imminent threat of unusual flooding. Advance measures include, but are not limited to sandbagging, Hesco barriers, and construction of dams.

- **Emergency Operations**: Emergency-related assistance from the USACE Engineers to meet immediate threats can be provided to the local sponsor regardless of participation or status in the RIP. It is not intended to provide permanent solutions to flood problems and the sponsor must remove all material used in flood fighting after the flood has receded. The USACE will only provide these types of assistance after local and state authorities have committed all available resources and are still unable to cope with the situation, and in some cases will only do so if the benefits of constructing the project are found to outweigh the cost of the construction. Coordination with the USACE’ district office is required to determine the proper assistance necessary.

- **Rehabilitation of Flood Control Works**: An eligible flood protection system can be rehabilitated if damaged by a flood event. The flood control system can be restored to its pre-disaster status at 20 percent cost to the eligible non-Federal system owner. All systems eligible for PL 84-99 rehabilitation assistance have to be in the RIP prior to the flood event. Acceptable operation and maintenance by the public sponsor are verified by levee inspections conducted by the USACE on a regular basis. The USACE has the responsibility to coordinate levee repair issues with interested federal, state, and local agencies following natural disaster events where flood control works are damaged.

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70 **Hesco barrier** - A modern gabion used for flood control and military fortification and the name of the British company that developed it in the late 1980s. It is made of a collapsible wire mesh container and heavy duty fabric liner, and used as a temporary to semi-permanent dike.
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS  
PIERCE COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

Flood control works may qualify for the RIP when the following requirements are met:

1. **Protecting People and Property** – The principal function of the project must be to protect people or property from floods.

2. **Public Sponsor** – The project must have a non-federal public sponsor.

3. **Reliability** – The project must provide reliable flood protection, and it must be technically sound. To provide complete flood protection, the FCW must either make a complete ring around the community, or tie into high ground on both the upstream and downstream ends of the project. From an engineering perspective, it has to be geotechnically stable and properly designed, and it must be well maintained.

4. **Project Completion Required** – The project must be completed. If it’s still under construction, it can’t enter the RIP.

5. **Minimum Level of Protection** – To be eligible to enter the RIP, agricultural levees (those protecting predominantly agricultural areas or agribusinesses) must be built to provide at least a 5-year level of protection. Urban levees (those protecting land with residences, public or commercial buildings, and industrial facilities) must provide at least a 10-year level of protection.

6. **Primary Levee Requirement** – In the case of a levee project, the levee must be a primary levee. Secondary levees are not eligible to enter the rehabilitation program.

7. **Construction Compliance** – The project must have been constructed in accordance with all applicable federal, state, and local permits, codes, ordinances, and applicable laws.

4.4.1.2 **U.S. Army Corps of Engineers Inspections**

The U.S. Army Corps of Engineers has established minimum standards for the construction, operation, maintenance, and preparedness of flood control works that must be met in order for the flood control works to be eligible for federal rehabilitation assistance after a flood. These standards are currently under review by the USACE.

4.4.2 **Annual Repair and Maintenance Program**

**Problem Description**

Pierce County owns, operates, and maintains over 67 miles of flood risk reduction facilities (levees and revetments) on four major rivers (Puyallup, White, Carbon, and Nisqually), 39.76 miles of which are included in the U.S. Army Corps of Engineers (USACE) Public Law (PL) 84-99 program. The facilities are necessary to help reduce flood risk to citizens and public and private properties and infrastructure.

A challenge that Pierce County SWM currently faces is carrying out repair and maintenance activities on its flood risk reduction facilities in a complex regulatory environment. Permits for some repair and maintenance activities, including for in-water work and activities that
adversely impact wetlands, may be controversial and difficult to secure. SWM and the permitting and resource agencies sometimes disagree about how repairs are designed and methods used because of potential impacts on listed species. Many repair activities require in-water work to adequately restore a damaged facility to the pre-damage level of flood protection. Occasionally, vegetation must be removed to either inspect facilities or undertake repairs. However, these activities can have unacceptable adverse effects on aquatic habitat. A program of activities to resolve these differences is needed if flood risk reduction facilities are going to be maintained in good working order, while also protecting habitat.

Repair and maintenance are crucial components of operating flood risk reduction facilities. Maintaining a consistent level of flood protection requires an annual program composed of vegetation maintenance, repairs, and rehabilitation. Additionally, a consistent and reliable maintenance program is vital to remain eligible to receive federal assistance for repairs, rehabilitation, and flood fighting through the Rehabilitation and Inspection Program authorized through PL 84-99 (see FPW#12).

**FPW #13: Annual Repair and Maintenance Program**

<table>
<thead>
<tr>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pierce County should continue to perform routine repair and preventive maintenance activities on flood risk reduction facilities damaged from annual high water or flood events and normal wear and tear.</td>
</tr>
<tr>
<td>2. For flood risk reduction facilities where recurring repairs are necessary, Pierce County should continue to evaluate options for long-term capital solutions to reduce the need for recurring repairs.</td>
</tr>
<tr>
<td>3. Pierce County should continue with its current Puyallup River vegetation management program in cooperation with the Puyallup Tribe and in coordination with the U.S. Army Corps of Engineers.</td>
</tr>
<tr>
<td>4. Pierce County should create a Best Management Practices manual that defines the operations, repair and maintenance program and details how to complete the various tasks in a way that minimizes adverse impacts on water resources and habitat.</td>
</tr>
<tr>
<td>5. Pierce County should continue to work with resource agencies and tribes to obtain programmatic approval of annual repair and maintenance activities.</td>
</tr>
</tbody>
</table>

**Supporting Information**

**4.4.2.1 Vegetation Management**

Vegetation management is sometimes necessary to ensure that flood risk reduction facilities perform as designed. Vegetation can be both beneficial and detrimental to the structural integrity of flood risk reduction facilities. Vegetation can be beneficial by increasing roughness.

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71 **Best Management Practices (BMPs)** – Physical, structural, or managerial practices that have gained general acceptance for their ability to prevent or reduce environmental impacts.
on the surface of the facility, which reduces scour forces and energy associated with river flows against the bank. Vegetation with a suitable root structure, such as willow with fine roots, can help bind rock armoring and soil particles together resulting in increased resistance to erosion and added slope stability. Vegetation along riverine corridors is also essential for its ability to provide shading and habitat opportunities for a variety of fish and wildlife species.

In order for a local sponsor to remain eligible for federal assistance under PL 84-99, Pierce County must maintain flood risk reduction facilities to USACE standards. One key component of the maintenance standards is vegetation management. Vegetation that impedes visual inspection of levees and revetments may also hinder maintenance and flood response activities. Large vegetation may also cause structural failure of levees when trees fall due to wind throw or river flows and root balls damage armoring. Conversely, vegetation along rivers and streams is considered an essential part of critical habitat for ESA listed species. Additionally, Pierce County has a Vegetation Management Agreement with the Puyallup Tribe stipulated by court order and included as part of the federal tribal settlement agreement.

4.4.2.2 Puyallup River Vegetation Management Program (PRVMP)

Vegetation management within the Puyallup River drainage basin is performed by Pierce County SWM in accordance with the Puyallup River Vegetation Management Program Agreement. This legally binding agreement between Pierce County and the Puyallup Tribe of Indians sets standards for riparian vegetation management to ensure that the interests of the Puyallup Tribe for riparian habitat is protected while balancing the need to manage vegetation along flood risk reduction facilities.

The objective of the PRVMP is to outline a basic policy of cooperation and coordination between the Puyallup Tribe of Indians and Pierce County. It is understood by both parties that the program sets the standards of riparian vegetation management, removal and maintenance. The agreement describes a general plan for vegetation management for the main stem rivers along the Puyallup River system and its tributary streams. The general plan divides the Puyallup River system into five definitive river reaches with specific management strategies outlined for each one. An example of Reach specific requirements for Reach 2:

A. Permitted Vegetation Removals: In addition to the General Plan as set forth above, the following vegetation removal shall be permitted along Reach 2.

1. Non-herbaceous vegetation on the river-ward levee slope may be selectively mowed to within one foot of the ground only along the top one-third of the levee slope.

2. Vegetation with a mainstem diameter greater than six inches measured at the base may be selectively removed, only where required for levee integrity, along the lower two-thirds of the levee slope.

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72 Main Stem – The principal channel of a stream to which tributaries join.
4.4.2.3 Repair and Rehabilitation Alternatives

Pierce County has been repairing and maintaining river management facilities for over 100 years. For decades, Pierce County focused on structural measures for reducing flood risks, with minimal emphasis on reducing impacts to habitat and aquatic resources. In the 1980s, there was a growing awareness of natural resource issues and fisheries concerns. Concerns expressed by the Puyallup Tribe of Indians regarding vegetation management and the general maintenance of flood risk reduction facilities, as well as the listing of salmon and trout under ESA, has resulted in Pierce County modifying its operations and maintenance program to be more protective of fish and wildlife habitat. Since the early 1990’s Pierce County continues to evaluate and implement new approaches for achieving flood protection needs, while protecting or improving habitat conditions.

Examples of current structural and nonstructural river management strategies include:

- Incorporating large woody material into rehabilitation work when feasible, including engineered log jams;
- Constructing setback levees to reconnect floodplains and restore natural riverine processes;
- Floodplain and land acquisition;
- Willow plantings along levee and revetment facing;
- Selective vegetation management;
- Bio-Engineering – Integration of vegetation, rock armoring and LWD into the design and rehabilitation of flood risk reduction facilities;
- Near complete elimination of herbicide/pesticide use; and
- Reducing levee side slopes during repairs to lower flow velocities and reduce scour.
4.5 FLOOD EDUCATION, FLOOD WARNING AND EMERGENCY RESPONSE

4.5.1 Flood Education and Outreach Program

Problem Description

Flood Hazard education and outreach is an important and low-cost tool that can increase awareness and motivate actions that improve public safety, reduce flood and channel migration risks, and protect natural floodplain functions.

Without a coordinated, comprehensive education and outreach program, residents are less aware of the actions necessary to: (1) make informed decisions about property purchases and land use; (2) be prepared for flood events; and (3) know what to do during and after a flood. Limited education and outreach resources are not used efficiently and effectively.

Pierce County has a flood education and outreach program that includes a website, flood preparedness trainings, a flood warning system, technical assistance to respond to citizen’s flood–related inquires, outreach at local fairs and events, brochures, and an annual mailing (“flood bulletin”) for floodplain residents in unincorporated Pierce County. However, to further reduce flood hazard risks, improve public safety, and protect natural floodplain functions, a more comprehensive education and outreach program should be developed and implemented.

FPW #14 – Flood Education and Outreach Program

Recommendations

1. Pierce County should develop and implement a comprehensive flood education and outreach program to reduce flood risks and achieve the maximum outreach and education points under the Community Rating System (CRS). All education and outreach activities should be evaluated on an annual basis for effectiveness and consistency with current CRS criteria.

2. Pierce County should continue to provide flood education and outreach to floodplain property owners through use of the annual flood bulletin and other communication tools. Messages about how to reduce risks from flooding and channel migration and how to recover from a flood should be strategically developed and delivered in a geographically targeted way.

3. Pierce County should expand its education and outreach program to include promotion of all aspects of the County’s flood hazard management program, such as available mapping and hazard information, acquisition and elevation programs, and water quality impacts of flooding.

4. Pierce County should increase promotion of the purchase and maintenance of flood insurance through the National Flood Insurance Program (NFIP). Education and outreach efforts should focus primarily on river floodplain property owners, real estate agents and insurance companies.

5. All Pierce County departments and divisions with a role in flood hazard management should collaborate in the annual development and implementation of flood education and outreach programs.

6. Pierce County should collaborate with cities, towns and other agencies and organizations on flood education and outreach.
Supporting Information

4.5.1.1 CRS Outreach Criteria

The Community Rating System (CRS) currently awards up to 380 points for flood hazard education and outreach activities under Activity 330. A total of 774 points are available for public information activities and approximately 15,000 points are available overall. To receive maximum CRS credit, information must be conveyed to the entire community and floodplain residents on the following ten topics: (1) local flood hazards, (2) flood safety, (3) flood insurance, (4) property protection measures, (5) natural and beneficial functions of the local floodplain, (6) mapping of local flood hazards, (7) flood warning systems, (8) floodplain development permit requirements, (9) substantial improvement/damage requirements, and (10) drainage system maintenance.

Maximizing CRS credits for flood education and outreach contributes to Pierce County’s overall CRS credit which, in turn, reduces flood insurance premium rates. Lower insurance rates are an incentive for residents to purchase and maintain flood insurance.

The National Flood Insurance Program (NFIP) is currently revising the 2012 Community Rating System (CRS) manual and proposing significant changes to Activity 330. The proposed changes should allow greater flexibility in planning for and implementing Pierce County’s flood education and outreach program. Pierce County should develop and implement a Public Information Program (PIP) to meet the 2012 CRS Manual education and outreach requirements. The PIP should be developed by a committee comprised of Pierce County staff and stakeholders, who will conduct a needs assessment, identify target audiences, messages, and projects to implement, and include monitoring and evaluation to ensure the program is efficient and effective. The PIP would be a comprehensive flood education and outreach program.

The number of homeowners and citizens purchasing and maintaining flood insurance is low in Pierce County. The draft 2012 CRS Manual proposes addition of a new activity (370) to improve flood insurance coverage in communities. This new activity will provide additional CRS credits to communities who actively encourage citizens and businesses to purchase and maintain flood insurance coverage. Promotion of the flood insurance program, education about flood risks, and awareness about the flood insurance discounts available should increase participation. Prior to adoption of the new countywide FEMA floodplain maps, Pierce County should conduct education and outreach to residential and commercial property owners impacted by revised flood insurance coverage requirements.

4.5.2 Flood Warning and Evacuation System

Problem Description

Flood forecasting is not an exact science and the forecast of peak river flows and stages often change throughout a flood event. The NWS identifies frontal storm systems out in the Pacific Ocean that could result in flooding, days in advance of reaching the Pacific Northwest coast.
The NWS also provides river peak flow forecasts early on in the storm system. As the storm system moves into Western Washington, the NWS issues updated river forecasts that differ from original forecasts. The forecasts continue throughout the storm and flood event, in which forecasted peaks continue to change. This complicates the work of emergency managers because decisions regarding public safety need to be made ahead of time, prior to the onset of flooding.

When the NWS issues river peak flow forecasts, they do not provide much indication on the confidence or probability of the forecasted peak. Further research and development of the technology to provide probabilistic river forecasts would be quite beneficial to emergency managers and responders. This would provide better indication on the confidence of the NWS forecast data. Otherwise, emergency personnel are left speculating and deriving their own conclusion as to the confidence and accuracy of the forecast flow data.

Making decisions on when to evacuate an area due to flood risk are extremely challenging given the uncertainty of forecast information. It is detrimental to issue evacuation notices when floods do not materialize from forecasts. It is also detrimental when evacuation notices are sent out too late to allow for adequate evacuation time, due to an under prediction of flood peaks. There is a need for better tools and information in order to provide credible evacuation notices and gain the public’s trust.

### FPW #15 – Flood Warning and Evacuation System

**Recommendations**

1. Pierce County should continue to monitor National Weather Service (NWS) flood information bulletins, advisories, watches, and warnings for information that could impact Pierce County operations, facilities and citizens.
2. Pierce County should monitor the river gauges along all rivers and match the results against the forecast information from the NWS. If there is a discrepancy in the information received, a physical check of the river should be conducted by Pierce County River Watch and/or Surface Water Management.
3. Pierce County should continue to coordinate with Tacoma Public Utilities (operators of Alder Dam) and the USACE (operators of Mud Mountain Dam) and King County (for flows along the White River) regarding reservoir levels, inflows and release rates that affect the magnitude and timing of downstream flood flows and incorporate this information into flood warnings.
4. Pierce County should coordinate with and disseminate information to local public safety answering points (PSAPs) concerning flood advisories, watches and warnings, and conditions as they become available. When required, Pierce County should work with the NWS to alert the public of imminent flooding through various methods, including National Weather Radio, Pierce County Alert, and when necessary door-to-door notification. In portions of the Puyallup Valley, Pierce County should use the voice portion of the lahār^74 warning AHAB sirens and the AM 1580 emergency radio station.
5. Pierce County should continue to support the River Watch Program in support of County flood response activities.

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73 **Peak Flow** – The maximum instantaneous rate of flow during a storm usually in reference to a specific design storm event.

74 **Lahar** – A landslide or mudflow of volcanic fragments on the flanks of a volcano.
FPW #15 – Flood Warning and Evacuation System

Recommendations

6. Pierce County should continue to work in collaboration with the NWS to assist them with climatic gauge station installations so that the NWS can develop and implement new technology for more accurate river flooding forecasts. Pierce County should encourage NWS efforts to develop technology to provide probabilistic river forecasts to improve the information available to emergency managers and responders.

7. Pierce County should develop a stage-discharge/evacuation rating curve or chart for each river system. Pierce County should work with local partners to develop protocols or criteria to guide when evacuation procedures should be implemented.

8. Pierce County should develop flood inundation mapping for various river flow peaks. The range of peaks should reflect 10-yr, 25-yr, 50-yr, and 75-yr recurrence intervals.

Supporting Information

4.5.2.1 Flood Warning

Floods by their very nature are dynamic and can impact various areas differently depending on the local conditions, differences in local rainfall, quantity of snow pack in the mountains, freezing level, previous rainfall, soil saturation and channel changes in the river bed itself. Flooding problems are exacerbated by a number of different factors, including new development of flood prone areas, and the changing nature of local river beds including sediment deposition and channel migration.

Real time information on river flows and stage (levels) during flood events are critical to inform citizens, emergency personnel, and agencies in making evacuation and emergency response decisions. Flow and stage data support this effort. These data are also important for hydrologic and hydraulic modeling of river systems for updated floodplain mapping.

Pierce County has a four phase flood warning system (see Table 4.2):

- Phase 1 – No Flooding -no flooding is occurring; however, river flows may be at an elevated flow stage;
- Phase 2 – Minor Flooding – minor flooding is likely to occur. Low lying areas and pasture may flood due to rivers or streams overtopping their banks;
- Phase 3 – Moderate Flooding – moderate flooding is likely to occur. Adjacent property may be flooding and have more dangerous high-velocity flow and debris; and
- Phase 4 – Severe Flooding – severe flooding is likely to occur. Adjacent and nearby property may be flooding with a very dangerous high-velocity flow, debris and deep water.
Table 4.2 – Four Phase Flood Warning Systems for Different River Systems in Pierce County

<table>
<thead>
<tr>
<th>River System (location)</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle/Lower Puyallup River (Puyallup gauge)</td>
<td>Less than 25,000 cfs</td>
<td>25,000-30,000 cfs</td>
<td>30,000-45,000 cfs</td>
<td>&gt; 45,000 cfs</td>
</tr>
<tr>
<td>Upper Puyallup (Orting gauge)</td>
<td>Less than 4,500 cfs</td>
<td>4,500-8,000 cfs</td>
<td>8,000-10,000 cfs</td>
<td>&gt; 10,000 cfs</td>
</tr>
<tr>
<td>Carbon River (Fairfax gauge)</td>
<td>4,000 - 6,500 cfs</td>
<td>6,500 - 8,000 cfs</td>
<td>8,000 - 10,000 cfs</td>
<td>&gt; 10,000 cfs</td>
</tr>
<tr>
<td>White River (Auburn gauge)</td>
<td>6,000 - 8,000 cfs USGS</td>
<td>8,000 - 12,000 cfs</td>
<td>12,000 - 15,000 cfs</td>
<td>&gt; 15,000 cfs</td>
</tr>
<tr>
<td>White River (above Buckley)</td>
<td>2,500 - 6,000 cfs</td>
<td>6,000 - 8,000 cfs</td>
<td>8,000 - 12,000 cfs</td>
<td>&gt; 12,000 cfs</td>
</tr>
<tr>
<td>Nisqually River (McKenna gauge)</td>
<td>10,000 - 15,000 cfs</td>
<td>15,000 - 22,000 cfs</td>
<td>22,000 - 35,000 cfs</td>
<td>&gt; 35,000 cfs &amp; Greater</td>
</tr>
<tr>
<td>Nisqually River (National gauge)</td>
<td>4,000 - 9,000 cfs</td>
<td>9,000 - 12,000 cfs</td>
<td>12,000 - 16,000 cfs</td>
<td>&gt; 16,000 cfs &amp; Greater</td>
</tr>
</tbody>
</table>

4.5.2.2 Evacuations

As rivers approach overbank levels, it may become necessary to send out warning and evacuation notices to residents informing them of the risk. Because the decision to evacuate is both an individual decision and voluntary on the part of the individual, Pierce County will attempt, through the use of accurate incident information, convince citizens of the necessity to evacuate. The more citizens understand the flooding problems and risks, the better informed they will be in making life safety decisions. Evacuation notices should be given by a credible source, such as the County Executive, city mayors, and fire chiefs. This helps convince citizens of the seriousness of the flooding problem and risks. Similarly, door-to-door notifications should be done by a person in uniform such as a member of the local police department, a sheriff’s deputy or a member of the fire district.

Protocols or criteria should be developed to guide when evacuation procedures should be implemented. This should be based on various river stages and flows at different gauge locations. Some flood-prone areas are impacted by lower stages of river flow while others are more impacted at higher flow stages. This will likely require more detailed investigation and hydraulic analysis to determine these relationships. Ultimately, a Stage-Flow vs. Evacuation rating or chart could be developed. Depending upon actual conditions, this could be a useful tool for evacuation planning and decision making purposes.

4.5.2.3 Gauging Information

The U.S. Army Corps of Engineers (USACE) Mud Mountain Dam currently does not have a gauge located on its discharge outlet. It is not possible to determine the actual discharge coming directly from the reservoir. USACE operating personnel can only provide approximate flow magnitudes being released from the reservoir. No information is available online, necessitating
a call to reservoir operators for flow release information. The County should support a collaborative effort with the USACE so that flow release information can be made readily available.

Development of flood inundation mapping for more frequent recurrent interval events (i.e. 10, 25, 50, 75 year events) would aid in planning for evacuations and help in flood warning decision making. Pierce County currently only has mapping for the 100-yr and 500-yr peak flood flow events.

4.5.3 Emergency Response and Flood Fighting

Problem Description

Central coordination, communication, and well-established protocols are necessary components of an effective and timely emergency response to flooding. Local governments, agencies, emergency personnel and citizens all benefit from an approach with defined roles and responsibilities and clear expectations. In the absence of these features, roles may overlap, gaps in coordination and communication may occur, and emergency response and flood fighting become less effective.

Some flooding is minor and localized, while other flooding is more severe and widespread. The need to protect both public and private structures becomes necessary during many flood events. Flood preparation and flood fighting responses frequently utilize sandbags to contain floodwaters or reduce the risk of flooding.

Following a flood, a timely and predictable process for review of permits to allow citizens to remove flood deposited sediment and debris to and to make necessary repairs to flood damaged structures is essential. Such a process allows citizens to recover more quickly from flood events and supports broader economic recovery.

While every flood that impacts Pierce County has some features in common, there are always new twists, changes in regulations, changes in the recovery process, and new personnel. Exercises or drills identify problems and improve coordination, and make actual response go much smoother. The more a skill is practiced the easier it becomes in an actual situation. Repetition is an effective means to executing and responding to the real event according to plan. Different jurisdictions, agencies or organizations are not always familiar with the capabilities, methods or response orientation of neighboring jurisdictions or the other agencies involved in a flood response. Being able to work together, initially in an exercise format prior to an actual emergency, enhances their ability to respond and work together during an actual flood event.

<table>
<thead>
<tr>
<th>FPW #16 – Emergency Response and Flood Fighting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommendations</strong></td>
</tr>
<tr>
<td>1. Pierce County should continue to coordinate flood response and recovery activities by supporting the maintenance and operations of the Pierce County Emergency Operations Center (EOC) and</td>
</tr>
</tbody>
</table>
FPW #16 – Emergency Response and Flood Fighting

Recommendations

1. Ensuring that individual departments support its flood related activities by assigning staff to the EOC. Pierce County should operate under the guidelines of the County’s Comprehensive Emergency Management Plan (CEMP), develop or modify existing standard operating procedures (SOPs) for flood operations within the various departments, and ensure that flood response activities are carried out within the parameters of the Incident Command System (ICS) and the National Incident Management System (NIMS).

2. As the threat of potential flooding develops, Pierce County should continue to monitor the rivers on scene through the use of the Pierce County River Watch program and Surface Water Management staff at both historical flood sites and other areas with at risk structures in order to provide advance warning of emerging flood risks.

3. During a flood event, Pierce County should, as much as practicable, work with cities, towns, tribes, the U.S. Army Corps of Engineers, Tacoma Public Utilities, and state agencies (e.g., WSDOT, Emergency Management) to monitor and respond as necessary to any flood incident within the confines of Pierce County. Pierce County should continue to coordinate flood response activities with adjacent counties and applicable jurisdictions for events that have inter-county and regional impacts.

4. Pierce County may provide sand bags and sand when available to Pierce County fire districts and city and town public works departments. Citizens may request them from the individual fire district or city/town public works departments. Property owners are responsible for placing sandbags and cleaning up sandbags after the flood event, and meeting any regulations relating to sandbagging activity.

5. Pierce County should continue to carefully document and track all costs associated with flood response and recovery activities to ensure that if a federal emergency or disaster declaration is proclaimed, the reimbursement process will be as efficient as possible.

6. To support disaster recovery programs and economic recovery following a flood, Pierce County should develop process to expedite permit review following a flood event. This process should allow for the removal of flood deposited sediment and debris and allow for the structural repair of flood damaged structures.

7. Pierce County should continue to carry out a flood emergency exercise involving the various departments active in flood response on an annual basis. Exercises can range from simple tabletop/drills to more involved functional or full scale exercises that include specific aspects of preparedness, response and recovery. The exercise should be in compliance with the Homeland Security Exercise and Evaluation Program (HSEEP). Pierce County should coordinate flood exercises with the various jurisdictions, agencies, and organizations typically impacted by floods.

8. Pierce County should periodically review and update its standard guidance and protocols for emergency flood hazard response to address internal and external coordination before, during and after conducting emergency response activities.

Supporting Information

Pierce County has a long history of flood related activities by various County Departments, much of which is coordinated with cities, towns, tribes, and other agencies in the County. Effective and timely response requires good coordination of all resources available. In flood response this means coordinating the response efforts of federal, state, tribal, and local...
agencies. In order for this to happen, all operations should work under nationally developed and accepted protocols as put forth in the federal National Incident Management System (NIMS). In addition, County operations should be coordinated through an Emergency Operations Center (EOC), working cooperatively with other EOCs, both local and state, and follow the outlines put forth in the County’s CEMP.

The development of the federal Incident Command System (ICS) and later the NIMS created nationally recognized guidelines for response both in the field and in EOC operations. Pierce County trains its responders in ICS and NIMS and operates the EOC under the same guidelines.

Pierce County’s Comprehensive Emergency Management Plan (CEMP) follows the format recommended by the federal Comprehensive Preparedness Guide 101 and is compliant with the National Incident Management System. This format is a reflection of the National Response Framework and the format adopted by the Washington State CEMP. Having all levels of government operate within a standard framework means that all levels understand and can easily support the response and resource needs at the local level.

Since 1962 there have been 15 presidential disaster declarations that included flooding in Pierce County. These declarations do not include the many flood responses that Pierce County has responded to that do not qualify as a federal disaster.

<table>
<thead>
<tr>
<th>Federal Flood Disaster Declarations</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-1817-WA—01/06-16/2009</td>
<td>Flooding from a severe storm throughout much of Washington. 23 counties declared.</td>
</tr>
<tr>
<td>DR-1734-WA—12/1-17/2007</td>
<td>Flooding throughout most of W. Washington. Pierce County, while having flooding, was not declared.</td>
</tr>
<tr>
<td>DR-1499-WA—10/2003</td>
<td>Surface flooding</td>
</tr>
<tr>
<td>DR-1079-WA—11-12/1995</td>
<td>100-year flood at Alderton on the Puyallup and 50-year flood at La Grande</td>
</tr>
<tr>
<td>DR-896-WA—12/1990</td>
<td>Stafford Act assistance provided $5.1 million</td>
</tr>
<tr>
<td>DR-883-WA—11/1990</td>
<td>Stafford Act assistance provided $57 million</td>
</tr>
<tr>
<td>DR-852-WA—1/1990</td>
<td>Stafford Act assistance provided $17.8 million</td>
</tr>
<tr>
<td>DR-784-WA—11/1986</td>
<td>Two deaths. $11 million in private property damage and $6 million in public damage</td>
</tr>
<tr>
<td>DR-545-WA—12/1977</td>
<td>16 counties were declared. Very heavy rain in the upper Nisqually caused significant damage.</td>
</tr>
<tr>
<td>DR-492-WA—12/1975</td>
<td>13 counties flooded</td>
</tr>
<tr>
<td>DR-328-WA—2/1972</td>
<td>King, Pierce and Thurston counties flooding</td>
</tr>
<tr>
<td>DR-185-WA—12/1964</td>
<td>Wide ranging flooding affected 19 counties in both eastern and western Washington</td>
</tr>
</tbody>
</table>
4.5.3.1 County Department Standard Operation Procedures, Mutual Aid and Finance

Each department through their individual Standard Operating Procedures (SOPs) has determined the basic structure of their department’s flood operations. Departments attempt to maintain administrative and operational continuity as much as possible. The decision to make additions to the regular department operations is determined by the severity of the incident and the need for individual department response.

Some floods go beyond the ability of individual departments to handle. Prearranged contracts for flood response, Memorandum of Understanding (MOU) or Memorandum of Agreement (MOA) may already exist or could be signed to bring resources to individual areas of flood response. Requests for assistance may occur through mutual aid agreements that departments have with other local jurisdictions, or through the Omnibus Mutual Aid Agreement at the state level (requests go through the state EOC). If the flood incident is throughout western Washington and goes beyond the state’s capability to assist, the Emergency Management Assistance Compact (EMAC) may be used to request resources from other states.

Each County department is responsible for tracking, compiling and submitting accurate and complete flood-related expenditures to the PC EOC finance chief throughout the response and recovery period. When flooding damages are severe enough, expenditure information is used to assist with the development of the application for federal assistance under the Stafford Act.

Pre-incident resources, like acquisition of sandbags and sandbagging equipment, are usually funded by grants or approved general fund purchases. Incident specific acquisitions may be purchased outright, come through local agency mutual aid, pre-arranged contracts, or EMAC requests submitted through Washington State Emergency Management Department.

4.5.3.2 Sandbag Operations

Placement of sandbags during flood events can provide local protection of structures and infrastructure. Sand bags may be placed locally by an individual or group of homeowners, or in a coordinated fashion with substantial use of volunteers. Flood response coordination will generally occur within a three phase approach: before, during, and after the flood event.

**Before Flood Event** - Pre-flood preparatory efforts typically entail coordination of volunteers, public education, and flood fighting materials. Public education can inform the public of flood prone areas, the need to protect themselves, and locations to obtain flood fighting materials and contact information for volunteer assistance for sandbagging. Coordination and training of volunteers improves flood hazard awareness, flood fighting techniques, and the use of materials and equipment. Management of flood fighting materials is a crucial component of flood fighting. Stock piled materials need to be counted, inspected, and replenished on an annual basis. Distribution locations should be coordinated prior to flood season. Pre-flood preparation should enhance flood fighting efficiencies by maximizing the use of available resources.

**During Flood Event** – The dissemination of information and coordination of resources are two critical components during a flood event. The County should broadcast locations where citizens can pick up sandbags and other flood fighting materials. Flood fighting materials placed on
private property by the property owner and/or volunteers becomes the property of the property owner and appropriate disposal is their responsibility. Coordination between Pierce County DEM (PCDEM), other jurisdictions, and citizens is imperative during a flood event to increase the chances of successful deployment of flood-fighting resources. Volunteers should be coordinated with assistance provide by PCDEM. Field coordination is also critical to ensure resources are deployed efficiently and effectively. This includes identifying staging areas, establishing safe traffic circulation patterns and allocation of volunteers.

**After Flood Event** – Pierce County should inform the public that users of sandbags are responsible for their proper disposal. Users of sandbags should also be reminded that sandbags which have come into contact with flood waters may be contaminated. Functionally, there are three categories of used sand bags that must be treated differently: clean, light contamination (solid waste) and heavy contamination (hazardous waste).

**4.5.3.3 Flood Emergency Drills or Exercises**

Exercises test the effectiveness of emergency response plans so that gaps can be identified. Gaps can be corrected either in changes to standard operating procedures used or changes in the plan itself. With floods being the most frequent incident to impact Pierce County, finding what needs modifying ahead of time could prevent undesirable results during the incident. Exercises set a baseline of knowledge and capabilities against which future exercises and actual events can be compared. Each exercise will show both the strengths and gaps in the portion of the plan being exercised. An after-action review (or debriefing) should point out those areas of the plan that may need revision.

This is best done by using the HSEEP compliance Guidance Checklist. The HSEEP is a capabilities and performance based exercise program, developed to provide a common exercise standard nationally. Key aspects of it are having a consistent terminology, design process, evaluation tools, and common documentation standards. Developed from a survey of previous best practices and lessons learned, compliance with it includes:

- Having an annual training and exercise planning workshop and maintaining a multiyear training and exercise plan;
- Planning and conducting exercises in accordance with HSEEP guidelines and policy;
- Developing and submitting properly formatted After Action Reports/ Improvement Plan (AAR/IP); and
- Tracking and implementing corrective actions identified in the AAR/IP.

Exercises demonstrate the effectiveness of preparedness and mitigation activities. Over time as the County incorporates different preparedness and mitigation activities, the results of those activities should show up both in exercises and during actual flood events.

Including community partners of all levels, in various exercises, ensures that members of those organizations are knowledgeable of each other’s roles, responsibilities, and abilities prior to having to rely on them in an actual flood situation. It helps to forge relationships and clear up misconceptions about each other’s abilities leading to an improved regional flood response.
Due to the silo effect, many organizations see things including response and recovery from their own perspective, sometimes missing critical points that a member from another organization with a different frame of reference will notice. Having this diverse representation, in an exercise, allows those different viewpoints to be recognized and may lead to a better understanding of how operations work and may point to further ways the organizations may work with each other. This cross fertilization may lead to necessary changes in the plan or supportive standard operating procedures for any of the participating organizations. Skills and processes learned from other individuals and organizations may be incorporated into Pierce County emergency plans through an adaptive management process. The ultimate goal of developing an emergency exercise program is to institutionalize a process of continuous improvement.
4.6  COORDINATION, ADAPTIVE MANAGEMENT, AND MULTIPLE BENEFITS

4.6.1  Incidental Take Authorization

Problem Description

Flood hazard management activities can adversely affect habitat of fish, but they are crucial to public safety. Violating “take” prohibitions of the federal Endangered Species Act (ESA) may result in civil or criminal penalties, loss of federal funding on a broad scale, potentially extensive legal expenses, and injunctions to stop operations. However, ESA also provides for authorizing take that is incidental to and not intended as part of an action when in compliance with an incidental take statement or permit. Long-term cumulative adverse effects of some flood hazard management activities cannot be mitigated adequately through on-site mitigation. The only way to mitigate these adverse effects is through off-site mitigation and long-term programmatic efforts.

FPW#17 – Incidental Take Authorization

<table>
<thead>
<tr>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pierce County Surface Water Management (SWM) should seek incidental take authorization for its activities that affect species listed as threatened or endangered under the federal Endangered Species Act (ESA).</td>
</tr>
</tbody>
</table>

Supporting Information

The federal Endangered Species Act (ESA) prohibits the take of species listed as threatened or endangered. Take is defined as “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or any such conduct.” Harass means an intentional or negligent act that creates the likelihood of injuring wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns such as breeding, feeding, or sheltering (50 CFR 17.3). Harm means an act that actually kills or injures a protected species (50 CFR 222.102). Harm can result from habitat modification or degradation that kills or injures protected species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering.

ESA provides protection from a finding of “take” in three ways; through a Section 4(d) exemption, an incidental take statement as part of a biological opinion per Section 7, and an incidental take permit per Section 10.

4.6.1.1  Section 4(d) Rule

Section 4(d) of the ESA authorizes the National Marine Fisheries Service (NMFS) to customize regulations to conserve threatened species and it also applies to Section 9 take prohibitions. A
4(d) rule “excepts” activities or programs deemed by NMFS to “conserve” listed species from ESA restrictions. The rule may adopt local or regional programs, thus providing protection for program activities from “take” prohibitions. The program or activities become part of the species recovery plan. An example of this is the Regional Road Maintenance Program, 2002.

4.6.1.2 Section 7 Incidental Take Statements

Section 7 of the ESA directs federal agencies to ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any endangered or threatened species. Section 7 applies to projects requiring a federal permit or seeking federal funding.

The process usually begins as an informal consultation with U.S. Fish and Wildlife Service for terrestrial species and the National Marine Fisheries Service for marine species, and affected tribes. If it appears that the proposal may affect a listed species, the federal agency prepares a biological assessment to assist in determining the degree of effect on a species. When the federal agency determines that its action is likely to adversely affect a listed species, formal consultation is requested. The respective Service(s) prepare a biological opinion on whether the proposed activity will jeopardize the continued existence of a listed species. Jeopardy occurs when an action is reasonably expected, directly or indirectly, to diminish a species’ numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced. When the Service finds that an action may adversely affect a species, but not jeopardize its continued existence, the Service prepares an incidental take statement. The statement includes the amount or extent of expected take, reasonable and prudent measures to minimize the take, and terms and conditions that must be observed when implementing the measures.

4.6.1.3 Incidental Take Permits (10.a.1(b))

In contrast, an incidental take permit contains all the conditions that must be implemented in order to be exempt from the take prohibition and provides an explanation of the evidence that the Services have considered in reaching their conclusions about issuing the permit. An application is filed with the Services along with a habitat conservation plan (HCP). After public review and comment, the Services must find that the habitat conservation plan and proposed actions (1) involve a taking of an endangered species that will be incidental to an otherwise lawful activity; (2) the permit applicant will minimize and mitigate the impacts of the taking "to the maximum extent practicable"; (3) the applicant has ensured adequate funding for its conservation plan; and (4) the taking will not appreciably reduce the likelihood of the survival of the species.

At the heart of incidental take permits is a habitat conservation plan. An HCP starts with a group of activities with potential adverse effects, frequently those with long-term direct and indirect cumulative adverse effects. Adverse effects are quantified to the extent possible. Next, the range of programs, projects, methods, and activities that can overcome the adverse effects are identified. If the permit applicant adopts a plan that the Services and Tribes agree will not appreciably reduce the likelihood of the survival and recovery of the species in the wild, the applicant can file for the incidental take permit.
Federal funding of up to 75 percent of the cost of preparing an HCP, 90 percent for multi-sponsors, is available for qualifying applicants. ESA also provides federal grants to implement HCPs.

A successful HCP starts with a clear focus on activities with incidental take not covered by Section 7 consultations. For Surface Water Management, that means repair and maintenance activities and other activities of SWM which benefit water quality and aquatic habitat (e.g., floodplain acquisition, setback levees, etc.). This broadens the dialogue between stakeholders to maintenance and repair within the context of the whole SWM system.

### 4.6.2 Adaptive Management

**Problem Description**

The Rivers Flood Plan contains recommendations and capital projects to guide Pierce County’s flood hazard reduction over the next 10-20 years. The Plan reflects the best available information at the time of plan completion, but there remains much to be learned through implementation. Several of the recommendations in this Plan include future evaluation and/or monitoring (see FPW #10, PR #1, CR #1). Without a well-designed approach to determine the effectiveness of strategies and actions in meeting project objectives, learning opportunities are lost for improving future actions. Adaptive management offers a framework and systematic approach for understanding the effectiveness of individual projects as well as to measure progress made towards meeting stated project goals and objectives. This information may be used to make adjustments to projects over time as well as to continually improve the effectiveness of new management policies and practices. Adaptive management leads to improved outcomes and more comprehensive ways to communicate results to technical and non-technical audiences.

<table>
<thead>
<tr>
<th>FPW#18 – Adaptive Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommendations</strong></td>
</tr>
<tr>
<td>1. Pierce County should use the principles of adaptive management to assess problems, define strategies and actions, identify objectives to be achieved through these activities, implement actions, monitor to determine if actions are meeting objectives, evaluate and compare actual outcomes, and adjust future actions to reflect new understanding over time. Projects and programs should be monitored to assess their effectiveness and the degree to which they function relative to their stated purpose, goals and objectives (see also FPW#10).</td>
</tr>
<tr>
<td>2. Pierce County should develop a coordinated information management system to manage data and document performance, costs, and effectiveness. The information should be reviewed annually to (a) summarize projects and programs monitored and evaluated through the adaptive management process, (b) inform future actions, and (c) present information to decision makers.</td>
</tr>
</tbody>
</table>
Supporting Information

Pierce County rivers are dynamic systems in terms of flow, sediment and wood transport. Flooding, channel migration and river interaction with the floodplains are all natural processes that can occasionally conflict with human land uses and activities, and create risks. Managing for the health of natural and human dimensions of ecosystems often requires decision-making in the face of uncertainty, unexpected change, and variability.

4.6.2.1 Adaptive Management

Adaptive management frameworks provide a strategic approach to problem solving and decision-making in the face of ongoing uncertainty. The Puget Sound ecosystem recovery process has adopted the Open Standards for the Practice of Conservation (Open Standards), as the adaptive management framework for the region. The Open Standards framework was developed by the Conservation Measures Partnership and has been deployed nationally and internationally in support of conservation and resource management projects and initiatives. In addition to the Puget Sound Partnership’s deployment of the Open Standards, other regional applications of the Open Standards include: regional salmon recovery implementation, the Hood Canal Watershed Protection Initiative, the Pilchuck Watershed Protection Project, and Port Susan Conservation the Snohomish Basin Watershed Protection Plan. The Open Standards is a simple five-step process as identified within figure 4.11.

Figure 4.11 - Framework for Adaptive Management
Step 1 (conceptualize) involves defining the extent of the problem and examining potential opportunities for taking action. Step 2 (plan actions and monitoring) involves developing goals, strategies and theories of change associated with primary strategies, as well as the selection of indicators to monitor the effectiveness of the chosen action. Step 3 (implement actions and monitoring) involves implementation of the project or program and monitoring to determine how effective the actions are in meeting project goals and management objectives. This sometimes involves formal hypothesis testing. Step 4 (analyze, use and adapt) involves the evaluation of data, comparing actual outcomes to forecasted outcomes, and adaptation of strategic plan, as necessary. Step 5 (capture and share learning) involves sharing information and knowledge with all interested stakeholders to reflect new understanding from results of steps 1-4 in a continual cycle of improvement.

Adaptive management is an integral component of implementation. An adaptive management framework includes an institutional structure that, in combination with monitoring and evaluation, can be used to judge progress in achieving Plan goals and objectives. The framework also lays out how information from monitoring and evaluation efforts will guide decisions about future strategies and actions.

### 4.6.2.2 Application to Flood Plan Projects

When permits are issued for maintenance, repair, or replacement of flood risk reduction facilities, the permits often require monitoring to ensure the facility is functioning as designed. Post project monitoring of selected indicators can provide valuable information on the effectiveness of project types and how to improve the design and construction of future projects. Pierce County should use this information to modify and adjust design approaches and construction and maintenance practices to ensure that the most appropriate methods and materials are used. This information may also be used to communicate progress achieved towards reaching flood hazard management project and reach level goals over time. Adaptive management approaches to plan implementation require a commitment to an ongoing coordinated information management system.

### 4.6.3 Climate Change

**Problem Description**

Climate change in the Pacific Northwest is predicted to have significant effects on flooding and channel migration within Pierce County river systems. More precipitation is expected to fall as rain instead of snow, which could increase the magnitude of fall and winter flooding along the major rivers. As a result, flood events may be more frequent and longer in duration. Glacial retreat on Mt. Rainier is expected to continue, exposing large quantities of sediment to transport downstream, potentially increasing aggradation and channel migration in river valleys. It is necessary to account for these changes as part of project and program implementation within the river corridors and floodplains of the planning area.
FPW#19 – Climate Change

Recommendations

1. Pierce County should consider emerging information about the impacts of climate change on precipitation patterns, future peak flows and sediment transport when developing recommended design criteria for public infrastructure projects including levees, revetments and bridges and in the development of a rivers sediment management plan.

2. Pierce County should work with regional experts (e.g., USGS, UW Climate Impacts Group) and other counties to exchange information and better understand the potential effects of climate change on river conditions, in terms of peak flows and sediment transport.

Supporting Information

Twice during the last ten years, Pierce County has experienced record peak flows on one or more major rivers: November 2006 and January 2009. In November 2006, 18 inches of rainfall was recorded at Paradise on Mt. Rainier during a 36-hour period, resulting in the highest recorded peak flow for the upper Nisqually River at National and the upper Puyallup River upstream of Orting. During the January 2009 storm event, South Prairie Creek and the lower Puyallup River experienced record peak flows. These peak flows exceeded any on record, which date to the 1940s on the Nisqually River and South Prairie Creek and the 1930s on the middle and lower Puyallup River.

Climate change has already altered and will continue to alter local and regional water cycles (Global Climate Change Impacts in the United States, 2009). Floods are likely to become more common and more intense as regional and seasonal precipitation patterns change, and rainfall becomes more concentrated into heavy events. In the Northwest, more precipitation will be falling as rain instead of snow.

Major river flooding is generally dependent on four factors (King County, 2010): (1) the intensity and duration of rainfall; (2) antecedent soil moisture conditions; (3) basin area and elevations; and (4) snow pack presence, location and depth. An analysis using two global climate model scenarios by King County suggest an increase in the magnitude, duration, frequency, and earlier timing of extreme precipitation and river flow. In particular, increases in the magnitude of 10- to 100-year return interval flows are predicted.

The FEMA Model Ordinance (2010) also addresses climate change as it relates to both future flood risks and impacts on salmon and habitat. Reasonable and Prudent Alternative Element 2 - Mapping notes that FEMA will revise map modeling methods to consider future land use change and climate change. Future conditions considered should include changes in the watershed, its floodplain, and its hydrology; climate change, and other conditions that affect

75 Antecedent Soil Moisture Condition - The amount of moisture present in the soil at the beginning of a storm event, frequently expressed as an index corresponding to the weighted average of daily rainfalls for a given period of time preceding the storm event
flood risks. Communities are also to evaluate and identify the risk of flooding behind 100-year levees based on these anticipated future conditions.

The Climate Impacts Group at the University of Washington has made projections for some local rivers based on different modeling scenarios. For example, the average increase in 100 year flood flows for the Snohomish River at Monroe for the 2040s is estimated at +20 percent under the A1B greenhouse gas emissions scenario. Generally speaking, 100 year flood magnitudes (Q100 values) are projected to systematically increase in many areas of the PNW due to increasing precipitation and rising snowlines. (The Pacific Northwest Climate CIGnal, Issue #24, Winter 2011).

From 1913 to 1994, Mt. Rainier glaciers decreased by approximately 25 percent. Preliminary data from Mount Rainier National Park indicates that the glacier has lost another 18 percent since 2003. The south-facing Nisqually Glacier has retreated more than one mile since 1840, but in the last seven years its recession rate has seen a three-fold increase (Abbe et al., 2010). The Emmons and Nisqually glaciers have been measured using a mass balance approach to look at annual changes, comparing winter accumulation and summer melting. In all years between 2003 and 2009, there has been a net melting of the both glaciers between 0.5 and 2.0 m water equivalent (Kennard et al., 2010).

4.6.4 Habitat and Riparian Areas Mitigation

Problem Description

Flood management capital projects require permits from multiple local, state and federal agencies. These agencies have policies that vary regarding allowable impacts to the resources they regulate. Agencies share a general strategy for conditioning permits for projects, focusing first on attempting to eliminate the impact if possible, then to minimize and mitigate for any unavoidable habitat impacts or consequences. Mitigation may not be limited to new projects but also be applied to projects that maintain a condition that is detrimental to the resource (e.g. fish, wetlands, shorelines) being protected.

Many of the proposed projects within the Flood Plan will be unable to completely avoid impacts and it will be important to proactively define mitigation opportunities that address anticipated impacts in support of improving the efficiency of permitting process. This requires an understanding of projects, river processes, and factors that currently limit or adversely impact river and floodplain systems. Anticipating and preparing for adequate mitigation will help to expedite projects proposed by the Flood Plan and provide better protection for fish and riparian habitat.

<table>
<thead>
<tr>
<th>FPW#20 – Habitat and Riparian Areas Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendations</td>
</tr>
<tr>
<td>1. Pierce County should engage resource agencies and tribes in creating fish and riparian habitat area advance mitigation opportunities to mitigate for impacts of Flood Plan projects that cannot be mitigated on-site. Pierce County should work with agencies to establish policies for crediting</td>
</tr>
</tbody>
</table>
### FPW#20 – Habitat and Riparian Areas Mitigation

<table>
<thead>
<tr>
<th>Recommendations</th>
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<tbody>
<tr>
<td>advance mitigation.</td>
</tr>
<tr>
<td>2. Pierce County should work with resource agencies and tribes to identify specific sites for fish and riparian habitat restoration or enhancement at the watershed and reach scale as candidates for off-site mitigation. The list of fish habitat problem areas described in Chapter 5 should be used as a starting point.</td>
</tr>
<tr>
<td>3. Pierce County should allocate funds to a mitigation account that is available to acquire property or construct projects identified in #2 above.</td>
</tr>
</tbody>
</table>

### Supporting Information

#### 4.6.3.1 Existing Conditions

In a natural state the river and floodplain are inseparable. They act as a single ecological unit that absorbs energy and stores sediment and flood water. If viewed as a single entity, the river ecosystem is stable and its boundaries are predictable (see Figure 4.12). This relationship is expressed in meandering channels, pools with large wood, side channels, gravel bars, wetlands and off mainstem channel stream areas (e.g., ox bow cutoffs, wall base channels). Over the past two+ million years salmon have successfully evolved to use this ecosystem. Adult salmon use the gravel bars for spawning, and wood-enhanced pools for holding and cover. Juvenile salmon use the slower water off channel areas for rearing, especially during flood events. Over the past 150 years the floodplain has been systematically separated from the river channel by dams, levees, estuary filling, and floodplain development. Today wild salmon (e.g., Chinook and steelhead) are threatened by extinction in the Puget Sound region, including the Puyallup and Nisqually rivers.

![Figure 4.12 – Natural River and Floodplain](image-url)
Salmon populations throughout the Puget Sound are in decline, for example the Puyallup River Chinook stock was estimated to have a historic run of 64,000 fish compared to about 2,000 today. In addition Puyallup River Chinook that spawn naturally are expected to produce fewer than two returning adults while historically they were expected to produce seven to ten returning adults (Pierce County Lead Entity 2008). The loss in productivity and abundance is tied directly to the loss of habitat in the Puyallup River (EDT 2000). The salmon habitat loss in the flood planning area is well documented in the Limiting Factor Reports (Kerwin 1999, Kerwin 2000) and is attributed primarily to filling of the estuary and floodplain, levees, and dams. Each of these categories represents projects that isolate the floodplain from the river channel.

Flood Plan projects are proposed for levee and revetment construction or repair, flood walls and sediment management. Because the energy and sediment load of the river is focused between the levees, river power will work on the straightened banks and streambed. The resulting bank erosion and streambed scour will require projects to maintain the system as the river attempts to resume its natural connection with the floodplain. Sediment accumulation will be restricted to a narrow band and deposition will occur in areas of relatively low gradient. Managers will be left with only three main options to keep levees from being over topped in areas of excessive sediment accrual: elevate the levees, remove the sediment or move levees and allow portions of the flood plain to be reclaimed and used for storage.

Environmental impacts of levee channelization and gravel removal are well documented in the literature (see references) and highlight a need for mitigation. These projects essentially eliminate much of the native riparian vegetation, wetland, riverine and estuarine habitat for fish and wildlife. What is left has been degraded by excessive energy focused on the remaining channel which pushes juvenile fish prematurely from the river, scours fish eggs and reduces the number and quality of spawning riffles and pools.

Ideally, flood management projects would result in the removal of levees to improve the long-term storage capacity of the floodplain for water and sediment. These types of floodplain reconnection projects provide flood, fish, and riparian habitat benefits and have limited maintenance requirements over time. Given development patterns and densities within the Plan’s study area, opportunities to achieve larger scale floodplain reconnection projects are limited and will have associated mitigation requirements.

To date, mitigation for smaller flood management projects have usually been limited to site-scale willow planting and wood placement into levees. These efforts have some localized benefit when successful but they do not treat the underlying cause for degraded habitat; the separation of rivers and floodplains. Improving degraded habitat conditions requires taking a multi-scale approach, one that reflects site, reach and watershed scales of evaluation and project identification. Broader scale mitigation opportunities can be identified, such as levee removal or setback projects, shoreline acquisitions, off channel habitat creation, and wetland restoration.

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Channelization – The straightening, deepening, or widening of a stream channel for the purpose of increasing the stream's conveyance capacity.
Reach scale mitigation is accomplished in the area of the project having the same habitat type. For example, in the estuary the reach may be from the mouth of the river up to the area of tidal influence where physical and ecological habitats are similar. Another example would be in the middle Puyallup where numerous gravel bars existed in the past and were expected to produce excellent spawning habitat, especially for Chinook salmon. Opportunities for mitigation in these large reaches would be explored for projects occurring anywhere within the reach. Examples would be levee setbacks or removals and off channel or side channel restoration.

Watershed-scale mitigation is located using the best available science and judgment of scientists for the watershed in which the project occurs. For salmon recovery, many of these areas have been located or are in process (Strategy 2008). Some locations may not involve the mainstem areas of rivers, but important tributaries such as South Prairie Creek, Boise Creek, and Ohop Creek. Watershed scale may be a tool for those projects with little or no reach scale opportunities.

Since many of the proposed Flood Plan projects are small in scale and have associated small scale mitigation requirements, improving the degraded habitat conditions of major rivers and floodplains will require a more comprehensive approach to mitigation, such as the creation of mitigation banks or the development of a Habitat Conservation Plan. These approaches provide certainty for both Flood Plan project proponents and agencies with the mandate to protect resources. Groundbreaking work for reach and watershed-scale mitigation projects has been initiated in the Levee Setback Study (2006). Mitigation which allow for the reconnection of the floodplain are vital for the formation of spawning riffles, pools with wood, off channel habitat, wetlands, riparian vegetation, and water quality. At the same time this type of mitigation which promotes the restoration of natural fluvial processes will also provide for flood attenuation and gravel storage.

4.6.5 Public Access to Rivers

Problem Description

Rivers and associated riparian corridors are desirable locations for passive or active recreational uses for the citizens of Pierce County. Activities include trail use, fishing, boating, and passive recreation. Within the planning area, there is extensive river mileage with minimal public access. Many fisherman and boaters access the river at unauthorized locations, and numerous people are using the river with few appropriate supporting facilities (e.g., parking, restrooms). The Pierce County Park, Recreation and Open Space (PROS) Plan (Chapter 19D.160) identifies riverfront water access as a high priority and value.

Some public lands in flood hazard areas may be highly suitable for public use, whereas others may not be due to regulatory issues, liability concerns, easement issues, or compatible use. Levees and revetments that appear to provide public access may be limited by an easement granted exclusively to Pierce County for flood management purposes. Such lands cannot legally be used for public access. Other issues include costs to make improvements for public access, available net-useable land, ongoing operation and maintenance costs, and concerns about
potential environmental degradation such as impacts on habitat and water quality due to human traffic and incompatible uses.

Public access may be appropriate at suitable locations along river corridors, but it is necessary to balance costs, liability, and environmental considerations.

**FPW # 21 – Public Access to Rivers**

<table>
<thead>
<tr>
<th>Recommendation</th>
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<tbody>
<tr>
<td>1. Pierce County should consider opportunities to improve public access to rivers, making use of publicly owned land along river corridors, including lands used for flood management purposes, so long as it does not interfere with flood management objectives. Opportunities for public access include:</td>
</tr>
<tr>
<td>a. Passive use – viewing rivers, associated open space, habitat, and wildlife</td>
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<tr>
<td>b. Shoreline access points for fishing, swimming, or boat launching</td>
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<tr>
<td>c. Multi-purpose, non-motorized trails along rivers for pedestrian and other recreational users</td>
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<tr>
<td>2. Pierce County should inventory public lands and open spaces adjacent to and along river corridors to identify opportunities for improved public access and recreational trail connectivity.</td>
</tr>
<tr>
<td>3. Pierce County should convene an ad-hoc committee to recommend appropriate levels of future public access along river corridors. Considerations such as compatibility with river reach flood hazard management objectives, costs, available net-usable land, liability, public safety, regulatory issues, and potential for impacts on habitat and water quality should inform future decisions regarding public access.</td>
</tr>
<tr>
<td>4. Pierce County should educate the public regarding restrictions on public access along flood risk reduction facilities, where the underlying land is privately owned. This may include signage at appropriate locations.</td>
</tr>
<tr>
<td>5. Pierce County should seek to purchase land for future flood risk reduction facilities (e.g., setback levees) on a fee-simple basis and make limited use of easements on private land and incorporate provisions for public access where feasible.</td>
</tr>
</tbody>
</table>

**Supporting Information**

There is a high degree of interest in enhancing public access to publicly owned land and natural environments in Pierce County. Facilities associated with public access include parking areas, restrooms, signage, and other public use amenities. Rivers and associated open spaces are desired by people for passive and active recreational use. Input from stakeholders during the problem identification phase of this planning effort resulted in the identification of possible locations for future consideration of improved public access or trails.

Some opportunities to improve public access to Pierce County’s major rivers may be highly feasible and have few implications in terms of cost, liability, environmental degradation, or other issues. Other opportunities may not be feasible due to high costs, liability concerns, and high risk of environmental damage. Where high costs are the primarily issue (such as for multi-
purpose trails), grants may be available to support capital construction, but operation and maintenance costs usually must be covered by local agencies and/or jurisdictions.

Concerns about environmental degradation along rivers are mostly related to habitat and water quality impacts. This includes impacts to fish habitat (such as salmon spawning or rearing habitat) and wildlife habitat (such as vegetation and riparian corridor habitat). Water quality impacts can occur from bank erosion, pedestrian use of river beds and gravel bars, excessive or damaging use, littering (during general use or during fishing season), and improper disposal of garbage and human waste or dumping.

4.6.6 Minimizing Water Quality Impacts of Flooding

Problem Description

Three issues relate to flooding that affect aquatic life, ecosystem health and clean water. First, sources of pollution including chemicals, pesticides, fertilizers, metals, petroleum-based products, hazardous waste, and animal waste have the potential to contaminate flood waters when mobilized during flood events. This can be from improperly stored waste in the floodplain, or properly stored waste that is displaced due to flood flows. Locations of chemical or waste storage can include houses, garages, outbuildings, barns, and commercial and industrial businesses and a broad range of agricultural, residential, commercial, and industrial land uses. Second, septic systems and drainfields in floodplains are at risk of inundation and failure from floodwaters. Third, flood waters can erode and mobilize large amounts of sediment from watershed sources, instream and bank erosion that is later deposited downstream in rivers, floodplains, or Puget Sound. While some amount of sediment transport is natural and beneficial, excess sediment can degrade water quality and habitat.

Once chemicals, waste or other pollutants are mobilized by floodwaters the result can be degraded water quality conditions, toxic effects on fish and other aquatic biota, and habitat impacts. The proper storage, handling, and management of chemicals, waste and other pollutants is necessary to protect aquatic resources from adverse impacts. Components of a program to address these issues include education of citizens and businesses, technical assistance, best management practices, and regulation.

Septic systems and drainfields located in floodplains are at risk of inundation and failure. New development requirements prevent the construction of septic systems and drainfields in floodplains, but pre-existing systems remain a problem in some areas. Such systems need to be carefully managed to reduce risks to water quality.

Sources of excess sediment include watershed sources such as urban areas, agricultural activities, construction sites, and logging, as well as instream and bank erosion along rivers. Erosion control best management practices and stabilization of excessively eroding river banks can help reduce sediment sources.
### FPW #22 – Minimizing Water Quality Impacts of Flooding

#### Recommendations

1. Pierce County, cities, and towns should provide technical assistance and education to residents and businesses within the 100-year floodplain on issues related to source control, proper storage and isolation of hazardous materials, chemicals, wastes and other pollutants to prevent contamination of flood waters and to isolate them from exposure to stormwater.

2. Pierce County, cities, and towns should require source control and proper storage of hazardous materials, chemicals, wastes, fertilizers and pesticides within floodways and 100-year floodplains.

3. Pierce County, cities, and towns should leverage existing resources focused on stormwater best management practices and source control for erosion and sediment to reduce sediment sources when addressing protection of flood waters from contamination.

4. Pierce County, cities, and towns should prohibit new on-site sewage systems and implement an operations and maintenance inspection program for on-site sewage systems within the 100-year floodplain. Local jurisdictions should coordinate with the Tacoma-Pierce County Health Department during implementation.

5. Pierce County, cities, and towns with existing on-site sewage systems in the floodplain should establish an on-site grant and loan program for the repair of failing on-site sewage systems or to fund sewer connections by decommissioning existing on-site sewage systems within the 100-year floodplain.

6. Pierce County, cities, and towns should educate floodplain residents and businesses with on-site sewage systems and drain fields to not use them during flooding, as this can cause contamination of water in the soil and risk backup of sewage into the home or business.

### Supporting Information

The extent and magnitude of water pollution caused by large flood events is not well known. However, regularly flooded drain fields contaminate potable wells. Observation of numerous structure types and their chemical and waste contents strew about in the aftermath of a flood indicate that it is likely that chemicals, wastes and other pollutants are mixing with flood waters. Deposition of debris (plastics, construction materials and other wastes) in the floodplain is another sign of flood impacts.

Pollutant sources may be widespread from various land uses, including:

- **Residential** – household chemicals and hazardous wastes, oil/fuels, fertilizers/pesticides, garden products, automobile fluids, paints/thinners
- **Agricultural** – farm equipment fluids and by-products, animal wastes, fertilizers/pesticides, paints/preservatives
- **Commercial/Industrial** – includes many business types such as automotive, landscaping, construction, manufacturing, and food-related businesses.

Education and outreach, technical assistance, and regulation should all be included in a comprehensive program to address water quality impacts resulting from flooding.
Pierce County Code 18E.70.040.B.8.k addresses chemical storage in floodways. It specifies that “storage of agricultural chemicals, fertilizers, pesticides, and similar hazardous materials shall be permitted only where no other on-site storage alternative outside of the floodplain exists.”

4.6.6.1 Impacts on Water Quality, Fish and Wildlife, and Habitat

Water quality degradation can result from numerous pollutant types, including oxygen demanding materials (e.g., organic wastes), sediment, nutrients (phosphorus, nitrogen), metals (copper, zinc), trace organics (e.g., pesticides, fuels, oils and automobile products), and bacteria. Discharge of pollutants to receiving waters during flooding can cause violation of water quality standards, acute effects on fish and other aquatic biota, and impacts on habitat.

Impacts on aquatic species can lead to direct mortality from acute effects at toxic levels or chronic effects from sustained exposure to elevated levels of pollutants. For example, elevated levels of copper can impair olfaction (sense of smell) in salmon and impair the behavior of fish, in terms of their ability to migrate, feed, or detect predators. Water quality degradation can also reduce the diversity and abundance of aquatic insects and other stream biota, shifting to species that are more pollutant-tolerant. Examples of habitat impacts include sedimentation of spawning areas, or reduction of dissolved oxygen levels in water or interstitial areas of gravel.

4.6.7 Coordination with Other Jurisdictions, Tribes and Agencies

Problem Description

Flooding and channel migration along major rivers affects multiple jurisdictions and entities, including cities, counties, and tribes. Actions taken by one floodplain jurisdiction or property owner can have beneficial or adverse effects on others along the same river or sharing the same floodplain. This Flood Plan and its proposed policies, programs and projects will require close coordination, collaboration, and partnerships to ensure effective implementation. Coordination between governments, agencies, citizens, and others will help build support for proposed actions and ensure alternative perspectives are heard and considered. Because flooding affects multiple jurisdictions, flood management efforts must be coordinated at a regional level. Pierce County is well positioned to coordinate and provide regional flood management services.

FPW #23 – Coordination with Other Jurisdictions, Tribes and Agencies

Recommendations

1. Flood and channel migration hazard management activities will be planned and implemented in close cooperation with cities, towns, counties, tribes, state and federal agencies (e.g., resource agencies, public agencies with infrastructure), and salmon recovery lead entities.

2. Pierce County will coordinate with local governments both adjacent to and across the river from proposed capital projects, including where the river is the boundary between counties (e.g., Lewis and Thurston counties along the Nisqually River, King County along the White River).

3. Pierce County will coordinate with local governments in the development of a recovery plan for rebuilding infrastructure and major facilities following a flood or other major disaster within the floodplain.
Supporting Information

Given the variety of jurisdictions and stakeholders in the floodplains of Pierce County’s major rivers, it is critical to coordinate with the diverse set of interests. All of the river floodplains contain cities and towns, some of which have significant floodplain areas. Pierce County also shares jurisdiction with Lewis and Thurston counties along the Nisqually River and King County along the White River. The Puyallup, Muckleshoot, and Nisqually tribes have treaty rights, reservations, usual and accustomed areas, and significant interests along the rivers included in this Plan. State and federal agencies, business and agricultural interests, non-governmental organizations, salmon recovery lead entities, land owners and citizens all have significant concerns and interests. Pierce County will continue to coordinate and work with these parties as part of plan implementation.

4.6.8 Inter-County River Improvement Agreement

Problem Description

Approved in 1914, the Inter-County River Improvement Agreement between Pierce and King Counties established the Inter-County River Improvement entity (ICRI) to provide flood control on the lower White and lower Puyallup Rivers. The agreement calls for the counties to jointly fund the work of the ICRI through an Inter-County River Improvement Fund. Both counties jointly funded activities through approximately 1979, with King County funding 60 percent and Pierce County 40 percent of the first $50,000, and equal funding for expenses over $50,000 (see ICRI agreement and ICRI annual reports). Since the 1980s, Pierce and King counties have largely funded necessary maintenance and capital needs unilaterally on their respective sides of the county line. Because this 105-year agreement is due to expire in 2019, it is for both counties to discuss renewal of the agreement before that time. Any proposed changes to the existing agreement need to be negotiated between the two counties, with input as necessary from other impacted parties.

The permanent diversion of the White River in 1906 into the Puyallup River system has had ongoing impacts on the lower Puyallup River and lower White River in Pierce County. The lower Puyallup River levees were accredited as 100-year levees in development of the 1987 Flood Insurance Rate Maps (FIRM). Since then sediment deposition and changes in river bed elevations have raised river water levels so that the tops of the levees are no longer at least three feet above the predicted 100-year water levels; one of the requirements for federal accreditation (TetraTech 2009). In 2005, this resulted in draft updates to the FIRM for the lower Puyallup River. These revisions indicate a significant increase in the 100-year flood plain, because of de-accreditation of the levees. In January 2009, flooding on the White River caused substantial damage to residential and other structures on both sides of the county-line in the vicinity of the cities of Pacific and Sumner.
CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS

Pierce County Rivers Flood Hazard Management Plan

PR#2/WR #2* – Inter-County River Improvement Agreement

**Recommendations**

1. Pierce County should collaborate with King County to renew the Inter-County River Improvement Agreement to address flood hazard management activities for the lower White and lower Puyallup River systems. This should include a discussion of capital and maintenance needs, responsibilities, and funding considerations.

2. Pierce County and King County should convene a work group to develop a list of issues for discussion and establish a process and timeline to develop and ratify an agreement to cooperatively fund necessary flood hazard management needs.

* PR = Puyallup River; WR = White River

**Supporting Information**

The Inter-County River Improvement (ICRI) was created under the authorization of RCW 86.13 for the purpose of jointly funding the maintenance and control of approximately 19 miles of rivers (eight miles on the Puyallup River and 11 miles on the White River). The agreement specifies that:

1. The existing embankment (Auburn Wall) was erected in King County by the ICRI crews for the purpose of preventing flow northward to Elliott Bay shall be strengthened and maintained to ensure flow down the Stuck River channel into the Puyallup River;

2. A drift barrier may be erected near the present embankment to collect and hold drift (wood debris) coming down the river;

3. The channel below the embankment shall be straightened and deepened, and the banks strengthened to permanently confine the waters to the channel and prevent inundation of adjoining lands;

4. The logs, drift, and debris in the river above and below the embankment shall be removed, if deemed advisable, to prevent breaches in the banks. Timber standing near the bank of the river above the embankment which is likely to be washed into the river creating a new danger, shall be removed; and

5. A fund shall be created in each County, to be known as the “Inter-County River Improvement Fund” to support construction work on the rivers. King County’s share was 60 percent and Pierce County’s share was 40 percent.

**4.6.8.1 Evolution of the 1914 Inter-County River Improvement Agreement**

Major Chittenden of the U.S. ACE stated in the 1907 Flood Control Report to the State Commission that “King County should bear at least one-half of the total cost of the work on the White and Puyallup Rivers...and [the Board of Engineers] recommends the permanent diversion of the White to the Puyallup only on the condition that Pierce County shall be relieved, in one
way or another, of at least that portion of the construction costs” (Chittenden 1907; King County 1988). Between 1914 and the present, the ICRI went through many challenges and of course, large flood events.

During the first six years (1914-1920), much of the work anticipated in the agreement was completed, but a large 1917 flood seriously damaged many structures. Repairs were carried out and by 1920, over $1.63 million had been expended for flood control in the lower White and Puyallup Rivers. There were many challenges in the relationship between the counties from the 1920s-1940s, with ongoing trust issues between the county commissioners, a record flood event on the White River in 1933, and a decision to construct the Mud Mountain Dam (MMD) on the White River (approved by the federal government in 1936).

King County attempted to terminate the agreement in 1943. After an initial judge ruled in favor of King County, it was overturned on appeal in favor of Pierce County, which sought to maintain the agreement. Maintenance was variable in the 1940s due to World War II, but in 1945-46, focus shifted to construction of MMD, which was completed in 1948. After the litigation of the 1940s, Pierce and King counties had very little direct dealings under the Inter-County Agreement. In the 1950s-1960s, the ICRI reports no longer summarized the activities, but presented only accounting information. From the mid-1950s to mid-1970s the ICRI was aided substantially by the contributions from the state and federal governments. In 1975, the State refused to continue funding for ICRI projects, asserting that the County governments needed to assume greater financial responsibility. In the mid- to late-1970s, concerns continued about the level of funding from King County to the ICRI, which was as low as $30,000 per year. Federal Disaster funds after the large 1977 flood allowed flood damage repairs to be made.

In 1986, the King County Council directed the Public Works Department to evaluate the ICRI and provide recommendations for King County’s future involvement. This eventually resulted in the in-depth analysis that resulted in the 1988 report (King County 1988). Since the 1980s, Pierce and King counties have largely funded necessary maintenance and capital needs unilaterally on their respective sides of the county line. In the mid-1990s, an effort was begun to formalize this arrangement through the development of an inter-county agreement for the ICRI, but this agreement was never concluded.

Because the 105-year agreement is in effect until 2019, it is necessary for Pierce and King Counties to initiate a process to renew the agreement before that time, or jointly determine that it should be allowed to expire. Discussions should include consideration of capital and maintenance needs, responsibilities, and funding considerations for the eight miles of the Puyallup River and 11 miles of the White River governed by the agreement.
4.7 IMPLEMENTATION OF CAPITAL PROJECTS

4.7.1 River Reach Management Strategies

Problem Description
This Flood Plan focuses on over 82 miles of river along four major rivers (Puyallup, Carbon, White, and Nisqually) and three large tributaries (Greenwater and Mashel Rivers and South Prairie Creek), segmented into 11 distinct reaches. The river systems are highly variable, both from river to river and between reaches within any river. Major sources of variability include: (1) existing development and land use patterns in the adjacent floodplain, (2) service levels of existing river management facilities (levees, revetments), (3) river channel gradient and width, (4) presence of fish spawning and rearing habitat, and (5) sediment transport conditions. The vast majority of river risk reduction facilities, which total over 70 miles in length (the sum of both left and right banks), lay along the lower 29 miles of the Puyallup River, the lower 5.5 miles of the White River, and the lower 8.4 miles of the Carbon River.

Pierce County’s Comprehensive Plan (19E.50.130) establishes a level of service for flood risk reduction facilities, and recommends a “storm protection level standard” for water surface elevations of the one percent annual chance flood (i.e., 100-year flood), plus three feet of freeboard for the Puyallup, Carbon, White, Greenwater and Nisqually Rivers.

For several reasons, this level of service has not been achieved. Generally, funds for maintenance and repairs of river management facilities and capital projects have not been enough to achieve the level of service set out in the Comprehensive Plan. Additionally, this “one size fits all” level of service in the Comprehensive Plan does not take into account the significant differences in land use, assessed value, river channel conditions, salmon habitat areas, sediment transport and similar factors.

This Flood Plan recommends levels of service be established which reflect the unique physical and cultural differences among the various reaches of Pierce County’s rivers. These recommendations propose to link management strategies to the land uses being protected and other factors noted above. Levels of protection are tailored to flooding and channel migration risks and reach priorities. Management strategies for reaches containing flood risk reduction facilities identify levels of protection goals for levees and revetments. Non-structural management strategies (e.g., floodplain development regulations and acquisition/buyout of flood prone properties) are proposed for all reaches.

### FPW #24 – River Reach Management Strategies

<table>
<thead>
<tr>
<th>Recommendation</th>
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<tbody>
<tr>
<td>1. Pierce County should manage flood hazards by river reach and establish structural and non-structural management strategies based on the following factors: (1) existing development and land use patterns in the adjacent floodplain, (2) service level of existing river management facilities (levees, revetments), (3) river channel gradient and width, (4) presence of fish spawning</td>
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Pierce County Public Works & Utilities
Surface Water Management
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CHAPTER 4: PROGRAMMATIC RECOMMENDATIONS

PIERCe COUNTY RIVERS FLOOD HAZARD MANAGEMENT PLAN

Supporting Information

Pierce County and the Flood Plan Advisory Committee set the strategic direction for applying river reach management strategies in June 2010. Land use types, level of service, resource expenditures, and urgency were all factors considered in applying alternative strategies to the 11 river reaches. The proposal recommends continued structural approaches for reaches with levees and revetments and non-structural approaches for reaches without facilities and some locations where facilities exist. If adopted as part of the Rivers Plan, policy changes and amendment of the Comprehensive Plan will follow.

The river systems in Pierce County are highly variable, both from river to river and between reaches within any given river. Major sources of variability include:

- **Existing development and land use patterns in the adjacent floodplain** – The type and density of land uses and the assessed value of land and improvements varies significantly from lower to upper watershed. The lower Puyallup, lower White and Orting area have the highest density of urban land use (e.g., Port, commercial/industrial, residential). Other river reaches are mostly rural or moderate density residential, agricultural, forest, with small towns or commercial areas. Assessed values of flood-prone property vary from $340 million to $1.8 billion in the three high density areas, and from $7 to 100 million in the other eight river reaches.

- **Service levels of existing “river management facilities”** – The two most common river management facilities operated by Pierce County are levees and revetments. Levees

### FPW #24 – River Reach Management Strategies

**Recommendation**

1. **Surface Water Management**
   - FPW #24 – River Reach Management Strategies
   - and rearing habitat, and (5) sediment transport conditions (see Appendix F).

2. Pierce County should identify river reach “Levels of Protection” as goals for flood risk reduction facility design and maintenance and to guide future capital projects. Levels of flood protection for levees should include:
   - a. 200-year design, plus three feet of freeboard,
   - b. 100-year design, plus three feet of freeboard,
   - c. Maintenance of existing (2009) conveyance capacity, and
   - d. Maintenance of existing levee prisms.

Levels of erosion protection for revetments should include:
   - a. Channel migration prevention design, and
   - b. Channel migration resistance design.

3. Non-structural management strategies (e.g., floodplain development regulations and acquisition, buyout, or purchase of development rights) should be applied to all river reaches to reduce future flood risks.

4. Where feasible, agriculture, recreation, and open space should be promoted as the most compatible land uses within 100-year floodplains.
are raised embankments along a river designed to reduce the risk of flooding. Revetments are toe and facing rock placed along a river bank to prevent or resist bank erosion and reduce the risk of channel migration.

- **River channel gradient and width** – The gradient and width of river channels affect sediment transport, deposition (accumulation) and incision (erosion), as well as water surface elevations during flood events. The river gradients vary from relatively flat (e.g., 0.035-0.06 percent in the lower Puyallup and 0.03-0.23 percent in the lower White) to steep (e.g., 0.75-1.14 percent in the upper Puyallup to 1.01-1.15 percent on the Carbon above SR-162). Widths vary from narrow mainstem rivers confined between levees (150-250 feet wide) to broad river channels at levee setback areas or with large floodplain valleys (350-700 feet in the lower Puyallup to 450-1000 feet in the upper Puyallup or Carbon Rivers.

- **Presence of salmon spawning and rearing habitat** – All rivers in the study area are used by salmon, with the exception of the upper Nisqually River for which passage is prevented due to existing dams. Migration and rearing occur throughout the study area; however spawning areas vary by species, river gradient and width, substrate conditions and habitat. Chinook, steelhead and bull trout species are listed as threatened under the Endangered Species Act.

- **Sediment transport, accumulation, and incision** – Sediment (sand, gravel, cobble, and boulder) and woody material transport and deposition are affected by sources, loading, river management facilities, and channel conditions (gradient and width). Some reaches are primarily transport reaches, whereas others may be aggrading (deposition areas) or degrading (erosion or incision). Downstream sediment transport and deposition is governed by stream power. Stream flow (discharge), slope, and width are the major factors affecting sediment transport potential. Sediment deposition occurs where there is a change in slope (flattening), increased river width, and lower stream power.

The combination of factors shaped historical river management. River management activities have included both structural (e.g., construction, repair, and maintenance of levees and revetments) and non-structural approaches (e.g., floodplain development regulations and acquisition/buyout of private property or structures).
Figure 4.13 - River Reach Management Strategies Map. A full size map can be found in Appendix F.
4.7.1.1 Structural Approaches for Levee and Revetment Reaches

1. **200-year Level of Protection** – Levees are designed and maintained to the 200-year level of protection with three feet of freeboard.

   *Proposed Application:* Lower Puyallup River from the river mouth at Commencement Bay to the confluence of the White River (RM 0 – RM 10.3), including the cities of Tacoma, Fife, and Puyallup, and parts of unincorporated Pierce County. This could include a setback levee along North Levee Road, flood walls or some other approach.

2. **100-year Level of Protection** – Levees are designed and maintained to the 100-year level of protection with three feet of freeboard.

   *Proposed application:* Most new levees, including setback levees (e.g., Soldiers Home, Calistoga setback levees) and in urban areas (e.g., city centers, high density residential) such as Puyallup, Sumner, Pacific, and Orting, not including the lower Puyallup River.

3. **Maintenance of Existing Level of Protection** – Maintain the existing level of protection as defined in USGS 2009 conveyance capacity analysis. This might be achieved through actions such as sediment management in river reaches with ongoing sediment accumulation, or improvements in freeboard through construction of temporary or permanent flood walls, Hesco™ barriers, super sacks or other means.

   *Proposed Application:* Existing levees in the middle Puyallup River reach between RM 12.0 and RM 17.4; this is an urban/rural transition area, with higher value agricultural areas, with some Chinook and steelhead spawning.

4. **Maintenance of Existing Levee Prism** – Maintain the existing levee in terms of height, toe and facing rock to ensure minimum standard of levee integrity. In some locations with long-term net sediment accumulation, the level of protection will decrease over time.

   *Proposed Application:* Rural (low density residential) and open space areas, agricultural areas, areas of salmon spawning and rearing (particularly for listed species, including Chinook, steelhead and bull trout). This is proposed for all levee reaches not in the lower and middle Puyallup, lower White or Orting area.

Two levels of protection for revetment reaches (channel migration reduction) are proposed as follows:

1. **Channel Migration Prevention Design** – Revetment design and river channel management is carried out to “prevent” a 100-year flow event from causing channel migration and significantly eroding the river bank. There is a commitment to “put the river back” if the revetment fails. Designs might include large toe/facing rock, large woody debris, bio-revetments, and engineered log jams.

   *Proposed application:* Revetment at the entrance to Mt. Rainier National Park, the only year-round access road (SR-706) to Mt. Rainier.
2. **Channel Migration Resistance Design** – This strategy maintains current revetment conditions. Revetment design and river channel management is carried out to “resist” channel migration and river bank erosion. There is not a commitment to “put the river back” if the revetment fails; a revetment repair might be constructed at the new location of the river channel, depending on river conditions, channel migration zone mapping, and a post-event evaluation of site conditions.

*Proposed Application:* This design applies to all revetments along the Puyallup, Carbon, and White rivers not designated as prevention design, or proposed for conversion to levee to provide flood risk reduction.

### 4.7.1.2 Non-Structural Approaches for All Reaches

1. **Floodplain Development Regulations to Reduce Risk and Limit Incompatible Land Uses** – Prevent location of critical facilities (e.g., schools, hospitals, wastewater treatment plants) in the 100-year regulatory floodplain; Limit new development in the 100-year regulatory floodplain and severe channel migration hazard areas to minimize new risks to life and property; Ensure new development in floodplain complies with regulations consistent with Pierce County standards in terms of zero rise, compensatory storage, and elevation above base flood elevation.

*Proposed Application:* Floodplain development regulations should be applied in all floodplain areas subject to flooding if river management facilities (e.g., levees, revetments) fail. Exceptions might be levees certified and accredited by the U.S. Army Corps of Engineers and FEMA.

2. **Acquisition/Buyout of Repetitive Loss and Flood-prone Property** – Purchase through fee-simple acquisition or transfer of development rights (TDR)

*Proposed Application:* Low density residential or commercial areas; promote agricultural, recreation and open space land uses (Example: South Prairie Creek). Protect important salmon spawning and rearing areas (e.g., Carbon River, between RM 2.9 and RM 6.0). Use revetments only to protect existing public infrastructure (e.g., roads, bridges, fire stations). With exception of repetitive loss properties in all river reaches, acquisition and buyout programs should focus on low density areas and areas without flood risk reduction facilities.

The table and map in Appendix F shows the proposed river reach management strategies for all river reaches, including left and right banks. The table also includes information about current channel conveyance capacity (in cubic feet per second and approximate recurrence interval), land uses, roads, channel gradient, channel width, salmon habitat and use, and sediment gradations, and bed elevation changes.

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77 **Regulatory Floodplain** - A portion of the geologic floodplain that may be inundated by the base flood where the peak discharge is 100 cubic feet per second (C.F.S.) or greater. Regulatory floodplains also include areas which are subject to sheet flooding, or areas on existing recorded subdivision plats mapped as being flood prone.
4.7.2 Levee and Revetment Setback Program

Problem Description

In 2004, Pierce County published its Setback Levee Feasibility Study. That study identified 32 potential setback levee flood protection and floodplain/restoration sites for the Puyallup River system. The study identified 20 sites along the Puyallup River, six sites along the Carbon River and six sites along the White River main stems. The sites were ranked using comprehensive ranking criteria that integrated three goals: (1) increase floodplain connectivity and flood storage; (2) reestablish short and long-term geomorphic processes and function, and (3) maximize aquatic habitat diversity and use.

The study identifies several setback levee site locations where the river channel bank is either in the form of a levee, revetment, or natural bank-line. Many of the identified setback levee site locations are in areas where the existing river bank is a revetment rather than an actual levee. Since there are no levees at these revetment locations, they are better described as floodplain restoration and reconnection projects rather than levee setback projects.

The locations of the setbacks were based on orthophotos, floodplain characteristics, habitat restoration opportunities, and impacts to existing structures and infrastructure at the time of the study. The setback levee feasibility is based on the assumption that the identified sites are suitable for setback levee projects. Pierce County should confirm this assumption by reviewing each of the setback levee site locations and distinguishing levees from revetments or natural bank lines using information from the river and levee inventory map. This will require ground truthing and field verification. Where revetments and/or natural bank lines are found to exist rather than levees, these site locations should be re-analyzed, scored and the ranking/priority re-computed.

The Setback Levee Feasibility Study included hydraulic modeling for each of the identified independent setback levee site locations for the pre-setback levee and post-setback levee project condition. Modeling was done for the 2, 5, 25, 50, and 100 year recurrence interval events. However, the study did not include modeling for the cumulative effects (e.g., flood protection benefits) on the whole Puyallup River system for the entire setback levee build-out condition. While it is likely significant flood protection benefit would occur, these benefits have not been quantified for the overall system and the lower reach of the Puyallup River channel and its floodplain. This study and findings will benefit planning efforts in order to address flooding, habitat problems, and deficiencies on the system.

Currently, there is no dedicated program which focuses on funding, designing, permitting, and constructing setback levee projects. Projects are opportunity based as grant funding or other funding sources arise. A more specific program for implementing setback levee projects should be developed and supported with resources.
FPW #25 – Levee and Revetment Setback Program

**Recommendations**

1. Pierce County should update the river levee and revetment inventory map to accurately identify, distinguish and delineate existing levees and revetments along the Puyallup, Carbon, White and Nisqually Rivers.

2. Pierce County should update the Setback Levee Feasibility Study to reflect the updated Inventory Map and re-evaluate sites identified as primarily revetment. On the ground surveys may be necessary to investigate new opportunities for sediment storage, flood reduction and habitat restoration. Pierce County should update the Priority and Ranking Spreadsheet to reflect the updated information on setback revetment sites. The ranking should also account for the current status of acquired floodplain properties.

3. Pierce County should perform a comprehensive hydraulic modeling study to determine the cumulative effects of flood protection benefits to the Puyallup River system and its floodplain for the proposed setback levee and revetment build-out scenario. The study should also account for existing revetment and levee segments.

4. Pierce County should continue to pursue funding to complete setback levee and revetment design projects and pursue construction funding for completed designs. Funding will also need to include costs for property acquisitions.

5. Pierce County should evaluate additional sites for possible levee or revetment setback projects as potential new needs or opportunities are identified.

**Supporting Information**

### 4.7.2.1 Applicability of the 2008 Levee Setback Feasibility Study to Rivers Flood Plan

The Levee Setback Feasibility Study identified sites that were ranked based on physical site attributes, and estimated costs for property acquisition and construction. The project was based on the premise that setting back levees will reconnect the main stem channel with its floodplain, which will in turn recover lost flood storage and aquatic habitat. Many of the 32 potential levee setback projects are expected to be key components of the capital program for the Pierce County Rivers Flood Hazard Management Plan. The levee setback projects are expected to lower flood surface elevations in the immediate vicinity, provide enhanced flood storage, reduce damaging high flow velocities, restore natural riverine processes, improve habitat conditions, and possibly provide opportunities for gravel removal.

The Levee Setback Feasibility Study – Puyallup River Watershed (Pierce County, GeoEngineers 2008) was initiated to identify, evaluate, and prioritize potential sites for setting back existing levees. Levee setback sites were identified and ranked based on two primary factors: (1) physical site attributes to increase floodplain connectivity/storage, re-establish short- and long-term channel forming and geomorphic processes, and improving aquatic habitat diversity and use; and (2) estimated property acquisition and project construction costs. The study was overseen by Pierce County with the assistance of a Technical Advisory Group (TAG) consisting of county, tribal, and other agency interests. The TAG provided project sites, for consideration and recommendations regarding project approach, evaluation criteria, analytical methods, and a site prioritization strategy.
The Puyallup River has been confined by revetments and levees to reduce flooding of farmland and to open the floodplain to rural, industrial, commercial, and residential development since the early 1900s. Most sections of the lower Carbon and White Rivers have been similarly confined since the mid-1960s. Historical aerial photos show that many sections of the three rivers were up to three times wider than currently confined river channels. Up until the 1970s, the prevailing trend of river management was to straighten and narrow river corridors, construct levees or revetments on both sides, with the intent of keeping flood flows, sediment, and woody debris moving orderly downstream. While arguably somewhat successful in flatter, low gradient segments of the river, it became clear that in reaches with steeper gradient and heavy sediment load, substantial maintenance would be required for both river management facilities (levees and revetments) and for sediment removal. In addition, it became clear that these simplified river channel systems resulted in loss of channel complexity\(^{78}\) (multiple channels, meander bends, and gravel bars) and loss of off-channel aquatic and riparian habitat for both fish and wildlife. In the past few decades, interest has grown in setting back existing levees to reconnect the mainstem channel with its floodplain and recover lost floodplain storage and aquatic habitat.

The study ranked 32 selected sites based on the feasibility of setting back the levee using three goals, each with multiple objectives. The objectives for each goal included rigorous analysis involving qualitative and quantitative analysis to determine the following: (1) floodplain elevations favorable for achieving main channel connectivity, (2) flood storage capacity, (3) character of existing in-channel geomorphic processes, (4) sufficient sediment transport capacity to accommodate site needs, and (5) high potential for channel forming processes to improve aquatic habitat conditions without intervention. The next steps were to: (1) evaluate each site using a property acquisition cost/benefit analysis, (2) evaluate each site using estimated levee setback project costs, (3) develop an approach to prioritize and weight individual sites, and (4) design a prioritization workbook spreadsheet to compile and quantify selected site attributes.

A total of 41 potential setback sites distributed throughout the project area were evaluated and 32 sites were selected for the levee setback feasibility study (see Figure 4.12). A detailed description of each site and a site map showing an approximate setback levee location are presented in the final report. The prioritization workbook was designed to provide an unbiased assessment of site benefits and setback feasibility based on the three goals and multiple objectives. The workbook was also designed as a flexible, interactive tool that can be modified to meet future needs.

### 4.7.2.2 Feasibility Study Results

Total project costs (based on 2008 dollars) varied from $17.9 million for the Alward Road setback on the Carbon River (site 26) to $2.2 million for the Pacific Park site on the White River.

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\(^{78}\) **Channel Complexity** - Channel complexity describes salmon habitat. A complex channel contains a mixture of habitat types that provide areas with different velocity and depth for use by different salmon life stages. In contrast, a simple channel contains more uniform flow and few habitat types.
The total estimated project cost for all 32 sites is $182.2 million, with approximately $100 million in construction costs. The length of levees to be removed ranged between 8,923 feet at the Alward Road site to 141 feet at the Interurban-White site (site 27), and the length of levee setback ranged from 9,853 feet at Alward Road to 1,491 feet at the 24th Street East setback (site 29). Most of the proposed setback sites have some combination of privately and publicly owned properties, thus necessitating some level of property acquisition.
Figure 4.14 - Potential Levee Setback Locations in Puyallup, Carbon and White Rivers
4.7.3 Additional Capital Project Analysis

Problem Description

Over 150 problem areas were identified as part of the flood planning process for the 2011 Flood Plan. The problems were scored and ranked using four criteria to prioritize problems for further analysis and to determine the level of resources that could be allocated to the development of solutions or capital projects. Problem areas were ranked as Tier 1, 2, and 3 based on the criteria. Tier 1 problems received the highest level of effort in evaluating the problem and developing proposed capital projects. Tier 3 problems were identified and are listed in the Appendix B of the plan. The 55 Tier 2 problems received an expedited evaluation and 15 of the highest scoring problems were analyzed in greater detail. There are 30-40 remaining Tier 2 problems needing further analysis.

FPW #26 – Additional Capital Project Analysis

Recommendation

1. Pierce County should complete the analysis of “Tier 2” problem areas identified as part of the flood planning process to further characterize the problems, analyze possible solutions (options), examine feasibility and costs, and develop a preferred option.

Supporting Information

The four criteria used to prioritize problem areas were as follows:

1. Existing land use of affected area - This criterion is intended to give different weights to different types of land uses. Higher scores are given for critical facilities, infrastructure and commercial/industrial land uses, and lower scores for recreational and resource lands.

2. Severity of potential flood or channel migration impact - This criterion is intended to evaluate the type and magnitude of the impacts irrespective of the scale at which the impact occurs. Public safety and severe infrastructure or property damage are scored higher than moderate or minor damage.

3. Area of Impact - This criterion describes the scale of the problem. Is the problem manifest over a large area or in a manner that will affect a large number of people, or is it localized?

4. Frequency of flooding or channel migration occurrence - This criterion is used to describe how often the flood or channel migration event occurs (i.e., a channel migration event is any significant landward bank erosion). The score is determined by the number of occurrences over the past 20 years (e.g., 0, 1, 2, 3).
The land use criterion had a maximum score of 20 and the other three criteria had a maximum score of 10 each, for a total of 50 maximum. Tier 1 problems had a score of 29 or above, Tier 2 scored from 23 to 28, and Tier 3 had a score of 22 or less.

Resource constraints limited the number of projects that could be fully analyzed for the plan (Tier 1) and those that could receive a partial analysis (Tier2). Due to resource constraints, only the highest scored Tier 2 problem areas were analyzed.

4.7.4 Transportation - Roads and Bridges

Problem Description

Many existing roads in the valley floors evolved from paths that served short term needs and were placed where it was easiest to build, such as flat floodplains. Interruptions of services and rebuilding of roads damaged by flooding were acceptable costs since little was invested in the construction and the road only served a small population. Although this might have been an acceptable situation when the road was used infrequently, it is more problematic when the road is more heavily used and supports a larger community, measured in both population and area. Some roads may also be sole access to a residential area, and if impassible due to flooding, this may be considered unacceptable to many property owners. Citizens expect a higher level of service from new infrastructure.

New roads and significant improvements to existing roads need to account for flooding and channel migration hazards. Addressing these hazards will likely require different solutions than used in the past. Formerly acceptable practices of re-aligning river courses, armoring riverbanks, or dredging river channels may either be prohibited or have adverse environmental impacts that are very expensive to mitigate.

The policies listed above may have large up-front costs, but avoid ongoing impacts and therefore lower the long-term maintenance and other associated costs of having the road out of service.

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<th>FPW #27 – Transportation – Roads and Bridges</th>
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<td><strong>Recommendation</strong></td>
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<tr>
<td>1. The construction of new roads and the rebuild of existing transportation corridors should be at least one foot above the base flood elevation. Road design should account for compensatory storage in the floodplain, flood flow paths in the overbank areas, and have a zero rise impact with respect to the existing condition. Consideration should also be given to susceptibility to CMZ damage when considering the alignment of a new or relocated road.</td>
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<td>2. A cost benefit analysis (CBA) should be conducted for existing roads and bridges with high associated flood and erosion protection costs to determine if other options, including but not limited to, relocation, vacating, or different bridge designs might be a more cost effective and suitable long-term solution. These options could be deemed impracticable due to engineering standards, right-of-way limitations, environmental impacts and/or level of service. If CBA is utilized, considerations should include, but not be limited to, right-of-way acquisition, construction costs, long-term maintenance costs, mitigation costs and habitat benefits,</td>
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### FPW #27 – Transportation – Roads and Bridges

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<td>permitting, interruptions of service levels, flood events, planning and acquisition of travel corridors, and transportation needs.</td>
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<td>3. Bridges should be designed with consideration of scour and freeboard above the base flood event. The most current and/or best available data needs to be used including assessments of future peak discharge flows and backwater effects.</td>
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<tr>
<td>4. Roads and bridges should be designed to accommodate planned levee and revetment setback projects, and other flood protection projects. Adopted transportation plans should be reviewed and any identified bridge replacements corresponding with levee setback projects should incorporate opportunities to lengthen the span and accommodate the widened river channel into their descriptions.</td>
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<td>5. Bridges should be designed to safely pass large woody material.</td>
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**Supporting Information**

Please see discussion under section 4.1.2
## Sub-Planning Areas

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<td>Carbon River</td>
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<td>5.9</td>
<td>Middle Nisqually River</td>
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<td>Upper Nisqually River</td>
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<td>5.11</td>
<td>Mashel River</td>
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CHAPTER FIVE
RIVER REACH CHARACTERIZATION, MANAGEMENT STRATEGIES AND RECOMMENDED CAPITAL PROJECTS

This chapter describes river characteristics, river management facilities, flooding, and flood damage for each of the 11 sub-planning areas. For each sub-planning area shown in Figure 5.1, river reach management strategies and capital projects are recommended to address flood and channel migration risks. Sections of this chapter are divided into the following sub-sections:

- Overview;
- Geology and Geomorphology;
- Hydrology and Hydraulics;
- Ecological Context and Salmonid Use;
- River Management Facilities, Flooding and Flood Damage;
- Key Accomplishments Since the 1991 Flood Plan;
- Flood and Channel Migration Hazard Mapping;
- Problem Identification;
- River Reach Management Strategies; and,
- Recommended Capital Projects.

Flooding and Channel Migration Problems

Flooding and channel migration problems for each sub-planning area were identified by Pierce County, cities, tribes, the Advisory Committee, other stakeholders, and the public. Problems include, but are not limited to:

1. Levee/revetment overtopping or breaching,
2. Tributary backwater flooding,
3. Public safety/emergency evacuation,
4. Channel migration problem areas
5. Flooding of structures and infrastructure,
6. Sediment/gravel bar accumulation,
7. Facility maintenance and repair needs

79 Geomorphology – The study of landforms and the processes that shape them. Fluvial geomorphology is the study of processes associated with riverine or stream environments.
8. Floodplain development regulations,
9. Fish habitat problem areas, and

A list of nearly 250 problems was identified, though some problems address the same issue (e.g., levee overtopping that flooded roads and houses, and resulted in emergency evacuations might be listed under items 1, 3, and 5).

The list of problems for items 1 through 6 were evaluated and scored using four criteria to help prioritize the level of effort that was expended on developing alternative solutions. The four criteria were:

1. **Existing land use of affected area** (Consequences) – This criterion gave different weights to different types of land uses affected by flooding including: 1) critical facilities; 2) public infrastructure; 3) commercial or industrial uses; 4) residential; 5) resource lands; and, 6) recreational lands.

2. **Severity of potential flood or channel migration impact** – This criterion was intended to evaluate the type and magnitude of the impacts irrespective of the scale at which the impact occurred. This included: 1) public safety problems; 2) severe, moderate or minor infrastructure or property damage; and 3) inconvenience flooding or channel migration.

3. **Area of impact** (consequences and severity) – This criterion describes the scale of the problem. Is the problem impacting a large area or affecting a large number of people, or is it largely localized? Categories were: 1) regional (large scale impacts); 2) severe (city center, large neighborhoods); 3) moderate (numerous structures or roads impacted); and 4) localized (affects a few homes or businesses).

4. **Frequency of flood or channel migration occurrence** – This criterion was used to describe how often the flood or channel migration event occurred in the past 20 years. Channel migration was defined as any significant landward bank erosion. Categories were: 1) three or more occurrences in the past 20 years; 2) two occurrences; 3) one occurrence; or 4) has not occurred (but would likely occur in a one percent annual chance flood).

### River Reach Management Strategies

The river systems in Pierce County are highly variable, both from river to river and between reaches within any given river. Major sources of variability include: (1) development and land use in the adjacent floodplain; (2) presence of “river management facilities”; (3) river channel gradient and width; (4) presence of salmon spawning and rearing habitat; and (5) sediment transport, accumulation or erosion. The combination of these factors has shaped historical river management by Pierce County.

The Comprehensive Plan of Pierce County currently specifies a standard “Level of Service” for levees along the Puyallup River, Carbon River, White River, Greenwater River, and Nisqually
River. Levees are to be designed for the one percent annual chance flood (i.e., 100-year flood) plus three feet of freeboard. However; the Flood Plan proposes a more dynamic, customized level of service using different management strategies for each sub-planning area or reach based on the characteristics noted above. This includes structural approaches for levee and revetment reaches. Four levee levels of protection and two different revetment designs are available for application by reach or sub-reach. Additionally, non-structural approaches, such as floodplain development regulations and acquisition/buyout of property or structures, are also proposed for each reach. More detail on the river management strategies is presented for each of the 11 sub-planning areas below and in Chapter 4 (see Section 4.7.1 and Appendix F).

Capital Projects

The capital improvement projects recommended within the Flood Plan address many of the problems identified for each river reach. Project descriptions and graphics provide a general overview of each project. Figure 5-2 shows the location of the proposed projects. Projects were selected after the completion of an initial feasibility analysis, permitting considerations, assessment of benefits, and project cost estimates. For many of the projects multiple options were considered, however only those which provided the most benefit were recommended for inclusion in the Plan. Initial project analysis for each project was completed by multi-disciplinary teams of Pierce County staff or by consultants. Conceptual designs and cost estimates were developed as a starting point for further project development as the Flood Plan is implemented. The cost estimates are for capital expenditures only and are preliminary, based on 2011 costs at planning level design, (approximately 15 percent design level) and the information available at the time. Additional design and engineering will be required for each project as they are developed.

Preliminary prioritization of capital projects was carried out by scoring the projects based on eight criteria, the four problem criteria discussed above and four project criteria, as follows:

5. **Project Effectiveness** – This criterion was used to assess the effectiveness of the proposed project at addressing and solving the problem. Project effectiveness was categorized as: 1) complete solution to identified problem (e.g., acquisition/buyout that removes all structures in impacted area); 2) project addresses majority of identified problem, but some residual risk remains; and 3) project provides partial or temporary (defined as generally less than five years) solution to the identified problem (e.g., gravel removal, temporary super sack sandbags).

6. **Benefit-Cost Analysis of Project** – This criterion was used to assess the estimated benefit-cost ratio (BCR) for the project based on a 50-year project life. Analysis was based on a coarse-level assessment of benefits and costs and categorized by: 1) high (BCR greater than 2.0); 2) moderate (BCR between 1.0 and 2.0); and 3) low (BCR less than 1.0).

7. **Multiple Project Benefits** – This criterion was used to assess the additional project benefits that result from project implementation (beyond flood and channel migration
risk reduction). This included benefits in terms of: 1) aquatic and riparian habitat; 2) water quality (e.g., shading, sediment reduction, filtering); and 3) public access (e.g., trail, passive uses, aesthetics).

8. **Partnerships and Opportunity** – This criterion was used to assess the partnerships, funding and leveraging issues, land ownership and project readiness affecting project implementation, as follows: 1) partnerships/funding – project has partners (e.g., city, tribe, Corps of Engineers) contributing funding and political leverage; 2) land ownership – relative extent of land in public ownership or with willing land owner within project area; and 3) project readiness – extent to which project design and permitting are completed.

Scoring was based on a 10-point scale for all criteria except existing land use of the affected area, which was a 20-point maximum, based on the two predominant land uses. The maximum score was 90 points and the range of total scores was 33 to 66 (see Table ES.3 and Appendix B).
Figure 5.2
Recommended Capital Projects

Pierce County Rivers Flood Hazard Management Plan

Legend
- Project Sites
- Study Area Reaches
- Major Roads
- County Boundary
- Rivers/Streams
- Lakes/Puget Sound

Pierce County
Public Works & Utilities
Surface Water Management

This map is intended only to provide an indication of said feature. It is not a survey, orthophotos and other data may not align. The County assumes no liability for variants ascertained by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.

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2023 River Flood Management Plan
Public Participation Fund - Data and Maps
5.1 LOWER PUYALLUP RIVER

5.1.1 Overview

The lower Puyallup River begins at its mouth in Commencement Bay at River Mile (RM) 0.00 and continues upstream to its confluence with the White River at RM 10.3. It flows through the cities of Sumner, Puyallup, Fife, and Tacoma and portions of unincorporated Pierce County. The Puyallup Tribe of Indians owns the river bed, below the mean high water line, within the 1873 survey area from approximately RM 1.4 to RM 7.2. The lower Puyallup River is primarily straight with levees on both the right bank, North Levee Road, and left bank, River Road. Surrounding land uses are mostly urban in the cities and a mixture of agricultural, rural, and urban in unincorporated Pierce County.

Several tributaries enter the lower Puyallup River including the larger Clear Creek and Clarks Creek and smaller streams such as First Creek and Deer Creek. Most of these tributaries have steep gradients and high-velocity flows in their canyon reaches until they meet the flat valley floor of the Puyallup River. All local species of salmon are found in the lower Puyallup River. Many are also present in the tributaries.

The lower Puyallup River corridor includes extensive areas mapped as 100-year floodplain, based on the 2009 FEMA Flood Insurance Study80 (FEMA 2009) and preliminary Digital Flood Insurance Rate Map81 (DFIRM).

5.1.2 Geology and Geomorphology

The lower Puyallup River Valley is a broad low-gradient alluvial plain. Historically the river was once a complex area of river channels, wetlands, and thick riparian forests (Entrix 2008). Between 1914 and 1930 the river was altered to its present condition by channelization and levee construction projects. Since construction of the levees, there has been little change in the river’s position and the threat of lateral channel migration is now low. Streambed elevation in this segment varies from – 10 feet at the mouth to +25 feet at RM 10.3. The average channel gradient varies from 0.035 percent to 0.06 percent between RM 3.75 and RM 10.3.

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80 Flood Insurance Study - The official report provided by the Federal Insurance Administration, a division of FEMA, that includes flood profiles, a map of the 100-year floodplain and floodway boundaries, and the water surface elevation of the base flood.

81 Flood Insurance Rate Map (FIRM) – The official map on which the Federal Insurance Administration, a division of FEMA, has delineated areas of special flood hazard and the risk premium zones applicable to Pierce County. Through FEMA’s Map Modernization program, the FIRM is being replaced with the Digital Flood Insurance Rate Map (DFIRM), which utilizes modern computer Geographic Information Systems (GIS) to show the flood hazard areas.
The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.
The river thalweg meanders across the river bottom between the levees throughout this segment, resulting in a series of transient and alternating gravel bars that form and erode over time. Bed materials are primarily medium and fine sands with minor amounts of gravel. More than 95 percent of the sediment is less than one millimeter (mm) in diameter. The median particle diameter is 0.35 mm (medium sand) (Tetra Tech 2009).

Analysis by the USGS as part of a Sediment Transport Study funded by Pierce County (2010) indicates an average river bed elevation change of -0.5 feet to nearly +2.0 feet between 1984 and 2009, from the mouth at RM 0.0 to approximately RM 8.5 (see Figure 5.4). Upstream of RM 8.5 to the confluence of the White River at RM 10.3, sediment deposits increased the bed elevation between +0.5 feet to +3.5 feet.

5.1.3 Hydrology and Hydraulics

The lower Puyallup River drainage basin contains 106 square miles of tributary area, approximately ten percent of the 1,040 square miles of the entire river watershed. The primary period of runoff and major floods extends from October through March. Since 1948, Mud Mountain Dam (MMD) on the White River has provided a mechanism for flood control on the lower Puyallup River. The dam is operated by the U.S. Army Corps of Engineers and provides storage of up to 106,000 acre-feet of water. See Section 5.3.3 for dam operation details.

MMD modifies the lower Puyallup’s flow-frequency curve so it does not fit standard statistical methods of estimating discharge. Flow data are available for 1906 and 1915-1947 for natural flows, and estimates for selected events since the dam was built. These data fit a mathematical curve, suitable for adjusting based on the MMD Water Control Plan, and extrapolating to rare
events such as 200 and 500-year recurrences. Table 5.1 summarizes the flood frequency flows for the lower Puyallup River.

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Puyallup R.@ White R. confluence</td>
<td>36,000 45,000 45,000 49,000</td>
<td>1987 FEMA Flood Insurance Study</td>
</tr>
<tr>
<td>Lower Puyallup R.@ Puyallup Gauge (#12101500)</td>
<td>41,000 46,000 48,000 63,000</td>
<td>2009 FEMA Flood Insurance Study for Pierce County (Northwest Hydraulics, Inc. 2006)</td>
</tr>
</tbody>
</table>

The USGS study of conveyance capacity (USGS 2010) indicates that the lower Puyallup River channel can convey between 48,000 and 50,000 cfs in the lower six miles of the river. However, between RM 6.0 and RM 10.3 the conveyance capacity of the main channel diminishes to between 23,000 and 50,000 cfs (see Figure 5.5).

The location, duration, and magnitude of potential levee overtopping sites were identified using a simulation carried out by Tetra Tech et al. (2009). The simulation indicated that a 100-year event would overtop the levee on the right bank at RM 3.3, lasting nine hours. For the 500-year event the simulation showed extended overtopping (greater than 24 hours) would occur on the right bank at RM 3.3 and the left bank at RM 3.1. Shorter periods of overtopping would occur on the right bank at RM 3.7 and RM 4.1 and on the left bank at RM 4.5, RM 5.55, and RM 7.2.
5.1.4 Ecological Context and Salmonid Use

The lower Puyallup River was historically the most ecologically diverse segment in the study area and is now heavily modified by dredging, levees, and urbanization. Several ecotones, all with specific physical and biological properties that impart unique habitats still exist and are encountered in this reach as it transitions from marine to estuarine to freshwater. Each habitat is characterized by a collection of specific plants and animals. Pink, chum, fall and spring Chinook, steelhead, coho, sockeye, bull trout, and cutthroat trout all use this area. Because this is the lowest part of the river, all species of local fish are found here at adult and juvenile stages.

5.1.4.1 Estuary

The Puyallup River estuary is the body of water formed where freshwater from the river flows into Commencement Bay, mixing with seawater. Estuaries and the lands surrounding them are places of transition from land to sea, and from freshwater to saltwater. Although influenced by the tides, estuaries like the Puyallup River estuary are areas protected from the full force of waves, winds, and storms by the fingers of land, mud, or sand that surround them. Tidal conditions in Puget Sound directly affect the Puyallup River estuary and habitat formation. As the Puyallup River discharges into Puget Sound, fresh water flows over the top of the more dense marine waters. At the same time with the incoming tide a deep saltwater wedge surges upriver to about RM 2.5 (WSDOT per Puyallup Tribe of Indians, PTI). The height of the tide and the flow in the river influence the upstream extent of tidal surge. Higher river flows reduce the length of the surge, so the salt wedge moves furthest up the river during low river flows and high tides. Although the wedge may move up the river only a few miles, the tide elevates the
river water level further. During low flow/high tide events the Puyallup River will elevate due to tide action up to about RM 6.0 (Marks, E.L. et al 2009). This area of tidal influence defines the upstream extent of the estuary.

The salt water wedge and freshwater river do not have a clean separation in salinity. As the wedge meets the river, sheering occurs and a stratified range of salinities form as the waters mix. This mixing or “transition zone” is very important for salmon. The salinity gradient allows salmon to gradually adjust to differing biochemical conditions. A shallow embayment with large mudflats and salt marshes frequently characterize the transition zone under natural conditions. The transition zone provides juvenile fish with abundant food sources and safety from predators due to the shallow water and the salinity gradient.

The Puyallup River estuary has been greatly diminished from its natural state. Ninety-one percent of the mudflats and 98.7 percent (Kerwin, 1999a; Shared Strategy 2007) of the emergent marsh have been excavated and filled since the late 19th century.

5.1.4.2 Lower Fresh Water River

Prior to levee construction, the lower Puyallup River was an area prone to flooding, where tributaries such as Hylebos Creek, Wapato Creek, Clear Creek and Clarks Creek meandered through the Puyallup River floodplain. The tributaries would backwater during floods and high tides which helped create wetlands. The merging of tributaries and wetlands provided over winter habitat where juvenile salmon could avoid the higher velocities of the main river channel. During other times of the year these wetland and stream complexes provided areas to feed and grow. Most of these areas no longer provide these functions due to floodplain development and migration barriers such as flap gates and culverts.

A continuous shelf of silt extends 10 to 50 feet from the levee between RM 3.3 – RM 8.0. The top of the silt bench occurs at approximately the elevation of the two-year flood event. Silt is deposited during floods and stabilized by well-rooted vegetation. River flows routinely erode silt and undercut the vegetation to form small scalloped areas of trees which slump into the river. Trees and their roots reduce flow velocity and provide cover for fish habitat. In these areas juvenile salmon can avoid being swept prematurely to Puget Sound and adults can find areas to rest and acclimate to fresh water before continuing upstream.
From about RM 5.0 to RM 10.3, sand and gravel bars begin to form. Chum and pink salmon begin to find some marginal spawning areas in this area. It is an area where sport and tribal fishing is popular. Figure 5.6 shows some of the key habitat features for salmonids\(^{82}\) in the lower Puyallup River, including the transition zone, rearing, holding, and spawning habitat\(^{83}\) for various species.

**5.1.5 River Management Facilities, Flooding, and Flood Damage**

The lower Puyallup River is confined by nearly continuous levees and revetments from the river mouth at Commencement Bay to the Puyallup River’s confluence with the White River at RM 10.3. By restraining floodwaters from inundating the adjacent floodplain area which includes residential, commercial, and industrial and port facilities within the cities of Tacoma, Fife,

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\(^{82}\) **Salmonids** – Fish of the family Salmonidae, including salmon, trout, char (salmon and steelhead stock inventory), whitefish, and grayling native to Washington State.

\(^{83}\) **Spawning Habitat** – Areas used by adult fish for laying and fertilizing eggs.
Puyallup, and Sumner, these flood risk reduction facilities collectively protect the highest land and improvement values in Pierce County. Substantial damage to these flood risk reduction facilities has the highest consequence and risk on the Puyallup River system. The taxable assessed value of property and improvements in the floodplain in the lower Puyallup is estimated at $1.8 billion (Entrix, Inc, 2010).

The lower two and a quarter miles of levee from RM 0.7- RM 2.8 are owned and maintained by the U.S. Army Corps of Engineers. They were constructed in the late 1940s and completed in 1950 to protect the Port of Tacoma and other industrial areas (USACE 905b Report 2009) (see Figure 5.7a). Below RM 0.7, revetments extend to the mouth of the river at Commencement Bay (see Figure 5.7b).

The channel conveyance included straightening of the channel, building levees and making necessary bridge changes to convey 50,000 cfs between the East 11th Street Bridge and RM 2.9. The remaining levees along the lower Puyallup River are owned and operated by Pierce County as summarized in Table 5.2.
Table 5.2 Levees and Revetments in the Lower Puyallup River

<table>
<thead>
<tr>
<th>Name</th>
<th>Location a</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right Bank</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port of Tacoma Revetment</td>
<td>RM 0.0 – RM 0.7</td>
<td>Port of Tacoma</td>
</tr>
<tr>
<td>COE Port of Tacoma Levee</td>
<td>RM 0.7 – RM 2.8</td>
<td>US Army Corps of Engineers</td>
</tr>
<tr>
<td>North Levee Road Levee</td>
<td>RM 2.8 – RM 8.15, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Murphy Levee</td>
<td>RM 8.1 – RM 8.6</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Benston/Boatman Levee</td>
<td>RM 8.6 – RM 9.7</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Old Cannery Levee</td>
<td>RM 9.7 – RM 10.3, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Left Bank</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simpson Revetment</td>
<td>RM 0.0 – RM 0.7</td>
<td>Simpson Tacoma Kraft Company</td>
</tr>
<tr>
<td>COE Portland Ave Levee</td>
<td>RM 0.7 – RM 2.8</td>
<td>US Army Corps of Engineers</td>
</tr>
<tr>
<td>River Road Levee</td>
<td>RM 2.8 – RM 7.4, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Tiffany’s Revetment</td>
<td>RM 7.4 – RM 8.6</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Linden/Flashcube Revetment</td>
<td>RM 8.6 – 10.7</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

a RM = river mile; PL 84-99 USACE Flood Control and Coastal Emergency Act
Source: USACE and Pierce County Surface Water records

From RM 2.8 to 10.3, levees were constructed by Inter-County River Improvement (ICRI), mostly between 1914 and 1916, although levee construction continued until 1934. These levees were built to protect the surrounding mostly agricultural areas from floodwaters of the White River and Puyallup River after the permanent diversion of the White River into the lower Puyallup River in 1906. Prior to 1906, the White River flowed north through King County and joined the Green River before flowing into Elliott Bay (see Section 2.2.1).

Available geotechnical information indicates that the lower Puyallup River levees are generally constructed on fine grained silt and clay intermixed with deposits of clean to silty sand and gravelly sand (Tetra Tech et al. 2009). The levees were constructed primarily using draglines to form the channel with excavated alluvial material. Cast-in-place concrete panels on the river bank facing slope of the levee protect the levee fill. Brush mats were placed at the toe of the levees and weighed down with rocks and concrete block to discourage undermining the toe of the panels. Over time, silt benches formed on top of the brush mattresses, creating a silt bench between the exposed concrete levee face and the active rivers edge. Colonization of riparian vegetation also played an important role in the development and stabilization of the silt bench (Entrix 2008).

Over time, the original brush mats have become deteriorated. In some cases groins or spurs have been constructed of wood pilings, rocks, or concrete to deflect high velocity flows to the
center of the channel. In other instances, sheet piles were driven along the toe of concrete slabs to protect them (ICRI Annual Report, Jan 1936).

Prior to 1983, ICRI and Pierce County performed periodic channel deepening and dredging to maintain flood conveyance capacity, particularly in the upper portions of the lower Puyallup River. Levees were mowed to maintain access and large trees were removed to prevent damage to the levee caused by invasive roots and tree overthrow. Since 1983, legal limitations have modified vegetation management practices and gravel and silt removal. In 1985, Pierce County and the Puyallup Tribe of Indians adopted an inter-governmental agreement for the Puyallup River Vegetation Management Program.

Risk assessment analyses for the lower Puyallup River found that the existing levee systems prevent average annual equivalent damage costs of approximately $7.6 million ($6.4 million for the right bank and $1.2 million for the left bank) (Tetra Tech 2009). The estimated costs for substantial levee damage vary for right-bank and left-bank structures and contents as shown in Table 5.3. Total costs of damages are estimated at $60 million for a 10-year event, $78.7 million for a 100-year event and $93 million for a 500-year event (Tetra Tech 2009). More than 70 percent of estimated damage costs apply to commercial and industrial structures and activities.

Levee stability studies conducted in 2007-2008 indicate that the levees are generally structurally sound and in reasonably good condition. Historical aerial photos show little evidence of instability or erosion, with the exception of two areas of potential instability in photos from 1969 (Tetra Tech 2009): (1) on the right bank at RM 5.0 and the left bank at approximately RM 7.2. A reconnaissance performed for this study found little evidence of significant erosion of the silt benches. However, the levees in the lower Puyallup River, which were constructed under prior construction standards, have been de-accredited because they do not have adequate freeboard, which is defined by the U.S. Army Corps of Engineers as 3 feet above the 100-year flood event elevations.
### Table 5.3 Damage Costs by Flood Event (based on October 2007 costs)

<table>
<thead>
<tr>
<th>Event</th>
<th>Right Bank Residential</th>
<th>Right Bank Commercial</th>
<th>Right Bank Industrial</th>
<th>Right Bank Total</th>
<th>Left Bank Total</th>
<th>Total Damage Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-year</td>
<td>$5.6M</td>
<td>$17.0M</td>
<td>$35.6M</td>
<td>$58.6M</td>
<td>$1.4 M</td>
<td>$60M</td>
</tr>
<tr>
<td>100-year</td>
<td>$6.5M</td>
<td>$27.7M</td>
<td>$38.0M</td>
<td>$72.3M</td>
<td>$6.4M</td>
<td>$78.7M</td>
</tr>
<tr>
<td>500-year</td>
<td>$6.7M</td>
<td>$37.3M</td>
<td>$38.2M</td>
<td>$82.4M</td>
<td>$10.6M</td>
<td>$93.0M</td>
</tr>
</tbody>
</table>

Source: Lower Puyallup River Flood Protection Investigation – Without Project Analysis (Tetra Tech 2009)

### 5.1.5.1 Major Flooding


### Table 5.4 Historical Flooding in Lower Puyallup River

<table>
<thead>
<tr>
<th>Date</th>
<th>Puyallup River Flows at Puyallup Gauge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1917</td>
<td>40,500&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>December 1933</td>
<td>57,000&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>January 1965</td>
<td>41,500</td>
</tr>
<tr>
<td>December 1977</td>
<td>40,600</td>
</tr>
<tr>
<td>November 1986</td>
<td>43,800</td>
</tr>
<tr>
<td>January 1990</td>
<td>44,800</td>
</tr>
<tr>
<td>November 1990</td>
<td>41,900</td>
</tr>
<tr>
<td>February 1996</td>
<td>46,700</td>
</tr>
<tr>
<td>November 2006</td>
<td>39,700</td>
</tr>
<tr>
<td>January 2009</td>
<td>48,200</td>
</tr>
</tbody>
</table>

<sup>a</sup> Mud Mountain Dam (constructed on the White River in 1946) not in place

Source of data: USGS Puyallup Gauge flow records

### 5.1.5.2 Flood Damage to Facilities

Flood damage to the levees along the lower Puyallup River has been infrequent in recent decades. In 2002, loss of riparian vegetation and bank erosion began on the right bank of the levee at RM 5.3. Bank erosion continued between 2002 and 2009; until it was repaired by Pierce County in 2009 (see Section 5.1.6 for further explanation).
The levee and revetment in the vicinity of 12th Street SE (approximately RM 9.3, left bank) has been overtopped on several occasions in the last 20 years, including 1996, 2006 and 2009, resulting in flooding and sediment deposition along the top of levee and adjacent areas. No significant damages were identified.

5.1.6 Key Accomplishments since the 1991 Flood Plan

5.1.6.1 Major Projects

Since the 1991 Puyallup River Comprehensive Flood Plan was completed, Pierce County has carried out an annual program that includes maintenance of revetments and levees, and major repairs as listed in Table 5.5. In addition, the Puyallup Tribe of Indians, City of Tacoma, Port of Tacoma, and the US Army Corps of Engineers have completed several habitat restoration projects along the lower Puyallup River and adjacent tributaries.

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Type</th>
<th>Year</th>
<th>Location</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shotcrete repair of concrete panels</td>
<td>Levee</td>
<td>2005</td>
<td>RM 7.1-7.2 LB</td>
<td>$186,000</td>
</tr>
<tr>
<td>Silt Bench</td>
<td>Levee</td>
<td>2009</td>
<td>RM 5.3 RB</td>
<td>$550,000</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

1. **Puyallup River Walk Trail, RM 7.1 – 7.2, left bank**

   In 2005, Pierce County SWM repaired 500 linear feet of concrete panels along the left bank of the lower Puyallup River between RM 7.1 and RM 7.2 in the City of Puyallup. During construction of the Puyallup Riverwalk Trail, engineers discovered that concrete panels along a 500-foot section were cracked and failing. The project included removing the old panels, installing soil nails, and applying shotcrete.

2. **Sha Dadx Restoration Project, RM 4.4, right bank**

   Completed in 2008, by the Puyallup Tribe, the Sha Dadx Restoration Project created off-channel habitat including riparian buffers with a connection to the Puyallup River. A culvert\(^{84}\) under North Levee Road was installed to connect the Puyallup River to newly constructed pools and channels in an abandoned oxbow\(^{85}\) system. A ring levee was constructed around the site to contain floodwater within the off-channel habitat area and to protect adjacent properties. Total project cost was approximately $10 million.

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\(^{84}\) **Culvert** – A single length of pipe open to the ground surface at both ends that carries stream flow under a road grade or other type of fill embankment. Typically, no manholes or catch basins are installed along its length.

\(^{85}\) **Oxbow** - Generally, a U-shaped bend or meander in a channel. Oxbows are sometimes “cut off” and abandoned when a channel is straightened. This can occur both naturally or by man-made means.
The off-channel habitat covers approximately 12 acres inside the ring levee including two acres of riparian edge buffer. The project improves habitat for juvenile salmonids by increasing areas for rearing and foraging and by enhancing conditions for important prey resources such as resident fish and insects. Re-vegetation of the area with native plants provides wildlife habitat for insects, small mammals, and migratory waterfowl including resident birds.

3. **Silt Bench Protection, RM 5.3, right bank**

In 2009, Pierce County SWM constructed 200 linear feet of bank and toe protection along the right bank of the lower Puyallup River near RM 5.3, along North Levee Road in the City of Fife. Known as the “silt bench” project, the project consisted of constructing a matrix of logs and precast concrete dolosse tied together (see Figure 5.8). The dolosse “self settle”, so in-water excavation was not necessary. The wood and dolosse both added roughness to slow water velocities and encourage silt deposition and the reformation of the silt bench. The large woody material added river complexity and improved fish habitat. Native vegetation was planted at the site to increase the stream bank stability and habitat.

5.1.6.2 **Land Purchases**

Twenty-one parcels totaling 16.24 acres have been purchased by Pierce County in the Clear Creek area of the lower Puyallup. Many of the properties have experienced repetitive flooding as a result of the backwatering of Clear Creek. The backwatering is caused by the closing of the flood gate at the mouth of the creek preventing the creek from draining into the Puyallup River. The flood gates are necessary to prevent the further rise of flood waters in the creek from the elevated flows of the Puyallup River.

One parcel of 10.6 acres along Rody Creek was purchased by Pierce County for the construction
of a sediment pond and habitat restoration project. Rody Creek is a tributary of Clarks Creek.

5.1.6.3 Partnerships

In 2008, the Lower Puyallup River Executive Task Force was convened to address issues arising from the de-accreditation of the lower Puyallup River levee system and subsequent changes to FEMA’s floodplain maps. In June 2008, the Pierce County Council passed resolution R2008-74s, requesting all local governments to participate in developing and funding the work to bring the flood control system back into compliance. The project goals are to: (1) ensure local agencies understand the problems and support finding a solution, and (2) work closely with affected agencies to develop alternatives, select an alternative, cooperatively seek funding, and construct the selected alternative. The Puyallup River General Investigation, a joint partnership with the ACOE as the federal sponsor, is also currently evaluating significant flooding problems on the Puyallup, White, and Carbon rivers and formulating, evaluating, and screening potential solutions.

5.1.7 Flood and Channel Migration Hazard Mapping

5.1.7.1 Flood Hazard Mapping.

Hazard mapping in the lower Puyallup includes detailed flood studies (FEMA 2009, NHC 2006) and the creation of preliminary Digital Flood Insurance Rate Maps (DFIRM), which as of this publication of this document have not been issued by FEMA. Flood prone areas along the lower Puyallup River include extensive industrial, commercial, residential, and agricultural land uses along the right bank at the Port of Tacoma; cities of Tacoma, Fife and Puyallup; and unincorporated Pierce County. Along the left bank, there are fewer commercial and industrial uses, but extensive residential and agricultural uses, and public infrastructure. The Tacoma wastewater treatment plant, on the left bank between State Route 509 and Lincoln Avenue, is an example of a critical facility along the lower Puyallup River potentially subject to flooding. The preliminary DFIRM maps for the lower Puyallup show 4,494 acres within the special flood hazard area (SFHA) or 100-year floodplain. The mapped deep and fast flowing area is 1,087 acres.

5.1.7.2 Channel Migration Hazard Mapping.

No channel migration zones have been mapped for the lower river due to the attenuation of flood flows from Mud Mountain Dam. Few levee repairs have been documented since construction of the dam. The regulated FEMA floodway within existing levees is the default channel migration zone (CMZ) for the lower Puyallup River according to Pierce County Code 18E.70.020. The severe CMZ covers an area of 27 acres.
5.1.8 Problem Identification

Table 5.6 sets out the flooding and channel migration problems identified in the lower Puyallup River floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Levee and Revetment Overtopping and Breaching</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 2.9 – RM 3.1 LB</td>
<td>Levee overtopping potential upstream threatens Tacoma Wastewater Treatment Plant</td>
<td>City of Tacoma</td>
</tr>
<tr>
<td>RM 2.8 - RM 8.15 RB</td>
<td>De-accredited North Levee Rd. levee results in increased flood risk for infrastructure and property</td>
<td>City of Fife, Tacoma, Pierce County, Port of Tacoma</td>
</tr>
<tr>
<td>RM 4.4 - RM 4.4 RB</td>
<td>Settlement of levee at Sha-Dadx restoration site causes road settling and possible future destabilization</td>
<td>City of Fife</td>
</tr>
<tr>
<td>RM 4.6 – RM 4.7 RB</td>
<td>Flood levels in 2006 and 2009 nearly overtopped levee at 54th Ave. E.</td>
<td>City of Fife</td>
</tr>
<tr>
<td>RM 6.8 – RM 6.9 RB</td>
<td>Flood levels in 1996 and 2009 nearly overtopped levee at Freeman Road</td>
<td>City of Fife</td>
</tr>
<tr>
<td>RM 7.9 – RM 8.3 LB</td>
<td>Levee overtopping floods Tiffany’s skating rink, Riverwalk Apts., and road underpass</td>
<td>City of Puyallup, Pierce County</td>
</tr>
<tr>
<td>RM 8.1 – RM 8.2 RB</td>
<td>Levee overtopping floods N. Meridian-north shore underpass</td>
<td>City of Puyallup</td>
</tr>
<tr>
<td>RM 9.1 – RM 9.25 LB</td>
<td>Levee overtopping floods E. Main St. “flash cube” building</td>
<td>City of Puyallup</td>
</tr>
<tr>
<td>RM 9.3-9.5 LB</td>
<td>Levee overtopping floods Rite Aid shopping center parking lot and loading docks</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 9.8 – RM 10.3 LB</td>
<td>Levee overtopping floods Linden golf course</td>
<td>City of Puyallup</td>
</tr>
<tr>
<td>RM 9.4 – RM 10.6 LB</td>
<td>Levee overtopping and sedimentation impacts levee access road and public trail</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Tributary Backwater Flooding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 2.1 LB</td>
<td>Backwater flooding at Cleveland Way pump station caused extensive flooding in 1996</td>
<td>City of Tacoma</td>
</tr>
<tr>
<td>RM 2.9 LB</td>
<td>Clear Creek backwater flooding caused extensive flooding in 1996 and 2009; some flooding in 2006</td>
<td>Pierce County, City of Tacoma</td>
</tr>
<tr>
<td>RM 5.0 RB</td>
<td>Oxbow Lake backwater flooding of pump station</td>
<td>City of Fife</td>
</tr>
<tr>
<td>RM 5.8 LB</td>
<td>Clarks Creek backwater flooding of homes</td>
<td>Pierce County, Tacoma</td>
</tr>
<tr>
<td>RM 6.9 LB</td>
<td>City storm drain flooding (NW 13th Ave.)</td>
<td>City of Puyallup</td>
</tr>
<tr>
<td>RM 7.9 LB</td>
<td>City storm drain flooding (4th St. NW)</td>
<td>City of Puyallup</td>
</tr>
<tr>
<td>Location</td>
<td>Problem Description</td>
<td>Source</td>
</tr>
<tr>
<td>----------</td>
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<td>--------</td>
</tr>
<tr>
<td>RM 9.4 LB</td>
<td>Deer Creek backwater flooding (Shoppe concrete)</td>
<td>City of Puyallup</td>
</tr>
</tbody>
</table>

**Public Safety/Emergency Rescues**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 2.9 – RM 4.8 LB</td>
<td>Clear Creek (&gt;10 emergency rescues in 2009)</td>
<td>Pierce County Sheriff</td>
</tr>
<tr>
<td>RM 4.2 – RM 8.2 LB</td>
<td>Emergency evacuation in Fife in 2009</td>
<td>City of Fife</td>
</tr>
</tbody>
</table>

**Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 0.7 – RM 2.2 RN/LB</td>
<td>Three bridges of concern (11th Ave., Lincoln Ave., and Puyallup Ave.) – wood on piers and capacity</td>
<td>City of Tacoma</td>
</tr>
<tr>
<td>RM 2.9 – RM 6.9 RB</td>
<td>Critical facilities (schools, police station) at risk of flooding due to overtopping/breaching of levee</td>
<td>City of Fife</td>
</tr>
<tr>
<td>RM 3.1 LB</td>
<td>Localized road flooding north of I-5</td>
<td>City of Tacoma</td>
</tr>
<tr>
<td>RM 4.0 – RM 5.5 RB</td>
<td>Potential flooding of Tacoma Power’s Fife substation</td>
<td>City of Tacoma</td>
</tr>
<tr>
<td>RM 5.75 RB/LB</td>
<td>Milroy bridge fails to meet minimum standard for bridge clearance</td>
<td>Pierce County Transportation, City of Fife</td>
</tr>
<tr>
<td>RM 6.8 – RM 6.9 LB</td>
<td>Puyallup Wastewater Treatment Plant flooding</td>
<td>City of Puyallup</td>
</tr>
<tr>
<td>RM 9.1</td>
<td>SR-512 bridge at Pioneer – wood accumulation and bed scour at piers</td>
<td>WSDOT</td>
</tr>
</tbody>
</table>

**Sediment and Gravel Bar Accumulation**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 2.9 – RM 6.9</td>
<td>Bed elevation increases between I-5 and Freeman Rd. a concern due to reduced conveyance capacity</td>
<td>City of Fife, Pierce County</td>
</tr>
<tr>
<td>RM 5.8 – RM 10.3</td>
<td>Bed elevation increases from Clarks Cr. to White River a concern due to reduced conveyance capacity</td>
<td>City of Puyallup, Pierce County</td>
</tr>
</tbody>
</table>

**Facility Maintenance and Repair Needs**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 2.8 – RM 8.6 RB/LB</td>
<td>Concrete panel repair as needed due to veg./roots</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

**Fish Habitat Problem Areas**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 2.6 – RM 3.7 RB</td>
<td>Levee separates river from historic estuary on Union Pacific property and adjacent farmland</td>
<td>Pierce County, Puyallup Tribe</td>
</tr>
<tr>
<td>RM 5.0 RB</td>
<td>Oxbow Lake is former river meander that has been cut-off from river by levee</td>
<td>City of Fife</td>
</tr>
<tr>
<td>RM 6.7 – RM 7.4 RB</td>
<td>Freeman Road Oxbow cut-off from river by levee</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 8.2 RB</td>
<td>72” Wapato Cr. outflow to Puyallup River prevents headwater flow to Wapato Cr.</td>
<td>Puyallup Tribe</td>
</tr>
</tbody>
</table>
Table 5.6 Priority Problems Identified in Lower Puyallup River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 9.4 – RM 10.3 RB</td>
<td>Levee cuts off confluence wetlands river channel</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>RM 9.6 – RM 10.5 LB</td>
<td>Levee cuts off-channel habitat and floodplain from river channel</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>Public Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.6 – RM 2.9 RB/LB</td>
<td>Corps of Engineers limits access to levee</td>
<td>City of Tacoma</td>
</tr>
<tr>
<td>RM 2.0 – RM 6.5 RB/LB</td>
<td>Lack of connecting trail along river from RM 6.5 to City of Tacoma (on left or right bank)</td>
<td>City of Tacoma, Pierce County Parks</td>
</tr>
<tr>
<td>RM 6.8 – RM 10.7</td>
<td>Repeated flood damage to trail limits access; no trespassing sign at RM 6.8 discourages access</td>
<td>City of Puyallup</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management

5.1.9 River Reach Management Strategies

Recommended river reach management strategies for the lower Puyallup River take into account numerous conditions as follows:

- **Development and land use in adjacent floodplain** – The lower Puyallup River floodplain is the most developed in the planning area, with extensive industrial, commercial, residential, and agricultural land uses and an assessed value of $1.8 billion in the 100-year floodplain.

- **River management facilities** – Both the left and right banks of the Puyallup River are constrained by levees and revetments along the entire reach.

- **River channel gradient and width** – Channel gradient varies from 0.035 to 0.06 percent. Width varies from 350 feet to 700 feet in the lowest part of the river and narrows to 250 feet in the upper portion of the lower Puyallup River.

- **Presence of salmon spawning and rearing habitat** – All species of salmon are found in the lower Puyallup, including Chinook, pink, chum, coho and sockeye, as well as steelhead, bull and cutthroat trout. Both spawning and rearing habitats are present.

- **Sediment transport accumulation and incision** – Mostly sand and silt accumulate below RM 8; mixed sand and silt and some gravel above RM 8. The mean river bed elevation between RM 0.0 to approximately RM 8.5 changed in elevation from -0.5 feet to +2.0 feet between 1984 and 2009. Upstream of RM 8.5 to the confluence of the White River at RM 10.3 sediment deposits ranged from 0.5 feet to 3.5 feet (see Figure 5.1).

The primary objective for the lower Puyallup River is to maintain the structural integrity of the levee and revetment system so the system continues to reduce risks to public health and safety, and reduce public and private property damages. Another objective is to make improvements to the levees so they can be flood accredited by the US Army Corps of Engineers.
and FEMA and so that areas in the floodplain prone to flooding are reduced. The final management strategy objective is to identify capital projects that enhance and create aquatic habitat through levee setbacks, riparian re-vegetation, and strategic placement of large woody material.

Given the significant amount of development, major interstate transportation infrastructure, and commercial industry centers in the lower Puyallup River, the Flood Plan recommended River Reach Management Strategies are (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**
- RM 0.0 – RM 10.3 left and right bank - The “level of protection” goal for levees should be 200-year design plus three feet of freeboard.

**Non-structural management strategy:**
- Floodplain development regulations
- Property acquisition, or purchase of development rights
5.1.10 Recommended Capital Projects

The following capital improvement projects are recommended to address the priority problem areas identified in Table 5.6. Capital projects are defined as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Pierce County Comprehensive Plan. Projects less than $75,000 are classified as small works.

5.1.10.1 LP1 Tacoma Wastewater Treatment Plant Flood Wall

Location Information:
Sub Area: Lower Puyallup
Basin Plan: None
River Mile 1.45 – 1.98, Left Bank
Council District 2
Jurisdiction: City of Tacoma
Local Government Lands

*Estimated Cost:* $3,200,000 - $5,200,000

*What is the Issue?*

The Tacoma Wastewater Treatment Plant (WWTP) provides advance secondary treatment for approximately 154,000 citizens in the City of Tacoma and portions of unincorporated Pierce County and has a maximum treatment capacity of 60 million gallons per day. The WWTP is on the left bank of the Puyallup River and discharges to Commencement Bay. The base flood elevation at the WWTP is approximately 13.0 to 14.8 feet. The top of the Corps of Engineers Portland Avenue Levee that protects the WWTP along the Puyallup River has an elevation ranging from +14.0 feet to +15.5 feet. The entire WWTP complex sits below the top of the levee with the lowest point within the complex at elevation 9.5 feet. There is no flood protection along the landside (southern boundary) of the facility. If a levee washout or overtopping of the levee occurs upstream of the levee between RM 2.9 and RM 3.1, floodwaters would inundate the WWTP from the unprotected southern boundary.

*What is at Risk?*

If the existing levee was to be overtopped or breached and the WWTP flooded, the facility would become inoperable and could lead to the release of untreated wastewater to the Puyallup River and Commencement Bay. This release would likely continue until the WWTP was repaired. Once the flood waters recede, pumping out the treatment plant could take several days. Primary treatment may be resumed within one month and secondary treatment could be resumed within three months. Residential and commercial customers would experience decreased service, with businesses possibly having to close for extended periods of time.
**What is the Recommended Solution?**

![Figure 5.9 – Approximate location of proposed floodwall around the Tacoma WWTP](image)

Construction of a floodwall to surround the Tacoma WWTP on the east, west and south sides of the WWTP will protect the treatment plant from floodwaters from an upstream overtopping of the levee. The top of the proposed floodwall will tie into the existing levee along the Puyallup River. To accommodate access points into the WWTP a sliding gates or drop-in gates would be installed.

**What are the Project Benefits?**

- Eliminates the potential of raw or untreated sewage being discharged to the Puyallup River and/or Commencement Bay,
- Eliminates cleanup and repair costs at the WWTP,
- Provides continuous sewer service to customers, and
- Eliminates financial burdens to businesses in the service area.

**Coordination**

City of Tacoma, Washington State Department of Transportation, US Army Corps of Engineers, Pierce County, local railroads, and various utilities.

**Environmental Considerations**

The City of Tacoma is currently in the process of submitting permits for the new floodwall project. Because the project is located on the landward side of the Corps of Engineers Portland Avenue levee it is not expected to adversely impact fish and wildlife or wetlands.
5.1.10.2 LP2 Clear Creek Acquisition and Levee

Location Information
Sub Area: Lower Puyallup
Basin Plan: Clear/Clarks Creek
River Mile: 2.9, Left Bank, confluence of Clear Creek and Puyallup River
Council District: 2
Jurisdiction: Pierce County
Private Lands

Estimated Cost: $36,000,000 - $55,000,000

What is the Issue?
The base flood elevation in the project area is 19.0 to 23.0 feet with the floodplain elevation ranging from +10.0 feet to +20.0 feet. Clear Creek enters the Puyallup River at an elevation of approximately eight feet. During high flows on the Puyallup River the two Clear Creek flood gates close. This prevents the river from flooding the lowlands behind the levee, but also results in Clear Creek backing up and flooding approximately 400 acres of farmland, commercial, and residential properties.

What is at Risk?
There was extensive emergency evacuation of this area by boat during the January 2009 flood event. Properties that are impacted by the backwater flooding of Clear Creek are estimated to be in excess of $42 million.
What is the Recommended Solution?

Construction of a new levee at either the +14 foot or +18 foot contour would provide the most flood protection for the commercial and residential structures, while still preserving farmland. The levee would have a top elevation of +22 feet, allowing vehicle traffic over the levee and manual emergency relief gates to allow for the release of trapped flood waters should upstream flooding over River Road occur. The existing flood gates and infrastructure would be removed and the floodplain would be allowed to re-establish allowing for a more natural interaction with the Puyallup River.

What are the Project Benefits?

Construction of the levee preserves existing infrastructure, preserves farmland, and relieves the level of flooding in the Clear Creek floodplain. Removal of the flood gates will allow for free fish passage in and out of Clear Creek.

Coordination:

Environmental Considerations:

Additional floodplain and habitat enhancement projects are possible and desirable to encourage the return of juvenile salmonids to the Clear Creek system.
5.1.10.3 LP3 Oxbow Lake Flooding/Sewer Lift Station Protection

Location Information
Sub Area: Lower Puyallup
Basin Plan: Mid-Puyallup
River Mile: 5.0, Right Bank and backwater area
Council District: 2
Jurisdiction: City of Fife
Local government property

Estimated Cost: $410,000

What is the Issue?
A remnant oxbow wetland of the Puyallup River serves as a storm water pond for the surrounding residential and commercial development. A flap gate controlled outlet drains the oxbow to the Puyallup River at RM 5.0. During periods of high flow in the Puyallup River the flood gate closes and does not allow the oxbow to drain, causing localized flooding in the surrounding neighborhoods. A sanitary sewer lift station is located in the immediate area, eight feet below the base flood elevation.

What is at Risk?
The highest risk is the flooding of the sanitary sewer lift station from backwater flooding of the storm water wetland. Flooding of critical infrastructure poses a risk of possible discharge of untreated wastewater to the Puyallup River. Localized damage to surrounding neighborhoods is also a threat.

What is the Recommended Solution?
Elevation of the existing lift station above the base flood elevation plus two feet of freeboard would provide the greatest benefit to the environment and surrounding neighborhoods for the least investment of public funds.

What are the Project Benefits?
Elevating the sewer lift station out of the BFE protects critical infrastructure and eliminates a possible release of untreated wastewater to the oxbow wetland and surrounding property.

Coordination:
Coordination with the City of Fife, Puyallup Tribe of Indians, and Pierce County
Environmental Considerations:

Elevation of the lift station would not trigger a Washington State Department of Fish and Wildlife Hydraulic Project Approval\(^\text{86}\) (HPA) or a USACE 404 permit. Permitting would be through the City of Fife.

Other Information or Needs:

Water levels within the oxbow have risen two feet over the last five years due to beaver activity on the adjacent Puyallup Tribal land. Coordination with the Puyallup Tribe to mitigate the impact of the beaver could increase the capacity of the oxbow.

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\(^{86}\) Hydraulic Project Approval – Permit issued by Washington State Department of Fish and Wildlife required for projects with construction activity in or near state waters (RCW 75.20.100-160) that affect the bed or flow of a stream.
5.1.10.4 LP4 North Levee Road Setback Levee

Location Information:
Sub Area: Lower Puyallup
Basin Plan: Hylebos and Mid-Puyallup
River Mile: 2.8 – 8.15, Right Bank
Council District: 2
Jurisdiction: City of Fife, City of Puyallup, Pierce County
Local government and private lands

Estimated Cost: $104,000,000

What is the Issue?
The current levee system along the right bank was de-accredited by FEMA because of inadequate freeboard. The levees along North Levee Road on the right bank of the Puyallup River are typically narrow, steep sided earth-filled levees covered with concrete panels, and constructed with brush mats at the toe of slope for erosion protection. The top of the levee has a road system varying in width from one lane to three lanes, with portions of the road experiencing traffic in excess of 10,000 average daily trips. Sand boils, an indicator of potential levee destabilization, have been observed along the silt bench near RM 4.5 along the right bank between the river and the landward side of the levee during periods of high flows.

What is at Risk?
If the existing levees were to overtop or breach during a flood event, there is a potential for loss of life and significant damage to property with the City of Fife. There is a likelihood that basic infrastructure, including roads, will be heavily damaged and that large sections of commercial, industrial and residential properties within the cities of Fife and Puyallup would be damaged. Transportation corridors, including Interstate-5 and other roads, as well as railroads would be closed.

What is the Recommended Solution?
The levee must be set back and raised to safely convey the 100-year flood elevation plus three feet of freeboard to be re-accredited by the Corps of Engineers and FEMA. Due to the significant assessed value of the developed lands and risk to public infrastructure and to increase flood conveyance capacity, the right bank levee would be set back as much as possible. The level of protection goal for this reach is the 200-year flood design plus three feet of freeboard.

Three different levee cross sections are proposed based on use and road width:
- Section 1: RM 2.4 – Frank Albert Road. Excavate the existing levee to ground level and construct a new setback levee along the railroad right-of-way. This would require the

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87 Boil- A concentration of seepage in one spot, usually caused by pressure from the river on a strata of coarse sand or gravel
acquisition of approximately 35 parcels with a total of 250 acres of land and several homes. This segment includes the proposed Union Pacific setback levee within the 2008 Levee Setback Feasibility Study.

- Section 2: Frank Albert Road – RM 7.1. Move the levee back from its current location and rebuild a new levee designed to convey the 200-year flood event plus 3 feet of freeboard. Construction would also include a new roadway constructed on top of the levee. This segment includes a setback levee at the Freeman Road Oxbow similar to that proposed within the 2008 Levee Setback Feasibility Study.

- Section 3: RM 7.1 – RM 8.1. This section of levee would be set back up to 100 feet and rebuilt to current standards, with an increased top width. It would also be designed to convey the 200-year flood event plus 3 feet of freeboard.

![Figure 5.13 – Potential location of Section 1 of the North Levee Road Setback](image-url)
What are the Project Benefits?

Reconstruction of the existing right bank levee system would be designed to achieve Corps of Engineers certification and FEMA accreditation of the levee system, increasing protection from less than 100 year up to the 200-year plus three feet of free board level of protection. Safety improvements also include widening of a heavily travelled roadway. The project will significantly reduce the threat to local residents, damage to public infrastructure, and commercial, industrial, and residential areas. Environmental benefits of the setback levees include increased channel complexity, more natural sediment conveyance and storage process, and enhancement of off-channel habitats.

Coordination Required:


Environmental Considerations:

The project will improve connectivity of the river to wetlands and historical meander channels. There will be short-term adverse impacts to the riparian vegetation and silt bench habitat. Threatened species present included Chinook salmon, steelhead, and bull trout.

Other Information or Needs:

The existing levee upstream of the Interstate-5 Bridge (approximately between RM 2.4 and RM 3.1) is owned and controlled by the US Army Corps of Engineers (USACE) as a Section 408 levee. Modification of Section 408 levees are complex and require approval at the USACE headquarters.
Pierce County’s Park, Recreation & Opens Space Plan, 2008 includes connector and regional trail segments along portions of the North Levee Road. During final design of the North Levee Road Setback, the feasibility of including a public trail should be considered.
5.1.10.5 LP5 Puyallup Wastewater Treatment Plant Flood Wall

Location Information

Sub Area: Lower Puyallup  
Basin Plan: Clear/Clarks Creek  
River Mile: 6.8 – 6.9, Left Bank  
Council District: 2  
Jurisdiction: City of Puyallup  
Local government property

Estimated Cost: $2,500,000 - $3,500,000

What is the Issue?

The Puyallup Wastewater Treatment Plant (WWTP) is a secondary wastewater treatment plant serving approximately 37,000 citizens of Puyallup and the surrounding area. The WWTP discharges to the Puyallup River and has a design capacity of 9.46 million gallons per day with a permitted peak hydraulic capacity of 14 million gallons per day. The WWTP was constructed in what was once an oxbow that was abandoned when the river was straightened. The treatment plant is protected by a plug levee. The base flood elevation at the WWTP is approximately 34.2 feet. The plug levee elevation is approximately 36 feet. If the levee were to fail or overtop the existing concrete fence around the WWTP is only able to provide protection for the initial 18 to 24 inches of flood waters.

What is at Risk?

If the existing floodwall was to be breached and the WWTP flooded, the facility would become inoperable, causing the release of untreated wastewater to the Puyallup River. After the floodwaters recede it is likely to take between several weeks to a month to restart the biological secondary treatment process. Residential and commercial customers would be impacted for some interim period of time, resulting in possible business closures.

What is the Recommended Solution?

Construction of a floodwall to protect the WWTP from a 100-year flood. Where feasible the existing concrete fence would be retrofitted and construction of a new concrete flood wall would be constructed where necessary. The new floodwall would range in height from 8 to 12 feet.
What are the Project Benefits?
The major project benefit would be no shut down of the Puyallup WWTP as a result of flooding. Other benefits include:

- Eliminates the potential of raw or untreated sewage being discharged to the Puyallup River,
- Eliminates cleanup and repair costs at the WWTP,
- Provides continuous sewer service to customers, and
- Eliminates financial burdens to businesses in the service area.

Coordination:
Coordination with Pierce County, City of Puyallup, and various utility companies.

Environmental Considerations:
Since the project is located away from the Puyallup River there is no impact to fish, wildlife, or wetlands.

Other Information or Needs:
This project is currently not on the City’s Capital Improvement Plan due to cost.
5.1.10.6 LP6 Tiffany’s Skate Inn/Riverwalk Flood Wall

**Location Information**

Sub Area: Lower Puyallup  
Basin Plan: Mid-Puyallup  
River Mile: 8.2-8.6, Left Bank  
Council District: 2  
Jurisdiction: City of Puyallup  
Private and local government property

**Estimated Cost:** $4,500,000

**What is the Issue?**

During larger flood events the Tiffany revetment overtops results in flooding of Riverwalk Apartments, Tiffany’s Skate Inn and the Fred Meyer parking lot. Floodwaters also prohibit travel at the North Levee Road underpass and close the Riverwalk Trail along the river. Flooding is exacerbated by the storm water system which services the Riverwalk Apartments and Tiffany’s Skate Inn. The storm water system outfall does not have a backflow protector and enters into the Puyallup River at an elevation below the base flood elevation. The base flood elevation in this section of the river is at 40.5 feet. The surrounding development sits at an elevation of between 30 to 36 feet and the revetment sits at 34 to 36 feet elevation. This causes back water flooding to occur even before the water overtops the revetment.

**What is at Risk?**

Localized damage to private property, public infrastructure, and closure of commercial businesses. Closure of North Levee Road underpass and public trail system impacts the travelling public.

**What is the Recommended Solution?**

Construction of a four to eight foot floodwall at the base flood elevation from Milwaukee Avenue Bridge to approximately RM 8.1 and the addition of a tideflex outfall treatment on the existing stormwater outfall will decrease flooding at Tiffany’s Skate Inn and the Riverwalk Apartments. Because North Levee Road is within the 100- and 500-year flood plains and alternative routes exist, road closures and detours are the recommended solution for roadway flooding.

*Figure 5.16 – Example of a flood wall next to a public trail*
What are the Project Benefits?

- Installation of the tideflex on the existing stormwater outfall prevents backwater flooding during high flows
- Installation of a flood wall minimizes the need to disturb the high functioning mature riparian habitat that exists along this portion of the river
- Protection of commercial businesses and apartment complex

Coordination:

City of Puyallup, Pierce County, Puyallup Tribe of Indians, Muckleshoot Tribe, Washington State Department of Fish and Wildlife, and US Army Corps of Engineers.

Environmental Considerations:

The river is utilized by Puget Sound Chinook, steelhead, and bull trout and the project area is within Chinook and bull trout critical habitat area. Construction of a floodwall greatly reduces the amount of vegetation needed to be cleared near the left bank of the river. The modification of the existing outfall will require work within the shoreline environment, but will not trigger federal permitting requirements.
5.1.10.7 LP7 Puyallup Executive Park Flood Wall

Location Information
Sub Area: Lower Puyallup  
Basin Plan: Mid-Puyallup Basin  
River Mile: 9.1 - 9.25, Left Bank  
Council District: 2  
Jurisdiction: City of Puyallup  
Private Lands

Estimated Cost: $160,000

What is the Issue?

Base flood elevation in this section of the river is at approximately 46 feet. The surrounding development sits at an elevation of between 40 to 44 feet and the Linden/Puyallup Executive Park revetment sits at approximately 40 to 46 feet of elevation. During periods of high flow, this low point in the revetment allows floodwaters to overtop causing flooding of the commercial office building known as the Puyallup Executive Park and the adjacent Riverview Court Mobile Home Park.

What is at Risk?

Localized damage to the bottom floor of a commercial office building and recreational trailers stored in the adjacent mobile home park.

What is the Recommended Solution?

Construction of a small four foot high floodwall between the parking lot and office building would provide needed flood protection for the lower floors. A removable barrier would maintain building access. It is recommended that an emergency evacuation plan be developed for the Riverview Court Mobile Home Court.

What are the Project Benefits?

Installation of a small localized floodwall and an evacuation plan are cost effective solutions that eliminate impacts to the riparian area and do not appreciably diminish the floodplain in this area.

Figure 5.17 – Example of a temporary flood wall
**Coordination:**

Pierce County, City of Puyallup, Pierce County Department of Emergency Management, property owners.

**Environmental Considerations:**

The proposed solution avoids the riparian area.
5.1.10.8 LP8 Linden Golf Course Oxbow Setback Levee

Location Information
Sub Area: Lower Puyallup
Basin Plan: Mid-Puyallup Basin
River Mile: 9.6 – 10.5, left bank
Council District: 2
Jurisdiction: City of Puyallup & Private Lands
Estimated Cost: $43,000,000

What is the Issue?
The City of Puyallup contracted with Cardno Entrix to complete a feasibility study for the Linden Golf Course Oxbow Setback Levee project. The project is located at the confluence of the White and Puyallup Rivers, downstream of the Sumner Wastewater Treatment Plant. Existing flood control facilities constrain the river channel within a narrow 300 to 350 feet wide corridor. The flood control facilities have eliminated much of the side channel habitat and flood plain connectivity. During periods of high flows, the channel banks are over topped. The location is further constrained by the presence of three historic landfill sites adjacent to the river. Landfill B is approximately 14 acres in size and is located within the proposed project area. Portions of this landfill become inundated during high flows.

What is at Risk?
- The Riverwalk Trail and portions of the Linden Golf and Country Club flood during high flow events, limiting use during flood events and requiring clean up
- The City of Sumner has expressed concerns about flooding hazards at the Sumner Sewage Treatment Plant, which is along the right bank of the Puyallup River, just upstream of this location
- Portions of a former landfill become inundated during flood events
- Side channel habitat and floodplains are cut off from the river

What is the Recommended Solution?
Construction of a 100 year plus three feet of freeboard setback levee approximately 3700 feet long. The project would tie into existing flood walls and areas already elevated above the 100-year flood level and would reconnect 35 acres of floodplain. The project would also include the removal of Landfill B and all its materials (approximately 14 acres), creation of side channel enhancements and reconnection, and construction of engineered log jams to promote formation of side channels and habitat. The proposal would relocate the Riverwalk Trail to follow the new levee alignments.
Because of the size and scope of removing the landfill, the project can be phased. The phased project would concentrate on the removal of the left bank levee between landfill B and landfill D along with minor modifications and habitat improvements.

**What are the Project Benefits?**

- Reconnection of 35 acres of floodplain;
- Removal of a 14 acre landfill adjacent to the Puyallup River;
- Creation of longterm salmon habitat;
- Increased flood conveyance and sediment storage;
- A decrease in surface water elevation through this section of the river of up to two feet, providing additional protection to the Sumner Wastewater Treatment Plant.

**Coordination:**

Pierce County, City of Puyallup, City of Sumner, property owners, Puyallup Tribe of Indians, Muckleshoot Indian Tribe, Department of Fish and Wildlife, Department of Ecology and US Army Corps of Engineers.

**Environmental Considerations:**

The primary objective of the Linden Golf Course Oxbow Setback Levee feasibility study was to determine the alternative which would provide the greatest possible restoration of floodplain connectivity and off-channel habitat. The Study looked for alternatives which provide the highest quality habitat for the longest period of time. The cost of the project was not a deciding factor. This project is able to be phased over the long term.
5.2 MIDDLE PUYALLUP RIVER

5.2.1 Overview

The middle Puyallup River reach begins at the confluence of the White River at RM 10.3 and continues upstream to the confluence with the Carbon River at RM 17.4, downstream of the City of Orting. Approximately 438 square miles drains to the middle Puyallup River. Throughout this reach the river channel is a combination of large meander bends with segments which are straightened and confined by a combination of levees, revetments, and valley walls. The surrounding watershed and land use are mostly urban near the White River confluence in the cities of Sumner and Puyallup, while predominantly agricultural and rural residential through the Alderton-McMillan communities, and upstream to the Carbon River confluence (GeoEngineers 2003).

Several tributaries enter the middle Puyallup River in this reach including Alderton Creek, Van Ogles Creek, Fennel Creek, Ball Creek, and Canyon Falls Creek. The largest tributary Fennel Creek drains most of the eastern upland plateau, including much of the City of Bonney Lake. Fennel Creek flows into the Puyallup River near RM 15.2. Salmon and trout, including Chinook, coho, pink, chum, sockeye, steelhead salmon, and cutthroat and bull trout use the entire reach of the middle Puyallup River.

5.2.2 Geology and Geomorphology

The middle Puyallup River Valley is a broad low-gradient alluvial plain in which the river meanders and periodically floods. The river is within a trough-like valley with steep valley walls that widen in the vicinity of the City of Orting. The average channel gradient varies from 0.17 to 0.25 percent between RM 10.3 and RM 17.4. The sediment transport capacity of the Puyallup River is exceeded in this reach, resulting in channel aggradation, widening and braiding.

Channelization and levee construction within the middle Puyallup River occurred mostly from the 1930s to the 1960s. Prior to channel confinement, the main channel of the Puyallup River in this reach was a freely migrating channel, a natural response of the river to high sediment loads from the upper Puyallup River and Carbon River. The reaches immediately downstream of the Carbon River confluence (RM 14.2- RM 17.4) are braided due to a significant decrease in channel gradient and the high influx of sediment load from the Carbon River. The Puyallup River transitions back to a sinuous meander bend pattern below RM 14.2 indicating a generally even balance between sediment transport capacity and sediment influx (GeoEngineers 2003).

The channel width is generally confined to between 200 and 300 feet. In 2003, a channel migration zone (CMZ) analysis delineated severe, moderate, and low–risk channel migration zones along the middle Puyallup River. The approach was based on the relationships between
Figure 5.18
Mid Puyallup River Planning Area
RM 10.4 - RM 17.4
Pierce County Rivers Flood Hazard Management Plan

Legend
- Project Sites
- River Miles
- Repetitive Loss Property
- Flood Control Facility
- Major Roads
- County Boundary

Rivers/Streams
- Lakes/Puget Sound
- Regulatory 100 Year Floodplain (within City Boundaries)
- Regulatory 100 Year Floodplain (outside of City Boundaries)
- Channel Migration Zone Floodway

The map features are approximate and are intended only to provide an indication of said features and may not align. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS EXPRESSLY PROVIDED "AS IS" AND "WITH ALL FAULTS." The County makes no warranty of fitness for a particular purpose.

Pierce County Public Works & Utilities
Surface Water Management

For more information, please visit Pierce County Public Works & Utilities Surface Water Management at:
\[\text{https://www.piercecountywa.gov/surfacewater}\\)
channel topography, sediment influx, transport capacity and the type and character of channel migration in each reach prior to confinement (GeoEngineers 2003). The most extensive severe CMZs in the middle Puyallup River are between RM 13.2 and RM 14.3, where the CMZ has a maximum width of 3500 feet, and between RM 15.8 and RM 16.7, where the CMZ has a maximum width of 2200 feet.

### 5.2.3 Hydrology and Hydraulics

The USGS stream gauge (#12096500) at Alderton produced a variable period of record, with gaps in the data due in part to flood damage. The Alderton gauge flow data appears to consistently show data which does not correlate to what is expected based on flow data from the lower Puyallup gauge (#12101500). Measuring discharge at this site is difficult due to unstable channel conditions. This condition persists from the State Route 162 Bridge in Sumner through a series of three 90-degree bends upstream to Riverside County Park. A table of “streamflow measurement data” can be used to derive a reasonable flow regime at Alderton by the Log-Pearson Type III method (see Table 5.7).

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge (Cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Puyallup River Gauge (at Alderton, #12096500)</td>
<td>24,400</td>
<td>50-yr</td>
</tr>
<tr>
<td>Middle Puyallup River Gauge (at Alderton, #12096500)</td>
<td>27,500</td>
<td>50-yr</td>
</tr>
</tbody>
</table>

Source: FEMA Flood Insurance Studies (1987 and 2009)

The USGS study of conveyance capacity (USGS 2010) indicates that the middle Puyallup River channel can convey between 15,000 to 35,000 cfs before overtopping either the left or right bank (see Figure 5.19). The change in conveyance capacity since the 1984 USGS study (Sikonia 1990) has been variable. The variability is largely due to increased sediment deposition within the channel which has decreased the channel conveyance capacity overall.
5.2.4 Ecological Context and Salmonid Use

Historically, the middle Puyallup River likely contained the best main channel spawning habitat in the Puyallup River, especially for Chinook. This is due to the mild gradient, wide flood plain, a relatively stable meander pattern, and large gravel bars that created a complex of riffles and pools. Prime spawning sized gravel characterized this part of the river. Here the bedload transitions from the predominant sand bed in the lower Puyallup River to the cobble of the upper Puyallup River. This reach also contained oxbows and remnant channels which would have produced wetlands and high quality rearing habitat for juvenile salmon, especially during the winter when flow velocities are high in the main channel. Along the base of the valley walls were many “wall based” channels, which are small, cool water, spring fed streams that create prime summer rearing habitat for juveniles and spawning habitat for coho and chum salmon and cutthroat trout. Beaver were a driving force on the landscape and increased the rearing habitat through construction of dams and creation of ponds within the floodplain.

Today, this section of the river is predominantly a single thread due to levee channelization for protection of farmland, residential and commercial land uses. The floodplain and associated habitats have become disconnected from the river by containment by levee and revetment system and land development. Numerous migration barriers exist that prevent or limit the use of off-main channel salmon habitat. River channelization has increased flow velocities during
floods and increased the risk that scour will destroy fish redds\textsuperscript{88}. In addition, the lack of a functioning riparian area limits fish habitat by reducing the amount of wood and salmon food sources from entering the river. Despite these challenges, the middle Puyallup River still provides valuable habitat for salmonid spawning and rearing at select locations within the reach (see Figure 5.20)

5.2.5 River Management Facilities, Flooding and Flood Damage

The middle Puyallup River levees and revetments form nearly continuous bank protection from the confluence with the White River at RM 10.3 to the confluence with the Carbon River at RM 17.4. Many levees within the middle Puyallup River system are included in the U.S. Army Corps of Engineers, Public Law (PL) 84-99 Levee Rehabilitation program. Revetment structures make up a significant number of the river management facilities that are ineligible for inclusion in the PL 84-99 program. Table 5.8 contains a list of river management facilities and their ownership.

\textsuperscript{88} Redds- Redds are nests made in gravel (particularly by salmonids); consisting of a depression that is created and then covered.
From the late 1920s to 1939, Pierce County River Improvement focused on channelization and bank stabilization using wooden bulkheads and debris barriers along the Puyallup and Carbon Rivers. In 1939, Pierce County approved a plan (Resolution No. 686) for flood control along the Puyallup above the mouth of the White River. The 1939 flood plan recommended creation of a single channel on the Puyallup River by excavating gravel and river sediments and side casting them to form levees that were armored with rock riprap. In the 1930-50s levees and revetments were constructed to prevent channel migration through agricultural lands.

### 5.2.5.1 Major Flooding

The middle Puyallup River experienced major flood events most recently in 1996, 2006, 2008, and 2009. The highest peak flow recorded at the Alderton Gauge occurred on January 7, 2009 with 53,600 cfs (based on the USGS calculation). However, this is thought to be an overestimate, because it is higher than the peak flow measured at the same time downstream.
at the Puyallup gauge in the lower Puyallup River. The discrepancies between these two measurements are unknown.

<table>
<thead>
<tr>
<th>Date</th>
<th>Puyallup River Flow at Alderton Gauge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1921</td>
<td>20,000</td>
</tr>
<tr>
<td>December 1946</td>
<td>22,600</td>
</tr>
<tr>
<td>December 1953</td>
<td>21,900</td>
</tr>
<tr>
<td>December 1955</td>
<td>23,300</td>
</tr>
<tr>
<td>January 1990</td>
<td>34,600</td>
</tr>
<tr>
<td>November 1990</td>
<td>42,300</td>
</tr>
<tr>
<td>February 1996</td>
<td>41,500</td>
</tr>
<tr>
<td>November 2006</td>
<td>51,600a</td>
</tr>
<tr>
<td>November 2008</td>
<td>40,200</td>
</tr>
<tr>
<td>January 2009</td>
<td>53,600a</td>
</tr>
</tbody>
</table>

a These two estimates are questionable because they exceed downstream peak flow estimates
Source: USGS Alderton Gauge flow records

Examples of flooding in both the urban and rural portions of the middle Puyallup River are shown in Figure 5.21.

Figure 5.21 - (a) Flooding of residential structures in Sumner in 2006, and (b) rural residential and farmland in unincorporated Pierce County in 2006
5.2.5.2 Flood Damage to Facilities

Damage to the levees and revetments along the middle Puyallup River occurred following major flooding events in the last 20 years. The levee and revetments that have experienced repetitive damage include the Riverside Levee, WSU Revetment, Bowman/Hilton Levee, Sportsman Levee, and Bowen/Parker Levee. Damages sustained ranged from complete washouts resulting in the loss of several hundred lineal feet of flood control structure to localized moderate scour and erosion. Segments subject to the most significant and repetitive damages are summarized below in Table 5.10.

Table 5.10 Summary of Damages to Middle Puyallup River Facilities (1991 – 2009)

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowen/Hilton</td>
<td>RM 13.2 LB</td>
<td>Partial Washout</td>
<td>150</td>
<td>November 1995</td>
</tr>
<tr>
<td>Bowman/Hilton</td>
<td>RM 13.4 RB</td>
<td>Partial Washout</td>
<td>225</td>
<td>November 1995</td>
</tr>
<tr>
<td>Mosby</td>
<td>RM 16.2 RB</td>
<td>Partial Washout</td>
<td>250</td>
<td>November 1995</td>
</tr>
<tr>
<td><strong>1996</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSU</td>
<td>RM 12.2 LB</td>
<td>Toe/slope failure</td>
<td>600</td>
<td>February 1996</td>
</tr>
<tr>
<td>Riverside</td>
<td>RM 12.8 RB</td>
<td>Toe/slope failure</td>
<td>600</td>
<td>February 1996</td>
</tr>
<tr>
<td>Bowman/Hilton</td>
<td>RM 13.2 LB</td>
<td>Toe/slope failure</td>
<td>500</td>
<td>February 1996</td>
</tr>
<tr>
<td>Bowman/Hilton</td>
<td>RM 13.2 LB</td>
<td>Total Failure</td>
<td>600</td>
<td>February 1996</td>
</tr>
<tr>
<td>Mosby</td>
<td>RM 16.0 RB</td>
<td>Toe/slope failure</td>
<td>600</td>
<td>February 1996</td>
</tr>
<tr>
<td>Bowen-Parker</td>
<td>RM 16.7 LB</td>
<td>Total Failure</td>
<td>100</td>
<td>February 1996</td>
</tr>
<tr>
<td>Bowen-Parker</td>
<td>RM 16.8 LB</td>
<td>Toe/slope failure</td>
<td>800</td>
<td>February 1996</td>
</tr>
<tr>
<td>Bowen-Parker</td>
<td>RM 17.4 LB</td>
<td>Toe/slope failure</td>
<td>100</td>
<td>February 1996</td>
</tr>
<tr>
<td><strong>2006</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSU</td>
<td>RM 12.2 LB</td>
<td>Face Erosion</td>
<td>300</td>
<td>November 2006</td>
</tr>
<tr>
<td>Bowman/Hilton</td>
<td>RM 13.2 LB</td>
<td>Top scour</td>
<td>880</td>
<td>November 2006</td>
</tr>
<tr>
<td>Sportsman</td>
<td>RM 13.6 LB</td>
<td>Fracture</td>
<td>40</td>
<td>November 2006</td>
</tr>
<tr>
<td>Sportsman</td>
<td>RM 14.0 LB</td>
<td>Washout</td>
<td>300</td>
<td>November 2006</td>
</tr>
<tr>
<td>Evanger/White</td>
<td>RM 15.0 RB</td>
<td>Face Erosion</td>
<td>300</td>
<td>November 2006</td>
</tr>
<tr>
<td>Bowen/Parker</td>
<td>RM 17.3 LB</td>
<td>Face Erosion</td>
<td>220</td>
<td>November 2006</td>
</tr>
<tr>
<td>Lindsay</td>
<td>RM 17.4 RB</td>
<td>Face Erosion</td>
<td>50</td>
<td>November 2006</td>
</tr>
</tbody>
</table>
### Key Accomplishments since the 1991 Flood Plan

#### 5.2.6.1 Major Projects

Since the 1991 Puyallup River Comprehensive Flood Plan was completed, Pierce County has carried out an annual program that includes maintenance and repair of revetments and levees, including those listed in Table 5.10, as well as capital projects noted below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Milestone Description</th>
<th>Severity</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>WSU</td>
<td>Partial Washout</td>
<td>150</td>
<td>November 2008</td>
</tr>
<tr>
<td></td>
<td>Riverside</td>
<td>Damaged Toe Face</td>
<td>236</td>
<td>November 2008</td>
</tr>
<tr>
<td></td>
<td>Sportsman</td>
<td>Blocked Culvert</td>
<td>105</td>
<td>November 2008</td>
</tr>
<tr>
<td></td>
<td>Bowen/Parker</td>
<td>Toe Rock Failure</td>
<td>125</td>
<td>November 2008</td>
</tr>
<tr>
<td>2009</td>
<td>WSU</td>
<td>Face Erosion</td>
<td>100</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Bowman/Hilton</td>
<td>Scour facing rock failure, water leaking thru levee</td>
<td>200</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Bowman/Hilton</td>
<td>Top/Face Scour</td>
<td>390</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Bowman/Hilton</td>
<td>Top Scour</td>
<td>50</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Sportsman</td>
<td>Blocked culvert and scour</td>
<td>200</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Sportsman</td>
<td>Top Scour</td>
<td>250</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Sportsman</td>
<td>Major scour 40percent of facing rock missing for 100 lineal feet</td>
<td>310</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Sportsman</td>
<td>Head cutting on back side of levee adjacent to Sportsmen Access Road, scour</td>
<td>150</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Evanger/White</td>
<td>Total failure at end of revetment</td>
<td>200</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>McMillin</td>
<td>Access Road Grading / Debris Removal</td>
<td>900</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>McMillin</td>
<td>Toe and face rock failure</td>
<td>60</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Bowen/Parker</td>
<td>Toe/Face failure</td>
<td>300</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Bowen/Parker</td>
<td>Toe rock failure</td>
<td>75</td>
<td>January 2009</td>
</tr>
<tr>
<td></td>
<td>Lindsay</td>
<td>Toe/Face failure</td>
<td>100</td>
<td>January 2009</td>
</tr>
</tbody>
</table>

LB = Left bank; RB = Right bank; RM = River Mile
Source: Pierce County Surface Water Management records
1. **96th Street Oxbow Culvert Replacement**  
The four acre project created a wetland and reconnected the oxbow and associated wetland to the mainstem of the Puyallup River by replacing the 12-inch diameter culvert with a 72-inch diameter culvert and excavating and widening a 190-foot channel. This project was completed in 2005.

2. **Sportsman’s Oxbow Culvert Replacement**  
The three-foot diameter culvert was replaced with a seven-foot diameter culvert with an internal fish ladder. The culvert provides juvenile salmonid access to the oxbow at most flood levels and the beneficial habitat for juvenile salmon and trout within the oxbow. This project was completed in 2005.

Table 5.11 shows major repairs, generally considered 750 lineal feet or more in length, along the middle Puyallup River following significantly large storm events. Records maintained by Pierce County SWM Operations and Maintenance show several major repairs have been completed between RM 10.3 and RM 17.3.

### Table 5.11 Major Projects Completed on Middle Puyallup River since 1991 Flood Plan

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Estimated Cost</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowman-Hilton Levee</td>
<td>RM 13.2 LB</td>
<td>Total Levee and Toe/slope failure</td>
<td>1,100LF</td>
<td>$498,600</td>
<td>November 1995/February 1996</td>
</tr>
<tr>
<td>Bowen/Parker Levee</td>
<td>RM 16.8 LB</td>
<td>Toe/slope failure</td>
<td>800LF</td>
<td>$249,600</td>
<td>February 1996</td>
</tr>
<tr>
<td>Bowman-Hilton Levee</td>
<td>RM 13.2 LB</td>
<td>Scour from levee overtopping</td>
<td>880LF</td>
<td>$220,000</td>
<td>November 2006</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

### 5.2.6.2 Land Purchases

The following land and home acquisitions have occurred since 1991, using a combination of federal and state grant funds and local match.

1. Acquisition of home and property between 128th Street and the confluence with the Carbon River (48 acres)
2. Acquisition of home and property between (RM 15.9 RM 16.7) 116th Street and 128th Street (50 acres)
3. Acquisition of homes and property near Fennel Creek confluence (44 acres)
4. Acquisition of homes and property in the area of 96th Street and McCutcheon Road between RM 13.8 – RM 15.0 (78 acres)
5. Acquisition of homes and property near Riverside Drive (1.8 acres)
6. Acquisition of homes and property near/in the City of Sumner (11 acres)

5.2.6.3 Partnerships

Pierce County has partnered with FEMA and Washington State Department of Ecology (Ecology) on Hazard Mitigation Grant funds for acquisition of homes and property as noted above. The US Army Corps of Engineers has provided 80 percent cost-share for levee rehabilitation for damaged facilities eligible for funding under the PL 84-99 program. Funding provided by the Salmon Recovery Funding Board (SRFB) helped support the two culvert replacement projects that reconnected adjacent floodplain to the Puyallup River.

5.2.7 Flood and Channel Migration Hazard Mapping

Hazard mapping in the middle Puyallup River includes detailed flood studies (FEMA 2009, NHC 2006) and the creation of Preliminary Digital Flood Insurance Rate Maps (DFIRM), which as of the publication of this document have not been issued by FEMA. Flood prone areas along the middle Puyallup River include local roads such as Riverside Drive and McCutcheon Road, the Sumner Wastewater Treatment Plant, several groupings of single family residential structures (including Rainier Manor Mobile Home Park in Sumner), multi-family residential structures, agricultural and rural lands, and other mobile home parks. The DFIRM maps for the middle Puyallup River show 1,153 acres within the Special Flood Hazard Area (SFHA) or 100-year floodplain. The mapped deep and fast flowing area is 986 acres.

Severe, moderate, and low channel migration zones (CMZ) were mapped for the middle Puyallup River (GeoEngineers 2003) and adopted in November 2004. The CMZ refers to the geographic area where a stream or river has been located in the past and so is susceptible to channel erosion and channel reoccupation (WSDOE 2003). The severe CMZ covers an area of 1047 acres. Pierce County regulates severe CMZ mapped areas as floodway per Chapter 18E.70, Pierce County Code.

5.2.8 Problem Identification

The following flooding and channel migration related problems were identified in the middle Puyallup River (see Table 5.12). For more detail on these problems, see Appendix G.

<p>| Table 5.12 Flooding-related Problems Identified in Middle Puyallup River |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|</p>
<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee and Revetment Overtopping and Breaching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 10.4 – RM 10.6 RB</td>
<td>High water surface elevations threaten to flood of Sumner Wastewater Treatment Plant</td>
<td>City of Sumner</td>
</tr>
<tr>
<td>RM 11.0 – RM 11.5 RB</td>
<td>Revetment overtopping floods Rainier Manor and Rivergrove Apts. and threaten Riverwalk condos</td>
<td>City of Sumner</td>
</tr>
</tbody>
</table>
## Table 5.12 Flooding-related Problems Identified in Middle Puyallup River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 12.4 – RM 12.8 RB</td>
<td>Levee/revetment overtopping floods 76th St E and homes</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 12.8 – RM 13.5 RB</td>
<td>Levee/revetment overtopping floods property and home along Riverside Drive</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 13.2 – RM 14.1 LB</td>
<td>Levee/revetment overtopping floods Tree farm, Bowman-Hilton, and Sportsman Club property</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 14.2 – RM 14.6 RB</td>
<td>Revetment overtopping floods McCutcheon Rd. and property, including structures</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 15.2 - RM15.6 LB</td>
<td>Levee/revetment overtopping floods property along 110th St. E. in vicinity of McMillin</td>
<td>Public Input (March 2010)</td>
</tr>
<tr>
<td>RM 15.6 – RM 16.7 LB</td>
<td>Levee/revetment overtopping floods property along 151st Ave. E. and 116th St. E.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 15.9 – RM 16.7 RB</td>
<td>Levee/revetment overtopping floods property along 153rd Ave. E. near Canyon Falls Creek</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 16.7 – RM 17.2 RB</td>
<td>Levee overtopping floods McCutcheon Rd. and many properties and structures in the vicinity</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

### Tributary Backwater Flooding

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 12.8 – RM 13.0 RB</td>
<td>Backwater at tributary floods Pierce County’s Riverside Park</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 15.9- RM 16.4 RB</td>
<td>Canyon Falls backwater floods McCutcheon Rd.</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

### Public Safety/Emergency Rescues

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 11.0 – RM 11.5 RB</td>
<td>Flooding of Rainier Manor and Rivergrove Apts resulted in emergency evacuations</td>
<td>City of Sumner</td>
</tr>
<tr>
<td>RM 16.7 – RM 17.3 RB</td>
<td>McCutcheon Rd. flooding south of 128th E. resulted in emergency evacuations in 2006 &amp; 2009</td>
<td>Pierce County Sheriff</td>
</tr>
</tbody>
</table>

### Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 10.8 – RM 11.0 RB</td>
<td>Flooding of SR-410 under railroad bridge occurred in 1996, 2006, 2008 and 2009</td>
<td>City of Sumner, WSDOT</td>
</tr>
<tr>
<td>RM 12.6 - RM12.8 RB</td>
<td>Flooding of 76th St. E. &amp; 159th Ave. E. (off Riverside Drive) during major floods closes roads</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 14.15 RB/LB</td>
<td>Flooding of 96th St. E. and bridge closed roads and wood buildup on bridge piers</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 16.7</td>
<td>128th St. E Bridge woody debris buildup on piers</td>
<td>Pierce County Roads</td>
</tr>
</tbody>
</table>

### Sediment and Gravel Bar Accumulation
<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 10.3-10.7</td>
<td>Gravel bar accumulation from the confluence of White River upstream to Main St. bridge</td>
<td>City of Puyallup</td>
</tr>
<tr>
<td>RM 10.4-12.0</td>
<td>Large gravel bar along right bank adjacent to Sumner WWTP causes flow constriction</td>
<td>City of Sumner</td>
</tr>
<tr>
<td>RM 12.2-17.4</td>
<td>Gravel accumulation between Sumner and Orting a concern due to reduced conveyance capacity and directing flows at levees, damaging structures</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

### Facility Maintenance and Repair Needs

| RM 12.2 – RM 17.4, RB/LB | See comprehensive list shown in Table 5.2.5 above | Pierce County           |

### Fish Habitat Problem Areas

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 10.7 – RM 11.5 LB</td>
<td>Levee/revetment construction cut off floodplain from river channel, limiting rearing/spawning habitat (Sumner setback levee location)</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>RM 12.4 – RM 13.5 RB</td>
<td>Revetment construction cut off floodplain from river channel, limiting rearing/spawning habitat (Riverside Drive and Park setback levee locations)</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 13.2 – RM 14.0 LB</td>
<td>Levee/revetment construction cut off floodplain and oxbow wetlands from river channel, limiting rearing/spawning habitat (Sportsman setback levee)</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 15.2 – RM 16.0 RB</td>
<td>Levee/revetment construction cut off floodplain from river channel, limiting rearing/spawning habitat (Fennel Creek setback levee location)</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 15.8 – RM 17.4 RB/LB</td>
<td>Levee/revetment construction cut off floodplain from river channel, preventing access to off-channel rearing/spawning habitat (4 setback levees)</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
</tbody>
</table>

### Public Access

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 10.7 – RM 11.5 LB</td>
<td>Lack of connecting trail between Main Street and Foothills trail at East Puyallup Trailhead</td>
<td>Pierce County Parks</td>
</tr>
<tr>
<td>RM 12.7 – RM 13.4 RB</td>
<td>Desire to maintain public access for boat launch and fishing at Riverside Park if setback levee is constructed</td>
<td>Pierce County Parks</td>
</tr>
<tr>
<td>RM 15-16</td>
<td>Lack of connecting trail between Foothills Trail and Fennel Creek Trail across Puyallup River</td>
<td>Pierce County Parks</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records
5.2.9 River Reach Management Strategies

The recommended river reach management strategies for the middle Puyallup River take into account numerous conditions as follows:

- **Development and land use in adjacent floodplain** – the middle Puyallup River floodplain is densely developed in Sumner, with rural residential and agricultural development upstream of Sumner in the unincorporated area. The total assessed value of property in the 100-year floodplain is $100.8 million (Pierce County Assessor/Treasurer Office, 2010).

- **River management facilities** – both the left and right banks of the Puyallup River are constrained by levees and revetments along most of this reach (see Table 5.8).

- **River channel gradient and width** – channel gradient varies from 0.17 to 0.25 percent within the reach and width of the channel varies from 205 feet to 300 feet.

- **Presence of salmon spawning and rearing habitat** – All species of salmon are found in the middle Puyallup, including Chinook, pink, chum, coho and sockeye, as well as steelhead, bull and cutthroat trout. Coho, chum salmon, steelhead and cutthroat trout all spawn within this reach.

- **Sediment transport accumulation and incision** – sediment consists of mostly gravel and sand below RM 12.0; and mixed gravel, cobble and sand between RM 12.0 and RM 17.4. The average river bed elevation change from 1984 to 2009 was -0.1 feet to +2.0 feet between RM 10.4 and RM 12.0; and -1.5 feet to +3.8 feet from RM 12.0 to RM 15.6, and -1.8 feet to +1.5 feet from RM 15.6 to RM 17.4 (see Figure 5.1).

The primary objective for the middle Puyallup River is to maintain the structural integrity of the existing levee and revetment system so that the system continues to reduce risks to public health and safety, and reduce public and private property damage. Other objectives are to design improvements to the levees and revetments so they provide a 100-year level of protection in the City of Sumner and reduce areas of the floodplain prone to flooding. Capital projects should take advantage of opportunities to improve aquatic habitat through levee setbacks, riparian re-vegetation, and strategic placement of large woody material.

The Recommended river reach management strategy for the middle Puyallup is as follows (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**

- **RM 10.3 – RM 12.0 right and left banks** – “Level of protection” goal for levees should be 100-year design plus three feet of freeboard. Revetments should be designed to resist channel migration.
• RM 12.0 – RM 15.6 right and left banks – “Level of protection” goal for levees should be to maintain the current (2009) level of protection. Revetments should be designed to resist channel migration.

Non-structural management strategies:
• Floodplain development regulations
• Acquisition, buyout or purchase of development rights
5.2.10 Recommended Capital Projects

The following capital improvement projects are recommended to address the problem areas identified in Table 5.11. Capital Projects are defined as construction projects over $75,000 and included within the yearly Capital Improvement Element, of the Comprehensive Plan for Pierce County Washington. Projects less than $75,000 are included within the Maintenance Program.

5.2.10.1 MP1 Rainier Manor/Riverwalk/Rivergrove and SR-410 Flood Wall and Levee

Location Information
Sub-Area: Mid-Puyallup
Basin Plan: Mid-Puyallup
River Mile: 10.7 – 11.8, Right Bank
Council District: 1
Jurisdiction: City of Sumner
Property Ownership Affected: Private and local government property

Estimated Cost: $11,000,000

What is the Issue?
Base flood elevation in this section of the river ranges from approximately 52 to 62 feet. The existing Knutson revetment and levee sits at an elevation of 48 feet to 64 feet. The surrounding development of Rainier Manor Mobile Home Park sits below the levee and once the levee overtops it floods the mobile home park and portions of State Route 410 and holds the water until floodwaters recede. The flooding causes a portion of State Route 410 to close and traffic diverted to other routes. The adjacent River Grove Apartments and River Walk developments experience localized flooding in the first floor units closest to the river.

What is at Risk?
- Damage to private structures and homes on the right bank,
- Damage to public infrastructures, including State Route 410, and
- Impact to regional economy due to the closure of State Route 410.

What is the Recommended Solution?
A combination of floodwall and flood berm would provide protection to the adjacent State Route 410, apartments, and mobile home park. Between RM 10.7 and RM 11.0 and between RM 11.46 and RM 11.8 the levee would be set back and raised. Between RM 11.0 and 11.46 a floodwall will be constructed to protect the Rainier Manor Mobile Home Park. The height of the levee and floodwall will vary between six to ten feet to provide three feet of freeboard from the 100 year flood elevation.
What are the Project Benefits?

- Protection of private structures and homes on the right bank,
- Prevention of State Route 410 and local street flooding, and
- Protection of regional economy due to the closure of State Route 410.

Coordination


Environmental Considerations

The proposed project is intended to be outside of the ordinary high water, so it is not expected to need federal permitting. The project will require local permitting including shorelines substantial development.
Other Information or Needs

The proposed flood wall will increase the river base flood elevation by approximately 0.4 feet. Any increase in excess of 0.001 feet will require mitigation to compensation for lost flood plain storage and the small rise in the Base Flood Elevation.
5.2.10.2 MP2 McCutcheon Rd & 96th St E Road Barricade

Location Information
Sub-Area: Mid Puyallup
Basin Plan: Mid Puyallup
River Mile 14.2 – 14.9, Right Bank
Council District 1
Jurisdiction: Pierce County
Property Ownership affected: Private property and Pierce County right-of-way

Estimated Cost: $50,000

What is the Issue?
Base flood elevation in this section of the river is at approximately 86.1 to 96 feet. The surrounding development sits below the base flood elevation at 84 to 94 feet. The current levee system provides less than a 30 year level of service and has experienced extensive flooding during past events. During flood events up to 3800 feet of McCutcheon Rd and the intersection of 96th St East are covered by several feet of flood waters stranding three homes from access. Water can stand over three feet deep and a dip in the road creates an illusion for drivers that it is safe to drive through. Historically cars have been stranded and almost submerged during flood events. The concern is to keep the public from attempting to drive through the flooded roads and direct them to an alternative route.

What is at Risk?
Public safety is the primary concern. Although the roadway floods, no permanent damage is evident and the road is quickly cleaned up and restored to full function.

What is the Recommended Solution?
Community engagement to inform local residents of the risks as soon as possible to allow people time to take steps to prepare and protect themselves. This could include working the Pierce County Alert and Pierce County Neighborhood Volunteer Watch to safely evacuate prior to the road becoming impassible. Installation of a gate at McCutcheon and 96th St East to block access is easily and quickly implemented.

What are the Project Benefits?
This is a simple low cost solution with minimal construction costs and impacts to the floodplain. A previous mitigation project constructed at the intersection of 96th Street East to improve habitat on an existing oxbow would be undisturbed.

Coordination
Coordination with Pierce County Transportation Department for the installation of the gate would be required.
Environmental Considerations

None. While the Puyallup River is utilized by the ESA listed Puget Sound Chinook, steelhead and bull trout, the gate will have no impact to the floodplain or river.
5.2.10.3 MP3 McCutcheon Rd and 128th St East

Location Information
Sub Area: Mid Puyallup
Basin Plan: Mid Puyallup
River Mile: 16.7 – 17.4, Left and Right Bank
Council District: 1
Jurisdiction: Pierce County
Property Ownership Affected: Private lands and local government property

Estimated Cost: $12,500,000 (per 2008 Levee Setback Feasibility Analysis)

What is the Issue?
Base flood elevation in this section of the river is at approximately 114.9 to 121.1 feet. The surrounding development sits at an elevation of between 112 to 130 feet. The current levee system is intermittent, providing less than a 30 year level of service and has experienced extensive flooding between 1996 and 2009. The existing right bank levee section abruptly ends, leaving a 1400 foot gap in the right bank protection. This allows flood waters to backwater making the southern end of McCutcheon Road impassible and stranding approximately 20 homes with water over the roadway. Additionally an old levee built in the 1930s is located approximately 350 feet east of the existing right bank levee. The basin created between the old levee and the newer levee captures Dollar Creek and overtops during flood stage. The presence of water on both sides of the newer levee could potentially undermine the existing structure, leading to failure.

What is at Risk?
During periods of flooding McCutcheon Rd becomes impassible, stranding the 20 homes with no other viable way in our out. During flood periods, these property owners are cut off from emergency services and individuals take risks trying to navigate through flooded roadways. A higher risk is the potential for failure of the newer Puyallup River levee due to water on both sides.

What is the Recommended Solution?
The proposed solution is for the construction of setback levees on both the left and right bank of the Puyallup (setbacks #12 and #13 from the Levee Setback Feasibility Study). The right bank levee would follow the alignment of McCutcheon Road then follow the topography and tie back into the river at the confluence of the Puyallup and Carbon Rivers. The left bank levee would follow the contour of the historic channel migration and tie back into the Puyallup just prior to the 128th Street Bridge crossing.
What are the Project Benefits?

- The two setback levees would be constructed to the current level of service plus three feet of freeboard; water surface elevations would be lowered,
- Increased floodplain, allowing the river to emulate a more natural process, and
- The project would also provide off channel habitat and refuge for juvenile salmon and protect the riverine wetland adjacent to the levee, south of 128th St Bridge.

Coordination

Environmental Considerations

The project is located in an area utilized by ESA listed Puget Sound Chinook, steelhead and bull trout and within the Puget Sound Chinook and bull trout critical habitat. A 404 permit (including federal consultation), SEPA, WDFW Hydraulic Permit Approval, PC Shorelines Substantial Development Permit and Critical Areas Approvals will be required for this project.

Other Information or Needs

Two projects have the potential to change the dynamics of the river in the area of the 128th St. Bridge. The first project is the proposed City of Tacoma Water Pipeline No. 1 project which will replace the existing double pipeline with overwater crossing with a single pipeline located under the river. Replacement of the overwater crossing will remove a mid-river pier which could decrease the base flood elevation.

The second project is the Rhodes Lake Road East New Alternative Corridor which would construct a new road from the east side of 128th St East up the hillside and eventually connect to Falling Water Blvd. This would provide an alternative evacuation route for the 20 homes located at the end of McCutcheon Rd. This project is currently unfunded.
5.2.10.4 MP4 116th St E. Point Bar Gravel Removal

Location Information
Sub Area: Mid Puyallup
Basin Plan: Mid- Puyallup
River Mile: 15.8 – 16.0, Left Bank
Council District: 1
Jurisdiction: Pierce County
Property Ownership Affected: Private Lands

Estimated Cost: $220,000

What is the Issue?
The existing levee within this section of the river provides less than 100 year protection. The base flood elevation ranges from 105 feet to 107 feet and the surrounding area ranges in elevation from 96 feet to 108 feet. Conditions on this section of the Puyallup River lead to the deposition of sediment, reducing the channel capacity and causing the levee to overtop during periods of high flow. Gravel deposition creates a gravel bar that varies in depth from two to eight feet. Historically, gravel has been removed from this location by Pierce County and private gravel miners on a consistent basis (three – five years). The area falls within the channel migration zone and much of the surrounding property has been purchased by Pierce County.

What is at Risk?
- Reduction of conveyance capacity near 116th St E terminus,
- Flooding of 116th St East, a minor residential collector street, and
- Flooding of mobile homes, travel trailers, and infrastructure which service these structures.

What is the Recommended Solution?
Removal of approximately 13,700 cubic yards of gravel can be removed from the top portion of the gravel bar, a practice called scalping. The upstream portion of the gravel bar will remain untouched and serve as a head-cut protection area. Large Woody Debris clusters would be placed in the head-cut area and a groundwater channel will be excavated in the lower portion of the bar to provide rearing habitat for juvenile salmon.

Figure 5.24 – Air photo showing location of gravel removal site
What are the Project Benefits?

- Less gravel available for transport and deposition downstream,
- Improved channel conveyance capacity, and
- Some degree of reduced flooding risk.

Coordination


Environmental Considerations

The project is located in an area utilized by ESA listed Puget Sound Chinook, steelhead and bull trout and within the Puget Sound Chinook and bull trout critical habitat. A 404 permit (including federal consultation), SEPA, WDFW Hydraulic Permit Approval, PC Shorelines Substantial Development Permit and Critical Areas Approvals will be required for this project.

Other Information or Needs

Washington State Department of Fish and Wildlife owns the property on which the gravel bar is located. This will require a formal written agreement and Right-Of-Entry permit.

Other considerations for gravel removal projects:

- Comprehensive sediment management in Pierce County should be guided by technical sediment transport studies.
- An analysis of the economic and engineering feasibility for removing quantities of gravel that effectively reduce flood hazards will be conducted. The assessment will consider logistics and technical capability of removing gravel and sediment as well as available markets for the materials.
- Implementation of a five year monitoring program at gravel removal sites to assess sediment accumulation, project effectiveness, and duration of benefit.
- Gravel removal sites should target areas where gravel deposition has modified the direction of the river channel in a way that creates a risk of levee overtopping or levee or revetment erosion.
- Additional criteria to be met prior to initiation of gravel removal:
  1. It can be demonstrated that gravel accumulation poses a flood risk; and
  2. Hydraulic and sediment transport studies conclude gravel removal has a benefit of flood or channel migration risk reduction; and
  3. It is in a demonstrated area of gravel accumulation; and
  4. It is part of a comprehensive flood hazard management strategy; and
5. Biologic studies determine that gravel removal does not, with mitigation, result in a net loss of ecological function; and
6. All proper approvals have been secured.
5.3 UPPER PUYALLUP RIVER

5.3.1 Overview

The upper Puyallup River begins at the confluence of the Carbon River at River Mile 17.4 and continues upstream to the Champion Bridge at RM 28.6, just downstream of Electron Road. The contributing drainage basin for this reach is approximately 188 square miles. In the lower portion of this reach, the river is confined by a combination of levees and revetments. In the middle portion there is less confinement due to the presence of two setback levees, the Soldiers Home setback levee at RM 21.5 to RM 22.5 and Ford setback levee at RM 23.4 to RM 25.0. Above RM 25.0 few levees and revetments remain on the right bank due to past flood damages and changes in flood management strategies. The surrounding watershed and land use is mostly urban on the right bank of the Puyallup near the City of Orting between RM 17.4 to RM 21.8, but predominantly agricultural, rural residential and forested upstream of RM 21.8. Like the middle Puyallup River, by the 1930’s much of the valley and surrounding hills in the upper Puyallup River were harvested for timber and the valley cleared for agriculture (GeoEngineers 2003).

Several tributaries enter the upper Puyallup River including Horse Haven Creek, Fiske Creek, Kapowsin Creek, and Fox Creek. The largest tributary, Kapowsin Creek, originates in Ohop Lake and Lake Kapowsin located approximately 3.7 miles upstream from its confluence with the Puyallup River at RM 26.0. Salmon and trout, including Chinook, coho, pink, chum, and steelhead use the entire reach of the upper Puyallup River.

5.3.2 Geology and Geomorphology

The upper Puyallup River Valley is steeper and narrower compared with the lower and middle Puyallup River reaches. Above the confluence with the Carbon River, the width of the Puyallup River channel migration zone is generally defined by the remnants of the Electron mudflow, which was deposited as a thick layer of mud that blanketed the Puyallup valley bottom about 500 years ago. Abandoned channels situated near the main channel reflect relic channel locations, indicating the potential for episodic avulsions. The most pronounced abandoned channel is situated along the west valley wall between RM 19.2 and RM 22.7. Recent setback levees constructed at the Soldiers Home in 2006 and Ford levee in 1998 have allowed a braided channel to develop within these reaches. Between RM 25.1 and RM 25.3, the Puyallup River flows through a straight, narrow bedrock constriction. At RM 23.4, the valley floor widens considerably, and converges with the Carbon River valley, forming the Orting valley (GeoEngineers 2003).

Channelization and levee construction within the lower portion of the upper Puyallup River occurred mostly from the 1930s to the 1960s. In the 1930s and 1940s, revetments were constructed to prevent channel migration through agricultural lands. In the 1960s, the river
Figure 5.25
Upper Puyallup River Planning Area
RM 17.4 - RM 29.0
Pierce County Rivers Flood Hazard Management Plan

Legend

- Project Sites
- River Miles
- Repetitive Loss Property
- Flood Control Facility
- Major Roads
- County Boundary

Rivers/Streams
Lakes/Puget Sound
Regulatory 100 Year Floodplain
(inside of City Boundaries)
Regulatory 100 Year Floodplain
(outside of City Boundaries)
Channel Migration Zone Floodway

The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County makes no warranty of fitness for a particular purpose. All data is provided 'as is' and 'with all faults'. The County assumes no liability for variations as certified by actual survey.

Pierce County
Public Works & Utilities
Surface Water Management

:F:\projects\1360 Flood Hazard Management Plan\Flood Plan\Adopted Plan\GIS Data and Maps
channel was further straightened and confined with levees and revetments, decreasing channel width to an average of 250 feet. Levee placement greatly reduced the width of the active channel up to 60 percent on the Puyallup River, upstream of the Carbon confluence (GeoEngineers 2003).

The average channel gradient varies from 0.32 to 0.54 percent between RM 17.4 to RM 22.5 and from 0.75 to 1.14 percent between RM 22.5 to RM 28.6. The channel width is generally confined to between 200 and 300 feet downstream of the Calistoga Bridge. Between the Calistoga Bridge and High Bridge channel widths vary from 250 to 1200 feet. In 2003, a channel migration zone (CMZ) analysis was carried out to delineate severe, moderate, and low channel migration zones in the upper Puyallup River. The severe CMZ in the upper Puyallup River generally varies from about 700 to 1200 feet in width throughout much of the reach. Channel migration eroded several levees in this reach in the 2006 and 2009 flood events, including upstream of Rock Point at RM 23.6 left bank and near Neadham Road at RM 25.3 to RM 26.8 right bank.

5.3.3 Hydrology and Hydraulics

The upper Puyallup River contributing drainage basin is approximately 188 square miles and extends from Mount Rainier National Park downstream to the City of Orting. The upper Puyallup River receives flows from the North and South Fork Puyallup Rivers, Mowich River and several streams.

The USGS stream gauge (#12093500) upstream of Orting has a long-term record that dates back to 1932. This gauge is located within a channel primarily composed of bedrock, ensuring the gauge data are reliable. Flood frequency flows for the upper Puyallup River from the 1987 and 2009 FEMA Flood Insurance Studies, and calculated by Pierce County SWM through the 2009 water year are presented in Table 5.13. The November 2006 flood on the upper Puyallup River resulted in a peak flow of 21,500 cfs. Based on the Pierce County 2009 flood frequency discharge forecast, this was considered to have a recurrence interval of approximately 160 years.

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89\footnote{Flood Frequency Discharge – How often or frequent the discharge magnitude occurs}
Table 5.13  Flood Frequency Flows for the Upper Puyallup River

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-yr</td>
<td>50-yr</td>
</tr>
<tr>
<td>Upper Puyallup River Gauge</td>
<td>11,700</td>
<td>16,400</td>
</tr>
<tr>
<td>(above Orting, #12093500)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Puyallup River Gauge</td>
<td>12,200</td>
<td>16,800</td>
</tr>
<tr>
<td>(above Orting, #12093500)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Puyallup River Gauge</td>
<td>12,500</td>
<td>17,550</td>
</tr>
<tr>
<td>(above Orting, #12093500)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*SWM regression analysis (not official or formal published data)
Source: FEMA and Pierce County Surface Water Management (based on United States Geologic Survey records)

The USGS channel conveyance capacity study (USGS 2010) indicates that the upper Puyallup River between RM 17.4 and RM 28.6 can convey flows ranging from 6,000 to 17,200 cfs before overtopping either the left or right bank (see Figure 5.26). The change in conveyance capacity since the 1984 flood conveyance capacity USGS study has been variable for the channel reach between RM 17.4 and RM 22.8. Overall, the trend mostly shows channel conveyance capacity to be decreasing between 1984 and 2009, except for the segment of channel between RM 22.0 and RM 23.0, where conveyance capacity has increased.

Figure 5.26 - Channel conveyance capacity for the upper Puyallup River
No cross-section measurements were made upstream of RM 22.8 in 1984, so there is no point of comparison available.

### 5.3.4 Ecological Context and Salmonid Use

Along the upper Puyallup River, the floodplain narrows, the gradient steepens and the channel becomes increasingly braided. The substrate changes from gravel to cobble and boulders in the upper segment. Side channels flow through immature stands of alder and provide some of the most stable fish habitat within this reach. All species of salmonids use the upper Puyallup River. The best habitat is found in side channels and at the mouths of tributaries. For spawning and rearing, Chinook and steelhead prefer the large side channels and stable main channel areas near large pools with wood. Coho, chum, and cutthroat trout occupy smaller side channels or along the margins of the main channel. Figure 5.27 shows some of the key habitat features for salmonids in the upper Puyallup River, including rearing and spawning habitat for coho, pink, Chinook, and steelhead.

![Figure 5.27 – Salmonid habitat in the upper Puyallup River](image)

As a result of the last three recent major floods since 2006, the upper Puyallup River has experienced rapid channel migration and bed load aggradation leading to an unstable environment for spawning and rearing salmon. The river delivers large amounts of wood and sediment to this reach from the glacier and forests upstream and deposits them into the levee constricted channel. Because the channel is constricted in most locations, the energy of the river is not distributed across the floodplain and salmon redds located in the main channel may have low survival due to scour or excessive sediment deposition.

In the upper portions of this reach, the levees become less continuous and maintained. Some of the bank hardening remains from an old railroad grade. Due to dwindling development...
upstream of Orting, this reach holds high potential for restoration activities and floodplain reactivation.

5.3.5 River Management Facilities, Flooding and Flood Damage

Levees and revetments form nearly continuous bank protection in the lower segment of the upper Puyallup River system between RM 17.4 and RM 23.6. Near the City of Orting, flood risk reduction facilities help protect residential, commercial, agricultural areas, and public facilities. Above RM 23.6 the levee segments were heavily damaged by major flood events between 1996 and 2009. Table 5.14 contains a list of river management facilities, including ownership.

| Table 5.14 Levees and Revetments in the Upper Puyallup River |
|------------------|----------------|----------------|
| Name             | Location a    | Ownership      |
| **Right Bank**   |                |                |
| High Cedars Revetment | RM 17.4 – RM 17.5 | Pierce County   |
| High Cedars Levee    | RM 17.5 – RM 19.7, PL 84-99 | Pierce County   |
| Calistoga Levee     | RM 19.7 – RM 21.25, PL 84-99 | Pierce County   |
| Jones Levee         | RM 21.25 – RM 22.5, PL 84-99 | Pierce County   |
| Ford Levee          | RM 22.5 – RM 24.9, PL 84-99 | Pierce County   |
| High Bridge Revetment | RM 24.9 – RM 25.45 | Pierce County Roads |
| Neadham Road Levee  | RM 26.4 – RM 26.9, PL 84-99 | Pierce County   |
| **Left Bank**      |                |                |
| South Fork Levee    | RM 17.5 – RM 18.5 | Pierce County   |
| Leach Road Levee    | RM 19.1 – RM 21.25, PL 84-99 | Pierce County   |
| Soldier’s Home Levee| RM 21.25 – RM 23.1, PL 84-99 | Pierce County   |
| McAbee Levee        | RM 23.1 – RM 23.6, PL 84-99 | Pierce County   |
| Orville Road Revetment | RM 25.6 – RM 28.1 | Pierce County   |
| Champion Bridge Levee/Revetment | RM 28.1 – RM 28.6 | Pierce County   |

a RM = river mile; PL 84-99 USACE Flood Control and Coastal Emergency Act
Source: Pierce County Surface Water Management records

5.3.5.1 Major Flooding

The upper Puyallup River experienced flooding most recently in 1990, 1996, 1999, 2000, 2006, 2008, and 2009 (see Table 5.15). The largest flood event on record at the USGS gauge near
Orting occurred on November 6, 2006 with a flow of 21,500 cfs, estimated to be approximately a 160-year event in the upper Puyallup River.

Table 5.15 Historical Flooding in Upper Puyallup River

<table>
<thead>
<tr>
<th>Date</th>
<th>Puyallup River Flow at Orting Gauge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 1932</td>
<td>11,800</td>
</tr>
<tr>
<td>December 1933</td>
<td>12,800</td>
</tr>
<tr>
<td>December 1955</td>
<td>12,100</td>
</tr>
<tr>
<td>November 1959</td>
<td>12,900</td>
</tr>
<tr>
<td>November 1962</td>
<td>15,300</td>
</tr>
<tr>
<td>January 1965</td>
<td>12,200</td>
</tr>
<tr>
<td>December 1977</td>
<td>12,100</td>
</tr>
<tr>
<td>January 1990</td>
<td>11,600</td>
</tr>
<tr>
<td>February 1996</td>
<td>18,300</td>
</tr>
<tr>
<td>November 1999</td>
<td>11,600</td>
</tr>
<tr>
<td>November 2006</td>
<td>21,500</td>
</tr>
<tr>
<td>November 2008</td>
<td>15,200</td>
</tr>
<tr>
<td>January 2009</td>
<td>16,900</td>
</tr>
</tbody>
</table>

Source: United States Geologic Survey records

5.3.5.2 Flood Damage to Facilities

Flood damage to the levees along the upper Puyallup River has occurred following major flooding events in recent decades. The levees that have experienced the most significant repetitive damage include the Champion Bridge, High Cedars, Neadham Road, Calistoga, and Orville Road. Damages sustained have ranged from total washouts resulting in the loss of several hundred lineal feet of flood risk reduction facility to localized moderate scour and erosion (see Table 5.16).
### Table 5.16 Flood Damage to Levees in the Upper Puyallup River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Estimated Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1990</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neadham Road Levee</td>
<td>RM 25.9 RB</td>
<td>Reconstruction</td>
<td>900</td>
<td>November 1990</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.2 LB</td>
<td>Reconstruction</td>
<td>800</td>
<td>November 1990</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.4 LB</td>
<td>Reconstruction</td>
<td>700</td>
<td>November 1990</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.6 LB</td>
<td>Reconstruction</td>
<td>900</td>
<td>November 1990</td>
</tr>
<tr>
<td>Neadham Road Levee</td>
<td>RM 26.8 RB</td>
<td>Reconstruction</td>
<td>250</td>
<td>November 1990</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 27.0 LB</td>
<td>Reconstruction</td>
<td>800</td>
<td>November 1990</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 27.6 LB</td>
<td>Reconstruction</td>
<td>1000</td>
<td>November 1990</td>
</tr>
<tr>
<td>Neadham Road Levee</td>
<td>RM 25.4 RB</td>
<td>Reconstruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM26.3 RB</td>
<td>Reconstruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1995</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leach Road Levee</td>
<td>RM 20.0 LB</td>
<td>Reshape and replace riprap and toe rock</td>
<td>195</td>
<td>November 1995</td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 20.0 RB</td>
<td>Land Acquisition and setback Levee</td>
<td>375</td>
<td>November 1995</td>
</tr>
<tr>
<td>Soldiers Home Levee</td>
<td>RM 22.5 LB</td>
<td>Partial Washout</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Soldiers Home Levee</td>
<td>RM 22.9 LB</td>
<td>Partial Washout</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Ford Levee</td>
<td>RM 23.7 LB</td>
<td>Partial Washout</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Rock Point</td>
<td>RM 24.0 LB</td>
<td>Partial Washout</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM 25.1 RB</td>
<td>Partial Washout</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM 25.6 RB</td>
<td>Re-face RR grade as setback Levee</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.2 LB</td>
<td>Full Levee Washout</td>
<td>1500</td>
<td>November 1995</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.5 LB</td>
<td>Partial Washout</td>
<td>225</td>
<td>November 1995</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.6 LB</td>
<td>Partial Washout</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM 26.8 RB</td>
<td>Land Acquisition and setback Levee</td>
<td>500</td>
<td>November 1995</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 27.0 LB</td>
<td>Full Levee Washout</td>
<td>600</td>
<td>November 1995</td>
</tr>
<tr>
<td>Segment Name</td>
<td>Estimated Location</td>
<td>Damage</td>
<td>Length</td>
<td>Storm Event</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------</td>
<td>-------------------------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 27.6 LB</td>
<td>Full Levee Washout</td>
<td>400</td>
<td>November 1995</td>
</tr>
<tr>
<td>Champion Bridge Levee</td>
<td>RM 28.1 LB</td>
<td>Full Levee Washout</td>
<td>700</td>
<td>November 1995</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Fork Levee</td>
<td>RM 17.4 LB</td>
<td>Toe/Slope Failure</td>
<td>100</td>
<td>February 1996</td>
</tr>
<tr>
<td>High Cedars Levee</td>
<td>RM 17.6 RB</td>
<td>Toe/Slope Failure</td>
<td>400</td>
<td>February 1996</td>
</tr>
<tr>
<td>High Cedars Levee</td>
<td>RM 19.0 RB</td>
<td>Total Levee Failure</td>
<td>100</td>
<td>February 1996</td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 19.8 RB</td>
<td>Total Levee Failure</td>
<td>1200</td>
<td>February 1996</td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 20.2 RB</td>
<td>Mostly Toe with some</td>
<td>200</td>
<td>February 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slope Failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 20.7 RB</td>
<td>Mostly Toe with some</td>
<td>300</td>
<td>February 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slope Failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 20.8 RB</td>
<td>Mostly Toe Failure</td>
<td>100</td>
<td>February 1996</td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 20.9 RB</td>
<td>Toe/Slope Failure</td>
<td>300</td>
<td>February 1996</td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 21.2 RB</td>
<td>Toe/Slope Failure</td>
<td>200</td>
<td>February 1996</td>
</tr>
<tr>
<td>Soldiers Home Levee</td>
<td>RM 21.9 LB</td>
<td>Toe/Slope Failure</td>
<td>400</td>
<td>February 1996</td>
</tr>
<tr>
<td>Jones Levee</td>
<td>RM 22.5 RB</td>
<td>Total Failure</td>
<td>200</td>
<td>February 1996</td>
</tr>
<tr>
<td>Jones Levee</td>
<td>RM 22.9 RB</td>
<td>Toe/Slope Failure</td>
<td>300</td>
<td>February 1996</td>
</tr>
<tr>
<td>Jones Levee</td>
<td>RM 23.1 RB</td>
<td>Full Levee Washout</td>
<td>200</td>
<td>February 1996</td>
</tr>
<tr>
<td>McAbee</td>
<td>RM 23.6 LB</td>
<td>Full Levee Washout</td>
<td>1200</td>
<td>February 1996</td>
</tr>
<tr>
<td>Ford Levee</td>
<td>RM 23.6 RB</td>
<td>Full Levee Washout</td>
<td>900</td>
<td>February 1996</td>
</tr>
<tr>
<td>Rock Point</td>
<td>RM 24.0 LB</td>
<td>Full Levee Washout</td>
<td>500</td>
<td>February 1996</td>
</tr>
<tr>
<td>Rock Point</td>
<td>RM 24.1 LB</td>
<td>Full Levee Washout</td>
<td>300</td>
<td>February 1996</td>
</tr>
<tr>
<td>Ford Levee</td>
<td>RM 24.6 RB</td>
<td>Full Levee Washout</td>
<td>1200</td>
<td>February 1996</td>
</tr>
<tr>
<td>Rock Point</td>
<td>RM 25.2 LB</td>
<td>Toe/Slope Failure</td>
<td>250</td>
<td>February 1996</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.2 RB</td>
<td>Full Levee Washout</td>
<td>2000</td>
<td>February 1996</td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM 26.4 RB</td>
<td>Full Levee Washout</td>
<td>600</td>
<td>February 1996</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.6 LB</td>
<td>Full Levee Washout</td>
<td>900</td>
<td>February 1996</td>
</tr>
</tbody>
</table>
## Table 5.16 Flood Damage to Levees in the Upper Puyallup River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Estimated Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orville Road</td>
<td>RM 26.7 LB</td>
<td>Full Levee Washout</td>
<td>1200</td>
<td>February 1996</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 26.8 LB</td>
<td>Full Levee Washout</td>
<td>2000</td>
<td>February 1996</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 27.1 LB</td>
<td>Full Levee Washout</td>
<td>3000</td>
<td>February 1996</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 27.6 LB</td>
<td>Full Levee Washout</td>
<td>2000</td>
<td>February 1996</td>
</tr>
<tr>
<td>Orville Road</td>
<td>RM 28.0 LB</td>
<td>Full Levee Washout</td>
<td>2500</td>
<td>February 1996</td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cedars Revetment</td>
<td>RM 17.4 RB</td>
<td>Face Erosion</td>
<td>50</td>
<td>November 2006</td>
</tr>
<tr>
<td>South Fork Levee</td>
<td>RM 17.7 LB</td>
<td>Washout</td>
<td>40</td>
<td>November 2006</td>
</tr>
<tr>
<td>High Cedars Levee</td>
<td>RM 18.0 RB</td>
<td>Washout</td>
<td>50</td>
<td>November 2006</td>
</tr>
<tr>
<td>High Cedars Levee</td>
<td>RM 19.4 RB</td>
<td>Washout</td>
<td>150</td>
<td>November 2006</td>
</tr>
<tr>
<td>High Cedars Levee</td>
<td>RM 19.8 RB</td>
<td>Washout</td>
<td>100</td>
<td>November 2006</td>
</tr>
<tr>
<td>Leach Road Levee</td>
<td>RM 19.4 LB</td>
<td>Washout</td>
<td>50</td>
<td>November 2006</td>
</tr>
<tr>
<td>Leach Road Levee</td>
<td>RM 19.8 LB</td>
<td>Washout</td>
<td>200</td>
<td>November 2006</td>
</tr>
<tr>
<td>Soldiers Home Levee</td>
<td>RM 22.6 LB</td>
<td>Face Erosion</td>
<td>100</td>
<td>November 2006</td>
</tr>
<tr>
<td>Ford Levee</td>
<td>RM 22.8 RB</td>
<td>Washout</td>
<td>350</td>
<td>November 2006</td>
</tr>
<tr>
<td>McAbee Levee</td>
<td>RM 23.6 LB</td>
<td>Washout</td>
<td>600</td>
<td>November 2006</td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM 26.8 RB</td>
<td>Washout</td>
<td>1000</td>
<td>November 2006</td>
</tr>
<tr>
<td>Champion Bridge</td>
<td>RM 28.4 LB</td>
<td>Washout</td>
<td>450</td>
<td>November 2006</td>
</tr>
<tr>
<td>Champion Bridge</td>
<td>RM 28.6 LB</td>
<td>Washout</td>
<td>700</td>
<td>November 2006</td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soldiers Home Levee</td>
<td>RM 22.01 LB</td>
<td>Toe/Slope Failure</td>
<td>80</td>
<td>November 2008</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cedars Levee</td>
<td>RM 19.4 RB</td>
<td>Toe/Slope failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM 26.3 RB</td>
<td>Washout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Champion Bridge</td>
<td>RM 28.3 LB</td>
<td>Toe/Slope Failure</td>
<td>135</td>
<td>January 2009</td>
</tr>
<tr>
<td>Champion Bridge</td>
<td>RM 28.5 LB</td>
<td>Washout</td>
<td>400</td>
<td>January 2009</td>
</tr>
</tbody>
</table>
### Table 5.16 Flood Damage to Levees in the Upper Puyallup River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Estimated Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RM = River Mile; RB = Right Bank; LB = Left Bank</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source: Pierce County Surface Water Management records</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3.6 Key Accomplishments since the 1991 Flood Plan

5.3.6.1 Major Projects

Since the 1991 Puyallup River Comprehensive Flood Plan was completed, Pierce County has carried out an annual program that includes maintenance and repair of revetments and levees, listed in Table 5.14, as well as the capital projects noted below and major repairs shown in Table 5.17.

1. **Ford Levee setback project 1998, RM 23.1 – RM 25.4, right bank**

   The setback project consisted of constructing a new 8,400-foot levee setback up to 600 feet from the main channel of the Puyallup River. Portions of the existing levee structure were removed to allow the river to meander and remove the remainder of the levee over time. The project reconnected 125 acres of floodplain with the river. The total cost was approximately $3.3 million.

2. **Soldiers Home levee setback project 2006, RM 21.8 – 23.0, left bank**

   The project consisted of constructing a new 5,000-foot levee which was set back 900 feet from the main channel of the river. The existing levee was removed to allow the river to meander in the opened floodplain area. The project reconnected 67 acres of floodplain isolated from the river into a complex of braided channels. Large woody material was placed along the setback levee alignment to enhance habitat. (NOAA, Natural Resource Restoration projects). The total cost was approximately $6.4 million.

3. **Orville Rd Revetment 2002 (US Army Corps of Engineers Project) between RM 26.2 and RM 26.3 left bank.**

   US Army Corps of Engineers constructed approximately 250 lineal feet of setback revetment along Orville Road as part of the PL 84-99 program. The revetment was built to replace a Puyallup River levee that had been washed out from the November 1995 and February 1996 flood events. The primary purpose was to protect undermining and erosion of the Orville Road embankment. Large woody material was incorporated into the revetment structure and was planted with woody plant species.

Table 5.17 shows major repairs, generally 750 lineal feet or more in length, along the upper Puyallup River following significantly large storm events. Records maintained by Pierce County show several major repairs have been completed between RM 17.3 and RM 28.6.
Table 5.17 Major Projects Completed on Upper Puyallup River Since 1991 Flood Plan

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Estimated Cost</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Champion Bridge</td>
<td>RM 28.1 LB</td>
<td>Full Levee Washout</td>
<td>700LF</td>
<td>$264,416</td>
<td>November 1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cut Off Levee</td>
<td>300LF</td>
<td>$164,275</td>
<td></td>
</tr>
<tr>
<td>High Cedars</td>
<td>RM 18.0 RB</td>
<td>Levee &amp; Toe Failure</td>
<td>900LF</td>
<td>$338,400</td>
<td>February 1996</td>
</tr>
<tr>
<td>Calistoga Levee</td>
<td>RM 19.8 RB</td>
<td>Levee Washout</td>
<td>1,200LF</td>
<td>$685,200</td>
<td>February 1996</td>
</tr>
<tr>
<td>McAbee</td>
<td>RM 23.6 LB</td>
<td>Levee Washout</td>
<td>1,200LF</td>
<td>$685,200</td>
<td>February 1996</td>
</tr>
<tr>
<td>Neadham Road</td>
<td>RM 26.2 RB</td>
<td>Full Levee Washout</td>
<td>2,000LF</td>
<td>$1,142,000</td>
<td>February 1996</td>
</tr>
<tr>
<td>Neadham Rd Levee</td>
<td>RM 26.6 RB</td>
<td>Full Levee Washout</td>
<td>1,000LF</td>
<td>$571,000</td>
<td>February 1996</td>
</tr>
<tr>
<td>Champion Bridge</td>
<td>RM 28.4 – RM 28.6 LB</td>
<td>Full Levee Washout</td>
<td>1,300LF</td>
<td>$1,040,000</td>
<td>November 2006</td>
</tr>
<tr>
<td>Neadham Rd Levee</td>
<td>RM 26.8 RB</td>
<td>Full Levee Washout</td>
<td>1,000LF</td>
<td>$800,000</td>
<td>November 2006</td>
</tr>
<tr>
<td>Neadham Rd</td>
<td>RM 26.3 RB</td>
<td>Full Levee Washout</td>
<td>738LF</td>
<td>$369,000</td>
<td>November 2008</td>
</tr>
<tr>
<td>Neadham Rd Levee</td>
<td>RM 26.75 RB</td>
<td>Setback Levee &amp; 3 ELJ’s</td>
<td>550LF</td>
<td>$945,000</td>
<td>January 2009</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

5.3.6.2 Land Purchases

The following land and home acquisitions have occurred since 1991, using a combination of federal and state grant funds and local match.

- Acquisition of homes and property along Orville Road near Champion Bridge (53 acres)
- Acquisition of homes and property in the Neadham Road area (180 acres)
- Acquisition of homes and property near the High Bridge (8.5 acres)
- Acquisition of homes and property along Orville Road in Ford levee area (192 acres)
- Acquisition of property along Puyallup River left bank in Soldiers Home area (136 acres)
- Acquisition of homes and property near Leach Road (15 acres)
- Acquisition of homes and property near the confluence with Horsehaven Creek (29 acres)
- Acquisition of homes and property for the South Fork Setback levee (58 acres).

5.3.6.3 Partnerships

Pierce County has partnered with FEMA and Washington State on Hazard Mitigation Grant funds for acquisition of the homes and property as noted above. The US Army Corps of Engineers has provided 80 percent cost-share for levee rehabilitation for some of the damage facilities eligible for funding under the PL 84-99 program. Funding from the Salmon Recovery

Source: Pierce County Surface Water Management records
Funding Board (SRFB), Hylebos Partners, Port of Tacoma, Pierce County and the Corps of Engineers helped support construction of the Soldiers Home Levee setback project.

5.3.7 Flood and Channel Migration Hazard Mapping

Hazard mapping in the upper Puyallup includes detailed flood studies (FEMA 2009, NHC 2006) and the creation of preliminary Digital Flood Insurance Rate Maps (DFIRM), which as of the publication of this document have not been issued by FEMA. Flood prone areas along the upper Puyallup River include the High Cedars Golf Club, local roads such as Orville Road and Neadham Road, numerous roads and structures in the Village Green area of Orting, agricultural and rural lands and structures in unincorporated Pierce County, and Orting School District property. The preliminary DFIRM maps for the upper Puyallup River show 2,562 acres within the special flood hazard area (SFHA) or 100-year floodplain. The mapped deep and fast flowing area is 119 acres.

Severe, moderate, and low channel migration zones (CMZ) were mapped for the upper Puyallup River (GeoEngineers 2003) and were adopted in November 2004. The CMZ refers to the geographic area where a stream or river has been and is susceptible to channel erosion and/or channel occupation (WSDOE 2003). The severe CMZ covers an area of 1,325 acres. Pierce County regulates severe CMZ mapped areas as floodway per Chapter 18E.70, Pierce County Code.

5.3.8 Problem Identification

Table 5.18 identifies flooding and channel migration related problems in the upper Puyallup River. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee and Revetment Overtopping and Breaching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 17.6 – RM 17.9 LB</td>
<td>Revetment overtopping in 2006 and 2008 deposited debris and blocked access road</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 18.0 – RM 19.2 RB</td>
<td>Levee overtopping floods High Cedars Golf Course</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 19.2 – RM 19.8 LB</td>
<td>Levee overtopping damaged levee and levee access road</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 22.5 – RM 22.55 RB</td>
<td>Levee overtopping floods Calistoga Street and baseball fields</td>
<td>City of Orting</td>
</tr>
<tr>
<td>Tributary Backwater Flooding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 25.3 RB</td>
<td>Backwater flooding at Fiske Creek results in flooding of Brooks Rd. bridge causing road closure</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>
Table 5.18Flooding-related Problems Identified in Middle Puyallup River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 26 LB</td>
<td>Kapowsin Creek backwater flooding impacts Orville Rd. bridge over creek</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 25.8 – RM 26.5 RB</td>
<td>Emergency evacuations of Neadham Rd. area occurred during 1996 flood event</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 23.6 – RM 23.9 LB</td>
<td>Channel migration occurred numerous times since 1995 eroding left bank levee upstream of Rock Pt.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 23.9 – RM 25 LB</td>
<td>Channel migration causes bank erosion of threatening 6-8 homes in “The Country”</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 26.1 – RM 26.3 LB</td>
<td>Channel migration upstream of high bridge eroding bank near Brooks Rd. and upstream during 2006, 2008 and 2009</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 26.1 – RM 26.3 LB</td>
<td>Channel migration threatens Orville Rd.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 26.6 – RM 27.1 LB</td>
<td>Channel migration threatens Orville Rd.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 27.1 – RM 27.7 LB</td>
<td>Channel migration starting in 1996 and ongoing threatens 10-12 homes in Stehn large lot area</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 28.1 – RM 28.4 RB</td>
<td>Channel migration downstream of Champion Bridge threatens forested area</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 28.2 – RM 28.5 LB</td>
<td>Channel migration threatens revetment, 6 homes and Orville Rd.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 20.5 – RM 21.3 RB</td>
<td>Leach Rd. E. flooding north of Calistoga bridge</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 21.3 LB/RB</td>
<td>Calistoga bridge is a constriction point for flow (gravel deposition, LWD impacting bridge)</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 25.4 – RM 26.7 RB</td>
<td>Neadham Rd. E. flooding causes road and infrastructure damage during major floods</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 17.4-19.4</td>
<td>Gravel bar accumulation downstream of Orting reduces conveyance capacity; one specific bar at 116th Ave. E. causes levee overtopping threatens homes</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 19.4-22.0</td>
<td>Gravel bar accumulation downstream of Calistoga bridge reduces conveyance capacity</td>
<td>City of Orting</td>
</tr>
<tr>
<td>RM 22.5-28.4</td>
<td>Gravel accumulation upstream of Orting reduce conveyance capacity and threaten levee integrity</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

**Public Safety/Emergency Rescues**

**Channel Migration Problem Areas**

**Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]**

**Sediment and Gravel Bar Accumulation**

**Facility Maintenance and Repair Needs**
Table 5.18 Flooding-related Problems Identified in Middle Puyallup River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 19.8 – RM 28.6</td>
<td>Numerous locations along levees and revetments have required repairs following many flood events (see Table 5.3.4 above)</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

Fish Habitat Problem Areas

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 17.8 - RM 18.1 LB</td>
<td>Historical side channel habitat and wall-based cool water channel has been cut off from Puyallup River by revetment construction</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>RM 19.2 – RM 20.2 LB</td>
<td>Levee/revetment construction cut off floodplain from river channel, limiting rearing/spawning habitat (Horsehaven and 150th St. setback levee locations)</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 21.3 – RM 23.0 RB</td>
<td>Levee/revetment construction cut off floodplain from river channel, limiting rearing/spawning habitat (190th Ave. upstream/downstream levee setback locations)</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 24.8 – RM 25.2 LB</td>
<td>Mint Creek wetland cutoff from Puyallup River by remnant left bank levee preventing off-channel rearing</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>RM 27.0 – RM 28.2 RB</td>
<td>Remnant railroad bed limits channel migration which degrades riparian habitat and connection with floodplain</td>
<td>Puyallup Tribe</td>
</tr>
</tbody>
</table>

Public Access

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 17.5 – RM 17.6 RB</td>
<td>McMillan trailhead – Lack of public access to water (e.g., for fishing or viewing)</td>
<td>Pierce County Parks</td>
</tr>
<tr>
<td>RM 29 – RM 30 RB</td>
<td>Lack of access to river/water; interest in new regional park in Kapowsin vicinity near river</td>
<td>Pierce County Parks</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

5.3.9 River Reach Management Strategies

The recommended river reach management strategies for the upper Puyallup River take into account numerous conditions as follows:

- **Development and land use in adjacent floodplain** – The upper Puyallup River floodplain is densely developed along the right bank in Orting, but otherwise rural residential and agricultural in land use. The total assessed value of property in the 100-year floodplain is $342 million.

- **River management facilities** – Both the left and right banks of the Puyallup River are constrained by levees and revetments downstream of RM 23.6. Above RM 23.6 to the Champion Bridge there are limited facilities.
• **River channel gradient and width** – Channel gradient varies from 0.16 to 1.14 percent. Channel width varies from 130 feet to 1200 feet, with the widest segments of the channel in the area of the two levee setbacks at Ford and Soldiers Home.

• **Presence of salmon spawning and rearing habitat** – Most species of salmon are found in the upper Puyallup, including Chinook, pink, chum, and coho, as well as steelhead, bull and cutthroat trout. Both spawning and rearing habitats are present.

• **Sediment transport accumulation and incision** – This reach is dominated by sand, gravel, and cobbles, with extensive boulders above RM 22.5. The average river bed elevation change is from 0 feet to +4.0 feet between 1984 and 2009 from RM 17.4 to RM 22.5; and -0.5 feet to +7.5 feet from RM 22.5 to RM 25.7 (see Figure 5.1.1).

The primary objective for the upper Puyallup River is to maintain the structural integrity of the levee and revetment system so the system continues to reduce risks to public health and safety, and reduce public and private property damage. Another objective is to make improvements to the levees so that they provide 100-year level of protection in the urban portion of the City of Orting, on the right bank between RM 19.4 and RM 22.5. The final management strategy is to realize capital projects that enhance and create aquatic habitat through levee setbacks, riparian re-vegetation, and strategic placement of large woody material.

The recommended river reach management strategy for the upper Puyallup is as follows (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**

• RM 17.4 – RM 19.4 left bank; RM 19.1 – RM 22.5 left bank; RM 22.5 – RM 28.6 right and left bank – Goal for levees is to maintain the existing levee prism

• RM 19.4 – RM 22.5 (right bank) – The “level of protection” goal for levees should be 100-year design plus three feet of freeboard.

• Revetments should be designed to resist channel migration.

**Non-structural management strategy:**

• Floodplain development regulations

• Acquisition, buyout or purchase of development rights
5.3.10 **Recommended Capital Projects**

The following capital improvement projects are recommended to address the priority problem areas identified in Table 5.3.5. Capital projects are defined as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Comprehensive Plan for Pierce County, Washington (Comprehensive Plan). Projects less than $75,000 are classified as small works.

5.3.10.1 **UP1 Calistoga Setback Levee**

**Location Information**

Sub Area: Upper Puyallup  
Basin Plan: Mid-Puyallup  
River Mile: 20.0 – 21.3, Right Bank  
Council District: 1  
Jurisdiction: City of Orting  
Property Ownership Affected: Local government and private property

**Estimated Cost**  
$8,000,000 - $12,000,000

**What is the Issue?**

The base flood elevation for this area is between 164 feet and 199.6 feet and the surrounding development is approximately between 164 and 188. The existing levee system between RM 20.0 and RM 21.3 provides less than 100 year protection and is not accredited by FEMA. The existing levee has overtopped on multiple occasions in the past five years. In November 2006 severe flooding inundated nearby housing developments and Ptarmigan Ridge Intermediate School causing hundreds of thousands of dollars in damage and impacted the local economy.

**What is at Risk?**

The existing levee system does not provide adequate flood protection and endangers hundreds of homes, local business, two schools, and public infrastructure. Additionally the existing levee system constricts the active channel width not allowing the river to freely migrate. The levee system in this area has reduced salmonid habitat in the area and led to a decline in spawning Chinook numbers on the river, as well as severe impacts on fry colonization and juvenile rearing.

**What is the Recommended Solution?**

The project will remove the majority of the existing right bank levee and construct a new setback levee between RM 20.0 and RM 21.3 along the Puyallup River. The levee will tie into the existing levee at RM 20.0 and into the raised fill which supports Calistoga Avenue. From Calistoga Avenue the new levee will tie into the existing east bank levee immediately upstream of the Calistoga Avenue Bridge. This will protect the City from backwatering that could occur undermine the bridge. The design of the levee will meet US Army Corps of Engineer standards (100 year base flood elevation, plus 3 feet of freeboard) plus allow for an additional two feet increase in flood elevation which could occur overtime due to climate change and sediment
accumulation. The top of the levee will be 18 feet wide to allow for future increase in levee height. The riverside bank of the levee will be armored per US Army Corps of Engineer standards with armor stone to prevent erosion and scour and minimize future maintenance costs. No vegetation will be on the levee; however, a levee bench with riparian vegetation will be constructed along a portion of the setback levee.

Thirty to forty percent of the existing levee system will remain in segments along the project area forming levee islands with engineered log jams (ELJs) installed upstream of each segment and throughout the project area to promote accumulation of large woody debris. A 600-foot segment of the levee will be retained to protect the Calistoga Bridge and two utility poles.

**What are the Project Benefits?**

- Increased level of flood protection for the City of Orting
- Construction of an ACOE certified and FEMA accredited levee with room for expansion to accommodate a future rise in the base flood elevation.
- Reconnection of 46 acres of the floodplain to the Puyallup River, increasing critical habitat for Chinook salmon and bull trout.
- The levee islands will promote river channel braiding, and increase salmon habitat

**Coordination**


**Environmental Considerations**

The Puyallup River supports a variety of salmonid species; including ESA listed Puget Sound Chinook, Puget Sound steelhead and bull trout. Implementation of this project will significantly increase their habitat in this stretch of the river system.

The City of Orting has completed federal environmental review, a biological assessment, a critical areas report, a cultural resources assessment and has received a Finding of No Significant Impact. Additionally, the project has been through local environmental review and received a Mitigated Determination of Non-Significance. The City will be preparing a Joint Aquatic Resources Permit Application form prior to construction.

**Other Information or Needs**

In 2011 the City is in the process of acquiring the remaining parcels for this project. Once the levee is complete, the project will be owned and maintained by Pierce County.
5.3.10.2 UP2 Ford Levee Setback Gravel Removal

**Location Information**

Sub Area: Upper Puyallup  
Basin Plan: Mid-Puyallup  
River Mile: 23.4 – 24.9, Right Bank  
Council District: 3  
Jurisdiction: Pierce County  
Property Ownership Affected: Local government

**Estimated Cost:** $900,000 plus study, design and permitting costs

**What is the Issue?**

The Puyallup River channel has experienced rapid accumulation of gravel since the 1990’s which has led to concerns about flood conveyance. The reduction in the channel area increases the potential for more frequent flooding and damage to existing infrastructure and private property.

**What is at Risk?**

- Private property
- Public infrastructure
- River carrying capacity
- Downstream gravel accumulation
- Salmon habitat

**What is the Recommended Solution?**

The project will identify major highly imbedded wood structures which typically form at the head of large gravel bars. Areas with non-imbedded wood would be re-contoured to emulate a braided side channel, excess gravel removed and existing wood re-distributed within the new braided channel habitat.

**What are the Project Benefits?**

- Improved channel conveyance capacity
- Some degree of reduced flooding risk
- Reduced downstream transport of sediment

**Coordination**

Environmental Considerations
The project site is within an area identified as Chinook spawning habitat. Several side channels currently exist in the project area and most likely provide juvenile rearing and adult spawning habitat. The best habitat in the main channel is provided in close proximity to the large stable log jams. The site is also used extensively by bald eagles.

Other Information or Needs
Other considerations for gravel removal projects:

- Comprehensive sediment management in Pierce County should be guided by technical sediment transport studies.
- An analysis of the economic and engineering feasibility for removing quantities of gravel that effectively reduce flood hazards will be conducted. The assessment will consider logistics and technical capability of removing gravel and sediment as well as available markets for the materials.
- Implementation of a five year monitoring program at gravel removal sites to assess sediment accumulation, project effectiveness, and duration of benefit.
- Gravel removal sites should target areas where gravel deposition has modified the direction of the river channel in a way that creates a risk of levee overtopping or levee or revetment erosion.
- Additional criteria to be met prior to initiation of gravel removal:
  1. It can be demonstrated that gravel accumulation poses a flood risk
  2. Hydraulic and sediment transport studies conclude gravel removal has a benefit of flood or channel migration risk reduction
  3. Demonstrated area of gravel accumulation
  4. Part of a comprehensive flood hazard management strategy
  5. Biological studies indicate that with mitigation there would be no net loss of ecological function; and
  6. All proper approvals have been secured.
5.3.10.3 UP3 Neadham Road Flooding/Channel Migration Protection

Location Information
Sub Area: Upper Puyallup
Basin Plan: Carbon River/Upper Puyallup (future plan)
River Mile: 25.3 – 26.9 Right Bank
Council District: 3
Jurisdiction: Pierce County
Property Ownership Affected: Private Lands & Public Lands

Estimated Cost: $8,100,000

What is the Issue?
This section of the river is highly dynamic and is actively migrating towards the right bank. The existing levee system provides less than 100 year level of flood protection and has experienced substantial damages from past flood events, particularly since the November 2006 flood event. The levee segment between RM 25.55 to RM 26.4 has been completely destroyed by the river. The remaining levee segment extends from RM 25.55 to RM 26.9. The base flood elevation for this river segment lies between 374 feet at RM 25.3 and 467 feet at RM 27.0. The adjacent residential properties within the floodplain lie approximately two feet below the surrounding flood elevation. Additionally, during periods of high flows, Fiske Creek is unable to discharge to the Puyallup River flooding Brooks Road and Needham Road, making the road impassible cutting off the 19 homes which remain. As of 2010, only 2,000 feet of levee remain. As a preventative measure a 450 lineal foot cut off levee and a 550 lineal foot setback levee were constructed.

What is at Risk?
- Damage of 19 private properties and structures
- Damage to public infrastructure, including roads and levees
- Potential loss of life, dangerous area to conduct flood fighting in and use of limited emergency services.
What is the Recommended Solution?

Pierce County is actively purchasing properties in the area with the ultimate goal of removing all residences within the flood hazard areas, including the AE Zone, Channel Migration Zone and area(s) of Deep and/or Fast Flowing Waters. The long term goal is to minimize and/or eliminate Pierce County’s responsibility of maintaining an area which experiences repetitive flood damages along the Needham Road corridor. Needham Road would be abandoned in place and protective measures would be constructed to preserve Brooks Road. Until the buys outs can be completed, a 550 lineal foot setback levee along with two Engineered Log Jams was constructed, completing the emergency work which was begun in 2010. The levee and log jams, will help slow down the rate of channel migration but may not prevent future flooding.

What are the Project Benefits?

- Purchase of the existing properties will facilitate the opportunity for reconnection of approximately 200 acres of historic floodplain to the Puyallup River, increasing critical habitat potential for Chinook salmon and bull trout.
- Anticipated decreased levee maintenance in this area
- Protection of Brooks Road, an indentified line road.

Figure 5.28 – This figure shows the floodway at the Needham Road site
Coordination


Environmental Considerations

The upper Puyallup River supports a variety of salmonid species; including ESA listed Puget Sound Chinook, Puget Sound steelhead and bulltrout. Reconnection of the floodplain will increase habitat in this stretch of the river system.

In the short term the construction of the setback levee will require: a Shoreline Substantial Development permit and Critical Areas approval from Pierce County; and, a Hydraulic Project Approval from the Department of Fish and Wildlife. This project will not require a Section 404 permit from the US Army Corps of Engineers.

Other Information or Needs

Kapowsin Creek flows north along the west of the project area and enters the Puyallup River at RM 26.3. Kapowsin Creek is the largest and most productive Chinook and steelhead spawning tributary in the upper Puyallup River.
5.3.10.4  UP4 Orville Road Revetment at Kapowsin Creek

Location Information
Sub Area:  Upper Puyallup  
Basin Plan:  Mid-Puyallup  
River Mile:  26.2 – 26.4, Left Bank  
Council District:  3  
Jurisdiction:  Pierce County  
Property Ownership Affected:  Private Lands  

Estimated Cost:  approximately $1,500,000

What is the Issue?
This stretch of the upper Puyallup River left bank levee has been severely damaged in numerous locations by channel migration and erosion, threatening approximately two miles of Orville Road, a major north-south arterial highway in eastern Pierce County. Prior to the flood events of 2006, the existing levee provided less than 20-year protection. At this time it provides no flood protection. During that event over 2,000 lineal feet of the levee was washed away. On the downstream portion of the levee the Puyallup River breached the levee and sent flows behind the remaining levee segment and into the Kapowsin Creek channel. Since the river has occupied the Kapowsin channel it has migrated 200 feet to the left bank and is now eroding away private property and is moving towards Orville Road. The Base Flood Elevation in this area ranges from 420 to 430 feet.

What is at Risk?
• Public Welfare and Safety  
• Public infrastructure, including Orville Road  
• Severe risk to adjacent private properties

What is the Recommended Solution?
The remaining 600 feet of levee in this area would be removed. The adjacent properties would be purchased and the residences removed and a new 750-lineal foot combination of engineered log jam (ELJ) and dolo timber structures will provide scour and erosion protection for Orville Road. The project will tie back upstream from where Kapowsin Creek enters the active channel of the Puyallup River. Consideration will be given to installation of a small floodplain bench incorporated into the downstream end of the revetment. The bench would be planted with willows and other native grasses, to provide some new shading and to withstand overbank flow.

What are the Project Benefits?
• Increased channel width will allow for increased conveyance through this reach of the river,
• Setback revetment design approach minimizes flooding and erosion,
• Dolo timber alternative does not require excavation, minimizing impacts to the riparian wetlands and side channels,
• Protection of a portion of Orville Road, and
• Enhancement of the riparian corridor.

**Coordination**


**Environmental Considerations**

The Puyallup River supports a variety of salmonid species; including ESA listed Puget Sound Chinook, Puget Sound steelhead and bulltrout.

Kapowsin Creek flows enter the Puyallup River at RM 26.3. Kapowsin Creek is the largest and most productive Chinook and steelhead spawning tributary in the upper Puyallup River.

Construction of the revetment and removal of the existing levee would likely require working within the ordinary high water of the Puyallup River. Excavation or fill within the river, wetlands or other aquatic habitats will require: a Section 404 permit from the US Army Corps of Engineers; a Section 401 Water Quality Certification from the Washington State Department of Ecology; an Hydraulic Project Approval (HPA) from the Department of Fish and Wildlife; a Shoreline Substantial Development Permit and Critical Areas Approval from Pierce County.
5.3.10.5 UP 5 Orville Road Channel Migration Protection

Location Information
Sub Area: Upper Puyallup
Basin Plan: Mid-Puyallup and Upper Carbon River/Upper Puyallup River (future plan)
River Mile: 26.4 – 28.6 Left Bank
Council District: 3
Jurisdiction: Pierce County
Property Ownership Affected: Local government property

Estimated Cost: $17,300,000 - $38,000,000

What is the Issue?
This stretch of the upper Puyallup River left bank levee has been damaged in numerous locations by channel migration and erosion, threatening approximately two miles of Orville Road, a major north-south arterial highway in eastern Pierce County. Within the project area, large sections of Orville Road are within the low to severe Channel Migration Zone. The levee from RM 26.4 to RM 27.2 is completely washed out and at RM 26.9 the river channel is approximately 200 feet from Orville Road. West of Orville Road in the vicinity of Kapowsin Creek, the valley is at an elevation 10 to 20 feet below the Puyallup River. As the main river channel migrates closer to Kapowsin Creek, this may cause future flooding issues. The upper Puyallup River Assessment Report (Cardno Entrix, December 2010) estimates that channel migration could damage Orville Road in as little as eight years.

What is at Risk?
- Damage to public infrastructure, including Orville Road
- Risk to adjacent private property
- Impact on regional economy from flooding

Figure 5.29 – Showing channel migration in the upper Puyallup River near Orville Road and Neadham Road
**What is the Recommended Solution?**

The protection of Orville Road has two solutions, short and long term. The long term solution is the relocation of Orville Road to a new location outside of the Channel Migration Zone limits between Kapowsin Creek Bridge (RM 26.5) and Electron Rd E (RM 28.6) and the purchase of the 58 single family homes located on the waterward of the road. The new road would be built at least three feet above Base Flood Elevation.

During the short term protection of Orville Road will be provided by: 8500 feet of discontinuous dolo timber setback revetments; 2900 feet of setback levee with an average height of four feet; 13 Engineered Log Jam deflectors; and 3 Engineered Log Jams.

**What are the Project Benefits?**

- Protection of a portion of Orville Road and adjacent private properties
- Setback revetment design approach minimizes flooding and erosion
- Re-connects 750 acres of floodplain
- Dolo timber alternative does not require excavation, minimizing impacts to the riparian wetlands and side channels
- Relocation of Orville Rd places it outside the Puyallup River CMZ limits, and lowers overall maintenance (when compared with the short term solution)
- Relocation of the Road will also revert approximately 750 acres of land to active floodplain and increase flood plain connectivity and improve salmonid habitat

**Coordination**


**Environmental Considerations**

The Puyallup River supports a variety of salmonid species; including ESA listed Puget Sound Chinook, Puget Sound steelhead and bulltrout. Reconnection of the floodplain will increase habitat in this stretch of the river system.

Construction of the setback levee and revetment would likely require working within the ordinary high water of the Puyallup River. Excavation or fill within the river, wetlands or other aquatic habitats will require: a Section 404 permit from the US Army Corps of Engineers; a Section 401 Water Quality Certification from the Washington State Department of Ecology; an Hydraulic Project Approval (HPA) from the Department of Fish and Wildlife; a Shoreline Substantial Development Permit and Critical Areas Approval from Pierce County.
**Other Information or Needs**

Kapowsin Creek flows north along the west of the project area and enters the Puyallup River at RM 26.3. Kapowsin Creek is the largest and most productive Chinook and steelhead spawning tributary in the upper Puyallup River.
5.3.10.6 UP6 Orville Road Revetment and Riparian Habitat Restoration

Location Information
Sub Area: Upper Puyallup
Basin Plan: Carbon River/Upper Puyallup (future plan)
River Mile: 26.7 – 27.1, Left Bank
Council District: 3
Jurisdiction: Pierce County
Property Ownership Affected: Local government property

Estimated Cost $3,700,000

What is the Issue?
This stretch of the Puyallup River left bank levee has been damaged in numerous locations by channel migration and erosion threatening approximately two miles of Orville Road, a major north-south arterial highway in eastern Pierce County. The Upper Puyallup River Assessment Report (Cardno Entrix, December 2010) estimates that channel migration could damage Orville Road in as little as eight years.

What is at Risk?
• Damage to public infrastructure, including Orville Road.
• Risk to adjacent private property.
• Impact on regional economy from flooding.

What is the Recommended Solution?
This is part of an overall project which will address the area between RM 26.7 – 27.1. The remainder of the project will be completed under project UP 5. The project will construct a setback revetment along the existing bank with 1,500 lineal feet of discontinuous dolo timber units or crib wall units and 12 Engineered Log Jam (ELJ) reflectors. The ELJs would consist of a series of traditional wood matrix or with dolo timbers and would be constructed on the gravel bar along the section of river.

What are the Project Benefits?
• Protection of a portion of Orville Road and adjacent private properties.
• Setback revetment design approach minimizes flooding and erosion.
• Increased floodplain connectivity.
• Dolo timber alternative does not require excavation, minimizing impacts to the riparian wetlands and side channels.
Environmental Considerations

The Puyallup River supports a variety of salmonid species; including ESA listed Puget Sound Chinook, Puget Sound steelhead and bulltrout. Reconnection of the floodplain will increase habitat in this stretch of the river system.

Construction of the setback revetment would likely require working within the ordinary high water of the Puyallup River. Excavation or fill within the river, wetlands or other aquatic habitats will require: a Section 404 permit from the US Army Corps of Engineers; a Section 401 Water Quality Certification from the Washington State Department of Ecology; an Hydraulic Project Approval (HPA) from the Department of Fish and Wildlife; a Shoreline Substantial Development Permit and Critical Areas Approval from Pierce County.
5.4  LOWER WHITE RIVER

5.4.1  Overview

The lower White River reach begins at the confluence with the Puyallup River and extends upstream to River Mile 5.5 at the Pierce-King County-line. The lower White River flows through the cities of Auburn, Pacific, and Sumner before joining the Puyallup River at RM 10.3. Several tributaries enter the lower White River in this reach, including Bowman Creek, Government Ditch, Jovita Creek, and Salmon Creek. The drainage basin is approximately 496 square miles. Prior to 2004, the majority of flow in the White River was diverted by Puget Sound Energy’s Buckley Diversion Dam located at RM 24.3. The Buckley Diversion Dam sent flow to Lake Tapps for power generation. Return flows from Lake Tapps enter the White River at RM 3.6. The dam is now owned by the Cascade Water Alliance and no longer produces energy. The White River is well known for its large sediment discharge and high turbidity levels. The heavy sediment load is the combined result of a relatively young channel and glacial headwaters (King County 1988).

Prior to 1906, the White River (Stuck River) flowed north past Auburn, where it joined the Green River and flowed to Elliott Bay in Seattle. Record flood flows in November 1906 caused a massive log jam that pushed flood flows into the Stuck River channel to the south and out through the Puyallup River to Commencement Bay. This became permanent in 1914 with the construction of a diversion dam in Auburn near RM 8.0. The dam prevented the White River from flowing back to the north. Between 1914 and the mid 1930s the lower White River was channelized and confined by a combination of revetments or levees.

Prior to development, the Stuck (lower White River) Valley was flat, swampy lowland positioned between the Puyallup River and White River. Lower White River Valley soils are composed of fine sand, silt, and peat, suggesting that the area was subject to periodic flooding and backwater ponding. During periods of high flows the White River would be diverted by wood debris jams into the Stuck Valley. (GeoEngineers 2003).

Today, substantial residential, industrial, and commercial development exists along the lower White River valley within the cities of Sumner, and Pacific. Salmon and trout, including bulltrout, cutthroat spring and fall Chinook, coho, sockeye, pink, chum, and steelhead use the entire reach of the lower White River.
Figure 5.31
Lower White River Planning Area
RM 0 - RM 5.5
Pierce County Rivers Flood Hazard Management Plan

Legend
- Project Sites
- River Miles
- Repetitive Loss Property
- Flood Control Facility
- Major Roads
- County Boundary
- Rivers/Streams
- Lakes/Puget Sound
- Regulatory 100 Year Floodplain (within City Boundaries)
- Regulatory 100 Year Floodplain (outside of City Boundaries)
- Channel Migration Zone Floodway

The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.

Pierce County Public Works & Utilities
Surface Water Management
Pierce County Rivers Flood Hazard Management Plan
P:\projects\1360 Flood Hazard Management Plan\Flood Plan\Adopted Plan\GIS Data and Maps
5.4.2 Geology and Geomorphology

The White River flows in a lightly meandering pattern in a southwesterly direction from the Muckleshoot Indian Reservation to the Countyline, RM 8.8 to RM 5.5. Above this point, the White River flows through a canyon the river has cut within the late Holocene (last 5000 years) into glacial and volcanic lahar sediments (Collins and Sheikh 2004). Sediment generated from incision of the White River canyon augmented sediment from the Osceola and later lahars to build a large alluvial fan in Auburn and Pacific, mostly downstream of RM 7.6. The White River consists of several meander bends from the Pierce County line at RM 5.5 to the Lake Tapps return flow at RM 3.6. The meander bends appear to be relatively stable over the period of record primarily due to the construction of revetments after the 1914 diversion of the White River, as described later in Section 5.4.5. Aggradation documented by recent monitoring in this section of the river indicates that sediment flux and transport capacity are not in balance. Channel gradient decreases steadily from 0.19 to 0.23 percent in a downstream direction from RM 5.6 to RM 3.6. From RM 3.6 to RM 0.0 the gradient varies from 0.03 to 0.1 percent. Downstream of RM 3.6, the channel is generally straight and incised, with incision increasing downstream (GeoEngineers 2003). The lower 1.4 miles of the river is entrenched by as much as 15 feet and entirely disconnected from its floodplain. The mapped severe channel migration zone is narrow in the incised reach from RM 0.0 to RM 3.2.

Analysis by the USGS (2010) as part of the Channel Conveyance Capacity, Channel Change, and Sediment Transport in the lower Puyallup, White and Carbon Rivers study indicates an average river bed elevation change of -0.5 feet to +2.0 feet between 1984 and 2009, from the mouth at RM 0.0 to approximately RM 4.0 (see Figure 5.32). Between RM 4.0 and RM 5.5, the average bed elevation has increased from +2.0 to +5.0 feet, with even larger increases (+6 feet) occurring north into King County.

---

90 Alluvial Fan – A sedimentary deposit located at a topographic break, such as the base of a mountain front, escarpment, or valley side, that is composed of streamflow and/or debris flow sediments and which has the shape of a fan, either fully or partially extended.
5.4.3 Hydrology and Hydraulics

The White River flows about 75 miles from its source at the Emmons and Winthrop glaciers on Mt. Rainier’s northeast side, to its confluence with the Puyallup River in the City of Sumner. The river’s several major tributaries include West Fork White River, Huckleberry Creek, Greenwater River, and Clearwater River. Mud Mountain Dam (MMD) at RM 29.6 influences the hydrology of the White River during flood events.

Releases from MMD are based on maintaining a maximum flow of 45,000 cubic feet per second (cfs) at the Puyallup River gauge located near Milroy Bridge in Puyallup. The target flood control parameter for the MMD is authorized by Congress. Detention at the dam delays peak flows of the White River typically one to two days behind Puyallup River peak flows. In the original US Army Corps of Engineers MMD 1948 Water Control Plan, water stored in Mud Mountain Reservoir was to be discharged to the White River at up to 17,600 cfs (USACE 2002) because the river channel capacity downstream was estimated to be at least 20,000 cfs. Field observations in the 1970s noted that the threshold for flooding on the White River had declined to 12,000 cfs. The reduction of flood conveyance capacity was attributed to multiple factors including encroachment into the floodplain by development, vegetation along the channel, sediment in the channel, and restrictions on channel dredging (USACE 2002).

Flows on the White River can be better controlled in medium storms than large ones, when the reservoir nears capacity and local inflows increase. In recent years, discharge from MMD was limited to 12,000 cfs when operations allow. Further reduction in target discharge for
moderate events, between 6,000 - 8,000 cfs, is planned in 2010 and beyond. Table 5.19 below presents flood frequency flows from the 1987 and 2009 Flood Insurance Studies. Flows reflect operating policy changes and peak lag time due to detention at MMD.

The change in conveyance capacity since the 1984 USGS study (Sikonia 1990) has been significant, particularly in the reach from RM 2.0 to RM 5.5. King County and USGS are funding sponsors to install radar gauges along the White River to gain more accurate flow measurements.

The USGS study of conveyance capacity (USGS 2010) indicates that the lower White River channel can convey between 10,100 to 19,000 cfs before overtopping either the left or right bank between the mouth and RM 2.3 (see Figure 5.33). From RM 2.3 to RM 5.5 at the Pierce/King County line, conveyance capacity ranges from 5,000 to 9,500 cfs. The change in conveyance capacity since the 1984 USGS study (Sikonia 1990) has been significant, particularly in the reach from RM 2.0 to RM 5.5.

<table>
<thead>
<tr>
<th>Table 5.19 Lower White River Flood Frequency Flows at the USGS Auburn Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>White River at the Mouth @ Puyallup R. Confluence</td>
</tr>
<tr>
<td>White River at the Mouth @ Puyallup R. Confluence</td>
</tr>
</tbody>
</table>

Source: 1987 and 2009 FEMA Flood Insurance Study based on United States Geologic Survey data
5.4.4 Ecological Context and Salmonid Use

The lower White River is the most heavily modified reach in the planning area. The system today is less than 100 years old. The White River predominantly flowed into the Green River until 1906 when it was directed into its present day channel. The reach also has been affected by Lake Tapps water withdrawals, dredging, levees, revetments, and flushing of sediment from the Mud Mountain Dam.

All species of salmonids in the Puyallup River basin use the lower White River. Particularly important is the stock of White River Spring Chinook, which were on the brink of extinction in the mid 1980s. The stock has rebounded recently due to the WDFW and South Puget Sound tribe’s brood stock program. Recovery of the White River Spring Chinook stock is integral to the recovery of the entire ESA-listed Puget Sound Chinook population.

There is significant incision and floodplain isolation from RM 0.0 to RM 2.6 where the river is confined in a dredged channel and the bed is composed of sand. The reach is primarily a transport area for salmonids and it provides little rearing or spawning opportunity (see Figure 5.34). Enhancement in this reach is difficult because 15 feet of entrenchment would require major excavation to broaden the flood plain and provide salmonid habitat attributes such as cover and side channels.
From RM 2.6 to RM 8.8 the river channel is incised several feet and steepens to approximately a two percent gradient. The bed is composed of cobble and gravel with some gravel bars and tight braids becoming formed. Due to the constricted channel, scouring of redds can be expected during high flows. This area lends itself better to restoration activity since the mainstem incision is not as severe as the downstream areas and the flood plain can be reasonably accessed by salmon once restored (i.e. levee setback) King County is currently spearheading a levee setback project to enhance salmon rearing habitat and reduce flooding near RM 5.5.

5.4.5 River Management Facilities, Flooding and Flood Damage

The lower White River revetments and levees form nearly continuous bank protection from RM 0.0 at the Puyallup River to the Pierce-King County line at RM 5.5. The flood risk reduction facilities protect property and improvements in the floodplain, with an estimated assessed value of $535 million (Economic Analysis 2010). The facilities are owned and operated by Pierce County as summarized in Table 5.20.

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sumner Industrial Revetment</td>
<td>RM 0.0 – RM 5.1</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Butte Revetment</td>
<td>RM 5.1 – RM 6.2</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Left Bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fleishman Revetment</td>
<td>RM 0.0 – RM 2.05</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Dieringer Revetment</td>
<td>RM 2.05 – RM 4.9</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>
### Table 5.20 Levees and Revetments in the Lower White River

<table>
<thead>
<tr>
<th>Name</th>
<th>Location a</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potelco</td>
<td>RM 4.9 – RM 6.2, PL 84-99</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

a RM = river mile; PL 84-99 USACE Flood Control and Coastal Emergency Act

b This facility functions as a revetment, but the facility was originally constructed as a levee and has been subsequently backfilled during development by adjacent industrial and commercial property owners

Source: Pierce County Surface Water Management records

As previously stated, in 1914, Inter-County River Improvement (ICRI) constructed a diversion dam to prevent the White River from avulsing back into its pre-1906 channel and partially channelized the White River to the Puyallup River confluence between 1914-1920s (GeoEngineers 2003). Aerial photos in 1931 and 1940 show riprap and concrete levees and revetments protecting the river banks and three bridges located near Sumner. In the lower 1.5 miles of the lower White River, the river is entrenched by as much as 15 feet, which is apparent from the 1920s era concrete slabs placed to protect the now elevated upper banks (GeoEngineers 2003).

#### 5.4.5.1 Major Flooding

In the last 20 years major flooding in the lower White River occurred in 1990, 1996, 2006, and 2009 (see Table 5.21). The largest flood on record occurred in December 1933, prior to the construction of Mud Mountain Dam.

### Table 5.21 Historical Flooding in Lower White River

<table>
<thead>
<tr>
<th>Date</th>
<th>White River Flows near Auburn a (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1933</td>
<td>&gt;28,000</td>
</tr>
<tr>
<td>December 1946</td>
<td>&gt;12,300</td>
</tr>
<tr>
<td>December 1955</td>
<td>&gt;13,700</td>
</tr>
<tr>
<td>November 1959</td>
<td>&gt;13,000</td>
</tr>
<tr>
<td>December 1977</td>
<td>&gt;14,800</td>
</tr>
<tr>
<td>January 1986</td>
<td>&gt;14,000</td>
</tr>
<tr>
<td>November 1986</td>
<td>&gt;15,200</td>
</tr>
<tr>
<td>January 1990</td>
<td>14,500</td>
</tr>
<tr>
<td>February 1996</td>
<td>15,000</td>
</tr>
<tr>
<td>December 1996</td>
<td>13,600</td>
</tr>
<tr>
<td>November 2006</td>
<td>14,700</td>
</tr>
<tr>
<td>January 2009</td>
<td>12,000</td>
</tr>
</tbody>
</table>

a Auburn Gauge #12100496 was installed by 1990 event. Prior to 1990, Buckley Gauge #12098500 data is shown which reflects a slightly lower value than seen at Auburn.

Note: Mud Mountain Dam was constructed on the White River in 1948.
Table 5.21 Historical Flooding in Lower White River

<table>
<thead>
<tr>
<th>Date</th>
<th>White River Flows near Auburn(^*) (cfs)</th>
</tr>
</thead>
</table>

Source: United States Geologic Survey data

5.4.5.2 Flood Damage to Facilities
Flood damages to facilities along the lower White River are shown in Table 5.22.

Table 5.22 Damage to Facilities in the past 20 years along the Lower White River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potelco</td>
<td>RM 4.2 LB</td>
<td>Toe/Slope Failure</td>
<td>150</td>
<td>February 1996</td>
</tr>
<tr>
<td>Potelco***</td>
<td>RM 5.05 – RM 5.15 LB</td>
<td>Levee overtopping from adjacent wetland, 3ft of scour</td>
<td>650</td>
<td>January 2009</td>
</tr>
<tr>
<td>Potelco***</td>
<td>RM 5.35 – RM 5.5 LB</td>
<td>Levee overtopping from adjacent wetland, 3ft of scour</td>
<td>570</td>
<td>January 2009</td>
</tr>
<tr>
<td>Sumner Industrial Revetment</td>
<td>RM 3.85 RB</td>
<td>Face scour &amp; toe failure with exposed core</td>
<td>100</td>
<td>December 2010/January 2011</td>
</tr>
</tbody>
</table>

***Note: levee overtopping likely due to loss of channel capacity due to gravel aggradation along this segment of the White River near the City of Pacific.

Source: Pierce County Surface Water Management records

5.4.6 Key Accomplishments since the 1991 Flood Plan
Since the 1991 Puyallup River Comprehensive Flood Plan was completed, Pierce County has carried out an annual program that includes maintenance and repair of facilities. Specific capital projects are listed below.

5.4.6.1 Major Projects

1) Butte Pit Wetlands Mitigation, RM 5.0 right bank

In 2000, Pierce County Public Works and Utilities constructed the Butte Pit Wetlands Mitigation project on five acres within unincorporated Pierce County near the City of Pacific. The project relocated Government Ditch and installed weirs within wetlands cells to raise the water elevation and create a variety of saturated, seasonally inundated, and permanently inundated areas. Planted with native trees, shrubs, and emergent plants, the site provides off-channel habitat and flood refuge for a variety of salmon species. The site was previously used to mine gravel from the White River to maintain the flood conveyance capacity through this reach. Cost $400,000.

2) US Army Corps of Engineers, RM 5.7 – 6.0 right bank, City of Pacific
After flooding the City of Pacific in January 2009, the US Army Corps of Engineers raised the right bank levee between River Mile 5.7 and 6.0 as an emergency measure to reduce flooding.

Prior to the 2009-2010 flood season, King County with assistance from Pierce County, and the US Army Corps of Engineers constructed temporary flood walls constructed of sandbags and a HESCO™ barrier to protect the Town of Pacific as an interim solution until the Inter-County setback project can be constructed. Pierce County filled over 10,000 sandbags for the project and delivered them to the project site.

5.4.6.2 Land Purchases

There have been no land purchases or buyouts along the lower White River by Pierce County since 1991.

5.4.6.3 Partnerships

In 2008, Pierce County SWM convened the Puyallup River Executive Task Force to address issues arising from the de-accreditation of the lower Puyallup River levee system, problems with other Puyallup, White and Carbon River reaches, and changes to FEMA’s floodplain maps. In June 2008, the Pierce County Council passed Resolution R2008-74s, requesting all local governments to participate in developing and funding the work to bring the flood control system into FEMA compliance. Project goals are to: (1) ensure local agencies understand the problems and support finding a solution, and (2) work closely with affected agencies to develop alternatives, select an alternative, cooperatively seek funding, and construct the selected alternative.

5.4.7 Flood and Channel Migration Hazard Mapping

5.4.7.1 Flood Hazard Mapping.

Hazard mapping in the lower White River includes detailed flood studies (FEMA 2009, NHC 2006) and preliminary Digital Flood Insurance Rate Maps (DFIRM), which as of the publication of this document, have not been issued by FEMA. Flood prone areas along the lower White River include extensive industrial, commercial, and residential land uses along the right and left banks in the cities of Sumner and Pacific, and a small area of unincorporated Pierce County. The preliminary DFIRM maps for the lower White River show 1,043 acres within the special flood hazard area) or 100-year floodplain. The mapped deep and fast flowing area is 312 acres.

5.4.7.2 Channel Migration Hazard Mapping.

Severe, moderate, and low risk channel migration zones (CMZ) were mapped for the lower White River as part of the upper Puyallup River study (GeoEngineers 2003) and adopted in November 2004. The CMZ refers to the geographic area previously occupied by a stream or river and susceptible to channel erosion and/or channel avulsion (WSDOE 2003). In the lower White River, the severe CMZ covers an area of 227 acres. Pierce County regulates severe CMZ mapped areas as floodway per Chapter 18E.70, Pierce County Code.
5.4.8 Problem Identification
Table 5.23 identifies flooding and channel migration problems identified in the lower White River floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levee and Revetment Overtopping and Breaching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 3.3 – RM 3.9 RB</td>
<td>Levee/revetment overtopping caused damage to City of Sumner trail and flooding of industrial and commercial parking areas/loading docks</td>
<td>City of Sumner</td>
</tr>
<tr>
<td>RM 3.9 – RM 4.5 RB</td>
<td>Levee/revetment overtopping causes flooding of residential and industrial areas and 116th St. E.</td>
<td>City of Sumner, Pierce County</td>
</tr>
<tr>
<td>RM 3.8 – RM 4.0 LB</td>
<td>Revetment overtopping causes flooding of golf course and clubhouse (damaged in 2009)</td>
<td>City of Sumner</td>
</tr>
<tr>
<td>RM 4.9 – RM 5.5 RB</td>
<td>Levee/revetment overtopping caused flooding of homes in King and Pierce counties, and business and equipment flooding along Butte Ave. in 2009</td>
<td>Pierce County, City of Pacific</td>
</tr>
<tr>
<td>RM 5.1 – RM 5.3 LB</td>
<td>Levee overtopping causes flooding of Stewart Rd. and downstream areas (up to 3 feet in 2009)</td>
<td>City of Sumner, Pierce County</td>
</tr>
<tr>
<td>Tributary Backwater Flooding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 4.9 – RM 5.5 RB</td>
<td>Backwater from ditches causes backwater flooding at Countyline ditch (RM 5.5), government ditch (RM 5.35) and Stewart Rd. ditch (RM 4.9)</td>
<td>City of Pacific, Pierce County</td>
</tr>
<tr>
<td>Public Safety/Emergency Rescue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 5.4 – RM 5.5 RB</td>
<td>Evacuation of children from vicinity of 701 Butte Ave. due to deep, fast flowing water (2-2.5 feet)</td>
<td>City of Pacific</td>
</tr>
<tr>
<td>Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.2 – RM 0.2 LB</td>
<td>Flooding of State St. (access to Sumner wastewater treatment plant)</td>
<td>City of Sumner</td>
</tr>
<tr>
<td>RM 3.4 – RM 3.5 LB</td>
<td>Flooding of roadways at 24th St. E. &amp; 148th Ave.</td>
<td>City of Sumner</td>
</tr>
</tbody>
</table>

Note: all other flooding noted in levee/revetment overtopping entries above.

| Sediment and Gravel Bar Accumulation |                                                                                   |                         |
| RM 3.5 – RM 4.5             | Gravel bar accumulation from Dieringer flume to river meander at RM 4.5          | City of Sumner          |
| RM 3.6 – RM 5.5             | Concern about debris and log jams at (a) RM 5.0-5.5, (b)                          | City of Sumner          |
### Table 5.23 Priority Problems Identified in Lower White River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stewart Rd. bridge during floods, and (c) log jam at golf course (RM 3.6-3.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 4.9 – RM 5.5</td>
<td>Gravel bar accumulation from Stewart Rd. crossing to countyline has led to reduced conveyance capacity, as low as 5500 cfs (ACOE 2009)</td>
<td>City of Pacific, City of Sumner, Pierce County</td>
</tr>
</tbody>
</table>

**Facility Maintenance and Repair Needs**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 4.3 LB</td>
<td>Repetitive plugging of culvert by sediment and debris at Sumner golf course in 2007 and 2009</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 5.1 LB</td>
<td>Repetitive plugging of culvert by sediment and debris behind Potelco levee in 2007 and 2009</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

**Fish Habitat Problem Areas**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 1.25 RB</td>
<td>Soaten Creek (aka Jovita Cr.) refuge habitat is degraded at mouth with White River</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>RM 3.2-3.6 LB</td>
<td>Revetment construction cut off floodplain from river channel, preventing off-channel rearing</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 3.6-4.5 LB/ RB</td>
<td>Revetment/levee construction cut off floodplain from river channel, preventing off-channel rearing</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 4.2 LB</td>
<td>Fish passage barrier(^{91}) at 8(^{th}) St. Creek inflow to White River cuts off coho spawning habitat</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>RM 4.9 – RM 5.35 LB/ RB</td>
<td>Revetment/levee construction cut off floodplain from river channel, preventing off-channel rearing</td>
<td>Puyallup Tribe, Pierce County</td>
</tr>
<tr>
<td>RM 4.9 – RM 5.5 RB</td>
<td>Butte Pit wetland and side channel habitat impacted by sediment deposition (2006, 2008, 2009) impacting function and value of habitat</td>
<td>City of Pacific</td>
</tr>
</tbody>
</table>

**Public Access**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 0.5 – RM 5.0 LB</td>
<td>Four gaps in the public trail along the White River</td>
<td>City of Sumner</td>
</tr>
<tr>
<td>RM 4.9 – RM 5.5 RB</td>
<td>Improved access to Butte wetland for passive recreation</td>
<td>City of Pacific</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

---

\(^{91}\) **Fish Passage Barrier** – An obstacle that prevents fish from moving either upstream or downstream, such as certain dams, weirs, floodgates, roads, bridges, causeways and culverts.
5.4.9 River Reach Management Strategies

The Recommended river reach management strategies for the lower White River take into account numerous conditions as follows:

- **Development and land use in adjacent floodplain** – The lower White River floodplain is the second most developed in the planning area, with extensive industrial, commercial, and residential land uses and an assessed value of $525 million in the 100-year floodplain.

- **River management facilities** – Both the left and right banks of the lower White River are constrained by revetments along the entire reach with levees in some locations.

- **River channel gradient and width** – Channel gradient varies from 0.03 to 0.23 percent. The river channel width varies from 160 feet to 280 feet.

- **Presence of salmon spawning and rearing habitat** – All species of salmon are found in the lower White, including Chinook (spring and fall stocks), pink, chum, coho, and sockeye salmon, as well as steelhead, bull and cutthroat trout. Both spawning and rearing habitats are present.

- **Sediment transport accumulation and incision** – Mostly sand and silt accumulate between RM 0.0 and RM 3.0. From RM 3.0 to RM 5.5, there is a mix of cobble, gravel, and sand. The average river bed between RM 0.0 and RM 4.0 changed in elevation from -0.4 feet to +2.0 feet between 1984 and 2009. Upstream of RM 4.0 to the county-line at RM 5.5, the average bed elevation changed from +2.0 feet to +4.8 feet (see Figure 5.11).

In the near term, the primary objective for the lower White River is to maintain the structural integrity of the revetment and levee system so that the facilities continue to reduce risks to public health and safety, and reduce public and private property damage. Another goal is to make improvements to the facilities over time through construction of levees or setback of revetments so that the level of protection is increased to provide flood protection to the 100-year flood. The final management strategy objective is to realize capital projects that enhance and create aquatic habitat through levee or revetment setbacks, riparian revegetation, and strategic placement of large woody material.

The recommended river reach management strategies for the lower White are (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**

- **RM 0.0 – RM 5.5 left bank ; RM 0.0 – RM 1.8 right bank** – The “level of protection goal” for revetments should be channel migration resistance design

- **RM 1.8 – RM 5.5 right bank** - The “level of protection” goal for levees and flow conveyance should be 100-year design plus three feet of freeboard
Non-structural management strategy:

- Floodplain development regulations should be implemented by the cities of Sumner and Pacific consistent with Pierce County critical area regulations for flood hazard areas
- Property acquisition of repetitive loss properties and to enable capital project construction, or purchase of development rights to prevent new floodplain development
5.4.10 Recommended Capital Projects

The following capital improvement projects are recommended to address the priority problem areas identified in Table 5.23. Capital projects are defined as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Pierce County Comprehensive Plan. Projects less than $75,000 are classified as small works.

5.4.10.1 LW1 State Street Flood Wall or Emergency Access

Location Information
Sub Area: Lower White River
Basin Plan: Whiter River (to be adopted)
River Mile: 0.2 – 0.3, left bank
Council District: 2
Jurisdiction: Sumner
Property Ownership Affected: Local government property

Estimated Cost: Approximately $2,000,000

What is the Issue?
State Street is the only access to the Sumner Wastewater Treatment Plant (WWTP) and two single family homes. The Base Flood Elevation in this area is approximately 51 feet and the lowest portion of State Street is at 44 feet. During major flood events, the river overtops the revetment flooding State Street, cutting off access to the wastewater treatment plant and the homes.

What is at Risk?
- Public Infrastructure, State Street
- Lack of access to the Sumner WWTP could potentially affect facility operations

What is the Recommended Solution?
There are two possible solutions in maintaining access to the WWTP. The first option is the construction of an 850 lineal foot floodwall providing three feet of freeboard over the 100 year flood elevation. This floodwall would be integrated into the existing floodwall which surrounds the Sumner Wastewater Treatment Plant. Construction of this option would potentially raise the base flood elevation in the area, requiring compensatory mitigation.

The second option would be the construction of a limited use emergency access road into the WWTP from the State Route 410 Traffic Avenue Off-Ramp. This option would require the purchase of the remaining private parcels located between State Route 410 and the Sumner WWTP.

What are the Project Benefits?
- Construction of the State Street Floodwall would allow State Street to remain open during flood events and maintain access to the WWTP
Construction of the State Route 410 Off-Ramp would provide emergency access to the WWTP during floods, and would not raise the base flood elevation.

**Coordination**


**Environmental Considerations**

Construction of either alternative would not encroach within the riparian area, and not fish and wildlife would be impacted. No habitat mitigation would be anticipated for either alternative.

**Other Information or Needs**

There is concern that the floodwall may cause a backwatering affect on the lower White River. Compensatory flood mitigation may be required.
5.4.10.2  LW2 Lower White River Flood Protection

Location Information
Sub Area:  Lower White River
Basin Plan: Whiter River (to be adopted)
River Mile: 1.8 – 4.9, right bank
Council Districts: 1 and 2
Jurisdiction: Sumner
Property Ownership Affected: Local government and private property

What is the Issue?
Over the last dozen years the right bank of the White River to SR-167 has been converted from farm land to commercial-industrial development. While much of the area has been mapped in the 100-Year floodplain the risk of flooding has increased due to losses in channel capacity at the same time the value of the built environment has increased. The United States Geological Survey (USGS) conducted a flood conveyance capacity or sediment transport study in the lower White river in 1984 and 2009. The studies indicated an average river bed elevation change between 1984 and 2009 of -0.5 feet to +2.0 feet from the mouth of the river to approximately RM 4.0 and a change of +2.0 feet to +5.0 feet from RM 4 to RM 5.5. The channel conveyance capacity in 1984, between RM 2.0 and RM 5.0, was approximately 12,000 cfs to 19,000 cfs.

Since the 2009 study, the channel capacity decreased to from over 15,000 cfs to approximately 10,000 cfs. The reduction in channel conveyance capacity and floodplain area is attributed to several factors, such as commercial, industrial, and residential development in the floodplain, increased deposition of sediments in the channel, encroachment of vegetation, and the restrictions on channel dredging.

What is at Risk?
Damage to commercial and industrial lands and facilities,

- Damage to public roadways,
- Damage to private homes,
- Damage to City trails,
- Financial impacts to local businesses, and
- Local employment

Commercial and industrial properties comprise approximately 31 percent of the land use in the 100-year floodplain. A major flood event would result in temporary loss of business for commercial and industrial properties. Short-term output, income, employment, and tax revenues may decrease. If businesses were to close due to financial effects of flooding, economic activity would be slower to recover, and longer term economic impact would be seen.
What is the Recommended Solution?
Provide a level of protection from the 100-year Flood for the Right Bank from RM 4.9 to RM 1.8. In this section of the river flood waters leave the channel in relatively shallow depth as they spill out onto the broad floodplain. A solution, which combines a feature such as low setback levees, revetments to limit scour and channel widening excavation on the left bank would increase conveyance capacity and provide some mitigation benefits.

What are the Project Benefits?
All scenarios modeled will provide 100 year level of protection to the industrial, commercial, and residential areas located on the right bank between RM 1.8 and RM 5.5. Depending on the scenario, the 100-year floodwater elevation may or may not be lowered. Flood protection may be provided by levees, creating floodwater storage areas through excavation, replacing bridges, or a combination of protection methods. The benefits would include:

- Reduces or eliminates flood damage to local industrial, commercial, and residential properties and structures,
- Ensures transportation corridors to remain open during major flood events,
- Reduces or eliminates financial impacts to local businesses and associated employees

Coordination

Environmental Considerations
The lower White River habitat (RM 0.0 to RM 2.6) is limited by revetments constructed along both banks of the river. The reach is primarily a transport area for salmonids and provides little rearing or spawning opportunity. From RM 2.6 to RM 5.5 the channel remains incised in many areas although some gravel aggradation has occurred. In these areas gravel bars and tight braids occur and the floodplain can be reasonably accessed.

Salmonids found within the lower White River include the spring and fall Chinook, pink, chum, and coho salmon. Other species include the bull, steelhead, and cutthroat trout. The native White River spring Chinook salmon, steelhead, and bull trout are listed as “threatened” under the Endangered Species Act. Particularly important is the stock of White River spring Chinook which were on the brink of extinction in the mid-1980s, but have rebounded recently due to the Washington Department of Fish and Wildlife (WDFW) and South Puget Sound tribes’ brood stock program.
5.4.10.3  LW3 Butte Avenue Levee and Berm

Location Information
Sub Area:  Lower White
Basin Plan:  Whiter River (to be adopted)
River Mile:  4.9 – 5.5, Right Bank
Council District:  2
Jurisdiction:  City of Sumner
Property Ownership Affected:  Private Lands

Estimated Cost:  $1,700,000

What is the Issue?
During high flow periods on the White River, Government (Boeing) Ditch backwaters flooding Butte Avenue, White River Estates, and surrounding industrial land and areas. Low points in the existing berm allow floodwater to cross over Butte Avenue and affect the industrial area.

What is at Risk?
- Damage to industrial land, facilities, and equipment
- Damage to public infrastructure, Butte Avenue
- Damage to private structures, including homes

What is the Recommended Solution?
Modify the existing berm and levee system between Government Ditch and the railroad embankment to raise low spots approximately three feet to prevent future flooding.

What are the Project Benefits?
- Protection of public infrastructure
- Protection of industrial lands, other structures, and equipment

Coordination
This project is located near the Pierce County/King County line. Coordination with King County on the setback levee on the right bank will be necessary during final design. Coordination for
this project includes the Muckleshoot Indian Tribe, Puyallup Tribe of Indians, Pierce County, King County, Washington State Department of Fish and Wildlife, and US Army Corps of Engineers.

**Environmental Considerations**

Salominds found within the lower White River include the spring and fall Chinook, pink, chum, and coho salmon. Other species include the bull, steelhead, and cutthroat trout. The native White River spring Chinook salmon, steelhead, and bull trout are listed as “threatened” under the Endangered Species Act. The river at this location is a transportation corridor with main and side channel rearing and high-flow refuge for adult and juvenile salmon.

This project is a modification of an existing flood protection system along Butte Road. If the project is not considered exempt at the time of application a shorelines permit and critical areas permit will be required. There is no anticipated federal permitting or funding for this project. If after final review, compensatory mitigation is needed that may impact the river, US Army Corps review may be required.
5.5  UPPER WHITE RIVER

5.5.1 Overview
The upper White River reach in the study area extends from approximately RM 43.2 to RM 50.5, from downstream of the community of Greenwater to upstream of Crystal Village and Crystal River Ranch. State Route 410 parallels the river throughout this reach. Large tributaries include the Greenwater River, which enters the White River at RM 44.6 and the West Fork White River, which enters the White River at RM 48.2. Land uses in the reach include two residential communities, Greenwater Village and Crystal Village, which are supported by several commercial businesses located in Greenwater. Revetments have been constructed on the right bank of the river at Greenwater Village along 583rd Avenue East at RM 46.2 and in Crystal Village near RM 50.0. The upper White River has a large sediment discharge and high turbidity levels due to the proximity to its glacial headwaters. Salmon and trout, including spring Chinook, coho, pink, and steelhead, bull trout and cutthroat use this reach of the White River.

5.5.2  Geology and Geomorphology
The White River is unconfined within this reach; however the valley bottom expands in the downstream direction to the community of Greenwater (WRIA 10, WDFW 1977). Generally, the terrain slopes moderately upward away from the river, and in some areas meeting sharply rising mountainside slopes of nearly 5,000 feet. The glacier-fed White River has a braided form, with channel slopes ranging from 0.8 percent to 1.0 percent. The channel is generally straight, which is characteristic of rivers with high sediment loads. Bank erosion occurs throughout the reach; however, the extent is generally localized. River banks are mostly natural earth or rock cuts, but limited bank protection (revetments) occur near bridges and where logging roads abut the river. This reach of the White River was not included in the USGS sediment transport study.
Upper White River Planning Area
RM 44.2 - RM 50.5

Figure 5.37

Pierce County Rivers Flood Hazard Management Plan

Legend
- Project Sites
- River Miles
- Repetitive Loss Property

- Flood Control Facility
- Major Roads
- County Boundary
- Rivers/Streams
- Lakes/Puget Sound
- Regulatory 100 Year Floodplain (within City Boundaries)
- Regulatory 100 Year Floodplain (outside of City Boundaries)
- Channel Migration Zone Floodway

not applicable to White River Study Area
5.5.3 Hydrology and Hydraulics

The upper White River above the confluence with the Greenwater River at RM 44.6 consists of flows primarily from the West Fork White River, White River (mainstem) and Huckleberry Creek. A USGS river gauge originally existed on the upper White River, but it often experienced problems. There are 35 water years of data, when gauge #12098500 functioned from 1929-68. The best available estimates of flood frequency flows are from the 1987 Flood Insurance Study (see Table 5.24). The table does not reflect more recent peak flows from 1990, 1996, 2006 and 2009.

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>White River @ Greenwater River per 1987 Flood Insurance Study (drainage area = 294 sq. mi.)</td>
<td>18,600</td>
<td>25,800</td>
</tr>
<tr>
<td>White River, upstream of confluence with Greenwater River per 1987 Flood Insurance Study (drainage area = 217 sq. mi.)</td>
<td>13,500</td>
<td>18,700</td>
</tr>
</tbody>
</table>

Source: 1987 FEMA Flood Insurance Study based on USGS flow records

5.5.4 Ecological Context and Salmonid Use

The upper White River reach is particularly important ecologically because it provides spawning habitat for all three ESA listed species in the Puyallup River watershed which are bull trout, Chinook, and steelhead salmon. The stock of spring Chinook which spawn in this reach and its tributaries have been identified by NMFS as a priority for the Puget Sound and bear regional significance. It is relatively undeveloped when compared to most watersheds and for this reason is earmarked for preservation by salmonid recovery groups. This reach of the White River is steep, about a 0.90 percent gradient (Williams, 1975) and the bed is composed primarily of medium to large gravel, cobble, and boulders. Large amounts of glacier derived sediment are deposited in this reach and the channel forms into a meandering series of primarily fast flowing riffles and pools. Patches of suitably sized spawning gravel occasionally appear near the confluence with other streams and at the tail out of pools that provide substrate for the construction of redds.
Spring Chinook and steelhead are the species most likely to use the main channel for spawning, but they primarily spawn in the tributaries of the upper White River (see Figure 5.38). Coho and bull trout could use the main channel for spawning, but like the spring Chinook and steelhead, are found in the tributaries. Pink salmon are using the reach in increasing numbers and use the low velocity main channel areas or the tributary streams for spawning. Due to the normally turbid conditions of the main channel, spawning ground counts are often imprecise and likely underestimated for this reach. Juvenile steelhead, spring Chinook, bull trout and cutthroat use this reach for rearing year round.

Figure 5.38 - Spring Chinook spawning is documented on the White River, downstream of the confluence with the Greenwater River from approximately RM 43.0 to RM 44.6
5.5.5 River Management Facilities, Flooding and Flood Damage

The upper White River has a single levee in the vicinity of 583rd Avenue East, just upstream of RM 45.0 on the right bank (Figure 5.39). The levee is owned and operated by Pierce County as summarized in Table 5.25. The taxable assessed value of property and improvements in the floodplain in the upper White and Greenwater River areas is estimated at $36 million (Economic Analysis 2010).

![River Management Facilities, Flooding and Flood Damage](image)

**Figure 5.39 - RM 46.2 right bank levee at 583rd Ave E along the White River**

<table>
<thead>
<tr>
<th>Name</th>
<th>Location a</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenwater Village Levee</td>
<td>RM 46.0 – RM 46.2 RB, PL 84-99</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

a RM = river mile; RB = right bank

Source: Pierce County Surface Water Management records

5.5.5.1 Major Flooding

The White River gauge downstream of the Clearwater River confluence has operated intermittently from 1975 to the present, with several data gaps resulting from damage during large floods. In the last 20 years major flooding in the upper White River occurred in 1990, 1995, 1996, 2006, and 2009 (see Table 5.26). Flow values in the table are shown as “less than” due to the larger drainage area for the Clearwater gauge.
### Table 5.26 Historical Flooding in Upper White River

<table>
<thead>
<tr>
<th>Date</th>
<th>White River Flows downstream of Clearwater River Gauge (#12097850) (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1990</td>
<td>&lt;17,200</td>
</tr>
<tr>
<td>November 1990</td>
<td>&lt;18,400</td>
</tr>
<tr>
<td>November 1995</td>
<td>&lt;20,500</td>
</tr>
<tr>
<td>February 1996</td>
<td>&lt;30,000(^{a})</td>
</tr>
<tr>
<td>November 2006</td>
<td>Not Available</td>
</tr>
<tr>
<td>January 2009</td>
<td>&lt;18,100</td>
</tr>
</tbody>
</table>

\(^{a}\) Estimated value at MMD inflow by US Army Corps of Engineers

Source: Pierce County Surface Water Management and United States Geological Survey

5.5.5.2 Flood Damage to Facilities

The Greenwater Village Levee on the upper White River along the right bank at RM 46.0 to RM 46.2 experienced severe toe and face scour during the November 2006 flood. The damaged levee was partially repaired in December 2006 and completed in summer 2007. Damages are summarized in Table 5.27.

Toe scour of the river bank during November 2006 threatened homes and public drinking water facilities in the Crystal River Ranch vicinity. Rock groins with large woody debris, and gabion basket walls were constructed by the residents of that community.

Significant damage to State Route 410 occurred as a result of the 1996 flood. This section of State Route 410 between RM 43.5 and RM 43.8 is the most prone to damage and ongoing need for repairs following floods and is the most vulnerable stretch of highway outside of Mt. Rainier National Park. In this location, State Route 410 is constructed within the floodplain and experiences flooding on a regular basis. Large rock placed by WSDOT to protect the highway experiences frequent damage due to the force of the White River at this sharp bend in the river channel and needs to be repaired and replaced more frequently than in other areas along the White River.

### Table 5.27 Damages to Facilities in the past 20 years along the Upper White

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenwater Village Levee</td>
<td>RM 46.2 RB</td>
<td>Toe/Slope Failure</td>
<td>100</td>
<td>February 1996</td>
</tr>
<tr>
<td>Greenwater Village Levee</td>
<td>RM 46.1 - RM 46.2 RB</td>
<td>Face Erosion</td>
<td>300</td>
<td>November 2006</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records
5.5.6 Key Accomplishments since the 1991 Flood Plan

5.5.6.1 Major Projects

Major repairs are generally 750 lineal feet or more in length. Records maintained by Pierce County show only one major repair along the upper White River following significantly large storm events (see Table 5.28).

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Estimated Cost</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenwater Village Levee</td>
<td>RM 46.0 – RM 46.2</td>
<td>Severe Toe and Face Erosion</td>
<td>750</td>
<td>$252,5000</td>
<td>Nov. 2006</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

5.5.6.2 Land Purchases

There have been no land purchases or buyouts along the upper White River since 1991.

5.5.7 Flood and Channel Migration Hazard Mapping

5.5.7.1 Flood Hazard Mapping.

Hazard mapping in the upper White River has not been updated since the 1987 flood insurance study. Flood prone areas along the upper White River include State Route 410, Pierce County roads and bridges, and low-density residential areas. The 1987 FIRM maps for the upper White show 443 acres within the special flood hazard area (SFHA) or 100-year floodplain.

5.5.7.2 Channel Migration Hazard Mapping.

Severe, moderate, and low channel migration zones (CMZ) have not been mapped for the upper White River.

5.5.8 Problem Identification

Table 5.29 identifies the flooding and channel migration problems identified in the upper White River floodplain. For more detail on these problems, see Appendix G.
### Table 5.29 Priority Problems Identified in Upper White River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public Safety/Emergency Rescue</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 44.4- RM 44.6 RB</td>
<td>White River channel migration and Greenwater flooding led to isolation of the community of Greenwater and Crystal Mountain in 1996 for several days.</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Channel Migration Problem Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 45.0- RM 45.2 RB</td>
<td>Channel migration threatens 583rd Avenue E. where there is an existing levee and revetment.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 49.0- RM 50.5 LB/RB</td>
<td>Channel migration at Crystal River Ranch and Crystal Village on both sides of the White River threatens property and homes near Crystal Lane and Crystal Drive, and riverward of Alpine Dr. E.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 49.4- RM 49.8 LB</td>
<td>Channel migration and toe scour of river bank during Nov. 2006 flood threatened homes and public drinking water facilities.</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Flooding of Structures and Infrastructure (Roads/Bridges)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 43.5- RM 43.8 RB</td>
<td>Flooding and channel migration along this segment of White River threatens SR-410, resulting in heavy damage on several occasions.</td>
<td>WSDOT</td>
</tr>
<tr>
<td>RM 48.9</td>
<td>Crystal River Ranch Rd. bridge (there are two bridges) – old bridge accumulates LWM on bridge piers; new bridge has abutments vulnerable to washout.</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td><strong>Facility Maintenance and Repair Needs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 46.0- RM 46.2 RB</td>
<td>Levee experienced toe and facing rock scour during November 2006 flood.</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Fish Habitat Problem Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 49.1- RM 50.5 LB/RB</td>
<td>Crystal River Ranch and Crystal Village – Armoring and groin construction reduces channel migration that limits habitat formation.</td>
<td>Puyallup Tribe</td>
</tr>
</tbody>
</table>

RM= River Mile; RB = Right Bank; LB = Left Bank  
Source: Pierce County Surface Water Management records

### 5.5.9 River Reach Management Strategies

In conjunction with updated flood hazard mapping discussed in Section 5.5.7, the recommended river reach management strategies for the upper White River take into account numerous conditions as follows:
• **Development and land use in adjacent floodplain** – The upper White River floodplain has light residential development and a major highway (State Route 410) along the entire reach. The assessed value within the upper White and Greenwater 100-year floodplain is $36 million.

• **River management facilities** – There is a single levee and revetment along the right bank at RM 46.0 to RM 46.2 owned by Pierce County. Bank armoring protects portions of State Route 410 maintained by WSDOT. Limited armoring at the Crystal River Ranch Road Bridge is maintained by Pierce County Transportation Services.

• **River channel gradient and width** – Channel gradient varies from 0.8 to 1.03 percent. River channel width varies from approximately 100 feet to 660 feet.

• **Presence of salmon spawning and rearing habitat** – Species of salmon found in the upper White River include Chinook, pink, coho, steelhead, bull, and cutthroat trout. Both spawning and rearing habitats are present.

• **Sediment transport accumulation and incision** – River bed sediment is dominated by gravel and cobble, with some sand and boulders. Portions of this reach are aggrading and others degrading, but there is no clear trend towards long-term aggradation.

The primary objective for the upper White River reach management strategy is to maintain the structural integrity of the levee and revetment system so the facilities continue to reduce risks to public health and safety, and reduce public infrastructure and private property damage. Another objective is to realize capital projects that enhance and create aquatic habitat through riparian re-vegetation, and strategic placement of large woody material.

Recommended river reach management strategies for the upper White follow (see also 4.7.1 and Appendix F):

**Structural management strategy:**

- RM 44.4 to RM 50.5, right bank - The “level of protection” goal for the existing levees should be to maintain the existing levee prism. The level of erosion protection for revetments should be the channel migration resistance design.

**Non-structural management strategy:**

- Floodplain development regulations should be implemented by Pierce County.
- Property acquisition of repetitive loss properties and acquisition to enable capital project construction, or purchase of development rights to prevent new floodplain development.
5.5.10  **Recommended Capital Projects**

There are no capital projects proposed for the upper White River.
5.6 GREENWATER RIVER

5.6.1 Overview
The Greenwater River lies in northeastern Pierce County and enters the White River at RM 44.6. The headwaters of the Greenwater River are in the Norse Peaks Wilderness area on Castle Mountain, elevation 6700 feet, and it flows northwest for 21 miles to the community of Greenwater. The drainage basin is approximately 76 square miles. Primary tributaries include Maggie, Lost, Pyramid, and Twenty-Eight Mile creeks. Salmon and trout, including spring Chinook, coho, pink, and steelhead are present in the Greenwater River. The river forms part of the easterly boundary between King County and Pierce County. The planning area is from the mouth of the Greenwater River upstream to approximately RM 4.0. Land use consists of forested terrain, recreational and rural residential uses, and the community of Greenwater.

5.6.2 Geology and Geomorphology
Over its lower four miles, the river travels over a relatively broad, flat valley with steeper slopes along the north bank (WRIA 10 Catalogue 1977). The lower five miles of the Greenwater River valley includes a deposit from the Osceola Mudflow, a lahar from Mt. Rainier originating 5600 years ago. The lahar traveled down the White River valley and flowed back into the Greenwater River valley, traveling several miles upstream (Entrix 2007).

Average channel gradient in the project reach is 1.0 to 1.5 percent. Bed materials consist primarily of small gravels to large cobbles (see Figure 5.42). Past logging activities in the watershed destabilized soils both on the hill sides and along the river banks. The resulting instabilities caused landslides, rapid channel migration, destabilizing natural log jams, and coarse sediment loading. These changes altered the river from its natural anabranching form to a more single thread channel. The effects of these changes were pronounced during the 1977 flood and led to an increase in sediment supply downstream, rapid channel widening, and severe flooding. No channel migration zones have been mapped for the lower Greenwater River, nor was the Greenwater River included in the USGS sediment transport study.

---

92 Anabranching – refers to rivers that have distributary channels that depart from the main channel, run parallel or nearly so to the main channel, and then reenter the main channel downstream.
The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.
5.6.3 Hydrology and Hydraulics

The Greenwater River watershed covers about 76 square miles, 60 percent of which is in Pierce County. There is a USGS stream gauge (#12097500) at RM 1.1 on the Greenwater River on the left bank about 0.7 miles east of the community of Greenwater.

The Greenwater sub-basin is approximately 18 percent of the upper White Basin. The Greenwater River had a disproportionately high peak flow of 10,500 cfs, recorded on Dec. 2, 1977. By comparison, the December 9, 1933 flood that set the record on the White River caused only the 7th highest peak on the Greenwater River. Remaining annual peak flows are typically much smaller, including several in the range of 4,500 cfs to 6,000 cfs. Table 5.30 displays estimates of flood frequency flow from the 1987 FEMA Flood Insurance Study (FIS). Using data from more recent peak flow events over the past 20 years, Pierce County used regression analysis to estimate revised flood frequency flows (Table 5.30 and Figure 5.43).
Table 5.30 Greenwater River Flood Frequency Flows at the USGS Greenwater Gauge\textsuperscript{a}

<table>
<thead>
<tr>
<th>Version</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEMA 1987 Flood Insurance Study</td>
<td>5,620 8,080 9,180 11,900</td>
<td>Log Pearson III Fit of Gauge Data with adjustment for Precipitation &amp; Drainage Area</td>
</tr>
<tr>
<td>Updated Curve Fit with data through 2009\textsuperscript{b}</td>
<td>13,500 18,700 20,900 26,400</td>
<td>Log Pearson III Fit of Gauge Data with adjustment for Precipitation &amp; Drainage Area</td>
</tr>
</tbody>
</table>

\textsuperscript{a}The Greenwater River gauge was not operational from 1978 to 1992.

\textsuperscript{b}Pierce County SWM estimated flow and recurrence values are not official nor formally published data and is intended for comparative analysis and reference purposes only.

Source: FEMA (1987), Pierce County Surface Water Management and United States Geologic Survey data

Incorporating data from the past 20 years results in a curve with a steeper slope than the existing FEMA curve (see Figure 5.43), and a forecast for higher peak flows. This is due in part
to the December 1977 flow peak that far exceeded other recorded flow peaks. The floods of November 2006 and January 2009, significant in many other rivers of the study area, were only 10-year and 5-year events, respectively, in the Greenwater River (See Table 5.31).

5.6.4 Ecological Context and Salmonid Use

The Greenwater River is the principal tributary stream for spawning spring Chinook in the Puyallup River watershed. The Greenwater River flows through a steep channel with a narrow flood plain until it enters the study area reach. At about RM 4.0 the river enters a relatively broad floodplain and the stream gradient diminishes to about 1 percent. The channel then takes a mild meander in primarily a single thread channel to the White River. This area is the prime spawning and rearing reach of the river as it contains abundant high quality spawning gravel and a pool-riffle configuration (Marks, E.L et al 2009). Spring Chinook, steelhead, and large numbers of coho and pink salmon spawn in this reach (see Figures 5.44 and 5.45). In addition to the existing habitat, a spring Chinook acclimation pond near RM 11 was constructed in 2007 that can hold over 500,000 juveniles as part of a broodstock program (Puyallup Tribe of Indians).

Past logging practices and the removal of trees from the channel to protect the community of Greenwater and the SR-410 bridge from flooding, has created a deficit in large woody material to supply rearing and adult holding habitat. Replacing large wood has become a recent focus of local watershed recovery groups; 13 engineered log jams were installed in 2011 to increase channel complexity, promote sediment deposition and accumulation of wood (See Figure 5.46).

![Figure 5.44 – White River Spring Chinook spawning in lower four miles of Greenwater River](image-url)
5.6.5 River Management Facilities, Flooding and Flood Damage

Pierce County has not actively maintained flood risk reduction facilities along the Greenwater River within the study area since 1982. There are a series of intermittent revetments along the left bank of the river between RM 0.1 and RM 1.27. King County maintains a series of intermittent revetments along the right bank of the river in the same area. A private revetment exists on the left bank between RM 0.6 to RM 0.7. There is also some armoring at the SR-410 crossing of the Greenwater River near RM 0.1.

5.6.5.1 Major Flooding

In December 1977, the Greenwater River experienced its most severe flooding with a peak flow of 10,500 cfs. Other large floods occurred in 1946, 1959, 1965, 1996, and 2009 (see Table 5.31). The 1977 event caused the most extensive damage. A large log jam at the State Route 410 crossing of the river contributed to extensive flooding and damage in the community of Greenwater.
Table 5.31 Historical Flooding in Greenwater River

<table>
<thead>
<tr>
<th>Date</th>
<th>Greenwater River Flows (#12097500) (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1946</td>
<td>5,000</td>
</tr>
<tr>
<td>November 1959</td>
<td>5,360</td>
</tr>
<tr>
<td>January 1965</td>
<td>5,090</td>
</tr>
<tr>
<td>December 1977</td>
<td>10,500</td>
</tr>
<tr>
<td>February 1996</td>
<td>5,900</td>
</tr>
<tr>
<td>January 2009</td>
<td>4,530</td>
</tr>
</tbody>
</table>

Source: United States Geological Survey Data Records

5.6.5.2 Flood Damage to Facilities

As noted above, there is currently no actively maintained Pierce County flood risk reduction facility on the Greenwater River. The most significant damage occurred during the 1977 peak flood event that affected the State Route 410 Bridge and approaches. Some toe and facing rock protecting the bridge banks and approaches probably have been damaged by the peak flows since 1977. The condition and status of the private revetment is not known.

5.6.6 Key Accomplishments since the 1991 Flood Plan

5.6.6.1 Major Projects

Pierce County has not constructed any projects on the Greenwater River since the 1991 Flood Plan. In 2011, the South Puget Sound Salmon Enhancement Group (SPSSEG) and U.S. Forest Service completed the construction of 13 engineered log jams and the placement of large wood on the Greenwater River between RM 4.5 and RM 7.5 (see Figure 5.46).

Figure 5.46 - (a) ELJs near RM 4.5 on Greenwater River, and (b) pink salmon holding in ELJ pond
5.6.6.2 Land Purchases

- Acquisition of three parcels, consisting of 0.47 acres along the left bank of the Greenwater River near RM 0.7, at a cost of $103,000. Two parcels were vacant. One parcel contained a house at high risk of being destroyed by channel bank erosion. The house was removed.

5.6.6.3 Partnerships

The South Puget Sound Salmon Enhancement Group partnered with USFS, Salmon Recovery Funding Board and Pierce County lead entity to complete the log jam construction.

5.6.7 Flood and Channel Migration Hazard Mapping

5.6.7.1 Flood Hazard Mapping.

Hazard mapping in the Greenwater River has not been updated since the 1987 flood insurance study. Flood prone areas along the Greenwater River include the State Route 410 crossing and residential areas on the left bank, mostly between RM 0 and RM 1.0. The 1987 FIRM maps for the Green Water River show 129 acres within the special flood hazard area or 100-year floodplain. There are no mapped deep and fast flowing areas on the Greenwater River.

5.6.7.2 Channel Migration Hazard Mapping.

Severe, moderate, and low channel migration zones (CMZ) have not been mapped for the Greenwater River.

5.6.8 Problem Identification

Table 5.32 identifies the flooding and channel migration problems in the Greenwater River floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Migration Problem Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.4 - RM 0.7 LB</td>
<td>Channel migration north of Lumpy Lane East threatens 3-5 homes along this reach</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management Records

5.6.9 River Reach Management Strategies

In conjunction with updated flood hazard mapping discussed in Section 5.6.7, the recommended river reach management strategies take into account numerous conditions summarized as follows:
• **Development and land use in adjacent floodplain** – The Greenwater River floodplain has light residential development along the left bank of the river between RM 0.1 and RM 1.3, and a bridge crossing of State Route 410 at RM 0.1.

• **River management facilities** – There are several private revetments along the left bank between RM 0.1 to RM 1.3. Bank armoring also exists at the State Route 410 bridge crossing.

• **River channel gradient and width** – Channel gradient ranges from 1 to 1.5 percent. The river channel varies in width from approximately 50 feet to 200 feet.

• **Presence of salmon spawning and rearing habitat** – Species of salmon found in the Greenwater River include Chinook, pink, coho salmon, and steelhead trout. Extensive spawning of spring Chinook occurs in the lower four miles.

• **Sediment transport accumulation and incision** – The river bed sediment is a mix of sand, gravel, cobble, and boulders. Sediments have become coarser over time due to the extensive removal of large wood following the 1977 flood. The extent of sediment accumulation or decrease has not been determined.

In the near term, the primary objective for the Greenwater River is to maintain the structural integrity of the revetments so the facilities continue to reduce risks to public infrastructure (particularly State Route 410) and private property damage. Another objective is to enhance and create aquatic habitat by replanting riparian areas, and strategically placing large wood material when conducting future repairs.

Recommended river reach management strategies for the Greenwater River are (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**

• RM 0.0 – RM 4.0 - The “level of protection” for revetments should be the channel migration resistance design.

**Non-structural management strategy:**

• Floodplain development regulations should be implemented by unincorporated Pierce County

• Property acquisition or purchase of development rights should be considered on a case-by-case basis
5.6.10 Proposed Capital Projects

There are no capital projects proposed for the Greenwater River.
5.7 CARBON RIVER

5.7.1 Overview

The Carbon River drains an area of 230 square miles that originates on the north face of Mt. Rainier at the Carbon Glacier. The river flows 33 miles downstream joining the Puyallup River downstream of the City of Orting at RM 17.4. This plan concentrates on the lower 8.4 miles, from the eastern end of Alward Road (177th St E) to the confluence with the Puyallup River, and a short segment in the upper Carbon River between RM 22 and RM 24. Most of the lower 8.4 miles lies within unincorporated Pierce County, but the left bank between RM 0.75 and RM 3.5 lies along the easterly border of the City of Orting. Above RM 11.0 the river is contained within steep canyon walls up to the community of Fairfax at RM 17.5 (WRIA 10 Stream Catalogue 1977). From RM 8.5 to RM 11.0, the river is confined within a deep and narrow ravine, below which it broadens into a wider valley with channel splitting and formation of large gravel bars. Between RM 0.0 and RM 8.3, the channel corridor lies in a relatively narrow trough-like valley.

The right bank is largely forested from RM 0.8 to RM 8.4. Below RM 0.8 the right bank is largely agricultural land. The left bank of the river from RM 0.75 to RM 3.54 is within the City of Orting and contains the Orting Wastewater Treatment Plant and single family residential development. Between RM 3.4 and RM 8.3, the left bank land use consists mostly of agricultural and rural residential land. The left bank has a levee from RM 0.1 to RM 5.6 and RM 6.0 to RM 8.2. The right bank has a levee from RM 0.0 to RM 1.2 and RM 5.9 to RM 7.0.

Two major tributaries enter the Carbon River in this reach, Voight Creek at RM 4.0 and South Prairie Creek at RM 5.8. South Prairie Creek is described in Chapter 5.8. Voight Creek, a smaller tributary, collects runoff from the foothills to the south and west and flows across the valley floor before entering the Carbon River (GeoEngineers 2003). The Carbon River contains the most productive mainstem spawning habitat remaining in the Puyallup River watershed for all species of salmon. Chinook, steelhead, chum, and pink salmon are found in relative abundance.
The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. All data is expressly provided 'as is' and 'with all faults'. The County makes no warranty of fitness for a particular purpose.

Legend
- Project Sites
- River Miles
- Repetitive Loss Property
- Flood Control Facility
- Major Roads
- County Boundary
- Rivers/Streams
  - Lakes/Puget Sound
  - Regulatory 100 Year Floodplain (within City Boundaries)
  - Regulatory 100 Year Floodplain (outside of City Boundaries)
  - Channel Migration Zone Floodway

Insert Not To Scale
RM 22.4 - RM 24.0

Pierce County
Public Works & Utilities
Surface Water Management

The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. All data is expressly provided 'as is' and 'with all faults'. The County makes no warranty of fitness for a particular purpose.

Pierce County Rivers Flood Hazard Management Plan

Miles
0 1
0 0.5
1
5.7.2 Geology and Geomorphology

From the confluence with the Puyallup River to just upstream of Orting at RM 4.0, the Carbon River flows next to the Cascadia plateau. The Electron mudflow deposited more than 15 feet of dense clay-rich mud across the Orting Valley. Prior to land development in the valley, the entire length of the Carbon River reach was a continuous complex of braided and multi-threaded meandering channels. As the river reach developed, growing gravel bars within the braided river system forced the river to the sides of the valley walls, leading to erosion of large scalloped cut banks in the mudflow deposits and steep side walls. Beginning in the 1960s, river improvement policies focused on construction of levee and revetments along the Carbon River to straighten the river, increase sediment transport downstream, and prevent valley wall sediment from eroding into the river (GeoEngineers 2003). Since the levees were constructed, residential homes and the Orting Wastewater Treatment Plant have been built near the river in areas historically occupied by the river. The levees changed the river from a complex braided and multi-threaded meandering channel to an essentially straight, single thread stream from RM 0.0 to RM 3.1.

From RM 0.0 to RM 3.1 the gravel and cobble bedload is currently depositing as side bars that build out from channel edges. These lateral bars aggrade into terraces alongside the levees and revetments, reducing channel conveyance (GeoEngineers 2003). The channel gradient from RM 0.0 to RM 4.2 is 0.46 to 0.60 percent, and from RM 4.2 to RM 8.3 the channel gradient varies from 0.72 to 1.15 percent. Typical bed conditions in the upper portion of this reach are shown in Figure 5.48. The mapped severe channel migration zone is quite narrow from RM 0.0 to RM 3.1, with a width from 400 to 1000 feet, and more extensive from RM 3.1 to RM 5.6, with width

![Figure 5.48 - Carbon River bed looking upstream near RM 7.0](image-url)
varying from 800 to 1800 feet (GeoEngineers 2003). Upstream of RM 6.0 to RM 8.3, the severe CMZ varies from 500 to 1200 feet.

Analysis by the USGS (2010) as part of the Sediment Transport Study indicates an average river bed elevation change between RM 0.0 and RM 3.2 of -2.9 feet to +0.3 feet between 1984 and 2009 (see Figure 5.49). From RM 5.6 to RM 6.0, the average bed elevation change is between -1.5 to +2.1 feet. There is no data above RM 6.0 from 1984.

![Figure 5.49 - Change in average river bed elevation between 1984 and 2009 on the Carbon River (segment between 3.2 and 5.5 not available due to problem with 1984 survey)](image)
5.7.3 Hydrology and Hydraulics

Hydrologic analyses established peak discharge-frequency relationships for the Carbon River. Flood frequency flows were estimated for the 10-, 50-, 100-, and 500-year floods using Bulletin #17B procedures (USGS, 1981). The USGS-operated stream gauging station, Carbon River near Fairfax, Washington (#12094000), has recorded peak discharges from water years 1930 to 2010. The gauge is located approximately 15 miles upstream of the Carbon River mouth.

For purposes of the hydrologic analysis, the Carbon River was divided into three segments as follows:

- Downstream segment from the Puyallup River to Voight Creek;
- Middle segment, from Voight Creek to South Prairie Creek; and
- Upper segment, from South Prairie Creek to RM 8.0

Flow estimates for the middle segment were determined by accounting for flows from South Prairie Creek, sub-basin drainage area and precipitation. Regression analysis methods were utilized to compute the peak flow values. The resultant flood frequency flows are summarized in Table 5.32 below. The USGS study of conveyance capacity (USGS 2010) indicates that the Carbon River channel can convey between 15,200 to 23,000 cfs before overtopping either the left or right bank between the mouth and RM 5.6, with one exception at RM 3.7, where the right bank capacity is 6,300 cfs (see Figure 5.50). Above RM 5.8, the conveyance capacity is generally 15,000 or greater cfs, with the exception of the right bank at RM 5.8 (2,500 cfs) and right bank at RM 7.2 (9,300 cfs). The change in conveyance capacity since the 1984 USGS study (Sikonia 1990) has improved below about RM 1.5 due to erosion of the stream bed.

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>10-yr</strong></td>
<td><strong>50-yr</strong></td>
</tr>
<tr>
<td>Mouth to Voight Creek Confluence</td>
<td>13,100</td>
<td>17,600</td>
</tr>
<tr>
<td></td>
<td>18,600</td>
<td>26,800</td>
</tr>
<tr>
<td>Voight Creek Confluence to South Prairie Creek Confluence</td>
<td>11,300</td>
<td>15,300</td>
</tr>
<tr>
<td></td>
<td>15,300</td>
<td>22,100</td>
</tr>
<tr>
<td>South Prairie Creek Confluence to Upstream Study Reach Boundary</td>
<td>6,650</td>
<td>9,350</td>
</tr>
<tr>
<td></td>
<td>8,700</td>
<td>12,700</td>
</tr>
</tbody>
</table>
Source: FEMA (1987, 2009) and United States Geologic Survey Data Records

Figure 5.50 - Channel conveyance capacity for the Carbon River (USGS, 2010)

5.7.4 Ecological Context and Salmonid Use

The Carbon River contains some of the most concentrated areas of productive spawning habitat remaining in the Puyallup River watershed for multiple species of salmon, especially from RM 3.0 to RM 5.8 (Frissel 2000). Figure 5.51 shows the spawning areas within the Carbon River. Spawning Chinook, steelhead, chum, and pink salmon are found in relative abundance. The most productive areas in this reach exist where the unconfined right bank allows for meandering and creation of side channel habitat. The right bank in between RM 3.0 and RM 5.8 segment also offers some excellent summer juvenile rearing habitat where the cool spring water from at the base of the valley wall intersects the river. Abundant numbers of fish may result from the close proximity to the Washington State Department of Fish and Wildlife Voight Creek hatchery and the productive South Prairie Creek.

Both preservation and restoration action along the Carbon River will benefit fish. The unconfined right bank from RM 3.0 to RM 5.8 should be preserved. Projects such as a setback levee along the left bank of Alward Road near RM 7.0 are a high priority for salmon recovery. Potential also exists along the right bank in the lowest two miles of the river.
5.7.5 River Risk Reduction Facilities, Flooding and Flood Damage

On June 5th, 1939 Pierce County approved Resolution No. 686, a plan for flood control of the middle Puyallup River, upper Puyallup River, and Carbon River. The plan was to establish a single channel on the Carbon River and Puyallup River (upstream of the White River confluence) by excavating gravel and river sediments and side casting them to form levees that were armored with rock riprap. This was the standard practice until the 1970s.

Current levees along the Carbon River were primarily built in the 1960s. The once meandering river channel was straightened and confined to an average width of 250 feet. The levee system was designed to prevent sediment sources from the banks and cliffs adjacent to the river from entering the channel contributing to increased sediment transport. It was believed that by constricting the channel width, there would be increased flow velocities to continue sediment transport downstream.

Pierce County currently owns and maintains approximately 10.5 miles of flood risk reduction facilities along the Carbon River in a combination of levees and revetments (see Table 5.34).
### Table 5.34 Levees and Revetments along the Carbon River

<table>
<thead>
<tr>
<th>Name</th>
<th>Location a</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right Bank</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lindsay Levee</td>
<td>RM 16.9 (PR) – RM 1.7, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 5.95 – RM 7.0, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Left Bank</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riddell Levee</td>
<td>RM 0.0 – RM 1.7, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Orting Treatment Plant Levee</td>
<td>RM 1.7 – RM 3.05, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Bridge Street Levee</td>
<td>RM 3.05 – RM 3.7, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Voight Downstream Revetment</td>
<td>RM 3.7 – RM 4.0</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Voight Upstream Revetment</td>
<td>RM 4.0 – RM 4.4</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Guy West Levee</td>
<td>RM 4.6 – RM 5.6, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Guy West Revetment</td>
<td>RM 5.6 – RM 5.95</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 5.95 - RM 6.4, PL 84-99</td>
<td>Pierce County</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 6.55 – RM 8.26, PL 84-99</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

*a RM = river mile; PL 84-99 = USACE Flood Control and Coastal Emergency Act
Source: Pierce County Surface Water Management records

### 5.7.5.1 Major Flooding

Major flooding of the Carbon River occurred in 1933, 1959, 1977, 1990, 1996, 2006, 2008, and 2009 (see Table 5.35). The November 2006 flood is the largest on record, with a measured flow of 14,500 cfs. The categorization of major flooding is based on a threshold of discharges in excess of approximately 10,000 cfs at the Fairfax gauge.
Table 5.35 Historical Major Flooding on Carbon River

<table>
<thead>
<tr>
<th>Date</th>
<th>Carbon River Flows at Fairfax Gauge (cfs) – USGS #12094000a</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1933</td>
<td>11,000</td>
</tr>
<tr>
<td>November 1959</td>
<td>9,970</td>
</tr>
<tr>
<td>December 1977</td>
<td>10,000</td>
</tr>
<tr>
<td>November 1990</td>
<td>13,000</td>
</tr>
<tr>
<td>February 1996</td>
<td>12,000</td>
</tr>
<tr>
<td>December 1996</td>
<td>13,600</td>
</tr>
<tr>
<td>November 2006</td>
<td>14,500</td>
</tr>
<tr>
<td>November 2008</td>
<td>11,700</td>
</tr>
<tr>
<td>January 2009</td>
<td>11,300</td>
</tr>
</tbody>
</table>

Note: There is a gap in the USGS record from 1977 to 1989
Source: Pierce County Surface Water Management and United States Geologic Survey records

5.7.5.2 Flood Damage to Facilities

Flood damages to Carbon River flood risk reduction facilities have been extensive in the past two decades. Six significant flood events have occurred along the study reach since 1990. Damages sustained ranged from full washout of the flood control structure over several hundred lineal feet to localized moderate scour and erosion. Damages from the major flood events resulted in approximately 99 identified damage locations comprising 5.9 miles of levees and revetments. Damages have been estimated at nearly $15 million dollars (based on 2010 dollars). Table 5.36 summarizes levee and revetment segments subject to the most significant and repetitive damages. The upper portion of this Carbon River reach between RM 6.0 and RM 8.3 incurred the most damage. Examples of existing levees on the Carbon River are shown in Figure 5.52.

Table 5.36 Damage to Facilities in the past 20 years along the Carbon River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge Street Levee</td>
<td>RM 3.2 LB</td>
<td>Washout</td>
<td>175</td>
<td>January 1990</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.4 RB</td>
<td>Partial Washout</td>
<td>300</td>
<td>January 1990</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.4 RB</td>
<td>Washout</td>
<td>450</td>
<td>January 1990</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 5.9 LB</td>
<td>No Record Found</td>
<td>400</td>
<td>November 1990</td>
</tr>
</tbody>
</table>
### Table 5.36 Damage to Facilities in the past 20 years along the Carbon River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 6.8 LB</td>
<td>No Record Found</td>
<td>750</td>
<td>November 1990</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 7.2 LB</td>
<td>No Record Found</td>
<td>1,300</td>
<td>November 1990</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.4 RB</td>
<td>No Record Found</td>
<td>500</td>
<td>November 1990</td>
</tr>
<tr>
<td><strong>1995</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RN 6.3 LB</td>
<td>Partial Washout</td>
<td>250</td>
<td>November 1995</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 6.7 LB</td>
<td>Partial Washout</td>
<td>350</td>
<td>November 1995</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.9 RB</td>
<td>Partial Washout</td>
<td>200</td>
<td>November 1995</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 7.1 LB</td>
<td>Washout</td>
<td>700</td>
<td>November 1995</td>
</tr>
<tr>
<td><strong>1996</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lindsay Levee</td>
<td>RM 0.2 RB</td>
<td>Toe/Slope Failure</td>
<td>500</td>
<td>February 1996</td>
</tr>
<tr>
<td>Lindsay Levee</td>
<td>RM 0.8 RB</td>
<td>Toe/Slope Failure</td>
<td>379</td>
<td>February 1996</td>
</tr>
<tr>
<td>Bridge Street Levee</td>
<td>RM 3.6 LB</td>
<td>Washout</td>
<td>350</td>
<td>February 1996</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 6.05 LB</td>
<td>Toe/Slope Failure</td>
<td>250</td>
<td>February 1996</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 6.25LB</td>
<td>Toe/Slope Failure</td>
<td>250</td>
<td>February 1996</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 6.6 LB</td>
<td>Toe Failure</td>
<td>500</td>
<td>February 1996</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.9 RB</td>
<td>Washout</td>
<td>400</td>
<td>February 1996</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 6.9 LB</td>
<td>Toe/Slope Failure</td>
<td>250</td>
<td>February 1996</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 7.1 RB</td>
<td>Washout</td>
<td>800</td>
<td>February 1996</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 7.2 LB</td>
<td>Washout</td>
<td>850</td>
<td>February 1996</td>
</tr>
<tr>
<td><strong>2006</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridge Street Levee</td>
<td>RM 3.6 LB</td>
<td>Face Erosion</td>
<td>200</td>
<td>November 2006</td>
</tr>
<tr>
<td>Voight Downstream Revetment</td>
<td>RM 3.8 LB</td>
<td>Face Erosion</td>
<td>180</td>
<td>November 2006</td>
</tr>
<tr>
<td>Guy West Levee</td>
<td>RM 4.6 – RM 4.9 LB</td>
<td>Toe Erosion</td>
<td>1,700</td>
<td>November 2006</td>
</tr>
<tr>
<td>Guy West Levee</td>
<td>RM 5.0 LB</td>
<td>Face Erosion</td>
<td>270</td>
<td>November 2006</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 6.0 – 6.1 LB</td>
<td>Face Erosion</td>
<td>600</td>
<td>November 2006</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.0 RB</td>
<td>Washout</td>
<td>500</td>
<td>November 2006</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.0 RB</td>
<td>Washout</td>
<td>300</td>
<td>November 2006</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 6.3 LB</td>
<td>Washout</td>
<td>600</td>
<td>November 2006</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.4 RB</td>
<td>Washout</td>
<td>500</td>
<td>November 2006</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.8 RB</td>
<td>Washout</td>
<td>550</td>
<td>November 2006</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 7.5 LB</td>
<td>Washout</td>
<td>1,200</td>
<td>November 2006</td>
</tr>
</tbody>
</table>
### Table 5.36 Damage to Facilities in the past 20 years along the Carbon River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 7.6 LB</td>
<td>Washout</td>
<td>700</td>
<td>November 2006</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 8.3 LB</td>
<td>Face Erosion</td>
<td>300</td>
<td>November 2006</td>
</tr>
<tr>
<td><strong>2008</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riddell Levee</td>
<td>RM 0.4 LB</td>
<td>Toe/Face Scour</td>
<td>634</td>
<td>November 2008</td>
</tr>
<tr>
<td>Bridge Street Levee</td>
<td>RM 3.5 LB</td>
<td>Toe/Face Scour</td>
<td>300</td>
<td>November 2008</td>
</tr>
<tr>
<td>Bridge Street Levee</td>
<td>RM 3.6 – RM 3.7 LB</td>
<td>Toe/Face Scour</td>
<td>380</td>
<td>November 2008</td>
</tr>
<tr>
<td>Voight Upstream Revetment</td>
<td>RM 4.2 LB</td>
<td>Washout</td>
<td>324</td>
<td>November 2008</td>
</tr>
<tr>
<td>Guy West Levee</td>
<td>RM 4.8 LB</td>
<td>Undercut Bank And Piping</td>
<td>1,200</td>
<td>November 2008</td>
</tr>
<tr>
<td>Guy West Levee</td>
<td>RM 5.0 LB</td>
<td>Toe/Face Scour</td>
<td>290</td>
<td>November 2008</td>
</tr>
<tr>
<td>Guy West Levee</td>
<td>RM 5.2 LB</td>
<td>Toe/Face Scour</td>
<td>196</td>
<td>November 2008</td>
</tr>
<tr>
<td>Guy West Levee</td>
<td>RM 5.3 LB</td>
<td>Toe/Face Scour</td>
<td>253</td>
<td>November 2008</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.0 RB</td>
<td>Toe/Face Scour</td>
<td>336</td>
<td>November 2008</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 6.0 RB</td>
<td>Face Scour</td>
<td>824</td>
<td>November 2008</td>
</tr>
<tr>
<td>Alward Segment No 2 Levee</td>
<td>RM 6.25 LB</td>
<td>Toe/Face Scour</td>
<td>302</td>
<td>November 2008</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.45 – RM 6.6 RB</td>
<td>Toe/Face Scour</td>
<td>900</td>
<td>November 2008</td>
</tr>
<tr>
<td>Alward Segment No 1 Levee</td>
<td>RM 7.2 – RM 7.3 LB</td>
<td>Toe/Face Scour</td>
<td>796</td>
<td>November 2008</td>
</tr>
<tr>
<td><strong>2009</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.2 RB</td>
<td>Toe/Face Scour</td>
<td>255</td>
<td>January 2009</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.4 RB</td>
<td>Toe/Face Scour</td>
<td>310</td>
<td>January 2009</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.75 RB</td>
<td>Toe/Face Scour</td>
<td>200</td>
<td>January 2009</td>
</tr>
<tr>
<td>Riddell Levee</td>
<td>RM 0.9 LB</td>
<td>Toe/Face Scour</td>
<td>180</td>
<td>January 2009</td>
</tr>
</tbody>
</table>

RB= Right Bank; LB= Left Bank

Source: Pierce County Surface Water Management records
5.7.6  Key Accomplishments since the 1991 Flood Plan

5.7.6.1  Major Projects

Since 1991, major repairs (generally 750 lineal feet or more in length) have occurred along the Carbon River following large flood events (see Table 5.37). Records maintained by Pierce County Surface Water Management show that the most extensive repairs have occurred between RM 6.0 and RM 7.6. Since 1991 no new flood risk reduction facilities have been constructed.

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Approx. Location</th>
<th>Damage</th>
<th>Length</th>
<th>Estimated Cost</th>
<th>Flood Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Bank</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.8</td>
<td>Toe damage and face scour</td>
<td>1,075</td>
<td>$357,500</td>
<td>December 2007</td>
</tr>
<tr>
<td>Water Ski Levee</td>
<td>RM 6.45 – RM 6.6</td>
<td>Face scour</td>
<td>900</td>
<td>$279,000</td>
<td>November 2008</td>
</tr>
<tr>
<td>Left Bank</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alward Rd Levee</td>
<td>RM 7.2</td>
<td>Full washout</td>
<td>850</td>
<td>$485,350</td>
<td>February 1996</td>
</tr>
<tr>
<td>Alward Rd Levee</td>
<td>RM 7.5</td>
<td>Full washout</td>
<td>1,200</td>
<td>$960,000</td>
<td>November 2006</td>
</tr>
<tr>
<td>Alward Rd Levee</td>
<td>RM 6.6 – RM 6.7</td>
<td>Full washout</td>
<td>810</td>
<td>$283,500</td>
<td>December 2007</td>
</tr>
<tr>
<td>Alward Rd Levee</td>
<td>RM 7.2 – RM</td>
<td>Full washout</td>
<td>850</td>
<td>$425,000</td>
<td>December 2007</td>
</tr>
</tbody>
</table>
Table 5.37 Major Projects Completed on Carbon River since 1991 Flood Plan

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Approx. Location</th>
<th>Damage</th>
<th>Length</th>
<th>Estimated Cost</th>
<th>Flood Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alward Rd Levee</td>
<td>RM 6.0</td>
<td>Face rock scour &amp; core exposure</td>
<td>824</td>
<td>$288,400</td>
<td>November 2008</td>
</tr>
<tr>
<td>Alward Rd Levee</td>
<td>RM 7.2 – RM 7.3</td>
<td>Toe scour and loss of face rock. Lower face slumping.</td>
<td>796</td>
<td>$398,000</td>
<td>November 2008</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

5.7.6.2 Land Purchases

A significant number of parcels and flood damaged homes have been purchased along the Carbon River since the 1991 flood plan was adopted.

Pierce County SWM acquired 193 acres of land divided into 43 parcels, 16 of which contained structures, at a total cost of $4.1 million. Thirty-one of the parcels were purchased largely with Real Estate Excise Tax (REET) funds at a cost of $1.9 million. The remaining twelve parcels, all of which contained homes were purchased using Hazard Mitigation Grant Program (HMGP) funds (75 percent federal funding) at a total cost of $2.2 million following federal disaster declarations related to the 2006 flooding.

5.7.6.3 Partnerships

As noted above, Pierce County has partnered with FEMA following disaster declarations #1671 and #1682 to purchase numerous flood damaged or repetitive loss properties resulting from the November 2006 flood. HMGP grants pay 75 percent of acquisition costs, with match of 12.5 percent from the State of Washington and 12.5 percent from Pierce County.

5.7.7 Flood and Channel Migration Hazard Mapping

5.7.7.1 Flood Hazard Mapping.

Flood hazard mapping for the Carbon River includes detailed flood studies (FEMA 2009, NHC 2006) and the creation of preliminary Digital Flood Insurance Rate Maps (DFIRM). As of the publication of this document FEMA has not issued new maps. Flood prone areas along the Carbon River include residential and commercial lands, schools in the City of Orting, and agricultural land both upstream and downstream of Orting. The preliminary DFIRM maps for the Carbon River show 1,317 acres within the special flood hazard area or 100-year floodplain. The mapped deep and fast flowing area is 945 acres.

5.7.7.2 Channel Migration Hazard Mapping.

Severe, moderate, and low channel migration zones (CMZ) were mapped for the Carbon River (GeoEngineers 2003) and adopted in November 2004. The CMZ refers to the geographic area
where a stream or river has been and is susceptible to channel erosion and/or channel occupation (WSDOE 2003). The severe CMZ covers an area of 999 acres along the Carbon River. Pierce County regulates severe CMZ mapped areas as floodway per Chapter 18E.70, Pierce County Code.

5.7.8 Problem Identification

Table 5.38 lists the flooding and channel migration problems identified in the Carbon River floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Levee and Revetment Overtopping and Breaching</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.0 - RM 1.2 LB</td>
<td>Levee overtopping observed at or near RM 0.0 (2006) and RM 0.4 (2009). 400 LF of washout at RM 0.8 in 1990. Threatens SR-162 and homes</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 0.0 - RM 1.2 RB</td>
<td>Levee washout of 400 LF at RM 0.8 (1990) and 150 LF at RM 1.2 (2006)</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 3.0 - RM 3.8 LB</td>
<td>Levee overtopping and breaching in 1996, 2006 and 2009 at RM 3.6-3.7; Additional washouts between RM 3.0 and 3.2 in 1990 and 2006</td>
<td>City of Orting; Pierce County; WSDOT</td>
</tr>
<tr>
<td>RM 3.9 – RM 5.9 LB</td>
<td>Levee has experienced major damages (face and toe scour and undercut banks) in last 3 major flood events in 2006, 2008 and 2009.</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 6.0 - RM 6.4 LB</td>
<td>Levee has experienced repetitive damages since 1990, including overtopping at RM 6.0 and 6.1 in 2006 (see Table 5.7.4 above)</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 6.0 - RM 6.4 RB</td>
<td>Levee has experienced repetitive damages since 1990. One home washed into river and flooding of SR-162 in 2006 (see Table 5.7.4 above)</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 6.4 - RM 8.3 LB</td>
<td>Levee has experienced repetitive damages since 1990 (see Table 5.7.4 above).</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 6.4 - RM 8.3 RB</td>
<td>Levee has experienced repetitive damages since 1990 (see Table 5.7.4 above). Levee/revetment has not been repaired above RM 7.0 since 2006</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Tributary Backwater Flooding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.45 - RM 0.8 LB</td>
<td>Orting stormwater outfall near RM 0.8 has no outlet to river; backwater conditions near RM 0.45 over-saturates levee from RM 0.45-0.8</td>
<td>City of Orting, Pierce County</td>
</tr>
<tr>
<td>RM 1.7 - RM 3.65 LB</td>
<td>Backwater channel flows downstream behind levee and discharges to river behind Orting waste water treatment plant at RM 1.7</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 3.9 - RM 4.0 LB</td>
<td>Voight Creek and Coplar Creek backwater along riparian zone behind levee resulting in flooding along Corrin Ave. NW and SR-162; also some backwater effects upstream to hatchery</td>
<td>City of Orting, Pierce County</td>
</tr>
</tbody>
</table>
Table 5.38 Priority Problems Identified in Carbon River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 6.45 LB</td>
<td>Backwater flooding of small creek behind fish ladder (on south side of Alward Rd.) occurred in 2006 and 2008</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Public Safety/Emergency Rescue</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 6.4 - RM 8.4 LB</td>
<td>Levee breach and flooding along Alward Rd. and failure to evacuate led to emergency rescue in 2006 (helicopter and boat); evacuations also occurred in 1996</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Channel Migration Problem Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 7.0 - RM 7.9 RB</td>
<td>Channel migration during 2006 and 2009 events eroded right bank levee/revetment exposing steep slopes and valley wall to erosion</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 6.0 - RM 8.0 LB</td>
<td>This segment highly susceptible to channel migration due to high sediment load affecting left bank levees and revetments</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 22.4 - RM 24.0 LB</td>
<td>Channel migration near entrance to Mt. Rainier National Park impacting county access road (Fairfax Forest Reserve Road); washouts in 2006 and 2008</td>
<td>Mt. Rainier National Park; Pierce County Roads</td>
</tr>
<tr>
<td><strong>Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.0 - RM 0.5 RB</td>
<td>McCutcheon Rd. closures caused by Carbon River flooding near the mouth of Carbon River</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 4.2 - RM 5.8 LB</td>
<td>SR-162 floods along Carbon River east of Orville Rd.</td>
<td>WSDOT</td>
</tr>
<tr>
<td><strong>Sediment and Gravel Bar Accumulation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.0 - RM 3.0</td>
<td>Gravel deposition reduces channel conveyance capacity and threatens levee/revetments in this segment; Orting has identified 20+ gravel bars</td>
<td>Pierce County, City of Orting</td>
</tr>
<tr>
<td>RM 3.0 - RM 5.9</td>
<td>Gravel accumulation reduces channel conveyance capacity and contributes to overbank flow in this segment (see Figure 5.7.3) and exacerbate levee damages</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 5.9 - RM 8.4</td>
<td>This segment has high bluffs along right bank between RM 7.0 and 8.0 contributing large sediment load to river</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 24 - RM 29</td>
<td>Gravel and debris accumulation increases risk of flooding and channel migration</td>
<td>Public Input (Meeting #1)</td>
</tr>
<tr>
<td><strong>Facility Maintenance and Repair Needs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Repetitive damages noted in Table 5.7.4 above and under “levee/revetment overtopping and breaching” portion of this table</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 6.4 LB</td>
<td>Revetment damage resulted in washout of 177th St. E. (Alward Rd.) exposing water main in 2008</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Fish Habitat Problem Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.0 – RM 3.0 LB/RB</td>
<td>Levee/revetment construction cut off floodplain from river channel, preventing off-channel rearing and refuge for salmon and flood</td>
<td>Puyallup Tribe</td>
</tr>
</tbody>
</table>
Table 5.38 Priority Problems Identified in Carbon River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>storage (Carbon confluence, Right Bank Carbon, High School, Bridge St. (sites 21, 22, 23, 24 in feasibility report)</td>
<td></td>
<td>Pierce County Surface Water Management records</td>
</tr>
<tr>
<td>RM 4.5 – RM 5.5 LB</td>
<td>Levee/revetment construction cut off floodplain from river channel, preventing off-channel rearing for salmon and flood storage (West setback – site 25 and Rauch Creek restoration potential)</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>RM 6.3 – RM 6.4 LB</td>
<td>Rocks displaced from levees block fish passage at Bradley Creek fish ladder near Alward Rd.</td>
<td>Public Input (Meeting #1)</td>
</tr>
<tr>
<td>RM 6.4 – RM 8.3 LB</td>
<td>Existing levee constricts channel migration in a high energy segment of Carbon River and results in loss of side-channel habitat for Chinook, steelhead and other salmon (Alward Rd. setback – site 26 in feasibility report)</td>
<td>Pierce County, Puyallup Tribe</td>
</tr>
</tbody>
</table>

5.7.9 River Reach Management Strategies

The recommended river reach management strategies take into account numerous conditions summarized as follows:

- **Development and land use in adjacent floodplain** – The Carbon River floodplain has a relatively small portion that is urban along the east edge of Orting. Agricultural and low-density residential lands exist near the mouth, upstream of Orting, and along Alward Road. The assessed value of real property within the 100-year floodplain is approximately $79 million.

- **River risk reduction facilities** – Both the left and right banks of the Carbon River are constrained by levees and revetments, with the exception of the right bank from RM 1.3 to RM 5.9 and RM 7.0 to RM 8.4 adjacent to steep valley walls.

- **River channel gradient and width** – Channel gradient varies from 0.46 to 0.60 percent between RM 0.0 to RM 3.9 and 0.6 to 1.15 percent between RM 3.9 and RM 8.4. The river channel width generally varies from 160 feet to 420 feet, but is substantially wider at RM 3.5 and from RM 4.0 to RM 6.0, with the width varying from 540 feet to 890 feet.

- **Presence of salmon spawning and rearing habitat** – Species of salmon found in the Carbon River include Chinook, pink, coho and chum salmon, as well as steelhead and bull trout. The highest concentration of spawning occurs from approximately RM 3.0 to RM 6.0.

- **Sediment transport accumulation and incision** – Mostly cobbles, gravel, and sand are present in the river bed in the lower 8.4 miles of the Carbon River, with some boulders above RM 6.0. The average river bed between the mouth (RM 0) and RM 3.2 changed in elevation from -2.9 feet to +0.3 feet between 1984 and 2009. From RM 5.6 to RM 6.0, the average bed elevation change is between -1.5 to +2.1 feet. Between RM 3.2 and RM
5.6, bed elevation changes are unknown. From observation by Pierce County personnel, the Carbon River segment between RM 6.0 and RM 8.4 appears to be in a cycle of substantial sediment aggradation.

In the near term, the primary objective for the Carbon River is to maintain the structural integrity of the levee and revetment system so the facilities continue to reduce risks to public health and safety and reduce public and private property damage. Another objective is to construct setback levees to increase the level of flood protection to the 100-year flood in the City of Orting. The final management strategy objective is to realize capital projects that enhance and create aquatic habitat through levee or revetment setbacks, riparian re-vegetation, and strategic placement of large woody material in addition to providing flood protection.

The recommended river reach management strategies for the lower Carbon are (see subsection 4.7.1 and Appendix F):

**Structural Management Strategies:**

- RM 0.8 to RM 3.9 left bank – The “level of protection” goal for levees and flow conveyance should be the 100-year design plus three feet of freeboard in the City of Orting.

- RM 0.0 to RM 0.8 left bank; RM 3.9 to RM 8.4 left bank; RM 0.0 to RM 1.3 right bank; and RM 5.9 to RM 7.0 right bank – The “Level of protection” goal for levees should be to maintain the existing levee prism.

**Non-structural Management Strategies:**

- Floodplain development regulation consistent with Pierce County critical area regulations for flood hazard areas should be administered by the City of Orting.

- Property acquisition of repetitive loss properties and to enable capital project construction, or purchase of development rights to prevent new floodplain development. A particular area of focus is the left bank from RM 6.0 to RM 8.4.
5.7.10  Recommended Capital Projects

The following capital improvement projects are recommended to address the priority problem areas identified in Table 5.37. Capital projects are defined as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Pierce County Comprehensive Plan. Projects less than $75,000 are classified as small works.

5.7.10.1  C1 Carbon Confluence Setback Levee

Location Information

Sub Area: Carbon River
Basin Plan: Carbon River/ Upper Puyallup (future)
River Mile: 0.0 – 0.4, Left Bank
Council District: 1
Jurisdiction: Pierce County
Property Ownership Affected: Private and public lands

Estimated Cost: $5,300,000

What is the Issue?

This section of the Carbon River was confined by levees and revetments beginning in the early 1930s and completed by the 1960s. Records indicate the levees reduced the width of the high flow channel from 700 feet in 1931 to approximately 250 feet in 1965. This reduction in channel flow is causing overtopping of the levees, threatening State Route 162 and surrounding private property. The high velocity created by the narrowed river channel is damaging the older levee system within this segment of the river, leading to higher ongoing maintenance costs.

What is at Risk?

- Damage to private property,
- Damage to infrastructure and State Route 162, and
- Damage to levee segments on the left and right bank of the Carbon River.

What is the Recommended Solution?

Construction of a setback levee between RM 0.0 and RM 0.4 would include acquisition of three properties within the floodplain, removal of the 2,200 lineal feet of existing levee and construction of a new 2,300 lineal feet setback levee. A setback levee within this section will widen the channel and slow the velocity of the river, reducing scour action.
**What are the Project Benefits?**

- Protection of infrastructure and State Route 162 from flooding
- Returning 16.5 acres to the active floodplain and increasing floodplain complexity

**Coordination**


**Environmental Considerations**

This project is located in an area utilized by ESA listed Chinook salmon, bull trout and winter steelhead. Coho salmon are also know to be present.
5.7.10.2  C2 Carbon Levee Bank Stabilization / Flow Deflection and Coplar Creek Backwater Improvements

Location Information

Sub Area: Carbon River
Basin Plan: Carbon River/ Upper Puyallup (future)
River Mile: 3.2 – 4.9, Left Bank
Council District: 1
Jurisdiction: Pierce County, City of Orting
Property Ownership Affected: Private and public lands

Estimated Cost: $2,700,000

What is the Issue?

In the 1990s the river moved its channel from the right bank to the left bank between RM 3.6 and RM 4.2, pushing the river up against the levee. Voight Creek enters the Carbon River at RM 3.98. During periods of high flows in the Carbon River, Voight Creek and its tributary Coplar Creek are unable to discharge and backwater behind the levee. Depending on the volume of water, the Voight and Coplar creek flows will split with a portion continuing north into the City of Orting and the remainder flowing under the Foothills Trail and flooding adjacent property. The existing levee currently does not provide a 100-year level of service.

What is at Risk?

- Damage to private property and structures
- Damage to public infrastructure

Figure 5.54 – Proposed engineered log jam location
What is the Recommended Solution?

With the active channel against the levee there is an increase in the potential for overtopping and scour of the existing infrastructure creating long term maintenance and operation costs. The project will install approximately 15 – 20 engineered log jams or dolotimbers within the active channel to encourage the river to migrate away from the levee/revetment back to its former channel on the right bank of the river.

What are the Project Benefits?

- Protection of existing levee system,
- Protection of Foothills trail,
- Reduced long-term maintenance costs, and
- Creates new habitat within the active channel.

Coordination


Environmental Considerations

This project is located in an area utilized by ESA listed Chinook salmon, bull trout and winter steelhead. Chinook and winter steelhead spawn in this section of the river. Coho salmon are also know to be present.
5.7.10.3 C3 Alward Road Floodplain Acquisition

**Location Information**

Sub Area: Carbon River
Basin Plan: Carbon River/ Upper Puyallup (future)
River Mile: 6.0 – 6.4, Left Bank
Council District: 1
Jurisdiction: Pierce County
Property Ownership Affected: Private lands and residents

**Estimated Cost:** $1,200,000

**What is the Issue?**

The existing levee provides less than 50-year level of protection. The existing base flood elevation is between 307 feet and 331.6 feet. Portions of the existing levee are two feet below the base flood elevation and the surrounding development sits three to four feet below base flood elevation and are located within an area mapped as “Deep and Fast Flowing” Floodway. During flood events the levee overtops and floods surrounding development.

**What is at Risk?**

- Ten adjacent properties are in immediate danger of flood damage and are located within the Deep and Fast Flowing Floodway,
- Public infrastructure, including State Route 162 bridge and approaches and the Foothills Trail bridge, and
- Potential flooding of Alward Road (177th St East) and State Route 162.

**What is the Recommended Solution?**

The existing levee would remain to protect the State Route 162 and the Foothills Trail Bridges. Ten properties would be purchased and the structures removed allowing the area to revert to open space floodplain.

*Figure 5.55 – Air photo of SR 162 and Foot Hills Trail bridges over the Puyallup River*
What are the Project Benefits?

- Removal of properties from danger of flooding,
- Reduced safety threat to residents, and
- Increased floodplain storage.

Coordination

Pierce County; need demolition permit from building department, Puget Sound Clean Air Agency

Environmental Considerations

There are no anticipated environmental impacts.
5.7.10.4  C4 Alward Road Floodplain Acquisition and Setback Levee

Location Information
Sub Area: Carbon River
Basin Plan: Carbon River/ Upper Puyallup (future)
River Mile: 6.4 – 8.8, Left Bank
Council District: 1
Jurisdiction: Pierce County
Property Ownership Affected: Private and public lands

Estimated Cost: $29,600,000

What is the Issue?

The Carbon River transports significant amounts of sediment and woody material from Mount Rainier and the upper watershed river banks. During normal flows this segment of the river is unable to transport the large quantities of material moving through the system. This causes the excess material to deposit within the channel. The excess material remains in place until flood events provide enough energy and velocity to suspend the material and move it downstream. As flows increase and water levels rise, excess gravel material reduces channel conveyance capacity, thereby contributing to flooding within this segment. Additionally, this segment of the river is within the mapped severe Channel Migration Zone hazard area. Repeated damages in this area from the November 2006 and January 2009 flood events has caused over $3.5 million in damages to the existing levee system and over $2 million in damages to adjacent private properties. During the same time frame substantial damages of several private residences resulted in complete losses of structures. In November 2006, an emergency rescue of a family by helicopter was necessary.

Figure 5.57 – Air photo of flood near Alward Road
What is at Risk?

- Public infrastructure,
- Severe risk to adjacent properties located between Alward Road and Carbon River, and
- Public Safety and Welfare.

What is the Recommended Solution?

Acquisition of approximately 43 properties located north of Alward Road. Pierce County currently owns 19 parcels within this same area. A new 9,800 lineal foot levee would be constructed along Alward Road which includes removal of the existing levee. To increase roughness along the levee, 25 engineered log jams would be installed along the left and right bank of the river. The ELJs will provide protection against erosion, scour, and undercutting of the levee and river banks. A new fish passage culvert will need to be incorporated within the setback levee for the unnamed tributary which enters on the left bank at RM 7.4.

What are the Project Benefits?

- Reconnection of 1,175 acres of riparian floodplain to the Carbon River,
- Enhanced fish habitat,
- Increased floodplain storage, and
- Substantial reduction in public safety risks.

Coordination


Figure 5.58- Potential location of Alward Road setback levee
Environmental Considerations

This project is located in an area utilized by ESA listed Chinook salmon, bull trout and winter steelhead. Coho salmon are also known to be present. Some spawning occurs in this segment. Coho salmon and cutthroat trout have been identified within the un-named stream which enters at RM 7.4 left bank.
5.7.10.5  C5 Upper Carbon/Fairfax Road Bank Stabilization

Location Information

Sub Area: Carbon River
Basin Plan: Carbon River/ Upper Puyallup (future)
River Mile: 22.4 – 24.0, Left Bank
Council District:
Jurisdiction:
Property Ownership Affected:

Estimated Cost: $1,500,000

What is the Issue?

Channel migration along the left bank of the Carbon River near the Carbon River Entrance to Mount Rainier National Park is impacting the access road, Fairfax Forest Reserve Road and the park entrance. Approximately one mile is within the 100-year floodplain. The park entrance road within the park boundary has been washed out twice, in 2006 and 2008. After the second washout the decision was made to not rebuild the road.

What is at Risk?

- Adjacent US Forest Service Land, and
- Fairfax Forest Reserve Rd and Carbon River entrance to Mt. Rainier National Park.

What is the Recommended Solution?

To protect the two miles of Fairfax Forest Reserve Road, three engineered log jams with large rock and wood matrix would be installed along the left bank of the Carbon River. In addition, six engineered log jams would be installed at two locations, RM 23 and RM 23.7. Installation will stabilize the river bank and direct the river away from the bank.

Figure 5.59 – (a) potential location of engineered log jams to protect Fairfax Forest Reserve Road; (b) looking downstream on Carbon River at project location
**What are the Project Benefits?**

- Protection of Fairfax Reserve Road and entrance to Mount Rainier National Park,
- Improvement of salmonid habitat, and
- Reduced maintenance costs for river bank armoring.

**Coordination**


**Environmental Considerations**

This project is located in an area likely utilized by ESA listed bull trout and winter steelhead. The shoreline within the project area has been designated as Natural, a more restrictive designation than other designations.
5.8 SOUTH PRAIRIE CREEK

5.8.1 Overview

South Prairie Creek lies in the center of the Puyallup River Basin, east of the City of Orting. South Prairie Creek has a drainage basin of 90 square miles and ranges in elevation from 285 feet above sea level to 5,933 feet at the summit of Pitcher Mountain (USGS 1998). The focus of this study area is the lower floodplain area of South Prairie Creek between RM 0.0 and RM 6.4 extending from the confluence with the Carbon River (RM 5.9) to the upstream end of the Town of South Prairie. From 1950 to 2009, South Prairie Creek experienced nine flood events over 5000 cubic feet per second (cfs). The two largest peak flows, over 8000 cfs, occurred in 1996 and 2009. Tributaries to South Prairie Creek include Wilkeson Creek, Spiketon Creek, and Beaver Creek.

Land use consists of agricultural and rural residential, and the Town of South Prairie. There are no Pierce County levees along lower South Prairie Creek, but there are isolated rock riprap revetments and earthen berms that have been constructed by agricultural and residential landowners, and near State Route 162 bridge crossings of the creek. Salmon and trout, including fall Chinook, coho, pink, chum and steelhead use South Prairie Creek. South Prairie Creek is one of the most productive salmon and steelhead tributaries in the entire Puyallup River Basin.

5.8.2 Geology and Geomorphology

The subsurface geology consists mostly of sedimentary and volcanic rock. Surface geology consists primarily of unconsolidated Pleistocene glacial-drift deposits, known as Vashon Drift, with small areas of mudflow deposits (USGS 1998). About 5,600 years ago after volcanic eruptions on Mt. Rainier, the Osceola mudflow flowed down the White River, and a sizable lobe flowed down the South Prairie Creek valley. Prior to this event, the White River flowed through a narrow gorge at the south end of Mud Mountain and occupied the present day South Prairie Creek Valley. The massive lahar diverted the White River into its historic course and created the much smaller South Prairie Creek watershed, a stream lacking the power to mobilize the large amount of alluvium93 on the valley floor deposited by the historic White River and the lahar. Much of the mudflow material remains exposed on the surface of the lower valley. The remainder has been eroded and replaced with recently deposited gravel and cobble alluvium in the stream channel and silt and sand in the adjacent floodplain (USGS 1998, Crandell 1963).

93 Alluvium – A general term for all deposits laid down by present-day rivers, especially at times of flood.
Figure 5.60
South Prairie Creek Planning Area
RM 0 - RM 6.4
Pierce County Rivers Flood Hazard Management Plan

Legend
- Project Sites
- River Miles
- Repetitive Loss Property
- Flood Control Facility
- Major Roads
- County Boundary
- Rivers/Streams
- Lakes/Puget Sound
- Regulatory 100 Year Floodplain (within City Boundaries)
- Regulatory 100 Year Floodplain (outside of City Boundaries)
- Channel Migration Zone Floodway

The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations ascertained by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.
The South Prairie Creek valley is about 1000 feet wide with steep valley walls that range from 100 to 250 feet in height (GeoEngineers 2005). The presence of the Osceola mudflow and the abrupt decrease in basin size has had significant effects on the fluvial and geomorphic character of South Prairie Creek. Many segments of South Prairie Creek show evidence of incision and vertical channel migration, as demonstrated by riprap stranded high on channel banks and undercut root systems of riparian trees. The average channel gradient varies from 0.27 to 0.46 percent between RM 0.0 and RM 3.5 and from 0.60 to 0.80 percent between RM 3.5 and RM 5.8. Channel migration in South Prairie Creek is limited insufficient energy to mobilize the floodplain alluvium laid down from the historic White River and the Osceola mudflow. South Prairie Creek was not included in the USGS Sediment Transport Study.

### 5.8.3 Hydrology and Hydraulics

The South Prairie Creek USGS Gauge Station (#12095000) has a 53-year record (1950 to 2011, with a gap from 1979-1987). The gauge measures 87 percent of the 90 square-mile basin area. Flood concerns and problems in recent years involve flood damage to private property including house structures and driveway access, as well as public utilities and roadway infrastructure. In addition, South Prairie Creek is incised along several segments.

The hydraulic model and Flood Insurance Mapping Study for South Prairie Creek was completed for FEMA in 2006 (NHC 2006). However, peak flows from 2006 and 2009 warranted further analysis to see how the additional flows would affect flood flow frequencies. The NHC (2006) and SWM (2009) flood frequency flows are shown in Table 5.39 for the 10-, 50-, 100-, and 500-year floods.

<table>
<thead>
<tr>
<th>Version</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-yr</td>
<td>50-yr</td>
</tr>
<tr>
<td>South Prairie Creek at USGS gauge</td>
<td>5,030</td>
<td>6,640</td>
</tr>
<tr>
<td>South Prairie Creek at USGS gauge</td>
<td>6,200</td>
<td>8,600</td>
</tr>
<tr>
<td>South Prairie Creek at USGS gauge with Updated Curve Fit with data through 2009a</td>
<td>6,350</td>
<td>9,100</td>
</tr>
</tbody>
</table>

a SWM regression analysis (not official or formal published data)

Source: FEMA (1987, 2009), Pierce County Surface Water Management and United States Geologic Survey records
5.8.4 Ecological Context and Salmonid Use

South Prairie Creek is the most productive tributary stream for salmonids in the Puyallup River watershed. Without the productivity of this stream, Chinook and steelhead populations in the Puyallup River watershed may not be sustainable. Chinook, coho, chum, and pink salmon, and steelhead and cutthroat trout all spawn and rear in the study reach in significant numbers (see Figure 5.61). Bull trout and sockeye have also been documented using the stream.

The stream has a gentle gradient and abundant high quality spawning gravel within the project reach. The reach also contains numerous deep pools, but large wood that adds quality habitat to the pools is sparse. Logging practices and the conversion of the flood plain to agriculture removed most of the wood from the stream. Prior to development the stream was lined by a cedar, fir, and spruce forest. Small streams enter South Prairie Creek and often provide a corridor to excellent spring water rearing habitat at the base of the valley walls. Many of these small streams and wall based channels have been ditched or drained to facilitate agriculture and residential development.

Figure 5.61 Salmon and steelhead spawning in South Prairie Creek
Local efforts are underway to preserve extensive portions of riparian and stream habitat in the study area and significant land is currently in Pierce County and Pierce Conservation District ownership. Several salmon recovery grant funded projects are currently underway to preserve and restore the stream and riparian area within this reach.

### 5.8.5 River Management Facilities, Flooding and Flood Damage

No flood risk reduction facilities are owned and maintained by Pierce County Surface Water Management along South Prairie Creek. However, there are some rip rap\(^{94}\) revetments and armoring maintained by WSDOT along State Route 162 crossings and by Pierce County Roads along South Prairie Road East.

#### 5.8.5.1 Major Flooding

Major flood events since 1991 have damaged infrastructure, residential, agricultural, and recreational properties. Widespread flooding of roads, residential, and agricultural properties occurred in February 1996, November 2006, and January 2009. In most large floods, the Veteran of Foreign Wars campground sustains some damage. In January 2009, the Town of South Prairie Fire Station was flooded and sustained $36,000 in damage. State Route 162 and other local roads have been regularly closed during flooding due to water and debris over the roadway.

Major flooding occurred in the South Prairie Creek in 1955, 1965, 1990, 1996, 2006, and 2009 (see Table 5.40). The January 2009 flood is the largest on record, with a measured flow of 9,480 cfs, close to the 100-year flood flow of 9,700 cfs estimated by FEMA (FEMA 2009, NHC 2006).

#### Table 5.40 Historical Major Flooding on South Prairie Creek

<table>
<thead>
<tr>
<th>Date</th>
<th>South Prairie Creek Flows at South Prairie Gauge (cfs)(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1955</td>
<td>6,859</td>
</tr>
<tr>
<td>January 1965</td>
<td>6,400</td>
</tr>
<tr>
<td>January 1990</td>
<td>5,930</td>
</tr>
<tr>
<td>February 1996</td>
<td>8,170</td>
</tr>
<tr>
<td>November 2006</td>
<td>6,540</td>
</tr>
<tr>
<td>January 2009</td>
<td>9,480</td>
</tr>
</tbody>
</table>

\(^a\) Note: There is a gap in the USGS record from 1979 to 1987 for South Prairie Gauge – USGS #12095000

Source: Pierce County Surface Water Management and United States Geologic Survey records

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94 Rip Rap – Broken stone placed on shoulders, slopes, or other such places to protect them from erosion. Stones typically range in size from 6 inches to several feet in diameter.
5.8.5.2 Flood Damage to Facilities

WSDOT reported scour of bridge piers and large woody debris buildup on bridges as problems on several bridges. Water and debris on roadways is a common problem for Pierce County roads, but damage to roadways is not widespread. Typically some repair and maintenance of toe and facing rock follows large flood events.

Records show that in 1996 South Prairie Creek jumped the right bank and washed out South Prairie Road near 246th Avenue East. Road reconstruction, bank stabilization, and an armored overflow flood re-entry channel repaired the flood damage.

![Figure 5.62 - Right bank armoring along South Prairie Road East near RM 5.6.](image)

5.8.6 Key Accomplishments since the 1991 Flood Plan

5.8.6.1 Major Projects

Since the 1991 Puyallup River Comprehensive Flood Control Management Plan was completed, Pierce County has carried out an annual program that includes maintenance and repair of facilities. Specific capital projects are listed below:

South Silver Springs, RM 3.7 right bank
A habitat restoration project installed by Pierce County, consisted of restoring a 12.8-acre site adjacent to South Prairie Creek and a cool water tributary. There is improved floodplain connection, wetland and tributary enhancement, and placement of large woody material.

5.8.6.2 Land Purchases

There have been extensive land purchases in the South Prairie Creek basin by Pierce County and its partners since 1991 for both flood and habitat related purposes. Approximately 142 acres have been purchased. Between 2006 and 2009, six parcels totaling 55.6 acres and four flood prone homes were purchased and removed. Funding has been provided by the Salmon Recovery Funding Board, Pierce County SWM fees, and the Real Estate Excise Tax (REET) funds. In addition, some properties have also been purchased by the Pierce Conservation District.

5.8.6.3 Partnerships

Pierce County partnered with the Pierce Conservation District and Forterra (formerly the Cascade Land Conservancy) to acquire the 107 acre South Prairie Creek Preserve (the former Inglin dairy farm) in 2003.

5.8.7 Flood and Channel Migration Hazard Mapping

5.8.7.1 Flood Hazard Mapping

Hazard mapping along South Prairie Creek includes detailed flood studies (FEMA 2009, NHC 2006) and the creation of preliminary Digital Flood Insurance Rate Maps (DFIRM), which as of the publication of this document had not been issued by FEMA. Flood prone areas along South Prairie Creek include rural residential land, agricultural and recreational land, and limited areas in the Town of South Prairie. The DFIRM maps for South Prairie Creek within the study area show 469 acres within the special flood hazard area or 100-year floodplain. The mapped deep and fast flowing area is 247 acres.

5.8.7.2 Channel Migration Hazard Mapping

Channel migration is naturally limited by the coarse substrate of boulders and large cobbles deposited by the ancestral White River and the Osceola mudflow. The creek has carved out a channel into the mudflow depositions, but is essentially entrenched within these deposits in many locations (Geo Engineers 2005). Only during large flood in 1964 and 1996 have there been significant channel adjustments and erosion. Channel migration has been further limited or stopped altogether by bank revetments.

Severe, moderate and low channel migration potential areas (MPAs) were delineated for South Prairie Creek in 2005 (GeoEngineers 2005). The CMZ refers to the geographic area where a stream or river has been located and is susceptible to channel erosion and/or channel occupation (WSDOE 2003). The severe CMZ covers an area of 183 acres along South Prairie Creek. Pierce County regulates severe CMZ mapped areas as floodway per Chapter 18E.70, Pierce County Code, but the South Prairie Creek CMZ map has not yet been adopted.
5.8.8 Problem Identification

Table 5.41 includes the flooding and channel migration problems identified in the South Prairie Creek floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bank and Revetment Overtopping and Breaching</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.0 – RM 1.24 LB/RB</td>
<td>Overtopping and severe flooding; SR-162 flooded in 2006 and several homes cut off from highway</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 2.0 – RM 2.4 LB/RB</td>
<td>Flooding between SR-162 &amp; S. Prairie Carbon River Rd. (homes and properties); flooded near wood pallet business (2006, 2008); bank overtopping near RM 2.0 and 2.4</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 4.9 LB/RB</td>
<td>Both banks overtopped with property and homes flooded (2006)</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 5.6 RB</td>
<td>South Prairie flooded near 246th Ave. E.; several properties affected (2006)</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Public Safety/Emergency Rescue</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 3.5 – RM 3.5 RB</td>
<td>Several homes evacuated by boat during 2006 flood in vicinity of Kaperak Rd. and SR-162; also one evacuation in 2008.</td>
<td>Pierce County Sheriffs</td>
</tr>
<tr>
<td><strong>Channel Migration Problem Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.4 – RM 0.6 RB</td>
<td>Channel migration threatens private road and access to 3-5 homes</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 3.7 – RM 3.7 LB</td>
<td>Channel migration threatens SR-162 at Spring Site Rd.</td>
<td>Pierce County</td>
</tr>
<tr>
<td><strong>Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 0.0 – RM 3.8 LB/RB</td>
<td>SR-162 floods in numerous locations forcing closure of road from Carbon River bridge to Soler Farm or Town of South Prairie; 3 bridges between RM 2.7 and 3.8 are a problem from LWD buildup on piers (#162/016, 017, and 018)</td>
<td>WSDOT</td>
</tr>
<tr>
<td>RM 0 – RM 6.2 LB/RB</td>
<td>Floods damage multipurpose trail along South Prairie Creek, requiring repair</td>
<td>S. Prairie Cr. Adv. Comm. member</td>
</tr>
<tr>
<td>RM 1.7 – RM 2.5 LB</td>
<td>South Prairie Carbon River Rd. E. – during flood events, water over roadway/sediment deposits result in closure from SR162 to 157th St. E.</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 3.3 – RM 3.4 RB</td>
<td>Kaperak Rd E. – during flood events, creek overtops flooding road and causing infrastructure damage – off SR-162</td>
<td>Pierce County Roads</td>
</tr>
</tbody>
</table>
Table 5.41 Priority Problems Identified in South Prairie Creek

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 3.7 – RM 3.7 RB</td>
<td>Spring Site Rd. – during flood events, creek overtops flooding road and causing infrastructure damage – 100 feet north of SR-162</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 5.4 – RM 5.9 RB</td>
<td>South Prairie Rd. E. – during flood events, creek overtops flooding road and causing infrastructure damage – from 246th Ave. Ct. E. to SR-162</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 5.4 LB</td>
<td>Outfall from Town of South Prairie WWTP becomes covered in sediment from large floods</td>
<td>Town of South Prairie</td>
</tr>
<tr>
<td>RM 6.0 LB</td>
<td>Town of South Prairie Fire Station floods when creek overtops bank upstream of SR-162 crossing; station also used for Emergency Management ($36,000 damage in 2009)</td>
<td>Town of South Prairie</td>
</tr>
<tr>
<td>Fish Habitat Problem Areas</td>
<td>Development at mouth of South Prairie Creek and Carbon River has impacted productive salmonid area at mouth of creek</td>
<td>Puyallup Tribe</td>
</tr>
<tr>
<td>Public Access</td>
<td>Lack of access to creek near South Prairie Trailhead</td>
<td>Pierce County Parks</td>
</tr>
</tbody>
</table>

Sources: Pierce County Surface Water Management records

5.8.9 River Reach Management Strategies

The recommended river reach management strategies take into account numerous conditions summarized as follows:

- **Development and land use in adjacent floodplain** – The South Prairie Creek floodplain is primarily rural and includes both low-density residential and agricultural land uses, and the Town of South Prairie upstream of RM 5.6. State Route 162 is adjacent to the creek along the lower four miles. The assessed value of property within the 100-year floodplain is $14.6 million.

- **River management facilities** – Revetments along short stretches of roads and near bridges is the extent of public river management facilities along the creek. Private revetments exists along the creek but are not maintained by the County.

- **River channel gradient and width** – Channel gradient varies from 0.27 to 0.46 percent between RM 0.0 to RM 3.5 and from 0.60 to 0.80 percent between RM 3.5 and RM 5.8. The river channel width generally varies from approximately 40 feet to 160 feet.

- **Presence of salmon spawning and rearing habitat** – Chinook, coho, chum, and pink salmon, and steelhead and cutthroat trout all spawn and rear in South Prairie Creek.

- **Sediment transport accumulation and incision** – Streambed sediment is composed of sand, gravel, cobble, and some boulders (GeoEngineers 2005). Little information is
available about sediment transport conditions in South Prairie Creek, though some segments are incising. The creek was not included in the USGS sediment transport study.

The primary objective for South Prairie Creek is to protect the public infrastructure (roads, bridges). Another objective is to improve aquatic habitat through riparian revegetation, and strategic placement of large woody material.

The recommended river reach management strategies for South Prairie Creek are (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**

- The level of erosion protection for revetments should be the channel migration resistance design in areas near bridges and where the creek is adjacent to public roads.

**Non-structural management strategy:**

- Floodplain development regulations should be implemented by unincorporated Pierce County; floodplain development regulations should be implemented by the Town of South Prairie consistent with Pierce County critical area regulations for flood hazard areas
- Property acquisition or purchase of development rights should be considered on a case-by-case basis to remove the most flood prone structures and people out of the most hazardous areas. Encourage the property owners within the flood hazard area to purchase flood insurance.
- Creation of side channels and riparian wetlands to store flood water.
5.8.10  Recommended Capital Projects

The following capital improvement projects are recommended to address the priority problem areas identified in Table 5.41. Capital projects are defined as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Pierce County Comprehensive Plan. Projects less than $75,000 are classified as small works.

5.8.10.1  SP1 South Prairie Floodplain Acquisition

Location Information

Sub Area: South Prairie
Basin Plan: Carbon River & Upper Puyallup River (future)
River Mile: 1.6 – 3.5, Right Bank
Council District: 1
Jurisdiction: South Prairie
Property Ownership Affected: Private Lands

Estimated Cost: $570,000

What is the Issue?

Flooding of South Prairie Creek causes damage to four adjacent private properties, including structures and a camp ground. The properties have experienced repeated flooding and Pierce County has already purchased the surrounding properties in an attempt to mitigate flooding and loss in the area.

What is at Risk?

- Risk to private property and structures, and
- Public welfare and safety for visitors to the camp ground.

What is the Recommended Solution?

Purchase of the four properties within the floodplain.

What are the Project Benefits?

- Removal of structures within the floodplain and floodway will prevent future damage,
- Reduce taxpayer expenditures for flood impacted residents, and
- Increased floodplain storage.
Environmental Considerations

The project will require the demolition of existing structures. Permits will be required for demolition, decommissioning of the septic fields and water wells, and abatement of any asbestos.
5.8.10.2 SP2 South Prairie Fire Station Flood Protection

Location Information

Sub Area: South Prairie
Basin Plan: Carbon River & Upper Puyallup River (future)
River Mile: 6.0, Left Bank
Council District: 1
Jurisdiction: South Prairie
Property Ownership Affected: Local government property

Estimated Cost: $27,000

What is the Issue?

The South Prairie Creek Fire Station is located within the 500-year flood plain of South Prairie Creek and has an average Base Flood Elevation of approximately 439.5. The fire station sits within a natural depression between two weirs. The approximate elevation within this depression is 438 feet. There is an existing constructed weir east of the fire station with an opening at approximately 437 feet and a natural occurring weir to the west with an average elevation at 439.05. A combination of bio-swale and drainage pipes control surface water runoff for the fire station with some of the drainage discharging into South Prairie Creek. During flood events the storm water system is unable to discharge to the creek. When the creek overtops its banks it floods through the constructed weir where the water is trapped until the level is high enough to flow out the natural weir. Once water levels drop, the storm drainage system allows the remainder of the water to leave the site.

What is at Risk?

- Damage to public infrastructure (fire station), and
- Damage to private structures and property.

What is the Recommended Solution?

The project will modify the existing constructed weir, filling the gap to an elevation of 440 feet, approximately 0.5 feet above the base flood elevation. This will provide protection for a 100 year event. Installation of a rubber back flow prevention check valve on the storm water pipe which discharges to South Prairie Creek will keep creek water from flooding back into the fire station from the creek.

---

95 **Weir** – A dam or obstruction in a stream or river to raise the water level or divert streamflow.
Figure 5.64 – Air photo of project area at the South Prairie Creek Fire Station

What are the Project Benefits?

- Protection of public infrastructure for a 100 year flood event,
- Minimal impact to the built environment, and
- Minimal impact to the natural environment.

Coordination

5.9  MIDDLE NISQUALLY RIVER - MCKENNA AREA

5.9.1  Overview

The Nisqually River drains a watershed of approximately 760 square miles. The river originates on the south slope of Mount Rainier and flows 78 miles to the estuary at the Nisqually National Wildlife Refuge before flowing into Puget Sound. Nearly 58 percent of the Nisqually River watershed lies in Pierce County, with the remainder in Thurston County (about 16 percent) and Lewis County (about 26 percent).

The drainage area to the USGS gauge on the Nisqually River at McKenna is 517 square miles. The middle Nisqually River at McKenna forms the boundary between Pierce County and Thurston County. The focus of this reach is from approximately RM 21.3 to RM 26.0, where the 100-year floodplain is up to 2900 feet wide, and where substantial flooding occurred in the McKenna area during the February 1996 flood event. Land use in the McKenna vicinity consists of medium-density residential, rural residential and agriculture and pasture lands. There are also extensive lakes and wetlands in the surrounding area. Salmonid use in this reach of the Nisqually River includes fall Chinook, coho, chum and pink salmon and winter steelhead trout.

5.9.2  Geology and Geomorphology

The broad valley in this section of the river historically accommodated a wide channel migration zone. In the lower half of this reach where the valley is over 2000 feet wide on average, several remnant historical channels are still visible throughout the historical channel migration zone (Nisqually Basin Plan 2008). The channel is currently confined and channel migration is limited due to flood-control modifications, mostly on the left bank of the river in Thurston County. The bank protection and levees have mostly been constructed by various private landowners. No channel migration zone has been mapped for this area. The gradient of the river channel in this reach is 0.1 to 0.2 percent.
Mid Nisqually River
McKenna Planning Area
RM 21.3 - RM 26.0

The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.
5.9.3 **Hydrology and Hydraulics**

There are two dams on the Nisqually River LaGrand Dam at RM 42.4 and Alder Dam at RM 44.2 which forms the 3,000 acre Alder Lake. The two dams are part of the Nisqually hydroelectric project owned and operated by Tacoma Power which is part of Tacoma Public Utilities. According to Tacoma Power, the dams provide incidental attenuation of floods, but their Federal Energy Regulatory Commission (FERC) operating agreement and license has no flood control requirements (Nisqually Basin Plan, 2008). Table 5.42 shows the 1987 FEMA Flood Insurance Study flood frequency flows for the Nisqually River at the mouth and upstream of Horn Creek (near McKenna). An update of the Nisqually Flood Insurance Study is planned, but not funded at this time. A combination of methods, including peak revision, event ranking, and Log-Pearson regression analysis, were used to project flood flow frequencies up to 500-year flows for this Plan. They are unofficial estimates and used for reference purposes only until the official Flood Insurance Study revision is completed. For lesser event flows, existing flow frequencies from the 1987 Flood Insurance Study are reasonably reliable.

### Table 5.42 Middle Nisqually River Flood Frequency Flows

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nisqually River at Mouth</td>
<td></td>
<td>1987 FEMA Flood Insurance Study (Log Pearson III Fit of gauge data)</td>
</tr>
<tr>
<td>Nisqually River, upstream of Horn Creek (near McKenna)</td>
<td></td>
<td>1987 FEMA Flood Insurance Study (Log Pearson III Fit of gauge data)</td>
</tr>
<tr>
<td>Nisqually River, (near McKenna) SWM 2009a</td>
<td></td>
<td>2009 SWM Estimate at USGS gauge at McKenna</td>
</tr>
</tbody>
</table>

*a Not official or formal published data

Source: Pierce County Surface Water Management and United States Geologic Survey records

The 1987 Flood Insurance Study estimate of the 100-year flow of 10,400 cfs substantially underestimated the discharge of the Nisqually River above the LaGrande and Alder Lake dams. Additional analysis will be needed to rectify the larger upstream discharge with the operations of the non-flood control dams. Two events recorded in 1996 and 2006 more than doubled the expected discharge of the upper Nisqually River.

5.9.4 **Ecological Context and Salmonid Use**

The middle Nisqually River of the study area flows downstream from the Centralia diversion dam at RM 26.2 through McKenna, the Tacoma Rail and Highway 507 bridges to RM 21.3.
Historically, this section of the river was in a broad valley of low gradient, 0.1 to 0.2 percent, which allowed wide channel migration. Several remnant historical channels are still evident from the air. Currently the channel is confined and channel migration is limited due to areas of old flood control levees and revetments, including several apparently installed by private landowners.

This reach serves as a migration corridor for all species of salmon in the Nisqually River, and provides spawning habitat for chum, coho, pink and Chinook salmon, and steelhead. There is abundant spawning gravel just downstream of the Centralia diversion dam. Further downstream the habitat is characterized by deep pools, boulders, and pockets of spawning gravel. Riparian habitat varies considerably, with long forested stretches of medium sized hardwood stands. Bank development and forest removal for agriculture, especially on the left bank, limits large woody material recruitment opportunities, as does the diversion dam at the upstream end of the reach. The Nisqually Indian Tribe conducts steelhead redds surveys in this reach, and WDFW uses it as an index reach for Chinook spawning.

5.9.5 River Management Facilities, Flooding and Flood Damage

There is no known flood risk reduction facility infrastructure, past or present, owned or maintained by the Pierce County Surface Water Management Division. WSDOT has limited armoring along the SR-507 bridge crossing. The extent of armoring along the Thurston County (left bank) side of the river is not well known.

5.9.5.1 Major Flooding

One major flood in 1996, with flows estimated near 50,000 cfs, severely impacted the McKenna area (see Table 5.43). Since construction of the Alder Dam in 1948, peak flow events exceeding 20,000 cfs have occurred five times. There have been no peak flows over 16,200 cfs since 1996.

<table>
<thead>
<tr>
<th>Date</th>
<th>Nisqually River Flows at McKenna Gauge (cfs) – USGS #12089500</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1955</td>
<td>20,200</td>
</tr>
<tr>
<td>November 1959</td>
<td>20,500</td>
</tr>
<tr>
<td>January 1965</td>
<td>25,700</td>
</tr>
<tr>
<td>December 1980</td>
<td>21,100</td>
</tr>
<tr>
<td>February 1996</td>
<td>50,000(^a)</td>
</tr>
</tbody>
</table>

\(^a\) The flow rate for February 1996 is an estimate

Source: United States Geologic Survey records
Records from the 1996 flood event indicate that 24 flooding problems were identified in the database for this area (Nisqually Basin Plan 2008).

5.9.5.2 Flood Damage to Facilities

The 1996 flood eroded out the State Route 507 bridge approach on the Pierce County side (right bank), resulting in a 2-day closure of the road and bridge. There is also ongoing scour and accumulation of large woody debris on the bridge piers during high flow events. The bridge is on WSDOT’s Scour Critical List for shallow spread footings and it is monitored during all high water events.

Flooding in 1996 resulted in extensive flooding of homes and roads in the McKenna area, as well as the Nisqually Valley Care Center, a nursing home located on the right bank downstream of the State Route 507.

5.9.6 Key Accomplishments since the 1991 Flood Plan

5.9.6.1 Major Projects

Since the 1991 Puyallup River Comprehensive Flood Control Management Plan was completed, Pierce County has carried out an annual program that includes maintenance and repair of facilities. Specific capital projects are listed below:

WSDOT State Route 507 Repair, right bank

WSDOT did a major repair of the right bank SR-507 bridge approach and armoring following the 1996 flood event that closed SR-507. Pierce County undertook substantial floodplain buyouts in the McKenna area following the 1996 flood.
5.9.6.1 Land Purchases

A significant number of parcels and flood damaged homes were purchased along the middle Nisqually River in the McKenna vicinity following the 1996 flood.

- Acquisition of 25 parcels totaling 42.5 acres at a total cost of $2.04 million. Funding was a combination of Hazard Mitigation Grants (HMGP), with state and local match, including Real Estate Excise Tax (REET) funds.

5.6.6.2 Partnerships

As noted above, Pierce County has partnered with FEMA following disaster declaration #1100 to purchase numerous flood damaged or repetitive loss properties resulting from the February 1996 flood. HMGP grants pay 75 percent of acquisition costs, with match of 12.5 percent each from the State of Washington and Pierce County.

5.9.7 Flood and Channel Migration Hazard Mapping

5.9.7.1 Flood Hazard Mapping

Flood hazard mapping in the middle Nisqually River includes the flood insurance study from 1987 (FEMA 1987). The data on which that study was based is over 25 years old, and does not include the record 1996 flood. Flood prone areas along the middle Puyallup in Pierce County include residential land in McKenna, a few commercial buildings, and State Route 507. Upstream there is low density residential, agricultural and forest land use. The 1987 FIRM maps for the middle Nisqually River show 886 acres within the special flood hazard area or 100-year floodplain. Many of the destroyed properties purchased after the 1996 flood were not shown to be within the Special Flood Hazard Area on the 1987 FIRM maps. Deep and fast flowing areas have not been mapped for this reach.

5.9.7.2 Channel Migration Hazard Mapping.

Severe, moderate, and low channel migration zones (CMZ) have not been mapped for the middle Nisqually River. The Nisqually River is listed in Title 18E.20 of the Pierce County Code as a river to be mapped for Channel Migration Zone.

5.9.8 Problem Identification

Table 5.44 includes the flooding and channel migration problems identified in the middle Nisqually River floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Safety/Emergency Rescue</td>
<td>Flooding of McKenna in 1996 flood in vicinity of 356th/357th and</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>
### Table 5.44 Flood and Channel Migration Problems Identified in Middle Nisqually River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 21.6 – RM 21.9 RB</td>
<td>Flooding of all local roads in McKenna area in mapped 100-year floodplain downstream of SR-507 on right bank in 1996</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 21.6 – RM 21.9 RB</td>
<td>Flooding of McKenna in 1996 flood caused inundation of portions of 80 parcels and damaged numerous structures</td>
<td>Pierce County (Nisqually River Basin Plan)</td>
</tr>
<tr>
<td>RM 21.9 RB</td>
<td>SR-507 – the 1996 flood eroded road and approach to bridge on Pierce County side resulting in 2-day road closure; also ongoing scour and LWD accumulation on bridge (#507/128)</td>
<td>WSDOT</td>
</tr>
</tbody>
</table>

**Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 21.6 – RM 21.9 RB</td>
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<td>WSDOT</td>
</tr>
</tbody>
</table>

**Fish Habitat Problem Areas**

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 23.5 – RM 24.5 RB</td>
<td>Large wetland complex near mouth of Brighton Creek appears to be an oxbow or remnant side channel of the mainstem Nisqually River. This reach of the Nisqually is the most impaired reach on the mainstem, and suffers from a loss of channel complexity, LWD and channel migration</td>
<td>Pierce County, Nisqually Indian Tribe</td>
</tr>
<tr>
<td>RM 26.3 –RM 26.5 RB</td>
<td>Due to floodplain restrictions by large channel-redirecting riprap levees, there is a lack of side-channels and off-channel wetlands and degraded fish habitat</td>
<td>Nisqually Basin Plan (CIP11-NIS-RST01)</td>
</tr>
<tr>
<td>RM 28.0 – RM 29.5 RB</td>
<td>Floodplain and riparian habitat along this reach were degraded due to forest clearing, road building, and colonization by invasive species (Now owned by Nisqually Land Trust)</td>
<td>Nisqually Basin Plan (CIP11-NIS-RST02)</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

### 5.9.9 River Reach Management Strategies

In conjunction with updated flood hazard mapping discussed in Section 5.9.7, the recommended river reach management strategies take into account numerous conditions summarized as follows:

- **Development and land use in adjacent floodplain** – The middle Nisqually River floodplain consists of medium-density residential, within McKenna, rural residential, agriculture, and pasture lands. The assessed value is $24.3 million within the 100-year floodplain.

- **River management facilities** – There is limited armoring along the right bank in Pierce County, mostly in the vicinity of the State Route 507 Bridge.

- **River channel gradient and width** – Channel gradient varies from 0.1 to 0.2 percent between RM 21.3 to RM 26.0. The river channel width generally varies from 100 feet to 220 feet.
• **Presence of salmon spawning and rearing habitat** – Species of salmon found in the middle Nisqually River include Chinook, pink, coho and chum salmon, as well as steelhead trout.

• **Sediment transport accumulation and incision** – The river bed sediment is predominantly boulder and cobble, with some gravel riffles and some patch gravel strips (WRIA 11, WDFW 1977). Downstream gravel transport is greatly limited due to Alder Dam and the Centralia diversion dam.

The primary objective for the middle Nisqually River is to maintain the structural integrity of the armoring that protects public infrastructure, including the State Route 507 Bridge. A secondary objective is to enhance and create aquatic habitat through riparian re-vegetation, and strategic placement of large woody material.

The recommended river reach management strategies for the middle Nisqually River are (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**
- The level of erosion protection for revetments should be the channel migration resistance design.

**Non-structural management strategy:**
- Floodplain development regulations should be implemented by unincorporated Pierce County, and
- Property acquisition of repetitive loss properties and to enable capital project construction, or purchase of development rights to prevent new floodplain development.
5.9.10 Recommended Capital Projects

The following capital improvement project is recommended to address the priority problem area identified in Table 5.43. Capital projects are defined as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Pierce County Comprehensive Plan. Projects less than $75,000 are classified as small works.

5.9.10.1 MN1 McKenna Area Flood Plain Acquisition and Structure Elevation

Location Information

Sub Area: Middle Nisqually
Basin Plan: Nisqually (to be adopted)
River Mile: 21.6 – 22.00, Right Bank
Council District: 3
Jurisdiction: Pierce County, McKenna area
Property Ownership Affected: Private Lands

Estimated Cost: $10,900,000

What is the Issue?

Tacoma Power owns and operates the LaGrande and Alder dams on the Nisqually River. The topography of the Nisqually River below these dams makes the area naturally susceptible to flooding. The dams are maintained at optimal hydroelectric production and safety levels. While not flood control dams, flow on the lower Nisqually is regulated by the hydroelectric dams. In 1996 an unprecedented amount of rain fell on Mt. Rainier. In order to maintain the safety of the dams and reservoirs, Tacoma Power had to substantially increase discharge flows. The result was that the McKenna area near State Route 507 experienced severe flooding, with water over three feet and high to moderate flow velocity in the overbank floodplain area. The floodplain contained a nursing home, gas station, tavern, 80 plus single family homes, Tacoma Railroad Bridge and the approach to the State Route 507 Bridge. Immediately after the flood, Pierce County was able to purchase twenty-two of the properties with funding through a FEMA Hazard Mitigation Grant. Funding ran out and 60 homes, the nursing home, gas station, tavern, and bridge remain unprotected.

What is at Risk?

- Public welfare and safety to the citizens who remain living in the area
- Future flood damage to 60 single family homes, nursing facility, tavern and gas station
- Public safety and first responders are at risk. The nursing home in particular is located immediately adjacent to the Nisqually River. First responders had to recue residents of the facility and in the surrounding neighborhoods.
**What is the Recommended Solution?**

Accurate floodplain and floodway mapping does not exist at this time for the McKenna area. As part of this project a detailed review and investigation of existing site conditions are necessary to determine which structures are suitable for elevation and which would need to be bought out. Structures near the river and considered critical facilities, such as the nursing facility and gas station, are not suitable for elevation and are proposed for buyout. The final solution will concentrate on flood mitigation for the residential and commercial structures and does not include the SR-507 or Tacoma Rail bridges.

![Figure 5.67](image-url) – A combination of buy-outs and structure elevation proposed for McKenna area
**What are the Project Benefits?**

- Mitigation for future flood damages,
- Return of a portion of the floodplain to the river system,
- Increase floodplain storage, and
- Increased protection of public welfare and safety.

**Coordination**


**Environmental Considerations**

Permitting requirements would include demolition permits to remove structures, testing, and abatement of asbestos materials, removal of water service and septic decommissioning, building permits to elevate foundation structures.
5.10  UPPER NISQUALLY RIVER

5.10.1  Overview

The upper Nisqually River begins on the slopes of Mount Rainier on the South Tahoma Glacier, Kautz Glacier, and Nisqually Glacier and flows generally east to west from the glaciers to Alder Lake, near the town of Elbe. The upper Nisqually River forms the boundary between Pierce County and Lewis County. Glacial melt water and sediment flow down the mountain from three major sources, Tahoma Creek, Kautz Creek, and the Nisqually River. From Alder Lake to the confluence of Tahoma Creek at about RM 65.8, the upper Nisqually River flows through a broad valley, occupied by terraces, glacial features such as moraines, and occasional bedrock outcrops (GeoEngineers 2007).

The focus of this reach is from RM 50.5, at the entrance to Alder Lake Park in Elbe, to the upstream end of the levee/revetment at RM 65.4, near the entrance to Mt. Rainier National Park. The drainage area to the USGS gauge on the Nisqually River near National is 133 square miles. The unincorporated towns of Elbe and Ashford provide residential and commercial land uses and are located adjacent to State Route 706. Recreational, forest and agricultural uses make up the balance of land uses within this sub area. There are no salmon in this reach of the river, due to natural barriers and the dams downstream; however, there are resident cutthroat trout.

5.10.2  Geology and Geomorphology

The topography of the upper Nisqually basin is a result of the combined effects of ongoing tectonic, volcanic, glacial, and fluvial activity associated with Mt. Rainier (GeoEngineers 2007). The U-shaped Nisqually River valley was carved out by alpine glaciers to the lower end of Alder Lake. After the retreat of the glaciers, the valley was filled with glacial drift, including deposits of glacial outwash and till material. Lahars have also shaped the topography of the upper Nisqually River valley. Three extensive lahar deposits over the past 5,000 years each buried entire sections of the Nisqually River channel and portions of the forested floodplain (Graham 2005; GeoEngineers 2007). Glacial outburst floods, releasing large volumes of water and sediment in a short time period, are another source of fluvial and glacial material being transported downstream. Since 2001, Van Trump Creek and Pyramid Glacier drainages, which drain to the Nisqually River, have experienced a total of five debris flows (Kennard 2009). Recent accelerated glacial retreat of the glaciers feeding the Nisqually Basin is exposing more terminal and lateral moraine sediments to erosion, increasing the sediment supply to the Nisqually system.
Upper Nisqually River Planning Area
RM 50.5 - RM 65.8
Pierce County Rivers Flood Hazard Management Plan

Legend

- Project Sites
- River Miles
- Repetitive Loss Property
- Flood Control Facility
- Major Roads
- County Boundary
- Rivers/Streams
- Lakes/Puget Sound
- Regulatory 100 Year Floodplain (within City Boundaries)
- Regulatory 100 Year Floodplain (outside of City Boundaries)
- Channel Migration Zone Floodway

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Pierce County Public Works & Utilities
Surface Water Management

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The upper Nisqually River between RM 50.5 and RM 65.8 is a braided river channel consisting of many bars and low-flow channels (see Figure 5.69). The character of channel migration is abrupt and unpredictable, typically occurring during high flow events (GeoEngineers 2007). Migration is expressed by both lateral bank movement through erosion or through channel avulsions. Channel avulsions also occur on a smaller scale annually in the Nisqually River as the sediments of the active channel are rearranged during annual snowmelt runoff. The average channel gradient varies from approximately 0.5 percent just upstream of Alder Lake to about 2.0 percent near the park entrance. The severe channel migration zone ranges from 1000 to 4000 feet in width within the study area, with the exception of a short portion of the river between RM 56.0- RM 56.5, where the river is confined in bedrock which prevents migration.

Figure 5.69 - (a) Nisqually River looking upstream from Kernahan Bridge near RM 61.8 and (b) right bank revetment/levee near Mt. Rainier Park entrance looking downstream near RM 65.4.

5.10.3 Hydrology and Hydraulics

The upper Nisqually River consists of flows primarily from Mount Rainier National Park, including the Nisqually River, Kautz Creek, and Tahoma Creek. A USGS river gauge located at National (#12082500) has been operating since 1942. The flood frequency flows for the National gauge and upstream near the National Park boundary is shown in Table 5.45. The USGS study of conveyance capacity (USGS 2010) did not include an evaluation of the upper Nisqually River.
### Table 5.45 Upper Nisqually River Flood Frequency Flows (based on USGS National Gauge)

<table>
<thead>
<tr>
<th>Location</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Nisqually at National Gauge (#12082500)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-yr</td>
<td>12,900</td>
<td>SWM regression analysis with data through 2009&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>50-yr</td>
<td>19,150</td>
<td></td>
</tr>
<tr>
<td>100-yr</td>
<td>21,950</td>
<td></td>
</tr>
<tr>
<td>500-yr</td>
<td>28,700</td>
<td></td>
</tr>
<tr>
<td>Upper Nisqually R. @ Mt. Rainier National Park Boundary</td>
<td>5,400</td>
<td>1987 FEMA Flood Insurance Study</td>
</tr>
<tr>
<td>10-yr</td>
<td>7,500</td>
<td></td>
</tr>
<tr>
<td>50-yr</td>
<td>11,200</td>
<td>SWM regression analysis with data through 2009&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>100-yr</td>
<td>12,800</td>
<td></td>
</tr>
<tr>
<td>500-yr</td>
<td>16,500</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> SWM regression analysis (not official or formal published data)

Source: FEMA Flood Insurance Study (1987), Pierce County Surface Water Management and United States Geologic Survey data

### 5.10.4 Ecological Context and Salmonid Use

The upper Nisqually River reach is upstream of the Alder and LaGrande Dams. The LaGrande Dam is the current upstream limit of salmonids within the Nisqually River. Prior to the construction of the dams, the natural falls which cascaded down the steep-walled canyon between RM 41.1 and RM 42.8 likely would have been a velocity barrier to salmonids and not allowed fish passage up into the upper Nisqually reach (Kerwin 1999).

Information on resident salmonids is scarce. Interviews with Nisqually Tribal biologists indicate that resident cutthroat, kokanee, and rainbow trout are assumed to inhabit the river upstream of Alder Dam, based on observations in the upstream tributaries. Seining of the upstream end of this reach in October 2010 identified cutthroat trout and sculpin as the only fish species present.

### 5.10.5 River Management Facilities, Flooding and Flood Damage

There is one levee/revetment in the upper Nisqually River owned and maintained by Pierce County Surface Water management (see Figure 5.70b). It is located near the entrance to Mt. Rainier National Park on the right bank, protecting both State Route 706 and Nisqually Park residences (see Table 5.46). There are also revetments and bank armoring at both road and rail crossings between Mt. Rainier National Park and Elbe which are maintained by Pierce County Roads, WSDOT and Tacoma Rail. Additionally, there is armoring on the right bank at the entrance to Alder Lake, downstream of the State Route 7 Bridge (see Figure 70a).
Table 5.46 Levees and Revetments on the Upper Nisqually River

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 67.6 – RM 68.4</td>
<td>Pierce County</td>
</tr>
</tbody>
</table>

RM = river mile; RB = right bank
Source: Pierce County Surface Water Management records

5.10.5.1 Major Flooding

Since 1942, major flooding occurred in the upper Nisqually River in 1974, 1977, 1990, 1996, 2006, and 2008 (see Table 5.47). The February 1996 and November 2006 floods both exceeded 21,000 cfs, and were similar in magnitude to the estimated 1.0 percent annual chance flood (100-year) of 21,950 cfs estimated by Pierce County SWM. The categorization of major flooding is based on a threshold of discharges in excess of 13,000 cfs for the Nisqually River gauge near National, Washington.

In addition to flooding, there was a major debris flow on Kautz Creek on October 2-3, 1947 that affected the upper Nisqually River. The debris flow was the largest in the recorded history of Mt. Rainier National Park and was apparently triggered when heavy rains caused an outburst flood from Kautz Glacier (USGS 1993-124). The flood passed over the lowest part of the glacier, eroding a gorge through the ice, then mobilized sediment and transformed into a debris flow as it continued down valley. The Nisqually-Longmire Road was buried by 28 feet of mud and debris and about 50 million cubic yards of sediment were moved, including boulders up to 13 feet in diameter (USGS 1993). The upper Nisqually River, downstream of Kautz Creek was covered in two to three feet of sediment.
### Table 5.47 Historical Major Flooding on Nisqually River

<table>
<thead>
<tr>
<th>Date</th>
<th>Nisqually River Flows at National Gauge (cfs) – USGS #12082500</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1974</td>
<td>15,000</td>
</tr>
<tr>
<td>December 1977</td>
<td>17,100</td>
</tr>
<tr>
<td>January 1990</td>
<td>14,500</td>
</tr>
<tr>
<td>February 1996</td>
<td>21,200</td>
</tr>
<tr>
<td>November 2006</td>
<td>21,800</td>
</tr>
<tr>
<td>November 2008</td>
<td>13,900</td>
</tr>
</tbody>
</table>

*aPeriod of record is 1941 – 2010
Source: United States Geologic Survey records

### 5.10.5.2 Flood Damage to Facilities

In November 2006, Mt. Rainier experienced a record breaking rain event resulting in severe flood damages throughout the National Park. Eighteen inches of rain fell in 36 hours near Paradise. One of the hardest hit areas was near the Nisqually entrance at the Sunshine Point Campground. More than 1,000 linear feet of river bank revetment and levee providing protection to the Nisqually park entrance and downstream residences was washed away (see Figures 5.71 and 5.72).
Figure 5.71 - (a) June 30, 2006 aerial photo of Sunshine Point area prior to flood damage, and (b) after repair of revetment and levee following November 2006 flood event.

Figure 5.72 - Aerial photo of Sunshine Point damage area along the upper Nisqually River after November 2006 flood event.
### Table 5.48 Damage to Facilities in the past 20 years along the Upper Nisqually River

<table>
<thead>
<tr>
<th>Segment Name</th>
<th>Location</th>
<th>Damage</th>
<th>Length</th>
<th>Storm Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.0 RB</td>
<td>Partial washouts of the toe and levee facing</td>
<td>200</td>
<td>2003</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.05 RB</td>
<td>Partial washouts of the toe and levee facing</td>
<td>150</td>
<td>2003</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.3 RB</td>
<td>Partial washouts of the toe and levee facing</td>
<td>540</td>
<td>2003</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 64.8 RB</td>
<td>Partial washouts of the toe and levee facing</td>
<td>1,200</td>
<td>2004</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.0 RB</td>
<td>Partial washouts of the toe and levee facing</td>
<td>70</td>
<td>2005</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.1 RB</td>
<td>Partial washouts of the toe and levee facing</td>
<td>850</td>
<td>2005</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 64.6 RB</td>
<td>Face Erosion</td>
<td>200</td>
<td>November 2006</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 64.9 RB</td>
<td>Wash Out</td>
<td>100</td>
<td>November 2006</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.1 – RM 65.4 RB</td>
<td>Wash Out</td>
<td>1,600</td>
<td>November 2006</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.3 – RM 65.4 RB</td>
<td>Toe scour and loss of face rock. Exposed core. Pretty vulnerable segment. State Route 706, MRNP and homes at risk</td>
<td>600</td>
<td>November 2008</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 65.1 – RM 65.3 RB</td>
<td>Toe scour and Loss of face rock. Exposed core.</td>
<td>1,150</td>
<td>November 2008</td>
</tr>
<tr>
<td>Nisqually Park Levee</td>
<td>RM 64.8+-</td>
<td>Toe scour and loss of face rock. Exposed core. Pretty vulnerable segment. Homes at risk</td>
<td>400</td>
<td>November 2008</td>
</tr>
</tbody>
</table>

Note:  No damage data found prior to 2003.
Source: Pierce County Surface Water Management records

### 5.10.6 Key Accomplishments since the 1991 Flood Plan

#### 5.10.6.1 Major Projects

### Table 5.49 Damage Repair Costs to Nisqually Park Levee

<table>
<thead>
<tr>
<th>Year</th>
<th>Repair Costs (Pierce County)</th>
<th>Repair Costs (Corps of Engineers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>$74,610</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>$142,718</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>$217,000</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>$50,000</td>
<td>$200,000</td>
</tr>
<tr>
<td>1996</td>
<td>$50,000</td>
<td>$200,000</td>
</tr>
<tr>
<td>2003</td>
<td>$122,500</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>$203,000</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>$131,000</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>$900,760</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>$529,500</td>
<td>$928,400</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$2,421,088</td>
<td>$1,328,400</td>
</tr>
</tbody>
</table>

Total Cost = $3,749,488 (inflation adjusted = $4.6 million)

Source: Pierce County Surface Water Management records

#### 5.10.6.2 Land Purchases

There have been no known land purchases or home buyouts by Pierce County in the upper Nisqually area since 1991. In 2006, the Nisqually Land Trust purchased 404 acres of timberlands and wildlife habitat in the upper Nisqually Valley, near the town of Ashford and the main entrance to Mount Rainier National Park.

#### 5.10.6.3 Partnerships

The mile long revetment and levee near the entrance to Mt. Rainier National Park is currently enrolled in the US Army Corp of Engineers PL 84-99 program. As long as Pierce County maintains the structure to meet PL 84-99 standards, the county remains eligible for assistance from the US Army Corps of Engineers for emergency response and rehabilitation projects. Pierce County owns and maintains the levee that extends into the National Park through the western boundary. The County is allowed to own and maintain the levee on national park lands through a right-of-way permit granted by the US Department of the Interior through the National Park Service. The flood control structure has been authorized to occupy National Park lands since 1961. The permit was reauthorized in May 2009 for another 10-year period.
5.10.7 Flood and Channel Migration Hazard Mapping

5.10.7.1 Flood Hazard Mapping.

Hazard mapping in the upper Nisqually River includes the flood insurance study from 1987 (FEMA 1987). The data on which that study was based is over 25 years old, and does not include the two largest floods of record which occurred in November 1996 and October 2006. Flood prone areas along the upper Nisqually include low- and medium-density residential land, limited commercial areas, and floodplain forests. The 1987 FIRM maps for the upper Nisqually River show 1,114 acres within the special flood hazard area or 100-year floodplain. Deep and fast flowing areas have not been mapped for this reach.

5.10.7.2 Channel Migration Hazard Mapping.

Severe and moderate channel migration zones (CMZ) were mapped for the upper Nisqually River (GeoEngineers 2007). The CMZ refers to the geographic area where a stream or river has been and is susceptible to channel erosion or channel occupation (WSDOE 2003). The severe CMZ covers an area of 1,830 acres along the upper Nisqually River. Pierce County regulates severe CMZ mapped areas as floodway per Chapter 18E.70, Pierce County Code, but the severe CMZ map has not been adopted for the upper Nisqually area.

5.10.8 Problem Identification

Table 5.50 includes the flooding and channel migration problems identified in the upper Nisqually River floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Migration Problem Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 53.2 LB/RB</td>
<td>Channel migration during 2006 flood washed out left and right bank abutments for Tacoma Rail bridge (see Figure 5.33)</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 58.5- RM 60.3 RB</td>
<td>Channel migration at Echo Valley subdivision threatens 3-5 homes</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 61.7 LB/RB</td>
<td>Kernahan Bridge – approaches eroded/damaged in 1996 on the Pierce County side and 2006 on the Lewis County side.</td>
<td>Pierce County Roads</td>
</tr>
<tr>
<td>RM 61.8 – RM 62.3 RB</td>
<td>Channel migration at Alpine Village subdivision threatens 12-18 homes (see Figure 5.34)</td>
<td>Pierce County</td>
</tr>
<tr>
<td>RM 64.3 – RM 65.3 RB</td>
<td>Revetment and levee at Nisqually Park and Mt. Rainier entrance (Sunshine Point Campground) experienced severe channel migration in Nov. 2006; significant damage at campground and downstream; over 3500 feet of levee repaired in 2006 at cost of $900,000</td>
<td>Mt. Rainier National Park; Pierce County</td>
</tr>
</tbody>
</table>
## Table 5.50 Priority Problems Identified in Upper Nisqually River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 50.4 RB</td>
<td>Elbe sewer system, a sand septic system, located at the confluence of Alder Lake and Nisqually River that serves the entire Elbe community is at risk of flood damage</td>
<td>Mt. Rainier National Park; Nisqually Advisory Comm. member</td>
</tr>
<tr>
<td>RM 61.7 LB/RB</td>
<td>Kernahan bridge – due to recent flood events, sediment and debris deposition is threatening bridge due to scour of bridge ends and buildup of LWD. Bridge is the only access for Lewis County residents in winter months</td>
<td>Pierce County Roads; Nisqually Advisory Comm. member</td>
</tr>
</tbody>
</table>

### Sediment and Gravel Bar Accumulation

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM 50.2 – RM 50.4</td>
<td>Accumulation of sediment at Alder Lake inlet delta, near intersection of SR-7 and SR-706 from 1947 Kautz Creek debris flow and recent floods (1996, 2006, 2009) creates the threat of flooding and channel migration in community of Elbe</td>
<td>Nisqually Advisory Comm. member</td>
</tr>
<tr>
<td>RM 50.4 – RM 66.0</td>
<td>Mt. Rainier National Park to Elbe – accumulation of sediment appears to have built up in this reach, contributing to channel migration and potential for erosion of river banks infrastructure</td>
<td>Nisqually Advisory Comm. Member; Pierce County</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

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![Figure 5.73 - Damage to Tacoma Rail bridge approaches due to channel migration (2006)](image_url)
5.10.9 River Reach Management Strategies

In conjunction with updated flood hazard mapping discussed in Section 5.10.7, the recommended river reach management strategies for the upper Nisqually River take into account numerous conditions as follows:

- **Development and land use in adjacent floodplain** – The upper Nisqually River floodplain contains low and medium density residential, a small commercial area, and forest land uses. The assessed value is $7.3 million within the 1987 mapped 100-year floodplain.

- **River management facilities** – There is a single levee and revetment at the entrance to Mt. Rainier National Park and along State Route 706 and the Nisqually Park subdivision on the right bank (RM 64.3 to RM 65.3). There is also armoring at bridge crossings and near the community of Elbe.

- **River channel gradient and width** – Channel gradient varies from about 0.5 percent near Alder Lake to 2.0 percent at the Mt. Rainier National Park entrance. The river channel width generally varies from 80 feet at its narrowest point near RM 56 to about 1200 feet in several locations.

- **Presence of salmon spawning and rearing habitat** – There are no anadromous salmon present. Fish present include cutthroat and rainbow trout, and possibly kokanee.

- **Sediment transport accumulation and incision** – Sediment is a mix of boulders, cobbles, gravel, and sand. Portions of this reach are generally aggrading and others are degrading over time, but there is no clear trend towards long-term aggradation.

Figure 5.74 - Channel migration at Alpine Village threatens homes and property (2009)
In the near term, the primary objective for the upper Nisqually River is to maintain the existing structural integrity of the levee and revetment system near the Mt. Rainier National Park entrance to reduce risks to public health and safety, maintain access to Mt. Rainier National Park, and reduce public and private property damage. A long-term objective is to prevent channel migration of the river adjacent to the revetment downstream of Sunshine Point.

The recommended river reach management strategies for the upper Nisqually River are (see sub-section 4.7.1 and Appendix F):

**Structural management strategy:**
- RM 50.2 to RM 64.2 – Tacoma Power, Tacoma Rail and Kernahan Bridge revetment protection (channel migration resistance design),
- RM 64.3 to RM 65.1 right bank – “Level of protection” goal for the Nisqually Park levee should be to maintain the existing levee prism, and
- RM 65.1 to RM 65.3 right bank – “Level of Service” goal for the Mt. Rainier National Park entrance revetment is the channel migration prevention design.

**Non-structural management strategy:**
- Floodplain development regulations should be implemented by unincorporated Pierce County, and
- Property acquisition of repetitive loss properties or purchase of development rights to prevent new floodplain development.
5.10.10 Recommended Capital Projects

The following capital improvement projects are recommended to address the priority problem areas identified in Table 5.49. Capital projects are defined as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Pierce County Comprehensive Plan. Projects less than $75,000 are classified as small works.

5.10.10.1 UN1 Nisqually Park Subdivision Levee Protection

Location Information

Sub Area: Upper Nisqually  
Basin Plan: Nisqually River (to be adopted)  
River Mile: 64.3 – 64.9, Right Bank  
Council District: 3  
Jurisdiction: Pierce County  
Property Ownership Affected: Private Lands

Estimated Cost: $2,000,000 - $4,000,000

What is the Issue?

This section of the Nisqually River has historically experienced severe channel migration, avulsions, bank erosion, and high flow velocities. This combination leads to repetitive flood damages to the levee structure protecting the Nisqually Park Subdivision. Between 1991 and 2010, an average of $250,000 a year was spent maintaining this section of the levee system. The high amount of sediment, steep channel grades, and high water velocities increases the potential for levee failure and channel migration to occur through the subdivision.

What is at Risk?

- Severe risk to adjacent private properties and structures,
- Severe risk to public infrastructure, including State Route 706 which is the gateway to Mount Rainier National Park, and
- Economic vitality.

What is the Recommended Solution?

Increase the level of protection offered by the existing levee system by installing an initial 10 to 15 Engineered Log Jams (ELJs). The ELJs will increase the roughness of the levee system, slowing the flow of the river enough to decrease damage from high flows. Further hydraulic modeling is needed to determine the exact number and style of engineered log jams.
What are the Project Benefits?

- Protection of the existing levee system,
- Engineered Log Jams provide habitat complexity for fish and protection from predation and high flows, and
- Protection of public welfare and safety.

Coordination


Environmental Considerations

Installation of the ELJs will require working within the ordinary high water of the Nisqually River. Excavation or fill within the river, wetlands or other aquatic habitats will require: a Section 404 permit from the US Army Corps of Engineers; a Section 401 Water Quality Certification from the Washington State Department of Ecology; an Hydraulic Project Approval (HPA) from the Department of Fish and Wildlife; a Shoreline Substantial Development Permit and Critical Areas Approval from Pierce County.

Figure 5.75 – Proposed location of engineered log jams
5.10.10.2 UN2 Upper Nisqually/Mt. Rainier National Park Revetment Retrofit/ELJs

Location Information

Sub Area: Upper Nisqually
Basin Plan: Nisqually River (to be adopted)
River Mile: 64.9 – 65.3
Council District: 3
Jurisdiction: Pierce County
Property Ownership Affected: Mt. Rainier National Park, State Route 706 Highway nearest to park entrance and Nisqually Park Subdivision.

Estimated Cost: $2,500,000 - $3,500,000

What is the Issue?

An existing armored revetment owned and maintained by Pierce County within Mount Rainier National Park suffers repetitive severe flood damages during moderate to high flow events. The damages are primarily due to scour and erosion of the toe of the structure as a result of high flow velocity of the Nisqually River. When the toe structure scours out, erosion and failure of the slope face typically occur which ultimately leads to partial or complete washout of the structure.

The November 2006 flood event had completely washed out and eroded away the former levee. The river channel migrated landward beyond the levee about 230 feet. The levee was re-built by constructing an armored revetment which followed the new landward recessed water line. The cost to rebuild the levee exceeded $900,000.

The January 2009 flood event resulted in additional damages to the re-constructed revetment in which repair costs exceeded $528,000. Moderate high flows in the winter of 2010 also resulted in additional partial damages to the revetment face and toe. A portion of the damages were repaired by the County in the summer of 2010 at a cost of about $529,000. The US Army Corps of Engineers (USACE) completed the remainder of the repairs during the summer of 2011 at a cost of over $928,000.

What is at Risk?

- Main entrance point to Mount Rainier National Park,
- Utility infrastructure within the park, and
- Economic vitality.

What is the Recommended Solution?

The proposed solution is to construct a series of engineered log jams (ELJ) along the revetment and levee toe to substantially reduce scour and erosion of the revetment and levee structure. The ELJs will serve to slow flow velocity along the revetment and levee structure, and encourage sediment deposition which will shift the channel thalweg away from the revetment and levee face and toe reducing scour and erosion potential.
What are the Project Benefits?

- Increased protection to the revetment and levee structure,
- Protection of adjacent property and infrastructure,
- Protection of main entrance to Mount Rainier National Park and Nisqually Park Subdivision, and
- Increased fish habitat features.

Coordination


Environmental Considerations

Installation of the ELJs and will require working within the ordinary high water of the Nisqually River. Excavation or fill within the river, wetlands or other aquatic habitats will require: a Section 404 permit from the US Army Corps of Engineers; a Section 401 Water Quality Certification from the Washington State Department of Ecology; an Hydraulic Project Approval (HPA) from the Department of Fish and Wildlife; a Shoreline Substantial Development Permit and Critical Areas Approval from Pierce County.
5.11 MASHEL RIVER

5.11.1 Overview

The Mashel River sub basin, covering about 85 square miles, is higher in elevation and steeper than most other tributaries to the Nisqually River. Over 40 percent of the basin has slopes greater than 30 percent (Nisqually Basin Plan 2008). Major tributaries of the Mashel River are the Little Mashel River, Beaver Creek, and Busy Wild Creek. Elevations range from 460 feet at the mouth to 4,845 feet on the flanks of Mount Rainier. The Mashel River winds through a steep, sinuous canyon as it approaches the Nisqually River, where it enters at approximately RM 39.6.

The Mashel River planning area is from the mouth of the Mashel River upstream to the Town of Eatonville (near RM 6.8). Land use consists of forested terrain, some agriculture (mostly livestock), rural residential development, and urban areas in the Town of Eatonville. Eatonville draws its drinking water from the Mashel River and the secondary-treated wastewater is discharged to the river downstream of the town. The Mashel River is the farthest upriver tributary to the Nisqually River that has anadromous fish use, including fall Chinook, coho, and pink salmon and winter steelhead trout.

5.11.2 Geology and Geomorphology

The majority of the Mashel River basin was not covered by continental glacial ice. The underlying geology is mostly volcanic deposits and unsorted glacial sediment (Nisqually Basin Plan 2008). The soils are primarily of low to moderate permeability. From the mouth to RM 3.2, the Mashel River flows through a natural canyon, with some room for the channel to migrate. From RM 3.2 to Eatonville, the canyon is more confined. A large section of the Mashel River in the Eatonville area is unconfined, but the channel is lined with riprap along many places and active channel migration is restricted. Timber management practices initiated in the 1940s resulted in mass wasting events in the upper watershed, delivering large quantities of sediment to the lower reaches. The channel response to this increase of sediment resulted in a plane-bed channel morphology with some interspersed pool/riffle sequences. The channel bed material is typically cobbles and large gravel with some bedrock outcrops (Nisqually Basin Plan 2008).

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96 **Channel Morphology** – The shape and gradient of a channel that forms due to streamflow forces and the composition of the underlying channel substrate.

97 **Bed Material** - The material of which a streambed is composed.
Figure 5.77
Mashel River Planning Area
RM 0 - RM 6.8

Pierce County Rivers Flood Hazard Management Plan

Legend

- Project Sites
- River Miles
- Repetitive Loss Property
- Flood Control Facility
- Major Roads
- County Boundary
- Rivers/Streams
- Lakes/Puget Sound
- Regulatory 100 Year Floodplain (within City Boundaries)
- Regulatory 100 Year Floodplain (outside of City Boundaries)
- Channel Migration Zone Floodway

The map features are approximate and are intended only to provide an indication of said feature. Additional areas that have not been mapped may be present. This is not a survey. Orthophotos and other data may not align. The County assumes no liability for variations as certified by actual survey. ALL DATA IS EXPRESSLY PROVIDED 'AS IS' AND 'WITH ALL FAULTS'. The County makes no warranty of fitness for a particular purpose.

Pierce County Public Works & Utilities
Surface Water Management

Pierce County Rivers Flood Hazard Management Plan
Visual Map developed by GIS, Data and Maps
5.11.3 Hydrology and Hydraulics

There is one USGS gauge installed on the Mashel River, located at RM 3.3 near the community of LaGrande, Washington. Flood frequency flows were estimated for the 10-, 50-, 100-, and 500-year floods for existing land use conditions using Bulletin #17B procedures (Water Resources Council, 1981). Computed discharges were estimated by applying a log-Pearson III analysis to 26 years of recorded annual instantaneous peak flows. Table 5.51 summarizes the resultant flow quantities.

<table>
<thead>
<tr>
<th>Location/Version</th>
<th>Discharge (cfs)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream of confluence with Little Mashel River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-yr</td>
<td>3,650</td>
<td>1987 FEMA Flood Insurance Study (Log Pearson III Fit of Gauge Data)</td>
</tr>
<tr>
<td>50-yr</td>
<td>5,020</td>
<td></td>
</tr>
<tr>
<td>100-yr</td>
<td>5,620</td>
<td></td>
</tr>
<tr>
<td>500-yr</td>
<td>7,070</td>
<td></td>
</tr>
<tr>
<td>Upstream of confluence with Little Mashel River</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-yr</td>
<td>3,490</td>
<td>2009 FEMA Flood Insurance Study (and NHC 2006) (Log Pearson III Fit of Gauge Data)</td>
</tr>
<tr>
<td>50-yr</td>
<td>5,045</td>
<td></td>
</tr>
<tr>
<td>100-yr</td>
<td>5,770</td>
<td></td>
</tr>
<tr>
<td>500-yr</td>
<td>7,620</td>
<td></td>
</tr>
<tr>
<td>Mashel River at Mouth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-yr</td>
<td>4,995</td>
<td>1987 FEMA Flood Insurance Study (Log Pearson III Fit of Gauge Data)</td>
</tr>
<tr>
<td>50-yr</td>
<td>7,215</td>
<td></td>
</tr>
<tr>
<td>100-yr</td>
<td>8,250</td>
<td></td>
</tr>
<tr>
<td>500-yr</td>
<td>10,900</td>
<td></td>
</tr>
</tbody>
</table>

Source: FEMA (1987, 2009) and United States Geologic Survey records

5.11.4 Ecological Context and Salmonid Use

The Mashel River from its mouth at the Nisqually River to State Route 7 (RM 3.2) flows through a canyon surrounded by mature riparian forests of large conifers and hardwoods. Rural residential land use predominates from RM 3.2 up to the Town of Eatonville. The river is mainly unconfined through this segment, but there are many places where the channel is lined with riprap, and active channel meandering is restricted, particularly within the town. Eatonville withdraws river water at RM 5.7, and returns water to the river about RM 5.4 after secondary treatment at its wastewater treatment plant.

Chinook, coho, and pink salmon, and steelhead trout spawn throughout the Mashel. The Washington State Department of Fish and Wildlife uses the Mashel River as an index reach for Chinook spawning. Chum usage has not been documented. The section of the river between RM 3.2 and RM 6.8 is used by coho, Chinook, and steelhead primarily for rearing. Cutthroat and rainbow trout have also been observed. The entire lower Mashel River from Eatonville to the mouth is deficient of in-stream large woody material to provide protection from the flows of short duration but high intensity which occur in this segment of the river. In the Town of
Eatonville, the Nisqually Tribe has conducted extensive habitat restoration and protection, with a particular focus on installing many large engineered log jams.

### 5.11.5 River Management Facilities, Flooding and Flood Damage

No flood control facilities are owned or maintained by Pierce County Surface Water Management along the Mashel River. Pierce County historically placed rip rap along the Mashel River near State Route 161 between RM 5.12 and RM 5.24. In 1950, a groin was built by dredging and straightening the river channel. A timber bulkhead paralleling the highway had become badly decayed and the river was eroding the highway causing PCRI take action. The groin was heavily blanketed with rock from the Orting quarry (PCRI Annual Report 1950). The last documented action of PCRI rip rapping the Mashel River was in 1962.

In the Town of Eatonville, riprap is present intermittently along both banks of the river from the wastewater treatment plant, located at RM 5.3, to the Alder Cutoff Road Bridge, located at RM 6.3. Rip rap protects the right bank from approximately 200 feet below the bridge to 50 feet above the bridge. The left bank has rip rap from approximately 50 feet below the bridge to 15 feet above the bridge. Much of the rip rap is old; however, WSDOT replaced rock on the right bank above the bridge (see Figure 5.78) and on the left bank upstream and downstream of the bridge in 2009. The town built a levee around the wastewater treatment plant following the 1996 flood. In 2004 log jams replaced rip rap on left bank in the vicinity of Smallwood Park, located at approximately RM 5.6, and at a private residence, located at approximately RM 5.33 (Watershed Professionals Network, LLC, 2004).
5.11.5.1 Major Flooding

Major flood events since 1991 have adversely affected transportation facilities and some private properties. There was channel migration in January 2009 along State Route 161 at the bridge crossing at RM 5.5 and downstream on the left bank from RM 5.2 to RM 5.3 (see Figure 5.36).

Past flooding of the Mashel River has occurred in 1946, 1996, 2007, and 2009 (see Table 5.52). The magnitude of flood flows is not known for the period of 1958 to 1991, due to a data gap in the USGS gauge record.

<table>
<thead>
<tr>
<th>Date</th>
<th>Mashel River Flows near La Grand Gauge (cfs) – USGS #12087000</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1946</td>
<td>6,859</td>
</tr>
<tr>
<td>February 1996</td>
<td>6,220&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>December 2007</td>
<td>5,790</td>
</tr>
<tr>
<td>January 2009</td>
<td>5,610</td>
</tr>
</tbody>
</table>

<sup>a</sup>The Mashel River gauge was not operational between 1958 and 1991
<sup>b</sup>Discharge is an estimate
Source: United States Geologic Survey records

5.11.5.2 Flood Damage to Facilities

There is little historical information about damage to flood control facilities along the Mashel River. As noted above, Pierce County has no current river management facilities in the study area. WSDOT has several bridge crossings of State Route 161 and State Route 7, and revetments where the river flows adjacent to State Route 161.

Figure 5.79 - (a) Left bank scour along State Route 161 (RM 5.2-5.3) from January 2009 flood event, and (b) repaired rip rap bank in same location (March 2010)
5.11.6 Key Accomplishments since the 1991 Flood Plan

5.11.6.1 Major Projects

Since the 1991 Puyallup River Comprehensive Flood Control Management Plan was completed, Pierce County has carried out an annual program that includes maintenance and repair of facilities. Specific capital projects are listed below:

1. **Mashel River Restoration Project (Nisqually Indian Tribe)**
   
   Numerous engineered log jam structures have and will be installed in a multiphase project to rehabilitate degraded in-stream and riparian habitat to restore geomorphic and ecological functions beneficial to native salmonid species. An example of these ELJs is located on the right bank of the Mashel River, upstream of the State Route 161 crossing (see Figure 5.37).

2. **Mashel River Bank Protection (Washington State Department of Transportation) RM 5.2 – RM 5.3 left bank**

   WSDOT undertook a major repair along the left bank of the Mashel River following severe bank erosion in January 2009 (see Figure 5.80). Work consisted of placement of large toe and facing rock along the bank to prevent future channel migration and construction of bank roughening log structures to improve habitat and riparian conditions.

*Figure 5.80 - Mashel River restoration project right bank near RM 5.5*
5.11.6.2 Land Purchases

Pierce County has not purchased floodplain in the Mashel River basin. However, the Town of Eatonville, the State of Washington, and the Nisqually Land Trust all own property along the Mashel River. The Land Trust owns 45 acres near Eatonville at Boxcar Canyon (purchased with Pierce County Conservation Future funds) and a 64-acre property that includes one mile of shoreline on the right bank of the Mashel River, downstream of the SR-7 crossing. The State of Washington and Washington State Parks and Recreation owns extensive property (over 1,000 acres) on the left and right banks of the lower Mashel River upstream of its mouth at the Nisqually River.

5.11.7 Flood and Channel Migration Hazard Mapping

5.11.7.1 Flood Hazard Mapping.

Flood hazard mapping along the Mashel River includes detailed flood studies (FEMA and NHC 2006) and the creation of preliminary Digital Flood Insurance Rate Maps (DFIRM). As of the publication of this document the DFRIM maps have not been issued by FEMA. Flood prone areas along the Mashel River include limited roads and infrastructure and private property which is mostly residential and forested in the Town of Eatonville and unincorporated Pierce County. The preliminary DFIRM maps for the Mashel River show 213 acres within the study area within the special flood hazard area or 100-year floodplain. The mapped deep and fast flowing area is 41 acres.

5.11.7.2 Channel Migration Hazard Mapping.

Channel migration mapping has not been completed for the Mashel River. It is identified in Chapter 18E.70 as one of seven rivers to be mapped.

5.11.8 Problem Identification

Table 5.52 lists the flooding and channel migration problems identified in the Mashel River floodplain. For more detail on these problems, see Appendix G.

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Channel Migration Problem Areas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 5.1 - RM 5.3 LB</td>
<td>Channel migration caused washout adjacent to SR-161 during January 2009 flood</td>
<td>Nisqually River Council, WSDOT</td>
</tr>
<tr>
<td><strong>Flooding of Structures and Infrastructure (Roads/Bridges) [not already noted above]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 5.5</td>
<td>SR-161 bridge (bridge #161/02) approach was eroded in 2008 flooding; needed to reinforce rip rap to prevent failure</td>
<td>WSDOT</td>
</tr>
<tr>
<td>RM 6.3</td>
<td>Mashel River bridge (Center St. E. and Alder Cutoff Rd. E. – debris)</td>
<td>Pierce County Roads</td>
</tr>
</tbody>
</table>
Table 5.52 Priority Problems Identified in Mashel River

<table>
<thead>
<tr>
<th>Location</th>
<th>Problem Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>buildup on bridge piers during floods threatens bridge</td>
<td></td>
</tr>
<tr>
<td>Facility Maintenance and Repair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM 6.8 – RM 6.9 LB</td>
<td>Private property erosion due to Mashel River flooding in 1996 and 2006</td>
<td>City of Eatonville public meeting</td>
</tr>
</tbody>
</table>

Source: Pierce County Surface Water Management records

5.11.9 River Reach Management Strategies

Recommended river reach management strategies for the Mashel River take into account numerous conditions as follows:

- **Development and land use in adjacent floodplain** – The Mashel River floodplain is primarily rural and forested, but also includes several road and highway crossings and some residential property in the Town of Eatonville. The assessed value of property within the 100-year floodplain is $11.2 million.

- **River management facilities** – Revetments exist along short stretches of roads and near bridges. There is also a levee at the Town of Eatonville wastewater treatment plant.

- **River channel gradient and width** – Channel gradient generally varies from 1.0 to 1.5 percent between RM 0.0 to RM 6.8. The river channel width varies from approximately 40 feet to 160 feet.

- **Presence of salmon spawning and rearing habitat** – Chinook, coho, and pink salmon, and steelhead trout all spawn and rear in the Mashel River.

- **Sediment transport accumulation and incision** – Caldwell and Kuzis (2001) note a cobble/boulder substrate with some gravel around and below the confluence with the Little Mashel River at RM 4.4. Little information is available about sediment transport conditions in the Mashel River. The river was not included in the USGS sediment transport study.

The primary objective for the Mashel River is to protect the public infrastructure (roads, bridges). Another objective is to enhance and create aquatic habitat through riparian re-vegetation, and strategic placement of large woody material.

River reach management strategies for the Mashel River are as follows (see sub-section 4.7.1 and Appendix F):
Structural management strategy:

- The level of erosion protection for revetments should be the channel migration resistance design in areas near bridges and where the creek flows adjacent to public roads.

Non-structural management strategy:

- Floodplain development regulations should continue to be implemented by Pierce County; floodplain development regulations of the Town of Eatonville should be consistent with Pierce County critical area regulations for flood hazard areas.

- Property acquisition or purchase of development rights should be considered on a case-by-case basis to remove the most flood prone structures and people from the flood hazard area. Encourage the property owners within the flood hazard area to purchase flood insurance.
5.11.10 Recommended Capital Projects

The following capital improvement projects are recommended to address the priority problem areas identified in Table 5.52. Capital projects are defined here as construction projects over $75,000. They are included within the six-year Capital Improvement Plan element of the Pierce County Comprehensive Plan. Projects less than $75,000 are classified as small works.

5.11.10.1 M1 – SR-161 Mashel River Bridge – Bridge Scour and Slope Repair Project

Location Information

Sub Area: Mashel River
Basin Plan: Nisqually River (to be adopted)
River Mile: 5.2 – 5.3 Left Bank and 5.5 Right Bank
Council District: 3
Jurisdiction: Pierce County, Eatonville
Property Ownership Affected: WSDOT

Estimated Cost: $2,000,000 - $2,500,000

What is the Issue?

The Mashel River experienced significant channel migration along the river bank adjacent to State Route 161, downstream of Eatonville during the January 7, 2009 flood. There was severe bank erosion along the State Route 161 roadway prism at milepost (MP) 2.26 and at the north bridge abutment and north roadway prism at MP 2.52 in Eatonville. State Route 161 was closed for two days to make the emergency bank repairs using large rip rap.

At MP 2.26 the left bank eroded approximately 50 feet laterally along roughly 350 feet of bank. At MP 2.52 the right bank immediately upstream of the State Route 161 Bridge eroded approximately 20 to 40 feet into an earthen embankment jeopardizing the north bridge abutment. The river is currently aligned into the north abutment of the State Route 161 Bridge. Scour of the spread footing is ongoing.

What is at Risk?

- Channel migration threatens the bridge approach and abutments with short term and/or extended highway closures,
- Stat Route 161 is at risk of future damage from bank erosion from high flows that result in highway closures, and
- Aquatic habitat for salmonids when flood hazard protection measures replace natural riparian features.

What is the Recommended Solution?

Construction of nine engineered bank roughening log structures (BRLSs) along the banks of the Mashel River: six BRLSs along State Route 161 at MP 2.26 and three BRLSs at MP 2.52. The BRLSs will be supported by steel pipe piles with grading on top of the log structures and riparian...
plantings. Both project sites are immediately downstream of engineered log jams (ELJs) previously constructed by the Nisqually Indian Tribe (NIT) as part of habitat restoration projects on the Mashel River.

**What are the Project Benefits?**

- Long-term permanent protection for highway infrastructure and adjacent river bank,
  and
- Improve fish and wildlife habitat

**Coordination**


**Environmental Considerations**

The Mashel River supports a variety of salmonid species, including ESA listed Puget Sound Chinook and steelhead trout. It also supports coho and pink salmon, and cutthroat trout.
CHAPTER SIX
FLOOD PLAN IMPLEMENTATION AND FUNDING

Chapter Six describes the implementation framework and the funding options to accomplish the projects and programmatic recommendations of the Plan. Major implementation steps are described. This Plan, and its proposed policies, projects, and programs, is based on the premise that major river flooding in Pierce County is a regional issue that requires regional collaboration, partnerships, and funding.

Maintaining and improving Pierce County’s flood risk reduction infrastructure and programs is important for public safety and for the economic vitality of the County. The current limited levels of service for ongoing maintenance, repair, and other flood hazard reduction programs will result in citizens facing safety issues and flood and channel migration risks that have severe effects on personal finances and economic stability. Pierce County faces significant challenges in the years ahead including an aging system of flood risk reduction facilities, many of which were built between the 1930’s and 1960’s and were constructed to a lower level of protection than is required today; and, areas with levees and revetments which were unincorporated at the time of construction, but are now in cities and towns. Failure of these facilities would have significant adverse impacts on public safety, public infrastructure, private property and the regional economy. In some areas, the dynamic nature of rivers, increases in sediment transport, channel migration, and more frequent and intense high flows are resulting in rising river beds, reduced river channel conveyance capacity, and increased flood risks. In addition, the environmental requirements resulting from administration of the Endangered Species Act, the Clean Water Act, the Growth Management Act, and other legislation has significantly increased the difficulty and cost of maintaining flood risk reduction facilities.

Existing funds generally pay for maintenance and repair of flood risk reduction facilities. Major repairs usually are associated with damage from flood events making them eligible for federal or state funds. New construction is almost entirely dependent upon grants, which are difficult to secure and often do not provide enough funds to contribute a meaningful amount of total project costs. Sources of existing funding include a portion of SWM fees collected from residents and businesses in unincorporated Pierce County, a small portion of the Real Estate Excise Tax (REET), grants, and designated federal and state funds that are conditionally available in declared flood disasters.

Flooding and channel migration risks on the major rivers of Pierce County transcend political boundaries; however, incorporated areas traditionally have not contributed financially to these activities. An exception is the City of Orting, which realized the importance of these facilities and has undertaken to implement one of the recommended projects (Calistoga Setback Levee) using city generated SWM fees collected from city residents and grants. Rivers often pass through numerous counties and cities. Actions taken in one area of the watershed can affect flooding downstream or across the river. There is a need for an equitable regional funding
source that can be expended in both incorporated and unincorporated areas and that funds new construction rather than merely maintenance.

6.1 PLAN IMPLEMENTATION

Plan implementation will result in multiple public benefits, including reduction in the impacts of flooding and channel migration, protection of roads and other critical facilities that support regional mobility, public safety, and economic viability, enhancement of aquatic habitat, and protection of open space within floodplains.

Changing conditions of the rivers and improved understanding of flood risk reduction facilities, sediment management, and overall floodplain management will influence how recommendations of this plan are carried out. At the time of implementation new data, mapping, studies, and monitoring information will be used to expand on the conceptual projects design.

The rate of Plan implementation will depend on several factors: the funding available, the extent, and severity of future flooding, the benefit-cost analysis existing at the time of potential funding, and other considerations. The order of Plan implementation will vary due to factors such as availability of funds, completion of other projects or activities on which a project relies, cooperation from private landowners, and new information or emerging issues which need to be addressed sooner rather than later.

6.1.1 Pierce County Role in Implementation

The Pierce County Rivers Flood Hazard Management Plan will be adopted by reference as part of Pierce County Code, Title 19D.60, as well as other comprehensive planning documents and the Pierce County Storm Drainage and Surface Water Management Plan. The Pierce County Storm Drainage and Surface Water Management Plan is a part of the Comprehensive Plan for Pierce County, Washington (Comprehensive Plan). The Plan will replace the Puyallup River Basin Comprehensive Flood Control Management Plan, Pierce County River Improvement, written by James M. Montgomery Consulting Engineers, Inc., 1991.

After adoption of the Plan, SWM will identify the capital improvement projects in the Plan to add to the Capital Facilities Element of the Comprehensive Plan (CFP). The CFP is updated annually and includes projects capital expenses over six years. Typically annual budgets reflect the adopted CFP. Pierce County will seek to partner with local governments on capital projects and maintenance and operations of flood risk reduction facilities in incorporated areas.

Implementation of programmatic recommendations will follow from an assessment of the degree of urgency, complexity, and links to projects and other programs, and the like.

Pierce County, in its historical role of providing facilities and services to reduce river flooding and channel migration risks, will lead Plan implementation and build upon the county’s history of coordinating and partnering with other local governments, tribes, state and federal agencies, and the public to reduce flood risks.
The Pierce County SWM Division provides regional flood risk reduction services primarily to unincorporated areas of the county, but also maintains levees and revetments in incorporated areas. This includes maintenance, repair, and capital projects on levees and revetments on the Puyallup, White, Carbon, and Nisqually Rivers, and numerous programs to reduce flood risks, such as education and outreach, floodplain mapping, technical assistance, floodplain acquisition, monitoring, and sediment management. Close coordination will be necessary between SWM, other Pierce County Departments, cities, tribes, state and federal agencies, and other stakeholders to successfully implement the flood plan and reduce the risks of flooding and channel migration.

Other County services that will assist plan implementation include emergency management operations, road maintenance and bridge projects, private development permitting, habitat restoration projects and programs, parks and recreation, open space and regional trail management. SWM coordinates flood warning and emergency response with Pierce County Emergency Management, cities and other regional, state, and federal partners. Regulation of floodplain development and technical assistance are coordinated with Pierce County Planning and Land Services and private landowners.

### 6.1.2 Role of Cities and Towns in Implementation

All communities that are required to plan under the Washington State Growth Management Act (Chapter 36.70A RCW) must adopt regulations for the protection of frequently flooded areas. Communities must also comply with regulations for floodplain management adopted under the Flood Control by Counties Act (Chapter 86.12 RCW). Additionally to remain eligible for the National Flood Insurance Program communities must comply with the requirements of the Biological Opinion issued by the National Marine Fisheries Service for compliance with the Endangered Species Act.

Chapter 86.12 RCW requires all jurisdictions within the planning area to participate in the development of a comprehensive flood hazard management plan and adopt the plan for implementation in their own community. Pierce County recognizes that each local jurisdiction has different levels of existing floodplain development, resources for implementing flood hazard management programs, and staff for enforcing regulations. Complete adoption of the policies and other elements of this Flood Plan may not be appropriate, but it is critical that flood hazard regulations and programs not have an adverse impact on other jurisdictions.

Following adoption of the Flood Plan and commitment of funding, Pierce County will provide technical assistance to help incorporated cities and towns develop policies, regulations, and programs that are consistent with the Pierce County Rivers Flood Hazard Management Plan, when funding and staffing are available.

### 6.1.3 Role of Tribes in Implementation

The Puyallup Tribe of Indians, Nisqually Indian Tribe, and Muckleshoot Indian Tribe have lived along the river systems of Pierce County for thousands of years. Prior to and during treaty
times, the tribes have had usual and accustomed fishing grounds throughout the Puyallup and Nisqually river basins. Ongoing coordination between Pierce County and the tribes will minimize the likelihood of impacts of flood hazard management projects on cultural and historic resources, habitat, and fishing rights. Tribes also play a key role in helping Pierce County achieve long-term habitat improvements through improved flood risk reduction and mitigation efforts.

6.1.4 Role of State and Federal Agencies

State and federal agencies play an important role in flood hazard management program implementation. State agencies include the Washington Departments of Ecology, Fish and Wildlife, and Natural Resources. Ecology is responsible for reviewing and approving the Flood Plan, administers the State’s Flood Control Account Assistance Program, provides guidance on channel migration zone mapping, and administers the Section 401 water quality certification program for proposed projects. The Department of Fish and Wildlife issues hydraulic project approvals for capital projects and gravel removal activities. The Department of Natural Resources has a role in gravel removal activities.

Federal agencies active in flood hazard management activities include the U.S. Army Corps of Engineers (ACOE), Federal Emergency Management Agency (FEMA), National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Services (USFWS), and Mt. Rainier National Park (MRNP). The ACOE sponsors emergency response and rehabilitation activities under PL 84-99, issues permits for Section 404 activities, gravel removal, and work in navigable waters. The ACOE also operates Mud Mountain Dam on the White River for flood control on the lower White and Puyallup Rivers. Finally, the ACOE is the federal sponsor for the Puyallup River General Investigation which is evaluating significant flooding problems on the Puyallup, White, and Carbon Rivers and formulating, evaluating, and screening potential solutions. FEMA provides federally backed insurance through the National Flood Insurance Program, maps special flood hazard areas, and oversees implementation of the new requirements under the Biological Opinion. NMFS and USFWS provide consultation on all projects and programs with a federal nexus (funding or permits) to ensure compliance with the Endangered Species Act (particularly as it relates to Chinook salmon, steelhead, and bull trout). The National Park Service works closely with Pierce County along the upper Nisqually River in relation to the gateway levee and revetment that helps protect the year-round entrance to Mount Rainier National Park (MRNP).

6.2 FUNDING

One of the four goals of the Rivers Flood Hazard Management Plan is to “develop a long-term and flexible funding strategy for river flood hazard management” (see Section 1.4). Although the Plan does not recommend a particular type of funding, it does advocate for equitable funding and system-wide continuity of flood control maintenance, operations, and improvements.
The integrity of the flood management system relies on its continuity, which relies on long-range planning, construction, monitoring, maintenance, and a reliable funding source. Flooding and channel migration risks on the major rivers of the county transcend political boundaries. Rivers pass through several cities and towns, and actions taken in one jurisdiction can affect flooding upstream, downstream, or across the river in other jurisdictions.

Pierce County Public Works and Utilities, Surface Water Management (SWM) Division does not generate sufficient funds to implement the Rivers Flood Hazard Management Plan. Current funding of river projects and programs is based on SWM fees paid by citizens of unincorporated Pierce County. Small portions of the Real Estate Excise Tax, grants, and designated federal and state funds that are conditionally available in declared flood disasters supplement SWM fee revenues. Cities and towns within the Puyallup River Basin are contributing to the USACE general investigation and they undertake certain capital improvement projects, such as the City of Orting’s Calistoga Setback Levee using city generated SWM fees and grants. But, incorporated areas currently do not contribute financially to SWM project, maintenance, and repair activities on the river, and by law SWM cannot expend funds generated by unincorporated areas on facilities and services in the cities and towns. There is a need for an equitable regional funding source that can be expended in both incorporated and unincorporated areas.

One objective is to identify possible funding sources for implementing the recommended flood hazard management projects and activities. The following funding policies were agreed upon by the Flood Plan Advisory Committee (see Chapter 3):

1. **Regional Funding (policy 3.5.1)** – New or expanded regional funding sources should be identified and secured to meet the need for enhanced or expanded flood and channel migration hazard management projects, maintenance, and programs.

2. **Fiscal Management (policy 3.5.2)** – Pierce County and partner jurisdictions and agencies should ensure that adequate funds for annual maintenance and operations, capital projects, and contingency funds are budgeted to meet program needs.

3. **Grant Funding (policy 3.5.3)** – Pierce County, cities/towns in Pierce County, and other local government agencies should identify, evaluate, and coordinate grant fund sources to determine their suitability and assess consistency with the goals and objectives of this plan, and apply for grants to leverage local sources of funding for flood management projects.

### 6.2.1 Local Sources of Funding

The following sections describe current funding sources and future funding options to enhance capital project and program implementation to reduce flood and channel migration risks.
6.2.1.1 Current Funding

Current sources of funding include the Pierce County’s Surface Water Management Fund collected from citizens and business in unincorporated Pierce Count, a portion of the Real Estate Excise Tax, and occasional designated federal and state funds that are limited and conditionally available in declared flood disasters, and through grants. Table 6.1 shows the amount of local funds, some federal and state funds, and some fund balance expended on river programs, maintenance and operations, capital projects and acquisitions over the past 20 years. In recent years, cities including Orting and Sumner have also expended local SWM and other funds to advance levee and flood wall capital projects, including acquisition, design and permitting, but this is not included in Table 6.1.

<table>
<thead>
<tr>
<th>Year</th>
<th>SWM Fund – River Improvement</th>
<th>REET – River Improvement</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>$1,069,114</td>
<td>$603,081</td>
<td>$1,672,195</td>
</tr>
<tr>
<td>1992</td>
<td>$1,037,639</td>
<td>$395,896</td>
<td>$1,433,535</td>
</tr>
<tr>
<td>1993</td>
<td>$970,904</td>
<td>$439,847</td>
<td>$1,410,751</td>
</tr>
<tr>
<td>1994</td>
<td>$980,417</td>
<td>$589,779</td>
<td>$1,570,196</td>
</tr>
<tr>
<td>1995</td>
<td>$1,042,750</td>
<td>$3,103,270</td>
<td>$4,146,020</td>
</tr>
<tr>
<td>1996</td>
<td>$1,058,160</td>
<td>$687,450</td>
<td>$1,745,610</td>
</tr>
<tr>
<td>1997</td>
<td>$1,113,354</td>
<td>$4,995,749</td>
<td>$6,109,103</td>
</tr>
<tr>
<td>1998</td>
<td>$884,112</td>
<td>$957,683</td>
<td>$1,841,795</td>
</tr>
<tr>
<td>1999</td>
<td>$967,045</td>
<td>$857,334</td>
<td>$1,824,379</td>
</tr>
<tr>
<td>2000</td>
<td>$848,157</td>
<td>$1,446,173</td>
<td>$2,294,330</td>
</tr>
<tr>
<td>2001</td>
<td>$897,817</td>
<td>$1,908,481</td>
<td>$2,806,298</td>
</tr>
<tr>
<td>2002</td>
<td>$708,892</td>
<td>$1,004,195</td>
<td>$1,713,087</td>
</tr>
<tr>
<td>2003</td>
<td>$1,240,191</td>
<td>$1,438,597</td>
<td>$2,678,778</td>
</tr>
<tr>
<td>2004</td>
<td>$321,628</td>
<td>$905,053</td>
<td>$1,226,681</td>
</tr>
<tr>
<td>2005</td>
<td>$460,257</td>
<td>$657,619</td>
<td>$1,117,876</td>
</tr>
<tr>
<td>2006</td>
<td>$4,116,737</td>
<td>$5,570,753</td>
<td>$9,687,490</td>
</tr>
<tr>
<td>2007</td>
<td>$2,285,977</td>
<td>$1,693,075</td>
<td>$3,979,052</td>
</tr>
<tr>
<td>2008</td>
<td>$1,553,752</td>
<td>$2,210,533</td>
<td>$3,764,285</td>
</tr>
<tr>
<td>2009</td>
<td>$3,979,509</td>
<td>$3,870,052</td>
<td>$7,849,561</td>
</tr>
<tr>
<td>2010</td>
<td>$2,597,370</td>
<td>$2,003,128</td>
<td>$4,600,498</td>
</tr>
<tr>
<td>Total</td>
<td>$28,133,773</td>
<td>$35,337,748</td>
<td>$63,471,521</td>
</tr>
</tbody>
</table>
There are several types of state and federal funding assistance that occasionally are available to Pierce County; however, none of these are always available. Currently, state and federal budget reductions continue to reduce the amount of money Pierce County is able to secure from these sources. Additionally, for federal funds, Pierce County often competes with flood and hazard damages that occur elsewhere in the country, such as in the Mississippi River valley and in the Gulf of Mexico. These areas are often able to secure the majority of available federal disaster relief funds, often eliminating or reducing available money for Pierce County.

Sources of federal and state funding to implement flood damage and mitigation projects include:

- Federal Emergency Management Agency (FEMA),
  - Hazard Mitigation Grant Program (HMGP)
  - Pre-Disaster Mitigation (PDM)
  - Flood Mitigation Assistance (FMA)
  - Repetitive Flood Claims (RFC)
  - Severe Repetitive Loss (SRL)
- U.S. Army Corps of Engineers (ACOE)
  - PL 84-99 Emergency Response and Rehabilitation Program
  - Puyallup River General Investigation
- State of Washington Department of Ecology (WDOE)
  - Flood Control Assistance Account Program (FCAAP)
- Community Development Block Grants (CDBG)
  - Typically made available following a Presidential Declared Disaster and administered by local jurisdictions

The availability of these fund sources is dependent on both Federal and State budgeting processes and funding levels vary dramatically from year to year and their availability has been declining over the years. Others are only available following federally declared disasters. There is no dedicated fund or amount that is made available to Pierce County under these sources. As such, these funds can help supplement implementation of the Flood Hazard Management Plan, but cannot be relied on for predictable, reliable, or long-term operational and capital needs.

6.2.1.2 Potential New and Enhanced Local Funding Options

Pierce County’s current funding levels do not provide sufficient funding to address the existing needs for flood risk reduction facilities, including maintenance, repair, and capital needs. Existing dedicated funding sources must be enhanced in order for Pierce County to provide adequate flood and channel migration zone hazard services and implement preventive projects.
and programs to reverse the trends of declining levels of protection. The section below describes new and enhanced funding options.

**Flood Control Zone District Levy or Fee**

RCW 86.15.025 gives the Pierce County Council the authority to establish either countywide or basin-level flood control zone districts (FCZD) that create additional opportunities for new, dedicated funding sources. A FCZD is a special purpose district (government agency) established to specifically address flooding issues. The purpose of the FCZD is to construct, operate, and maintain flood control projects to reduce flooding and channel migration risks. Funding for a FCZD can be initiated through a levy based on total assessed value of taxable property within the district’s designated boundaries or through the imposition of fees.

A FCZD can be established by an ordinance of the Pierce County Council or by a vote of the citizens if the County Council does not establish one. On April 3, 2012 the Pierce County Council passed Ordinance 2011-95s, creating the Pierce County Flood Control Zone District.

**River Improvement Fund Levy**

RCW 86.12.010 gives the Pierce County Council the authority to establish a county tax for a river improvement fund (e.g., flood control maintenance account). Washington State law allows it to be assessed up to $0.25 per $1000 of assessed value. The River Improvement Fund levy is limited, because the levy competes with other mandatory and essential services that are also funded by levies, and together they cannot exceed statutory levy limits.

**Surface Water Management Service Charge**

RCW 36.89 allows Pierce County the authority to assess surface water management service charges for managing surface water. Pierce County provides surface water management services in unincorporated Pierce County that are funded by an annual surface water management service charge assessed on residential and commercial properties. The SWM Utility service charge helps fund a variety of ongoing County projects and programs including flood management, levee repairs, NPDES municipal stormwater permit compliance, preventing water pollution, salmon recovery, and drainage system construction and maintenance. Additionally, incorporated cities within Pierce County, as well as King, Lewis and Thurston counties, can or do have local surface water management service charges. The SWM service charge from all of these jurisdictions could be increased to specifically pay for additional flood management programs and capital projects.

**Interlocal Agreements**

Local governments within Pierce County, including cities and towns could jointly fund implementation of the Flood Plan through development of an interlocal agreement (ILA), as authorized by RCW 39.34, Interlocal Cooperation Act, using any variety of local funds they choose, such as general funds, SWM fund, or road funds. The local jurisdictions would agree on the regional flood management services to be provided by Pierce County and the equitable
funding share. Individual ILAs would be developed between Pierce County and all participating jurisdictions.

**Potential Watershed Investment District**

The 2012 Washington State Legislature may consider creating the authority to establish a watershed investment district with taxing authority to support watershed investments to improve watershed health, including salmon habitat, flood protection, and water pollution control. This would allow independent districts to be formed on a watershed resource inventory area (WRIA) basis with respective County concurrence. While this source may become viable, until the legislature enacts this authority it remains only a potential source.

### 6.3 COST OF FLOOD PLAN IMPLEMENTATION

The cost of flood plan implementation includes capital and programmatic costs. In this plan, the estimated costs are planning-level costs based on preliminary conceptual design information and assumptions about program components and annual staffing levels. The costs are based on the capital projects included in Chapter 5 and the programmatic recommendations included in Chapter 4.

The total estimated cost of the 32 capital projects is between $350.8 and $396.4 million (see Table ES.2) and is broken out by sub-planning area in Table 6.2.

<table>
<thead>
<tr>
<th>Sub-Planning Area</th>
<th># of projects</th>
<th>Total Estimated Project Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Puyallup River</td>
<td>8</td>
<td>$195,770,000 - $215,700,000</td>
</tr>
<tr>
<td>Middle Puyallup River</td>
<td>4</td>
<td>$24,970,000</td>
</tr>
<tr>
<td>Upper Puyallup River</td>
<td>6</td>
<td>$39,500,000 - $64,200,000</td>
</tr>
<tr>
<td>Lower White River</td>
<td>3</td>
<td>$32,327,000</td>
</tr>
<tr>
<td>Upper White River</td>
<td>1</td>
<td>$0</td>
</tr>
<tr>
<td>Greenwater River</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Carbon River</td>
<td>5</td>
<td>$40,300,000</td>
</tr>
<tr>
<td>South Prairie Creek</td>
<td>2</td>
<td>$597,000</td>
</tr>
<tr>
<td>Middle Nisqually River</td>
<td>1</td>
<td>$10,900,000</td>
</tr>
<tr>
<td>Upper Nisqually River</td>
<td>2</td>
<td>$4,500,000 - $7,500,000</td>
</tr>
<tr>
<td>Mashel River</td>
<td>1</td>
<td>$2,000,000 - $2,500,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>33</strong></td>
<td><strong>$350,864,400,000 - $396,364,000</strong></td>
</tr>
</tbody>
</table>

The costs of implementing the programmatic recommendations vary due to the number of full-time equivalents to implement a program element, lump sum costs, and whether costs are
annual, one-time, or for example, once every five years or during/following a flood event. Table 6.3 summarizes the programmatic costs (see also Appendix J).

<table>
<thead>
<tr>
<th>Type of Programmatic Action</th>
<th>Staff (FTE(^a)/year)</th>
<th>Annual cost (based on FTE/year)</th>
<th>Annual Lump Sum (LS)</th>
<th>One-time LS or FTE</th>
<th>LS every 5 years</th>
<th>Total (annual; one-time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information/Mapping/Technical Assistance</td>
<td>1.2</td>
<td>$144,000</td>
<td>$0</td>
<td>$960,000</td>
<td>$0</td>
<td>Annual: $144,000 One-time: $960,000</td>
</tr>
<tr>
<td>Land Use/Regulatory/Acquisition/Elevation</td>
<td>0.7</td>
<td>$84,000</td>
<td>$0</td>
<td>$27,000</td>
<td>$0</td>
<td>Annual: $84,000 One-time: $27,000</td>
</tr>
<tr>
<td>River Channel Management</td>
<td>0.2(^b)</td>
<td>$24,000</td>
<td>$63,000</td>
<td>$350,000 - $470,000</td>
<td>$265,000 - $315,000</td>
<td>Annual: $87,000 One-time: $350,000 - $470,000 Every five years: $265,000 - $315,000</td>
</tr>
<tr>
<td>River Management Facility Repair and Maintenance</td>
<td>2.2</td>
<td>$264,000</td>
<td>$1,455,000 - $2,505,000</td>
<td>$252,400</td>
<td>$0</td>
<td>Annual: $1,719,000 - $2,769,000 One-time: $252,400</td>
</tr>
<tr>
<td>Education, Flood Preparedness, Flood Warning and Emergency Response</td>
<td>0.95</td>
<td>$114,000</td>
<td>$35,000</td>
<td>$105,000 - $115,000</td>
<td>$30,000</td>
<td>Annual: $149,000</td>
</tr>
<tr>
<td>Coordination, Adaptive Management, and Multiple Benefits</td>
<td>0.6</td>
<td>$72,000</td>
<td>$100,000</td>
<td>$325,000 - $545,000</td>
<td>$0</td>
<td>Annual: $172,000 One-time: $325,000 - $545,000</td>
</tr>
<tr>
<td>Capital Project Planning</td>
<td>0.0</td>
<td>$0</td>
<td>$0</td>
<td>$185,000 - $275,000</td>
<td>$40,000 - $60,000</td>
<td>One-time: $185,000 - $285,000 Every five years: $40,000 - $60,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5.85</strong></td>
<td><strong>$702,000</strong></td>
<td><strong>$1,653,000 - $2,703,000</strong></td>
<td><strong>$2,184,400 - $2,504,400</strong></td>
<td><strong>$335,000 - $405,000</strong></td>
<td><strong>Annual: $2,355,000 - $3,405,000 One-time: $2,204,400 - $2,574,400 Every five years: $335,000 - $405,000</strong></td>
</tr>
</tbody>
</table>

\(^a\) FTE= Full Time Equivalent
\(^b\) Other costs included as part of capital projects

6.4 FUTURE PLAN REVISIONS

It is expected that the Pierce County Rivers Flood Hazard Management Plan will be updated every five years, as required by the Community Rating System (CRS) of the National Flood Insurance Program. Progress of the plan will be monitored on an annual basis to support the CRS recertification process. Future updates will include identification of new flooding or
channel migration problem areas, updated FEMA flood mapping and Pierce County channel migration mapping, changes in repetitive loss properties, maintenance and repair of flood risk reduction facilities, implementation of capital projects, and status of programmatic recommendations.
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